



# Proceedings

## Conférence Nationale sur les nouvelles Technologies Informatiques

CN2TI'2015



CN2TI

Guelma, 10-11 Novembre 2015



## Préface

Ces actes regroupent les articles présentés lors de la première Conférence Nationale sur les Nouvelles Technologies Informatiques (CN2TI'15) qui s'est déroulées les 10-11 Novembre 2015 à l'Université 8 Mai 1945 de Guelma, Algérie.

L'objectif de cette conférence est de rassembler les jeunes chercheurs en informatique avec leurs différentes disciplines et domaines d'application pour leur permettre de présenter leurs travaux de recherches. Cette activité offre un cadre convivial aux participants pour présenter les travaux, confronter les idées et débattre les contributions dans les différents domaines de recherche. La présence de chercheurs seniors permet d'orienter et d'enrichir les idées des participants.

La manifestation couvre un spectre diversifié de thématiques de recherche, telles que:

- **Bioinformatique**
- **Big data**
- **Cloud computing**
- **Datamining**
- **Education et E-learning**
- **E-technologies**
- **Informatique mobile**
- **Réseaux sociaux**
- **Réalité virtuelle et augmentée**
- **Réseaux de capteurs**
- **Web social**
- **Sécurité informatique**
- **Système multi agents**
- **Systèmes distribués**
- **Traitements d'image & Multimédia**
- **Vision par ordinateur**
- **Web intelligent**
- **Web sémantique**
- **Génie du Logiciel**
- **Méthodes et vérification formelle**
- **Machine Learning**

Le programme de cette édition 2015 comporte à la fois des articles contenant des travaux théoriques ainsi que des applications pratiques qui font souvent appel à diverses techniques issues des différents thèmes couverts par cette manifestation. Le comité de programme a procédé à l'évaluation des articles soumis et il a sélectionné dix-sept articles pour une présentation orale soit un taux de sélection de 80%.

Nous tenons à remercier l'ensemble des auteurs qui ont montré un intérêt pour cette manifestation, les conférenciers invités qui n'ont pas hésité à apporter leurs contributions, les membres du comité de programme pour leur effort d'évaluation et les membres du comité d'organisation pour leur disponibilité.

Le Président du Comité d'organisation  
Dr. Mohamed Nadjib KOUAHLA

## **Présidents d'honneur**

Recteur de l'Université de Guelma: Pr. Mohamed Nemamcha

Doyen de la Faculté MI/SM : Pr. Athmane Meddour

## **Président de la Conférence**

Pr. Hamid Seridi

## **Président du Comité de Programme**

Dr. Yacine Lafifi

## **Président du Comité d'organisation**

Dr. Mohamed Nadjib Kouahla

## **Comité d'organisation**

Riad Bourbia  
Ali Seridi  
Mourad Hadjeris  
Brahim Farou  
Zine Eddine Kouahla  
Amina Zedadra  
Hocine Merabti

## Comité de Programme

Moussaoui Abdelouahab	University of Setif 1
Abdelmalek Amine	GeCoDe, University of Saida
Abdelkrim Amirat	LINA, University of Souk Ahras
Baghdad Atmani	LIO, University of Oran
Mohamed Chaouki Babahenini	University of Biskra
Halima Bahi	LabGED, University of Annaba
Mohamed Batouche	MISC, University of Constantine
Amel Behaz	University of Batna
Nadia Benalia	University of Annaba
Nadjia Benblidia	University of Blida
Chemesse Ennehar Bencheriet	LAIG, University of Guelma
Mohammed Benmohammed	LIRE, University of Constantine 2
Tahar Bensebaa	LRI, University of Annaba
Azeddine Bilami	LASTIC, University of Batna
Karim Bouamrane	LIO, University of Oran
Bachir Boucheham	University of Skikda
Houria Boudouda	LabSTIC, University of Guelma
Mahmoud Boufaida	LIRE, University of Constantine 2
Zizette Boufaida	LIRE, University of Constantine 2
Tahar Bouhadada	LRI, University of Annaba
Abdallah Boukerram	University of Bejaia
Abdelhani Boukrouche	University of Guelma
Douadi Bourouaieh	LabSTIC, University of Guelma
Beldjilali Bouziane	LIO, University of Oran
Allaoua Chaoui	MISC, University of Constantine 2
Salim Chikhi	MISC, Univerdity of Constantine 2
Cherki Daoui	University Sultan Moulay Slimane
Nadir Farah	LabGED University of Annaba
Hadria Fizazi	University of Oran
Cherif Foudil	LESIA, University of Biskra
Nacira Ghoualmi	LRS, University of Annaba
Salim Haddadi	LabSTIC, University of Guelma
Reda Hamou	University of Saida
Okba Kazar	LINFI, University of Biskra
Abdallah Khababa	University of Setif
Mohamed Tarek Khadir	LabGED, University of Annaba
Mohamed-Khireddine Kholladi	University of Eloued
Yacine Kissoum	University of Skikda
Mohamed Nadjib Kouahla	LabSTIC, University of Guelma
Yacine Lafifi	LabSTIC, University of Guelma
Mohamed Ridda Laouar	University of Tebessa
Mohamed Tayeb Laskri	LRI, University of Annaba
Smaine Mazouzi	University of Skikda
Kamal Melkemi	LESIA, University of Biskra

Ahlem Melouah	University of Annaba
Elkamel Merah	University of Khenchela
Hayet Farida Merouani	LRI, University of Annaba
Souham Meshoul	University of Constantine 2
Djamel Meslati	LRI, University of Annaba
Farid Mokhati	Université of Oum elbouaghi
Mohamed Nemissi	LabSTIC, University of Guelma
Zaidi Sahnoun	LIRE, University of Constantine 2
Djamel Eddine Saidouni	MISC, University Constantine 2
Maamar Sedrati	University of Batna
Hassina Seridi	LabGED, University of Annaba
Ismahane Souici	University of Jijel
Labiba Souici-Meslati	LRI, University of Annaba
Said Talhi	LASTIC, University of Batna
Thouraya Tebibel	ESI Alger
Bornia Tighiouart	LRI, University of Annaba
Yamina Tlili	LRI, University of Annaba
Mohamed Touahria	University of Setif
Belabbas Yagoubi	LIO, University of Oran
Nacereddine Zarour	LIRE, University of Constantine 2
Madjid Zidani	LASTIC, University of Batna
Samir Zidat	LASTIC, University of Batna

## Table of Contents

Test-repair technique for broken test cases during mobile Apps evolution .....	1
<i>Lynda Ait Oubelli and Abdelkrim Amirat</i>	
Une méthode d'alignement entre deux ontologies multi-points de vue .....	9
<i>Foughali Amira and Boufaida Zizette</i>	
Hybrid Energy Efficient Routing Protocol for Heterogeneous WSN .....	17
<i>Ayoub Benayache, Azeddine Bilami and Barkat Sami</i>	
Weighted Association Rules: Application in Medical Images fields .....	26
<i>Senaï Besma, Sid Ahmed Rahal and Salim Khiat</i>	
Résolution du problème de planification touristique par un Algorithme Génétique.....	31
<i>Mourad Bouatouche and Khaled Belkadi</i>	
Enhancement of Image Characterization with Discrete Wavelet Coefficients using the Third Statistical Moment for Texture-Based Image Retrieval .....	36
<i>Salah Bougueroua, Bachir Boucheham and Mohamed Belaoued</i>	
Agile Service-Oriented Architectures Development : A Case Study.....	42
<i>Hamza Chehili and Mahmoud Boufaida</i>	
Neighborhoods combination for Examination Timetabling Problem .....	47
<i>Meryem Cheraitia and Salim Haddadi</i>	
A Multi start Greedy Constructive Heuristic To The Nurse Scheduling Problem .....	52
<i>Fatima Guessoum and Salim Haddadi</i>	
Super-Resolution Techniques Applied to Magnetic Resonance Images.....	57
<i>Messaoud Hameurlaine, Abdelouahab Moussaoui and Hadda Cherroun</i>	
A review of Change Impact Analysis Approaches for Software Evolution.....	63
<i>Adenane Hidouci and Rabah Lebsir</i>	
Critères de sécurité pour l'utilisation de la e-santé en Algérie .....	70
<i>Mohammed El Mustapha Miroud and Khaled Belkadi</i>	
A Comparative Performance Study of Objective function of RPL in Low-power and Lossy Networks (LLN) ..	78
<i>Azza Mohammed and Sofiane Boukli Hacene</i>	
Composition of web services using multi agent based planning with high availability of web services.	83
<i>Mehdi Sabrina and Zarour Nacer Eddine</i>	
A Comparative Study of Application Layer Protocols for M2M communications in the IoT	89
<i>Barkat Sami, Bilami Azeddine and Benayache Ayoub</i>	
Interreflection effects based on Multi-virtual point light for rendering image synthesis.....	95
<i>Khemliche Sarra, Babahennini Mohamed Chaouki, Bahi Naima and Zerari Abdelmoumene</i>	
KNOWLEDGE CAPITALIZATION FOR MASSIVE OPEN ONLINE COURSES .....	101
<i>Nacera Hammid and Farida Bouarab-Dahmani</i>	

## **PLÉNIÈRES**

---

**Prof. Mohamed-Khireddine KHOLLADI**

**Université Echahid Hamma Lakhdar Eloued, Algérie**

*« Le SIG: un outil d'analyse, de représentation et de modélisation pour la prise de décision via des cas pratiques »*

---

**Prof. Okba KAZAR**

**Université Mohamed Khider Biskra, Algérie**

*« Méthodologie Agents entre théorie et pratique »*

---

**Prof. Cherki DAOUI**

**Université Sultan Moulay Slimane, Maroc**

*« Accélération des algorithmes classiques de résolution des Processus décisionnels de Markov »*

# ***Test-repair technique for broken test cases during mobile Apps evolution***

Lynda AIT OUBELLI and Abdelkrim AMIRAT

Dept of Mathematics and Computer Science

University of Souk-Ahras

Souk-Ahras, 41000, Algeria

**Abstract**— Successful mobile applications need to be rock solid before and after they are released to the market, they continue to make dramatic changes in response to their ecosystem requirements or better understanding of user needs. These changes incur high maintenance costs not only for the Mobile App under test ( $M_{appUT}$ ) but also for the regression test suites, which can often have larger complexity than the  $M_{appUT}$  itself, when requirements change and the  $M_{appUT}$  evolves, some existing tests break because they reflect the old behavior, and not the new intended one. Broken tests cause many problems. Updating them is time consuming and very expensive task, many works tackle this phenomenon in different ways by different tools and methods. This paper represents a new test repair technique for broken test suites during the evolution of an android mobile application; describing many aspects of design, development, testing, based on a model driven engineering approach where the models are serialized using the standard XMI.

**Keywords**—  $M_{appUT}$ , Software evolution, Test case adaptation, MDE, EMF compare;

## I. INTRODUCTION

Mobile applications are becoming an integral part of our life. Not long ago, many people used to feel uncomfortable without a cell phone, nowadays most people feel uncomfortable without a smart phone, a survey says that 47% of adults couldn't last a day without smart phone, this is mainly due to mobile applications. A great revolution in the world of mobile industry [1]. That has evolved very rapidly since its beginning, from simple tiny pieces of calendars, calculators to a huge growing number of modern applications that fulfil our everyday tasks such as shopping, business, banking, diary planning and social networking. All of this leads consumers to ask many questions such as: what kind of mobile application do we need in our lives? How can we choose them? How can we decide whether to keep using or to throw an application? These questions and many others lead developers to investigate and ask: what basic challenges of developing a mobile application are? How can we keep users away from uninstalling our Apps? How to improve the quality of our Apps? How to adapt our Apps with their ecosystems during their evolution? What is a good or bad mobile application? Generally software evolution is the dynamic behaviour of programming systems as they are maintained and enhanced over their lifetime. Lehman et al. [2] defined the phenomenon,

but what is the specificity of mobile application evolution? When can we say that this application has evolved? Lehman et al. [3] also proposed laws for software evolution, but, are they applicable on mobile Apps? In order to gain insights into the evolution of mobile application, Minelli et al. [4] investigated either Lehman's laws that were proposed for traditional systems are available for mobile Apps and they proved that mobile Apps evolution accepts the law of continuing change to be applied. Second law of the increase in complexity is also accepted despite the quality declining law; the authors recommend further study to be done. And a question mark is still put; testing is usually performed to improve quality, doing this task during mobile Apps evolution manually or automatically is a great challenge in the case of an application developed individually or by a team of developers in the same working area or in different ones. During mobile Apps development this has an impact on test cases, and forces the tester to generate test cases from scratch for each new change. It takes a lot of time and will be an obstacle of putting the application out the door because we are not sure of the quality criteria which leads to break the confidence of the relation consumer/products and throw the application after five minutes of its installation.

The remainder of this research paper is organized as follows: Section 2 describes an overview of several approaches for studying mobile applications and their testing manually or automatically, from their GUIs or codes, it seeks also mobile Apps and their test cases evolution. Furthermore, Section 2 takes a closer look at the related works to our proposal. Next, in Section 3 we discuss the theoretical sound of the model driven approach for test cases evolution, architecture of the proposal, technique environment. Section 4 represents case study of the proposal (Android mobile App, the kind of changes in the original application, the comparison pattern used in extracting the equivalences and differences between different versions, the generation of test suite from the original version). Section 5 provides conclusions and future works.

## II. BACKGROUND

Mobile Apps need to be rock solid before they are released to the market [5]. Their testing process is time consuming and

it involves huge amount of expenses. Yet critical to ensure that consumers have a positive experience when they use mobile applications. There are trade-offs that need to be considered and choices that need to be made regarding the mix of different techniques and methods that will be used in mobile Apps testing [6].

#### A. Mobile applications and their testing

Mobile application whatever its type (Native App, Mobile Web App or Hybrid App) [6], is a software application designed to run on a smart phone, tablet, computers and other mobile devices and/or taking in input contextual information [7]. In mobile computing an application is considered to be mobile if it runs on an electronic device that may move (e.g., mp3 readers, digital camera, mobile phones). Henry Mucciniin et al. [8], defines from a testing perspective an App for Mobile as an application that, driven by user inputs, runs on a mobile device with limited resources. Satyanarayanan et al. [9], synthetically captures the uniqueness and conceptual difference of mobile computing through four constraints: Limited resources, security and vulnerability, performance and reliability, and finite energy source. According to Wasserman et al. [10] software testing is usually performed for the following purposes: (1) to improve quality, (2) for verification and validation, and (3) for reliability estimation. Testing can also serve as a statistical sampling method to gain failure data [11]. For mobile devices is insufficient to merely test an Android application on an emulator; it must be tested across many different Android devices running on different versions of the operating system over various telecom networks. Using different tools, Figure1 summarizes techniques and paradigms for mobile application testing.

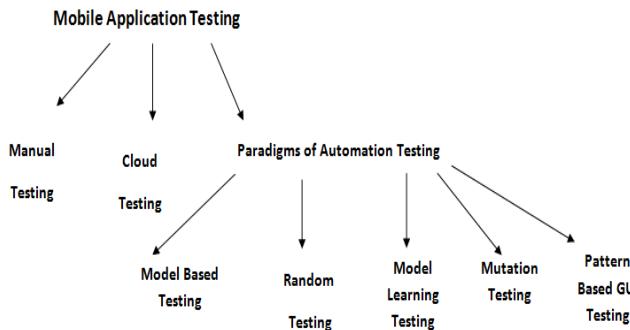


Fig. 1. Mobile Application testing techniques and paradigms.

Manual testing, i.e. using mobile emulators and simulators that can help developers to test their Apps on different devices without the need to actually have them on hand [12]. Cloud based testing strategy enables a distributed, cost effective way of testing mobile applications on a multitude of devices [13]. Testing as a Service(TaaS) is also sometimes known as on-demand testing: is most suitable for specialized testing efforts that don't require a lot of in depth knowledge of the design or the system. Services that are well-suited for the TaaS model includes automated regression testing, performance testing, security testing [14]. Today a relevant family of techniques

and tools for automated testing of mobile Apps focus on their GUI to find bugs. They were recently classified into Random testing, Model-based testing, and Model-learning testing techniques [15]. Random testing, the testing engineers generally use two approaches to automate their time consuming work. The first one is the capture and replay tool with which the testers can automatically record test scripts by manipulating the mobile application under test. Then the testers can replay the recorded test scripts repeatedly afterwards. The problem with record-replay technique is that the quality of the generated test scripts depends on the testers' familiarity and understanding of the application under test, which can fluctuate greatly across different testers and applications [16]. Model-based testing approaches are often applied to testing graphical user interfaces a set of techniques and tools to automate the creation of test cases based on a model of a system. The model typically is a UML representation or a finite state machine. And it is a description of a system (or part of it) that helps to understand and predict its behaviour [17]. D. Amalfitano et al. [15] presented new contributions where they realized a conceptual framework called MobiGUITAR for automated mobile App testing. It's a new fully automatic technique to test GUI-based Android Apps. It is based on the observation, extraction, and abstraction of the run-time state of GUI widgets. The abstraction is used to create a scalable state-machine model that, together with event-based test coverage criteria provide a way to automatically generate test cases. Model learning testing, where Choi et al. [18] proposed an automated technique, called Swift Hand, for generating sequences of test inputs for Android Apps. The technique uses machine learning to learn a model of the App during testing, uses the learned model to generate user inputs that visit unexplored states of the App, and uses the execution of the App on the generated inputs to refine the model. Pattern based (GUI) for mobile testing, where Pedro Costa et al. [19] apply a new methodology named Pattern-Based GUI Testing (PGBT) they started by fault seeding mutants into an open-source Android application named Tomdroid, this methodology intends to test mobile applications based on models built upon User Interface Test Patterns (UITPs) that were originally applied to test web applications. It is all about reusability and the models could be used to test different applications in different OSs. It's an approach based on mutation analysis. But what is a mutation analysis? Mutation Analysis it is a structural testing method aimed at assessing/improving the adequacy of test suites, and estimating the number of faults present in systems under test [20].

#### B. Evolution of Mobile Apps

The Research Institute in Software Evolution (RISE) [21] defined software evolution as: « The set of activities, both technical and managerial, that ensures that software continues to meet organizational and business objectives in a cost effective way ».

M.Lehman and J.Ramil (2000) [2] defined it as: all programming activity that is intended to generate a new software version from an earlier operational version [22].

Ned Chapin et al. [23] defined software evolution as: the application of software maintenance activities and processes that generate a new operational software version with a changed customer-experienced functionality or properties from a prior operational version together with the associated quality assurance activities and processes, and with the management of the activities and processes [2]. But what makes mobile application evolution different ? In many aspects, developing mobile applications is similar to other software systems. Common issues include integration with device hardware, as well as traditional issues of security, performance, reliability, and storage limitations. However, mobile applications present some additional requirements that are less commonly found with traditional software applications. Including the potential interactions with other applications because most embedded devices only have factory-installed software, but mobile devices may have numerous applications from varied sources, with the possibility of interactions among them. Second reason is sensor handling, most modern mobile devices, e.g., «smart phones», include an accelerometer that answers to device movement, a touch screen that answers to numerous gestures, along with real and/or virtual keyboards, a global positioning system, a second reason is families of hardware and software platforms, most embedded devices execute code that is custom-built for the properties of that device, but mobile devices may have to support applications that were written for all of the varied devices supporting the operating system, and the different versions of the operating system. An Android developer, for example, must decide whether to build a single application or multiple versions to run on the broad range of Android devices and operating system releases [24]. Final reason is Security: most embedded devices are «closed», in the sense that there is no straightforward way to attack the embedded software and affect its operation, but mobile platforms are open, allowing the installation of new «malware» applications that can affect the overall operation of the device, including the surreptitious transmission of local data by such an application. In addition to User interfaces with a custom-built embedded application, the developer can control all aspects of the user experience.

Elizabeth Phillips [16] described mobile App's evolution as an incremental dramatic change and development, it focuses nowadays on their design for example: before many Apps utilized a simple list or icon system to display features. Now, Apps are able to incorporate high quality photos and mobility throughout the App. Instead of just scrolling from top to bottom or clicking on one-destination icons. The Facebook App incorporates a more interactive user experience with a «swipe-over menu to the side for accessing the profile, News Feed, events,... etc. instead of that home screen grid» [25]. API evolution, API is an abbreviation of application program interface, is a set of routines, protocols, and tools for building software applications. The API specifies how software components should interact and are used when programming graphical user interface (GUI) components [26]. The transition of API level is considered as an evolution. Another kind of mobile Apps evolution is LTE evolution Long term evolution, it is in services provided by mobile Apps [27] besides to Requirement evolution, for example, in 2002, a powerful

smart phone BlackBerry released by RIM which increased the requirement of applications [28]. Furthermore, Ecosystem evolution where the application evolve according to changes in its surrounding environment Figure 2 shows the ecosystem of mobile devices [29].

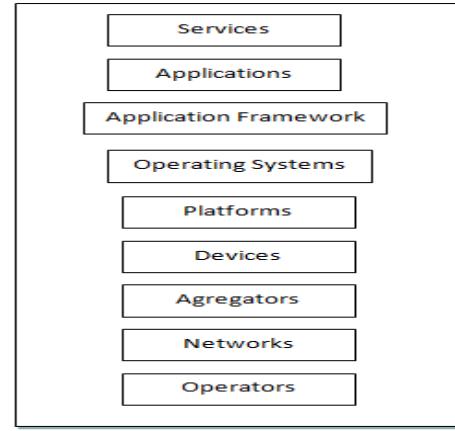


Fig. 2. The Mobile ecosystem. Figure reproduced from [29].

### C. Evolution of test cases

Test repair can be an expensive activity, automating it, even if only partially could save a considerable amount of resources during maintenance and this is the motivation behind the development of automated test-repair techniques [30], such as the ones targeted at unit test cases [31, 32] and those focused on GUI [33,34] or system test cases. For example a change in the GUI may render some of the test cases useless. In practice, since a large number of the original test cases cannot be reused, GUI regression testing requires redeveloping new test cases from scratch. Memon and Soffa [33] presented a repair technique that constructs models of the original and modified GUI components. Some test cases can be corrected by means of automatic refactoring techniques that can prevent simple errors by automating some refactoring activities like moving or renaming methods. Unfortunately, common refactoring practices like adding new parameters to methods [35] are only partially automated by existing tools and techniques. For example, ReBa [36] and the Eclipse IDE [37] can fix compilation errors caused by parameter changes, but only when the modified parameters can be replaced by default values. M. Mirzaaghaei et al. [30] presented a repair technique for fixing JUnit test cases that are broken because of changes in method signatures, that is, addition, deletion, or modification of parameters. It is a right step in the direction of developing more widely applicable automated repairs, however, the effectiveness of the technique is still limited, and the development of more sophisticated approaches is required. In particular, the technique attempts to fix a broken method call by adding, deleting, and modifying parameters, but it does not synthesize new method calls. In 2014 Mirzaaghaei et al. [32] focus on the problem of updating test suites automatically and they present a framework named: TCA Test Care

Assistant that implements eight algorithms to support the evolution of test suites written in Java. It takes as inputs original software, modified software, test cases of the original software and displays the output, which is test cases for the modified software. It is a first step towards the definition of techniques that take advantage of existing test cases to repair broken test cases or generate new ones; they worked on the code of the software not on the GUI [34]. One of the main reasons for test suite evolution is test obsolescence: test cases cease to work because of changes in the code and must be suitably repaired. There are several reasons why it is important to achieve a thorough understanding of how test cases evolve in practice. In particular, researchers who investigate automated test repair an increasingly active research area can use such understanding to develop more effective repair techniques that can be successfully applied in real world scenarios. More generally, analysing test suite evolution can help testers better understand how test cases are modified during maintenance and improve the test evolution process. To tackle this problem, Leandro Sales et al. [37] developed TestEvol. A tool that enables the systematic study of test-suite evolution for Java programs and JUnit test cases.

Mobile Applications Developers, with large freedom given to them, focus on satisfying market requirements and on pleasing consumer's desires. They are forced to be creative and productive in a short period of time. As a result, billions of powerful mobile applications are displayed every day. Therefore, every mobile application needs to continually change and make an incremental evolution from its creation until its expiration stage in order to survive and preserve its ranking among the top applications in the market. Mobile Apps Testers hold a heavy responsibility on their shoulders, the intrinsic nature of agile, swift change of mobile Apps pushes them to be meticulous, to be aware that things can be different at any time, and to be prepared for unpredicted crashes. Therefore, starting the generation or the creation of test cases from scratch is a tedious and error prone operation. The next section represents a new approach for repairing broken tests during mobile application evolution.

### III. PROPOSED APPROACH

To ease the adaptation process of test cases in mobile applications, there needs to be a solid protocol between developers and testers involved before and after deployment stages of a mobile application this is in order to capture the set of changes that might even be quicker. TCA [32], TESTEVOL [37], ReAssert [38] have been reported to be useful for studying test suite evolution and repairing broken test cases. However, such tools are proprietary and therefore cannot be extended to repair test cases in all testing levels, for example for Integration testing, Component interface testing or System testing, in addition to the fact that those tools are used only for repairing broken Unit Tests for software evolution generally. In this research study, we propose a model driven approach for test cases evolution that can be used for repairing broken test

cases for Android mobile applications starting by analysing the evolution of mobile Apps and therefore the possibility of automating the process of repairing old test cases and generate new version then verify if the latter covers the new evolved mobile App. An overview of the proposed approach is being illustrated in Figure 3. Initially an original version of a mobile App changes by adding new functions, or editing its design or its API level, in order to adapt to the requirements of the end user, or market trends, or within its ecosystem. The models based mobile Apps contain all essential components of a native Android mobile App, which is serialized to an XMI file complying with a pre-defined Java MoDisco meta model and XML MoDisco meta model [39].

It is worth noting that the MOF is using the XMI specification (standing for XML Metadata Interchange). Our process analysis the differences by taking the two « ecore » models the ancient and the new one and makes a comparison between them using *EMF compare*. The two models are considered as inputs of the framework (*EMF compare*) that generates an evolution model; Figure 4 shows the architecture of the framework [40].

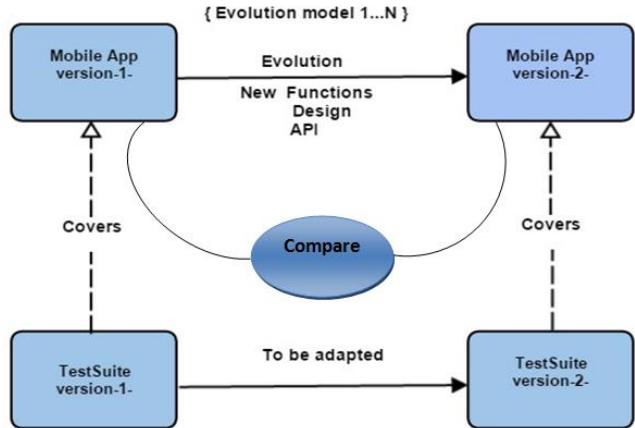


Fig. 3. Overview of the Model-driven Process for test cases evolution.

After that, from this given starting point EMF compare makes a model resolving, which means finding all other fragments required for the comparison of the whole logical model. For example, to compare two XML models (XML1.XMI) and (XML2.XMI) they are not a standalone model, but generally they are loaded as embedded within their XML meta-model.XMI that it must be present during the comparison process [40], [41].

The work flow of the global process of the proposed approach is being illustrated in Figure 5, where the result of a graphical comparison between mobile application version1(XMI model1) and mobile application version2 (XMI model2) using EMF compare is an XMI model containing equivalences and differences. Generating test cases from the original mobile application, using the comparison results of EMF compare as inputs, in order to obtain the list of deleted test cases that concern a deleted element from version 1 to version 2, kept test cases which are the common test cases between two versions, and the adapted test cases which are the most important, because by adapting them a new test cases

that covers the new version of a mobile application will be generated automatically as an XMI model.

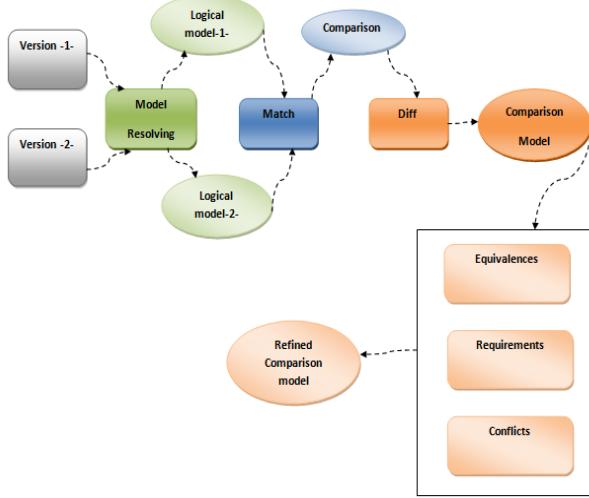


Fig. 4. Architecture of *EMF Compare* framework used for the comparison process. Figure reproduced from [40].

Then it can be transformed from XMI model to Java code, or Java script test suite. this depends on our purpose either we want to make a black box testing or a white box testing.

The main three processes in Figure 5 are: Compare, analyze, Adaptation where the control flow of operations and order of execution of those operations is defined, however, data flow defines data stream i.e. where the data come from (data sources).

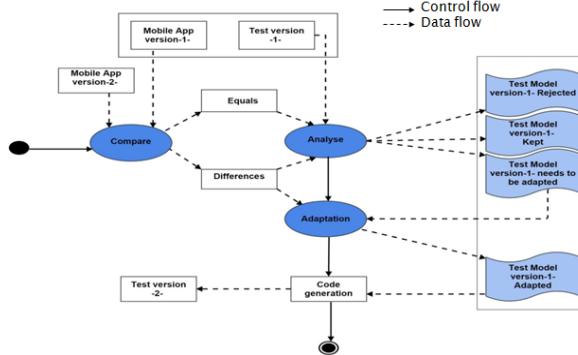


Fig. 5. High-level design of model driven approach for test cases evolution.

#### IV. CASE STUDY

##### A. Android native mobile application

Native Apps are installed through an application store (such as Google Play or Apple's App Store) on the device and are accessed through the icons on the device home screen.

They are developed specifically for one platform, and can take full advantage of all the device features, they can use the camera, the GPS, the accelerometer, the compass, the list of contacts, and so on [6]. Native Apps can use the device's notification system and can work offline. Figure 6 represents HandicApp application which is a native open source Android application, its main objective is, it allows to easily interact by voice with the interviewer. Transcribing words, HandicApp listen and when the interviewer finished, it displays what has been pronounced. HandicApp can also vocally synthesize a written text on the smart phone. Available in French and English (as the default language of the phone). This is done through voice. It is available free at the Play Store from Android 2.3.3 for smart phones and tablets [42].



Fig. 6. HandicApp native Android mobile application. Figure reproduced from [42].

##### B. Manual Testing

For manual testing, we have used the eclipse emulators using AVD manager, but we have found many disadvantages, for example, no support for placing or receiving actual phone calls, no support for USB connections, no support for camera /video capture, no support for determining battery charge level and AC charging state, no support for Bluetooth, Sometimes lower versions will not support completely, no support for orientation testing [43]. Figure 7 represents Android Acer smart phone version 4.2.2 and Google tablet that we have used in our experimentation study.



Fig. 7. Smart devices using in the manual testing of Android mobile App.

##### C. Automation testing Using Monkey Talk

Monkey Talk is enabling teams all over the world to achieve five star mobile app quality at agile speed [44]. Its advantage is the robust cross i.e. platform Recording /Play back, also the use of the simple Monkey Talk command language or powerful JavaScript , run the tests interactively or from continuous integration environments, and it is free and open source tool [45].

##### D. Evolution of HandicApp Application

In HandicApp application, we have started by proposing that the developer makes minor syntactic changes on the

interface of the application Figure 8 shows that. For example modify a button's content, **Text to speech to write to hear**, and the button **Listen** to **Listening**, After using monkey talk, we have generated two different Java script test cases Figure 9 (left side) represents JavaScript test cases that cover the original version and Figure 9 (right side) represents JavaScript test cases that cover the modified version, Figure 10 (left side) shows the results of execution of the first test cases on the first version, Figure 10 (right side) shows the results of execution of test cases on the second version, we always get positive results, however. The execution of the first test suite on the second version causes run time errors and that's what we call it broken tests that require a solid test repair technique as it shows Figure 11.



Fig. 8. Syntactic minor changes during HandicApp Application evolution.

<code>load("libs/Handicapp.js"); Handicapp.FirstTest.prototype.run = function() {     /* @type MT.Application  */     var app = this.app;      app.textArea("Text to speech").tap();     app.textArea("Text to speech").enterText("Hello");     app.button("Listen").tap();     app.image("Speech recognition").tap();     app.device().back(); };</code>	<code>load("libs/Handicapp.js"); Handicapp.SecondTest.prototype.run = function() {     /* @type MT.Application  */     var app = this.app;      app.textArea("write to hear").tap();     app.textArea("write to hear").enterText("Hello");     app.button("Listening").tap();     app.image("Speech recognition").tap();     app.device().back(); };</code>
---	---

FirstTest.js

SecondTest.js

Fig. 9. Java Script test cases generated using Monkey talk.

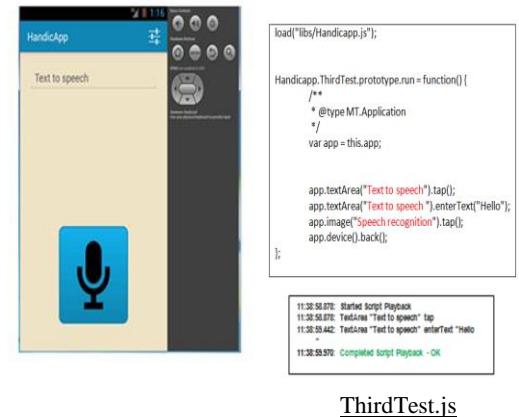
In Figure 12, from a visual comparison between test cases FirstTest.js represented in Figure 9 that concerns original version and test cases (Third Test. js) that concerns third version of HandicApp application without listen button. We can see that there are deleted test cases. But, how can we adapt the first test cases to cover the third version of HandicApp application ?

<code>10:32:35.482: Android agent(2.0.10_4 - 2014-12-13 17:07:56 EST) 10:32:35.492: Connection type set to: Android Emulator or Tethered Device  10:33:02.901: Started Script Playback 10:33:02.901: TextArea "Text to speech" tap 10:33:03.767: TextArea "Text to speech" tap 10:33:04.311: TextArea "Text to speech" tap 10:33:04.907: TextArea "Text to speech" enterText "Hello World" 10:33:05.502: Button Listen tap 10:33:06.043: Image "Speech recognition button" tap 10:33:06.566: Device * back 10:33:07.212: Completed Script Playback - OK</code>	<code>10:32:35.682: Android agent (2.0.10_4 - 2014-12-13 17:07:55 EST) 10:32:35.692: Connection type set to: Android Emulator or Tethered Device  10:47:10.744: Started Script Playback 10:47:10.750: TextArea "write to hear" tap 10:47:11.332: TextArea "write to hear" enterText "hello world" 10:47:11.878: TextArea "write to hear" tap 10:47:12.437: TextArea "write to hear" enterText "Hello world" 10:47:12.956: TextArea "write to hear" tap 10:47:14.522: TextArea "write to hear" enterText "Hello World" 10:47:15.038: Button Listening tap 10:47:16.689: Completed Script Playback - OK</code>
--	--

Fig. 10. Positive results of the execution of the first test cases on the first version and second test cases on the second version .

```
10:39:26.541: Started Script Playback
10:39:26.544: ButtonSelector "textto speech"
enterText hello
10:39:29.626: FAILURE: Unable to find
ButtonSelector(text to speech)
10:39:29.681: Completed Script Playback -
FAILURE Unable to find ButtonSelector(text
to speech)
```

Fig.11. Negative result of the execution of first test cases on the second version of HandicApp Application.



ThirdTest.js

Fig. 12. HandicApp application without listening button.

#### E. Beginning of the implementation of a framework to adapt model application's tests

- Analysing the evolution ( calling EMF Compare Graphically /Programmatically)

In order to analyze the evolution of different applications we have tried to use *EMF compare* graphically, but first we have made a reverse engineering from Java to XMI models using MoDisco, a framework in Eclipse added by Eclipse Marketplace. Calling *EMF compare* graphically or programmatically requires a meta-model of a mobile application. We have focused on Java and layout packages, i.e. rec and source components that require a Java Meta model and XML Meta model as it is shown successively in Figures 13 and 14.

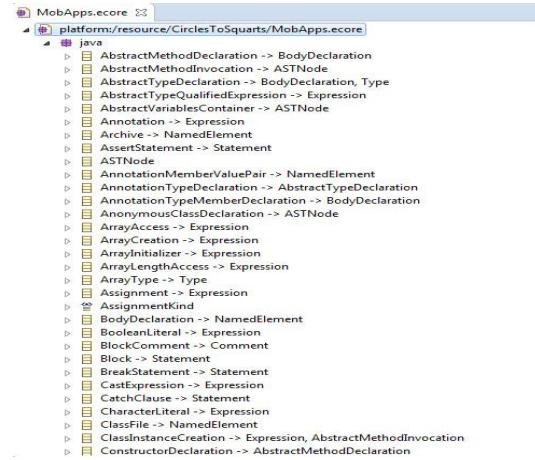


Fig. 13. Portion of Java Meta-model.

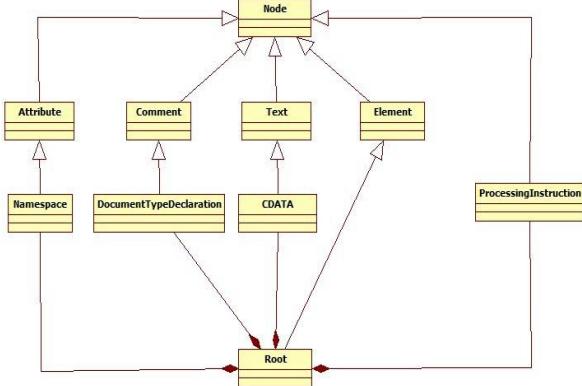


Fig. 14. XML Meta-model.

First, we have started by making a reverse engineering of res files (strings.xml to strings.xmi and strigns2.xml to strings2.xmi) and we have used *EMF compare graphically*.

In the example of changing the content of a button listen to Listening as shows Figure 14, text to speech to Write to hear, text Restart to Text Repeat, text speech recognition button to speech recognition. We have saved these results in a comparison xmi model, the format of this model is not useful. For the example of deleting a button listen besides the XML files we should do a reverse engineering of source files, i.e. Java classes (HandicApp.java and HandicAppdelete.java) to (HandicApp.java.xmi and HandicAppdelete.xmi) graphically always and we get those differences, here the delete operation affects the two folders rec and src because any method calls this button will be deleted. As a result *EMF compare* displays 548 differences between the two Java.xmi models, it is a little strange for one deleted button.

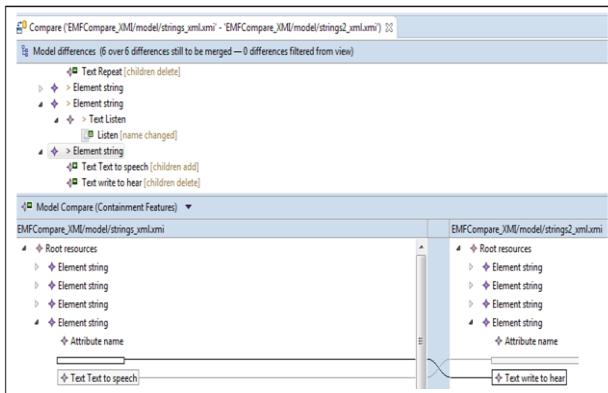


Fig. 15. The change of the content of a button from Text to speech to write to hear.

The investigations have proved that in graphical comparison *EMF compare* makes an error which is taking the order of elements into consideration when doing comparisons and MoDisco when makes a reverse engineering changes the order. By this strategy for the same version we can find many obsolete, useless differences. Because of many problems in *EMF compare* graphical comparison, we have decided to use the programmatically comparison concept of this Framework.

Here the developer is the leader and he controls the whole comparison process. This after using EMF Generator Model Figure 16 shows the generation of MobApps.genmodel file based on the MobApps. Ecore Meta-model. And the generated code will consist of the following components:

**mobapps** model : represents interfaces and the factory to create the Java classes.

**mobapps.impl** model: represents concrete implementation of the interfaces defined in model.

**mobapps.util** model: represents the AdapterFactory [46].

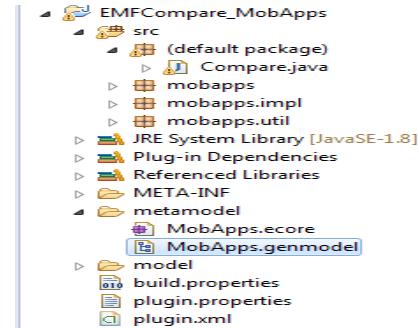


Fig. 16. The generation of Java code based on the .genmodel files.

## V. CONCLUSION

The main goal of this research study was to support reasoning about mobile application evolution; In order to reason about the adaptation of original test cases, mobile Apps testers require evolutionary information about systems evolution i.e. different commits made by developers before and after deployment stage. One way to acquire that information is by analyzing the artifacts stored in the repository of change management systems such as: Git, GitHub, SVN, ... etc. Test repair can be an expensive activity, automating it, even if only partially could save a considerable amount of resources during maintenance and this is the motivation behind the development of automated test-repair techniques[30]. In this paper we have talked about the evolution of mobile Apps, their testing and we have tackled the phenomenon of adaptation of their test cases during their evolution which has become a serious problem for both research and industry by proposing a new approach based on model driven engineering. As perspectives of this work, we plan to continue the implementation of the rest of the framework to adapt model application's tests, generalizing the approach and taking into consideration semantic changes that can involve several syntactic changes, apply it on other types of mobile Apps such as web or hybrid Apps, and other operating systems such as iOS, windows phone.

## References

- [1] J. DURANDO, USA today network, 2014. <http://goo.gl/acpzkt>.
- [2] M. LEHMAN AND J. F. RAMIL, Software evolution in the age of component-based software engineering, IEE Proceedings-Software, 147 (2000), pp. 249–255.
- [3] M. M. LEHMAN, J. F. RAMIL, P. D. WERNICK, D. E. PERRY, AND W. M. TURSKI, Metrics and laws of software evolution-the nineties view, in Software Metrics Symposium, 1997. Proceedings., Fourth International, IEEE, 1997, pp. 20–32.
- [4] R. MINELLI AND M. LANZA, Software analytics for mobile applications-insights & lessons learned, in Software Maintenance and Reengineering (CSMR), 2013 17th European Conference on, IEEE, 2013, pp. 144–153.
- [5] M. GORNOI, 6 key challenges of mobile app testing, 2014. <https://testlio.com/http://goo.gl/FQznk5/post/6-key-challenges-of-mobile-app-testing>.
- [6] R. BUDIU, Mobile: Native apps, web apps, and hybrid apps, 2013. <http://goo.gl/ZEsfGJ>.
- [7] G. CHEN AND D. KOTZ, A survey of context-aware mobile computing research (tech. rep.), Hanover, NH, USA, (2000).
- [8] H. MUCCINI, A. D. FRANCESCO, AND P. ESPOSITO, Software testing of mobile applications: Challenges and future research directions, in Automation of Software Test (AST), 2012 7th International Workshop on, IEEE, 2012, pp. 29–35.
- [9] M. SATYANARAYANAN, Fundamental challenges in mobile computing, in Proceedings of the fifteenth annual ACM symposium on Principles of distributed computing, ACM, 1996, pp. 1–7.
- [10] A. I. WASSERMAN, Software engineering issues for mobile application development, in Proceedings of the FSE/SDP workshop on Future of software engineering research, ACM, 2010, pp. 397–400.
- [11] J. PAN, Software testing, 1999. <http://goo.gl/Wosf3X>.
- [12] J. MOORE, mobile simulators and emulators an update, 2015. <http://goo.gl/fK3myE>.
- [13] B. KIRUBAKARAN AND V. KARTHIKEYANI, Mobile application testing, challenges and solution approach through automation, in Pattern Recognition, Informatics and Mobile Engineering (PRIME), 2013 International Conference on, IEEE, 2013, pp. 79–84.
- [14] M. ROUSE, Testing as a service (saas), 2014. <http://goo.gl/vHr0KY>.
- [15] D. AMALFITANO, A. R. FASOLINO, P. TRAMONTANA, B. TA, AND A. MEMON, Mobiguitar-a tool for automated model-based testing of mobile apps, (2014).
- [16] Z. LIU, X. GAO, AND X. LONG, Adaptive random testing of mobile application, in Computer Engineering and Technology (ICCET), 2010 2nd International Conference on, vol. 2, IEEE, 2010, pp. V2–297.
- [17] F. STORTONI, More about model based testing, 2012. <http://cqaa.org/Resources/Documents/Presentations>
- [18] W. CHOI, G. NECULA, AND K. SEN, Guided GUI testing of Android apps with minimal restart and approximate learning, in ACM SIGPLAN Notices, vol. 48, ACM, 2013, pp. 623–640.
- [19] P. COSTA, A. C. PAIVA, AND M. NABUCO, Pattern based GUI testing of mobile applications, in Quality of Information and Communications Technology (QUATIC), 2014 9th International Conference on the, IEEE, 2014, pp. 66–74.
- [20] S. ANDERSON, Mutation testing, 2011. <http://goo.gl/578c5K>.
- [21] U. RESEARCH INSTITUTE IN SOFTWARE EVOLUTION (RISE). DURHAM, Dept of computer science, university of Durham., 1999. <http://goo.gl/eViU6u>
- [22] I. HERRAIZ, D. RODRIGUEZ, G. ROBLES, AND J. M. GONZALEZ-BARAHONA, The evolution of the laws of software evolution: a discussion based on a systematic literature review, ACM Computing Surveys (CSUR), 46 (2013), p. 28.
- [23] N. CHAPIN, J. E. HALE, K. M. KHAN, J. F. RAMIL, AND W.-G. TAN, Types of software evolution and software maintenance, Journal of software maintenance and evolution: Research and Practice, 13 (2001), pp. 3–30.
- [24] B. FLING, Mobile Design and Development: Practical concepts and techniques for creating mobile sites and web apps, " O'Reilly Media, Inc.", 2009.
- [25] E. PHILLIPS, The evolution of the mobile app landscape, 2013. <http://goo.gl/TYuL1B>.
- [26] V. BEAL, Api - application program interface, 2015. <http://goo.gl/NIGDU8>.
- [27] R. M. . N. C.-H. PHILIP JAMES KITCHEN, Long term evolution mobile services and intention to adopt: a malaysian perspective, 2015. <http://goo.gl/6SFknQ>.
- [28] CAMERONMCKENZIE, Evolution of mobile apps, 2012. <http://goo.gl/eNj5k>.
- [29] D. AMALFITANO, A. R. FASOLINO, P. TRAMONTANA, AND B. ROBBINS, Testing Android mobile applications: Challenges, strategies, and approaches, Advances in Computers, 89 (2013), pp. 1–52.
- [30] M. MIRZAAGHAEI, F. PASTORE, AND M. PEZZÈ, Supporting test suite evolution through test case adaptation, in Software Testing, Verification and Validation (ICST), 2012 IEEE Fifth International Conference on, IEEE, 2012, pp. 231–240.
- [31] Z. XU, Y. KIM, M. KIM, G. ROTHERMEL, AND M. B. COHEN, Directed test suite augmentation: techniques and tradeoffs, in Proceedings of the eighteenth ACM SIGSOFT international symposium on Foundations of software engineering, ACM, 2010, pp. 257–266.
- [32] M. MIRZAAGHAEI, F. PASTORE, AND M. PEZZÈ, Automatic test case evolution, Software Testing, Verification and Reliability, 24 (2014), pp. 386–411.
- [33] A. M. MEMON AND M. L. SOFFA, Regression testing of GUIs, ACM SIGSOFT Software Engineering Notes, 28 (2003), pp. 118–127.
- [34] A. M. MEMON, Using tasks to automate regression testing of GUIs, In International Conference on Artificial intelligence and Applications (AIA 2004), Innsbruck, Austria, 2004.
- [35] W. G. HALFOND AND A. ORSO, Automated identification of parameter mismatches in web applications, in Proceedings of the 16th ACM SIGSOFT International Symposium on Foundations of software engineering, ACM, 2008, pp. 181–191.
- [36] D. DIG, S. NEGARA, V. MOHINDRA, AND R. JOHNSON, Reba: refactoring-aware binary adaptation of evolving libraries, in Proceedings of the 30th international conference on Software engineering, ACM, 2008, pp. 441–450.
- [37] L. S. PINTO, S. SINHA, AND A. ORSO, Testevol: a tool for analyzing test-suite evolution, in Proceedings of the 2013 International Conference on Software Engineering, IEEE Press, 2013, pp. 1303–1306.
- [38] B. DANIEL, D. DIG, T. GVERO, V. JAGANNATH, J. JIAA, D. MITCHELL, J. NOGIEC, S. H. TAN, AND D. MARINOV, Reassert: a tool for repairing broken unit tests, in Proceedings of the 33rd International Conference on Software Engineering, ACM, 2011, pp. 1010–1012.
- [39] H. BRUNELIERE, J. CABOT, G. DUPÉ, AND F. MADIOT, Modisco: A model driven reverse engineering framework, Information and Software Technology, 56 (2014), pp. 1012–1032.
- [40] ECLIPSE, Emf compare, A developer guide, 2011. <http://goo.gl/53XASj>.
- [41] OBEO, Hereweareemfcompare2, 2013. <http://goo.gl/Oi5jq0>.
- [42] R. PELLERIN, HandicApp, 2013. <https://goo.gl/UVVIOK>.
- [43] F.McCown, Audacious Android Application, Computer Science Dept. Harding University, Searcy, Arkansas, USA, March 9, 2011
- [44] MONKEYTALK, Cloudmonkey, 2015. <https://goo.gl/FrrXABY>.
- [45] T. SOLUTION, Monkey talk Android user manual, 2013. <http://goo.gl/pjXeJm>.
- [46] L. VOGEL, Eclipse Modeling Framework (EMF), 2014. <http://goo.gl/cJcZkU>

# *Une méthode d'alignement entre deux ontologies multi-points de vue*

Foughali Amira

Ecole nationale supérieur  
d'informatique, alger, algerie  
a\_foughali@esi.dz

Zizette Boufaida

Laboratoire LIRE université de  
Constantine 2- Abdehamid Mehri  
Constantine 2500, algerie  
zboufaida@gmail.com

## *Resumé —*

**Le problème de l'alignement des ontologies est bien connu depuis une dizaine d'années. Il existe plusieurs travaux qui s'intéressent à ce contexte. Dans le contexte du web sémantique, l'interopérabilité sémantique basée sur les ontologies, est devenue un challenge important. Dans ce travail, nous nous intéressons au problème de l'alignement des ontologies multi-points de vue (MPV) dans le but de partager les connaissances sémantiques et réutiliser ces ontologies qui restent indépendantes.**

Cet article présente un système qui détecte les relations sémantiques entre deux ontologies multi-points de vue (MPV) en supposant que notre ontologie se compose d'un ensemble d'ontologies classiques (une ontologie globale c'est l'ensemble des concepts et rôles globaux et des ontologies locales ce sont l'ensemble des descriptions locale pour chaque point de vue). Notre système repose sur l'enchaînement de trois étapes qui sont l'alignement global, l'alignement local et l'alignement des passerelles.

**Mots clés—** ontologies multi-points de vue ; alignement ; correspondances sémantique.

## I. INTRODUCTION

En général, les organisations vivent dans un environnement dynamique et hétérogène. Ceci rend la construction et l'exploitation des ontologies au sein d'une organisation difficile à réaliser. En plus de la difficulté de trouver des définitions adéquates des concepts d'un domaine. Ces définitions sont relatives à chaque utilisateur, traduisant son point de vue sur le domaine. La difficulté de construction des ontologies est aussi liée à l'existence de plusieurs communautés d'utilisation qui peuvent s'intéresser au même domaine mais avec des points de vue différents.

Afin de remédier à l'insuffisance des ontologies classiques, ces dernières années, les ontologies multi-points de vue (MPV) ont été développées dans les communautés de l'ingénierie des connaissances. Le développement de ce type d'ontologies représente un grand intérêt suscitant de nombreux travaux dans le domaine de Web sémantique [1] [2].

Deux ontologies multi-points de vue possèdent chacune une description globale et une description locale. La description globale est composée d'un ensemble de concepts globaux qui sont des concepts vus par l'ensemble des points de vue avec certaines propriétés communes, un ensemble d'associations entre les éléments de différents points de vue appelé rôles globaux et une hiérarchie globale qui organise les concepts globaux entre eux. Une description locale composée d'un ensemble de concepts locaux qui sont des concepts vus localement selon un point de vue donné, un ensemble de rôles locaux qui sont des relations entre les concepts locaux dans un même point de vue. Une hiérarchie locale lie l'ensemble des concepts locaux entre eux.

En plus des descriptions globales et locales, les ontologies multi-points de vue sont composées d'un ensemble de passerelles et d'individus. Le premier ensemble représente un canal de communication entre les points de vue et le deuxième relie une instance d'un concept global ou plusieurs concepts locaux définis dans un ou plusieurs points de vue différents. Aligner les deux ontologies multi-points de vue, consiste à trouver des correspondances entre les concepts et les rôles globaux et aussi entre les concepts et les rôles locaux et entre les individus et les passerelles. L'alignement des ontologies multi-points de vue permet aussi d'associer un concept ou rôle global à un autre local ou un individu à un concept global ou local. Ces alignements peuvent représenter des correspondances entre des concepts ou rôles primitifs mais également des correspondances entre des concepts définis [2]. La problématique générale est de contribuer au problème d'alignement des ontologies multi-points de vue dans une organisation hétérogène.

Cet article est organisé comme suit, la section 2 propose la notion d'ontologies multi-points de vue. La section 3 elle présente tout d'abord la notion d'alignement des ontologies multi-points de vue. Nous attachons à donner un aperçu de quelques travaux proposant des méthodes d'alignement des ontologies multiples points de vue.

La section 4 constitue le cœur de la contribution, à savoir la proposition d'un algorithme qui détecte les relations sémantiques entre deux ontologies multi-points de vue (MPV). Pour illustrer notre approche, une étude de cas sera présentée pour le domaine de la médecine. La section 5 présente une étude de cas adéquate pour notre approche proposée. L'article se termine par une conclusion.

## II. LES ONTOLOGIES MULTI-POINTS DE VUE (MPV)

[2] stipulent qu'« Une ontologie multi-points de Vue (MPV), confère à un même univers de discours, plusieurs descriptions partielles telles que chacune soit relative à un point de vue. De plus, les différentes descriptions partielles partagent à un niveau global des éléments ontologiques consensuels et des passerelles. Ces dernières établissent les communications entre les points de vue et représentent ainsi la collaboration interdisciplinaire ».

## III. DEFINITION DES ALIGNEMENTS DES ONTOLOGIES MULTI-POINTS DE VUE (MPV)

Dans [3] ils ont défini un alignement multi-points de vue (MPV) comme suit : « Étant donné  $O_{mpv}$  et  $O'^{mpv}$  deux ontologies multi-points de vue qui décrivent en logique de description possèdent chacune une signature, l'alignement entre ces deux ontologies multi-points de vue : est l'ensemble de correspondances multi-point de vue entre des paires d'éléments de deux signatures ».

Une correspondance multi-points de vue (MPV) est un triple  $(E_{mpv}, E'^{mpv}, R)$  tel que :  $E_{mpv}, E'^{mpv}$  sont des éléments des ontologies multi-points de vue (MPV) tel que  $E_{mpv} \in S_{mpv}$  et  $E'^{mpv} \in S'^{mpv}$ ,  $R$  : est la relation qui relie ces deux éléments tel que :  $E_{mpv}, E'^{mpv}$  sont liées par la relation  $R$ .

Les correspondances multi-points de vue (MPV) permettent d'associer :

### A. Systèmes d'alignement des ontologies multi-points de vue (MPV)

Jusqu'à présent il n'existe pas des systèmes d'alignement complets pour l'alignement des ontologies multi-points de vue mais il y'a un formalisme pour l'alignement des ontologies multi-points de vue (MPV) basé sur l'extension de la logique de description est proposé par [3]. Elle a défini aussi en 2009 une approche d'alignement entre une ontologie multi-points de vue (MPV) et une ontologie classique.

#### 1) Une approche d'alignement entre une ontologie multi-points de vue (MPV) et une ontologie classique

Dans [5] ils ont présenté une méthode d'alignement entre une ontologie classique et une ontologie multi-points de vue (MPV). Cette méthode se compose de trois phases : La phase de pré-alignement. Cette phase permet d'identifier les formats des ontologies en entrée, les adapter et de les transformer en structures de graphes. La phase de processus d'alignement, ce processus combine les techniques et les méthodes d'appariement syntaxiques selon les différents points de vue. La phase de post alignement dans cette phase, l'optimisation de l'appariement est effectuée par une technique de mét-heuristique de colonies de fourmis.

#### 2) Un formalisme pour l'alignement des ontologies multi-points de vue (MPV) basé sur une extension de la logique de description

[3] ont défini un formalisme pour l'alignement des ontologies multi-points de vue (MPV) basé sur une extension de la logique de description qui permet essentiellement de définir d'une manière claire la sémantique de la logique de description qui est rendue par le mécanisme d'estampillage. La sémantique permet de donner les interprétations de la signature de cette logique et de déterminer les contraintes sémantiques de chaque élément de la signature multi-points de vue.

[3] a aussi proposé un processus d'auto-alignement qui intègre les différentes correspondances entre les éléments multi-points de vue de deux ontologies, et les passerelles entre points de vue d'une même ontologie. Le processus proposé est basé sur la notion de composition d'alignements pour déduire de nouvelles correspondances simples et d'autres complexes entre les ontologies multi-points de vue (MPV) déjà alignées.

Nous avons présenté les différents aspects du domaine d'alignement. Nous avons tout d'abord commencé par la définition de l'alignement des ontologies multi-points de vue. Il ressort de ce qui précède, que de nombreuses méthodes d'alignement sont basées sur des combinaisons de mesures de similarité. Par conséquent, elles permettent de détecter seulement des relations entre des ontologies classiques qui ne prennent pas en compte la notion de multiples points de vue. De ce fait, nous proposerons par la suite un système qui détecte les relations sémantiques entre les ontologies multi-points de vue.

## IV. APPROCHE PROPOSEE:

Notre objectif est de proposer une méthode de détection des relations sémantiques en prenant en compte la notion de points de vue. L'originalité de notre approche réside dans le fait d'aligner deux ontologies multi-points de vue. Donc l'objectif est de mettre en correspondances ces deux ontologies multi-points de vue qui comprend chacune un ensemble d'ontologies globale et locales. On considère qu'une ontologie multi-points de vue (MPV) se compose d'une représentation globale qui contient des concepts et des rôles globaux. Des représentations locales qui contiennent des concepts et des rôles locaux. Pour définir une ontologie multi-point de vue (MPV) on définit : Une ontologie globale qui correspond à la description globale et des ontologies locales qui correspondent aux descriptions locales. Dans notre approche, ces ontologies (locales, globales) sont considérées comme étant des ontologies classiques.

Ce système génère une ontologie générique des relations sémantiques entre les entités. Nous allons utiliser le formalisme des graphes étiquetés pour représenter les cas d'une manière précise, lisible et utilisable par un ordinateur. L'ontologie d'alignement sera transformée sous forme de graphe étiqueté. Ce graphe permet de représenter toutes les informations contenues dans l'ontologie d'alignement ou la

base de cas (point de vue, concepts, rôles ou individu) et aussi les autres informations pour les correspondances sémantiques. Les nœuds de ce graphe représentent les types suivants : les concepts globaux, concepts locaux, rôles globaux, rôles locaux, individus. Les arcs qui existent dans ce graphe représentent les relations sémantiques qui existent entre les concepts, les rôles et les individus. Pour l'étiquetage du graphe : nous nous inspirons de l'idée proposée dans [5] pour étiqueter les nœuds et les arcs de ce graphe sont étiquetés par un préfixe  $PVi$  qui indique le nom de point de vue et le type de ce nœud (concept local, concept global ou individu). Chaque arc qui relie deux nœuds est étiqueté par le nom de la relation qui est l'un des cas :  $\equiv$ ,  $\subseteq$ ,  $\supseteq$ ,  $\perp$ .

L'approche se compose de trois phases successives : l'alignement global, l'alignement local et la phase d'alignement des passerelles.

### A. L'alignement global

Dans cette étape nous mesurons la similarité entre les concepts globaux. Le processus d'alignement global se déroulera en deux étapes, il consiste à : calculer la similarité entre tous les éléments de deux graphes (concepts), pour chaque couple de nœuds, nous calculerons d'abord la similarité terminologique, ensuite la similarité des graphes (similarité entre les hiérarchies).

#### 1) La similarité terminologique

Le but de cette étape, est de calculer la similarité entre les différentes entités des hiérarchies globales (concepts), cette mesure peut être effectuée une ou plusieurs fois pour chaque nœud du graphe de l'ontologie, mais elle est effectuée une seule fois pour chaque couple de nœuds durant le processus d'alignement globale. Le calcul de similarité est effectué pour les couples de nœuds de type (concept global, concept global), la similarité est calculée en extrayant le chemin racine possédant le nœud en question et la racine globale, puis nous calculons la distance entre les deux nœuds en utilisant la mesure de Wu et Palmer [6], choisie en raison de sa simplicité d'implémentation. Le résultat matrice de similarité terminologique. cette mesure est définie par la formule suivante :

$$\text{sim } WP(C1, C2) = \frac{2 \cdot \text{depth}(C)}{\text{depth}(C1) + \text{depth}(C2)}$$

Elle est basée sur le principe suivant : Etant donnée une hiérarchie globale formée par un ensemble de nœuds et un nœud racine  $R$ . Soit  $C1$  et  $C2$  deux éléments de l'ontologie dont nous vont calculer la similarité. Le principe de calcul de similarité est basé sur les distances ( $\text{depth}(c1)$  et  $\text{depth}(c2)$ ) qui séparent les nœuds  $C1$  et  $C2$  du nœud racine et la distance

qui sépare le concept subsumant ( $CS$ ) de  $C1$  et de  $C2$  du nœud racine. (Fig. 1).

Algorithme calcul-similarité-terminologique-globale	
<b>Données :</b>	
$D1$ et $D2$ : deux descriptions globales.	
$\text{Mat\_Sim}_{\text{termglob}}$ : matrice de similarité terminologique globale initialisée à 0.	
<b>Résultat</b> : $\text{Mat\_Sim}_{\text{termglob}}$ : matrice de similarité terminologique.	
<b>Début</b>	
Pour chaque concept global $C1$ appartient à $D1$ faire	
<b>Début</b>	
Pour chaque concept global $C2$ appartient à $D2$ faire	
<b>Début</b>	
$\text{SIM}_{\text{termglob}} = \text{similarité wp}(C1, C2);$	
$\text{Mat\_Sim}_{\text{termglob}} = \text{Mat\_Sim}_{\text{termglob}} + \text{Sim}_{\text{termglob}}(C1, C2);$	
<b>Fin</b> ;	
<b>Fin</b> ;	
Return $\text{Mat\_Sim}_{\text{termglob}}$ ;	
<b>Fin.</b>	

Fig. 1. L'algorithme qui calcule la similarité terminologique.

Cet algorithme prend en entré deux descriptions globales et génère une matrice de similarité globale et il calcule pour chaque couple de concepts globale la similarité terminologique entre ces deux concepts en se basant sur la formule proposée dans [6].

#### 2) La similarité des graphes

Elle est calculée en exploitant la matrice de similarité terminologique ainsi que la hiérarchie des concepts. Dans notre cas la similarité entre deux graphes est définie comme la moyenne pondérée des similarités entre les concepts qui les composent. Les concepts peuvent avoir d'importances différentes en fonction des applications. Ce degré d'importance est défini pour chaque concept subsumant de l'ontologie arbitrairement ou après une phase d'apprentissage. Le degré d'importance d'un concept correspond à celui du concept subsumant dont il est le descendant. Soient :

- $G1$  et  $G2$  deux hiérarchies de concepts.
- $N$ œuds ( $G$ ) l'ensemble des nœuds (i.e. les concepts) du graphe  $G$ .
- $G1i$  et  $G2j$  des concepts appartenant respectivement aux graphes  $G1$  et  $G2$ .
- $Coef(Gi)$  la fonction déterminant le degré d'importance d'un

$$\text{SimGraphes}(G1, G2) = \frac{\sum_{i=1}^{|N\text{œuds}(G1)|} \sum_{j=1}^{|N\text{œuds}(G2)|} Coef(G1_i) \cdot \text{Max}_{j=1}^{N\text{œuds}(G2)} (\text{SimConcept}(G1_i, G2_j))}{\sum_{i=1}^{|N\text{œuds}(G1)|} Coef(G1_i)}$$

concept du graphe  $G$ . Supposant dans notre cas que tous les coefficients égalent à 1 c'est-à-dire tous les concepts ont la même importance.

$\text{SimConcept}(G1i, G2j)$  est la similarité entre les concepts  $G1i$  et  $G2j$ . La similarité entre deux graphes de concepts est définie ainsi : SimConcept peut être déterminée par plusieurs mesures

de similarité, comme celle proposée par Wu et Palmer.

#### Algorithme calcul-similarité-graphe-globale

##### Données :

$D1$  et  $D2$  : deux descriptions globales pour deux ontologies MPV.

$\text{Mat\_Sim}_{\text{termglob}}$ : matrice de similarité terminologique.

Résultat :  $\text{SIM}_{\text{graphe}}$ : similarité entre deux graphes.

##### Début

$\text{SIM}_{\text{graphe}} = \text{SMI}_{\text{graph}}(D1, D2)$  ;

Return( $\text{SIM}_{\text{graphe}}$ ) ;

##### Fin.

Fig. 2. Algorithme qui calcule la similarité entre les hiérarchies globales.

La valeur de similarité globale est calculée en employant la méthode de la somme pondérée des deux valeurs de similarité partielles (terminologique, similarité des graphes), cette méthode est employée dans la plupart des applications [7]. Afin de pouvoir contrôler l'importance de chaque composante sur la valeur agrégée finale. Nous nous attribuons un poids pour chaque similarité ( $\mu_{\text{term}}$ ,  $\mu_{\text{graphe}}$ ), les poids sont des nombres réels non négatifs prédéfinis. Ils sont mis dans une matrice des poids et sont choisis en satisfaisant que leur somme soit toujours égale à 1. Cela assure que la mesure globale est toujours normalisée.

Avec :  $0 < \mu_{\text{term}} < 1$  : le poids de similarité terminologique.

$0 < \mu_{\text{graphe}} < 1$  : le poids de des similarités des graphes.

Et  $\mu_{\text{term}} + \mu_{\text{graphe}} = 1$ .

Nous conclurons la relation sémantique entre les deux termes comme suit :

$$\text{SIMglob}(C1, C2) = \mu_{\text{term}} * \text{SIMtermglob} + \mu_{\text{graphe}} * \text{SIMgrapheglob}$$

- Si  $\text{Simglob}=0$  alors la relation  $(C1, C2) = \perp$ .
- Si  $\text{Simglob}>V_{\text{min}}$  alors la relation  $(C1, C2) = \equiv$ .
- Si  $\text{Simglob}<V_{\text{min}}$  alors la relation  $(C1, C2) = \approx$
- Si la relation entre  $C1$  et  $C2$  est l'un des cas  $\{\perp, \equiv\}$  le cas sera rajouté directement dans la base de cas.
- Si non (la relation est floue) le cas sera déterminé plus tard durant la phase de composition. Le résultat de cette phase est une matrice de similarité globale, qui contient tous les couples d'entités comparées avec une valeur de similarité comprise entre  $[0, 1]$ .

#### Algorithme\_Calcul\_Similarité\_Globale

##### Entrée :

$D1, D2$  deux descriptions globales.

$\text{Mat\_Simtermglob}$  : matrice de similarité terminologique.

Simgraph : la similarité entre les hiérarchies globales.  
 $\mu_{\text{term}}, \mu_{\text{graphe}}$  : les poids respectifs des similarités terminologiques, graphe.

Sortie :  $\text{Mat\_Simglobale}$  : matrice de similarité globale  
 $\text{Mat\_Simglobale} \leftarrow 0$  ;

##### Début

Pour chaque concept global  $C1$  de  $D1$  faire

##### Début

Pour chaque concept global  $C2$  de  $D2$  faire

##### Début

$\text{SIMtermglob} = \text{Extraire\_Simtermglob}(C1, C2)$ ;

$\text{SIMglob}(C1, C2) = \mu_{\text{term}} * \text{SIMtermglob} +$

$\mu_{\text{graphe}} * \text{SIMgrapheglob}$ .

$\text{Mat\_Simglobale} = \text{Mat\_Simglobale} + \text{SIMglob}(C1, C2)$ ;

##### Fin ;

##### Fin ;

Return  $\text{Mat\_Simglobale}$

##### Fin.

Fig. 3. Algorithme qui calcule la similarité globale.

Cet algorithme prend en entré deux descriptions globales , la matrice de similarité globale et il calcule pour chaque couple de concepts globale la similarité globale entre ces deux concepts en se basant sur la somme pondéré entre ces similarité.

#### B. L'alignement local

Dans cette étape nous mesurons la similarité entre les concepts locaux. Le processus d'alignement local se déroulera en trois étapes, il consiste à : calculer la similarité entre tous les éléments de deux hiérarchies locales (concepts), pour chaque couple de nœuds, nous calculerons d'abord la similarité terminologique, ensuite la similarité des graphes (similarité entre les hiérarchies) et la similarité entre les point de vues.

La similarité terminologique et entre les graphes sera faite de la même façon dans l'étape d'alignement global. (Fig 4), (Fig 5).

#### Algorithme calcul-similarité-terminologique-locale

##### Données :

$D1$  et  $D2$  : deux descriptions locales.  
 $\text{Mat\_Sim}_{\text{termloc}}$  : matrice de similarité terminologique locale initialisée à 0.

Résultat :  $\text{Mat\_Sim}_{\text{termloc}}$  : matrice de similarité terminologique locale finale.

##### Début

Pour chaque concept local  $C1$  appartient à  $D1$  faire

##### Début

Pour chaque concept local  $C2$  appartient a  $D2$  faire

##### Début

$\text{SIMtermloc} = \text{similarité wp}(C1, C2)$ ;

$\text{Mat\_Simtermloc} = \text{Mat\_Simtermloc} + \text{SIMtermloc}(C1, C2)$ ;

```

Fin ;
Fin ;
Return Mat_Simtermloc ;
Fin.

```

Fig. 1. Algorithme qui calcule la similarité-terminologique entre les concepts locaux.

#### Algorithme calcul-similarité-graphe-locale

##### Données :

- 1)  $D1$  et  $D2$  : deux descriptions locales pour deux ontologies MPV.
- 2)  $Mat\_Sim_{termloc}$ : matrice de similarité terminologique locale.

**Résultat** :  $SIM_{graphe}$ : similarité entre deux graphes.

##### Début

$SIM_{graphe} = SMI_{graph}(D1, D2)$  ;

**Fin**

Fig. 5. Algorithme qui calcule la similarité-terminologique entre les hiérarchies locales

La similarité entre les points de vue consiste à représenter les hiérarchies par des ensembles de vecteurs de termes. La définition de la similarité entre les deux vecteurs de termes est obtenue par leurs contenus internes. Parmi les approches citées dans la littérature on peut utiliser : La mesure de similarité de Jaccard est définie par le nombre des objets communs divisé par le nombre total des objets moins le nombre d'objets communs.

$$Sim_j = \frac{|\alpha \cap \beta|}{|\alpha| + |\beta| - |\alpha \cap \beta|}$$

Dans cette étape on applique le processus précédent sur chaque combinaison de deux descriptions locales appartenant aux deux ontologies multi-points de vue (MPV). Chaque ontologie locale de la première ontologie multi-point de vue sera comparée avec toutes les ontologies locales de la deuxième en remplaçant la base de cas ( $O_A$ ). Le résultat de cette étape est une matrice de similarité entre les points de vue. (Fig 6).

#### Algorithme calcul-similarité-PV

##### Données :

- 1)  $D1, D2$  : descriptions locales de deux ontologies MPV correspond chacune à un vecteur de terme  $V1, V2$  respectivement.

$Mat\_Sim_{pv}$  : matrice de similarité entre les points de vue initialisée à 0.

**Résultat** :  $Mat\_Sim_{pv}$  : matrice de similarité entre les points de vue.

##### Début

$SIMPV$ =similarité Jaccard ( $V1, V2$ );  
 $Mat\_Simpv = Mat\_Simpv + SIMPv(Vi, Vj)$ ;  
 Return  $Mat\_Simpv$

**Fin**

Fig 2. Algorithme qui calcule la similarité entre les PV.

La valeur de similarité locale est calculée en employant la méthode de la somme pondérée des trois valeurs de similarité partielles (terminologique, similarité des graphes, similarité entre les points de vue). Cela assure que la mesure locale est la suivante :

$$SIMloc (C1, C2) = \mu_{term}*SIMtermloc + \mu_{graphe}*SIMgraphloc + \mu_{pv}*SIMpv$$

Avec :  $0 < \mu_{term} < 1$  : le poids de similarité terminologique.

$0 < \mu_{graphe} < 1$  : le poids de la similarité des graphes.

$0 < \mu_{pv} < 1$  : le poids de la similarité des point de vues.

Et  $\mu_{term} + \mu_{graphe} + \mu_{pv} = 1$ .

Nous conclurons la relation sémantique entre les deux termes comme suit :

- Si  $SIMloc=0$  alors relation  $(C1, C2) = \perp$ .
- $SIMloc > Vmin$  alors relation  $(C1, C2) = \equiv$ .
- $SIMloc < Vmin$  alors relation  $(C1, C2) = \not\equiv$ .
- Si la relation entre  $C1$  et  $C2$  est l'un des cas  $\{\perp, \equiv\}$  le cas sera rajouté directement dans la base de cas.
- Si non (la relation est flou $\equiv$ ) le cas sera déterminé après durant la phase de composition.

Le résultat de cette phase est une matrice de similarité locale, qui contient tous les couples d'entités comparées avec une valeur de similarité comprise entre [0, 1].

#### Algorithme\_Calcul\_Similarité\_locale

##### Entrée :

$O1, O2$  : deux ontologies multi-points de vue (MPV).

$Mat\_Simtermloc$  : matrice de similarité terminologique locale.

$Mat\_Simgraph$  : la similarité entre les graphes.

$Mat\_Simpv$  : la similarité entre les points de vue.

$\mu_{term}, \mu_{graphe}, \mu_{PV}$  : les poids respectifs des similarités terminologiques, graphe, point de vue.

**Sortie** :  $Mat\_Simlocale$  : matrice de similarité locale.

$Mat\_Simlocale \leftarrow 0$  ;

##### Début

Pour chaque description locale  $D1$  d' $O1$  faire

##### Début

Pour chaque description locale  $D2$  d' $O2$  faire

##### Début

Pour chaque concept local  $C1$  de  $D1$  faire

##### Début

Pour chaque concept local  $C2$  de  $D2$  faire

##### Début

$SIMterm = Extraire\_Simtermloc(C1, C2)$ ,

$SIMgraph = Extraire\_Simgraphloc(D1, D2)$ ,

$SIMPv = Extraire\_Simpv(D1, D2)$ ,

$SIMloc (C1, C2) = \mu_{term}*Simtermloc +$

$\mu_{graph}*Simgraphloc + \mu_{pv}*Simpv$ .

$Mat\_Simlocale = Mat\_Simlocale +$

$Simloc(C1, C2)$ ;

**Fin**;

**Fin**;

**Fin**;

**Fin;**  
Return Mat\_Simlocale.  
**Fin.**

Fig 3.Algorithme qui calcule la similarité locale

### C. L'alignement des passerelles

Il existe deux types de passerelles :

#### I. Les passerelles unidirectionnelles

Les passerelles unidirectionnelles en logique de description sont représentés comme suit:  $PVi : x \rightarrow \subseteq \rightarrow PVj : y$  ce type de passerelles représente une relation de subsumption ( $\subseteq$ ) alors nous obtiendrons le cas suivant ( $x \subseteq y$ ).

#### II. Les passerelles bidirectionnelles

Deux types de passerelles sont considérés. Représentent une relation d'égalité ( $\equiv$ ) ou bien une relation d'exclusion comme suit :

Une passerelle d'inclusion bidirectionnelle : les passerelles d'inclusion bidirectionnelle sont représentés en logique de description comme suit  $PVi : x \rightarrow \equiv \rightarrow PVj : y$ , on obtiendra le cas rel( $x,y$ ) =  $\equiv$  exprime une relation d'égalité. Elle sera rajoutée directement dans la base de cas.

Une passerelle d'exclusion bidirectionnelle : Les passerelles d'exclusion bidirectionnelle sont représentés en logique de description comme suit :  $PVi : x \rightarrow \perp \rightarrow PVj : y$ , on obtiendra le cas rel( $x,y$ ) =  $\perp$  exprime une relation de différence. Elle sera rajoutée directement dans la base de cas.

**Début**  
Ajouter  $((x,y), \subseteq)$  ;  
**Si non**  
    **Si**  $P2.type = 'd'inclusion\_bidirectionnelle'$  **then**  
        **Début**  
        Ajouter  $((x,y), \equiv)$  ;  
        **Si non**  
            **Si**  $P2.type = 'd'exclusion\_bidirectionnelle'$  **then**  
                Ajouter  $((x,y), \perp)$  ;  
                **Fin** ;  
        **Fin** ;  
    **Fin** ;  
**Fin** ;  
**Fin.**

Fig 4. Algorithme d'alignement des passerelles.

Le prototype que nous allons implémenter se découle de l'algorithme suivant : (Fig. 5)

### Algorithme détection des relations sémantiques entre deux ontologies multi-points de vue (MPV)

Données :

1)  $O1$  et  $O2$  : deux ontologies multi-points de vue à aligner possèdent chacune une description globale et des descriptions locales et un ensemble de passerelles.

2)  $OA$  : ontologie initiale d'alignement

Résultat :  $OA$ : ontologie finale d'alignement.

Début

Détection de la relation sémantique entre les descriptions globales ;

Composition des relations sémantiques ( $OA, OA$ ) ;

Détection des relations sémantiques entre les descriptions locales ;

Composition des relations sémantiques ( $OA, OA$ ) ;

Détection des relations sémantiques au niveau des passerelles ;

Composition des relations sémantiques ( $OA, OA$ ) ;

Fin.

Fig. 6.Algorithme de détection des relations sémantiques entre deux ontologies multi-points de vue (MPV)

Après chaque étape d'alignement nous appliquons les techniques de composition pour enrichir notre base de cas et détecter des correspondances manquantes .

### V. ETUDE DE CAS

Nous avons choisi d'évaluer notre approche sur deux ontologies de test dans le domaine de la médecine. Pour examiner le comportement de l'approche proposée, nous avons proposé deux petites ontologies de test, Une première nommée  $O1$  selon les points de vue *Cardiologie*, *Pneumologie* et *Infectieux*, l'hierarchie globale de cette ontologie est représenté dans (Fig10). La deuxième ontologie  $O2$  a été proposée par [9] dans le cadre de leur master selon les points de vue *Gynécologie*, *Pneumologie* et *Oncologie* l'hierarchie globale de cette ontologie est représenté dans (Fig11). Pour la

### Algorithme d'alignement des passerelles

**Entrée :**

$O1, O2$  : deux ontologies multi-points de vue (MPV).

$OA$  : ontologie initiale d'alignement ;

**Sortie :**  $OA$  : ontologie finale d'alignement ;

**Début**

    Pour toutes passerelles  $P1(x,y)$  d' $O1$  faire

**Début**

**Si**  $P1.type = 'unidirectionnelle'$  **then**

**Début**

                    Ajouter  $((x,y), \subseteq)$  ;

**Si non**

**Si**  $P1.type = 'd'inclusion_bidirectionnelle'$  **then**

**Début**

                            Ajouter  $((x,y), \equiv)$  ;

**Si non**

**Si**  $P1.type = 'd'exclusion_bidirectionnelle'$  **then**

**Début**

                                    Ajouter  $((x,y), \perp)$  ;

**Fin** ;

**Fin** ;

**Fin** ;

**then**

        Pour toutes passerelles  $P2(y,z)$  d' $O2$  faire

**Début**

**Si**  $P2.type = 'unidirectionnelle'$  **then**

**Début**

                        Ajouter  $((y,z), \subseteq)$  ;

**Fin** ;

codification de notre ontologie en langage OWL\_DL nous nous sommes servis de l'outil protégé –OWL et nous avons codifié l'ontologie multi-points de vue (MPV) en suivant les étapes de codification proposées par [3].

#### A. L'alignement global

Afin d'instancier notre base de cas (OA), nous prenons les hiérarchies globales des exemples que nous avons pris. Le premier problème est de trouver la relation sémantique entre deux concepts global appartenant aux hiérarchies par exemples : relation 1 (*Sujet, Personne*). La résolution de ce problème est faite par le calcul des deux similarités de graphe entre les hiérarchies et terminologique entre les concepts. Après le calcul la valeur pondéré entre ces deux similarités on compare cette valeur par rapport à un seuil minimale (0.8 par exemple), on trouve que les deux concepts (*Sujet, Personne*) sont similaires. La solution est : Sol = «  $\equiv$  ».

De la même façon nous appliquons la mesure de la similarité sur les autres concepts. On obtient les cas suivants

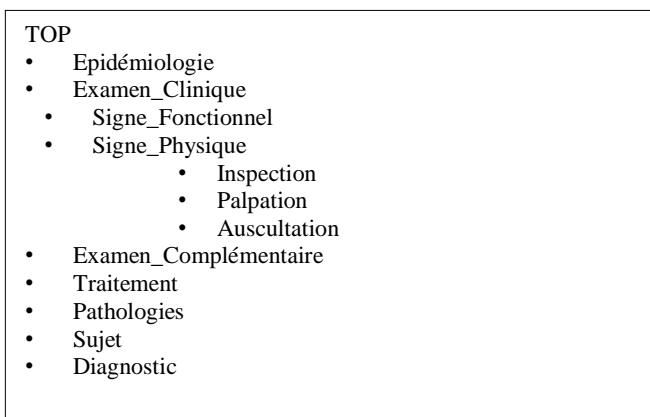


Fig 10. L'hierarchie globale d'O1.

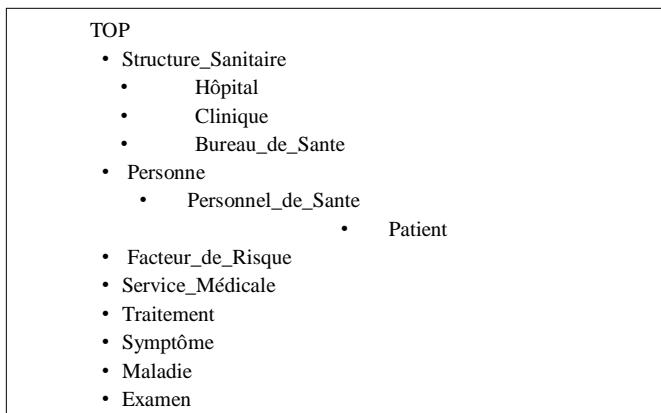


Fig 11. L'hierarchie globale d'O2 .

#### Exemple

Cas 1 : *Epidémiologie*  $\equiv$  *Facteur\_De\_Risque*

Cas 2 : *Pathologie*  $\equiv$  *Maladie*

Cas 3 : *Examen\_Clinique*  $\equiv$  *Examen\_Physique*

Cas 4 : *Epidémiologie*  $\perp$  *Examen*.

Les résultats d'équivalence et différence seront stockés directement dans l'ontologie d'alignement (OA) (cas 1,cas2,cas4). Les flou ( $\equiv$ ) seront déterminer par la suite (cas3).

Après avoir instancié notre base de cas par la relation entre les concepts globaux, on passera à l'étape suivante : qui est la détection des relations sémantique entre les différents autres concepts.

La relation entre les autres concepts peut être faite par l'opération de composition. Cette opération nous permettra la réutilisation des cas stockés dans la base de cas (OA). Mais l'application de l'opération de compositions ne résout pas complètement le problème de la détection de la relation sémantique. C'est pour cela que nous appliquons une autre opération qui est l'agrégation de similarité.

#### Composition

Dans notre exemple nous prenons par exemple les deux concepts *Sujet*, et *Personne*. Après le calcul de la mesure de similarité nous avons trouvé le cas (*Sujet*  $\equiv$  *Personne*) et nous avons les relations de subsumption  $Rel(Personne, Patient) = \sqsupseteq$ ,  $Rel(Personne, Personnel_de_santé) = \sqsupseteq$ . Selon la table de composition de la relation sémantique, l'application de l'opération de composition a ces cas, nous donne les résultats suivantes :

$$Rel(Sujet, Personnel_de_Santé) = \sqsupseteq$$

$$Rel(Sujet, Patient) = \sqsupseteq.$$

Nous pouvons aussi déduire selon la relation de subsumption les cas suivants :  $Rel(Epidémiologie, Patient) = \perp$ ,  $Rel(Epidémiologie, Personnel_de_Santé) = \perp$ .

De la même façon nous appliquons l'opération de composition aux autres cas .Cette opération permet l'augmentation de la taille de la base de cas.

$$Rel(Sujet, Personnel_de_Santé) = \sqsupseteq.$$

$$Rel(Sujet, Patient) = \sqsupseteq.$$

$$Rel(Epidémiologie, Patient) = \perp.$$

$$Rel(Epidémiologie, Personnel_de_Santé) = \perp .$$

Cette étape nous permettra d'associer les concepts globaux entre eux. Nous passerons maintenant à l'étape suivante qui est la détection des relations sémantique entre les ontologies locales.

#### 1) L'alignement local

Dans cette étape, on applique l'approche proposée sur chaque combinaison de deux descriptions locales appartenant aux deux ontologies multi-points de vue (MPV). Chaque ontologie locale de la première ontologie multi-point de vue sera comparée avec toutes les ontologies locales de la deuxième en remplaçant la base de cas (OA). Le résultat de cette étape est une matrice de similarité entre les points de vue. Si on prend le couple (*Infectieux, Gynécologie*), et si on applique la mesure de similarité entre les deux concepts locales : P V 2 : *Troubles\_des\_règles* un sous concept du concept global pathologie selon le point de vue Infectieux dans la première ontologie et P V 1 : *Trouble\_des\_règle* un sous concept du concept global symptômes selon le point de vue *Gynécologie* dans la deuxième ontologie on obtient le cas suivant :

$\text{Rel}(\text{Troubles_des_règles}, \text{Troubles_des_règles}) = \equiv$

Si en prend un autre exemple le couple des ontologies locales (*Infectieux*, *Gynécologue*), on obtient par exemple les cas suivants après l'application de l'opération de composition :  $\text{Rel}(\text{Sujet}, \text{personnel\_De\_Santé}) = \supseteq$  et  $\text{Rel}(\text{Personnel\_De\_Santé}, \text{Sage\_Femme}) = \supseteq$  on obtient  $\text{Rel}(\text{Sage\_Femme}, \text{Sujet}) = \subseteq$ . De la même façon on obtient :  $\text{Rel}(\text{Nouveau\_Né}, \text{sujet\_Fœtus}) = \subseteq$  et  $\text{Rel}(\text{sujet\_Fœtus}, \text{Sujet}) = \subseteq$ .

Le premier exemple désigne comment on associe deux concepts locaux. le deuxième exemple désigne comment on associe un concept global à un concept local.

en appliquant la mesure de similarité sur les deux concepts locaux *maladie\_tuberculeuse* un sous concept du concept global pathologie dans la première ontologie selon le point de vue *pneumologie et pathologie\_respiratoire\_infectieuse* un sous concept du concept global maladie selon le point de vue infectieux dans la deuxième ontologie selon le point de vue *pneumologie* on trouve que les deux concepts sont équivalents donc on a le cas suivant :  $\text{Rel}(\text{Maladie_Tuberculeuse}, \text{Pathologie_Respiratoire_Infectieuse}) = \subseteq$ .

Après l'application de la composition MPV on obtient le cas suivant :  $\text{Rel}(\text{Infection_Tuberculeuse}, \text{Pathologie_Respiratoire_Infectieuse}) = \subseteq$ .

Le résultat de cette étape est une matrice de similarité locale, qui associe chaque concept locale de la première ontologie avec un autre de la deuxième. A laide de cette matrice on peut déduire les correspondances entre ces concepts.

## 2) L'alignement des passerelles

On prend par exemple dans la deuxième ontologie la passerelle :

PV2 :  $\text{Facteur\_a\_Risque\_Liés\_a\_L'environnement} \rightarrow \equiv \rightarrow$

PV3 :  $\text{Pollution}$  qui exprime que tous les *Facteur\_a\_Risque\_Liés\_a\_L'environnement* sont des *Pollutions* et tous les types de *Pollution* sont des *Facteur\_a\_Risque\_Liés\_a\_L'environnement*. on obtient le cas suivant :  $\text{Rel}(\text{Facteur_a_Risque_Liés_a_L'environnement}, \text{Pollution}) = \equiv$ .

Pour la deuxième ontologie nous avons la passerelle PV2 :  $\text{Infection_Tuberculeuse} \rightarrow \subseteq \rightarrow$

PV3 :  $\text{Maladie_Tuberculeuse}$  on obtient le cas suivant :

$\text{Rel}(\text{Infection_Tuberculeuse}, \text{Maladie_Tuberculeuse}) = \subseteq$ .

Selon la table de la loi de composition, on a dans l'ontologie d'alignement le cas suivant :  $\text{Epidémiologie} \equiv \text{Facteur_a_Risque}$  et nous avons la relation de subsumption suivante :  $\text{Facteur_a_Risque} \supseteq \text{Facteur_a_Risque_Liés_a_L'environnement}$ . Si nous appliquons la composition on obtient le cas  $\text{Facteur_a_Risque_Liés_a_L'environnement} \subseteq \text{Epidémiologie}$  et  $\text{Pollution} \subseteq \text{Epidémiologie}$ .

## VI. CONCLUSION

cet article propose une méthode d'alignement multi point de vue, nous a permis essentiellement de détecter les correspondances sémantiques entre les descriptions globales ou locales de deux ontologies. La première étape était l'alignement de deux descriptions globales comme étant des ontologies classiques et la deuxième c'était l'alignement des différentes descriptions locales entre elles et finalement les passerelles.

Pour étudier l'impact de cette contribution proposée sur les applications réelles, nous avons choisi le contexte d'application de la médecine. Cet article a ouvert plusieurs perspectives pour compléter et améliorer le travail engagé dans celui la :

- La première perspective est l'alignement des rôles en général qui sera basé sur la notion de similarité sémantique et il n'existe pas, jusqu'à maintenant, une mesure de similarité entre les rôles définis avec la logique de description étendue par le mécanisme d'estampillage qui prend en considération la notion de point de vue .
- Une autre perspective est de développer une étape de maintenance afin de permettre à notre système proposé d'effectuer seul les opérations de maintenance.

## REFERENCES

- [1] T. BACH, "Construction d'un Web Sémantique Multi-Points de Vue", Thèse pour obtenir le titre de Docteur en Sciences, Ecole des Mines de Paris à Sophia Antipolis, Octobre 2006.
- [2] M. HEMAM et Z. BOUFAIDA, : "Représentation d'ontologies multipointsde Vue : une Approche basée sur la logique de description", Conférence en Ingénierie des connaissances, 25-29 mai, Hammamet, Tunisie, 2009.
- [3] L. Djakdjaka, « un formalisme pour l'alignement des ontologies multi – point de vue basé sur une extension de la logique de description », thèse de doctorat en informatique, université Mentouri Constantine,2014.
- [4] M. Hemam et z. boufaida, « Représentation des ontologies multi point de vue : une approche basée sur la logique de description », thèse de doctorat en informatique, université Mentouri Constantine , 2012.
- [5] L. Djakdjakha, « une méthode d'alignement entre une ontology classique et une ontology multi-points de vue », thèse de doctorat en informatique, université Mentouri Constantine,2009.
- [6] Z. Wu et M. Palmer, «Verb semantics and lexical selection», In Proceedings of the 32nd Annual Meeting of the Associations for Computational Linguistics, pp 133- 138, 1994.
- [7] J.Euzenat, P.Shvaiko,«Ontology matching», Springer, Heidelberg(DE), 2007.
- [8] M . Kolli et Z.Boufaida « Intégration d'ontologies dans le cadre du web semantique : une détection des relations sémantique basé sur le RAPC », thèse de doctorat en informatique , université mentouri constantine, 2011 .
- [9] M . Bouzidi et R . Saouchi « Développement d'une ontologies multi – point de vue du domaine médical spécialité : Gynécologie, pneumologie et oncologie », mémoire Master en informatique , université Mentouri Constantine , 2014 .

# Hybrid Energy Efficient Routing Protocol for Heterogeneous WSN

Ayoub Benayache\*, Azeddine Bilami, and Sami Barkat

LaSTIC Laboratory

Department of Computer Science,

University of Batna,

Email:[ayoub.inf30@gmail.com](mailto:ayoub.inf30@gmail.com)

Email:[abilami@yahoo.fr](mailto:abilami@yahoo.fr)

Email:[Barkat.sammi@gmail.com](mailto:Barkat.sammi@gmail.com)

**Abstract-** Wireless sensor network (WSN) is an emerging technology that aims to offer innovative capabilities. However, the sensor nodes present important limitations, mainly in terms of energy which depends on the lifespan of battery. This is why so many works focused on of the energy consumption. In this paper, we are interested especially in heterogeneous environment taking into account the communication and data routing algorithms. We present a new protocol called Hybrid Energy Efficient (H2E) Protocol for Heterogeneous WSNs, which is an improvement of HEEP protocol [1] making it more scalable and supporting heterogeneity of nodes. H2E protocol is implemented using TinyOS embedded system. Simulations under Tossim are performed to evaluate the performances of the proposed protocol.

**KeyWords-**Wireless Sensor Network, Heterogeneous WSN, Actuator, Routing, Energy efficiency, HEEP

## I. INTRODUCTION

The Wireless Sensor Network (WSN) is a type of network that consists of special nodes or motes composed at least of a micro controller, memory, radio interface to communicate with neighbors, a sensor to collect data, and energy unit. For special mission, the node must integrate other components like unit for movement capture, localization, etc. The nodes may be different and thus constitute a heterogeneous wireless sensor network. In the remaining of this paper, in section 2, we will discuss the heterogeneity of wireless sensor network which is categorized in three types: hardware, software and function-based, in section 3, we present a survey of HEEP [1] protocol as a new network self-organization approach which combines clusters-based and chain-based approaches. This new approach is

still suffering about the non support of scale-up and heterogeneity of the nodes, that is our concern in this paper while suggesting a new protocol (H2E) to support these two HEEP protocol's deficiencies, thus we discuss in section 4 and section 5, our proposal and some details related to its implementation and simulation tools. In section 6, we evaluate performances of H2E and finally, we present an overall conclusion.

## II. HETEROGENEOUS NETWORKS

When nodes in a network are different; we talk about heterogeneous wireless sensor network. We can categorize three types of heterogeneity.

### ❖ Heterogeneity in the hardware

Different architectures are supported by sensors nodes according to the nature and quality of their components and different suppliers like (micaz, telosb, iris,etc).

### ❖ Heterogeneity in the software

There are many operating systems, middleware and protocols developed for sensor nodes (tinyos, contiki, iros, mate, etc... ).

### ❖ Heterogeneity in the function:

The function of a node defines what it can do, so, different roles in the network are ensured by different nodes, for example: regular node, head cluster, base station. We explain details of these categories in the following:

### ❖ Heterogeneity in hardware architecture

#### ➤ Communication

There are many ways to share information over the air, different techniques are classified according to their speed and range: example: Wifi, Bluetooth, Zigbee[7,10,13,6]

#### ➤ The microcontroller

Sensor nodes often contain a microcontroller with few resources. Usually it is an architecture of 8 or 16 bits, with less than 16KOctets RAM and less than 192KOctetsflash memory. This architecture is

suitable for practical needs example: AVR MSP430, ATMEL,,,etc[3];

#### ➤ **memory**

Several types of memories are req node's operation. A

Memory) is required to store (programs)

in case of insufficient space of the case of power failure [2]

#### ➤ **Energy**

Many battery models are described in the literature, which take into account of the sensor node in the estimation lifetime of the battery. This latter depends on the type of battery (Alkaline, Lithium ion, Ni-Cd, Ni-MHz ...) and its technology. Indeed, the charge of the battery depends on its i

breakdown voltage, but also how constant current discharge or intermittent [2]

#### ➤ **The sensor**

multiple functions and different sensors.

a low data flow, long life; it is periodic or event-based transmission to the base station; simple detection patterns are

within a circular disc of radius called range[9,2].

### ❖ **Heterogeneity in software**

#### ➤ **Operating systems**

Current researches are focused on increasing the speed of information exchange and on other hand, on

through obstacles. For these applications of WSNs are being considerable development. Aware that some architecture is more powerful than logical to execute the code to software. We can have operating systems that offer more features, or that using TinyOS. We will present some most used operating systems for sensors: [11,3]: TinyOS, Mantis, Nano-RK, Contiki, Retos, Sos... our work uses TinyOS system.

Nom	Mémoire Flash	Mémoire RAM	Particularité
TinyOS	lié à l'application	"	premier OS pour WSNs
MantisOS	14KO	500 octets	filé préemptif, basse consommation
NanoRk	16KO	2KO	préemptif temps réel
Retos	24KO	800 octets	préemptif, résilient
SOS	20KO	1.1KO	préemptif, modules dynamiques

**Figure 1: Operating systems Summary best known WSNs**

#### ➤ **Middleware (virtual mac)**

Virtual machine:

low level code written for it are associated

in compatible with the architecture. There are also virtual machines f

intensive use of the Java virtual machine of the strong advantages of

more space that is available for the application.

virtual machines for microcontrollers created. In general, there is a cross-compiler (a compiler that targets to

that remains on the computer and runs on byte

when the intermediate result of the compilation is ready, it will be executed

machine remains on the node without interpreting the byte code to execute the algorithm. [3] Example mate, DAISY, VM, magnet.

#### ➤ **Protocols**

##### **MAC layer**

the network when the sensors function, or to change the types of protocols at the MAC layer

#### ➤ **(Scheduling protocols)**

ow peer-to-peer, may require inter-cluster

approaches: TDMA, FDMA, CDMA

➤ Contention based protocols

The medium access contention-based protocols are more flexible to the changes in the topology. They allow peer-to-peer communication, and require no synchronization. However, they often don't use resources efficiently because of collisions and unnecessary listening [4,8,6].SMAC, DS-MAC, T-MAC B-MAC etc.

**Routing**

Routing is one of the crucial issues in almost any type of network. The goal of a routing protocol is to find a route between two nodes of the network. In heterogeneous networks, they also require, at the same time, minimizing communication additional costs, energy consumption and the consideration of the diversity of capabilities of the network nodes components. In heterogeneous networks, more work focuses on the design of algorithms for creating clusters or sets of dominant nodes to take this heterogeneity to increase the lifetime of the network. The technique of creating a hierarchy has several advantages, in effect [14]:

- It reduces the size of the routing table stored on the nodes.
- It can save bandwidth communication: indeed, for the technique based on the creation of clusters, nodes of the communication field in the same cluster.
- It can prolong the life of the low-resource nodes and thus the network lifetime.
- It reduces the maintenance overhead of network topology: just because a node will monitor his connection with his CH or with the dominating node of the spine.
- It reduces the number of redundant packets using techniques aggregations level data prevailing at the nodes or CHs.

❖ **Heterogeneity in function**

Depending on the environment or the selected application, a WSN may contain different types of nodes: [5]

➤ **A regular node**

is a node having a transmission unit and a data processing unit. The data transmission unit is responsible for all programs and data reception via a wireless communication medium can be of the optical type (as in Smart Dust knots) or radio frequency type (as in Stargate nodes). The data processing unit is composed of a memory, a microcontroller and a specific operating system (such as TinyOS, developed at the University of Berkeley and currently used by over 500 universities and research

centers worldwide). She is responsible for processing data from the transmission unit. Depending on the field of application, a node may be provided with additional or optional units such as a positioning system (Global Positioning System or GPS, etc.) to determine its position, or an energy generating system (photovoltaic cell, etc.), or a mobile system to enable it to change its position or configuration if necessary.

➤ **A sensor node**

This is the source node is a regular node equipped with an acquisition or detection unit. The acquisition unit is generally equipped with a sensor or plurality of sensors that receive analog measurements (physical and physiological) and an analog / digital converter which converts the information recorded in a digital signal understandable by the unit treatment.

➤ **An actuator node or robot**

is a regular node has a unit for it to perform specific tasks such as mechanical tasks (move, fight a fire, a PLC control, etc.)

➤ **A hole node**

Is a regular node with a serial converter connected to a second communication unit (GPRS, Wi-Fi, Wi-Max, etc.). The second communication unit provides a transparent retransmission data from sensor nodes to an end user or other networks such as the Internet.

➤ **A gateway node (or Gateway)**

is a regular node for relaying the traffic in the network on the same communication channel. To optimize some parameters like the life of the network or the data delivery time, some work has focused on architecture (flat, hierarchical, multi-level) of the NSR. These architectures often define the roles of nodes in a WSN. We distinguish three main roles are:

➤ **Source node (NS)**

Whose main role is to detect physical or physiological phenomena occurring in their immediate environment in order to transmit, directly or through multiple hops, an end user. This is actually a sensor node.

➤ **Relay node (NR)**

Its role is to aggregate and retransmit the measurements from the NS so that they reach an end user. In a flat architecture, some work typically consider NS as NR .In a 2-level architecture, a gateway node plays the role of NR for one or more source nodes. In such a network configuration, NR transmission capacity is assumed to generally greater than that of the NS.

➤ **Collector node (NC) data**

Its role is to collect measurements from the source nodes and possibly aggregated. Generally, a "Cluster-Head" or cluster manager

is used as NC in a hierarchical where NS are partitioned into groups. [9.5]  
**Motivation**

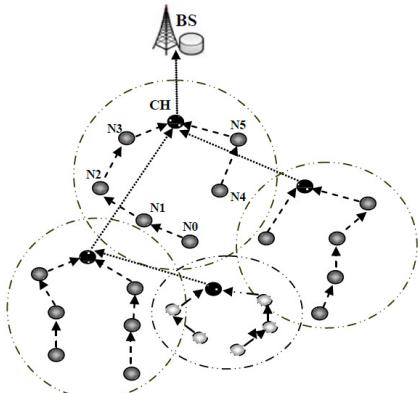
very sensitive parameters in this and range for each sensor. We cho [1] ped in our laboratory. Note that this protocol suffers from the scale-up problem to remedy the shortcomings of HE

### III. THE HEEP

on of sensor

regulate the energy dissipation and load on the CH (cluster-Head)

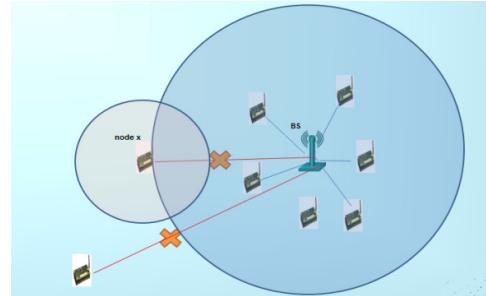
use of the bandwidth. Aggregating node in the chain reduces the amount exchanged between them has the effect of preserving the energy reserves [1].



**Figure 2:Organization of sensor nodes in the network**

**The problem that we try to solve**  
the main problems are figured in t picture :

- The network coverage de limited on the base station range.
- The BS can transmit a message to node x but the opposite may be not because node x can't detect BS in his range.

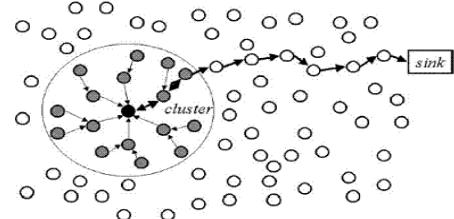


**Figure 3: problematic posed by heterogeneity of range**

### IV.

### L: H2E

our protocol, the distributed model centralized model. We choose to implement the distributed model under TinyOS Platform. Finally, we simulate the protocol in TOSSIM simulator. Both models phases, the initialization phase, a transmission phase, the following figure illustrates this principle.



**Figure 4: general outline of our protocol**

#### The distributed model

This model is based on the participation of all sensor nodes in the initialization phase. All nodes participate

can make two spots according to their energy, capacity).

#### The initialization phase

broadcasts its message to all neighboring nodes, this message contains: ID, range, and depth, ID is the identifier of the range is the coverage area, and depth represents the number of hops which initially takes the null value. each neighboring node of the BS after the receipt of the message (initialization phase) tests if it is a child of the BS, by comparing its own range with the range of its parent's range. In this approach we use the signal strength [12], if the conditions are satisfied, the node declares the BS its parent otherwise it waits for further messages.

After the declaration phase the node will transmit the BS message to other nodes which

they haven't parents. Before retransmission the message the node change fields of the message by its specific data (depth, and range ID), by repeating this phase each node will have a parent, Thus it can reach the base station through his parent. Then each node send a message to the BS contains the following parameters: the energy, range, and depth.

to minimize the number of messages in the network, each node sends a message to its parent with a random time slot to reduce collisions and interference, when the BS received all node messages , it calculates the average energy of all nodes, and then selects a percentage P of nodes that are elected cluster head (CH: Cluster-Head) with an energy greater than or equal to the calculated average power, and to reduce the number of messages sent to elected CH, the BS sends IDs of all CH in one message taking into consideration the size of the packet, each node receives the message sent by the BS, then rebroadcasts it to other nodes until all nodes receive the message and recover the average energy to recognize if it is a CH or not, after that the CH to the creating the forwarder chain (bridges).

#### **Formation of the chain of forwarders of CLUSTER-HEAD step**

Each CH sends a confirmation message to its parent, then it is received by the parent who declares itself as a forwarder, if the energy of this sensor is greater than or equal to the average of energy calculated by the BS then this node is also a sensor that can collect data, else the node declare itself just a forwarder.

Each CH must have a forwarder to reach the BS, each parent node on the way between the CH and the BS, becomes a forwarder if it is not the BS.

#### **Clusters chains training step**

This step is triggered by CH. Each CH broadcasts a message to its neighbors, this message contains id, range, depth. Each node which isn't a CH or a forwarder retrieves messages sent by the CHs. The node has a waiting period, if it doesn't receive a new message, then starts the election of a CH which becomes its parent by taking into account the received parameter (range and depth and strength signal). In our case the node saves the coefficient of each CH in a table and then selects the node with the highest coefficient value in the table, calculated as: coefficient=depth\*signal strength\*range

The range needs to be greater than or equal to the range of the parent and the signal strength have to be greater than -70 (in the specification of the environment of our network). After CH election, the node is declared as a cluster member and will also continue the formation

of the chain by broadcasting message to the nodes that are not members. Finally, the operation ends with the triggering of the data capture phase and the transmission to the base station.

#### **Data transmission step**

For this step it has several models according to the event or type of application, the data transmission task can vary; but the essential point in this step is the minimization of the energy consumption and the receipt of data (reliability); each node sends the captured data to its parent and so on; Among these models we can distinguish some models, for example the sensor can capture several times but transmits only one time, the node send the sum or the average depending on the type of application, CH also can send data after each reception or leave them until the arrival of all members data, taking into consideration the size of the packet; in our case we use the simplest model, where each node periodically captures value and transmits each time to its parent, and the same for the CH, it will transmit the data directly to the forwarder until the BS.

In the following we show resumed algorithm of our protocol

---

#### **The initialization phase**

```

Begin
If(is_BS ) brodcasts(bs_info); /* base station
broadcasts its message */
Else{
    if( range(self) >= range(receive_from)){
        /*if range of receiver is more than sender
range */
        Parent = receive_from;// recip_form is
the sender
        Brwdcast(self_info); /*each node have a
parent ,broadcast to other nodes*/
        } else wait_a_parent(); /* if range is less
than sender range , the node waits other
senders*/
}
End

```

---

Nodes send info to BS to calculate and choose Clusters Heads

```

begin
If (parent != null)
    Send_info_to_BS_by(parent); /*info
    arriving to BS using multi hop routing
    for each node via its parent */
If (is_exist(all_info_of_nodes)&&is_BS){
    Calculate_average_energy(); /*calculate
    the average of energy to set node as a
    cluster head or forwarder*/
    Select_CH();/* select a percentage of
    nodes as CH */
    Broadcast(CH is);
}
End

```

---

---

```

Formation of the chain of forwarders
begin
If(is_CH){
    create_chain_forwarder_to_BS(); /* the
        CH creates the link to the base station */
    broadcast(ch_info); /* broadcasts a
        message to nodes for joining the cluster */
}else if (!is_BS&& !is_forwarder) {
    Election_CH(list_of_ch_received); /* all
        nodes after receiving the messages of
        clusters , they elected who is CH*/
    Broadcast(nodes_not_member_in_cluste
r_yet);/*create chain in cluster */
}
End
Data transmission step
begin
if(parent!= null){
    collect_data(); /* sense data */
    send_data_to_BS(parent);/*sends sensed
        data to BS by parent */
}
End

```

---

### The centralized model

For this model the initialization task is effective at the BS level that triggers the first step of a message as we have seen already for the distributed model, after receiving the message from the BS by all nodes, each one of them must generate a message that contains ID, range, power, depth, and the key is the geographical coordinates and transmits it to the BS through the elected parents in the initialization step, at the end of this step the BS collects all messages, and use these information (id, coordinates ...) to create a topology and select the forwarders, the CH and their members. After the formation of the topology, the BS will inform all nodes, each node has its task or role, and for the transmission of data that it's similar to the distributed model. Among the problems of this model is the deficiency of a CH sensor, which implies a new initialization step. Contrary in the distributed model in case of deficiency of the CH, a member can choose the CH among the lower priority than the first, which are saved in the table of CHs. We can suggest that in the step of forming the CHs can also create his backup in case of deficiency. To know if there are deficient nodes, we can use the system acknowledgement, for example if there is no acknowledgement for five successive messages, the CH node is declared dead and we can then use its replacement.

## V. IMPLEMENTATION OF H2E

### Tinyos

TinyOS is an operating system specifically designed for sensor networks. It has a component-based programming model, provided by the NesC language [8], a dialect of C. TinyOS is not an OS in the traditional sense. It is a programming framework for embedded systems and set of components that enable building an application specific OS into each application.

A TinyOS program is a graph of components, each of which is an independent computational entity. Each TinyOS component has a frame, a structure of private variables that can only be referenced by that component. Components have three computational abstractions: Commands, events, and tasks. Commands and events are mechanisms for inter-component communication, while tasks are used to express intra-component concurrency.

A command is typically a request to a component to perform some service, such as initiating a sensor reading, while an event signals the completion of that service. Events may also be signaled asynchronously, for example, due to hardware interrupts or message arrival. From a traditional OS perspective, commands are analogous to down calls and events to up calls. Commands and events cannot block: rather, a request for service is split phase in that the request for service (the command) and the completion signal (the corresponding event) are decoupled. The command returns immediately and the event signals completion at a later time [15].

### Nesc

NesC (network embedded system C) is a component-based C dialect. In some ways, NesC components are similar to objects. For example, they encapsulate state and couple state with functionality. The principal distinction lies in their naming range. Unlike C++ and Java objects, which refer to functions and variables in a global namespace, NesC components use a purely local namespace. This means that in addition to declaring the functions that it implements, a component must also declare the functions that it calls. The names that a component uses to call these functions are completely local: the name it references does not have to be the same that implements the function. When a component A declares that it calls a function B, it is essentially introducing the name A.B into a global namespace. A different component, C, that calls a function B introduces C.B into the global namespace. Even though both A and C refer to the function B, they might be referring to completely different implementations [16].

**Tossim[17]:**

ntrolled and

philosophy of TOSSIM, its cap structure. It also provides a br how to use TOSSIM for testing or analysis.

**Power Tossim**

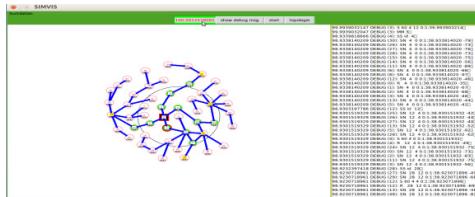
The PowerTossim is to perform si the same way as Tossim

allowing us to run the simulation death of the network.

**TinyViz[17]**

TinyViz is a Java visualization for TOSSIM. The main TinyViz file, TinyViz can be attached to simulation. Also, TinyViz to connect before it starts up, using the -gui flag. This allows users to TinyViz captures all the events simulation.

the simulation script to create a real-time graphical interface SimViz with simulator.



**Figure 5: SimViz**

## VI. EVALUATION

To evaluate our modified protocol, we present some performance parameters. The simulation uses always 50 nodes, with av between -110,-80 and dense and not-dense environment.

types of sensors depending on the or given task to perform: brid forwarder; sensor node; cluster-head node,

simultaneously, the following tabl number of nodes for each type in both dense and sparse cases:

Kind of node	Number
Cluster head	Preset (our case 10%) 5
Bridge (forwarder)	3
sensornode	36
Forwarder and sensornode	8

**Table 1:number of nodes for each node (not dense)**

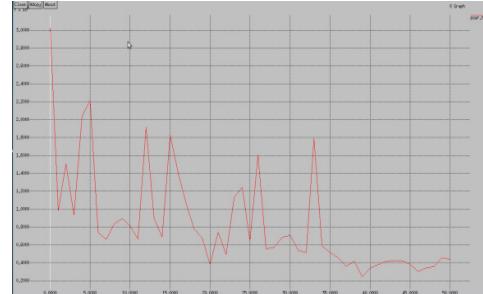
Kind of node	Number
Cluster head	Preset (our case 10%) 5
bridge(forwarder)	0
Sensor node	45
Forwarder and sensornode	0

**Table 2:number of nodes for e: (dense)**

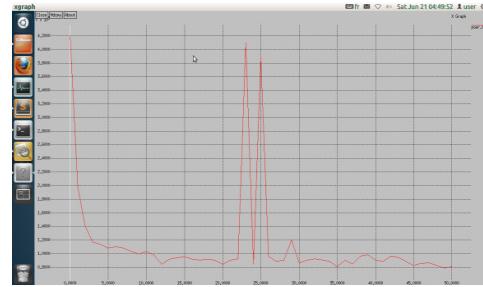
**Energy consumption**

We calculate the energy

of energy consumption, which is a predefined file in Power Tossim simulator for MICA2 and Micaz. The follow show the energy consumption for each sensor in the form of a curve:



**Figure 6:energy consumption for each node(not dense)**



**Figure 7: energy consumption for each node (dense)**

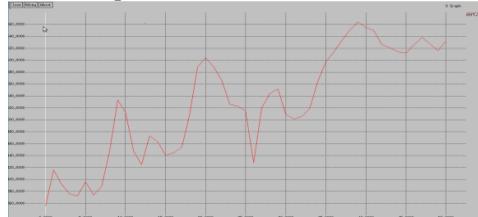
**Packet loss:**

There are

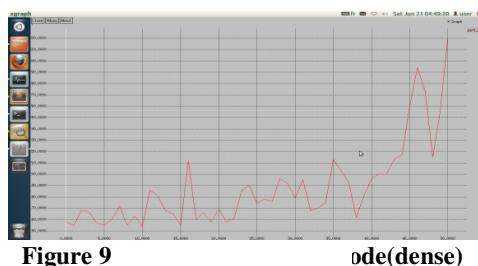
does not use the RTS / CTS mechanism; to

solve this problem we can different transmission time slot to avoid the collision and interference. There are also other mechanisms, which are assigned to each cluster of a frequency (FFL) internal exchanges event (inter-cluster level), in

regulation must be made within a slot for each cluster through mechanism; so the following picture shows the number of packet lost for each node;



**Figure 8: packet loss for each node(not dense)**



**Figure 9: packet loss for each node(dense)**

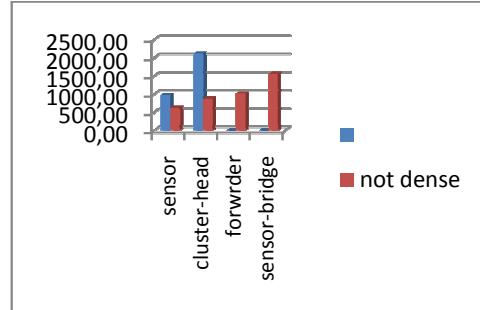
dense and not dense in energy consumption and packet loss

Kind of node	Energy average(unit)
Cluster	879.74
bridge (forwarder)	1013.1333333333333
Sensornode	1111
Forwarder and sensornode	1558.85

**Figure 10: energy consumption & the sensor type (not dense)**

Kind of node	Energy average(u)
Cluster	2114.06
bridge(forwarder)	0
Sensor node	971.3177777778
Forwarder and sensor node	0

**Figure 11: energy consumption & the sensor type (dense)**



**Figure 12: Comparison of packet loss in a non-dense environment depending on the sensor type**

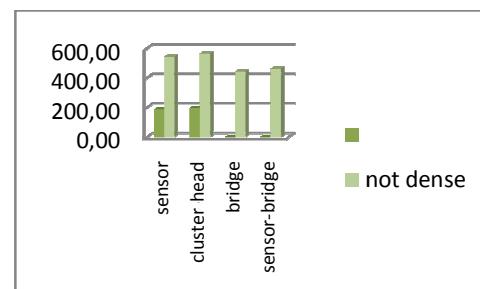
After this comparison, we note that the consumption of energy in dense cluster node is higher than sparse case because we haven't forwarder or sensor-bridge in dense case, so we conclude that all the hard work is done by cluster node

Kind of node	Packetloss(packet)(data)
Cluster	565.2
bridge	389
Forwarder and sensornode	463.25

**Table 3: packet loss according to the sensor type (not dense)**

Kind of node	Packetloss (packet)
Cluster	197.0
bridge(forwarder)	0
Sensor node	187.42222222222222
Forwarder and sensor node	0

**Table 4: packet loss according to the sensor type (dense)**



**Figure 13: Comparison of packet loss in a dense environment depending on the sensor type**

We note that the packet loss in sparse case is more than dense case, this is because the node's range can be different from another (for example: y sends message to x

but the last one can't receive), so we get more packet loss.

## VII. CONCLUSION

Despite the fact that we haven't made comparisons with other routing protocols, we can say that our modified protocol solves the problem of heterogeneity, for example the range problem i.e. change the range dynamically based on power consumption, and differs depending on the task performed by each type of sensor node. Our protocol also addresses the problem of scalability of the original protocol HEEP,

As a perspective, we plan to improve our protocol in order to support mobility and heterogeneity on many layers.

## References

- [1] BOUBICHE, Djallel Eddine et BILAMI, Azeddine. HEEP (Hybrid Energy Efficiency Protocol) based on chain clustering. International Journal of Sensor Networks, 2011, vol. 10, no 1-2, p. 25-35..
- [2] DESSALES, Denis. *Conception d'un réseau de capteurs sans fil, faible consommation, dédié au diagnostic in-situ des performances des bâtiments en exploitation.* 2011. Thèse de doctorat. Poitiers.
- [3] GALOS, Mihai. *Reconfiguration dynamique et simulation fine modélisée au niveau de transaction dans les réseaux de capteurs sans fil hétérogènes matériellement-logiciellement.* 2012. Thèse de doctorat. Ecole Centrale de Lyon.
- [4] AMINA, BOUDJAADAR. Plateforme Basée Agents Pour l'Aide à la Conception et la Simulation des Réseaux de Capteurs Sans Fil. 2010. G
- [5] ZATOUT, Youssouf. *Conception et évaluation de performances d'un réseau de capteurs sans fil hétérogène pour une application domotique.* 2011. Thèse de doctorat. Université Toulouse le Mirail-Toulouse II.
- [6] NEFZI, Bilel. *Mécanismes auto-adaptatifs pour la gestion de la Qualité de Service dans les réseaux de capteurs sans fil.* 2011. Thèse de doctorat. Institut National Polytechnique de Lorraine-INPL.
- [7] VAN DEN BOSSCHE, Adrien. *Proposition d'une nouvelle méthode d'accès déterministe pour un réseau personnel sans fil à fortes contraintes temporelles.* 2007. Thèse de doctorat. Université Toulouse le Mirail-Toulouse II. S
- [8] KAREL, H. *Protocoles Localisés pour Réseaux de Capteurs.* 2009. Thèse de doctorat. Thèse de doctorat, INSA de Lyon.
- [9] KONE, Cheick-Tidjane . *Conception de l'architecture d'un réseau de capteurs sans fil de grande dimension.* 2011. Thèse de doctorat. Université Henri Poincaré-Nancy I.
- [10] BARROS GAVILANES, Juan Gabriel. Réseaux de capteurs pour applications de suivi médical. 2013.
- [11] ZEYNEB, Bouzidi et AMINA, Benmeur. Mise en place d'un réseau de capteurs sans fil pour l'irrigation intelligente. *Master en Informatique, Université Abou Bakr Belkaïd-Tlemcen,* 2012.
- [12] Yannick Darcillon Localisation des nœuds dans les Réseaux de capteurs sans fil. report, université d'Avignon 2008.
- [13] Casas Chica Juan Pablo, Nguyen Viet Minh, Vu Ninh ThanhHien Application de vidéo surveillance avec un réseau de capteurs multimédia sans fil, report université de Pau et des Pays de l'Adour 2011.
- [14] ROMDHANI, Bilel. *Exploitation de l'hétérogénéité des réseaux de capteurs et d'actionneurs dans la conception des protocoles d'auto-organisation et de routage.* 2012. Thèse de doctorat. INSA de Lyon.
- [15] LEVIS, Philip, LEE, Nelson, WELSH, Matt, et al. TOSSIM: Accurate and scalable simulation of entire TinyOS applications. In : *Proceedings of the 1st international conference on Embedded networked sensor systems.* ACM, 2003. p. 126-137.
- [16] LEVIS, Philip et GAY, David. TinyOS programming. Cambridge University Press, 2009.
- [17] LEVIS, Philip et LEE, Nelson. Tossim A simulator for Tinyos networks. UC Berkeley, September, 2003, vol. 24.

## Weighted Association Rules:

### Application in Medical Images fields

Senai Besma

University of sciences and technologies –Mohamed Boudiaf-  
USTOMB  
Besma.senai@gmail.com

Rahal Sid Ahmed and Khiat Salim

University of sciences and technologies –Mohamed Boudiaf-  
USTOMB  
Computer sciences and Mathematics Faculty  
Signal, System and Data Laboratory (LSSD)  
rahalsa2001@yahoo.fr, Salim.khiat@univ-usto.dz

**Abstract---**Medical image mining is an important field in data mining literature. Association rule is very important technique in medical image mining. Finding these valuable rules from medical images is a significant research topic in the field of data mining. Discovering frequent itemsets is the key process in association rule mining. Traditional association rule algorithms adopt an iterative method which requires large amount of calculation like Apriori algorithm [1]. The FP-growth [2] algorithm is currently one of the fastest approaches to frequent itemset mining.

In this paper, we proposed a new algorithm called WFP-Growth of discovering significant binary relationships in transaction datasets in a weighted setting. It is adapted to handle weighted association rule mining problems where each item is allowed to have a weight. It implements a fast and stable algorithm to mining weighted association rules based on Frequent Pattern-tree (PF-tree).Experiments on performance study will prove the superiority of the new algorithm for different values of minimum support compared with MWAR algorithm [3].

**Keywords:** Image Mining, Association Rule, Apriori, medical imaging, Weighted Support.

#### I. INTRODUCTION

Nowadays, computers are used widely in different areas. Fast, reliable and un-limited secondary storage provides a perfect environment for the users to collect and store large amounts of the data. Computers are also used to extract the useful information from the mass of data. This is the knowledge discovery in database (KDD) or data mining. Image mining can automatically discover these implicit information and patterns from the high volume of images and is rapidly gaining attention in the field of data mining. Image mining is more than just an extension of data mining to image domain. It is an inter disciplinary endeavor that draws upon computer vision, image processing, image retrieval, machine learning, artificial intelligence, database and data mining, etc. While some of individual fields in themselves may be quite matured, image mining, to date, is just a growing research focus and is still at an experimental stage. Research in image mining can be broadly classified to two main directions: (1) domain specific applications; (2) general applications [4]. Data mining in medical images belongs to the first direction.

Nowadays, billions and millions of medical images have been generated routinely in medical care centers. Usually analyses of this lump amount of data have been done manually. Even experienced and trained sonologist find difficulty in analyzing a very small amount of images. So, physicians are aided with computer based techniques for diagnosing the patients. This has initiated the research in

creating a vast database for medical images. In Computer Aided System (CAS), the processed computer based output has been used as a second opinion for health care professionals to analyze and diagnose the patient details in a quicker way as compared to manual process. Using the automated CAS identification of different pathologies is clearer, accurate and more confident [15], [16]. It also helps the physicians in analyzing the information to bring out the possible outcomes of the diseases from the database stored.

In this paper image mining concepts have been used. It deals with the implicit knowledge extraction, image data relationship and other patterns which are not explicitly stored in the image.

The objective of the mining is to generate all significant patterns without prior knowledge of patterns. Association rules (ARs) [5] are a popular data mining technique used to discover behavior from market basket data. The technique tries to association rules (with strong support and high confidence) in large databases. Classical Association Rule Mining (ARM) deals with the relationships among the items present in transactional databases [1, 7].Typically, the algorithm first generates all large (frequent) itemsets (attribute sets) from which association rule (AR) sets are derived. A large itemsets is defined as one that occurs more frequently in the given data set than a user supplied support threshold. To limit the number of ARs generated, a confidence threshold is used to limit the number of ARs generated by careful selection of the support and confidence thresholds.

The remainder of this paper is organized as follows: Section 2 introduces related work. Section 3 gives the detail of the proposed approach for weighted Association Rule. Experimental results are described in the section 4 and in last section we terminate with conclusion and future work.

#### II. RELATED WORK

In [8] they proposed a new algorithm which based on association graph and matrix (GMA) pruning to reduce the amount of candidate itemsets. GMA algorithm draws on the advantages both association graph and feature matrix pruning to reduce the candidate itemsets generation. Instead the authors GMA algorithm greatly reduces the candidate itemsets and has improved the efficiency of frequent itemset mining. Experiment shows that GMA algorithm can adapt and adjust better to the change of the value of minsup. Moreover, GMA algorithm can be used for mining association rules on medical images effectively.

Fen & all [9] they identify the limitation of the traditional Association Rule Mining model, in particular, its incapacity for treating units differently. They proposed that weight can be integrated in the mining process to solve this problem.

They identify the challenge faced when making improvement towards using weight, in particular the invalidation of downward closure property. A set of new concepts are proposed to adapt weighting in the new setting. Among them is the proposal of using “weighted downward closure property” as a replacement of the original “downward closure property”. This is proved as valid and justifies the effective mining strategy in the new framework of “weighted support – significant”. The proposed new framework is designed to replace the original “support – large” framework in order to tackle the problem in weighted settings. Through studying the simulation of the lattice building, conclusion is drawn that weight can be used to steer the mining focus to those important itemsets with high degree of significance. This is further proven by experiments on synthetic datasets. The experiments show that the mining results in the weighted setting conform to the expected hypothesis. The experiments also show that the algorithm is scalable.

The proposal Weighted Association Rules in [3] consist of a new weighted association rules model. First they define the weighted support of a rule based on the maximal weight, which can reflect the different importance and unbalance of individual items in database and make the item with a heavy weight in an outstanding position. By constructing a new model of mining weighted association rules, they discuss the characters of the model and describe the algorithm MWAR accordingly. Then they illustrates the medical images data mining process by fact and the experiment results are compared with that of MINWAL[10], they show that MWAR is more efficient and the itemsets with the small weight are weight frequent itemsets and so do the itemsets with the big weight when they have the same frequency.

P. Rajendran, M.Madheswaran [11] proposed method with the classification of brain tumor in the CT scan brain images. The major steps involved in the system are: preprocessing, feature extraction, association rule mining and hybrid classifier.

The preprocessing step has been done using the median filtering process and edge features have been extracted using canny edge detection technique. The two image mining approaches with a hybrid manner have been proposed in [11].The frequent patterns from the CT scan images are generated by frequent pattern tree (FP Tree) algorithm that mines the association rules.

The decision tree method has been used to classify the medical images for diagnosis. This system enhances the classification process to be more accurate. The hybrid method improves the efficiency of the proposed method than the traditional image mining methods.

The experimental result on prediagnosed database of brain images showed 97% sensitivity and 95% accuracy respectively.The physicians can make use of this accurate decision tree classification phase for classifying the brain images into normal, benign and malignant for effective medical diagnosis.

MWAR is an important algorithm in medical image mining because it precedes with associate for each item a weight. Indeed, items in medical image mining has not the same weight for example the Benign and malignant items are very important that the texture items. Effectively, the two first items can help researchers more than the texture item so we attribute a high weighted value to these two items.

MWAR is based on the Apriori algorithm which needs a multiple scan of database. Apriori algorithm is advisable in the sparse databases like the commercial databases. In these

databases the size of the frequent itemsets are small it need small scan to the databases. But in the medical image database which are dense databases where the size of frequent itemset is very large. Apriori is not suitable in these kinds of databases. So for that raison we use the FP-Growth algorithm which is performed than apriori in the dense context.

In this view, we propose to introduce the weight concept in the FP-Growth algorithm. The propose algorithm Weighted FP-Growth is defined in the next section.

### III. PROPOSAL WEIGHTED FREQUENT PATTERN GROWTH IN MEDICAL IMAGES (WFP-GROWTH)

We propose a new algorithm for association rules in medical image called Weighted Frequent Pattern Growth (WFP-GROWTH). The proposed method has been divided into two main phases: defining weighted association rules and algorithm for mining association rules.

#### A. Weighted association rules

The reason why FP-Growth works is that if an itemset is frequent all the subsets of that itemset must be frequent. However, for the weighted case, the means of frequent itemset needs to be modified to handle weighted support. A new algorithm is needed to solve the mining of the weighted association rules.

The characters of weighted association rules are discussed in the following part:

**Theorem 1.**

Suppose the itemset  $X = \{i_1, i_2, \dots, i_k\}$ , where  $k > 1$ ,

$i_1 \in Y \subseteq X$ , so :

1)  $W(X) = W(Y)$ ;

2) If  $X$  is frequent itemset, so does  $Y$ .

**Definition 1.**

$X$  and  $Y$  is joinable, marked  $X \bowtie Y = \{X(1), X(2), \dots, X(k-1), Y(k-1)\}$ ,

when  $X(i) = Y(i)$ ,  $i=1, 2, \dots, k-2$ ;  $X(k-1) < Y(k-1)$  and  $k > 2$ .

**Theorem 2.**

When  $k > 2$ , any weighted frequent  $k$ -itemsets can be got through joining two frequent  $k-1$ -itemsets together.

**Proof :**

$\forall X$ , where  $X = \{i_1, i_2, \dots, i_k\}$ ,  $k > 2$ ,  $X \subseteq L_k$ .

Suppose  $Y = \{i_1, i_2, \dots, i_{k-1}\}$ ,  $Z = \{i_1, i_2, \dots, i_{k-2}, i_k\}$ , in accordance with theorem 1,  $Y, Z \in L_{k-1}$ ,  $X = Y \bowtie Z$ .

**Theorem 3.**

When  $k=1$ ,  $C_1 = \{\{x\} | x \in I\}$ ;

When  $k=2$ ,  $C_2 = \{\{x, y\} | \{x\} \in L_1, y \in I \text{ and } x < y\}$ ;

When  $k > 2$ ,  $C_k = \{X \bowtie Y | X \in L_{k-1}, Y \in L_{k-1}, \text{and } X, Y \text{ are joinable}\}$ .

So  $\forall k$ ,  $L_k \subseteq C_k$

#### B. Algorithms for mining weighted association rules

One of the most important Knowledge Distributed Database research issues is association rules. ARM task is to discover the hidden association relationship between the

different itemsets in transaction database [12], [13], [14], [1], [17].

Let  $I = \{i_1, i_2, \dots, i_m\}$  be a set of  $m$  distinct items. A transaction  $T$  is defined as any subset of items in  $I$ .

A transaction database  $T$  is said to support an itemset  $x \subseteq I$  if it contains all items of  $x$ .

The fraction of the transaction in  $D$  that support  $x$  is called support value is above some user defined minimum support ( $\text{minsup}$ ) threshold then the itemset is frequent, otherwise it is infrequent.

FP Growth [2] is one of the basic algorithm used for generating association rules. FP growth is an approach based on divide and conquer method. The main purpose of this technique is to produce frequent itemsets by using the combination of data attributes. It basically works on to generate frequent itemsets by using the combination of data attributes. It basically works on to generate frequent item sets without candidate set generation.

One way to construct a simpler model computed from data, easier to understand and with more predictive power is to create a set of simplified rules [6].

The major steps of WFP growth are consisting of the following steps:

*1) Step1-First condenses the database showing frequent itemset into WFP-tree.*

The special weighted prefix tree called WFP-tree consists of a frequent item header table. The root is labeled as “NULL” and a set of the item prefix sub-tree are called the children. There are four fields defined for each item prefix sub-tree, they are node-name, node-weighted-count, node-link and node-parent.

There are also three fields included for each entry of the frequent item header table, those are item-name, item-weight-sup, item-head[17].

The pointer pointing to the first node in the WFP-tree carrying node name is item-head algorithm. The WFP-tree construction steps include:

*a) First Transnational Database (TDB) Scan:*

Let  $L$  be the set of frequent items and weighted support values of each frequent item have been collected.

*b) Scan TDB again:*

All frequent items in every transaction has been selected and sorted according to the order of list of frequent items.

From the corresponding itemsets by combining the ordered frequent items in every transaction and insert them to WFP-tree respectively.

It consists of one root labeled as null, a set of item prefix sub-trees as the children of the root, and a frequent item header table.

Each node in the item prefix sub-tree consists of three fields: item-name, weighted count and node-link where:

- item-name registers which item the node represents;
- weighted count registers (the number of transactions \* the itemset weight) represented by the portion of path reaching this node;
- node link links to the next node in the WFP-tree each item in the header table consists of two fields : item name and head of node link, which points to

the first node in the WFP-tree carrying the item name.

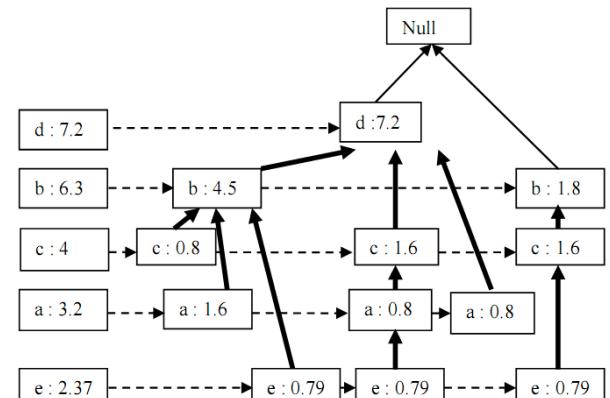
This first step is demonstrated in Table1, which shows an example transaction database on the left. The weighted frequencies of the items in this database, sorted descendingly, are shown in the middle of this table. If we are given a user specified minimal support of 2 transactions, items f and g can be discarded. After doing so and sorting the items in each transaction descendingly w.r.t. their frequencies we obtain the reduced databases shown in table 1 on right.

TABLE1: TRANSACTION DATABASE (LEFT), ITEM FREQUENCIES (MIDDLE), AND REDUCED TRANSACTION DATABASE WITH ITEMS IN TRANSACTIONS SORTED DESCENDINGLY W.R.T THEIR FREQUENCY (RIGHT)

item	weight	count	Count weighted	item	weight	count	Count weighted
d	0.9	8	7.2	d			
b	0.9	7	6.3	d c a e			
c	0.8	5	4	d b			
a	0.8	4	3.2	d b c			
e	0.79	3	2.37	b c			
f	0.7	2	1.4	d b a			
g	0.6	1	0.6	d b e			
				b c e			
				d c			
				d b a			

Figure 1 shows the WFP-tree related to the database in table 1.

Fig 1: WFP-tree for the (reduced) transaction

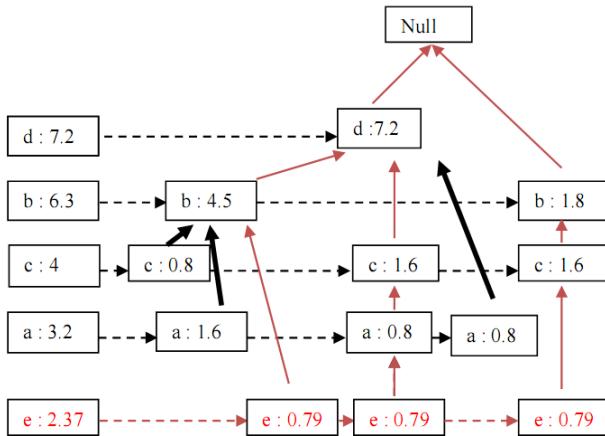


*2) Step2: It divides the WFP-tree into a set of conditional database and mines each database separately*

The core operation of the WFP-growth algorithm is to compute an WFP-tree of a projected database, that is, a database of the transactions containing a specific item, with this item removed. This projected database is processed recursively, remembering that the frequent itemsets found in the recursion share the removed item as a prefix.

Figure2 shows the e conditional WFP-tree of the WFP-tree shown in Figure1.

Fig 2: Computing a projection of the database w.r.t. the item by traversing to the lowest level and following all paths to the root.



#### IV. EXPERIMENTS

This paper uses the MIAS1 data, constructing the mammography database D, shown as table 2 where each item have specific medical meaning and is endowed with different weight in accordance with its importance in disease diagnose. In this database we can find four kinds of items. The first kind is the character of background tissue, it is composed of three items, F means Fatty and its weight is 0.95, G means Fatty-Glandular and its weight is 0.9, D3 means Dense-Glandular and its weight is 0.89. The second kind of items is the class of abnormality, it is composed in seven items, CALC means Calcification and its weight is 0.89, CIRC means Well-defined/ circumscribed masses and its weight is 0.89, SPIC means Spiculated masses and its weight is 0.89, MISC means Other ill-defined masses and its weight is 0.89, ARCH means Architectural distortion and its weight is 0.89, ASYM means Asymmetry and its weight is 0.89, NORM means Normal and its weight is 0.89. The third kind is the severity of abnormality, it is composed in two items, B means Benign and its weight is 0.99, M means Malignant and its weight is 0.86.

TABLE 2: THE MIAS DATABASE

TID	ITEMS	Weight
mdb001	G CIRC B	0,8
mdb002	G CIRC B	0,85
mdb003	D NORM	0,6
mdb004	D NORM	0,5
mdb005	F CIRC B	0,9
mdb006	F CIRC B	0,95
mdb007	F NORM	0,8
mdb008	G NORM	0,7
mdb009	G NORM	0,65
mdb010	F NORM	0,7
...	.....	

From the above tables, we will show how the large itemsets are generated from the transaction database. Suppose the wminsup is 0.1 and minconf is 0.45.

The weighted association rules and frequent item sets are found by Algorithm WFP-Growth, shown as in table 2. In this table, in the left textbox the weighted association rules are listed with their configurations; in the right textbox the frequent item sets are listed with their supports and weighted support.

We implemented the two algorithms MWAR and WF-Growth on an HP with a I3 CORE 2GHz CPU.

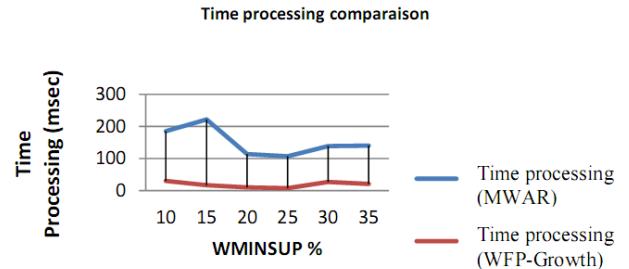
The test is based on the MIAS databases, in which 6 values of thresholds (wminsup) are used for each test, namely {0.1, 0.15, 0.2, 0.25, 0.3, 0.35} in the mining weighted association rules.

Table 3 and figure 3 show the time processing between MWAR et WFP-Growth. We can observe that for all values of wminsup WFP-Growth outperform MWAR.

TABLE 3: TIME PROCESSING BETWEEN MWAR AND WFP-GROWTH

WMINSUP %	Time processing (MWAR) (msec)	Time processing (WFP-Growth)
10	185	30
15	222	17
20	114	10
25	107	8
30	139	27
35	140	21

Figure 3: Time processing comparison between MWAR et WFP-Growth



#### V. CONCLUSION

In this paper, we explore the image medical data for extracting useful knowledge. For that we use modified FP-Growth in order to extract weighted association rules. All data in medical images database aren't the same importance. Some of them are more important and others are less important. Items in the medical databases aren't the same importance. To address this problem we extend the concept of association rule using weighted model, where each items have a defined weight. We give importance to the items of the data medical image. Items "Benign" has the high weight and the item "normal" has the low weight. So we introduce the weighted itemset in FP-Growth algorithm. Some interesting results were obtained by our algorithm and solved the excessive uninteresting rules to some extent. In the experiments we observe that WFP-Growth outperform MWAR in time processing.

Future work will be directed toward the use of suitable structure to overcome the drawbacks of FP-Tree space limit. And

<sup>1</sup> <http://peipa.essex.ac.uk/info/mias.html>

in order to reduce the association rules and expose only the interesting ones we can extend our work by classifying the association rules extracted from WFP-Tree.

## REFERENCES

- [1] Agrawal R. and Srikan R., "Fast Algorithms for Mining Association Rules," in Proceedings of the 20th International Conference on Very Large Data Bases, San Francisco, USA, pp. 487-499, 1994.
- [2] Han J., Pei J., Yin Y., and Mao R., "Mining Frequent Patterns without Candidate Generation: A Frequent-Pattern Tree Approach," Journal of Data Mining and Knowledge Discovery, vol. 8, no. 1, pp. 53-87, 2004.
- [3] Haiyan Xue and Lixia Zou, " Application of New Weighted Association Rules Model for Medical Images Data Mining", Springer- Verlag Berlin Heidelberg 2012 pp.829-834.
- [4] Wynne Hsu, Mong Li Lee, Ji Zhang, "Image Mining: Trends and Developments". Journal of Intelligent Information Systems, 19:1, 7–23, 2002.
- [5] Agrawal, R., Imielinski, T., Swami, A.: "Mining Association Rules Between Sets of Items in Large Databases". In: 12th ACM SIGMOD on Management of Data, pp. 207–216 (1993)
- [6] Mar\_a C. FERN\_ANDEZ\_, Ernestina MENASALVAS\_, Óscar MARB\_AN\_Jos\_e M. PE~NA\_, Socorro MILL\_AN, "MINIMAL DECISION RULES BASED ON THE APRIORI ALGORITHM y", Int. J. Appl. Math. Comput. Sc.i, Vol.11, No.3, 691704, 2001
- [7] Bodon, F.: A Fast Apriori implementation. In: ICDM Workshop on Frequent Itemset Mining Implementations, Melbourne, Florida, USA, vol. 90 (2003)
- [8] Haiwei Pan, Xiaolei Tan, Qilong Han, Xiaoning Feng, and Guisheng Yin, " GMA: An Approach for Association Rules Mining on Medical Images", Springer-Verlag Berlin Heidelberg pp. 425–432, 2012
- [9] Feng Tao, Fionn Murtagh, Mohsen Farid," Weighted Association Rule Mining using Weighted Support and Significance Framework". KDD'03 Proceedings of the ninth ACM SGKDD international conference on Knowledge discovery and data mining, page 661-666, ACM New York, NY, USA 2003.
- [10]C.H.Cai, Ada W.C. Fu, C.H. Cheng and W.W. Kwong, "Mining Association Rules with Weighted Items". Proceedings of the 1998 International Symposium on Database Engineering & Applications, Cardiff, Wales, 1998, pp. 68-77
- [11] P. Rajendran, M.Madheswaran: Hybrid medical image classification using association rule mining with decision tree algorithm". Journal of computing, volume 2, issue 1, January 2010, ISSN 2151-9617
- [12]B. Liu and C.K. Wong," Improving an association rule based classifier". Journal in principles of data mining and knowledge discovery, p.504-509, 2000.
- [13]Wang, L. Tang, J. Han and J. Liu, "Top-Down FP-Growth for Association Rule Mining", Leture Notes in Computer Science ,Springer Berlin, eidelberg Vol. 2336, pp.334-340, 2002.
- [14]A.Neumann, J.Holstein, J.Le Gall and E.Lepage., "Measuring performance in health care: case-mix adjustment by boosted decision trees,"Artificial Intelligence in Medicine, Vol. 32(3),pp.97-113, 2004.
- [15] Tourassi, G.D., "Journey toward computer-aided diagnosis role of image texture analysis". Radiology 213:317–320,
- [16] Erickson, B. J., and Bartholmai, B., "Computer-aided detection and Diagnosis at the start of the third millennium". Journal of Digit. Imaging 15:59–68, 2002.
- [17] Christian Borgelt, "An Implementation of the FP-growth Algorithm", Department of Knowledge Processing and Language Engineering School of Computer Science, Otto-von-Guericke-University of Magdeburg Universitmmätsplatz 2, 39106Magdeburg, Germany, 2005.

# Résolution du problème de planification touristique par un Algorithme Génétique

BOUATOUCHE Mourad<sup>1</sup>

Laboratoire LAMOSI, Département d'Informatique,  
Faculté des Mathématiques et Informatique, USTOMB,  
31000 Oran, Algérie

<sup>1)</sup> bouatouchemoeps@yahoo.fr

BELKADI Khaled<sup>2)</sup>

Laboratoire LAMOSI, Département d'Informatique  
Faculté des Mathématiques et Informatique, USTOMB,  
31000 Oran, Algérie,  
<sup>2)</sup> belkadi1999@yahoo.com

**Résumé**—Une des considérations la plus importante pour un touriste dans le tourisme est de savoir comment concevoir une planification de voyage optimale. La Sélection des sites touristiques les plus intéressants et la préparation d'un itinéraire personnalisé optimale se base sur une maximisation des facteurs de préférence des touristes tout en respectant la contrainte de temps . Ce problème s'appelle le problème de planification touristique. Il peut être modélisé sous la forme d'un problème d'orientation. Pour résoudre ce problème on a utilisé des techniques d'optimisation combinatoire métaheuristiques. L'objectif de cet article est de résoudre le problème avec l'Algorithme Génétique. Les résultats obtenus sont discutés et comparés avec d'autres résultats connus de la littérature.

**Mots clés:** Problème de Planification Touristique, Algorithme Génétique, E-Tourisme, TIC.

## I. INTRODUCTION

La contribution des technologies de l'information TIC et de la communication fait évoluer le tourisme le e-tourisme , et facilite la planification des voyages des touristes afin de les aider à trouver leur itinéraire de façon optimale

Un itinéraire d'un voyage touristique est le plan pour visiter certain sites touristiques en ville ou une région géographique pendant une période limitée, dans le temps. En général, le circuit contient une liste de sites à visiter qui sont classés en fonction des critères. Chaque visite a un début , une fin, une durée, une courte description de sites, etc. En outre, un itinéraire d'un voyage pourrait inclure une carte avec des informations nécessaires pour visiter les sites.

Habituellement, il pourrait y avoir un nombre élevé des sites touristiques dans une ville ou région qui pourraient potentiellement être visité. Néanmoins la durée du voyage est généralement limitée à quelques jours, et par conséquence, un sous ensemble des sites peut être visité. De plus, les touristes ont souvent des préférences des types par exemple, monument, château, statue, etc. et des catégories par exemple architecturales, de l'archéologie, de la nature, etc. Ce problème s'appelle le problème de planification du voyage touristique.

En général, le problème de planification du voyage touristique [1]. tient compte d'un certain nombre de point

d'intérêt POI dans une ville ou région. L'objectif est de préparer un itinéraire qui comprend des visites aux POIs qui répondent, en une grande partie aux préférences des touristes. En fonction des types, des caractéristiques ou des contraintes à étudier pour le problème, différentes modélisations du problème de la littérature pourraient être utilisées pour modéliser le problème de planification de voyage touristique. Le problème d'orientation OP [2] et le problème d'équipe d'orientation TOP [3] sont utilisés pour modéliser des itinéraires uniques et multiples respectivement. L'OP avec un temps de fenêtre OPTW [4] et TOP avec Time Windows TOPTW [5] permettent la modélisation des heures d'ouverture et de fermeture de POI, alors que le multi-contrainte TOPTW MCTOPTW [6] permet de respecter des contraintes supplémentaires pour l'itinéraire, tels que le budget maximal, ou le nombre maximum de points d'intérêt de certain type par exemple château, etc. pour être visité. L'OP avec un Hôtel de sélection NSPO [7] permet la sélection d'un hôtel à la fin du voyage de chaque tournée. Golden et al. [8] ont montré que l'OP est un problème NP difficile, et de nombreux chercheurs ont attaqué l'OP et ses extensions en utilisant différentes approches des métaheuristiques. Vansteenwegen et al. [9] ont discuté des approches les plus efficaces qui résolvent l'OP et ses extensions respectives.

Le but de cet article est de présenter un Algorithme Génétique pour résoudre le problème de planification du voyage touristique en maximisant le facteur de préférence d'un touriste aux POIs et en tenant compte de la contrainte de temps limité.

La suite de cet article est organisée comme suit: la Section II traite l'état de l'art des différents algorithmes utilisés dans la littérature et qui traitent les problèmes OP, TOP et TOPTW. La section III présente la modélisation mathématique du problème. La section IV présente la solution proposée. La Section V donne les résultats expérimentaux obtenus et la section VI présente la conclusion et quelques perspectives.

## II. ETAT DE L'ART

Il existe de nombreux algorithmes qui traitent l'OP, ou TOP et TOPTW et qui sont discutés dans la littérature. Ces algorithmes pourraient être également appliqués pour le problème de planification de voyage touristique. La recherche

Tabou RT résout efficacement TOP et elle est présentée dans [10]. Un autre algorithme basé sur la Recherche Locale guidée GLS [ 11] peut résoudre le problème TOP et elle est élaborée dans [12].

Un algorithme basé sur la méthode Locale à Voisinage Variable VNS [ 13], est présentée dans [14]. Dans [15], un algorithme simple qui appartient à la famille de Recherche locale Itérée ILS [ 16] est présenté avec la procédure GRASP [17] et qui est utilisée pour résoudre le TOP dans [18].

Souffriau et al. [19] étendent le problème MCTOPTW à la MCTOP avec un temps fenêtre Windows MCTOPMTW, où plusieurs travaux de POI peuvent être modélisés. La proposition approchée pour résoudre le MCTOPMTW est une hybridation entre ILS et l'algorithme de GRASP.

Dans [20], ils ont présenté une méthode de recherche tabou pour résoudre le problème MCTOPTW et à l'opposé de l'approche de Garcia et al. [6].

Li et al.[21] présentent l'Algorithme l'étiquette de la correction, Sylejmani et al.[22] ont résolu le problème avec la méthode Tabou . ils [23] l'ont résolu avec le recuit simulé.

Il y a d'autres algorithmes présentés pour différents types de problème de planification touristique [9].

### III.FORMALISATION MATHEMATIQUE

La formalisation du problème de planification de voyage touristique revient à le formuler avec le problème orientation

OP peut être formulé comme suit: Soit  $G = V, E$  un graphe d'arcs pondérés avec des profits récompenses ou scores sur ses nœuds. En tenant compte d'un nœud de départ  $s$ , un nœud terminal  $t$  et une durée limitée  $C_{max}$  , l'objectif est de trouver un chemin de  $s$  à  $t$  ou Tour Si  $s = t$  en maximisant le profit , et en respectant une durée limitée.

$$\begin{aligned}
 & \text{Max} \sum_{i=2}^{N-1} \sum_{j=2}^N p_i x_{ij}, & 1 \\
 & \sum_{j=2}^N x_{1j} = \sum_{i=1}^{N-1} x_{iN} = 1, & 2 \\
 & \sum_{i=1}^{N-1} x_i = \sum_{j=2}^N x_{rj} \leq 1 \text{ pour tout } r=2, \dots, N-1 & 3 \\
 & \sum_{i=2}^{N-1} \sum_{j=2}^N c_{ij} x_{ij} \leq C_{max} & 4 \\
 & 2 \leq u_i \leq N, \text{ pour tout } i=1,2, \dots, N & 5 \\
 & u_i - u_j + 1 \leq N - 1 - X_{ij}, \text{ pour tout } i, j = 2, \dots, N & 6 \\
 & x_{ij} \in \{0,1\}, \text{ pour tout } i, j = 1, \dots, N & 7
 \end{aligned}$$

Telque :  $p_j$  est le profit de site  $j$  ,et  $X_{ij}$  est défini comme suit, si le nœud  $i$  est suivi par le noeud  $j$  nous mettons la variable  $x_{ij}$  égale à 1 sinon égale à 0.

La fonction objectif 1 est de maximiser le s profits totaux des nœuds visités. La contrainte 2 assure que le chemin commence au nœud 1 et se termine au nœud N. La contrainte 3 fait en sorte que le chemin commençant au nœud 1 et se terminant au nœud N ,ils sont connectés et chaque nœud est

visité au plus une fois. La contrainte 4 assure que la longueur de chemin ne dépasse pas le temps limité. Enfin, les contraintes 5 et 6 assurent qu'il n'y a pas des sous tours fermés.

Les nœuds sont des sites touristiques et les arcs sont des routes qui relient les sites et la contrainte  $C_{max}$  c'est le jour de la visite du touriste.

### IV.ALGORITHME GENETIQUE

Dans l'Algorithm Génétique GA[24], après la génération de la population initiale, on a les procédures suivantes: sélection tournoi, croisement et mutation qui sont exécutées dans une boucle. L'algorithme s'arrête après un nombre de générations fixé.

#### A.Codage représentation

Les solutions sont codées par la représentation de permutation [24] qui est utilisée pour chaque chromosome. En tourchemin de l'OP, les points sont énumérés dans le même ordre qu'ils sont visités en conservant les points de début et de fin pour chaque chromosome.

Il est également appelé le chemin ou la représentation de l'ordre. Un exemple est donné ci-dessous

1	3	4	2	5	6
---	---	---	---	---	---

Fig. 1. Représentation de la permutation

#### B. Génération de la population initiale

Dans la population initiale, on a créé des solutions ou des individus réalisables de façon aléatoirement. La taille de la population est fixée pour garantir les solutions réalisables. On a utilisé la fonction de réparation qui est citée dans [24]

#### C. Calcul de la fonction Fitness

Pour estimer la qualité des solutions, nous avons utilisé la fonction fitness aussi appelée fonction objectif, puisque notre problème est un problème de maximisation d'un individu  $x$  donné qui est égale à la somme des profits des sites touristiques. La fonction Fitness  $F$  est formulée comme suit :

$$F_x = \text{Profit Total } x \quad 8$$

Le profit est une valeur affectée au site touristique, il permet au touriste de choisir quel sont les sites préférés.

Autrement dit, il représente l'intérêt personnel estimé du touriste au site .

#### D.Sélection

La sélection par tournoi est l'une des sélections les plus utilisées dans les algorithmes évolutionnaires. Le principe consiste à choisir un sous-ensemble d'individus  $S$  individus aléatoirement dans la population, puis on sélectionne le meilleur individu dans ce groupe en fonction de sa fitness. Ce processus est répété jusqu'à l'obtention du nombre d'individus requis

#### E.Croisement

D'une manière générale, le croisement consiste à appliquer des procédures avec une certaine probabilité sur les individus sélectionnés pour donner naissance à un ou plusieurs généralement deux enfants . Dans notre cas on utilise le Croisement par injection et son principe est suivant :

Un opérateur de croisement d'injection modifié [25] est utilisé dans cette étude pour manipuler le chromosome de différentes longueurs. On choisit aléatoirement un point insertion du premier parent d'insertion et une sous-liste du deuxième parent. Ensuite, la sous-liste est injectée dans le premier parent à partir point d'insertion.

Les sites doublons sont supprimés en dehors de la sous-liste pour obtenir un enfant.

Ensuite cet enfant est adapté sur la taille du premier parent. L'exemple de la figure 2 il illustre la représentation du croisement on rappelle que les points début et fin sont fixés

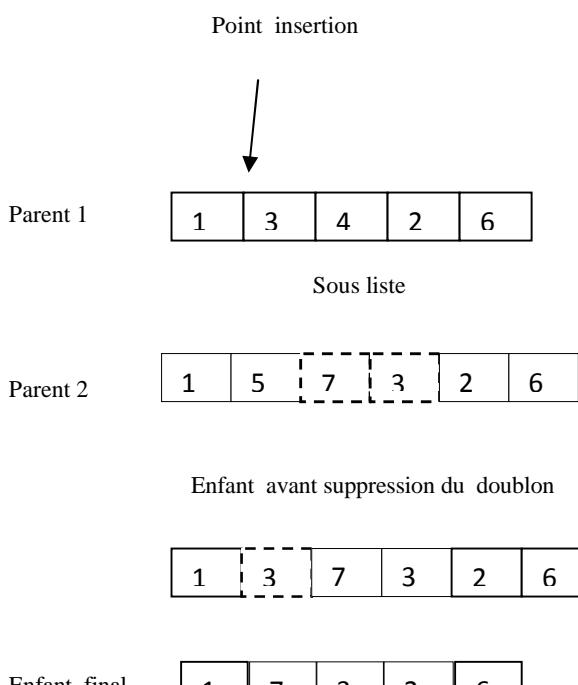


Fig. 2. Représentation du croisement

#### F. Mutation

##### a Opérateur échange swap

Le dernier opérateur génétique est la mutation. Le rôle de la mutation dans un GA est d'augmenter la diversité génétique dans une population. Avec l'opérateur échange deux sites dans la route sont choisis au hasard puis leurs positions sont simplement inversées Dans l'exemple de la figure 3 les sites 3 et 7 sont échangés

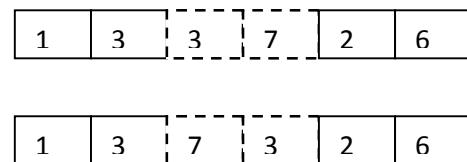


Fig. 3. Représentation de la Mutation avec l'opérateur d'échange swap

##### b Opérateur Insertion

On ajoute le site touristique qui donne le meilleur profit en respectant une contrainte. Dans la mutation d'insertion, un site est inséré dans un tour chemin seulement s'il n'est pas déjà présent.

Si deux sites sont égaux même profit on ajoute le site qui donne moins de distance la longueur de tournée est minimale par rapport aux autres sites

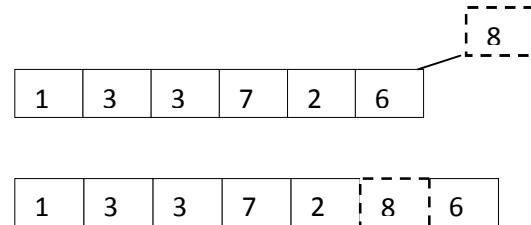


Fig. 4. Représentation de la Mutation avec l'opérateur d'insertion

#### G. Remplacement élitiste

L'élitisme est une façon de protéger la rémanence de bonnes solutions et d'assurer leur survie tout au long de la recherche. Cette sélection a l'avantage de permettre une convergence plus rapide des solutions.

## V. RESULTATS EXPERIMENTAUX

L'algorithme est développé en Java et l'éditeur Eclipse. Les expériences sont effectuées en utilisant une machine avec un processeur 2,5 GHz Intel Core Duo avec un système d'exploitation Windows 7 et 2 Go de mémoire RAM.

Les paramètres de L'algorithme génétique sont :

				<b>GA</b>
15	100	170	170	240
20	140	200	200	310
25	190	260	250	370
30	240	320	320	400
35	290	390	390	440
40	330	430	420	460
45	370	470	470	500
50	410	520	520	520
55	450	550	550	530
60	500	580	580	590
65	530	610	610	590
70	560	640	640	630
75	590	670	670	660
80	640	710	700	680
85	670	740	740	690
90	690	770	770	710
95	720	790	790	740
100	760	800	800	750
105	770	800	800	750
110	790	800	800	770

## VI. CONCLUSION

La principale contribution de cet article est l'introduction d'un algorithme de planification de voyage touristique qui est comparable au problème bien connu et qui est le problème d'orientation.

Nous avons proposé l'algorithme génétique GA pour résoudre le problème.

La performance de l'AG a été testée par des expériences qui ont donné des solutions équivalentes à ceux de la littérature .

Dans les travaux futurs nous allons essayer d'améliorer la qualité de la solution par l'ajout d'un algorithme local, ainsi que l'affichage des itinéraires des touristes sur les sites web ou bien sur Google map par le biais des Systems d'information géographiqueSIG .

## Références

				<b>GA</b>
5	10	10	10	35
10	15	15	15	50
15	45	45	45	60
20	65	65	65	85
25	90	90	90	105
30	110	110	110	130
35	135	135	135	150
40	150	155	155	165
46	175	175	175	185
50	130	190	190	195
55	205	205	205	210
60	220	225	225	225
65	240	240	240	220
70	255	260	260	240
73	260	265	265	255
75	270	270	270	260
80	275	280	280	270
85	280	285	285	275

				<b>GA</b>
15	120	120	120	220
20	190	200	200	250
23	205	210	205	270
25	230	230	230	310
27	230	230	230	330
30	250	265	265	365
30	250	265	265	365
32	275	300	300	375
35	315	320	320	405
38	355	360	360	440
40	395	395	395	450
40	395	395	395	450
45	430	450	450	450

- [1] W. Souffriau, P. Vansteenwegen, J. Vertommen, G. V. Berghe, and D. V. Oudheusden, “A personalized tourist trip design algorithm for mobile tourist guides,” *Applied Artificial Intelligence*, vol. 22, no. 10, pp. 964–985, 2008.
- [2] T. Tsiligrides, “Heuristic methods applied to orienteering,” *Journal of the Operational Research Society*, pp. 797–809, 1984.
- [3] I. Chao, B. L. Golden, E. A. Wasil et al., “The team orienteering problem,” *European journal of operational research*, vol. 88, no. 3, pp. 464–474, 1996.
- [4] M. G. Kantor and M. B. Rosenwein, “The orienteering problem with time windows,” *Journal of the Operational Research Society*, pp. 629–635, 1992.
- [5] P. Vansteenwegen, W. Souffriau, G. Vanden Berghe, and D. Van Oudheusden, “Iterated local search for the team

- orienteeing problem withtime windows,” Computers & Operations Research, vol. 36, no. 12, pp.3281–3290, 2009.
- [6] A. Garcia, P. Vansteenwegen, W. Souffriau, O. Arbelaitz, and M. Linaza,“Solving multi constrained team orienteering problems to generate tourist routes,” status: published, 2009.
- [7] A. Divsalar, P. Vansteenwegen, and D. Cattrysse, “A variable neighborhood search method for the orienteering problem with hotel selection,” International Journal of Production Economics, 2013.
- [8] B. L. Golden, L. Levy, and R. Vohra, “The orienteering problem,” Naval Research Logistics NRL, vol. 34, no. 3, pp. 307–318, 1987.
- [9] P. Vansteenwegen, W. Souffriau, and D. V. Oudheusden, “The orien teering problem: A survey,” European Journal of Operational Research, vol. 209, no. 1, pp. 1–10, 2011.
- [10] Tang, H., Miller-Hooks, E.: A Taboo search heuristic for the team orienteering problem. Comput. Oper. Res. 32, 1379 –1407 2005
- [11] Voudouris, C., Tsang, E.: Guided local search and its application to the travelling salesman problem. Eur. J. Oper. Res. 113, 469-499 1999.
- [12] [P. Vansteenwegen, W. Souffriau, G. Vanden Berghe, D. Van Oudheusden, D.: A guided local search metaheuristic for the team orienteering problem. Eur. J. Oper. Res. 1961, 118 - 127 2008. Doi: 10.1016/j.ejor.2008.02.037
- [13] Hansen, P., Mladenovic, N.: Variable neighbourhood search: Principles and applications, Eur. J. Oper. Res. 130, 449-467 2001.
- [14] P. Vansteenwegen, W. Souffriau, G. Vanden Berghe, D. Van Oudheusden, D.: Metahuristics for Trip Planning. Metaheuristics in the Service Industry, pages:15-31, 10.1007/978-3-642-00939-6\_2, 2009.
- [15] P. Vansteenwegen, W. Souffriau, G. Vanden Berghe, D. Van Oudheusden, D.: Iterated local search for the team orienteering problem with time windows, Journal of Computers & Operations Research, 36 2009 3281 -3290.
- [16] H.R. Lourenço, O. Martin, and T. Stützle, “Iterated local search,” in Handbook of Metaheuristics, ser. International Series in Operations Research & Management Science, F. Glover and G. Kochenberger, Eds., Kluwer Academic Publishers, vol. 57, pp. 321–353, 2002.
- [17] JFeo, T.A., Resende, M.G.C. : A probabilistic heuristic for a computationally difficult set covering problem. Operations Research Letters, 867-71, 1989.
- [18] Souffriau, W., Vansteenwegen, P., Berghe, G.V., Oudheusden, D.V. : A greedy randomised adaptive search procedure for the Team Orienteering Problem, EU/MEeting 2008 on metaheuristics for logistics and vehicle routing location, 2008
- [19] W. Souffriau, P. Vansteenwegen, G. Vanden Berghe, and D. Van Oud heusden, “The multi-constraint team orienteering problem with multiple time windows,” Transportation Science, Articles in Advance, pp. 1–11, 2011.
- [20] K. Sylejmani, J. Dorn, and N. Musliu, “A tabu search approach for multi constrained team orienteering problem and its application in touristic trip planning,” in Hybrid Intelligent Systems HIS, 2012 12th International Conference on. IEEE, 2012, pp. 300–305.
- [21] J.Li , P.Fu,” A Label Correcting Algorithm for Dynamic Tourist Trip Planning” journal of software, vol. 7, no. 12, december 2012
- [22] [K.Sylejmani a, A.Dika ,” Solving touristic trip planning problem by using taboo search approach”,IJCSI International Journal of Computer Science Issues, Vol. 8, Issue 5, No 3, September 2011 ISSN Online: 1694 -0814
- [23] K.Sylejmani, A. Muhamxiri , A.Dika , L.Ahmedi “Solving tourist trip planning problem via a Simulated Annealing Algorithm” MIPRO 2014, 26-30 May 2014, Opatija, Croatia
- [24] E. G.Talbi, Metaheuristics: From Design to Implementation, Wiley, 2009.
- [25] [E.Falkenauer, ADelchambre “A genetic algorithm for bin packing and line balancing”, Proceeding of the IEEE International Conference on Robotics and Automation, pp. 1186-1193,1992

# Enhancement of Image Characterization with Discrete Wavelet Coefficients using the Third Statistical Moment for Texture-Based Image Retrieval

Salah Bougueroua

s\_bougueroua@yahoo.fr  
 s.bougueroua@univ-skikda.dz

Bachir Boucheham

Department of computer science  
 20 août 1955 university of Skikda  
 Skikda, Algeria  
 boucheham\_bachir@yahoo.fr  
 b.boucheham@univ-skikda.dz

Mohamed Belaoued

belaoued.mohamed@gmail.com  
 m.belaoued@univ-skikda.dz

**Abstract**—Texture is a very important visual attribute in images. Moreover, classification and retrieval based on texture are very active topics among the research community. In this paper, we propose modified third statistical moments (Skewness) as a feature for wavelet sub-bands coefficients, for that purpose. Mainly, the proposed modification consists in calculating the skewness around the energy of each sub-band instead of the mean. We argue that this modification has important positive impact on retrieval accuracy. The experimentations are conducted with Haar basis wavelet, with different levels and with three distance metrics namely, Manhattan, Canberra and d1, using the Outex\_TC\_00000 database. Results show clearly that the proposed modified feature improves the discrimination power of the discrete wavelet in the context of image search/retrieval.

**Keywords**—*CBIR; image retrieval; discrete wavelet; Haar basis; statistical moment; skewness*

## I. INTRODUCTION

The retrieval of images based on their contents (CBIR: Content Based Image Retrieval) is a challenging task due to high diversity of images and especially ones uploaded on the network by different users from different localities. CBIR appeared in the early of the 90s as an alternative for the already existing approach based on the keywords (TBIR: Text Based Image Retrieval), which suffers mainly from two serious drawbacks: the hardness of the annotation, especially for large databases, and the subjectivity of the attributed keywords.

Mainly, Color, Texture and Shape are the visual attributes the most studied and exploited ones. Wherein texture taken a large part thanks to its existence in the most objects and images, which qualify it as a ubiquitous property. However, texture is confronted with the difficulty to come up with a formal and precise definition. Consequently texture became a big challenge for the researchers. Generally, the existing method dealing with this attribute can be categorized into

one of the three following categories: spatial, frequency and spatial-frequency domain. For instance, the renowned method “Co-occurrence Matrices” of Haralick *et al* [1], and also the interesting “Local Binary Patterns” (LBP) of Ojala *et al* [2] are both acting in the spatial domain. Later, the LBP method has known many improvements, such as ILBP[3], LDP[4] and EILBP[5]. The published method of Zhou *et al* [6] which uses the Fourier Transform is an example on the frequency methods. In the spatial-frequency category, we find a set of fascinating and sophisticated methods, which are based on the transformation of signal to a set of wavelets using the scaling and shifting of a specific wavelet called the mother wavelet. Indeed, many types of wavelet are proposed, and exploited in computer vision realm, specifically in texture-based image retrieval and classification. For instance, Lonnestad [7] used Haar basis based wavelet for texture classification, and the Daubechies basis are also used by Moghaddam *et al*[8] for image retrieval, and also the Gabor filter [9].

In this paper, we are interested by texture feature extraction using discrete wavelet based on the Haar basis. Thus, we proposed a modified third statistical moment (skewness), which will be used with two other existing measures for each wavelet sub-band. The conducted experimentations, showed improvements on the results compared to some existing methods based on average precision. This proves that the modified skewness brought new discriminative information.

The remains of the paper are organized as follow: in the next section, the discrete wavelet transform (DWT) and its pyramidal decomposition form [10] are presented in the 1<sup>st</sup> sub section, then the related works in the feature extraction and image classification/retrieval topics are addressed in the 2<sup>nd</sup> sub section. In the section 3, the proposed method is presented. The experimentations are shown in the 4<sup>th</sup> section and discussed in the 5<sup>th</sup>. And finally we conclude this paper in the 6<sup>th</sup> section.

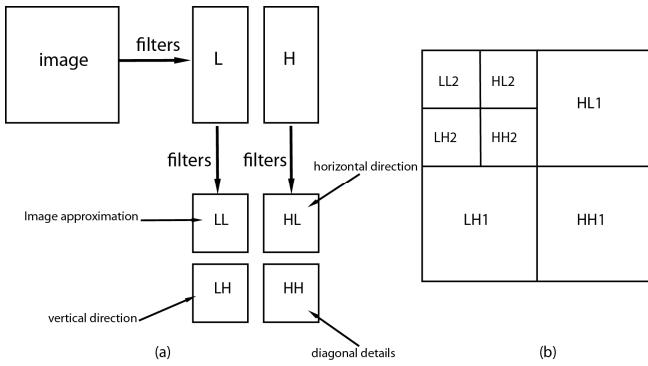


Fig. 1. Pyramidal decomposition. (a): detailed description of 1-level decomposition, (b): 2-levels decomposition.



Fig. 2. Pyramidal decomposition using Haar Basis. (Top): the original image, (Bottom): 2-levels decomposition.

## II. WAVELET TRANSFORM

### A. Discrete Wavelet Transform (DWT)

For presenting the wavelet transform, two functions should be first presented; the first is the *scaling function*, usually noted by  $\varphi$  and defined as follows:

$$\varphi(x) = \sqrt{2} \sum_k h(k) \varphi(2x - k) \quad (1)$$

The second function is the *mother wavelet*, usually noted by  $\psi$  and related with the scaling function  $\varphi$  by the following equation:

$$\psi(x) = \sqrt{2} \sum_k g(k) \varphi(2x - k) \quad (2)$$

Where

$$g(k) = (-1)^k h(1-k) \quad (3)$$

A Fast Wavelet Transform algorithm is proposed by Mallat [10], which based on a pyramidal decomposition using quadrature mirror filters. To decompose a bi-dimensional data as the images, first, the decomposition is applied on the image rows (horizontal direction), then, the columns (vertical direction) as shown in Fig. 1.a. the second execution (level 2) of DWT is performed on the image approximation (LL sub-band) obtained from the first level, this yields to 7 sub-bands, as shown in Fig. 1.b. if more decompositions are needed, again the image approximation (LL2 sub-band) is used. Generally, the number of channels obtained from  $L$  decompositions in DWT is  $3 \times L + 1$ .

The Haar basis wavelet is the earliest type of wavelets and the simplest one, proposed in 1910. Let  $c_i$  be a vector representing the signal to decompose at the  $i^{\text{th}}$  resolution,  $H$  and  $G$  are the low-pass and high-pass filters respectively, so the signal at the resolution  $(i-1)^{\text{th}}$  is calculated as follows:

$$c_{i-1}[k] = \sum_n H[n-2k]^* c_i[n] \quad (4)$$

$$d_{i-1}[k] = \sum_n G[n-2k]^* c_i[n] \quad (5)$$

Commonly, the values of the low-pass filter for the Haar wavelet are  $H[0] = H[1] = \frac{1}{\sqrt{2}}$  in the other hand, the

component values of the high-pass filter are  $G[0] = \frac{1}{\sqrt{2}}$  and  $G[1] = -\frac{1}{\sqrt{2}}$ . In the Figure 2.b, we show an example of the 2-levels decomposition using Haar wavelet of the image 2.a.

### B. Related Works

Images retrieval and classification based on texture using the wavelets have known many contributions since the early years of the 90s. For instance, Laine and Fan [11] compared the energy and the entropy measures for texture classification and they found that the first performed slightly better than entropy signature computed from the same wavelet packets. The averaged  $l_1$  norm energy is proposed by Chang and Kuo [12] as criterion to decide whether a decomposition is needed for a specific wavelet packet, in order to create the tree-structured wavelet transform. Pichler *et al* [13] proposed the variance as a criterion to decide whether a channel is decomposable or not for texture segmentation purpose, and they found that this criterion is poor one.

Porter and Canagarajah [14] combined the two diagonally opposite wavelet channels (LH and HL) in each decomposition level in order to achieve rotation invariance. The averaged  $l_1$  norm energy is used as feature measure.

The wavelet packet transform is used by Manthalkar *et al* [15] for texture feature based image classification. In their work, the authors calculated the features of HL and LH sub-bands using the averaged  $l_1$  norm energy of channels and an

introduced standard deviation (calculated around the energy). Then, the features extracted from these two sub-bands are averaged to get one feature rotation invariant. For the scale invariance they used the DFT on these two feature vectors (mean and standard deviation).

To lead to the rotation invariant features using Gabor wavelet, Zhang *et al* [16] normalized the feature vector (the feature vector is composed of the *mean* and *standard deviation* of different maps at different scales and rotations) by a circular shifting of feature vector elements such that the first features are those of the map which given the highest energy among all orientation (i.e. the energy is calculated for each orientation). The orientation with highest energy is called the *dominant* orientation/direction. Later, this method is experimented successfully on large database (4032 rotated textures derived from 112 textures) by Arivazhagan *et al* [17] and also compared against other methods.

A combination of different features for texture classification is proved experimentally that it gives better results by Arivazhagan and Ganesan [18]. In their work, they compared the statistical features, co-occurrence features and the combination of them, and they conclude that the combination of the features improves the classification rate.

Jiang *et al* [19] proposed the creation of a new sub-band from vertical and horizontal sub-bands to yield a rotation invariant representation. The energy and high order statistic (skewness) are the features considered by the authors.

Xin-Wu and Yu-Xi [20] have investigated many features as: (mean, energy, standard deviation ...) and also combinations of them. And have found that the combination of the energy and Kurtosis features gives the best results using Canberra distance metric.

Li-Wei *et al* [21] used a dual-tree complex contourlet transform to transform each image to contourlet domain, then sub-bands energy, standard deviation and skewness are calculated. The Canberra distance metric is used to compare the feature vectors.

### III. THE PROPOSED METHOD

From the previously presented related works, we can remark that the most of the works extract the energy as a feature since it is confirmed that it is better than the entropy [11]. The others features are the standard deviation and/or skewness which are considered with a lesser degree. But none of the previous works gives the attention to the features themselves with exception of [15], wherein the standard deviation is calculated around the energy instead of the mean.

According to our point of view, this manner of calculation of the features (i.e. calculation around the energy) improves

the discrimination since the average of wavelet coefficients are close to zero [7], [22]. Following this idea, we propose in this paper to calculate the third statistical moment (i.e. skewness, which it is a measure of asymmetry), for each sub-band, around the energy instead of the mean.

Formally, the skewness for a channel  $c$  can be calculated using the following equation:

$$skewness^{(c)} = \sqrt[3]{\frac{\sum_i (e_i^{(c)} - \mu^{(c)})^3}{N^{(c)}}} \quad (6)$$

Where  $\mu^{(c)}$  is the mean of a specific  $c$  sub-band:

$$\mu^{(c)} = \frac{\sum_i e_i^{(c)}}{N^{(c)}} \quad (7)$$

$e_i^{(c)}$  is the value of  $i^{\text{th}}$  coefficient in the  $c^{\text{th}}$  channel, and  $N^{(c)}$  is the total coefficients number within that channel.

In this paper, we propose to calculate it as follows:

$$s^{(c)} = \sqrt[3]{\frac{\sum_i (|e_i^{(c)}| - E^{(c)})^3}{N^{(c)}}} \quad (8)$$

$E^{(c)}$  is the  $L_1$  norm energy of a considered channel, and calculated as follows:

$$E^{(c)} = \frac{\sum_i |e_i^{(c)}|}{N^{(c)}} \quad (9)$$

So, our feature vector of an image is composed of three features for each channel, namely, they are : the Energy (Eq. 9), the standard deviation around energy [15] (Eq.10) and the skewness around the energy (proposed feature, Eq. 8.). In this paper, the HL, LH, and HH sub-bands are considered (without the approximation image (LL)) from each level.

For example, if we decompose an image two times ( $L=2$ ), we will have  $3*L$  (i.e. 6) sub-bands (without the image approximation). For each of these sub-bands three features are extracted: the energy (Eq. 9), the standard deviation (Eq. 10.) and the proposed skewness (Eq. 8.) which yields to a feature vector of 18 values.

$$std^{(c)} = \sqrt{\frac{\sum_i (|e_i^{(c)}| - E^{(c)})^2}{N^{(c)}}} \quad (10)$$

TABLE I. COMPARISON OF THE PROPOSED METHOD WITH SOME EXISTING FEATURE COMBINATIONS (K=20)

	energy-std(mean)			energy-std(energy) [15]			energy-std(Energy)-skew(energy) (Proposed)		
	Manhattan	Canberra	d1	Manhattan	Canberra	d1	Manhattan	Canberra	d1
L=2	69.11	72.60	72.62	65.85	77.57	75.65	80.25	80.40	81.2
L=3	70.25	76.95	76.67	68.91	80.71	78.58	78.2	82.57	82.67

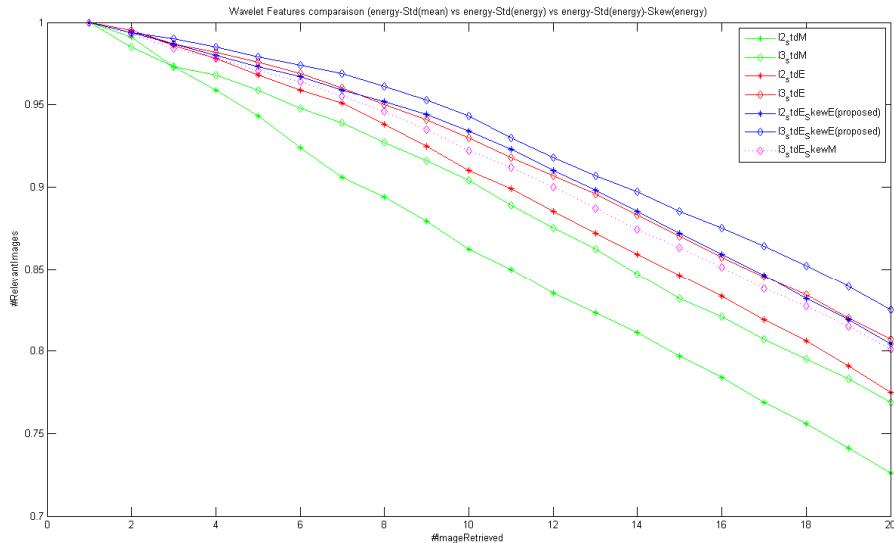


Fig. 3. Comparison of different methods effectiveness, in terms of mean precision.

#### IV. EXPERIMENTATION

We have conducted our experimentation on a purely textured database, namely it is the Outex database (Outex\_TC\_00000<sup>1</sup>). This database composed of 480 images, regrouped to 24 classes, with 20 samples in each class. The images have the size 128×128 pixels, and saved in bmp format.

For evaluation, the Average Precision (AP) is taken as criterion. The AP of a specific texture class  $I$  of size  $m$  samples is calculated as follows:

$$AP(I, k) = \frac{\sum_i^m p(i, k)}{m} \quad (11)$$

Where  $k$  is the window size (i.e. the number of retrieved images), and:

$$p(i, k) = \frac{\text{No of Relevant Retrieved Images}}{\text{No of Images Retrieved}(=k)} \quad (12)$$

<sup>1</sup>

[http://www.outex.oulu.fi/db/classification/tmp/Outex\\_TC\\_00000.tar.gz](http://www.outex.oulu.fi/db/classification/tmp/Outex_TC_00000.tar.gz)

For a comparison purpose, two existing feature combinations are considered (Table. 1): the first is a combination of the energy and the standard deviation (around the mean), this combination is the most used by the authors in the literature. The second combination is the energy and the standard deviation (around the energy) [15]. Note that these two feature combinations are extracted from the same three sub-bands considered in our system, as presented in the previous section. For the comparison between the feature vector  $FV_Q$  of the query  $Q$  and  $FV_B$  that of the target image  $B$ , three distance metrics are investigated: Manhattan (Eq. 13), Canberra (Eq. 14) and  $d_1$  (Eq. 15).

$$d_{man}(FV_Q, FV_B) = \sum_i |FV_Q[i] - FV_B[i]| \quad (13)$$

$$d_{can}(FV_Q, FV_B) = \sum_i \left| \frac{FV_Q[i] - FV_B[i]}{FV_Q[i] + FV_B[i]} \right| \quad (14)$$

$$d_{d1}(FV_Q, FV_B) = \sum_i \left| \frac{FV_Q[i] - FV_B[i]}{1 + FV_Q[i] + FV_B[i]} \right| \quad (15)$$

#### V. THE RESULTS AND DISCUSSION

The Table 1 shows a comparison based on the average precision (AP) over the considered database in the window

equal to 20 ( $k=20$  i.e. the number of the retrieved images equal to 20), using three distance metrics and two different decomposition levels ( $L=2$  and  $L=3$ ). So, as we can clearly see our feature combination gives the best AP (82.57% and 82.67% using Canberra and  $d_1$  distance metrics, respectively), followed by the combination of the energy and the standard deviation around it.

To prove that not only the number of features which improved the precision, we have added in the graph above (Fig. 3) furthermore to the two methods compared with, in

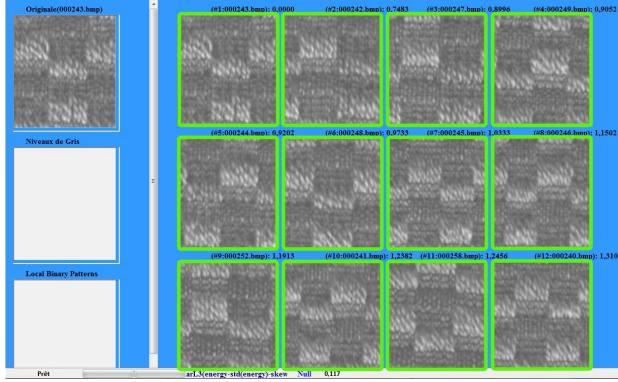


Fig. 4. Results obtained by querying with image #243; left: proposed method (precision=12/12), right: energy-std(energy) (precision=11/12).

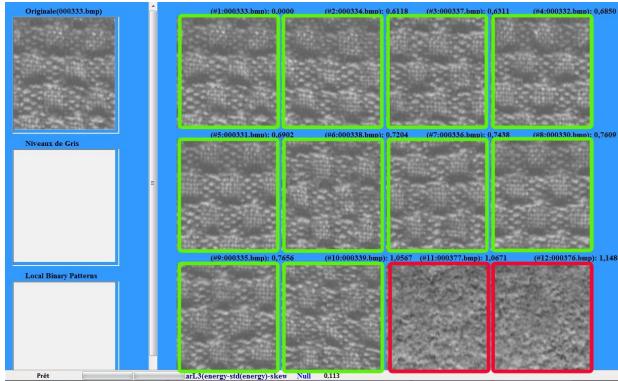


Fig. 5. Results obtained by querying with image #333; left: proposed method (precision=10/12), right: energy-std(energy) (precision=9/12).

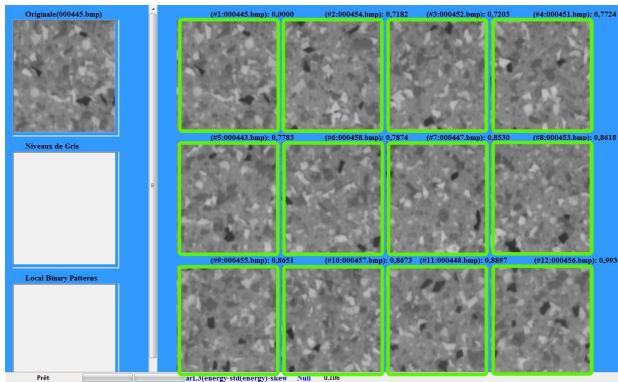
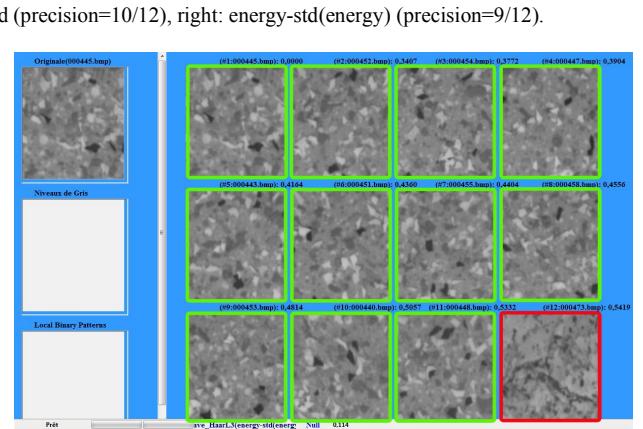
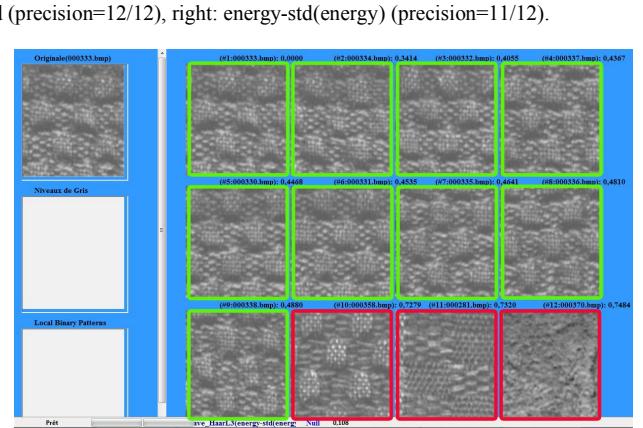
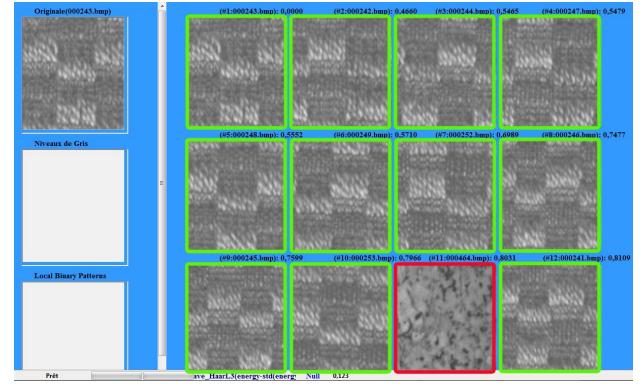


Fig. 6. Results obtained by querying with image #445; left: proposed method (precision=12/12), right: energy-std(energy) (precision=11/12).

the Table. 1. (Green and Red lines). A new combination which uses three features: energy, the standard deviation and the traditional skewness (calculated around the mean) (magenta line). In this graph, the Canberra distance metric is used. The graph shows clearly that our feature combination with the proposed feature gave the best AP from the window 1 ( $k=1$ ) to 20. The energy and the standard deviation (around the mean) gave the worst results.

In order to show visual examples on retrieval quality, we have depicted screenshots of three queries (Fig. 4-6).



## VI. CONCLUSION

In this work, we have proposed an effective modification for the skewness formula; by calculating it around the energy instead of the mean since it is known in the literature that the average sub-bands coefficients is close to zero. The proposed feature is combined with two existing features (energy and the standard deviation (around the energy)) for each channel of the three considered in our system. The proposed combination showed the best performance against other existing feature combination in term of the average precision over the Outex database (outex\_tc\_00000), and especially using Canberra and  $d_1$  distance metrics.

In the future, we plan to generalize this manner of calculation to the fourth statistical moment (Kurtosis), and also, testing other type of wavelets as the Daubechies wavelets.

## REFERENCES

- [1] R. M. Haralick, K. Shanmugam, and I. h. Dinstein, "Textures features for image classification," *IEEE transactions on systems, man and cybernetics*, vol. SMC-3, no. 6, pp. 610-621, November, 1973.
- [2] T. Ojala, M. Pietikäinen, and D. Harwood, "A comparative study of texture measures with classification based on featured distributions," *Pattern Recognition*, vol. 29, no. 1, pp. 51-59, 1996.
- [3] H. Jin, Q. Liu, H. Lu *et al.*, "Face Detection Using Improved LBP Under Bayesian Framework," in Proceedings of the Third International Conference on Image and Graphics (ICIG'04), 2004, pp. 306-309.
- [4] B. Zhang, Y. Gao, S. Zhao *et al.*, "Local Derivative Pattern Versus Local Binary Pattern: Face Recognition With High-Order Local Pattern Descriptor," *IEEE Transactions on Image Processing*, vol. 19, no. 2, pp. 533-544, February, 2010.
- [5] S. Bougueroua, and B. Boucheham, "Ellipse based local binary pattern for color image retrieval." pp. 1-8.
- [6] F. Zhou, J.-f. Feng, and Q.-y. Shi, "Texture feature based on local Fourier transform," in Image Processing, 2001. Proceedings. 2001 International Conference on, Thessaloniki, 2001, pp. 610-613.
- [7] T. Lonnestad, "A new set of texture features based on the Haar transform." pp. 676-679.
- [8] H. A. Moghaddam, T. T. Khajoe, and A. H. Rouhi, "A new algorithm for image indexing and retrieval using wavelet correlogram." pp. III-497-500 vol.2.
- [9] B. S. Manjunath, and W. Y. Ma, "Texture Features for Browsing and Retrieval of Image Data," *IEEE Transactions on Pattern Analysis and Machine Intelligence*, vol. 18, no. 8, pp. 837-842, August, 1996.
- [10] S. G. Mallat, "A theory for multiresolution signal decomposition: the wavelet representation," *IEEE TRANSACTIONS ON PATTERN ANALYSIS AND MACHINE INTELLIGENCE*, vol. 11, no. 7, pp. 674-693, 1989.
- [11] A. Laine, and J. Fan, "Texture classification by wavelet packet signatures," *IEEE TRANSACTIONS ON PATTERN ANALYSIS AND MACHINE INTELLIGENCE*, vol. 15, no. 11, pp. 1186-1191, 1993.
- [12] T. Chang, and C. J. Kuo, "Texture analysis and classification with tree-structured wavelet transform," *IEEE Trans Image Process*, vol. 2, no. 4, pp. 429-41, 1993.
- [13] O. Pichler, A. Teuner, and B. J. Hosticka, "A comparison of texture feature extraction using adaptive gabor filtering, pyramidal and tree structured wavelet transforms," *Pattern Recognition*, vol. 29, no. 5, pp. 733-742, 1996.
- [14] R. Porter, and N. Canagarajah, "Robust rotation-invariant texture classification: wavelet, Gabor filter and GMRF based schemes," *Vision, Image and Signal Processing, IEE Proceedings -*, vol. 144, no. 3, pp. 180-188, 1997.
- [15] R. Manthalkar, P. K. Biswas, and B. N. Chatterji, "Rotation and scale invariant texture features using discrete wavelet packet transform," *Pattern Recognition Letters*, vol. 24, no. 14, pp. 2455-2462, 2003.
- [16] D. Zhang, A. Wong, M. Indrawan *et al.*, "Content-based Image Retrieval Using Gabor Texture Features." pp. 13-15.
- [17] S. Arivazhagan, L. Ganesan, and S. P. Priyal, "Texture classification using Gabor wavelets based rotation invariant features," *Pattern Recognition Letters*, vol. 27, no. 16, pp. 1976-1982, 2006.
- [18] S. Arivazhagan, and L. Ganesan, "Texture classification using wavelet transform," *Pattern Recognition Letters*, vol. 24, no. 9-10, pp. 1513-1521, 2003.
- [19] J. Jiang, Y. Weng, B. Guo *et al.*, "Robust-to-rotation texture descriptor for image retrieval in wavelets domain," *Journal of Electronic Imaging*, vol. 15, no. 1, pp. 013013-013013-14, 2006.
- [20] C. Xin-Wu, and L. Yu-Xi, "Contourlet Retrieval System Using Absolute Mean and Kurtosis Features." pp. 1-4.
- [21] L. Li-Wei, C. Xin-Wu, and Y. Zhi-Wei, "Texture image retrieval algorithm with dual tree complex contourlet and three statistical features." pp. 349-352.
- [22] S. Livens, P. Scheunders, G. Van de Wouwer *et al.*, "Wavelets for texture analysis, an overview." pp. 581-585 vol.2.

# Agile Service-Oriented Architectures Development : A Case Study

Hamza Chehili

Laboratory LIRE, University of  
Constantine 2, Algeria  
h.chehili@umc.edu.dz

Mahmoud Boufaida

Laboratory LIRE, University of  
Constantine 2, Algeria  
mboufaida@umc.edu.dz

## Abstract

*During the last years, several methodologies have been devoted to develop Service-Oriented Architectures SOA. Their focus was more on the SOA life cycle and concepts rather than on the agility adopted largely in software engineering. In a previous work, we have proposed an agile approach to develop the SOA solutions with respect to the agile principles. Thus, we have developed a framework named FASOAD to implement this approach and offer the needed functionalities to respect the agile principles and to allow the evolution of the development process in case of environment or requirements changes during the development. This paper demonstrates, by means of a case study, the practical applicability of both proposals.*

**Keywords-** SOA; Development; Agile; Framework; SCA; model; Component.

## 1. Introduction

Nowadays, the companies' information system catalogs list a plethora of applications that need interactions, mechanisms and integrity to accomplish their businesses. Service-Oriented Architectures have emerged as a homogeneous enterprise-wide solution. This solution is considered as an approach to normalize the software architecture across the enterprise [1]. Thus, the adoption of such architectures has raised a plethora of interesting research challenges that need to be addressed, among which is the engineering oriented service [2]. Indeed, the need of methodologies for the implementation of this architecture is very critical and crucial.

In the literature, methodology proposals for the SOA development have focused on the implementation of a solution taking into account the business process level [3]. However, they are costly to use at the expense of the development speed provided for the adoption of SOA. Also, agile methods mark today a significant success in

software engineering. This success is essentially due to their pragmatic approaches. They are iterative and incremental. They allow the rapid development of deliverable software. Moreover, they take into account the changing needs by involving the client throughout the development cycle [4]. The main theme of agile methods is to promote and to speed up responses to changing environments, requirements and to meet deadlines [5].

In previous works, we have presented an approach for developing SOA solution. This proposal respect both, SOA concepts and agile method principles [6]. It is based on an iterative and incremental process that is composed of six phases which are: analysis of enterprise business, elaboration of the architecture model for each business process, identification of the granularity of business components, development of component operations, assembling business components, and assembling business processes.

Our approach exploits the BPMN model Business Process Modeling Notation to design incrementally the business processes of an enterprise [7]. Then, the SCA model Service Component Architecture is used to describe the business functions of the system as a reconfigurable assembly of components [8].

The framework FASOAD is proposed to complete the first proposal by implementing the phases of our agile SOA approach as a component assembly [9]. This allows the evolution of the development process to adapt it when needed. To meet this goal, we have used the platform FraSCAti [10] to deploy our framework. It offers management features and a dynamic reconfiguration of a SCA model. It also helps to support the evolution of the development process. Thus, our model contains a monitoring level to capture information exchanged between the different components of the lower level. The highest level concerns the presentation. It contains components offering services to track the evolution of the different phases of the project.

In this paper both proposals approach and framework are presented by means of a case study. We describe how

they fit together to develop an SOA solution with respect to agile method principles.

This paper is structured as follows. First, the case study statement is presented. Next, a case study development scenario is described. Finally, some conclusions and future work are given.

## 2. Case Study Statement: An SOA development project in the high education domain

The information system in the higher education sector has the particularity where the training management and research management are the core of its functionalities. The other functionalities can be seen as a support to accomplish the main objectives that can be traced in the human resources, finance, and logistics, etc.

The adoption of recent educational systems like ; Bachelor, Master, Doctorate and high schools' systems require universities to change every time their business processes and legislation to properly adopt these educational systems. However, this immature adoption gives to the development of applications that implement business processes an incomplete need in terms of software structure and behavior. Thus, after each development, the customers require other evolutions and enhancements because they do not know precisely their needs.

The goal of this case study is to demonstrate practical applicability of our proposals to develop an SOA solution in the higher education sector. This allows the sector actors to express their needs during the development iterations and allows it to change them after each test of the developed functionalities. Our proposals offer the possibility to accomplish this kind of development with respect to agile method principles like the end-user involvement throughout the development cycle; and by implementing the phases of the process development as a component assembly. This allows the evolution of the development process to adapt it when needed.

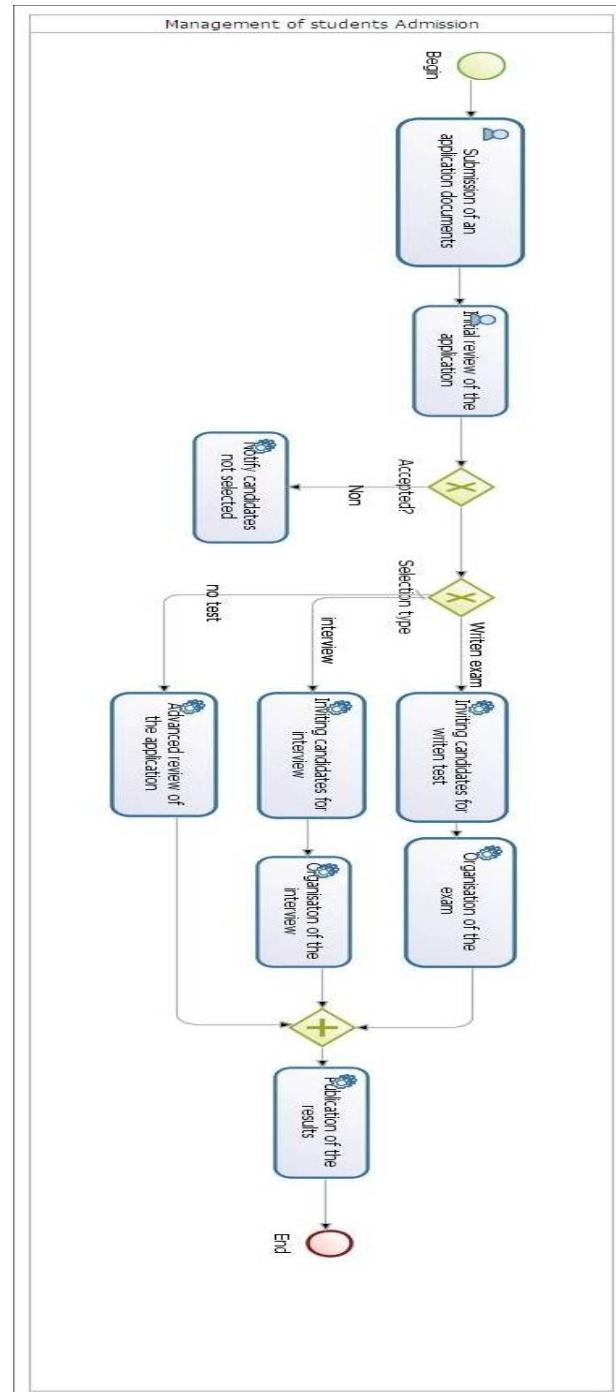
## 3. Case Study development scenario :

As an example, the training management contains the following business processes:

- Habilitation of training courses offers.
- Evaluation of training courses offers.
- Management of organizing campaign of admission.
- Management of students' admission.
- Management of administrative registration.
- Management of exams.

- Management of international mobility.

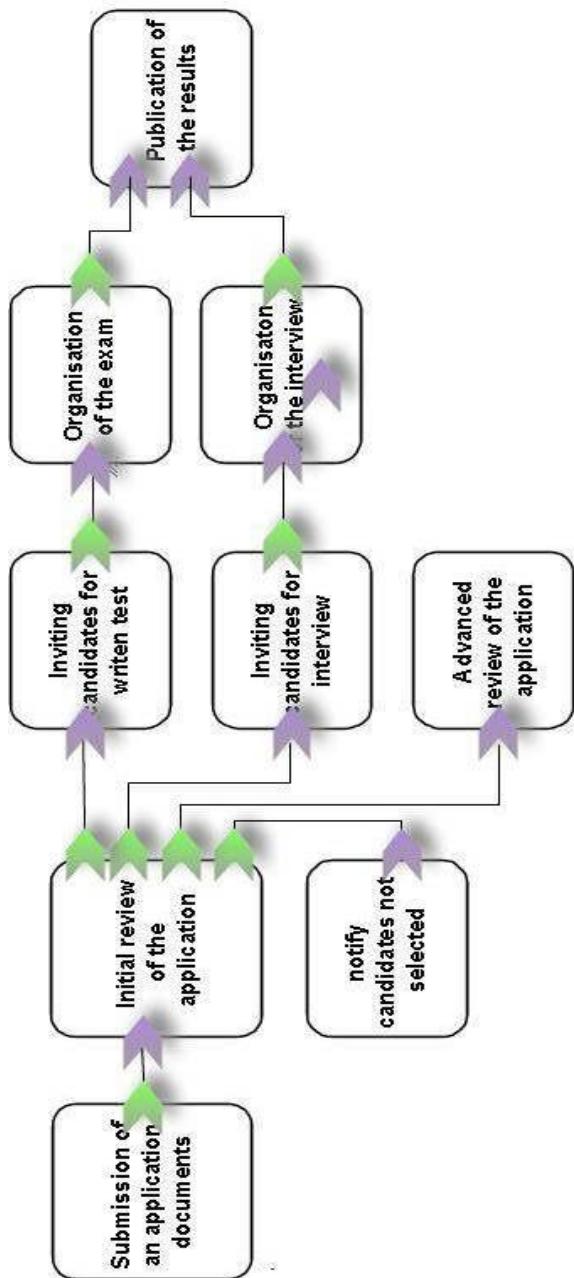
For developing this solution, the set of business process passes through the different components of the framework in order to reach a solution that respects the customers' needs.



**Figure 1. Management of students' admission model written using BPMN.**

### 3.1. Analysis

Using a specific interface, the analysts describe the different business processes in BPMN model. Figure 1 presents the BPMN diagram of the process ‘Management of students’ admission’.



**Figure 2. Management of students' admission model described using SCA.**

### 3.2. Architecture Elaboration

Once the process ‘Management of students’ admission’ is modeled, this component assists the architects to define its description in the SCA model. This description is presented in Figure 2.

### 3.3. Granularity Identification

Once the architecture of the process is described, each business component is passed to this composite to determine the components to be developed and the granularity of each one. For example, the business component ‘Initial review of the application’ which is involved in the process ‘Management of students’ admission’ is refined, basing on the fine-grained components found in the form of an assembly of components. Figure 3 presents the final architecture of this business component after research and refinement iterations.

The fine-grained components are available in the platform. However, the two components: ‘Automatic preliminary verification of applications’ and ‘Verification of applications’ have to be developed.

### 3.4. Development

The descriptions of the components to be developed are passed to this composite. In our case, the component ‘Verification of applications’ passes in the different component of this composite to be developed, tested and approved. The tasks identified for this component are:

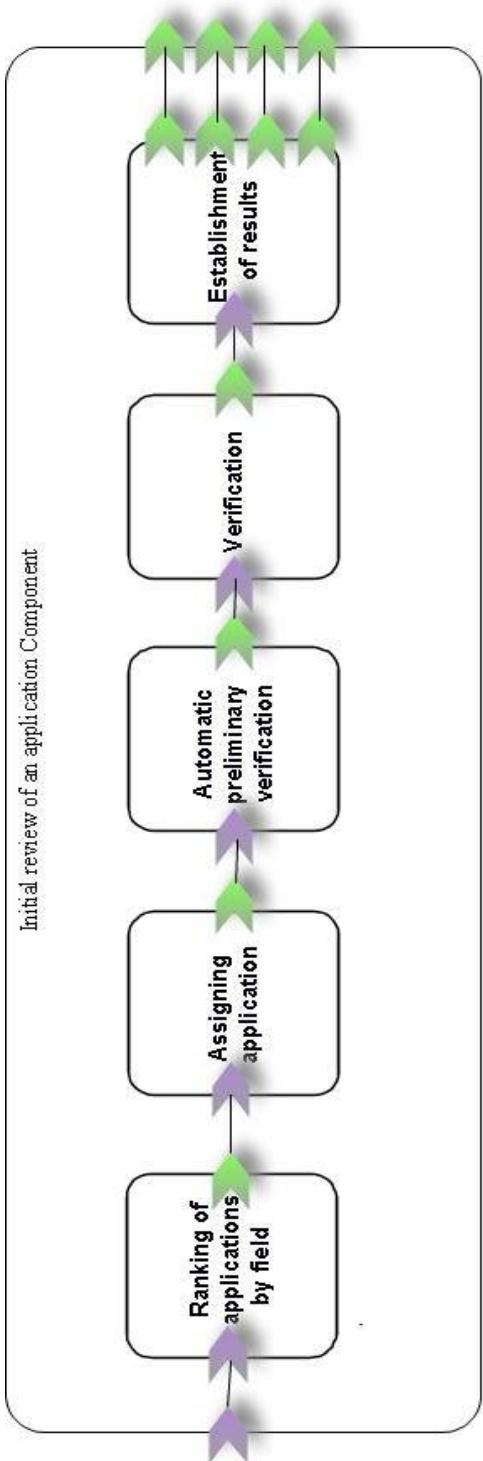
- Open a file.
- Make comments on the file.
- Enter the evaluation decision

### 3.5. Components Assembling

This component assists the assembling and the integration testing of the business components. In our case, the business component ‘Initial review of the application’ is assembled, configured and tested according to the available components and those that are developed.

### 3.6. Business Processes Assembling

In the business level, this component allows assembling and configuring the business process in which all the business components are configured, tested and deployed. In our case, the process ‘Management of students’ admission’ is assembled, configured, tested and deployed.



**Figure 3. Initial review of the application model written using SCA.**

#### 4. Conclusions and Future Work

In this work, we have presented the development of SOA solution according to an agile approach that respects both, SOA concepts and agile methods' principles. Thus, this work follows functionalities given by our proposed framework that permit the evolution of both business process under development and the development process adopted when needed.

This work has shown, by means of a case study, how both proposals fit together to develop SOA solution that implements the unstable business processes of the higher education sector.

As a part of the future work, we are developing more functionalities in our framework. Thus, we are experimenting more business processes development in order to refine and validate in depth our proposals.

#### 5. References

- [1] T. Erl "Service-Oriented Architecture: Concepts Technology and Design," Prentice Hall, 2005.
- [2] M.P. Papazoglou et al., "Service-oriented computing: a research roadmap," International Journal of Cooperative Information Systems. vol. 17, no. 2, 2008, pp. 223–255.
- [3] R. Ervin et al., "A Survey of Service Oriented Development Methodologies," The 2nd European Researchers Workshop on Service Oriented Computing, 2007.
- [4] Agile Manifesto, Manifesto for Agile Software Development, Available On line: <http://agilemanifesto.org/> 2001.
- [5] K.N. Rao, K. Naidu, P. Chakka "A Study of the Agile software Development Methods, Applicability and Implications in Industry," International Journal of Software Engineering and its Applications, vol. 6, No. 2, 2011, pp. 35-45.
- [6] H. Chehili, M. Boufaida, L. Seinturier "An Agile Approach for Service-Oriented Architectures," The 7th International Conference on Software Paradigm Trends ICSOFT'2012, Rome, Italy, July 2012, pp. 468-471, ISBN: 978-989-8565-19-8, 24 - 27.
- [7] M. Owen, J. Raj "BPMN and Business Process Management: An Introduction to the New Business Process Modelling Standard", Business Process Trends, March 2004.
- [8] Beisiegel, M. and al, "Service Component Architecture," 2007, [www.osoa.org](http://www.osoa.org).
- [9] H. Chehili, L. Seinturier, M. Boufaida "FASOAD: A Framework for Agile Service-Oriented Architectures

Development". DEXA Workshops 2013, Prague, Czech Republic: 222-226.

[10] L. Seinturier, P. Merle, R. Rouvoy, D. Romero, V. Schiavoni, J.-B. Stefani "A Component-Based

Middleware Platform for Reconfigurable Service-Oriented Architectures," Software Practice and Experience SPE Wiley, vol. 425. May 2012, pp. 559 -583, doi: 10.1002/spe.1077.

# *Neighborhoods combination for Examination Timetabling Problem*

Meryem CHERAITIA<sup>1</sup>, Salim HADDADI<sup>2</sup>

Science and Technology of Information and Communication Laboratory (LabSTIC)

8 May 1945 University

Guelma 24000, Algeria

meryem.cheraitia@hotmail.fr<sup>1</sup>, haddadi@yahoo.com<sup>2</sup>

**Abstract**— The incapacitated examination timetabling problem (ETTP) is the allocation of a set of exams to a limited number of timeslots in conformity with a set of hard and soft constraints eliminating room conditions. The aim of our research in this paper is to analyze the effect of combining different neighborhood structures. For that, different strategies were used rather than using each type of neighborhood in isolation, so as to speed up the exploration of the search space more effectively and escape from local minima. Simulated annealing (SA) is used in order to enhance the capability of the algorithm. The implementation of the algorithm has been experimented on Carter benchmark datasets. Results showed that exploring various neighborhood structures with a very good strategy of combination can jump to distant neighborhood that might be more promising region. Also, the use of SA can provide a remarkable improvement on the algorithms related to its thoroughness of neighborhood exploration.

**Index Terms**— Exam timetabling, Metaheuristics, Neighborhood, Simulated annealing.

## I. INTRODUCTION

ETTP is a discrete combinatorial optimization problem that generates a large interest from researchers in many different domains specially operations research and artificial intelligence. This problem is considered as an NP-hard real world problem for which there is unlikely to be an economically viable method for finding the optimal solution within polynomial time [19]. The manual solution is usually very time consuming, and the solution quality can hardly be satisfied due to the large size of the problem.

This timetabling problem consists of the assignation of a set of exams, each taken by a set of students, in a given limited number of timeslots (periods), in a way that satisfies a defined set of different constraints.

Two types of constraints appeared in the literature: hard constraints that should be completely satisfied and soft constraints that can be broken but it is desirable to satisfy them as much as possible [29].

Timetable which does not violate any of the hard constraints is called feasible. The measure of the timetable quality is calculated based upon an objective function which represents the violation degree of soft constraints.

In 1996, [17] introduced the first incapacitated problem where room capacity requirements are not taken into account and no limitation on available seating for each timeslot. These benchmark datasets were used widely as test beds for the examination timetabling problem. These datasets are publicly available and can be freely downloaded from <ftp://ftp.mie.utoronto.ca/pub/carter/testprob/>.

The problem has one hard constraint, where conflicting exams cannot be assigned to the same timeslot. In addition, a soft constraint is present to spreading conflicting exams in such a way as to reduce the number of students sitting exams in adjacent timeslots, in order to give students more time for preparation.

Several evaluation functions have been developed for Carter et al.'s benchmark data sets. The proximity cost function introduced in [17] was the first objective function proposed to evaluate the quality of timetables. The maximum number of timeslots for each data set is predefined and fixed, but no limitation of seating per timeslot is set. Consecutive exams either in the same day or overnight are treated the same, and there is no consideration of weekends or other actual gaps between consecutive days.

(Burke, and Newall, 2004) [12] presented the problem description that was widely adopted by most subsequent research in this area.

For these datasets the problem consists of the following inputs:

- $N$  is the number of examinations.
- $E_i$  is an examination,  $i \in \{1, \dots, N\}$ .
- $T$  is the given number of timeslots.
- $M$  is the total number of students.
- $C = (c_{ij})_{N \times N}$  is the conflict matrix, where each element denoted  $c_{ij}$ ,  $i, j \in \{1, \dots, N\}$  is the number of students taking examination  $i$  and  $j$ .
- $(t_k)$  ( $t \in \{1, \dots, T\}$ ) specifies the assigned timeslot for examination  $k$  ( $k \in \{1, \dots, N\}$ ).

The formulated cost function is to minimize:

$$\frac{\sum_{i=1}^{N-1} \sum_{j=i+1}^N c_{ij} . \text{Proximity}(t_i, t_j)}{M} \quad (1)$$

Where:

$$\text{Proximity}(t_i, t_j) = \begin{cases} 2^5 / 2^{|t_j - t_i|} & \text{if } 1 \leq |t_j - t_i| \leq 5 \\ 0 & \text{otherwise} \end{cases} \quad (2)$$

Subject to:

$$\sum_{i=1}^{N-1} \sum_{j=i+1}^N c_{ij} \cdot y(t_i, t_j) = 0,$$

Where:

$$y(t_i, t_j) = \begin{cases} 1 & \text{if } t_i = t_j \\ 0 & \text{otherwise} \end{cases} \quad (3)$$

- Equation (1) represents the objective function that ought to be minimized. It represents the sum of all penalties divided by the number of students. The final result is the average penalty for each student.
- Equation (2) represents a proximity value between two exams.
- Equation (3) represents a clash-free hard constraint so that no two conflicting exams will be scheduled to the same timeslot.

## II. RELATED WORK

Up to date, a wide variety of approaches for solving the ETTP have been described and discussed in the literature. In general, no one algorithm will give best results for all instances. Some algorithms will perform well on one instance but fail for another.

Graph colouring heuristics as simple and fast technique, is one of the most popular early approaches [5] [22] [30]. More general methods are Hyper-heuristics (seen as a heuristic to choose heuristics) that have received significant attention in the literature and also shown to be very effective. They search over (low level) heuristics rather than over potential solutions [13] [31].

Most recent, Metaheuristic approaches have attracted significant research interest because these techniques can take into consideration various constraints and are usually able to generate more satisfactory solutions. These methods are designed to tackle complex optimization problems where other optimization methods have failed to be either effective or efficient. The metaheuristic approach to solve such problem starts by obtaining an initial solution (Local search-based Approaches) or an initial set of solutions (Population-based Approaches) followed by an improvement method(s) [26].

Local search-based Approaches include Simulated Annealing [24], Great Deluge [3], TABU SEARCH [21] [24] [27], Hill Climbing [6], Variable Neighbourhood Search [14] [24].

Example of Population-Based Approaches include Memetic techniques [4] [2] [1], Bee Colony ([8] [9], [10]), Genetic algorithm ([11] [23], Particle Swarm Optimization ([34], [7], [18])).

The aim of our research in this paper is the exploitation of different neighborhood strategies so as to speed up the exploration of the search space more effectively and escape from local minima.

## III. METHODOLOGY

### 1. SOLUTION REPRESENTATION

Solution is represented as a vector of timeslots and each timeslot is a vector of a set of exams.

T1	T2	T3	T4
e3	e1	e4	e6
e5			e2
e7			

Figure 1 : Solution representation

### 2. INITIAL SOLUTION USING GRAPH COLORING HEURISTIC

Exam timetable without soft constraints can be represented as a graph colouring model. Vertices in the graph represent exams, colours represent timeslots and arcs between two vertices indicate the conflict between exams and weights on the arcs represent the number of common student enrolled in both exams. The objective is to find a colouring where no adjacent vertices having the same colour.

Early approaches for solving graph colouring problem were focused on Heuristic ordering methods. The main scheme of these heuristics is to estimating difficulty and schedule exams one by one, starting with the most difficult. Different ordering heuristics were developed for the examination timetabling problem:

- **Saturation Degree (SD):** Exams are ordered based on the number of available time-slots for each during solution construction.
- **Largest Degree (LD):** Exams are ordered based on the number of conflicts the exams have with the other exams.
- **Largest Weighted Degree (LWD):** Exams are ordered based on the number of students in conflicts with the other exams.
- **Largest Enrolment (LE):** Exams are ordered based on the number of students enrolled in each exam.
- **Largest Collared Degree (LCD):** Exams are ordered based on the number of conflicts the exams have with the scheduled exams.
- **Largest Uncoloured Degree (LUD):** Exams are ordered based on the number of conflicts the exams have with the unscheduled exams [15].

As simple and fast techniques, graph heuristics in timetabling had many advantages, particularly when being used in the initialization process for metaheuristics, or integrated with metaheuristics methods in various ways.

In order to generate a feasible initial timetable, the Saturation Degree heuristic is used. In this heuristic, exams are sorted in ascending order by the number of available feasible timeslots in the partial timetable at that time. If there is a tie between exams, exam with more number of students

involved is timetabled first. Finely exams are assigned into feasible timeslots that caused the lowest penalty without taking into consideration the violation of any soft constraints.

### 3. NEIGHBORHOOD SEARCH OPERATIONS

Most metaheuristic algorithms work on one single neighborhood structure. Other metaheuristics, such as Variable Neighborhood Search (VNS), use a set of neighborhood operations which gives the possibility to diversify the search. [32] [33] prove that the utilization of a more complex neighborhood than the standard single move neighborhood can yield significant improvements in solution quality.

In this work, a set of different neighborhood structures have been employed (adapted from [Abdullah et al., 2007]) to enhance the search:

**N1:** Select a set of exams randomly and move each one to a randomly feasible timeslot.

**N2:** Select a set of timeslots and displace them to a new random position.

**N3:** Select two exams randomly and swap their timeslots.

**N4:** Select two timeslots randomly and swap their exams.

### 4. NEIGHBORHOOD SEARCH STRATEGIES

There are many ways to combine different neighborhoods structures. In this work, we formally used the following notions which are not completely new :

- **S1: Neighborhood sequence:** the neighborhood is composed of chains of moves, each move belonging to a different neighborhood. The type of the moves at each step in the chain is fixed, and is based on the order of the neighborhoods appearing in the sequence.
- **S2: Token-ring search:** start the local search procedure with one neighbourhood. When the search ends with its best local optimum, we restart the local search from this local optimum, but with the next neighbourhood [20].
- **S3: Self adaptive strategy:** starts by filling a neighbour list (NL) with a set of neighborhood operations. During the search process, one neighborhood operation is taken from NL and is used to generate a new solution. If the new solution is better than the current one, this approach inserts the neighborhood operation into a new list known as the winning neighboring list (WNL). The process is repeated until NL becomes empty. (iii) When NL becomes empty, 75 % of NL is refilled from the WNL list, the remaining 25 % is refilled randomly, and WNL is reset to zero. If WNL is empty, then the most recent NL is used again [9].

### 5. DISRUPTIVE SELECTION

Disruptive selection gives more chances for higher and lower solution to be accepted. This mechanism allows the

search to attract areas of local minimums. In this work we use S. This metaheuristic provides the same mechanism that accept worse solutions with certain probability between [0,1] if it less than  $e^{-\frac{\delta}{T}}$ .  $\delta$  is the difference between the penalty cost of the new and current solutions (i.e.  $\delta = f(\text{New\_Sol}) - f(\text{Sol})$ ). The process is repeated until the temperature  $Temp$  is less than the final temperature  $Tf$  [24].

### IV. EXPERIMENTAL RESULTS

In order to evaluate the different neighborhood and strategies of combination, tests were made using Toronto benchmark exam timetabling problems. The main features of these instances are reported in Table 1 (number of exams, students and timeslots, densities, enrolments).

In order to obtain a fair comparison among all algorithms, we fix an upper bound on the overall computational time (1800 secs per instance) of each neighborhood operator and (900 secs per instance) for each strategy by equipping SA metaheuristic during multiple trials, and we record the best value found up to that time .

The results obtained from the execution are reported in table 2 and table 3. The best results stated in the literature for these instances are highlighted too with some selected previously proposed approaches for examination timetabling problem.

Feasible solutions are founded for all trials. From the results, it turns out that using more than one neighborhood is effectively better for escaping from local optimum for each neighborhood. Comparing different strategies of combination, best performance are obtained using Neighborhood sequence strategy with SA on all instances.

In comparison with the stat of the art approaches, acceptable and comparable results were obtained. Noting that our execution time is very small in comparison with most of these approaches; which can take more than one hour or more as execution time for only one run.

The main motivation for considering combination of diverse neighborhood is related to the diversification of the search nee de d to escape from local minima and jump to distant neighborhood that might be more promising region.

As **Table 2** shows, this experiment rather demonstrates the possibility of finding better solutions using **Token-ring search** more than other defined strategies. This method gives for each neighbourhood a chance to explore the entourage very effectively, and often find the best solution in this subspace before jumping to another subspace with the next neighbourhood operator.

**Table 3** shows the comparison of our results with Carter et al.'s approaches. Best results are shown in bold. As first step for our research, results are acceptable indeed. Furthermore this first step is simple enough to be easily implemented and can be readily hybridized with any other meta-heuristics to produce a better solution quality.

Data set	Exams	Students	Time slots	Conflict density
CAR-F-92	543	18 419	32	0.14
CAR-S-91	682	16 925	35	0.13
EAR-F-83	189	1 125	24	0.27
HEC-S-92	80	2 823	18	0.42
KFU-S-93	461	5 349	20	0.06
LSE-F-91	381	2 726	18	0.06
PUR-S-93	2419	30 032	42	0.03
RYE-S-93	481	11 483	23	0.07
STA-F-83	138	611	13	0.14
TRE-S-92	261	4360	23	0.18
UTA-S-92	638	21 267	35	1.13
UTE-S-92	184	2 750	10	0.08
YOR-F-83	180	941	21	0.29

Table 1. Characteristics of benchmark exam timetabling problems

	hecs-92I	sta-f83I	tre-s92	uta-s92I	utes-92	yorf-83I
N1	13.54	165.14	10.57	5.16	30.49	44.52
N2	12.14	159.62	10.38	4.45	33.14	44.59
N3	15.10	169.05	10.70	5.14	31.96	47.10
N4	11.91	159.55	10.50	4.45	33.14	44.39
S1+SA	11.37	157.57	9.55	4.40	27.95	40.66
S2+SA	11.16	157.54	9.43	4.14	27.19	40.46
S3+SA	11.34	157.93	9.58	4.45	28.50	40.50

Table 2. Comparison between different strategies

	hecs-92I	sta-f83I	tre-s92	uta-s92I	utes-92	yorf-83I
S1	11.37	157.57	9.55	4.40	27.95	40.66
S2	11.16	157.54	9.43	4.14	27.19	40.46
S3	11.34	157.93	9.58	4.45	28.50	40.50
[28]	11.5	157.8	8.4	3.4	27.2	39.3
[27]	10.52	157.29	8.71	3.71	25.18	39.08
[9]	10.43	157.06	8.00	3.27	25.16	35.58
[25]	10.39	157.05	8.51	3.63	24.87	37.15
[16]	11.11	157.64	8.27	3.33	26.18	37.88
Best	<b>9.2</b>	<b>157.03</b>	<b>7.72</b>	<b>3.13</b>	<b>24.4</b>	<b>34.78</b>

Table 3. Comparisons between our results with Carter et al.'s approaches

## V. CONCLUSION

This is only a step toward a full understanding of the capabilities of neighborhood strategies to speed up the exploration of the search space and escape from local minima.

We have analyze the effect of combining different neighborhood structures completely general, a comparison of these techniques on Toronto Benchmark datasets showed that exploring various neighborhood structures with a very good strategy of combination can jump to distant neighborhood that might be more promising region. Also, the use of SA can provide a remarkable improvement on the algorithms related to its thoroughness of neighborhood exploration.

This paper is the first step of our research on the problem of examination timetabling. An analysis phase of these approaches was conducted to explore the following points in future work:

- These neighborhood operators can be plugged into any metaheuristic giving rise to a very large local search.
- Favoring a diversification of the search to speed up the exploration of the search space more effectively and escape from local minima.
- We followed these results in order to experiment line of research which would have been entirely based on local search where it's most critical features is the definition of the neighborhood structure.
- For examination timetabling problem, there is a very large number of different neighborhood structure that is sufficiently natural and intuitive to deserve systematic investigation.

## VI. REFERENCES

- [1] M. A. Al-Betar, A. T. Khader and I. A. Doush. Memetic techniques for examination timetabling. Annals of Operations Research, 218(1), 23-50, 2014.
- [2] C. Altintas, S. Asta, E. Ozcan, T. Yigit. A self-generating memetic algorithm for examination timetabling. In the 10th International Conference of the Practice and Theory of Automated Timetabling (PATAT'2014), 26-29 August, York, United Kingdom, 2014.
- [3] S. Abdullah, H. Turabieh and B. McCollum, A hybridization of electromagnetic-like mechanism and great deluge for examination timetabling problems. In: M. J. Blesa, C. Blum, L. D. Gaspero, A. Roli , M. Sampels, A. Schaerf, Hybrid Metaheuristics. Lecture Notes in Computer Science, Volume 5818, pp 60-72, 2009.
- [4] S. Abdullah, H. Turabieh and B. McCollum, A Tabu-based Memetic Approach to the Examination Timetabling Problem. In: J. Yu, S. Greco, P. Lingras, G. Wang, A. Skowron, Rough Set and Knowledge Technology, Lecture Notes in Computer Science, Volume 6401, pp 574-581, 2010.
- [5] S. Abdul-Rahman, E. K. Burke, A. Bargiela, B. McCollum and E. Ozcan. A Constructive Approach to Examination Timetabling based on Adaptive Decomposition and Ordering. Annals of Operations Research, 2011.

- [6] M. A. Ahandani and M. T. Vakil-Baghmisheh. Examination timetabling using a hill climbing with combined neighbourhood structure. In Computer and Knowledge Engineering (ICCKE), 1st International eConference on (pp. 45-48), 2011.
- [7] M. A. Ahandani, M. T. V Baghmisheh, M. A. B. Zadeh and S. Ghaemi, (). Hybrid particle swarm optimization transplanted into a hyper-heuristic structure for solving examination timetabling problem. *Swarm and Evolutionary Computation*, 7, 21-34, 2012.
- [8] M. Alzaqebah and S. Abdullah. Hybrid Artificial Bee Colony Search Algorithm Based on Disruptive Selection for Examination Timetabling Problems. In: W. Wang, X. Zhu, D. Z. Du (editors), *Combinatorial Optimization and Applications*. Lecture Notes in Computer Science, Volume 6831, pp 31-45, 2011.
- [9] M. Alzaqebah and S. Abdullah. An adaptive artificial bee colony and late-acceptance hill-climbing algorithm for examination timetabling. *Journal of Scheduling*, pp 1:14, 2013.
- [10] M. Alzaqebah and S. Abdullah, Hybrid bee colony optimization for examination timetabling problems. *Computers & Operations Research*, 54, 142-154, 2015.
- [11] O.T. Arogundade, A. T. Akinwale and O. M. Aweda. A Genetic Algorithm Approach for a Real-World University Examination Timetabling Problem. *International Journal of Computer Applications*, Volume 12, Issue 5, pp 1-4, 2010.
- [12] E. K. Burke, and J. P. Newall. Solving examination timetabling problems through adaptation of heuristic orderings. *Annals of Operations Research*, Volume 129, Issue 1-4, pp 107-134, 2004.
- [13] E. K. Burke, R. Qu and A. Soghier. Adaptive selection of heuristics for improving constructed exam timetables. In: Proceedings of the 8th international conference on the practice and theory of automated timetabling (PATAT'10), pp 136–151, 2010.
- [14] E. Burke, A.J. Eckersley, B. McCollum, S. Petrovic and R. Qu. Hybrid variable neighbourhood approaches to university exam timetabling, *European Journal of Operational Research*, 206 (1), pp. 46-53, 2010.
- [15] E. K. Burke, R. Qu and A. Soghier. An Adaptive Tie Breaking and Hybridisation Hyper-Heuristic for Exam Timetabling Problems. In: D. A. Pelta, N. Krasnogor, D. Dumitrescu, C. Chira, R. Lung, *Nature Inspired Cooperative Strategies for Optimization (NICSO 2011)*. Studies in Computational Intelligence Volume 387, pp 205-223, 2011.
- [16] E. K. Burke, R. Qu & A. Soghier. Adaptive selection of heuristics for improving exam timetables. *Annals of Operations Research*, 218(1), pp 129-145, 2014.
- [17] M. W. Carter, G. Laporte, and S. Lee. Examination timetabling: Algorithmic strategies and applications. *Journal of the Operational Research Society*, Volume 47, Issue 3, pp 373-383, 1996.
- [18] R. M. Chen and H. F. Shih. Solving University Course Timetabling Problems Using Constriction Particle Swarm Optimization with Local Search. *Algorithms*, Volume 6, Issue 2, pp. 227-244, 2013.
- [19] T. B. Cooper and J. H. Kingston. The Complexity of Timetable Construction Problems. In E. K. Burke and P. Ross (editors): *Practice and Theory of Automated Timetabling*. Lecture Notes in Computer Science, Volume 1153, pp 281-295, 1996.
- [20] L. Di Gaspero, A. Schaerf. Neighbourhood portfolio approach for local search applied to timetabling problems. *Journal of Mathematical Modelling and Algorithms* 5(1):65–89, 2006.
- [21] R. Etemadi and N. M. charkari . A Novel Combinational Algorithm for Solving the Examination Timetabling Problem. *International Conference on Industrial and Intelligent Information (ICIIS 2012)*, Singapore, 17th to 18th March, 2012.
- [22] B. Hussin, A. H. Basari, A. S. Shibghatullah and S. A. Asmai. Exam Timetabling Using Graph Colouring Approach, *IEEE Conference on Open Systems (ICOS 2011)* , Langkawi, Malaysia, September 25-28, 2011.
- [23] S. Innet. A Noval Approach of Genetic Algorithm for Solving Examination Timetabling Problems. *13th International Symposium on Communications and Information Technologies (ISCIT)*, 4-6 September, Surat Thani, 2013.
- [24] M. Gendreau and J. Y. Potvin. *Handbook of Metaheuristics*. International Series in Operations Research & Management Science, Volume 146, 2nd ed, p:649, 2010.
- [25] V. Kolonias, G. Goulas, C. Gogos, P. Alefragis & E. Housos. Solving the examination timetabling problem in gpus. *Algorithms*, 7(3), 295-327, 2014.
- [26] S. Ólafsson. Metaheuristics. In Nelson and Henderson (editorss.), *Handbook of Simulation: Principles, Methodology, Advances, Applications, and Practice*. Handbooks in Operations Research and Management Science VII, Elsevier, pp. 633-654, 2006.
- [27] T. C. Pais, and P. Amaral. Managing the tabu list length using a fuzzy inference system: an application to examination timetabling. *Annals of Operations Research*, Volume 194, Issue 1, pp 341-363, 2012.
- [28] N. Pillay, W. Banzhaf, An informed genetic algorithm for the examination timetabling problem, *Applied Soft Computing* 10, pp 457–467, 2010.
- [29] R. Qu, E. K. Burke, B. McCollum, L. G. T. Merlot and S. Y. Lee, A Survey of Search Methodologies and Automated System Development for Examination Timetabling, *Journal of Scheduling*, Volume 12, Issue 1, pp 55-89, 2009.
- [30] N. R. Sabar, M. Ayob, R. Qu and G. Kendall. A graph coloring constructive hyper-heuristic for examination timetabling problems. *Applied Intelligence*, Volume 37, Issue 1, pp 1-11, 2012.
- [31] A. Soghier and R. Qu. Adaptive selection of heuristics for assigning time slots and rooms in exam timetables. *Appl Intell*, Volume 39, Issue 2, pp 438–450, 2013.
- [32] J. M. Thompson and K. A. Dowsland. Variants of simulated annealing for the examination timetabling problem. *Annals of Operations Research*, Volume 63, Issue 1, pp 105-128, 1996.
- [33] J. Thompson and K. Dowsland. A robust simulated annealing based examination timetabling system. *Computers and Operations Research*, Volume 25, Issues 7-8, pp 637–648, 1998.
- [34] H. Turabieh and S. Abdullah. A hybrid fish swarm optimisation algorithm for solving examination timetabling problems. In *Learning and Intelligent Optimization* (pp. 539-551). Springer Berlin Heidelberg, 2011.

# A Multi start Greedy Constructive Heuristic To The Nurse Scheduling Problem

Fatima Guessoum, Salim Haddadi

LabSTIC  
8 Mai 1945 University  
BP 401, 24000 Guelma, Algeria

fatima\_gessoum@yahoo.fr, salim.haddadi@yahoo.com

**Abstract:**

*This paper deals with the Nurse Scheduling Problem (NSP) that is a particular timetabling problem. It's the process of constructing a schedule that satisfies the requirements of the institution and personnel preferences while meeting a number of soft and hard constraints;*

*We propose a multi-start greedy constructive heuristic approach, it consist mainly of three phases, the first is a preprocessing to generate possible shift patterns ,the second is applying a constructive heuristic to generate an initial solution; finally, an improvement heuristic is used if the constructed roster from the second phase is not feasible. After a number of iterations without improvement we stop and get the best solution find.*

**Index Terms:** Nurse rostering, personnel scheduling, combinatorial optimization, timetabling, metaheuristic, heuristic

## I.INTRODUCTION:

The NSP is an optimization problem or constraint satisfaction problem where each nurse is assigned to one shift per day according to their skill level in order to meet the minimal coverage constraints taking into account both hard and soft constraints where the goal is to satisfy the nurses' preferences as far as possible and to minimize the soft constraints violations costs. [4], [2].

The problem that we deal with is based on the model proposed by (Vanhoucke and Maenhout 2007)[20] that is an artificially generated instances of the nurse scheduling problem including two type of data, the first is the set of nurse scheduling problem instances that represent the problem size, minimal coverage requirements as hard constraints and nurses preference as soft constraints (the smallest value is the most preferred) and the second file contain different sets of case-specific constraints that represent the time related or horizontal hard constraints that are

- Minimal and maximal number of assignment per period.
- Minimal and maximal number of assignment per shift
- Minimal and maximal number of consecutive working shifts
- Minimal and maximal number of consecutive same working shifts

- We have also another hard constraint that is the forbidden successive assignments but this constraint does not exist in the database but is used by several authors and it's inherent to personnel scheduling (forbidden successive assignments between night and early, night and late and late and early).

The IP model formulation proposed by (Maenhout & Vanhoucke ) [17].

Problem size:

N= set of nurses ( $N_i | i \in \{1..n\}$ )  
S= set of shifts ( $S_j | j \in \{1..s\}$ )  
D= set of days ( $D_k | k \in \{1..d\}$ )

Parameters:

$C_{jk}$  = minimal nurses required on shift  $j$  of day  $k$ .

$P_{ijk}$ = preference cost of nurse  $i$ , working on day  $j$  in shift  $k$

$P_{il}$ = total preference cost of nurse  $i$  working shift pattern  $l$

$F(i)$  = set of feasible shift patterns for nurse  $i$

The decision variables:

$$x_{il} = \begin{cases} 1, \text{nurse } i \text{ work shift pattern } l \\ 0, \text{otherwise} \end{cases}$$

$$a_{jkl} = \begin{cases} 1, \text{pattern } l \text{ covers shift } j \text{ on day } k \\ 0, \text{otherwise} \end{cases}$$

The objective is to minimize the following function that corresponds to the violation of the soft constraint:

$$\sum_{i=1}^n \sum_{l=1}^{f(i)} p_{il} x_{il} \rightarrow \min!$$

Subject to

$$\sum_{l \in F(i)} x_{il} = 1 \quad \forall i$$

$$\sum_{i=1}^n \sum_{l=1}^{f_i} a_{jkl} x_{il} \geq c_{jk} \quad \forall j, k$$

## II. RELATED WORK

In the last decades the nurse scheduling problem has received extensive attention hence an extensive overview of the problem descriptions and models can be found in literature, most research papers corresponding to the personnel scheduling (scheduling) vary drastically subject to a huge variety of constraint [5]

Enormous techniques are used to model and solve the nurse scheduling problem; generally two methods are applied:

- Exact method (exhaustive) that explores the search space as a whole to find the optimal solution if it exists otherwise prove the inconsistency of the problem.
- approached method (approximate) that explores a subset of the search space

The exact method that is found in abundance in the literature are linear programming (Thornton and Sattar 1996) [6] and (Trilling et al 2006) [7], and Branche & price by (Maenhout and Vanhoucke 2007) [8].

Unfortunately these exact methods are only efficient for small size problems that give a great

success, but for large size problems, approached methods are more preferred to find approximate solutions with a reasonable calculation time.

Among these methods there are IA Method, Heuristic, Metaheuristic.

the most common AI methods representation are logical programming where the logic used to represent knowledge and permit to deduce new fact from old facts through rules of inference furthermore there are also rules based programming where every constraint represents a rule in this ways (Li et al 2003) [9] and (Cheng et al 1996) [10] proposes a constraint programming; Furthermore, (Okada & Okada 1988) [11] and (Chen & Yeung 1992) [12] proposed an expert System.

Other approaches like Heuristics are conceived for particular optimization problems permitting to find feasible solutions with an acceptable calculation time translating a strategy or a manner to think, generally the heuristic don't guaranteed optimality; they developed to generate cyclic planning; as used by (Smith and Wiggins 1977) [15] and (Bilgin et al 2009)[13].

more recent paper use métahuristic to tackling the problem, it's a general heuristic that can be applied to several optimization problem it offer an acceptable solution for complex problem in a reasonable computational time, for example there are tabu search (TS) as used by (Bellatni et al 2001)[23], and (Ramli et al 2011) [24], and simulated annealing (SA) proposed by (Bai et al 2010) [14], TS and SA are based on single solution, There are also Genetic algorithm(GA) like used by (Aickelin & Dowsland 2000) [16] and (Maenhout & Vanhoucke 2008) [19], And bees Colony(BC) as proposed by (Todorovic & Petrovic 2013) [25], (GA)and (BC) are métahuristic based on population solution.

A General outline of nurse rostering problem can be found in (Cheang et al 2003) [3] and (Burke et al 2004) [2]. Or more generally staff scheduling by (Ernst et al 2004) [1].

## III.PROPOSED APPROACHES:

We propose a multi-start greedy constructive heuristic approach, it consist mainly of three phases, the first is a preprocessing to generate possible shift patterns ,the second is applying a constructive heuristic to generate an initial solution; finally, an improvement heuristic is used if the constructed roster from the second phase is not feasible.

### a. Phase 1:

To relax the problem constraints we apply a preprocessing to generate a set of possible shift patterns for all nurses (nurse have the same set of

shift patterns because no difference between them they have all the same skill level) by creating all possible combinations of shifts that satisfy all time related case-specific hard constraints and prohibited successive assignments, after this phase we have only the coverage demand as hard constraint to satisfy.

When we apply the preprocessing phase problem data are reformulated by generating a 0\_1 matrix represents feasible shift patterns ( $a_{jkl}$ ) and a cost\_ patterns matrix ( $p_{il}$ ) corresponding to the total nurse preference cost for every shift pattern

$$p_{il} = \sum_{j=1}^s \sum_{k=1}^d p_{ijk} a_{jkl}$$

#### b. Phase 2

In this phase we apply a constructive heuristic to generate an initial solution by assigning the shift patterns to the nurses to satisfy coverage demands and minimizing nurse's preferences.

At each step of the construction process every shift pattern is evaluated to select the more adequate shift pattern in a given empty or not yet completed roster.

firstly we create a new ratio\_ patterns matrix for every nurse corresponding to the ratio between weight pattern that is the number of shifts covered by this pattern and cost pattern add with the number of over load shifts (to minimizing the over load), weight and over load change iteratively for each step of the construction process as well as the minimum coverage demand; only one shift pattern is chosen in greedy fashion among the set of possible candidates to be assigned to the nurse having the minimum cost to construct the solution step by step, if there are many patterns having the same value we chose one randomly, when all nurses are affected we stop this process .

A random multi-start is used to diversify the solution; the best roster that has the minimum cost produced after repeated applications of this process is chosen to be the initial solution.

Weight pattern, over load, ratio pattern and the new coverage demand are calculated respectively as follow:

weight\_pattern<sub>i</sub>=

$$\sum_{j=1}^s \sum_{k=1}^d \min\{1, a_{jkl} * c_{jk}\}, L \in f_i$$

Over<sub>i</sub>= $\sum_{j=1}^s \sum_{k=1}^d (c_{jk} - a_{jkl})^+$  (+ represents the positive values)

$$\text{ratio}_{il} = \frac{(p_{il} + \text{over}_i)}{\text{weight\_pattern}_i}$$

$c'_{jk} = \max\{0, c_{jk} - a_{jkl}\}$  (New coverage demand calculated for each step)

#### c. Phase 3

this last phase is occurred only if the constructed roster from the second phase is not feasible (coverage demands are not satisfied), we apply an improvement heuristic by swapping a partial part of the solution, whither this part doesn't change more than a quarter of actual solution, then we reconstruct this part by the same process of the second phase as a feedback bat we haven't return to an empty roster, shift patterns selected to be swapped are those having the maximum over load cost calculated after a complete solution is built but if there are no more patterns having over load we chose it randomly. After a number of iterations without improvement we stop and get the best solution find.

The solution quality is the sum of the total preference cost add with the total coverage violation multiplied for 100 as penalty as used by [Maenhout and Vanhoucke 2007] [17].

## IV.COMPUTATIONAL RESULTS

We discusses results for our proposed approach performance in solving the NSP\_Lib benchmark problems with eight classes of case-specific constraints combined with three divers set of problem instance for 25, 50, 75 nurses, each dataset contains 7290 instances, to construct cyclical schedules for one week within 100 run for the constructive heuristic and 10 run for the improvement heuristic, so we have tested 174960 problem instance!.

Our heuristic is coded in C and Tests were run on an Intel Core i5 processor 2.40 GHz with 4 GB RAM and windows 7, 64-bit operating system

Computational results are presented in **Table1** compared with best known solutions find in literature (results presented in the official web site of the NSP\_Lib benchmark (<http://www.projectmanagement.ugent.be/nsp.php>); where AVG\_Pref is the average preferences cost, %Feas is the percentage of instances for which a feasible solution has been found among all instances, AVG\_CPU is the average computation time in seconds (for 1 run).

		N25			N50			N75		
		Avg Pref	%FEAS	Avg CPU	Avg Pref	%FEAS	Avg CPU	Avg Pref	%FEAS	Avg CPU
<b>our approach</b>	CASE1	263,72	86,47	0,09	522,95	86,61	0,59	794,06	86,10	0,65
	CASE 2	252,14	87,56	0,28	500,09	88,57	1,43	771,47	86,64	1,96
	CASE3	<b>263,72</b>	86,47	0,09	<b>522,95</b>	86,60	1,04	<b>794,07</b>	86,16	1,04
	CASE4	262,38	86,49	0,23	520,68	86,57	0,67	797,28	86,42	2,06
	CASE5	277,10	79,84	0,02	546,48	79,55	0,06	830,19	77,67	0,13
	CASE6	253,22	87,42	0,27	502,65	88,48	1,37	796,84	87,47	1,86
	CASE7	293,90	72,64	0,01	573,29	71,56	0,02	871,56	72,75	0,03
	CASE8	267,82	83,35	0,04	527,97	82,46	0,09	813,88	82,96	0,36
<b>best solutions</b>		Avg Pref	%FEAS	Avg CPU	Avg Pref	%FEAS	Avg CPU	Avg Pref	%FEAS	Avg CPU
	CASE1	252,76	88,27	0,53	503,80	89,95	1,55	763,78	88,67	2,67
	CASE 2	241,12	88,27	0,45	481,17	90,01	0,96	739,42	87,48	3,75
	CASE3	269,30	88,01	0,61	530,66	89,19	1,64	803,97	88,08	2,91
	CASE4	250,75	88,27	0,57	500,16	89,99	1,66	766,92	88,69	3,86
	CASE5	266,60	85,84	0,65	528,89	84,87	1,96	803,34	85,88	3,08
	CASE6	242,15	88,27	0,45	483,43	90,00	0,96	764,86	88,71	3,716
	CASE7	284,57	79,90	1,14	557,00	77,60	2,76	849,27	78,72	4,34
	CASE8	259,81	85,53	0,38	514,10	85,10	1,23	788,73	85,39	2,25

TABLE1. AVERAGE EXPERIMENTAL TEST RESULTS FOR THE 8 CASE-SPECIFIC CONSTRAINTS

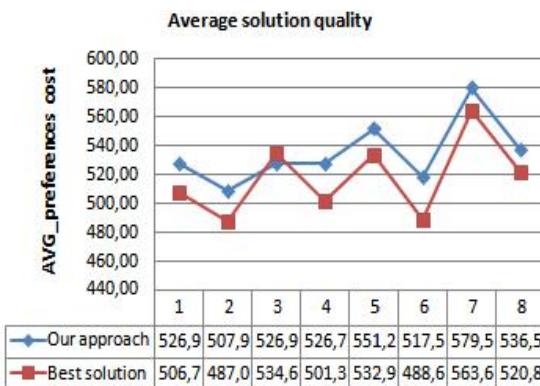


FIGURE1: COMPARATIVE GRAPH OF AVERAGE SOLUTION QUALITY FOR THE 8 CASE-SPECIFIC CONSTRAINTS.

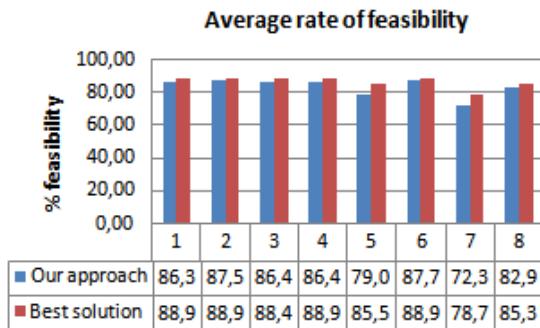


FIGURE2: COMPARATIVE GRAPH OF AVERAGE RATE OF FEASIBILITY FOR THE 8 CASE-SPECIFIC CONSTRAINTS.

Figur1 and Figur2 demonstrate that our approach can give good solution in a reasonable computational execution time when compared against the best solution in the literature without a large gap, these best results are collected from the

best of several approach counting the Electromagnetic method by Maenhout and Vanhoucke (2007)[17], Scatter Search by Maenhout and Vanhoucke (2006)[18] and Genetic Algorithms by Maenhout and Vanhoucke (2008)[19], in addition we must noted that some problems instance are not feasible as already noticed by (Flener and Pearson 2012)[21] and (Constantino et a 2013)[22]; so we can say that our approach is competitive with other approaches and can generate new best solutions for some instances.

## V.CONCLUSION AND FUTURE WORK

The overall goal of this work was to investigate a multi-start greedy constructive heuristic to the nurse rostering problem; Preliminary tests demonstrate that our approach can give good solution in a reasonable computational execution time when compared against other approaches in the literature.

Our future work will try to investigate a new intelligent heuristic or metaheuristic as simulated annealing, tabu search, variable neighbor search and others to improve our approach, and compare the results obtained with other approaches, and we will attempt to investigate the applicability of our approach on other sets of nurse rostering benchmark problems.

## BIBLIOGRAPHY

- [1] A.T. Ernst, H. Jiang, M. Krishnamoorthy , D. Sier; "Staff scheduling and rostering A review of applications , methods and models "; European Journal of Operational Research 153 ,3–27(2004).
- [2] E.K. Burke, P. De Causmaecker,, G. V. Berghe,H. V.Landeghem;"The State of the Art of Nurse Rostering"; Journal of Scheduling7,441– 499(2004).

- [3] B. Cheang a, H. Li b, A. Lim c, B. Rodrigues, "Nurse rostering problems—a bibliographic survey"; European Journal of Operational Research 151, 447–460(2003).
- [4] B. Bilgin ,P. De Causmaecker, B. Rossie , G.V. Berghe; the problem description and a solution method for the nurse rostering problem in Belgian hospitals ; Proceedings of the 22nd Annual Conference of the Belgian Operations Research Society (ORBEL 22) 22 ,37-38(2008).
- [5] P. De Causmaecker, G. V. Berghe, A categorization of nurse rostering problems. Journal of Scheduling, 14(1), 3-16(2011).
- [6] J. Thornton, A. Sattar; An integer programming-based nurse rostering system. In Concurrency and Parallelism, Programming, Networking, and Security. 357-358(1996). Springer Berlin Heidelberg.
- [7] L.trilling, A.guinet and D.le magny, Nurse scheduling using integer linear programming and constraint programming. In 12th IFAC Symposium on Information Control Problems in Manufacturing INCOM , 3, 651-656. (2006). Elsevier
- [8] B. Maenhout, M. Vanhoucke. A branch-and-price procedure for nurse staffing incorporating roster preferences. In 3rd Multidisciplinary International Conference on Scheduling: Theory and Applications, August 28–31(2007).
- [9] H. Li, A. Lim, B. Rodrigues, A hybrid AI approach for nurse rostering problem In: Proceedings of the 2003 ACM symposium on Applied computing, 730-735(2003).
- [10] B.M.W cheng, J. H. M lee and j.c.k Wu; A constraint-based nurse rostering system using a redundant modeling approach; In Tools with Artificial Intelligence; Proceedings Eighth IEEE International Conference on. 140-148(1996). IEEE.
- [11] M. Okada, M. Okada, Prolog-based system for nursing staffs cheduling implemented on a personal computer. Computers and Biomedical Research, 21(1), 53-63(1988).
- [12] J. G.Chen, , T. W. Yeung, Development of a hybrid expert system for nurse shift scheduling. International Journal of Industrial Ergonomics, 9(4), 315-327(1992).
- [13] B. Bilgin ,P. De Causmaecker G .Berghe, A Hyperheuristic Approach to Belgian Nurse Rostering Problem, In Proceedings of the 4th Multidisciplinary International Conference on Scheduling: Theory and Applications . 693-695(2009).
- [14] R. Bai, E.K. Burke, G. Kendall, J. Li, B. McCollum; A Hybrid Evolutionary Approach to the Nurse Rostering Problem ; IEEE transactions on evolutionary computation, 14(4), 580-590(2010).
- [15] L. D. Smith, A. Wiggins, A computer based Nurse scheduling system, Computers and Operations Research, 4(3), 195-212(1977) .
- [16] K. Aickelin, A. Dowsland; Exploiting problem structure in a genetic algorithm approach to a nurse rostering problem; Journal of Scheduling, 3 (3): 139-153 (2000).
- [17] B. Maenhout, & M. Vanhoucke. An electromagnetic meta-heuristic for the nursescheduling Problem. Journal of Heuristics 13, 359–385(2007)
- [18] B. Maenhout, & M. Vanhoucke. New computational results for the nurse scheduling problem: a scatter search algorithm. In Evolutionary Computation in Combinatorial Optimization , 159-170(2006). Springer Berlin Heidelberg.
- [19] B. Maenhout, & M. Vanhoucke , Comparison and hybridization of crossover operators for the nurse scheduling problem. Annals of Operations Research, 159(1), 333-353(2008).
- [20] M. Vanhoucke., & B. Maenhout. NSPLib—a nurse scheduling problem library: a tool to evaluate (meta-) heuristic procedures. In Operational research for health policy: making better decisions, proceedings of the 31st annual meeting of the working group on operations research applied to health services, 151-165 (2007).
- [21] He, J., Flener & P.Pearson, Solution neighbourhoods for constraint-directed local search. In Proceedings of the 27th Annual ACM Symposium on Applied Computing , 74-79(2012). ACM.
- [22] A. Constantino, D.Landa-Silva, E. L. de Melo, C. F. X de Mendonça, D. B.Rizzato, W. A Romão, heuristic algorithm based on multi-assignment procedures for nurse scheduling. Annals of Operations Research, 1-19 (2013).
- [23] F.Bellatni, G.Carello, F.Dellacroce ,R.Tadei, A Tabu Search Approach to a Nurse Rostering Problem, In Proceedings of the 4'h Metaheuristics Inter-national Conference, MIC. 165-167(2001).
- [24] R. Ramli, S. N. Ima Ahmad , Innovative Neighbor Generations In Tabu Search Technique For A Nurse Rostering Problem. In Proc. International conference on Information and Electronics Engineering, IPCSIT, 6 .228- 232(2001).
- [25] N. Todorovic and S. Petrovic, Bee colony optimization algorithm for nurse rostering. Systems, Man, and Cybernetics: Systems, IEEE Transactions on, 43(2), 467-473(2013).

# Super-Resolution Techniques Applied to Magnetic Resonance Images

Messaoud HAMEURLAINE

Faculty of sciences  
Amar Thledji university  
Laghouat, Algeria  
Hamessainf@yahoo.fr

Hadda CHERROUN

H.cherroun@gmail.com

**Abstract—** *Magnetic Resonance Images typically have poorer resolution. Resolution is for instance a key point in brain segmentation in Magnetic Resonance imaging. Then, it clearly appears that improving image resolution is still one of the main challenges in medical image processing. Super-Resolution reconstruction produces one or a set of high-resolution images from a sequence of low-resolution frames. In this paper, we have summarized the necessary statistical theory behind an image reconstruction, and it discusses the idea of super resolution as an inverse problem. Moreover, it presents the various contributions of various techniques to improve spatial resolution of magnetic resonance images using super resolution methods. Subsequently, it portrays the major findings pertaining to the study. Additionally, we give a glimpse of the numerous factors influencing the performance of super resolution.*

**Keywords—** Super-resolution; Magnetic Resonance Imaging; Inverse Problem; Image Reconstruction.

## I. INTRODUCTION

Image processing algorithm performances are often limited by the image resolution. Resolution in Magnetic Resonance imaging (MRI) is limited by hardware, signal to noise (SNR), time constraints and patients comfort. The current limits in HR imagery and high SNR in MRI are not due to the acquisition system resolution, but rather to the acquisition time. The acquisition times for 3-D HR imaging are impractical for the desired T2-weighted contrast. Resolution is for instance a key point in brain segmentation in Magnetic Resonance imaging. To improve image resolution a variety of interpolation techniques are commonly applied resulting in blurrier versions of the original data. In recent years super resolution (SR) techniques have emerged as an alternative to effectively increase the resolution of the reconstructed data. The objective of SR image reconstruction is to produce an image with a higher resolution using one or a set of images captured from the same scene. The basic idea behind Super-Resolution is the fusion of a sequence of low-resolution noisy blurred images to produce a higher-resolution image or sequence. Early works on Super-Resolution showed that the aliasing effects in the high-resolution fused image can be reduced (or even completely removed), if a relative sub-pixel motion exists between the undersampled input images [1].

Abdelouahab MOUSSAOUI

Faculty of sciences  
Ferhat Abbas university  
Setif, Algeria  
Moussaoui.abdel@gmail.com

However, contrary to the naive frequency domain description of this early work, we shall see that, in general, super-resolution is a computationally complex and numerically ill-posed problem. All this makes Super-Resolution one of the most appealing research areas for image processing researchers [2].

The intention of this article is to pinpoint the Super-Resolution problem and to clarify the challenges, model and techniques of super-resolution. We review the various contributions of various techniques to improve spatial resolution of images. The organization of this article is as follows. The second section presents the challenges of super-resolution. In Section III we study Super-Resolution as an inverse problem and address related regularization issues. In Section IV we analyze the techniques of super-resolution. In Section V we describe the previous research in MRI super-resolution. Finally, we conclude with a list of challenges to be addressed in future work on Super-Resolution.

## II. CHALLENGES IN SUPER-RESOLUTION

Spatial resolution determines how "sharp" the image looks. Low resolution will give either fuzzy edges, or a pixelly appearance to the image. In MRI, spatial resolution is defined by the size of the imaging voxels. Since voxels are three dimensional rectangular solids, the resolution is frequently different in the three different directions. The size of the voxel and therefore the resolution depends on matrix size, the field-of-view (FOV), and the slice thickness. The matrix size is the number of frequency encoding steps, in one direction; and the number of phase encoding steps, in the other direction of the image plane. Assuming everything else is constant, increasing the number of frequency encodings or the number of phase steps results in improved resolution. The frequency encoding depends of how rapidly the *Free Induction Decay* (FID) signal is sampled by the scanner. Increasing the sampling rate results in no time penalty. Increasing the number of phase steps increases the time of the acquisition proportionately. This is why images that have fewer phase encodings than frequency encodings, e.g., 128x256 or 192x256 will be used.

The FOV is the size of the area that the matrix of phase and frequency encoding cover. Dividing the FOV by the matrix size gives you the in-plane voxel size; hence, increasing the

FOV in either direction increases the size of the voxels and decreases the resolution. Decreasing the FOV improves the resolution.

The depth of the voxel is determined by the slice thickness. This is almost always the largest dimension of the voxel in 2D imaging. Therefore, the resolution perpendicular to the image plane is the poorest. This is related to the maximum strength of the z-gradient coils as well as time restraints limiting the number of slices available. 3-D imaging utilizing phase encoding in the z direction is capable of smaller slice thickness than 2-D imaging but carries a time penalty proportional to the number of slices.

Instrumental limitations, signal to noise, and nuclear relaxation times considerations impose limitations on the maximum feasible spatial resolution. Spatial resolution can be enhanced by [3]:

- Decreasing the FOV.
- Increasing the number of readout points.
- Increasing the number of phase encoding steps.

Where:

- FOV is limited by gradient strength and subject dimension in the readout direction.
- The number of readout points is limited by the transverse nuclear relaxation time ( $T_2$ ). Extending the readout period significantly beyond the transverse relaxation time decreases the signal-to-noise ratio (SNR) significantly. The maximum theoretical number of readout points is limited by the local oscillator frequency divided by the exciter/receiver register bit. This limit is impractical since the long acquisition time decreases the SNR to an unfeasible degree. Though  $T_2$  decay is usually the only important limit, the amount of available memory for storing the data also comes up occasionally as a limiting factor.
- The number of phase encoding steps is limited by the acquisition time. Increasing the number of phase encoding steps increases the acquisition time, proportionally.

The imaging system presents number of peculiar and challenging situations some of which are unique to brain MR image acquisition scenario [4].

- Image registration: small image displacements are crucial for beating the sampling limit of the original camera or machine, but the exact mappings between these images are unknown. To achieve an accurate super-resolution result, they need to be found as accurately as possible.
- Magnetic field variation: when the images are aligned geometrically, there may still be significant magnetic field variation, because of different voltage levels or machine exposure settings when the images were captured.

- Blur identification: due to patient movement blurs introduced in the image.

### III. IMAGE SUPER-RECONSTRUCTION

#### A. Super-Resolution as an inverse problem

Inverse problems deal with finding the cause of some results that is, we have results and we want to find the cause that has produced those results. The term inverse problem considers inferring the values of the parameters characterizing the system under investigation from the results of actual observations. An inverse problem will not satisfy one or more of the well-posed properties. In the context of SR, the results are low resolution (LR) images and causes are high-resolution (HR) images. We have LR images and we want to find the HR image that has produced the LR images.

Inverse problems are often ill-posed, since the process of computing an inverse solution can be extremely unstable in that a small change in observed data can lead to a great change in the estimated model. The condition of stability is often violated and the problems have to be reformulated for a numerical treatment.

Many of the super-resolution (SR) methods are ill-posed [5]. In this work, we consider regularization of the SR reconstruction by utilizing additional information in atlas (prior knowledge) to compensate for the loss of information.

#### B. Observation model for image

An observation model describes the process of obtaining an LR image from an HR image. Fig. 1 illustrates the process. Low-resolution images (right) are the result of geometric transformation, blurring, and down-sampling of high-resolution images (left), and the addition of noise.

The observation model can be defined as:

$$y = DBWx + n \quad (1)$$

Where  $x$  denotes the HR image,  $y$  is the LR image,  $n$  is the noise,  $W$  is geometric transformation,  $B$  is a blur matrix,  $D$  is the down-sampling matrix [6]. By assuming  $H = DBW$ , previous equation can be written as follows:

$$y = Hx + n \quad (2)$$

In MRI data, LR voxel value ( $y_i$ ) can be well modeled as an average of the corresponding HR voxels values ( $x_i$ ) [7]:

$$y_j = \frac{1}{N} \sum_{i=1}^N x_i + n \quad (3)$$

The aim of the SR reconstruction is the evaluation of HR voxels values ( $x_i$ ) from LR voxel value ( $y_j$ ). It is ill-posed because the infinity possible values of ( $x_i$ ) that respond to such equation. Additional information is needed to solve this problem and find an optimal solution respecting the following equality:

$$\hat{x} = \operatorname{argmin}_x \|y - Hx\|^2 \quad (4)$$

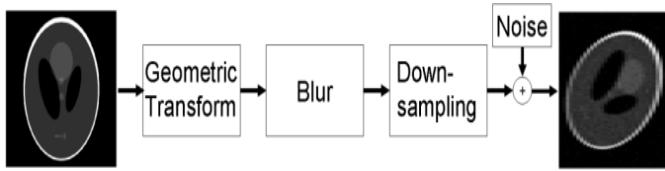


Figure 1. Illustration of the imaging model applied in super-resolution reconstruction.

For such an inverse problem, some form of regularization plays a crucial role and must be included in the cost function to stabilize the problem or constrain the space of solutions. A very common used approach is to apply constraints based on the assumption of smoothness of the reconstructed data in the reconstruction process:

$$\hat{x} = \operatorname{argmin}_x \|y - Hx\|^2 + \lambda R(x) \quad (5)$$

Where  $\lambda$  is a weight that balances the contribution of smoothness and data fidelity terms and  $R(x)$  is a regularization term. Popular pixel-based regularizers are Tikhonov regularization and Markov random field a priori image model [6].

#### IV. SUPER-RESOLUTION TECHNIQUES

In MRI super-resolution, there are two classes of super-reconstruction process: the single frame and multi frame super-reconstruction. Fig. 2 represents the Single Image SR techniques aimed at estimating an HR image using only one LR image as input. Fig.3 portrays the Multi-frame SR technique, where the SR estimation is done jointly using the LR image and a reference HR image.

In general, the SR image techniques are classified into four classes:

- Frequency domain-based approach
- Interpolation-based approach
- Regularization-based approach
- Learning-based approach

The first three categories get a HR image from a set of LR input images, while the last one achieves the same objective by exploiting the information provided by an image database [5].

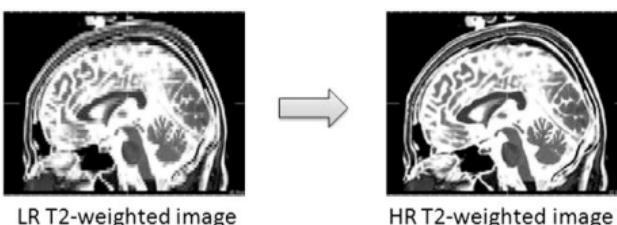


Figure 2. Single image SR framework

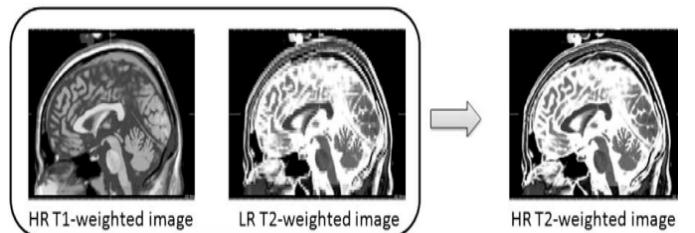


Figure 3. The Multi-frame SR approach

##### A. Frequency Domain Based Image Super-Resolution Approach

The frequency domain approach makes explicit use of the aliasing that exists in each LR image to reconstruct an HR image. It is an intuitive way to enhance the details (usually the high-frequency information) of the images by extrapolating the high-frequency information presented in the LR images. These frequency-domain-based SR approaches have low computational complexity. However, the frequency-domain based SR methods are insufficient to handle the real-world applications, since they require that there only exist a global displacement between the observed images and the linear space-invariant blur during the image acquisition process. Recently, many researchers have begun to investigate the use of the wavelet transform for addressing the SR problem to recover detailed information (usually the high-frequency information) that is lost or degrades during the image acquisition process. This is motivated by the fact that the wavelet transform provides a powerful and efficient multi-scale representation of the image for recovering high-frequency information [8]. These approaches typically treat the observed LR images as low-pass filtered sub-bands of the unknown wavelet-transformed HR image. The aim is to estimate the finer scale sub-band coefficients, followed by applying the inverse wavelet transform to produce the HR image.

##### B. Interpolation Based Image Super-Resolution Approach

The interpolation-based SR approach constructs a HR image by projecting all the acquired LR images to the reference image. Then it fuses together all the information available from each image, because each LR image provides an amount of additional information about the scene. Finally, it deblurs the image. Note that the single image interpolation algorithm cannot handle the SR problem well, since it cannot produce those high-frequency components that were lost during the image acquisition process. The quality of the interpolated image generated by applying any single input image interpolation algorithm is inherently limited by the amount of data available in the image. The interpolation-based SR approach usually consists of the following three stages:

- The registration stage for aligning the LR input images.
- The interpolation stage for producing a HR image.
- The de-blurring stage for enhancing the reconstructed HR image produced in the last step.

The interpolation stage plays a key role in this framework. There are various ways to perform interpolation. The simplest interpolation algorithm is the nearest neighbor algorithm, where each unknown pixel is assigned an intensity value that is the same as its neighboring pixels.

Irani and Peleg [9] proposed an Iterative Back Projection (IBP) algorithm, where the HR image is estimated by iteratively projecting the difference between the observed LR images and the simulated LR images. This kind of method is easy to be implemented and has the disadvantages of non-uniqueness, slow convergence, and high computational cost [5].

### C. Regularization Based Image Super-Resolution Approach

The basic idea of these regularization-based SR approaches is to use the regularization strategy to incorporate the prior knowledge of the unknown HR image. From the Bayesian point of view, the information that can be extracted from the observations (i.e., the LR images) about the unknown signal (i.e., the HR image) is contained in the probability distribution of the unknown. Then, the unknown HR image can be estimated via some statistics of a probability distribution of the unknown HR image, which is established by applying Bayesian inference to exploit the information provided by both the observed LR images and the prior knowledge of the unknown HR image.

Typically, the SR reconstruction algorithm is an ill-posed problem due to an insufficient number of LR images and ill-conditioned blur operators. Procedures adopted to stabilize the inversion of ill-posed problem are called regularization. Due to an MRF that can model the image characteristics, especially on image textures, Bouman and Sauer [10] proposed the single image restoration algorithm using a MAP estimator with the Generalized Gaussian-Markov Random Field (GGMRF) prior.

### D. Learning Based Image Super-Resolution Approach

In learning-based approaches, the high frequency information of the given single LR image is enhanced by retrieving the most likely high-frequency information from the given training image samples based on the local features of the input LR image.

Datsenko and Elad first assigned several high quality candidate patches at each pixel position in the observed LR image [11]. These are found as the nearest-neighbors in an image database that contains pairs of corresponding LR and HR image patches. These found patches are used as the prior image model and then merged into an MAP cost function to arrive at the closed-form solution of the desired HR image. Recent research on the studies of image statistics suggest that image patches can be represented as a sparse linear combination of elements from an over-complete image patch dictionary [12-13]. The idea is to seek a sparse representation for each patch of the LR input, followed by exploiting this representation to generate the HR output. By jointly training two dictionaries for the LR and HR image patches, the sparse representation of a LR image patch can be applied with the HR image patch dictionary to generate an HR image patch.

## V. PREVIOUS RESEARCH

Herment et al. [14-15] were one of the first groups to experiment with SR in MRIs. They combined partial k-space data of the same object but with different frequency domain sampling boundaries using three successive 3-D MRI volumes. To reconstruct an image using k-space data, their method zero-pads the unknown regions contained in the bounding box from the union of the three k-space data volumes. The shared center cube portion of the acquired k-space samples is averaged, while the remaining exclusive partial volumes of acquired k-space samples are left unchanged for Fourier reconstruction. The total acquisition time of the three 3-D MRI volumes is shorter than the acquisition time of an equivalent 3-D MRI scan with k-space data extending to the bounding box from the union of the three volumes. Their results show anisotropic HR imagery, but only in the directions shared by the high-frequency k-space data samples. This makes their method readily useful for imaging tissues with specific directions such as arteries, but not for brain imaging where isotropic resolution is desired.

Peled and Yeshurun [16] applied the IBP algorithm to a set of eight spatially shifted LR diffusion tensor images with equal resolutions and fields of view using 2-D multi-slice acquisitions. Diffusion tensor imaging relies on the Brownian motion of water molecules in brain tissue, which helps visualize white matter fibers (or tracts) of the brain as a way to detect strokes [17]. While Peled and Yeshurun claimed resolution improvement in the frequency and phase encoding directions, their results were subsequently invalidated by Scheffler [18].

Greenspan et al. [19] verified the statements of Scheffler [18] by applying SRR techniques to 2-D multi-slice MRI scans. They also showed that the SR reconstruction results based on the Peled and Yeshurun [16] experiments can be replicated with zero-padding interpolation from the LR images. The slice selection and phase and frequency-encoding directions of the LR images shared uniformly spaced voxel shifts. Applying the 3-D iterative back-projection algorithm, the frequency spectrum of the HR estimates showed a sharp cut-off in the phase encoded direction. Conversely, spectrum analysis in the slice selection direction revealed approximately twice the extent of bandwidth, thus providing a basis for SR reconstruction in this direction.

Consequently, further SR reconstruction experiments of Greenspan et al. relied on spatial shifts in only the slice selection direction from both real and phantom 2-D multi-slice MRI data. To account for the PSF needed in the iterative back projection algorithm, Greenspan et al. measured the slice profile to be well approximated by Gaussian functions, where the slice thickness is its full width at half maximum. The SNR per unit acquisition time or SNR efficiency of the LR image data sets was greater than the equivalent scan with equal spatial resolution in the HR estimate. It also shows that edge width is comparable to the HR image in the slice selection direction.

Peeters et al. [20] also considered SR in the slice selection direction, but for functional MRI data used in the 2-D multi-slice acquisition. As opposed to anatomical structures, a

functional MRI visualizes the temporal activity or physiology of the brain, which gives a dynamic time series of 3-D activation areas. They used an additive model, computing the volume of shared space from any given LR and HR image pixels. Carmi et al. [21] explored SR further using 2-D multi-slice MRI data sets, and recognized emerging problems caused by spatially-shifted LR images like those used by Greenspan et al. Their main contribution is a new sampling condition for the LR image that goes beyond MRI and into SR in general.

Specifically, they show how a set of LR images with equal sampling periods and uniform spatial shifts can propagate localized spatial errors globally to all the pixels of the HR estimate during the SR reconstruction process. They also show that in fully-determined SR scenarios, pixels of the HR estimate may remain unresolved despite the absence of any errors. If input errors are limited to some physical location such as scanner vibrations or non-rigid motions of the object, then it may be desirable to keep this spatial error localized.

This means that any pixel from the estimate of the HR images should be expressed by only a small combination of neighboring pixels in the LR images. In other words, each row in the inverse of the E & F matrix, when non-singular, would only have a small number of non-zero entries. While a small support region of the PSF equates to a small number of HR pixels expressed in the linear combination of any pixel in the LR images, it does not, however, guarantee sparsity for its inverse.

Rahman and Wesarg [22] employed the SR reconstruction for cardiac MR images. The cardiac images are highly anisotropic (1.5mm x 1.5mm x 8mm) and valuable information is missed along the slice-selection direction because of the poor resolution in that direction. They adopt exploit the equivalence between MRF and the Gibbs distribution to express the probability distribution of the prior. They employ a Bayesian approach for maximizing the posterior probability. In their work, they show the improvement of the quality of the reconstructed images after combining short-axis and long-axis cardiac MR images by applying an SR algorithm.

## VI. CONCLUSION

In this work, the challenges of super-resolution are presented, the current state-of-the-art in SR imaging techniques was reviewed. The SR as an inverse problem was also presented. The observation model for SR images was established. The chronological development of methods in this area was studied. Also, the limitations and drawbacks of these techniques were portrayed. Previous SR research in Magnetic Resonance Imaging was also reviewed.

In this paper, we presented only a few methods and insights for specific scenarios of Super-Resolution. Many questions still persist in developing a generic Super-Resolution algorithm capable of producing high-quality results on general image sequences. In this section, we outline a few areas of research in Super-Resolution that remain open. The types of questions to be addressed fall into mainly two categories. The first concerns analysis of the performance limits associated with Super-Resolution. The second is that of Super-Resolution system level design and understanding. A thorough study of Super-

Resolution performance limits will have a great effect on the practical and theoretical activities of the image reconstruction community. In deriving such performance limits, one gains insight into the difficulties inherent to super-resolution.

Systematic study of the performance limits of Super-Resolution would reveal the true information bottlenecks, hopefully motivating focused research to address these issues. Furthermore, analysis of this sort could possibly provide understanding of the fundamental limits to the Super-Resolution imaging, thereby helping practitioners to find the correct balance between expensive optical imaging system and image reconstruction algorithms. Such analysis may also be phrased as general guidelines when developing practical super-resolution systems.

## REFERENCES

- [1] T.S. Huang, R.Y. Tsai., “Multi-frame image restoration and registration”, *Adv Comput Vision Image Process*, 1984,1: 317–339.
- [2] S. Farsiu, D. Robinson, M. Elad, P. Milanfar, “Advances and Challenges in Super-Resolution”, *International Journal of Imaging Systems and Technology*, 2004, 14: 47-57.
- [3] E. Carmi, S. Liu, N. Alon, A. Fiat, D. Fiat, “Resolution enhancement in MRI”, *Magnetic Resonance Imaging*, 2006, 24: 133–154.
- [4] G. S. Sable , Dr. A.N. Gaikwad, “A Novel Approach for Super Resolution in Medical Imaging ”, *International Journal of Engineering and Innovative Technology (IJEIT)*, 2012, 2(5).
- [5] S. Kathiravan, J. Kanakaraj “An Overview of SR Techniques Applied to Images, Videos and Magnetic Resonance Images”, *smart computing review*, 2014,4(3):181-201.
- [6] F.Rousseau, “A non-local approach for image super-resolution using intermodality priors”, *Med Image Anal.*, 2010, 14(4): 594–605.
- [7] J.V.Manjón, P.Coupé, A.Buades, D.Louis Collins, M.Robles, “MRI Superresolution Using Self-Similarity and Image Priors”, *International Journal of Biomedical Imaging*, vol. 2010, Article ID 425891.
- [8] N. Nguyen, P. Milanfar, “A wavelet-based interpolation-restoration method for superresolution”, *Circuits, Systems and Signal Processing*, 2000, 19(4):321-338.
- [9] M. Irani, S. Peleg, “Improving resolution by image registration”, *CVGIP Graphical Models Image Processing*, 1991, 53(3):231-239.
- [10] C. Bouman, K. Sauer, “A generalized Gaussian image model for edge-preserving MAP estimation” *IEEE Transactions on Image Processing*, 1993, 2(3): 296-310.
- [11] D. Datsenko, M. Elad, “Example-based single document image super-resolution: a global MAP approach with outlier rejection” *Multidimensional Systems and Signal Processing*, 2007, 18(2):103-121.
- [12] K. I. Kim, Y. Kwon, “Single-image super-resolution using sparse regression and natural image prior” *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 2010, 32(6):1127-1133.
- [13] J. Yang, J. Wright, T. Huang, Y. Ma, “Image super-resolution via sparse representation” *IEEE Transactions on Image Processing*, 2010, 19(11):2861-2873.
- [14] E. Roullot, A. Herment, M. Bloch, M. Nikolova, E. Mousseaux, “Regularized reconstruction of 3D high-resolution magnetic resonance images from acquisitions of anisotropically degraded resolutions” in *Proc. of fifteenth international conference on pattern recognition*, 2000, 346-349.
- [15] A. Herment, E. Roullot, I. Bloch, O. Jolivet, A. D. Cesare, F. Frouin, J. Bitton, E. Mousseaux, “Local reconstruction of stenosed sections of artery using multiple MRA acquisitions”, *Magnetic Resonance in Medicine*, 2003, 49(4):731-742.
- [16] S. Peled, H. Yeshurun, “Superresolution in MRI: Application to human white matter fiber tract visualization by diffusion tensor imaging”, *Magnetic Resonance in Medicine*, 2001, 45(1):29-35.

- [17] W. Hacke, S. Warach, "Diffusion-weighted MRI as an evolving standard of care in acute stroke," *Neurology*, 2000, 54(8):1548-1549.
- [18] K. Scheffler, "Superresolution in MRI", *Magnetic Resonance in Medicine*, 2002, 48(2):408.
- [19] H. Greenspan, G. Oz, N. Kiryati, S. Peled, "MRI inter-slice reconstruction using super-resolution" *Magnetic Resonance Imaging*, 2002, 20(5):437-446.
- [20] R. Peeters, P. Kornprobst, M. Nikolova, S. Sunaert, T. Vieville, G. Malandain, R. Deriche, O. Faugeras, M. N. P. Hecke, "The use of superresolution techniques to reduce slice thickness in functional MRI", *International Journal of Imaging Systems and Technology*, 2004, 14(3):131-138.
- [21] E. Carmi, S. Liub, N. Alona, A. Fiata, D. Fia, "Resolution Enhancement in MRI", *Magnetic Resonance Imaging*, 2006, 24(2):133-154.
- [22] S. U. Rahman, S. Wesarg, "Upsampling of cardiac MR images: Comparison of averaging and super-resolution for the combination of multiple views", in Proc. of tenth IEEE international conference on information technology and applications in biomedicine, 2010, 1-4.

# A review of Change Impact Analysis Approaches for Software Evolution

Hidouci Adenane  
 Biskra University  
 Biskra, Algeria  
[a\\_hidouci@esi.dz](mailto:a_hidouci@esi.dz)

Lebsir Rabah  
 Constantine 2 University  
 Constantine, Algeria  
[r.lebsir@gmail.com](mailto:r.lebsir@gmail.com)

**Abstract—** During software maintenance, changes are often introduced to fix bugs, accommodate new requirements or improving performances. Understanding the impact scope of changes must be undertaken prior to estimating the effort required. However the implementation of a single change can impact many parts of the system. The high cost of maintenance leads researchers and professionals to the investigation of change impact analysis approaches which can reduce the maintenance cost each time the software system evolves. This article aims at providing an exploratory study of existing software change impact analysis approaches while describing the techniques used, the advantages and the limits of each type of approaches.

**Keywords—** Software maintenance; software evolution; change impact analysis approaches.

## I. INTRODUCTION

Changes play a central role in software evolution. In order to automate daily tasks and to remain competitive, the companies must install multiple software tools such as ERP (Enterprise Resource Planning), CRM (Customer Relationship Management), Workflow systems, etc. These systems do not meet all the needs for the company and many other applications or software systems are also developed. These software systems are frequently modified for various reasons: to correct anomalies, to answer new requirements or to improve the performances. Independently of its causes, the changes within a software system are generally not limited to one component only but they can propagate towards several other software components of the system. This is called, "Ripple effects" [24]. So change impact analysis is the determination process of the set of software artifacts likely to be changed each time one artifact has been modified [18].

When changing software, impact analysis is required to preserve the quality of the whole system [15]. However, making software changes without visibility of their effects can lead to bad estimations, delay in release schedules, degradation in software design, unreliable software products, and premature retirement of the software system [8,18].

The high cost of maintenance imposes that research and business investigate the field of change impact analysis which aims at averting avoidable changes, capturing change effects in early stages and rendering possible prediction of future effects from past time experiences [5].

Several approaches were proposed to evaluate the change impact while being often based on the analysis of the

dependency graph or on the traceability relations between the software components of the system at different abstraction levels. Furthermore, it was noted that the document the most used as bases knowledge in the majority of the impact analysis approaches is mainly the source code because this latter is easy to access and provided up to date information contrary to the conceptual documentation or specifications, for example, which is non-existent, incomplete or obsolete.

Considering the importance of the work already undertaken in this field and the numerous approaches which have been proposed, it appeared interesting to us to gather most relevant works as a comprehensive state of art. Thus, this article established a survey on software change impact analysis approaches currently used in the field of the software engineering and in particular in software maintenance. For each type of approaches, we will present the principle, the techniques and tools allowing their implementation, the advantages and the limits of such approaches.

The remainder of the paper is organized as follows: section II presents the work already achieved in this field. In section III, we will stress the types of impacts of a change before exposing in section IV the various software change impact analysis approaches. This paper concludes with some directions for future works.

## II. RELATED WORKS

Although it is not new field, the change impact analysis was widely discussed in the literature and remains an active field of research which is in perpetual evolution. In 1979, Weiser [11] introduced the technique of "Program Slicing" which aims at extracting the parts of a program impacted by a given change. The concept of "Ripple effects" was introduced in 1980 by Yau and Collofello [11]. Their model allows the evaluation of the impact due to the propagation of a change in the source code. In 1996, Arnold and Bohner published a series of research papers entitled: "Software Changes Impact Analysis" by gathering principal works relating to the analysis of change impact [3]. In their approach of "Document-Driven Development", Turver and Munro claim that during the development of a new version of software, various types of documents (design documents, user's manual) must be updated as well as the source code. The impact on the source code also relates to the associated documents [23]. In order to simplify the representation and the analysis of the networks of dependencies in the complex

systems, Bohner and Gracanin [11] proposed to combine the impact analysis techniques with 3D visualization techniques.

Since the 1980s, there have been many investigations on change impact analysis, especially in the field of code-based techniques [4]. Wilkerson proposes in [24] taxonomy of the types of impacts that can result from source code changes in both procedural and object-oriented code. In [14] Kilpinen identifies three groups of impact analysis approaches: dependency impact analysis, traceability impact analysis and experimental impact analysis.

In traceability impact analysis, traceability links are the basic mean to express relationships between system components, and they are used to connect entities of different levels of abstraction, e.g. requirements and source code. Traceability links can be utilized to propagate changes, or the impact of changes to related elements.

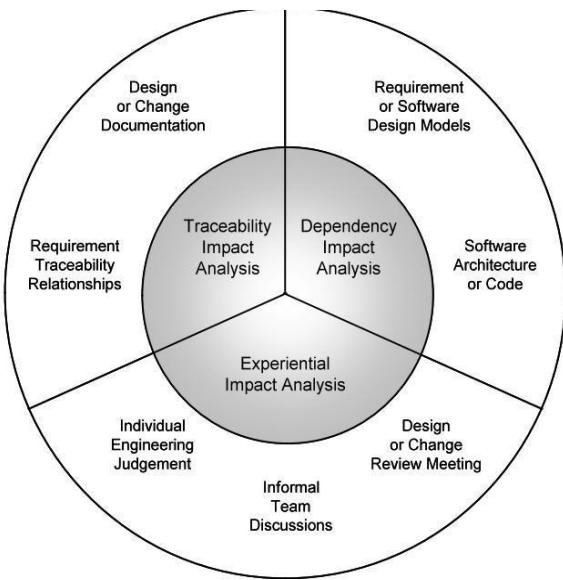


Fig. 1. Types of change impact analysis techniques [13].

In dependency impact analysis group, impact analysis can be conducted within the internal links of a software system, such as dependencies between objects, methods, and variables. Several techniques which utilize program dependencies have been proposed, for example program slicing.

Although the source code based techniques are the most used to asses change impact (see fig. 2.) because they have the advantage of being more precise in their calculus by identifying the impact at the surest state (i.e. on the final product); however, they have the disadvantage of being limited in the range, time consuming and they require the implementation of the change before the impact can be computed.

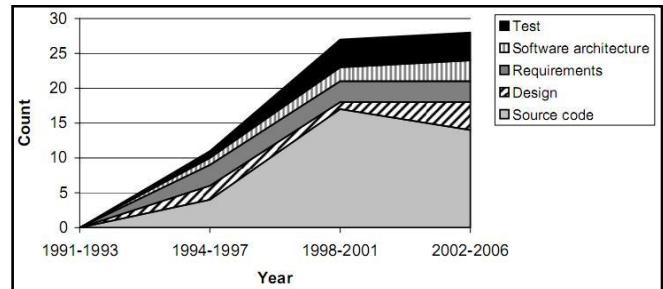


Fig. 2. Impact analysis target in research papers, distribution over time [11].

In contrast to source code based techniques like dependency analysis, experimental approaches are focused on manual analysis and therefore labor intensive techniques, such as audits, reviews, and code inspections [16].

### III. TYPES OF CHANGE IMPACT

An assessment of the impact of certain change requires explicit information about the nature of the change, about the type of the involved artifacts, as well as about dependency relations between the artifacts [15]. That change impact can be primary or secondary according to the distance from the origin of the change.

#### A. Primary impact

Primary impact, also referred to as direct impact, corresponds to the components of the system that are identified by analysing how a proposed change affects the system. This analysis is typically difficult to automate because it is mainly based on human expertise.

#### B. Secondary impact

Secondary impact or indirect impact is complementary changes following a primary change due to design constraints, system's structure or functional dependencies. The indirect impact can take two forms:

Side effects: are unintended behaviors resulting from the modifications needed to implement the change. Side effects affect both the stability and function of the system and must be avoided.

### IV. SOFTWARE CHANGE IMPACT ANALYSIS APPROACHES

Based on a thorough literature review, we distinguish five main classes of software change impact analysis approaches:

- Static impact analysis approaches.
- Dynamic impact analysis approaches.
- History based impact analysis approaches.
- Information retrieval (IR) based impact analysis approaches.
- Probabilistic based impact analysis approaches.

#### A. Static impact analysis approaches

##### 1) Automatable approaches

Automatable impact analysis approaches often employ algorithmic methods in order to identify change propagation and indirect impact. Nevertheless, these approaches require a structured specification of the system such as the object model, the control flow diagram, data flow, and dependency graph .etc.

The automatable approaches are more suitable to evaluate the secondary impacts than to determine the primary impacts. Several approaches were developed for the analysis of dependencies but three main lines of techniques have been described in the literature for implementing such analysis approach:

#### *a) Dependency analysis*

The dependency analysis consist in exploring, capturing and defining the dependence relationships that exist between the software artefacts being in the same level of abstraction, generally on the level of the source code: modules, functions, classes, methods or variables.

A network of dependencies can be represented in two manners: the written way (the dependency graph) [7] or a matrix way (dependency structure matrix) [19]. It is sometimes possible to enrich the matrix by semantic information such as the type of relationships in order to improve and simplify its interpretation.

#### *b) Traceability analysis*

Traceability is the capacity to describe and trace the life cycle of software artefacts from requirement specification to source code and reciprocally [22].

The traceability analysis, on the other hand, can provide information on the existing relationships between the requirements, the design and the implementation artefacts, being thus a support for studying the impact of changes. The quality of the analysis of traceability in addition, is determined by the completeness of the whole of the relations which were identified gradually during the development of the system.

The traceability analysis has the advantage of being applicable at first stages of the software development cycle and thus allows identifying various types of impacted artefacts. Consequently, the field of application of the traceability analysis is much broader than that of the dependency analysis which completely relies on the availability of the source code.

Among the tools for traceability analysis: DOORS, Rational Requisite Pro and TOOR (Traceability of Object-Oriented Requirements). The weak point of all these tools is that they do not support automatic or semi-automatic maintenance of traceability links and do not take into account the new versions of the artefacts. Thus, the detection and the maintenance of the bonds of traceability must be operated manually, generating high costs. The investment is all the more heavy if one takes into account the iterative nature of the development processes [22].

#### *c) Program slicing*

The program slicing technique seeks to delimit wide change in a program by breaking it up into two independent parts: the part affected by the change and the part representing the remainder of the program. To locate the impacted elements, the technique of program slicing employ the data flow, the control flow or the dependency graph. The whole of these algorithms are thus based on the analysis of the source code of the programs.

Architectural slicing is an alternative which was introduced by Zhao in 1998 [11]. The advantage of architectural slicing is that it can be applied independently of the availability of the source code.

#### *2) Semi automatable approaches*

Semi automatable approaches or interactive approaches rely on collaboration between the man (the analyst) and the machine (an impact analysis support tool). The analysis process consists then in alternating control between these two entities as follows:

At each iteration, the tool explores the dependency relationships; compute a whole of elements likely to be affected by the change which are proposed to the analyst. This last examines then determines among the identified elements those which he considers relevant.

These approaches allow, on a side, to accelerate the calculation part of the process of impact analysis and on the other, to improve quality of the predictions by giving the possibility to the analyst of intervening to correct the possible errors made by the tool support.

Among the tools most used in this category, we can find: JRipples (Ripples Java) which was integrated thereafter in the Eclipse development environment.

#### *3) Manual approaches*

Contrary to the automatable approaches, the manual ones are easy to integrate in a process of change management. However they miss some precision of calculation.

The manual approaches, generally, are intended to determine primary impacts generated by a change i.e. to identify the whole of the elements of starting impact set.

#### *a) Design document based manual approaches*

A design document (an architectural model, UML diagram, a simple textual specification describing the components of the system .etc) is characterized by a whole of attributes like: the context in which it was published, its version, the goal of its creation, its frequency of update and the data which it provides. The precision of the predictions and the quality of the impact analysis depend primarily on the quality of the design documents as well as the following factors:

- The availability and the quality of the documentation used during the analysis.
- The homogeneity of the vocabulary, terminology and used notations.

- The clearness and coherence of documentation.
- The experiment and preliminary knowledge of the analysts on the studied system.

#### *b) Interview approaches*

According to a study on the analysis of impact (Lindval, 1997), the interview with the developers is considered as the fastest means for the capturing information on a software and the possible consequences of a given change [11].

In [10] authors have conducted an empirical study using interviews in order to understand how issues associated with impact analysis are seen at different levels and under different perspectives.

Indeed, the analysts find that it is more practical to question the developers which are quite informed on the system than searching in documentation, if it exists, needed information.

#### *B. Dynamic impact analysis approaches*

Dynamic impact analysis approaches consist in collecting, through a series of executions, information on the behavior of a program such as: order of the functions (procedures or methods) calls, the results turned over, the end of execution of the program... etc. The whole of the impacted elements is the whole of the parts of the program which are executed simultaneously with the initially modified parts.

##### *1) Simulation*

Simulation is a dynamic approach which proposes also mechanisms to estimate quantitatively and qualitatively the impact due to a change.

By means of simulation tools one can, for example, assign values to the various components of the system, simulate a whole of changes and analyze the results obtained. That means we can anticipate the undesirable repercussions of a possible change, study the various aspects of the change: time, cost, resources and provide estimates concerning the impact of the change on the system performances.

In spite of the advantages mentioned above, simulation presents some limits:

- Failure to gather a large amount of data necessary to simulation what is sometimes difficult to achieve.
- The quality of the collection of simulation data which must be consistency in order to cover all possibilities.
- The simulation of complex systems comprising several processes in interaction requires more resources.

#### *C. History based impact analysis approaches*

With the availability of the historical data which allow to store and exploit the versions management systems as well as the bugs tracking systems, a new prospect of change impact analysis was born, namely: History based Impact

Analysis approaches. In fact, these approaches come to supplement those previously mentioned in bringing extra information's relating to the types of the frequent changes, the causes of these changes, elements changing simultaneously... etc.

##### *1) Association rules based approaches*

The approach suggested by Ying & Al [6], consists in representing the simultaneous changes (Co-changes) which were met in the past by a set of association rules which will be used thereafter to determine the impact of a future change. That means that the change of an artifact **A** will be probably followed by a change of an artifact **B** if these artefacts changed jointly in the past.

The advantage of this approach is its aptitude to capture the coupling relationship of change which exists between the entities of the system without there being explicit dependency relationship between them. However, the coupling and causality relationships from which the repercussions appears later in time are difficult to capture.

##### *2) Mining Software Repository approaches*

MSR for short treats system evolution and software impact change prediction from a historical point of view. The historical data analysis allows, in fact improving comprehension of the software evolution and the prediction of future changes.

Contrary to the techniques of static impact analysis where only the current version of the software is taken into account, MSR adopts a multi versions view to software change prediction [12].

MSR techniques are similar to those used in knowledge extraction and data mining. By analyzing the historical data of several versions of the source code, MSR techniques allow [1]:

- Detect the coupling and dependency relationships.
- To define patterns of modification which can be taken into account to predict the future changes of the later versions.
- To envisage trends of change.

However, the quality of the results obtained with this approach depends on the relevance of the historical data to take into account: neither too old thus become obsolete, nor too recent because it is likely to be based on unstable short period of the system [21].

#### *D. IR-based impact analysis approaches*

The software development is often accompanied by the production of various types of documents expressed in natural language like requirements specification, certain documents of design or simple user's guide. The fact of identifying dependency relationships and establishing traceability links between these informal documents and the source code (*text-to-code traceability links*) can play a crucial role in the change impact analysis process as well as

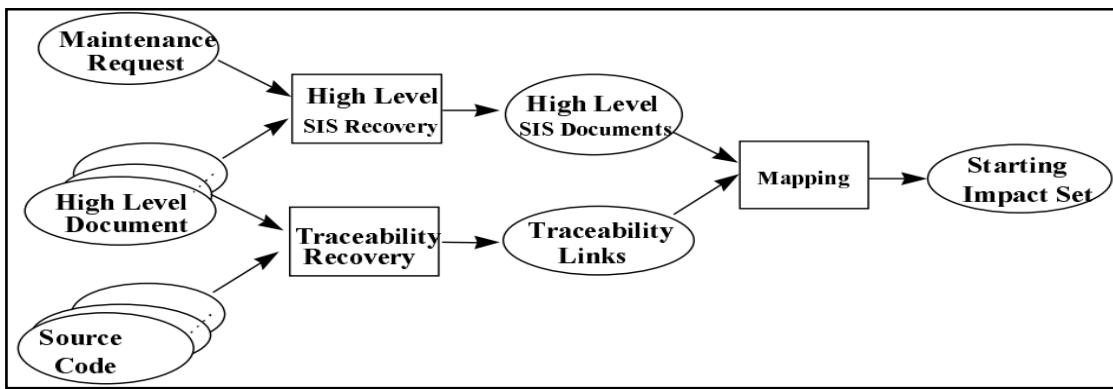


Fig. 3. Text to code traceability impact analysis method [2].

in several other activities like program comprehension and software maintenance.

The impact analysis based on information retrieval techniques allow us to trace the text of a maintenance request onto the set of system components initially affected by the maintenance request [2].

The first stage consists in sorting the documents according to their relevance to the text of the maintenance request. In the second phase, all the existing documents are "mapped" towards the source code components to which they refer. Finally, this "mapping" serve to find the impacted elements of the code corresponding to the relevant documents identified in the first stage.

In order to help counter the precision or recall deficit of individual techniques and improve the overall accuracy, a novel approach which combine information retrieval with dynamic analysis and mining software repositories techniques (MSR) has been proposed in [17].

#### E. Probabilistic based impact analysis approaches

##### 1) Bayesian networks-based approaches

As there exists always a part of uncertainty difficult to manage for the comprehension of the propagation process of the effects of a change, the Bayesian networks, by integrating uncertainty, then offer a particular quantitative approach which can provide suitable predictions in the presence of subjective judgments of experts or missing information that is inherent in the field of the software engineering [1].

The other advantage of Bayesian networks is their capacity of incremental learning from historical data. This capacity will contribute to the improvement, with time, of the structure of Bayesian networks and its parameters, and this, by the acquisition of new data.

Nevertheless, other probabilistic approaches have been developed such as CPM (Change Propagation Method) (for more details refer to [9]) and machine learning based approach for predicting maintainability.

## V. DISCUSSIONS

The ability to identify the change impact or possible effect will greatly help a maintainer or manager to determine

appropriate actions to undertake with respect to change decision, schedule plans, cost and resource estimations [20].

The amount of proposed approaches for change impact analysis is vast and a comprehensive paper is required to enable their evaluation and comparison. We provided through this article a repertory gathering the whole of the most relevant change impact analysis approaches while we have emphasized advantages, underlined the limits and exposed the techniques used.

The manual approaches are hard and error prone since it relies on the human factor while the automatable approaches are costly and more resources consuming. The tools used by the majority of impact analysis approaches are based on source code or need a substantial human interaction to achieve their task.

We project in our future works to extend the present work by considering new change impact analysis approaches, then comparing them empirically with standardized metrics and common benchmarks in order to provide some features and recommendations which could facilitate software maintainer's tasks .

In addition, one of interesting application domain of the approaches described in this paper is the information system evolution according to business processes. Indeed, business processes being the way to synchronize business rules, they have to be managed when these rules change. The impact can be important on information system such as the modification of database structure or evolution of services and programs. Before applying changes, it is necessary for manager to have an idea of the cost of changing. This application domain will necessitate both the investigation of new techniques for analyzing the impact of rule's change and revisiting existing ones.

Approaches	Techniques	Principle	Artifact/level of analysis
Static impact analysis	Automatable approaches (dependency, traceability & program slicing)	Consist in capturing and defining the dependence relationships that exist between the software artifacts	Change concerns the source code of the system: modules, functions, classes, methods or variables.
	Semi automatable approaches	Rely on collaboration between the man and the machine	Source code level
	Manual approaches	Rely on human capabilities	Design documents (an architectural model, UML diagram, .etc) Interview with experts
Dynamic impact analysis	Simulation	Change occurs during execution of the software	Source code artifacts
History based impact analysis	Mining Software Repository Association rules	Consists in capturing the simultaneous changes (Co-changes) which were met in the past	Source code repositories (multiple versions of source code)
Information retrieval (IR) based impact analysis	Text-to-code traceability	Consists in sorting the documents according to their relevance to the text of the maintenance request onto the set of software components initially affected by the maintenance request.	Design documents Source code artifacts
Probabilistic based impact analysis	Bayesian networks Change Propagation Method	Prediction of the propagation process of the effects of a change.	Different abstraction levels

Fig. 4. Summary of Change Impact Analysis Approaches.

## REFERENCES

- [1] Abdi, M.K., Lounis, H., Sahraoui, H. "Analyse et prédition de l'impact de changements dans un système à objets : Approche probabiliste". In COMPSAC '09 proceedings of the 33rd IEEE International Computers, Software and Applications Conference, (pp. 234-239). Seattle, USA, 2009.
- [2] Antoniol, G., Canfora, G., Casazza, G., & De Lucia, A. "Identifying the starting impact set of a maintenance request: A case study". In Software Maintenance and Reengineering, 2000. Proceedings of the Fourth European (pp. 227-230). IEEE, 2000.
- [3] Bohner, S.A. & Arnold, R.S., "Software Change Impact Analysis", IEEE Computer Society Press, Los Alamitos, California, US, 1996.
- [4] Bixin, L. & al. "A survey of code-based change impact analysis techniques". Software Testing, Verification and Reliability. Vol 23, issue 8, (pp 613-646). December 2013.
- [5] Breivoll, J & al. "Change Impact Analysis – A Case Study". In 8th Conference on Systems Engineering Research, 2010.
- [6] Ceccarelli, M., Cerulo, L., Canfora, G., & Di Penta, M. "An eclectic approach for change impact analysis". In ICSE '10 proceedings of the 32nd ACM/IEEE International Conference on Software Engineering-Vol 2 (pp. 163-166).ACM, 2010.
- [7] Chetna, G., Yogesh, S. and Durg, S.C. "Dependency based Process Model for Impact Analysis: A Requirement Engineering Perspective". In International Journal of Computer Applications. Vol 6–No.6, September 2010.
- [8] Chetna, G. & al. "An Efficient Dynamic Impact Analysis using Definition and Usage Information". International Journal of Digital

Content Technology and its Applications Vol. 3, No 4, December 2009.

- [9] Clarkson, J., Simons, C. and Eckert, C. "Predicting change propagation in complex design". In Proceedings of the 2001 Design Engineering Technical Conferences and Computers and Information in Engineering Conference. 2001.
- [10] Hassan, O.A & al. "Approaches of Impact Analysis Assessment and Classification towards Projects Changes". In World Journal of Social Sciences. Vol. 2. No. 7, (pp 167-173). November 2012 Issue.
- [11] Jönsson, P., "Exploring Process Aspects of Change Impact Analysis" .Doctoral dissertation. 2007.
- [12] Kagdi, H., & Maletic, J. I. "Software-Change Prediction: Estimated+Actual". In Software Evolvability, 2006. SE'06. Second International IEEE Workshop on (pp. 38-43). IEEE, 2006.
- [13] Kilpinen, M.S. and Clarkson, P.J., "Exploiting change impact analysis to support sustainability". In: 7th Annual Conference on Systems Engineering Research, CSER'09, Loughborough, UK, 2009.
- [14] Kilpinen M.S., "The Emergence of Change at the Systems Engineering and Software Design Interface: An Investigation of Impact Analysis", PhD Thesis, University of Cambridge, Cambridge, UK, 2008.
- [15] Lehnert, S. & al. "A Taxonomy of Change Types and its Application in Software Evolution". In ECBS '12 Proceedings of the 2012 IEEE 19th International Conference and Workshops on Engineering of Computer-Based Systems (pp 98-108), 2012.
- [16] Lehnert, S., "A Taxonomy for Software Change Impact Analysis ". In IWPSE-EVOL '11 Proceedings of the 12th International Workshop on Principles of Software Evolution and the 7th annual ERCIM Workshop on Software Evolution (pp. 41-50), 2011.
- [17] Malcom, G. "Integrated Impact Analysis for Managing Software Changes". In Proceedings of the 2012 International Conference on Software Engineering (pp. 430-440 ). 2012.

- [18] Michele, C. & al. "An Eclectic Approach for Change Impact Analysis". In 32nd ACM/IEEE International Conference on Software Engineering. Vol. 2, (pp 163-166). 2010.
- [19] Rutka & al. "Methods for engineering change propagation analysis". In 25<sup>th</sup> international congress of the aeronotical sciences. 2006.
- [20] Suhaimi, I. & al. "Integrating Software Traceability for Change ImpactAnalysis". In The International Arab Journal of Information Technology, Vol. 2, No. 4. October 2005.
- [21] Sunny, W., Yuanfang, C. and Michael, D. "Change Impact Analysis with Stochastic Dependencies". In the 33<sup>rd</sup> International Conference on Software Engineering. 2011.
- [22] Vasutiu, O., "Gestion des connaissances pour la maîtrise de la relation entre patrimoine documentaire et système d'information". Doctoral dissertation, 2009.
- [23] Vasutiu, O., Jouve, D., Amghar, Y. "Gestion des changements et étude d'impact dans un système d'information réglementaire". In INFORSID (pp. 1007-1022), 2006.
- [24] Wilkerson, J.W. "A Software Change Impact Analysis Taxonomy". In ICSM '12 proceedings of the 28th IEEE International Conference on Software Maintenance (pp. 625 - 628), 2012.

# Critères de sécurité pour l'utilisation de la e-santé en Algérie

MIROUD Mohammed El Mustapha <sup>(1)</sup>

Laboratoire LAMOSI, Département d'Informatique,  
Faculté des Mathématiques et Informatique, USTOMB,  
31000 Oran, Algérie  
<sup>(1)</sup> miroud.moeps@gmail.com

BELKADI Khaled (*Author*)

Laboratoire LAMOSI, Département d'Informatique,  
Faculté des Mathématiques et Informatique, USTOMB,  
31000 Oran, Algérie  
belkadi1999@yahoo.com

**Résumé:** Des défaiillances dans la protection des données médicales dans un système e-santé peuvent entraîner la divulgation d'informations sensibles et de graves préjudices pour les patients. Dans cet article nous utilisons la méthode d'analyse de risque « expression des besoins et identification des objectifs de sécurité » sur un système d'information hospitalier afin de définir les risques inhérent à la e-santé. Nous avons identifié les sources de menaces, les mesures de sécurité existantes et proposé d'autres mesures afin de réduire, ou de supprimer les risques identifiés. Nous avons également relevé les manques en matière de législation et de code d'éthique en Algérie pour arriver à avoir une base solide sur laquelle on peut travailler en matière de protection des données à caractère personnelles. Nous avons proposé des mesures de sécurité afin de réduire les risques identifiés.

**Mots clés:** e-santé, sécurité, protection des données personnelles, EBIOS, analyse de risques. ()

## I.INTRODUCTION SUR LA SÉCURITÉ DANS LA E-SANTÉ

Dans le contexte d'un système e-santé, il est primordial de fournir tous les moyens permettant de maîtriser les risques et les menaces pouvant toucher de près ou de loin aux informations liées à la santé des patients. Ces informations doivent être protégées contre les manipulations, les accès non autorisés et les abus. [1].

Les données médicales contenues dans les systèmes d'information hospitaliers sont considérées comme hautement sensibles, leur stockage, transfère ou utilisation comporte des risques spécifiques au domaine de la santé en plus des risques classiques partagés avec les autres types de données. En effet les données médicales sont sujettes au secret médical et doivent être en conformité avec la déontologie et la législation en vigueur dans le pays concerné. C'est pour cette raison que l'international standard organisation (ISO) a produit un standard spécifique pour ce genre de systèmes [2] qui est une extension et un complément du standard [3] traitant de la sécurité de l'information.

Mekanne et al. [1] ont déjà traité le contrôle d'accès aux données personnelles dans un système e-santé (dossier médical partageable) ils se sont néanmoins focalisés sur les droits d'accès, ils ont introduit un modèle de contrôle d'accès appelé OrBAC qui intègre les exigences en matière de protection des

données personnelles de patients en assurant les moyens adéquats pour garantir que les préférences des patients soient prises en considération lors de la demande d'accès. A travers ce modèle, le patient pourra exprimer sa politique de protection de données personnelles par l'étiquetage des données médicales sensibles et l'octroi des permissions d'accès à ces données pour le personnel de confiance. Cependant Mekanne et al. [1] ne se sont basés sur aucune loi, ou code médical pour définir ce qu'est une donnée sensible, ils ont conféré au patient la responsabilité de choisir lui-même les données sensibles auxquelles même son médecin traitant ne pourra pas accéder sans son autorisation. Par exemple le patient peut masquer une tentative de suicide, une maladie sexuellement transmissible ou un avortement alors que le médecin traitant se doit de connaître tous les antécédents du patient afin de pouvoir établir le bon diagnostic et prodiguer les soins adéquats. Nous jugeons que le patient n'a pas les compétences nécessaires pour jouer ce rôle de régulateur. Nous jugeons également que Mekanne et al. [1] se sont attaqués au droits d'accès sur les données sans définir au préalables une base solide sur laquelle ils peuvent s'appuyer. En effet ce genre de droit se doit d'être régi par une loi ou un code d'éthique adapté. Avant de pouvoir parler de sécurité des systèmes e-santé, il faut d'abord définir les risques et les menaces qui pèsent sur ces systèmes, la définition de ces critères peut se faire à l'aide d'une méthode d'analyse des risques.

Notre contribution est portée sur la définition des critères de sécurité nécessaires à un système e-santé en Algérie. Nous avons effectué une analyse de risques dans un Hôpital Universitaire utilisant un système d'information pour gérer ses dossiers patients. Nous avons utilisé la méthode EBIOS « expression des besoins et identification des objectifs de sécurité » et avons établi les risques inhérents à un système e-santé. Nous avons proposé des mesures de sécurité supplémentaires issus des standards internationaux [3] et [2] et réévalué les risque précédemment identifiés. Nous avons également étudié le code de déontologie médical Algérien et relevé ses manques et son inadaptabilité à l'e-santé. Nous avons également relevé le manque dans la législation Algérienne en termes de protection des données personnelles en comparaison avec nos voisins Tunisiens et Marocains.

## II.LA GESTION DU RISQUE

Les systèmes d'information actuels doivent faire face à plusieurs menaces susceptibles d'exploiter leurs vulnérabilités. Pour limiter l'impact de ces menaces, une politique de gestion des risques doit être mise en œuvre.

Un des outils à disposition du praticien de la sécurité de l'information et des organisations qui souhaitent mettre en œuvre un processus de gestion du risque informationnel est la méthodologie d'analyse de risque. De nombreuses méthodologies existent sur le marché, certaines gratuitement, d'autres à un coût non négligeable. Chacune de ces méthodologies peut s'avérer un outil efficace lorsqu'elles sont utilisées diligemment dans un contexte bien déterminé. Cependant, comme tout outil, elles ont des limites. Elles ont une utilité propre, souvent dans un contexte organisationnel particulier ou un domaine d'activité limité (Banques, ministère). Comme d'autres méthodologies de recherche, les méthodologies d'analyse de risque cherchent à mesurer des concepts. Dans ce cas précis, les méthodologies cherchent à mesurer le risque informationnel, par l'intermédiaire de variables (comme la menace ou l'impact) selon des échelles de mesure (par exemple : bas, moyen, élevé). Plusieurs des concepts mesurés ne peuvent être mesurés directement (par exemple comme lire la température sur un thermomètre) mais indirectement, en demandant à quelqu'un d'indiquer quelle est son estimation de la valeur de la mesure de la variable attribuée au concept. Ainsi comme toute méthodologie, la méthodologie d'analyse de risque informationnel doit tenir compte de plusieurs sources d'erreur ou de biais, soit en relation à la sélection des individus qui donnent les réponses, de l'interprétation à donner aux réponses, du type de mesures utilisées, de l'analyse (explicative ou statistique) ou de l'interprétation des résultats. [4].

Il est essentiel qu'une organisation puisse identifier ses critères de sécurité, il existe trois sources de critères de sécurité principaux :

La première source est dérivée de l'analyse de risque de l'organisation en prenant en compte la stratégie commerciale globale de l'organisme ainsi que ses objectifs. Cette analyse est effectuée à l'aide d'une méthodologie d'analyse des risques, les menaces sont identifiées, les vulnérabilités et leur probabilité d'occurrence et leur potentiel impact sont estimé.

La deuxième source consiste en le cadre légal et éthique que l'organisme et ses partenaires se doivent de respecter, le milieu socio-culturel dans lequel l'organisme évolue doit également être pris en compte.

La troisième source consiste en les principaux critères et objectifs commerciaux que l'organisation se doit de respecter et d'atteindre afin de garantir le bon déroulement de ses activités [3].

Les critères de sécurité sont identifiés par une méthodologie d'analyse de risques, les dépenses en matière de sécurité doivent être proportionnelles aux préjudices potentiels d'une exploitation de vulnérabilité.

Les résultats de l'analyse des risques vont aider à déterminer les actions à entreprendre ainsi que les priorités dans la gestion des risques informationnels. Ses résultats vont

également jouer un rôle dans la définition des mesures de sécurité à prendre afin de réduire ses risques [3].

L'analyse de risque doit être répétée périodiquement lors de chaque changement susceptible d'influencer les résultats de l'analyse précédente [3].

Dans cet article nous allons présenter les résultats d'une analyse de risques à l'aide de la méthodologie EBIOS, cette analyse a été effectuée dans un hôpital qui utilise un système d'information pour la gestion de ses dossiers patient. Nous allons proposer des mesures de sécurité afin de réduire les risques identifiés et que le système devienne plus conforme à normes internationales en la matière, en l'occurrence [3] qui traite des techniques de sécurité pour le management de la sécurité de l'information et [2] qui traite de la sécurité de l'information appliquée au systèmes e-santé. Nous allons enfin discuter des manques que nous avons constaté dans la législation Algérienne en termes de protection des données médicales et personnelles.

## III. LA MÉTHODOLOGIE EBIOS

La méthodologie EBIOS (Expression des Besoins et Identification des Objectifs de Sécurité) est un outil complet de gestion des risques de la sécurité des systèmes d'information (SSI) conforme aux dernières normes ISO 27001, 27005 et 31000.

Crée en 1995 par l'ANSSI (l'agence nationale française de sécurité des systèmes d'informations) la méthode EBIOS bénéficie des 20 ans d'expérience de l'agence dans le domaine de la gestion du risque. Elle permet d'apprécier et de traiter les risques relatifs à la (SSI). Elle permet aussi de communiquer à leur sujet au sein de l'organisme et vis-à-vis de ses partenaires, constituant ainsi un outil complet de gestion des risques SSI.

E BIOS est assortie d'une base de connaissances cohérente avec le référentiel général de sécurité, enrichie d'exemples concrets permettant d'élaborer des scénarios de risque pertinents pour l'organisme. Elle comprend enfin une étude de cas type, permettant d'appréhender la méthode. [5]

E BIOS est en outre gratuite open source et en français ce qui nous motive encore plus pour la choisir entre les différentes méthodes de gestion de risques existantes dans le monde.

E BIOS se décompose en plusieurs phases que nous allons détailler dans la section qui suit

### A. L'établissement du contexte

Un contexte bien défini permet de gérer les risques de manière parfaitement appropriée, et ainsi de réduire les coûts à ce qui est nécessaire et suffisant au regard de la réalité du sujet étudié. Pour ce faire, il est essentiel d'appréhender les éléments à prendre en compte dans la réflexion :

- le cadre mis en place pour gérer les risques ;
- les critères à prendre en considération (comment estimer, évaluer et valider le traitement des risques) ;
- la description du périmètre de l'étude et de son environnement (contexte externe et interne, contraintes, recensement des biens et de leurs interactions...). La méthode E BIOS permet d'aborder tous ces points selon le degré de connaissance que l'on a du sujet étudié. Il sera ensuite possible

de l'enrichir, de l'affiner et de l'améliorer à mesure que la connaissance du sujet s'améliore.

#### B. L'appréciation des risques :

Selon EBIOS, il y a risque de sécurité de l'information dès lors qu'on a conjointement une source de menace, une menace, une vulnérabilité, et un impact.

Le principal enjeu est de réussir à obtenir les informations nécessaires à l'analyse qui puissent être considérées comme fiables. C'est la raison pour laquelle il est extrêmement important de veiller à ce que ces informations soient obtenues de manière à limiter les biais et à ce que la démarche soit reproductible.

#### C. Le traitement des risques

Les risques appréciés permettent de prendre des décisions objectives en vue de les maintenir à un niveau acceptable, compte-tenu des spécificités du contexte. Pour ce faire, EBIOS permet de choisir le traitement des risques appréciés au travers des objectifs de sécurité : il est ainsi possible, pour tout ou partie de chaque risque, de le réduire, de le transférer (partage des pertes), de l'éviter (se mettre en situation où le risque n'existe pas) ou de le prendre (sans rien faire). Des mesures de sécurité peuvent alors être proposées et négociées afin de satisfaire ces objectifs.

#### D. Une démarche itérative en cinq modules :

La méthode formalise une démarche de gestion des risques découpée en cinq modules représentés sur la figure 1 suivante :

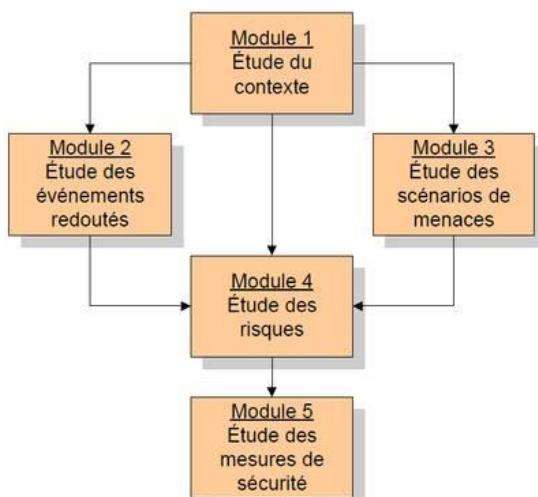


Figure 1: Démarche itérative en cinq modules

La démarche est dite itérative. En effet, il sera fait plusieurs fois appel à chaque module afin d'en améliorer progressivement le contenu, et la démarche globale sera également affinée et tenue à jour de manière continue surtout en cas d'ajout au système qui pourrait avoir une influence sur la sécurité.

#### Module 1 – Étude du contexte

À l'issue du premier module, qui s'inscrit dans l'établissement du contexte, le cadre de la gestion des risques,

les métriques et le périmètre de l'étude sont parfaitement connus ; les biens essentiels, les biens supports sur lesquels ils reposent et les paramètres à prendre en compte dans le traitement des risques sont identifiés.

#### Module 2 – Étude des événements redoutés

Le second module contribue à l'appréciation des risques. Il permet d'identifier et d'estimer les besoins de sécurité des biens essentiels (en termes de disponibilité, d'intégrité, de confidentialité...), ainsi que tous les impacts (sur les missions, sur la sécurité des personnes, financiers, juridiques, sur l'image, sur l'environnement, sur les tiers et autres...) en cas de non-respect de ces besoins et les sources de menaces (humaines, environnementales, internes, externes, accidentelles, délibérées...) susceptibles d'en être à l'origine, ce qui permet de formuler les événements redoutés.

#### Module 3 – Étude des scénarios de menaces

Le troisième module s'inscrit aussi dans le cadre de l'appréciation des risques. Il consiste à identifier et estimer les scénarios qui peuvent engendrer les événements redoutés, et ainsi composer des risques. Pour ce faire, sont étudiées les menaces que les sources de menaces peuvent générer et les vulnérabilités exploitables.

#### Module 4 – Étude des risques

Le quatrième module met en évidence les risques pesant sur l'organisme en confrontant les événements redoutés aux scénarios de menaces. Il décrit également comment estimer et évaluer ces risques, et enfin comment identifier les objectifs de sécurité qu'il faudra atteindre pour les traiter.

#### Module 5 – Étude des mesures de sécurité

Le cinquième et dernier module s'inscrit dans le cadre du traitement des risques. Il explique comment spécifier les mesures de sécurité à mettre en œuvre, comment planifier la mise en œuvre de ces mesures et comment valider le traitement des risques et les risques résiduels.

### IV. RÉSULTATS DE L'ANALYSE DE RISQUES

Nous allons à présent présenter nos résultats après l'application de EBIOS sur un système hospitalier qui utilise et stocke des données médicales sur ses serveurs.

Le but de l'étude est de permettre de faire une analyse des risques pour le SIH (système d'information hospitalier) de l'hôpital.

#### A. L'objectif de l'étude :

Gérer les risques SSI sur le long terme et élaborer une politique de sécurité de l'information. Nous souhaitons que les risques de sécurité de l'information qui pourraient empêcher l'hôpital d'atteindre ses objectifs soient gérés, et ce, de manière continue. Nous avons pour objectifs de :

D'optimiser les processus métiers en maîtrisant les risques de sécurité de l'information ;

De mettre en place un système de management de la sécurité de l'information ;

D'élaborer d'une politique de sécurité de l'information, (elle doit être produite, appliquée et contrôlée) ;

#### *B. L'organisme étudié :*

C'est un établissement hospitalier universitaire, ci-après dénommé, par abréviation « HC », c'est un établissement public à caractère spécifique, doté de la personnalité morale et de l'autonomie financière, sous la tutelle administrative du ministre de santé. Nous n'allons pas citer le nom exact de l'établissement pour des raisons de sécurité.

#### *C. Les principaux métiers représentés :*

Les médecins, infirmier, informaticien (pour la gestion du système informatique) et personnel administratif

#### *D. Normes et principes directeurs adoptés par l'organisme*

Etant un Hôpital HC sa mission principale est la fourniture de soins de qualité aux patients, il doit néanmoins avoir une politique de gestion de l'information des patient (gestion des dossiers médicaux, et des informations personnelles ) en accord avec les principes d'éthique et de déontologie médical ainsi qu'avec la législation en vigueur en Algérie, il doit entre autre respecter le secret médical des patients, mais néanmoins garantir que ces informations soient transmises aux proches du patients si celui-ci fournit son accord ou bien à d'autres médecins pour avis.

Le principal processus métier concerné par l'étude est la fourniture de soins, les autres processus ne seront pas concernés par l'étude (comptabilité, gestion des ressources humaines, gestion des stocks)

Le système informatique du HC se compose de serveurs, de switch, de machines, ainsi que d'un système d'information.

Le sujet de l'étude représente la partie du système d'information du SH indispensable pour qu'il exerce son cœur de métier. L'ensemble du patrimoine informationnel des patients est créé, traité et stocké sur ce système d'information. Le sujet représente également la conformité avec la législation en vigueur ainsi qu'avec les principes éthiques et déontologiques. L'étude s'est également portée sur la sécurité du site internet de l'établissement

#### *E. Les participants à l'étude sont définis comme suit :*

La population de l'étude est l'ensemble des collaborateurs travaillant dans le périmètre choisi (Médecins, infirmiers, aides soignant, secrétaires, agents de saisie, administrateurs système). Au moins un personnel de chaque catégorie participe à l'étude ; d'autres personnels peuvent également participer à l'étude afin d'apporter un point de vue extérieur ; Les critères de sélection sont les meilleures connaissances du métier en général.

#### *F. Les enjeux suivants ont été identifiés :*

Démontrer la capacité du l'établissement à protéger les informations sensibles.

Améliorer les services rendus aux patients et la qualité des prestations ;

Faire respecter les principes de déontologies et d'éthique médicale (confidentialité des données médicales).

Etre en conformité avec la législation (protection des données à caractère personnelles).

Garantir la disponibilité des données et du réseau à tout instant (la vie des patients peut en dépendre).

Garantir l'intégrité des données transmises à travers le réseau.

### V. IDENTIFICATION DES PARAMETRES A PRENDRE EN COMPTE LORS DE L'ETUDE

#### *A. Contraintes relatives au personnel :*

Le personnel doit avoir accès aux dossiers médicaux des patients se trouvant dans son service

Tous les personnels utilisant l'informatique n'est pas spécialisé en informatique

#### *B. Référence communautaire, légale et réglementaire à appliquer :*

L'aspect éthique et déontologique de la médecine doit être appliqué.

La législation relative à la protection des données personnelles doit être appliquée.

#### *C. Contrainte conjoncturelle :*

La continuité du service doit être garantie même en cas de grève ou de crise grave.

#### *D. Contrainte fonctionnelle :*

La disponibilité maximale des informations médicales doit être garantie à tout instant.

#### *E. Contrainte relative aux méthodes :*

La confidentialité des informations médicales ne doit pas être au détriment de la qualité du service.

#### *F. Contrainte d'environnement :*

Du fait que l'Algérie se trouve dans une zone sismique, qu'elle serait l'impact d'un tremblement de terre

#### *G. Contrainte relative au personnel :*

Le responsable de l'informatique est ingénieur de formation

#### *H. Les critères de sécurité retenus :*

Afin d'exprimer les besoins de sécurité, les critères de sécurité retenus sont les suivants :

*La Disponibilité* : Propriété d'accessibilité au moment voulu des biens essentiels.

*L'Intégrité* : Propriété d'exactitude et de complétude des biens essentiels.

*La confidentialité* : Propriété des biens essentiels de n'être accessibles qu'aux utilisateurs autorisés.

#### *I. Échelle de disponibilité*

Nous avons établie l'échelle suivante pour exprimer les besoins de sécurité en termes de disponibilité :

Niveau de l'échelle	Description détaillées de l'échelle
Disponibilité immédiate	Le bien essentiel ne peut pas être indisponible
Disponibilité dans les 4 heures	Le bien essentiel ne peut pas être indisponible plus de quatre heures

### J. Échelle d'intégrité

L'échelle suivante sera utilisée pour exprimer les besoins de sécurité en termes d'intégrité :

Niveaux de l'échelle	Description détaillée de l'échelle
Détectable	Le bien essentiel peut ne pas être intégrer si l'altération est identifiée.
Maîtrisé	Le bien essentiel peut ne pas être intégrer, si l'altération est identifiée et l'intégrité du bien essentiel retrouvée.
Intègre	Le bien essentiel doit être rigoureusement intégrer.

### K. Échelle de confidentialité

L'échelle suivante sera utilisée pour exprimer les besoins de sécurité en termes de confidentialité :

Niveaux de l'échelle	Description détaillée de l'échelle
Public	Le bien essentiel est public.
Limité	Le bien essentiel ne doit être accessible qu'au personnel et aux partenaires.
Réservé	Le bien essentiel ne doit être accessible qu'au personnel (interne) impliquées.
Privé	Le bien essentiel ne doit être accessible qu'à des personnes identifiées et ayant le besoin d'en connaître.

### L. Échelle de gravité

L'échelle suivante sera utilisée pour estimer la gravité des événements redoutés et des risques :

Niveaux de l'échelle	Description détaillée de l'échelle
Négligeable	Gravité négligeable
Limitée	Gravité limitée
Importante	Gravité importante
Critique	Gravité critique

### M. Échelle de vraisemblance

L'échelle suivante sera utilisée pour estimer la vraisemblance des scénarios de menaces et des risques :

Niveaux de l'échelle	Description détaillée de l'échelle
Minime	Cela ne devrait pas se (re)produire
Significative	Cela pourrait se (re)produire.
Forte	Cela devrait se (re)produire un jour ou l'autre
Maximale	Cela va certainement se (re)produire prochainement

### N. Echelle de niveaux de risque :

Gravité	4		4. intolérable
	3		significatif
	2		
	1	1. Négligeable	2. limité
		1	2
		3	4
		Vraisemblance	

### O. Les biens essentiels identifiés :

Chaque métier sélectionné précédemment dans l'étude est lié à plusieurs processus. Ces processus sont des fonctions qui traitent des informations essentielles en entrée et en sortie.

Dans le cadre de l'étude nous avons retenu les processus suivants en tant que bien essentiel :

Système d'information et logiciel métier utilisé	Gestion des dossiers patients informatisés Gestion des résultats d'analyse. Gestion du Site internet de l'établissement
La transmission des données	La gestion des transmissions informatiques

### P. Les biens support

Le schéma suivant décompose ces biens supports et les positionne les uns par rapport aux autres :

Canal informatique	
Logiciel métier utilisé	Le SGBD contenant les bases de données ainsi que les résultats d'analyse Le logiciel métier utilisé
Le matériel informatique	L'ensemble des machines clients utilisée pour le traitement des données ainsi que les serveurs informatique
Le canal informatique	L'ensemble des périphériques réseau utilisés

### Q. Liens entre biens supports et biens essentiels :

Bien essentiel	Gestion des dossiers patients informatisés	Gestion des résultats d'analyse.	Gestion du Site internet de l'établissement	La gestion des transmissions informatiques
Bien support				
Logiciel métier utilisé	×	×		
Canal informatique			×	×
Le matériel informatique				×

### R. Les mesures de sécurité existantes sur le système :

*Bien support : canal informatique :*

1. *Thème ISO 27799 : 7.6.1.zone sécurisée, Mesure de sécurité : Périmètre de sécurité physique, Description : Protéger les zones contenant des informations et des moyens de traitement de l'information par des périmètres de sécurité. Les serveurs doivent être inaccessibles par des personnes non autorisées et donc dans des salles hautement sécurisées,*

2. *Thème ISO 27799 : 9.2 sécurité du matériel ( iso 27002), Mesure de sécurité : Protection de l'Emplacement des équipements, Description : Protéger le matériel des coupures de courant et autres perturbations dues à une défaillance de services généraux.*

*Bien support : système informatique :*

3. *Thème ISO 27799 : 7.8.2.1 Gestion des accès utilisateurs, Mesure de sécurité : Gestion des priviléges, Description : Restreindre les droits d'accès aux dossiers médicaux, un médecin ou un infirmier ne peut accéder qu'aux dossiers des patients présents dans son service.*
4. *Thème ISO 27799 : 7.8.2.1 Gestion des accès utilisateurs, Mesure de sécurité : Gestion des accès aux postes client, Description : L'accès et l'utilisation des machines client est restreinte par une connexion via Active directory de Windows server,*
5. *Thème ISO 27799 : Iso 27002 14.1 Aspects de la sécurité de l'information en matière de gestion de l'activité, Mesure de sécurité : Plan de continuité de l'activité en cas de panne, Description : Cinq serveurs sont interconnectés entre eux, ils exécutent VMware (virtualisation) et les bases de données sont stockées sur des serveurs NAS, si l'un des serveurs crache, ses tâches seront automatiquement divisées entre les autres,*
6. *Thème ISO 27799 : ISO27002 12.3 backup des données, Mesure de sécurité : Etablissement d'une politique de sauvegarde régulière, Description : Des sauvegardes régulières sont effectuées et stockées dans un bâtiment différent de celui des serveurs,*
7. *Thème ISO 27799 : Iso 27002 contrôle antivirus et logiciel malveillant, Mesure de sécurité : Installation d'un antivirus, Description : Un antivirus est installé sur les serveurs mais pas sur les machines clients ,*
8. *Thème ISO 27799 : Iso 27002 13.1.1 contrôles sur le réseau : Mesure de sécurité : Utilisation d'un Pare feu logiciel, Description : Un pare feu logiciel est installé sur le réseau, l'administrateur réseau prévoit de mettre en place un autre pare feu matériel prochainement.*
9. *Thème ISO 27799 : Iso 27002 10 chiffrement : Mesure de sécurité : Utilisation du chiffrement des données transitant sur le réseau wifi, Description : Le réseau wifi est protégé par une clé WPA 2.*

## VI. LES EVENEMENTS REDOUTES :

Les sources de menace ont été identifiées les plus plausibles sont :

- Un code malveillant accidentellement ou intentionnellement introduit (Virus, ver, spyware...)
- Un pirate informatique cherchant des informations sur les antécédents médicaux d'une personne en particulier, ou cherchant à prouver que le système est vulnérable ou qu'il y a négligence au sein de l'hôpital.
- Le personnel médical a aussi été identifié comme étant une source de menace que ce soit délibérément ou bien par négligence ou par curiosité mal placée.
- L'administrateur système, les help desk ou le personnel de maintenance qui peuvent être soudoyé

pour voler des données, ou bien dans une volonté de nuire délibérément au système afin de se venger d'un licenciement par exemple.

- Les accidents et les catastrophes naturelles (panne de courant, tremblement de terre...).

Il est à noter que le personnel médical n'est pas sensibilisé à l'éthique, au secret médical ainsi qu'à la sécurité informatique.

L'étude a consisté par la suite à déterminer les risques à partir des éléments définis précédemment, et à estimer leur gravité et probabilité d'occurrence en prenant en compte les mesures de sécurité existantes.

## VII.RESULTATS DE L'ANALYSE DE RISQUES

Nous allons à présent présenter les résultats de l'analyse de ces risques.

### Étude des événements redoutés

*Evènement redouté n°1 : Indisponibilité des dossiers patients, Bien essentiel Gérer les dossiers patients informatiques, Critère Disponibilité, Besoin de sécurité : Disponibilité immédiate, Source de menace : Membre du service informatique, personnel utilisateur peu sérieux ou malveillant, Virus informatique, Script kiddies, Agence gouvernementale étrangère , Impact : Impossibilité de consulter les dossiers des patients, donc de fournir les soins, peut s'avérer mortel pour le patient Gravité : critique*

*Evènement redouté n°2: Modification non autorisée d'un dossier patient, Bien essentiel : Gérer les dossiers patients informatiques, Critère : Intégrité, Besoin de sécurité : Intègre, Source de menace : Personnel du service informatique ou utilisateur malveillant, Virus informatique, Impact : Données médicales transmises non intègres, risques très important pour le patient, gravité : critique.*

*Evènement redouté n°3 : Divulgation d'un dossier patient à une personne non autorisée, Bien essentiel : Gérer les dossiers patients informatiques, Critère : Confidentialité, Besoin de sécurité : Réservé, Source de menace : Membre du service informatique ou utilisateur système peu sérieux ou malveillant, Virus informatique, Script kiddies, Agence gouvernementale étrangère, Impact : Divulgation du secret médical, donc risques de préjudice importants pour le patient et pour la réputation de l'hôpital, Gravité : Critique*

*Evènement redouté n°4 : site internet indisponible, Bien essentiel : Gérer le contenu du site web, Critère Disponibilité, Besoin de sécurité : Entre 4 et 24 h, Source de menace : Virus informatique, Script kiddies, Impact : Site web piraté, Gravité : Limitée.*

*Evènement redouté n°5 : Modification non autorisée du site internet, Bien essentiel : Gérer le contenu du site web, Critère : Intégrité, Besoin de sécurité : Déetectable, Source de menace : Script kiddies, Impact : Site web piraté, Gravité : Limitée.*

*Evènement redouté n°6:* Indisponibilité des résultats d'analyse d'un patient, *Bien essentiel:* Gérer les résultats d'analyse, *Critère:* Disponibilité, *Besoin de sécurité:* Disponibilité immédiate, *Source de menace:* Membre du service informatique ou utilisateur quotidien peu sérieux ou malveillant, Virus informatique, Script kiddies, *Impact:* indisponibilité de données qui pourrait servir à soigner les patients, risques pour les patients, *Gravité:* Critique.

*Evènement redouté n°7:* Modification ou altération des résultats d'analyse, *Bien essentiel:* Gérer les résultats d'analyse, *Critère:* Intégrité, *Besoin de sécurité:* Intègre, *Source de menace:* Membre du service informatique ou utilisateur système peu sérieux ou malveillant, Virus informatique, Script kiddies, *Impact:* Risques de préjudices graves pour le patient et pour l'hôpital, *Gravité:* Critique,

*Evènement redouté n°8:* Divulgation des résultats d'analyse à une personne non autorisée, *Bien essentiel:* Gérer les résultats d'analyse, *Critère:* Confidentialité, *Besoin de sécurité:* Réservé, *Source de menace:* Membre du service informatique ou utilisateur système peu sérieux ou malveillant, Virus informatique, Script kiddies, Agence gouvernementale étrangère, *Impact:* Divulgation du secret médical, manquement à l'éthique et risques de préjudices graves pour le patient, *Gravité:* Critique,

*Evènement redouté n°9:* Indisponibilité du réseau et des transmissions, *Bien essentiel:* Gérer les transmissions, *Critère:* Disponibilité, *Besoin de sécurité:* Disponibilité immédiate, *Source de menace:* Membre du service informatique ou utilisateur du système peu sérieux ou malveillant, Virus informatique, Script kiddies, *Impact:* Peut causer un préjudice grave au patient et à la réputation de l'hôpital, *Gravité:* Critique.

*Evènement redouté n°10:* Interception et modification des données transitant sur le réseau, *Bien essentiel:* Gérer les transmissions, *Critère:* Intégrité, *Besoin de sécurité:* Déetectable, *Source de menace:* Membre du service informatique ou utilisateur système peu sérieux ou malveillant, Virus informatique, Script kiddies, Agence gouvernementale étrangère, *Impact:* Risque pour le patient et pour la réputation de l'hôpital, *Gravité:* Critique,

*Evènement redouté n°11:* Interception des données transitant sur le réseau, *Bien essentiel:* Gérer les transmissions réseau, *Critère:* Confidentialité, *Besoin de sécurité:* Réservé, *Source de menace:* Virus informatique, Script kiddies, Agence gouvernementale étrangère, *Impact:* Divulgation du secret médical et préjudice pour le malade et la réputation de l'hôpital, *Gravité:* Critique.

#### A. Evaluation des événements redoutés : 9 événements à la gravité critique

L'importance relative des événements redoutés précédemment analysés (identifiés et estimés) est évaluée à l'aide du tableau suivant (critères de gestion des risques) :

Gravité	Événement redouté
Critique	Altération des dossiers patients Divulgation des dossiers patients (secret médical) Modification non autorisée des dossiers patients Altération des résultats d'analyse Modification des résultats d'analyse Divulgation des résultats d'analyse à des personnes non autorisées Interception des transmissions transitant sur le réseau Indisponibilité du réseau ou du système Modification des données transitant sur le réseau
limitée	Modification non autorisée du site internet Indisponibilité du site internet

### VIII. ÉTUDE DES RISQUES

#### B. Les risques : 11 risques analysés

Nous avons établi la liste des risques à partir des événements redoutés et des scénarios de menaces précédemment appréciés.

Les mesures de sécurité existantes ayant un effet sur chaque risque ont également été identifiées.

La gravité et la vraisemblance ont finalement été estimées, sans, puis avec, les mesures de sécurité.

Risque lié à l'indisponibilité du réseau ou de la base de données.

Événement redouté	Besoin de sécurité	Sources de menace	Impact	Gravité
Indisponibilité de réseau ou des résultats d'analyse	Disponibilité immédiate	Employé peu sérieux ou malveillant, Incendie des locaux ou panne de courant, Script kiddies	Impossibilité de prodiguer les soins nécessaires à un patient	Critique
Intégrité des données stockées sur la base de données ou sur le réseau compromis	Intègre	Employé peu sérieux ou malveillant, Script kiddies	Les données transmises sont fausses	Critique
Confidentialité des données stockées sur le réseau compromis	Réservée	Employé malveillant ou ayant une curiosité mal placée	Divulgation du secret médical et d'informations à caractère personnel	Critique
Disponibilité du site internet	Disponible dans les 24h	Employé malveillant	Atteinte à la crédibilité de l'établissement	Limitée
Intégrité du site internet	Intègre	Employé malveillant	Atteinte à la crédibilité de l'établissement	Limitée

*C. Les mesures proposées pour l'amélioration de la sécurité du système :*

Le risque d'accès illégitime et de la modification non désirée des données personnelles des patients doit être évité ou réduit à un niveau acceptable, des mesures de sécurité supplémentaires doivent être déterminées et implémentées en plus de celles déjà existantes. Les mesures supplémentaires que nous allons proposer sont toutes issues des standards [2] et [3]

La législation algérienne est également en retard en matière de protection de données à caractère personnel en comparaison de la Tunisie et du Maroc et bien sûr en comparaison aux pays développés comme la France. En effet la France a adopté en 1978 une loi nommée « informatique et liberté ». Ce texte fournit un cadre légal pour la collecte, le stockage et l'exploitation ou la divulgation d'informations personnelles, ce texte définit également le droit des personnes à la vie privée. Mais le plus important c'est qu'en premier lieu cette loi a défini ce qu'est une donnée à caractère personnelle, le code de déontologie médical français renvoie aussi à cette loi en matière de protection du secret médical et des données collectées dans le cadre de la e-santé. La Tunisie et le Maroc ont aussi promulgué des lois similaires, depuis respectivement juillet 2004 et février 2009. Cependant l'Algérie reste sans cadre légal qui puisse définir les droits et responsabilités des Algériens ainsi que des organisations qui collectent et exploitent ces données.

Conformément à l'article 10.1 de [3] Nous proposons de chiffrer les données dans la base de données afin rendre les dossiers médicaux anonymes et indéchiffrables pour ceux qui ont un accès direct à la base de données, ou à d'éventuels pirates qui téléchargeraient ces données, cela va réduire le risque d'accès illégitime aux données, Les noms, prénoms et affiliations des patients ainsi que les mots de passe des utilisateurs du système doivent être chiffrés.

En application de l'article 7.8 de [2], Nous proposons également de mettre en place un système d'accès basé sur le principe de moindre privilège (exemple : une infirmière n'a pas besoin d'accéder à tout l'historique du patient ou à tout son dossier médical même si celui-ci est hospitalisé au sein de son service).

Conformément à l'article 9.2 de [3] nous proposons d'établir des procédures d'authentification forte pour l'ensemble du personnel médical, la solution la plus évidente est l'utilisation d'une carte professionnelle électronique, ce genre de carte peut fournir un haut degré de sécurité, et peut également être utilisé pour la signature électronique de documents. Cependant avec l'absence de ce genre de carte en Algérie, nous pouvons utiliser un système de mot de passe à usage unique (otp) en transmettant par exemple un mot de passe par sms à l'utilisateur qui veut s'authentifier. Ces mesures vont aider à réduire les risques en réduisant les capacités des sources de menace.

Par ailleurs, la traçabilité des transactions doit être sérieusement prise en compte, les connexions au système depuis les machines client ainsi que les requêtes de bases de données doivent être horodatées et enregistrées, les logs

doivent être transférés vers des serveurs dédiés, et des mesures doivent être prises afin de garantir l'intégrité de ces logs. Ceci va réduire les risques ainsi que le sentiment d'impunité des sources de menace.[3].

Une autre mesure devrait être prise afin de réduire les risques :

Formaliser une procédure à mettre en œuvre en cas de violation du périmètre de sécurité afin de réduire l'impact, et communiquer avec les utilisateurs du système afin de les rendre au courant des risques ainsi que des procédures à appliquer en cas de problème de sécurité. Le social engineering étant considéré comme la plus importante source de menace, toutes les mesures de sécurité ne seront pas efficaces si l'utilisateur de base du système n'est pas sensibilisé aux bonnes et mauvaises pratiques en matière de sécurité informatique. [3]

## IX.CONCLUSION

Les systèmes e-santé requièrent des mesures de sécurité spécifiques afin de garantir la protection des données personnelles et de façon générale la confidentialité, intégrité et disponibilité du système ainsi que des données.

La e-santé requiert également un cadre légal afin de réguler les activités qui lui sont liées, notamment la collecte, le stockage, et l'utilisation de ce genre de données.

Dans cet article nous avons présenté les résultats d'une analyse de risques à l'aide de la méthodologie EBIOS. Cette analyse a été effectuée dans un hôpital qui utilise un système d'information pour la gestion de ses dossiers patients. Nous avons proposé des mesures de sécurité afin de réduire les risques identifiés.

Nous avons proposé des mesures en accord avec les standards internationaux qui devraient permettre aux institutions utilisant déjà ce genre de système de continuer à les utiliser avec un degré de risque acceptable.

## X.REFERENCES

- [1] S. Mekanne , A.Meziane “Un modèle de contrôle d'accès pour la protection des données personnelles dans le dossier médical partageable ”, Biomedical Engineering International Conference Tlemcen-Algeria, October 15-16, 2014 .
- [2] ISO 27799:2008, Informatique de santé -- Management de la sécurité de l'information relative à la santé en utilisant l'ISO/CEI 27002.
- [3] iso 27002 Technologies de l'information -- Techniques de sécurité -- Code de bonne pratique pour le management de la sécurité de l'information.
- [4] M.A Léger “Introduction à la gestion de risques informationnel”, Centre de recherche Hochelaga-Maisonneuve 1691, Pie-IX, Montréal.,
- [5] M.A Léger “ Une grille d'évaluation des méthodologies d'analyse de risque”, Centre de recherche Hochelaga-Maisonneuve 1691, Pie-IX, Montréal.

# A Comparative Performance Study of Objective function of RPL in Low-power and Lossy Networks (LLN)

Mohammed AZZA\*, Sofiane BOUKLI HACENE†

\*†Djillali Liabes University of Sidi Bel Abbes - Algeria

Computer science department

EEDIS Laboratory

\* Email: azza.mohammed.amine@gmail.com

**Abstract**—The increasing of Internet of Things (IoT) call to scalable solutions. The IETF ROLL (Routing over low power and Lossy Network) working group proposed an IPv6 routing solution of these networks under the specific deployment scenarios and constraints (less memory, power consumption and complexity) for better performance of 6LoWPAN devices. In this work, we are studying a popular implementation of RPL (routing protocol for low power and lossy network) to provide knowledge of these standards. An objective function (OF) defines how a RPL node selects routes. we use the Contiki operating system and COOJA simulator to evaluate the behavior of the ContikiRPL implementation with this two OF. The metrics evaluation using is the traffic overhead, latency, and energy consumption and packet delivery ratio, which are essential to the global performance of a wireless sensor network. The result shown that, the ETX as a preferred objective function for most of the scenarios.

**Index Terms**—IOT, RPL, Objective Function, OF0, ETX, Contiki, COOJA.

## I. INTRODUCTION

IPv6 Low power Wireless Personal Area Networks 6LoWPAN group defined compression and encapsulation mechanisms that enable the IPv6 packet to be transmitted over an IEEE 802.15.4 protocol in intelligent switching networks. These networks with devices are limited through constrained computing and storage power often occurring in very variable link quality conditions that named LLNs. The growing network of IoT called scalable solutions Routing in LLNs is one of the key issues for the emergence IoT. A routing protocol suitable for LLNs must agree to strict constraints of delay, while maintaining a minimum control overhead, networks Convergence, energy consumption, latency and packet delivery rate (PDR) and should be able to provide rapid recovery of frequent failure link. The protocol must be optimized for different applications such as with limited resources. IPv6 routing protocol for low power and Lossy Networks (RPL) has been proposed in [1] because it met the initial requirements of LLNs [2]. However, another protocol called LOaDng Ad-hoc on demand distance vector routing protocol Next Generation has been proposed in [3]. It uses a completely different approach to RPL and some studies show it works better in

some scenarios. An objective function (OF) defines how a RPL node selects and optimizes routes within a RPL instance based on the information objects available. RPL uses two objective functions, namely OF0 and ETX. In this paper we evaluate the two objective functions. in this work we evaluate with different metric the impact of choice of OF. The remaining of the paper is organized like follows: we describe the RPL protocol in section 2 and existing work in section 3.performance evaluation and comparisons of two OF are provided in section 4.Finally, conclusions, perspectives are drawn in section 5.

## II. ROUTING

In this section we briefly preview the RPL protocol principles. For more information on RPL, the reader must relate to RFC 6550 [1].

### A. IPv6 routing protocol for low-power and lossy networks

Routing protocol for low power and lossy networks (RPL) is IPv6 routing protocol for low power and lossy networks designed by IETF routing over low power and lossy network (ROLL) group [4] as a proposed standard. He create a Destination oriented directed acyclic graph (DODAG) using an objective function (OF) and a group of constraints. DAG minimizes the cost of arriving the LLN DAG root of any node in the network using the OF. An objective function (OF) defines how a RPL node selects and optimizes routes within a RPL instance based on the information objects available.

ContikiRPL implements two routing metrics:

- Hop Count: This metric counts the number of hops from the source to the destination. A hop count of 2 means there are 2 intermediate links between the source and destination.
- Expected Transmission Count (ETX): ETX of a link is the expected number of transmissions required to send a packet over that link. The path ETX is the sum of the ETX of all the links along the path. The ETX of a path with 3 links of 100% delivery ratio is 3, whereas the ETX of a path with 3 links of 50% delivery ratio is 6.

RPL uses "up" and "down" directions terminology regarding the movement of traffic LBR (LLN border router) is a DAG root has a rank of 1 and initiates formation of DAG by advertising information on using the DAG information option (DIO) which carries much information about the DAG, including the transmitting node distance of the LBR.

Nodes receiving DIO, calculate its distance to LBR in along the cost received DIO and its own cost to reach the transmitting node. It selects a node that provides the lowest cost to reach the LBR as a parent.

The node unicast their addresses and reachable prefixes to their parents via Destination Advertisement Option (DAO) messages, which in turn unicast them further up the DAG to advertise destinations reachable through them in support of down traffic. Thus, eventually all DAOs reach the LBR, providing routing information about the whole DAG.

RPL has been normalized to operate two modes:

- In the storage mode: a node of the LLN is capable of storing routing tables and next hop information for all nodes in the subtree.
- Whenever the node transmits messages DAO via itself or one of its child nodes that contains a destination prefix available. A downward route is maintained at each node in the DAG. So, when a node 'n' Announces DAO for a specific destination, the receiving node store the node 'n' as the next hop for this specific destination. DAO method of propagation is shown in figure (1), where the node 21 acts as the next hop for destination nodes 5, 37, 24, 22 to nodes 45, 4, etc.
- In the non-storing mode: the nodes do not store the routes to a destination but only to the root of the DAG. Therefore, any node when it receives DAO from children or other nodes in its sub tree transmits directly to its parent. DAO in non-storage mode are unicasted toward root of the DAG. The LBR is a device who stores all routes to any node in the network and its more storage capacities than other LLN nodes. A DODAG information solicitation message (DIS) can be used by nodes to solicit information about DAG.

#### B. Trickle Timers

The algorithm Trickle controls the DIOs transmission interval [5]. The idea is to reduce overhead. DIO are also sent periodically to each node, initiated by a timer (trickle timer), the duration increases exponentially (doubled after each time it is fired). On any event that causes a change in the DAG structure (as a new parent selection), this counter is reset to the value Imin contained in the DIO

By increasing the time between DIOs, the protocol eliminates the need to exchange neighbor information early that the network can become stable after a few rounds of information exchange.

There are three configurable parameters in the Trickle Timer: Imin, Imax and redundancy constant k [5] and explained below.

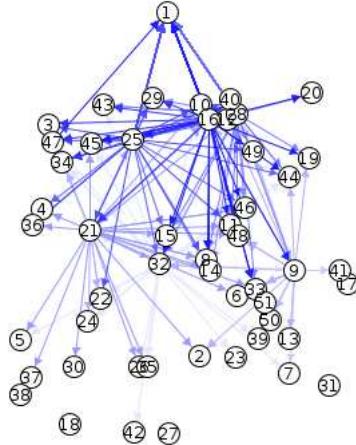


Fig. 1. RPL Network Construction

- The value of Imin: is determined by the RPL parameter DIO Minimum Interval (In Contiki: RPL\_DIO\_INTERVAL\_MIN) and computed as:

$$I_{min} = 2^{RPL\_DIO\_INTERVAL\_MIN} \quad (1)$$

- The value of Imax: is used to limit the number of times the Imin can be doubled. The value of Imax is determined by the RPL parameter DIO Interval Doublings (In Contiki: RPL\_DIO\_INTERVAL\_DOUBLINGS) and computed as:

$$I_{max} = I_{min} \times 2^{RPL\_DIO\_INTERVAL\_DOUBLINGS} \quad (2)$$

- Redundancy constant (k): It is a natural number greater than 0 and is used to suppress the DIO transmission. Trickle listening if the transmission is in progress, it increments its own counter C. At time t, Trickle performs transmission only if the counter C is smaller than the constant k redundancy otherwise, the transmission is suppressed.

### III. RELATED WORKS

Several papers discuss the performance of different implementations of routing protocol for Low Power and Lossy Networks (RPL). The RPL performance Internet draft [1] evaluates the protocol by set of routing metrics (control packet overhead, delay, routing table size, loss of path, path quality) in tested scenarios. Implementation of RPL for TinyOS is presented in [6] and authors discuss the packet reception ratio, routing protocol overhead and reply ratio, as part of the performance analysis. Stability metrics of RPL have been studied in [7], and Routing overhead and delay induced by ContikiRPL implementation is studied in [8]. Authors in [9] evaluate different optimized broadcast techniques for use in RPL. Possibility of applying broadcast-based metrics in wireless networks is discussed in [10], and authors observed the excessive sensitivity of broadcast-based metrics in their

TABLE I  
PARAMETRES OF SIMULATION

Settings	Value
Mote type	Tmote Sky
Transport layers	UDP +
network layers	_IPv6 + 6LoWPAN
MAC layer	non-slotted CSMA + ContikiMAC
Radio interface	IEEE 802.15.4
Wireless channel model	Unit Disk Graph Medium (UDGM):Distance Loss
Communication range	5 m
Simulation time	1h

TABLE II  
PARAMETRES OF RPL

Parameter	Value
Mode of operation	non-storing
Rank metric	hop count and ETX
DIOIntervalMin	2 s
DIOIntervalDoublings	20
DIO Redundancy Constant	1
DAOInterval	15s

test beds. [11] Uses ETX as the RPL routing metric for the advanced metering infrastructure (AMI) in Smart Grid to construct and maintain the DAG. A framework for low power IPv6 routing simulation, experimentation and evaluation based on Contiki OS and Cooja simulator has been proposed in [12], [13]. Authors in [14] used the Contiki framework to evaluate the performance of a PLC network serving as a LLN backbone.

#### IV. SIMULATION AND EVALUATION

##### A. SIMULATION SETTING

We used the link failure model is emulated by using Unit Disk Graph Model (UDGM) in [15]. It uses two different range parameters one for transmission and one for interference with other radios

The probability of success of packet reception at a node at a distance D from another node with R is the reception range and RX defines the success ratio and D is less than or equal to R can be computed as:

$$\text{Probability of success} = (1 - RX) \times (1 - (D^2/R^2)) \quad (3)$$

We create a network with the Cooja simulator containing 50 client nodes using UDP client and one server uses UDP server and act as the root. We use Contiki Test Editor to create a (log COOJA.test) log file for all outputs of the simulation we analyze at the end of the simulation using AWK script.

The parameters for the Simulation and its environment are shown in Table I

The settings for RPL are listed in table II

##### B. Measuring the performance metrics

We read the log file line by line and collect information about the node id, type of packet and his number and time for sending and receiving for calculate this metrics: [13]

- 1) The average Packet Delivery Ratio we measure the number of sent packets from all the nodes to the sink and

divide it by the number of successfully received packets at the sink.

$$PDR = (\text{Total Packets Received} / \text{Total Packets Sent}) \times 100 \quad (4)$$

- 2) The Network Latency can be computed using the following equation.

$$\text{Total Latency} = \sum_{K=1}^n (\text{recv time}(k) - \text{send time}(k)) \quad (5)$$

Where n is the total number of packets received successfully, and we compute the average Latency :

$$\text{Average Latency} = \text{Total Latency} / \text{Total Packets Received} \quad (6)$$

- 3) The Control Traffic overhead for each node, we collect the message DIO/DIS/DAO sent, upon the type of control message. these control messages per node sum up for the total RPL network control overhead.

$$\text{Control Overhead} = \sum_{K=1}^n DIO(k) + \sum_{K=1}^m DIS(k) + \sum_{K=1}^l DAO(k) \quad (7)$$

- 4) The power consumption is computed with the mechanism of Powertrace system available in Contiki [16]. Powertrace estimate the energy consumption for CPU processing, packet transmission and listening

##### C. Comparison of Objective Functions

In this section we evaluate two objective functions OFs implements in ContikiRPL for the path selected by these OFs its differ in Packet Delivery Ratio, Latency and Energy consumption, of the network for the upward traffic (traffic from client nodes towards the sink node and is a kind of multipoint to point traffic).

1) *Packet Delivery Ratio*: The figure (2) illustrates the increasing of the average packet delivery ratio computed from equation depending packet Reception Ratio RX (%). The packet delivery ratio of ETX is a little better than OF0 in this small simulation, which proves the efficiency of ETX versus OF0.

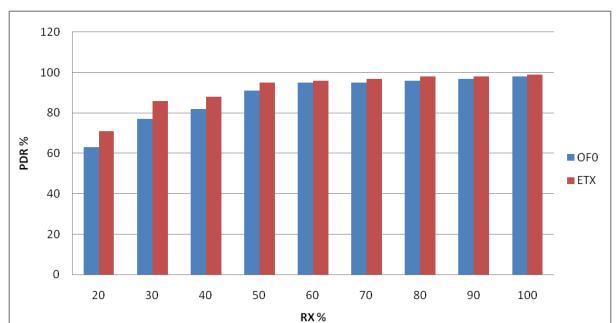


Fig. 2. Packet Delivery Ratio of OF0 and ETX in Contiki

2) *Network Latency*: The figure (3) shown the Latency of OF0 against ETX. We can see from the figure that ETX performs better than OF0 because it considers link constraints details i.e. ETX compute the best paths. The difference is more evident in more lossy links but as the lossyness decrease (RX ratio increase) the Latency becomes equal.

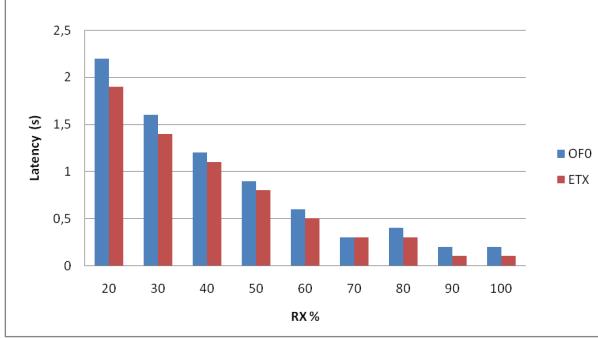


Fig. 3. Networks Latency of OF0 and ETX in Contiki

3) *Overhead*: The figure (4) shown the overhead of OF0 against ETX. The overhead of ETX is less than OF0, which proves the efficiency of ETX who generate less control packet versus OF0 because the environment converges quickly.

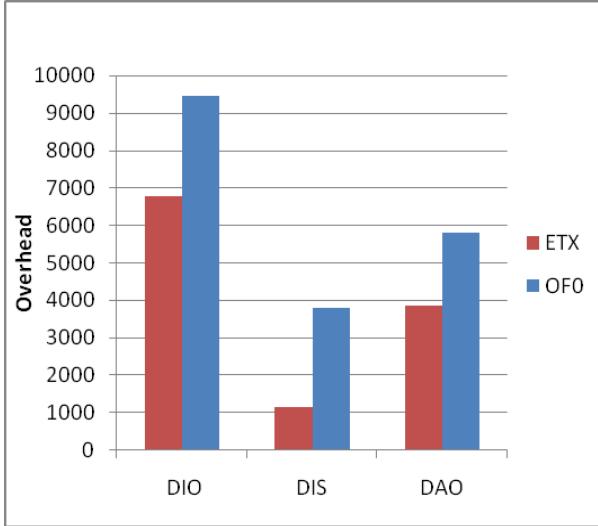


Fig. 4. Networks Latency of OF0 and ETX in Contiki

4) *Energy Consumption*: Network energy consumption early is more with a network with great loss but as we decrease the lossyness in network energy consumption also decreases as shown in figure (5)

This is because the environment with more loss than re-transmissions in an environment without loss.

The objective function OF0 selects the shortest path, which is not the best than objective function ETX in terms of ETX constraints. As a result, the nodes make other broadcasts, which there consume more energy. Since LLN has a nature with loss of quality rank changes frequently and therefore the

TABLE III  
SUMMARY OF THE RESULTS

Metric	OF0	ETX
Packet Delivery Ratio (%)	88.22	92.87
The Network Latency (s)	0.89	0.70
Overhead	3930	6353.33
Energy Consumption(%Radio ON)	42.93	32.63

ETX for path changes frequently. ETX takes into account the path ETX for computation and can therefore reproduce the link status more precisely at any time in a RPL network

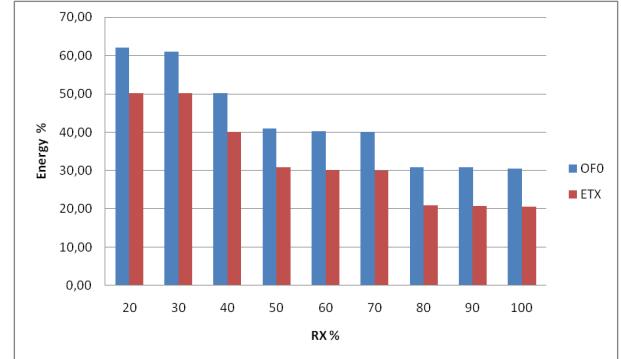


Fig. 5. Energy Consumption of OF0 and ETX in Contiki

5) *Summary of the results* : We observed in the Evaluation that Objective Function ETX provides better Network Latency, Energy consumption and PDR and this difference is more important in more lossy environments. Therefore, ETX is the most efficient Objective function from this analysis and it provides a better use of the limited resources of LLN. The performance of both OF0 and ETX is summarized in Table III

## V. CONCLUSION

In this article, we evaluate and analyze the performance of IETF routing protocol using RPL COOJA simulator under the Contiki operating system with these two objective function OF0 and ETX. We analyze the performance of network construction process by measuring several important parameters latency and energy pdr, then we study the performance and possible situations during the operating phase of the WSN. The results indicate that RPL with ETX is a fairly robust protocol for WSN. the ETX as a preferred objective function and its gives better performance in term of overhead , latency and PDR. In addition, our work provides guidelines for future Internet design objects with IPv6 enabled network. in perspective we will compare the RPL protocol with LOAD-ng

## REFERENCES

- [1] T. Winter, P. Thubert, A. Brandt, T. Clausen, J. Hui, R. Kelsey, P. Levis, K. Pister, R. Struik, and J. Vasseur, *RPL: IPv6 routing protocol for low power and lossy networks*. RFC 6550, IETF, apr 2012.
- [2] P. Levis, A. Tavakoli, and S. Dawson-Haggerty, “Overview of existing routing protocols for low power and lossy networks,” 2009.

- [3] T. Clausen, A. C. de Verdiere, J. Yi, A. Niktash, Y. Igarashi, and U. Herberg, *The LLN On-demand Ad hoc Distance-vector Routing Protocol - Next Generation (LOADng)*, Internet draft, IETF, apr 2012.
- [4] C. Perkins, E. Belding-Royer, and S. Das, “Ad hoc on-demand distance vector (aodv) routing,” 2003.
- [5] P. Levis, T. Clausen, J. Hui, O. Gnawali, and J. Ko, *The Trickle Algorithm*. RFC 6206, mar 2011.
- [6] J. Ko, S. D. Hagerty, O. Gnawali, D. Culler, and p. . I. m. p. . . y. . . A. Terzis”, title = Evaluating the Performance of RPL and 6LoWPAN in TinyOS.
- [7] X. Yang, J. Guo, P. Orlík, K. Parsons, and K. Ishibashi, “Stability metric based routing protocol for low-power and lossy networks,” in *Communications (ICC), 2014 IEEE International Conference on*, pp. 3688–3693, June 2014.
- [8] N. Accettura, L. Grieco, G. Boggia, and P. Camarda, “Performance analysis of the rpl routing protocol,” in *Mechatronics (ICM), 2011 IEEE International Conference on*, pp. 767–772, April 2011.
- [9] T. Clausen and U. Herberg, “Comparative study of rpl-enabled optimized broadcast in wireless sensor networks,” in *Intelligent Sensors, Sensor Networks and Information Processing (ISSNIP), 2010 Sixth International Conference on*, pp. 7–12, Dec 2010.
- [10] S. M. Das, H. Pucha, K. Papagiannaki, and Y. C. Hu, “Studying wireless routing link metric dynamics,” in *Proceedings of the 7th ACM SIGCOMM Conference on Internet Measurement*, IMC ’07, (New York, NY, USA), pp. 327–332, ACM, 2007.
- [11] D. Wang, Z. Tao, J. Zhang, and A. Abouzeid, *RPL based routing for advanced metering infrastructure in smart grid*. IEEE International Conference on Communications Workshops ICC, 2010.
- [12] N. Tsiftes, J. Eriksson, N. Finne, F. Osterlind, J. Hoglund, and A. Dunkels, *A framework for low-power IPv6 routing simulation, experimentation, and evaluation*. SIGCOMM Comput. Commun., aug 2010.
- [13] T. Zhang and X. Li, “Evaluating and analyzing the performance of rpl in contiki,” in *Proceedings of the First International Workshop on Mobile Sensing, Computing and Communication*, MSCC ’14, (New York, NY, USA), pp. 19–24, ACM, 2014.
- [14] L. B. Saad, C. Chauvenet, and B. Tourancheau, “Simulation of the rpl routing protocol for ipv6 sensor networks: two cases studies,” in *SENSORCOMM*, 2011.
- [15] F. Osterlind, A. Dunkels, J. Eriksson, N. Finne, and T. Voigt, “Cross-level sensor network simulation with cooja,” in *Local Computer Networks, Proceedings 2006 31st IEEE Conference on*, pp. 641–648, Nov 2006.
- [16] A. Dunkels, J. Eriksson, N. Finne, and N. Tsiftes, “Powertrace: Network-level power profiling for low-power wireless networks,” technical report t2011:05, Swedish Institute of Computer Science, mar 2011.

# *Composition of web services using multi agent based planning with high availability of web services*

*Sabrina MEHDI* \*

*University Constantine 2, LIRE Laboratory, Faculty of New Technologies of Information and Communication,*

*Ali Mendjeli, Constantine, Algeria*

\* *mehdi\_sabrina2011@yahoo.fr*

*Nacer eddine ZAROUR* \*\*

*University Constantine 2, LIRE Laboratory, Faculty of New Technologies of Information and Communication,*

*Ali Mendjeli, Constantine, Algeria*

\*\* *nasro-zarour@umc.edu.dz*

**Abstract**— The composition of web services can meet the needs of increasingly complex user by combining multiple distributed web services, which may be unavailable or inaccessible. The automatic planning can be exploited to dynamically compose web services. In this paper, we propose a model of web services composition based on multi-agent planning that integrates automatic substitution process based on communities. These last bring together agents services (web services representatives) that meet the same functional requirements to ensure high availability of services.

**Key Words**—web service, composition, multi agent system, planning, high availability of web services, community.

## I. INTRODUCTION

Web services are self-contained component applications that can be described, published, located and invoked over Internet. Descriptions of web services enable web services to be discovered and used by other web services. These descriptions are described using a standard XML-based language. Descriptions divided to two features: The functional features are needed to invoke the execution of a web service and non functional features are such as cost, response time, reliability etc ([1], [2], [3]). Web service composition is about finding services that perform a specified task [4]. Web service composition is an important technology in domain of web service and its targets is reusing existing web services. There are the two types of web service composition: syntactic composition and semantic composition. The syntactic composition is based on syntactic descriptions. And other is based on semantic descriptions. In semantic web service composition is used from concepts of ontology for to add semantic description instead of the parameter values. In the last years several papers have dealt with the composition of web services. The high availability of Web services engaged in composition scenarios is now supported by the approach based on the use communities grouping services according to their functionality. Order Web Services with preconditions and effects is very similar to an automatic planning problem [5]. Planning has indeed a role to find a sequence of actions, or plan to, from an initial state, reach a goal state, expressed by the user.

In our work we focus the various works of the composition of web services based on multi-agent automatic planning, and presents high availability of web services that ensures the proper functioning of the system where a web service is inaccessible. In this context, we propose a composition model based on automatic multi-agent planning. The proposed model incorporates a process of substitution based on communities. This process consists in replacing a failed service agent (web service) by another one. The new agent is adhering to community offering functionality equivalent to the failed agent service (web service) to ensure its availability.

Several works are oriented on artificial intelligence based on the automatic planning. They rely essentially based on classical planning ([6], [7], [8], [9] et [10]), planning based on the rules [11] and hierarchical planning [12] which propose planner shop2. It is used for the automatic composition of web services that are described using the DAML-S. Shop2 is a planner of type network task hierarchical (HTN, Hierarchical Task Network). The most of these works have highlighted the fact that the syntactic description (WSDL) service is insufficient and proposed solutions based rather on a semantic description (OWL-S).

The rest of the paper is organized as follows: Section 2 presents the high availability of web services. In Section 3 we present our multi-agent architecture based on communities and also our model of web service composition using multi-agent planning. In section 4 we present our implementation. We end this paper with a conclusion and some future work.

## II. HIGH AVAILABILITY OF WEB SERVICES

Availability is the ability to provide a certain level of service for a situation where one or more components of a system have failed. The failure can be programmed (scheduled maintenance) or unprogrammed (breakdown). The realization of high availability is to eliminate single points of failure which are summarized in the existence of a single source of a resource. The goal is that when a failure occurs, users can still access the service.

## Approaches supporting the availability

Traditional solutions realize the availability of web services on the replication [13] [14] [15]. Briefly, replication is the distribution of copies of a software application (eg web service) in a network according to strategies namely: active, passive or hybrid [16], and if one copy fails, the others can continuous to provide service. This approach known several drawbacks including two major namely:

- The synchronization of all recurrent states of copies after each query execution and that, to ensure consistency.
- The update of the code in these copies when a change will occur.

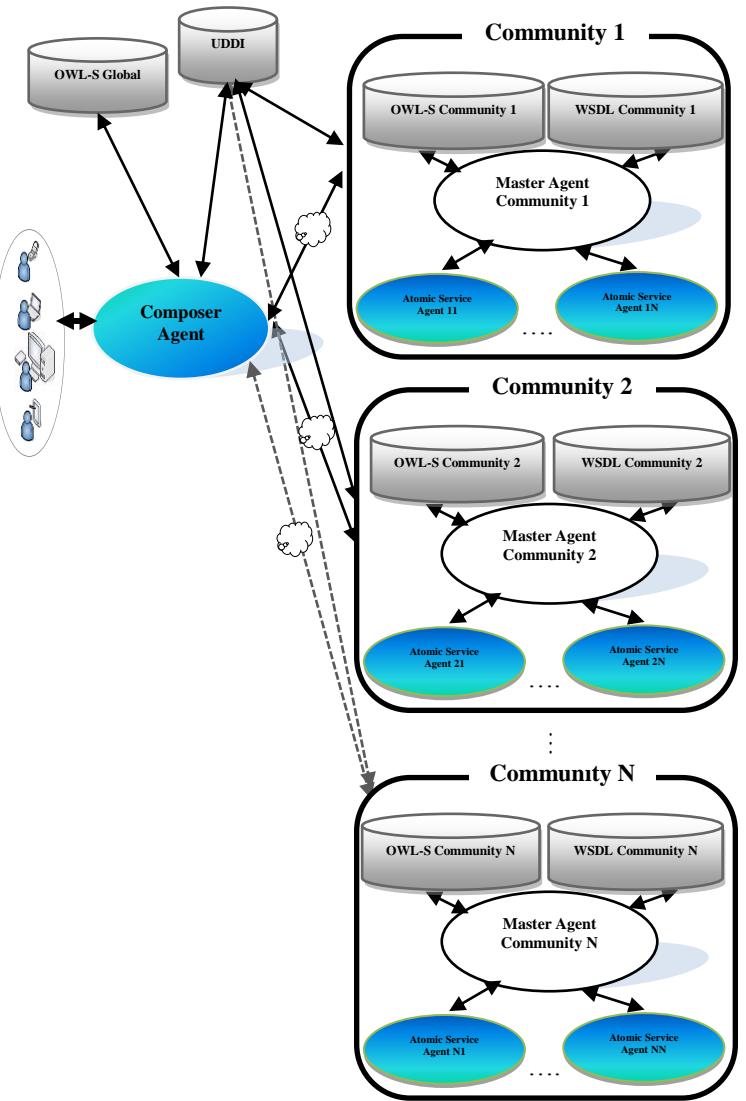
To cope with these drawbacks, Maamar et al propose their approach to the availability based community of web services [17] which is to group web services into communities according to their functionality.

### III. THE PROPOSED ARCHITECTURE AND MODEL OF WEB SERVICES COMPOSITION

Our model of web service composition is modeled by an agent-based architecture that defines several levels of responsibility. Three types of agents compose it: a set of **atomic services agents** (representative atomic web services), a **composer agent**, and a set of **master Agents communities** (representatives of special web services).

According to the different types of agents defined, our architecture allows to define several levels of responsibility:

- The responsibility of representing a web service atomic when composing is ensured by atomic service agent.
- The responsibility to analyze the user query (global service), to decompose it into sub-queries (sub-services), in case of composite service and coordinate the execution of the composed service, is provided by the composer agent.
- The responsibility to represent a special web service that defines a set of atomic services agents (web services atomic) with the same functionality, select an atomic service agent for the execution a atomic service of decomposition, and the substitution of a faulty atomic service agent or unavailable by another, is provided by the master agent community.

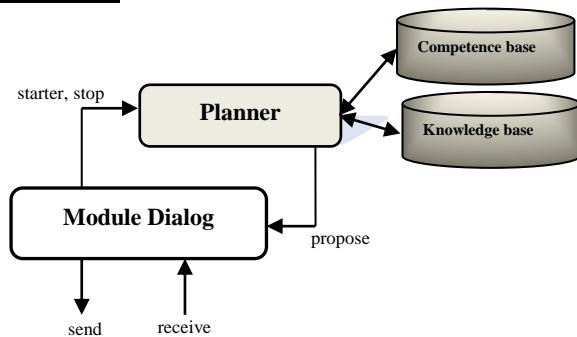


**Fig 1.** Multi-agent architecture based on communities for dynamic composition of Web services

#### III-1 INITIALIZATION AND ARCHITECTURES OF CONSIDERED AGENTS

All of our agents are initialized with their architecture semantic descriptions. The atomic service agent is initialized with the semantic description of a web service atomic. The master agent community is initialized with semantic descriptions of all atomic web services which offer the same functionality. The composer agent is initialized with the global semantic description. Services that are defined in OWL-S are represented by operators planning in the case of atomic services, by decomposition methods in case of composed services. In the following, we present different modules of the composer agent and atomic service agent.

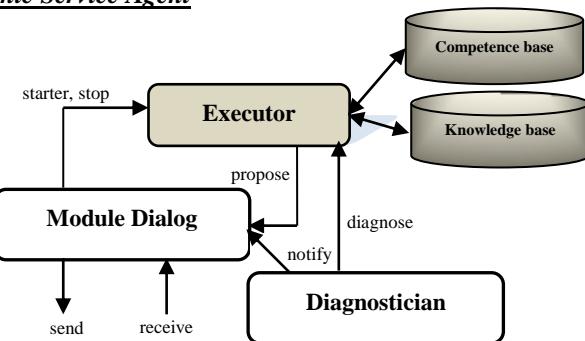
### Composer Agent



**Planner** : allows to decompose the composite service, until obtain atomic services.

**Module dialog** : allows to exchanging proposals between the composer agent and the masters agents communities for an atomic service.

### Atomic Service Agent



**Executor** : executes atomic service

**Module dialog** : allows to exchanging proposals between the atomic services agents and the masters agents communities.

**Diagnostician** : to detect the failure of the atomic service agent

### III-2 COMPOSITION MODEL

The phases that compose the proposed model are the planning, allocation of tasks (services) and execution of the plan with the substitution of an atomic service agent failed.

**Phase 1:** In the planning phase we seek to answer the question: 'What should we do?'. Planning is decomposed into two phases: determining the global service and the decomposition of composite service. Determination phase of global service (user request), composer agent must parse the query if the query concerns a service atomic the composer agent directly invokes the master agent community concerned, the latter selects an agent among agents atomic services in the community. By against, if the query is a description of a composite service, we go into the second phase is the decomposition of composite service. In this phase the composer agent must use the iterative decomposition method that represents the composite service. The effect of this method is to make the decomposition in order to arrive at atomic services (the operators planning).

- The goal of the decomposition phase is to build an atomic plane that contains only operators planning

(atomic services). These operators are linked by constraints (order relations).

**Phase 2:** After the decomposition of global service into atomic services, and for each atomic service the composer agent seeks community that offers this service to achieve atomic service. The master agent community must negotiate with atomic services agents in the community and after negotiation; it selects the atomic service agent who submitted the best deals perform this service. The selected atomic service agent assumes the role of primary, meaning that execute the atomic service. The negotiation protocol is characterized by a sequence of messages exchanged as part of the Contract Net Protocol [17]. The negotiation starts with master agent community who must announce (offers) a set of atomic services agents for the realization of service. The atomic services agents who receive service announcement to accomplish, evaluate it (create a commitment). Each atomic service agent may refuse to perform the service, accept, make a proposal in response-against or respond it did not understand.

**Phase 3:** After the creation of the atomic plane by composer agent, it coordinates the different services of the plan, according to the constraints defined at the atomic plane. Our model treats the failure or fault tolerance, for this we integrate a substitution process based communities [17] which can replace the failed primary agent by another agent before or during execution. Indeed, atomic services agents of the community can accept or refuse to take the role of support. In case of acceptance, if the primary agent fails (see Figure 2), their module diagnostician notify its master agent community to select another agent.

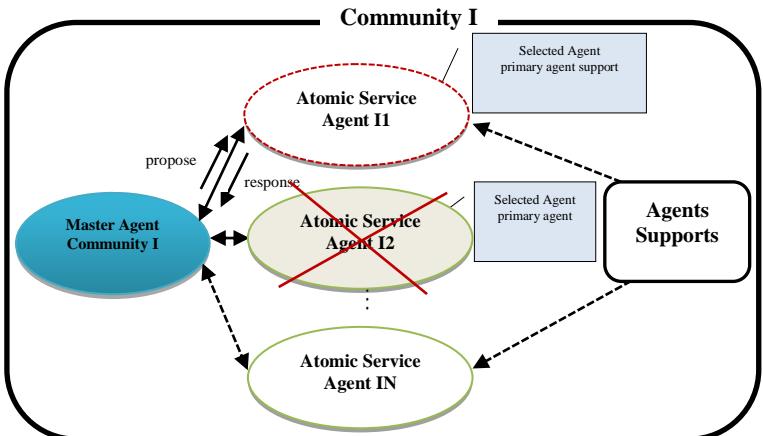


Fig 2. Substitution process based community

### IV. USE CASE

The proposed application implements the composition of two atomic web services (atomic services agents) to solve an equation of the second degree ( $Ax^2 + Bx + C$ ). In our proposed architecture, we will implement two communities (one provides a delta and the second provides solutions according to delta) to ensure high availability of atomic services agents. We use a Java language and platform JADE programming to develop our multi-agent systems.

#### IV-1 FUNCTIONS OF AGENTS

- **composer Agent:** Is an agent that manages the process of composition, initiating order (planning) both master agents communities, as follows:
  - Getting from user interface the parameters (A,B,C).
  - Start the master agent community 1 and their services atomic agents by sending a message request.
  - Send parameters (A, B, C) to the master agent community 1 (delta calculation).
  - Getting delta.
  - Start the master agent community 2 and their services atomic agents by sending a message request.
  - Send parameters (A, B, C and delta) to master agent community 2(Solutions calculation).
  - Retrieve and display solutions.
  - Show names of the atomic services of the two communities that have been unavailable and the names of the services agents who have substituted agents.
- Community 1 : Contains the following agents
  - ✓ **Master agent community 1 :** manages the community 1, after receipt of the request of the composer, it started negotiations with its three services atomic agents. Negotiation ends with the selection of a single atomic Service agent to perform the calculation of delta. The master agent community 1 get delta, and sends the result to the composer agent.
  - ✓ **Atomic service agent :** Three atomic services agents providing the same function (delta calculation) are defined in the community 1.
- Community 2 : Contains the following agents
  - ✓ **Master agent community 2 :** Is an agent that manages the community 2, after receipt of the request of the composer, it started negotiations with its three services atomic agents. Negotiation ends with the selection of a single atomic Service agent to perform the calculation of solution. The master agent community 2 get solution, and sends the result to the composer agent.
  - ✓ **Atomic service agent :** Three atomic services agents providing the same function (solution calculation) are defined in the community 2.

#### IV-2 NEGOCIATION BETWEEN THE MASTERS AGENTS COMMUNITIES AND THEIR ATOMIC SERVICES AGENTS

The master agent community (community 1 or 2) sends to his three atomic services agents a message that contains the primitive **REQUEST**. After reception of this message, each atomic Service agent can send a message that contains the primitive **ACCEPT\_PROPOSAL** or **REFUSE** or

**NOT\_UNDERSTOOD**. The master agent community selects one agent who sent **ACCEPT\_PROPOSAL**, this selection is made by sending a message containing the **CONFIRM** primitive and parameters.

The atomic service agent selected by the master agent community can be:

- Able to achieve the request, in which case it sends a message containing the primitive **CONFIRM** and the result to his master agent community.
- Failure, in this case the diagnostician of atomic service agent sends a message containing the primitive **FAILURE** to his master agent community, the latter receiving this message, it starts a new negotiation with its atomic services agents.

#### IV-3 EXEMPLE OF EXECUTION A COMPOSITION

The following example shows that the master agent community relaunch a negotiation process after each receiving a **FAILURE** message from an atomic Service agent to replace it with another. The first negociaction, the agent selected is displayed on the interface under the name agentseratoq1d2 is failure (see Figure 3). In the second negotiation, the agent selected is displayed on the interface under the name agentseratoq1d0 (see Figure 4) is failure. In the third negotiation, the selected agent and calculated delta is displayed on the interface as agentseratoq1d0 name and the result (see Figure 3).

For two negotiations, we can find the same atomic service agent failure in the first negotiation and available in the second negotiation.

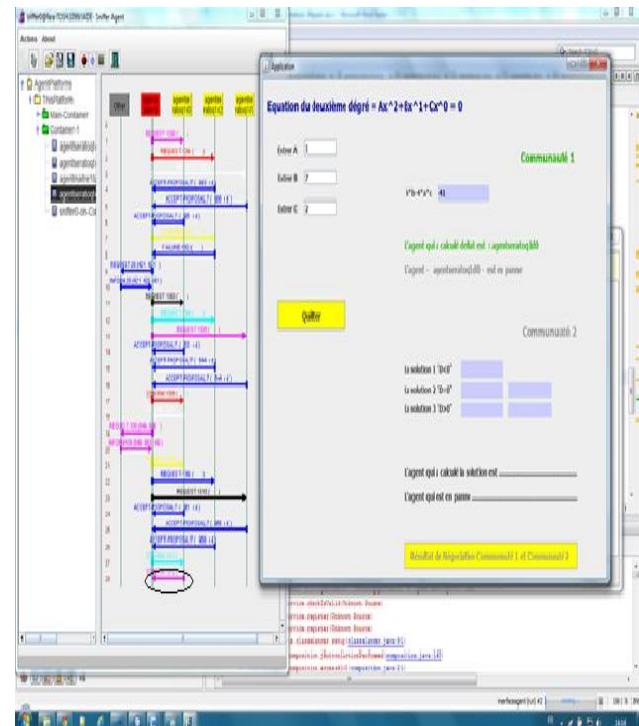
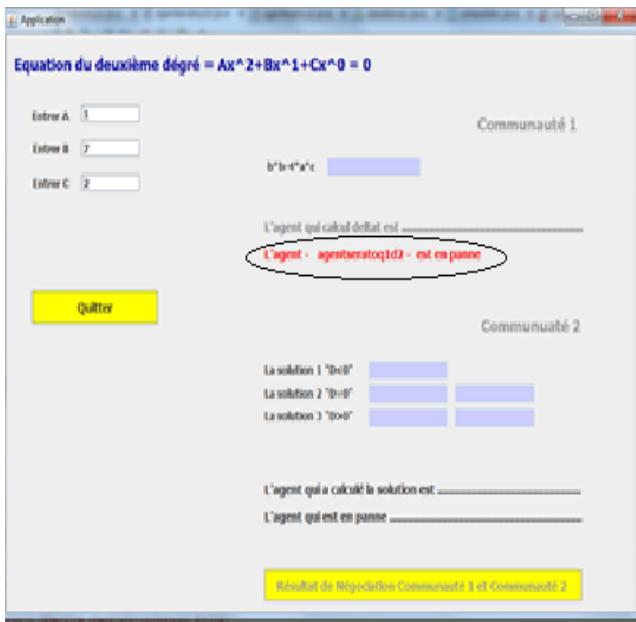


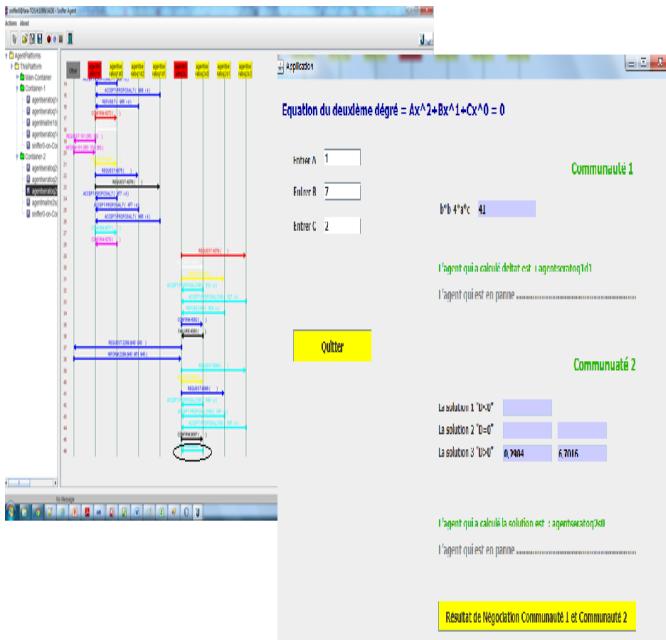
Fig 3 : Final result of a negotiation for community 1



**Fig 4.** Display the name of an agent that is in failure

After calculating delta, the master agent community 2 replaces the agent name agentseratoq2s0 in the first negotiation by the agent name agentseratoq2s0 in the second negotiation (see Figure 5).

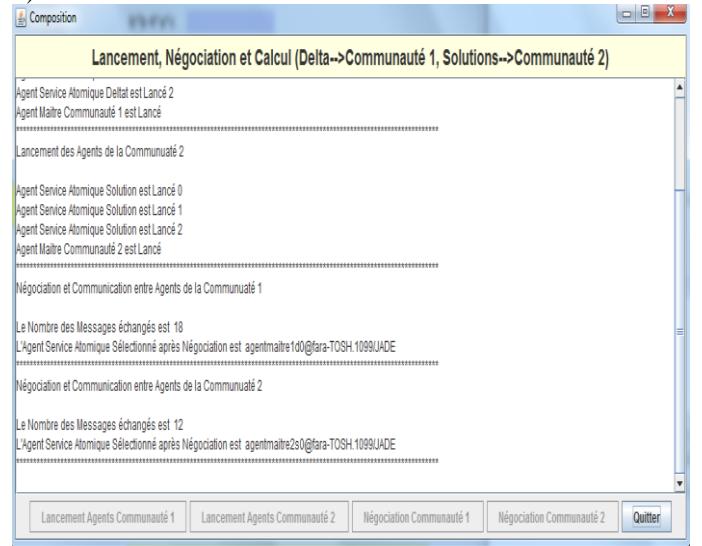
The agent who has been failed, the agent who made the calculation and its result are displayed on the user interface (see Figure 5).



**Fig 5.** Substitution of one agent failure by another for community 2

After the composition, we can see the result of the final negotiations of the two communities. The result of negotiating displayed contains the name of Atomic Service agent confirming the calculation and the number of message

exchanged between the master agent community and its atomic services agents (see Figure 6)



**Fig 6.** Final result of a negotiation for community 1 and community 2

## V. CONCLUSION

In this paper, we presented a multi-agent architecture based on communities for the dynamic composition of web services and proposed a substitution solution of a failed atomic service agent by another one equivalent belonging to the same community for ensuring high availability of services in the composition. The agents are initialized with their semantic descriptions (OWL-S). We proposed an implementation to validate the proposed architecture. The implementation provides two services dynamic composition and substitution of a service failed by another available service. Like perspective we try to apply our implementation for more than two services.

## REFERENCES

- [1] Mansour H. Elfawal and T. Dillon, "Dependability and Rollback Recovery for Composite Web Services," IEEE TRANSACTIONS ON SERVICES COMPUTING, (OCTOBER-DECEMBER 2011).
- [2] Pablo Rodríguez-Mier, Manuel Mucientes, Manuel Lama, and Miguel I. Couto, "Composition of web services through genetic programming," (December 2010).
- [3] Rajesh Karunamurthy, Ferhat Khendek, and Roch H. Glitho, "A novel architecture for Web service composition," Journal of Network and Computer Applications , (March 2012).
- [4] Thomas Weise, Steffen Bleul, Diana Comes, and Kurt Geihs, "Different Approaches to Semantic Web Service Composition," in Internet and Web Applications and Services, 2008. ICIW '08. Third International Conference on, (2008).
- [5] Ghallab, M., Nau, D., Traverso, P.: "Automated Planning : theory and practice", Morgan Kaufmann Publishers, (2004)
- [6] Sheshagiri, M., Desjardins, M., Finin, T.: "A planner for composing services described in DAML-S". In Proceedings of the AAMAS Workshop on Web Services and Agent-based Engineering (Jun. 2003)

- [7] Jayadev, M., William, C.: "Computation Orchestration: A Basis for Wide-area Computing", *Journal of Software and Systems Modeling*, (2007)
- [8] Singh, M., Huhns, M.: "Service-Oriented Computing: Semantics, Processes, Agents, Wiley and Sons", (2005)
- [9] Sirin, E., Hendler, J., Parsia, B.: "Semi-automatic composition of web services using semantic descriptions. In Proceedings Web Services : Modeling, Architecture and Infrastructure". Workshop in Conjunction with ICEIS2003 (Angers, France, 2002)
- [10] Peer, J.: "A PDDL based tool for automatic web services composition". In Proceedings of the Second Workshop on Principles and Practice of Semantic Web Reasoning (PPSWR 2004) at the 20th International Conference on Logic Programming (September 2004)
- [11] Medjahed, B., Bouguettaya, A., Elmagarmid, A.: "Semantic web enabled composition of web services". *The VLDB Journal* 12, 4 (November 2003)
- [12] Wu, D., Parsia, B., Sirin, E., Hendler, J., Nau, D.: "Automating DAML-S web services composition using SHOP2". In ISWC'03 (2003)
- [13] Israel, J., Froihofer, L., Goeschka, K.: "What Service Replication Middleware Can Learn from Object Replication Middleware", Melbourne, Australia, (2006)
- [14] Salas, J., Pérez-Sorrosal, F., Patino Martinez, M., Jiménez-paris, R.: "WS-Replication : A Framework for highly available Web services", Scotland, (2006)
- [15] Ye, X., Shen, Y.: "Amiddleware for Replicated Web Services", IEEE, Orlando, Florida, USA, (2005)
- [16] Wiesmann, M., Pedone, F., Schiper, A., Kemme, B., Alonso, G.: "Understanding Replication in Databases and Distributed Systemes", Taipei, Taiwan, (2000)
- [17] Maamar, Z., Tata, S., Quan Sheng, Z., Benslimane, D., Sellami, M.: "Towards An Approach to Sustain Web Services High-Availability Using Communities of web Services", *International Journal of Web Information Systems*, (2008)

# A Comparative Study of Application Layer Protocols for M2M communications in the IoT

Sami Barkat\*, Azeddine Bilami, and Ayoub Benayache

Department of computer science

University of Batna

Lastic Laboratory

Email:Barkat.sammi@gmail.com

Email:abilami@yahoo.fr

Email:ayoub.inf30@gmail.com

**Abstract**— The most important messaging technologies proposed as the foundation of the next generation of Internet of Things (IoT) and more specifically the application layer protocols are reviewed in this document. IoT is not largely deployed because of the absence of a unified architecture and there is no common agreement in defining protocols and standards for all IoT parts. In this paper, we present and compare existing IoT application layer protocols as well as protocols that are utilized to connect the things but also end-user applications to the Internet. We highlight on IETFs CoAP, IBMs MQTT, OASIS AMQP, XMPP from XMPP Standards Foundation, and RESTful. Then we argue their suitability for the M2M communications by considering reliability, security, and interoperability. Finally we present a conclusion about our study.

**Keywords**—Internet of Things (IoT), Application Layer Protocols, Request/Response, Publish/Subscribe, CoAP, MQTT, AMQP, XMPP, RESTful, M2M

## INTRODUCTION

The Internet of Things deals with a huge number of end-devices with sensing, actuating, treatment, and communication capabilities that are able to be connected to the Internet [1]. These devices can be connected using different technologies such as 2G, 3G, LTE (Long Term Evolution) or they can be connected over a gateway, creating a LAN (Local Area Network), to get Internet connection. The end-devices form Machine to Machine (M2M) networks using different radio technologies, such as Zigbee, Wi-Fi, or Bluetooth. Independently the précis wireless technology used to deploy the M2M network, all the end-devices should make their data available to the Internet [2]. This can be reached neither by transferring the information to a proprietary web server reachable from the Internet.

Our paper focuses on the protocols that handle the M2M communications. In section 2 we describe the application layer protocols that are used to update online servers with the latest end-device values but also to carry commands from applications to the end-device actuators. The rest of the paper is organized as follows. Section 3 describes the implementation architectures of application layer protocols. In Section 4 we discuss the QoS, interoperability and security features of each protocol, we present the results as a comparative table. Finally, in Section 5, we present overall

conclusions based on the previous sections and we provide further research areas.

## APPLICATION LAYER PROTOCOLS

### COAP

The Constrained Application Protocol (CoAP) is a synchronous request/response application layer protocol that was created by the Internet Engineering Task Force (IETF) to target constrained-resource devices. It was designed by using a subset of the HTTP methods making it interoperable with HTTP.

The protocol is used for machine-to-machine (M2M) applications like smart energy and building automation.

CoAP runs over UDP to maintain the global implementation lightweight. It uses the HTTP methods GET, POST, PUT, and DELETE to supply resource-oriented interactions in a client-server architecture. CoAP is a request/response protocol that utilizes both synchronous and asynchronous responses [3]. The aim for designing a UDP-based application layer protocol to handle the resources is to remove the TCP overhead and reduce bandwidth requirements [4]. Furthermore, CoAP supports unicast as well as multicast, as opposed to TCP, which is by its nature not multicast-oriented.

### MQTT

Is a Lightweight broker-based publish/subscribe messaging protocol created by IBM to be open, simple, lightweight and easy to implement. These features make it ideal for use in constrained environments, where the network is dear, has low bandwidth or is unreliable, or when resources runs on devices with limited processor or memory.

The protocol includes the publish/subscribe message pattern to provide one-to-many message distribution and decoupling of applications. It uses TCP/IP to provide basic network connectivity. [5]

In MQTT there is a broker (server) that contains topics. Each client can be a publisher that sends messages to the broker at a specific topic or/and a subscriber that receives automatic messages every time there is a new update in a topic he is subscribed to.

MQTT is designed to use battery and bandwidth usage moderately, which is why it is currently used by Facebook Messenger. [6]

Moreover, MQTT uses TCP, it have low overhead compared to other TCP-based application layer protocols. [7]MQTT Devices include sensors and actuators, embedded systems on vehicles, mobile phones, or laptops.

#### *AMQP*

The Advanced Message Queuing Protocol (AMQP) is originally created in 2003 by JPMorgan Chase, and it is accepted by world's leading banking, financial and IT companies. From October 2012 is member of OASIS.

AMQP is a binary, application layer protocol, created to efficiently support a wide variety of information applications and communication models. It can utilize different transport protocols but it assumes an underlying reliable transport protocol such as TCP [8].

AMQP provides flow controlled, message-oriented communication with message-delivery guarantees such as at-most-once, at-least-once and exactly-once, and authentication and/or encryption based on SASL and/or TLS [9].

It can utilize different transport protocols but it assumes an underlying reliable transport protocol such as TCP.

#### *XMPP*

The Extensible Messaging and Presence Protocol (XMPP) was standardized by the IETF over a decade ago, it was designed for streaming Extensible Markup Language (XML) elements in order to exchange structured information in close to real time between any two network endpoints.

XMPP uses TCP and furnish publish/subscribe and also request/response messaging systems. It is designed for near real-time communications and thus, it supports small messages and low latency message exchange [10].

#### *Restful*

The Representational State Transfer (REST) is not really a protocol but an architectural style. It was first introduced by Roy Fielding in 2000 [11].

REST uses the HTTP commands GET, POST, PUT, and DELETE to furnish a resource-oriented messaging system. To indicate the format of the data that it contains it uses the built-in accept header of HTTP. The content type depends on the HTTP server and its configuration it can be XML or JSON (JavaScript Object Notation). REST is supported by all the commercial M2M cloud platforms that's what makes him an important part of the IoT. Moreover it can be implemented in smartphone and tablet applications easily because it only needs an HTTP library. The characteristics of HTTP can be completely utilized in the REST architecture including authentication, cashing, and content type negotiation [12].

### IMPLEMENTATION ARCHITECTURES

#### *Message broker*

The most of implementations of AMQP, MQTT, and XMPP are broker-based. Publishers send messages to a broker which is considered as the core of the publish/subscribe protocol. A broker can supports thousands of simultaneous connected clients. The broker is responsible for receiving, filtering all messages, decide who is interested in it and then delivering

the message to the subscribers. The broker usually uses a store and forward function to route messages. Some messages in a queue may be prioritized by the broker before routing. Subscribers may register for specific messages at build time, initialization time or runtime.

Brokers may have a single queue, multiple queues. Flexible routing patterns are a benefit of using a broker. Due to its origin (the financial sector where the message exchanges are frequently transactional) AMQP afford transactional operations that permit to participate in a multi-phase commit sequence. MQTT and AMQP brokers support communications between publishers and subscribers over TCP/IP to provide reliability, although XMPP provides no reliability guarantees.

To suit specific system needs, brokers can be exploited in multiple configurations. Broker configurations include [13]:

- Centralized broker
- Centralized multi broker
- De-centralized broker

N.B.: There are other protocols such as DDS that uses another technology (Data-Bus) that are not included in our work.

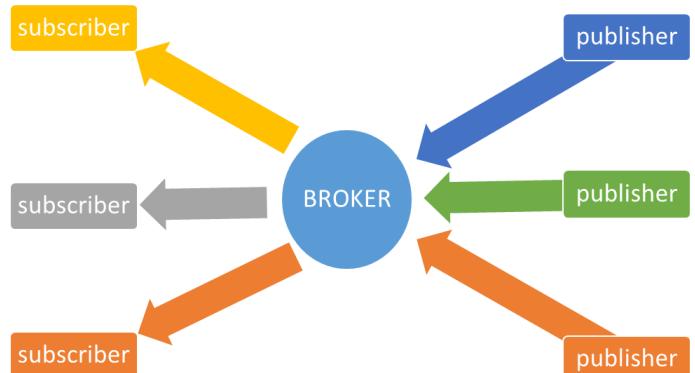


Figure 1: Message Broker Architecture

#### *Message-Centricity*

AMQP, MQTT, REST, CoAP and XMPP are all message-centric technologies. In a message-centric system the main mission is the delivery of the message independently of the payload it contains. The infrastructure's task is to make sure that messages reach their destinations.

On the other hand, Message-centric systems supplies a lower level abstraction as it pushes users to implement data sharing through the exchange of messages. [13]

N.B: There are other protocols such as DDS that uses another technology (Data Centricity) that are not included in our work

## CRITERIA OF COMPARISON

### *Interoperability*

MQTT concentrate on the interoperable exchange of messages. MQTT does not care about the message contains. It does not specify how data is represented in a message. Applications have to adopt the same serialization scheme during the message exchange, instead the messages cannot be understood. In distributed systems this can be hard and expensive to deploy. MQTT was created to be used with TCP/IP.

AMQP brokers process the message payload as an opaque byte array. The broker will not modify the content of the messages. AMQP clients use the "content-type" and "content-encoding" fields to communicate. This means the publishers and subscribers can only understand messages if the data serialization scheme is understood by both of them.

RESTful clients and servers based on HTTP are interoperable, (all is required is an HTTP stack). Almost every platform and device has that.

CoAP, like HTTP, supports content negotiation. Clients can choose a specific representation of a resource and servers can inform the clients what content-Type they will send. This allows clients and servers to adding new representations independently without affecting each other.

XMPP supports interoperability between different architectures. The protocol runs over TCP/IP sockets to exchange XML messages. This protocol supports asynchronous communication. XMPP clients and servers are interoperable and can modify messages without affecting the semantic meaning for the data. Similar to MQTT, message payload encoding is considered an application level issue.

### *Quality of Service*

The MQTT protocol provides very basic QoS support for delivering messages between clients and servers. MQTT ensures reliability by providing the option of three QoS levels [14]:

1. At most once: means that a message is sent once either if it is delivered or not.
2. At least once: means that a message will be definitely delivered one time, possibly more.
3. Exactly once: means that a message will be delivered only one time

AMQP messages have similar QoS properties to MQTT. This includes supporting message queuing and delivery semantics covering at-most-once, at-least-once and once-and-only-once (reliable messaging).

CoAP Running on the unreliable UDP, CoAP incorporated its own methods for achieving reliability. Two bits in the header of each packet state the type of message and the required Quality of Service (QoS) level. There are 4 message types:

1. Confirmable: A request message that requires an acknowledgement (ACK). The response can be sent either synchronously (within the ACK) or if it needs more computational time, it can be sent asynchronously with a separate message.

2. Non-Confirmable: A message that does not need to be acknowledged.
3. Acknowledgment: It confirms the reception of a confirmable message.
4. Reset: It confirms the reception of a message that could not be processed.

There is also a simple retransmission method Stop-and-Wait for confirmable messages and a 16-bit header field in every CoAP packet known as Message ID which is unique and used for detecting duplicates.

REST and XMPP provide no explicit support for quality of service and reliable delivery of messages.

### *Security*

To guarantee security, MQTT brokers may require username/password authentication (this can help simplify the authentication of individual clients in a system) which is controlled by TLS/SSL.

CoAP was designed for the IoT and for M2M communications; it does not ensure any security specifications. The Datagram Transport Layer Security (DTLS) protocol is proposed to secure CoAP communications. DTLS is the analogous of TLS for the TCP. It afford authentication, data integrity, confidentiality, automatic key management, and cryptographic algorithms [15].

DTLS handshakes need further packets that growth the network traffic, take over additional computational resources, and reduce the lifespan of mobile devices that run on batteries, a necessary part of the IoT.

CoAP is compatible with HTTP-, but the using of DTLS can make confusion to the HTTP servers.[16]

In case of the XMPP and AMQP security specifications, the connection is authenticated and negotiated an agreement with Simple Authentication and Security Layer (SASL) and encrypted with Transport Layer Security (TLS).

RESTful can make use of TLS/SSL for security. Nowadays the majority of M2M platforms do not support HTTPS requests. Instead, they propose a unique authentication keys that is included in the header of each request to guarantee some level of security.

	<b>MQTT</b>	<b>AMQP</b>	<b>REST</b>	<b>CoAP</b>	<b>XMPP</b>
<b>Standards</b>	Proposed OASIS MQTT standard M	OASIS AMQP	Is an architectural style rather than a standard	Proposed IETF CoAP standard	XMPP Standards Foundation
<b>Abstraction</b>	Pub/Sub	P2P or Pub/Sub	Request/Reply	Request/Reply	P2P or Pub/Sub (based on draft spec/ XEP-0060)
<b>Network Architecture</b>	Brokered (most common)	Brokered (most common)	Client-Server	Client-Server	XMPP Server (broker)
<b>QoS level configuration</b>	3	3	None	4	None
<b>Interoperability</b>	Partial	Yes	Yes	Yes	Yes
<b>Header size</b>	2 B	64 B	-	4 B	-
<b>Message size</b>	Up to 256 MB	Unlimited	-	Small to fit in single IP datagram.	-
<b>Transport layer</b>	TCP	TCP	TCP	UDP	TCP
<b>IPv6 support</b>	Yes	Yes	Yes	Yes	Yes
<b>Data distribution</b>	One-to-one , and oneto-many	One-to-one , and oneto-many	One-to-one	One-to-one	One-to-one
<b>Subscription Control</b>	Topics with hierarchical matching	Exchanges, Queues and Bindings in v0.9.1 standard, Queues and message filtering in v1.0 standard	-	Provides support for Multicast addressing	Nodes which are analogous to a Topic defined In draft spec XEP0060
<b>Data Serialization</b>	Undefined	AMQP type system or user defined	No	Configurable	XML
<b>Encoding</b>	Binary	Binary	Plain Text, also supports various types of content encoding e.g. ZIP, compress, deflate	Binary	Plain Text
<b>Licensing Model</b>	Open Source & Commercially Licensed	Open Source & Commercially Licensed	available for free on most platforms	Open Source & Commercially Licensed	Open Source & Commercially Licensed
<b>Library</b>	Mosquitto	RabbitMQ	RESTlibrary	libcoap	Iksemel
<b>Mobile devices (Android, iOS)</b>	Yes	Yes	Yes	Via HTTP proxy	Yes
<b>6LoWPAN devices</b>	Yes	Implementation specific	Yes	Yes	No
<b>Multi-phase Transactions</b>	No	Yes	No	No	No
<b>Main application</b>	IoT	Banking and financial systems	Mobile applications, social networking, Web sites.	IoT	Instant messaging
<b>Security</b>	Simple Username/Password Authentication, SSL for data encryption	SASL authentication, TLS for data encryption	Typically based on SSL or TLS	DTLS	TLS and SASL

*Table 1: Application layer protocols comparative table*

According to the latest researches about m2m protocols many studies was done, refer to the study [17], we found, in terms of delay that MQTT is more performance than CoAP for lower values of packet loss. However, the greater TCP overheads in the retransmission of messages compared to the UDP overheads in CoAP, CoAP performed better than MQTT when the packet loss rate is high

Because of the four-way handshake mechanism in the MQTT, its messages are more bandwidth consumption than CoAP for lower values of packet loss.

The size of the acknowledgement has little effect on the extra overhead caused when the message size raise. When the packet loss rate is low, CoAP produced less overhead than MQTT. When the packet loss rate is higher, CoAP still produce less overhead than MQTT when message size is small. When the message size rises, the reverse is produced. The probability that UDP loses the message is higher than TCP, which causes CoAP to retransmit the whole message more often than MQTT

Another study [18] shows, that the exchanged packets increases linearly with the size of transmitted encoded health data segments. These results are due to the complexity of the handshakes of the protocols as seen in fig 2.

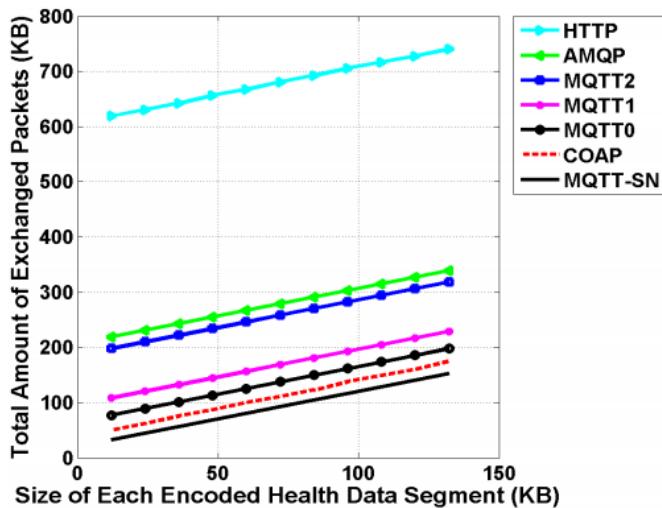


Figure 2: Performance of M2M Communication Protocols

## V. CONCLUSION

In this paper we presented a common IoT architecture by describing where application layer protocols are needed to handle communication. We, also, introduced in this paper, the messaging technologies such MQTT, AMQP, REST, CoAP and XMPP providing a comparison among each other, taking account of QoS, interoperability and security and argue about their suitability for the future of the IoT.

About the interoperability, we conclude that all of the protocols cited above can handle it, about security most of them use TLS/SSL for data encryption, exception made for CoAP and SASL, CoAP uses DTLS, and SASL for the authentication of XMPP and AMPQ, in another hand MQTT uses a simple authentication service. our aim in the future will be focused at implementing all of these protocols over different networks such (mobile networks..) and obtain an experimental and measurable comparison among them.

## REFERENCES

- [1] Tasos Kaukalias and Periklis Chatzimisios, Internet of Things (IoT) C Enabling technologies, applications and open issues, Encyclopedia of Information Science and Technology (3rd Ed.), IGI Global Press, 2014.
- [2] Periklis Chatzimisios, Industry Forum & Exhibition Panel on Internet of Humans and Machines, IEEE Global Communications Conference (Globecom 2013), Atlanta,USA, December 2013.
- [3] Shelby, Z., Hartke, K., and C. Bormann, "The Constrained Application Protocol (CoAP)", RFC 7252, DOI 10.17487/RFC7252, June 2014, <<http://www.rfc-editor.org/info/rfc7252>>.
- [4] Sye Loong Keoh, Sandeep S. Kumar, Hannes Tschofenig, Securing the Internet of Things: A Standardization Perspective, Internet of Things Journal IEEE (Volume: 1, Issue: 3), June 2014, pp. 265-275.
- [5] <http://www.ibm.com/developerworks/library/ws-mqtt/ws-mqtt-pdf.pdf>
- [6] <http://mqtt.org/2011/08/mqtt-used-by-facebook-messenger>, cited 28 Jul 2014.
- [7] Dinesh Thangavel, Xiaoping Ma, Alvin Valera, Hwee-Xian Tan, Colin Keng-Yan Tan, Performance Evaluation of MQTT and CoAP via a Common Middleware, IEEE Ninth International Conference on Intelligent Sensors, Sensor Networks and Information Processing (ISSNIP), 21-24 April 2014, pp. 1-6.
- [8] [[http://en.wikipedia.org/wiki/Advanced\\_Message\\_Queueing\\_Protocol](http://en.wikipedia.org/wiki/Advanced_Message_Queueing_Protocol)], cited 28 Jul 2014.
- [9] Internet of things: converging technologies for smart environments and integrated ecosystems.
- [10] Saint-Andre, P., "Extensible Messaging and Presence Protocol (XMPP): Address Format", RFC 6122, DOI 10.17487/RFC6122, March 2011, <<http://www.rfc-editor.org/info/rfc6122>>.
- [11] [https://fr.wikipedia.org/wiki/Representational\\_State\\_Transfer](https://fr.wikipedia.org/wiki/Representational_State_Transfer)
- [12] Bipin Upadhyaya, Ying Zou, Hua Xiao, Joanna Ng, Alex Lau, Migration of SOAPbased Services to RESTful Services, 13th IEEE International Symposium on Web Systems Evolution (WSE), 30 Sept. 2011, pp. 105-114.

- [13] Yi Huang, Scalable Web service-based XML message brokering across organizations, Ph. D. Indiana University, Computer Science Dept. 2007
- [14] [http://docs.oasis-open.org/mqtt/mqtt/v3.1.1/os/mqtt-v3.1.1-os.html#\\_Toc398718099](http://docs.oasis-open.org/mqtt/mqtt/v3.1.1/os/mqtt-v3.1.1-os.html#_Toc398718099)
- [15] Thamer A. Alghamdi, Aboubaker Lasebae, Mahdi Aiash, Security Analysis of the Constrained Application Protocol in the Internet of Things, Second International Conference on Future Generation Communication Technology (FGCT), 12-14 Nov. 2013, pp. 163-168.
- [16] Shahid Raza, Hossein Shafagh, Kasun Hewage, Ren Hummen, Thiemo Voigt, Lith: Lightweight Secure CoAP for the Internet of Things, Sensors Journal, IEEE 13(10), Oct. 2013, pp. 3711-3720.
- [17] Dinesh Thangavel, Xiaoping Ma, Alvin Valera and Hwee-Xian Tan, Colin Keng-Yan TAN, Performance Evaluation of MQTT and CoAP via a Common Middleware, 2014 IEEE Ninth International Conference on Intelligent Sensors, Sensor Networks and Information Processing (ISSNIP) Symposium on Sensor Networks Singapore, 21–24 April 2014
- [18] Sana Tmar-Ben Hamida 1,\* , Elyes Ben Hamida 2 and Beena Ahmed 1, A New mHealth Communication Framework for Use in Wearable WBANs and Mobile Technologies, Sensors 2015, 15, 3379-3408; doi:10.3390/s150203379

# Interreflection effects based on multi-virtual point light for rendering image synthesis

<sup>1</sup> khemliche sarra, <sup>2</sup>Babahenini Mohamed Chaouki, <sup>3</sup>BahiNaima, <sup>4</sup>Zerari Abd El Moumène

<sup>1,2,3,4</sup> LESIA laboratory

Mohamed Khider University  
Biskra, Algeria

<sup>1</sup>sarra.khemliche@gmail.com

<sup>2</sup>chaouki.babahenini@gmail.com

<sup>3</sup>naima.bahi@yahoo.fr

<sup>4</sup>a.zerari@live.fr

**Abstract**— Developing robust visual tracking algorithms for real-world is still a major challenge today in many fields such as design, manufacturing, ecommerce and other fields are used to simulate the appearance of objects and scenes. Realistic looking is often critical, and calculating global illumination (GI) is an important contributor to image reliability; in which we take into account all interreflection effects in the scene. GI approximation methods, such as virtual point light (VPL) algorithms, are efficient, but they can produce image artifacts and distortions of object appearance. In this paper we present a practical algorithm for rendering diverse frequency of interreflection effects. Our method builds upon a standard representation of the scene, based on which a new mathematical formulation of the interreflection equation is made. We systematically study simulation of complex effects on image quality and material appearance of global illumination approximations made by VPL algorithms to provide a fast and smoother complex illumination .Efficiently, the computational effort is heavily reduced. Finally, to achieve a real time rendering performance ranging from near interactive to a few seconds per frame we have implemented the present algorithm on the GPU, for various scenes with different complexity.

**Keywords**—global illumination; interreflection effects ; light source; virtual point light(vpl).

## I. INTRODUCTION

The goal of computer graphics is to create images according to the purpose of the user. Photorealistic rendering is used when images indistinguishable from real photographs are desirable. This issue has a big impact on a wide range of various industry applications such as simulation, film production, and video games. One of the essential aspects of creating photorealistic images is that objects look as though made of real materials. Additionally, appearance of objects should match the scene lighting and be in accord with the scene configuration. This match requires accurate, physically-based simulation of light transport in the scene, carried out by, so-called, global illumination (GI) algorithms, which describes the light propagation through a 3D environment and its interaction with all the scene geometry. In contrast to direct or local illumination where only one bounce of light is considered, global illumination considers several bounces.

In our paper we introduce new system which aims at solving some problems mentioned before in less time consuming .our model proposal inspired by the concept of *Instant Radiosity* [1]. Instant Radiosity is a solution to approximate global illumination by tracing rays from the light source to the scene,

letting them bounce around to a specified depth and creating secondary light sources at each intersection point which called virtual point light (VPL) this latter is at the core of our rendering system; The final results are then placed into the scene when doing the rendering at the client side. However, we extend it to simulate non-diffuse light paths as well.

Indirect Illumination is a key element to achieve realistic rendering. Unfortunately, since computing this effect is costly, there are few methods that render it with real-time frame rates. In this paper we present a new method based on virtual point lights and topological information about the scene to render indirect illumination in real-time.

Our main contribution includes:

- ❖ Approximation of indirect illumination using VPL.
- ❖ Simulating light transport of different environment.
- ❖ Giving an automatic setting of scene standard.

The remaining paper is structured as follows: Section 2 gives an overview of related work done in the field of real time global illumination and other recent called many light approaches. In Sections 3 we describe our method in detail. Results and performance measurements are presented in Section 4. We will conclude our paper and also give outlooks into possible future work in Section 5

## II. STAT OF THE ART

The problem of global illumination was first formalized mathematically by Kajiya [8]; Rendering Equation (RE) that calculates the equilibrium distribution of light energy in a scene. The rendering equation links light sources, surface reflectance (BRDFs), and visibility (fig.2). It says that at each particular point that has a position and direction on a surface, the outgoing light  $L_o$  at a surface location  $x$  in direction  $\omega$  is the sum of emitted radiance  $L_e$  and reflected radiance  $L_r$  (Eq.1).

$$L_o(x, \omega) = L_e(x, \omega) + L_r(x, \omega) \quad (1)$$

The reflected radiance is computed as

$$L_r(x, \omega) = \int_{\Omega^+} Li(x, w_i) f_r(x, w_i \rightarrow \omega) < N(x), w_i >^+ dw_i \quad (2)$$

Where  $\Omega^+$  is the upper hemisphere oriented around the surface normal  $N(x)$  at  $x$ ,  $f_r$  the bidirectional reflectance function (BRDF) and  $< >^+$  a dot product that is clamped to zero. To determine the incident radiance,  $L_i$ , the ray casting operator is used to determine from which other surface location this radiance is emitted and reflected. The goal of global illumination algorithms is to compute  $L_o(x, \omega)$  for a given scene; materials and lighting  $L_e$  [14]. It is a

recursive equation which makes it unsolved analytically by exact method for this end several methods have been developed to solve the rendering equation

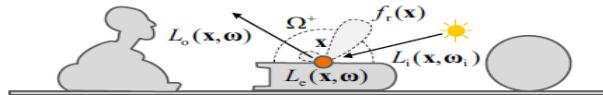


Figure.1 rendering equation

Global illumination is a set of techniques for approximating real-life lighting situations in computer graphics. State-of-the-art reference solutions of algorithms that are used for realistic image synthesis usually rely on; Monte carlo methods (e.g., ray tracing [16], metropolis light transport [15]), are general enough to allow light transport simulation in arbitrary scenes with all possible material types. However, those algorithms are too slow. Finite element methods such as radiosity [2], that can perform the rendering in real-time and also creates realistic images, but unfortunately the fast rendering is gained by an expensive pre-processing step, an enormous amount of storage and a limitation to static scenes, and the realism just includes indirect illumination, another category is density estimation methods (e.g., photon mapping [7]) that can be adapted to achieve interactive results under some conditions.

In contrast to those traditional algorithms, another category to do the rendering is the so-called **Many light rendering (MLR)** [3]. They are attractive because they offer a simple solution to many difficult rendering problems. Their main idea is that the general light transport problem can be approximated by the simpler problem of calculating the direct illumination from many virtual light sources. MLR derived from the instant radiosity algorithm of Keller [1] that offers a unified mathematical formulation to simulate the light transport in a scene by computing the direct illumination from many virtual points light sources (VPLs), it models light as a source of energy which distributes its energy outward to several surfaces and replaces the computation of indirect diffuse illumination by direct diffuse illumination from these virtual point lights by the end summing up their contributions and accumulating them to render low-noise images covering a wide range of performance and quality goals .This basic idea was then formulated as the many-lights problem and inspired a series of works .While some VPL generations have low importance because they are in a very little region of interest i.e. .Energy conservation; in general, each VPL does not contribute equally, scalable algorithm tries to exploit important VPLs and unimportant ones to reduce computation cost. In order to do this, some methods have tried to cluster unimportant VPLs together (e.g., Lightcuts [17]) but However, visibility based on ray tracing has to be evaluated for every element in the cut and remains the computational bottleneck. One way to quickly create VPLs is by rendering a so called Reflective Shadow Map (RSM) [4]. The RSM technique builds on the classical

shadow mapping technique, but augments the shadow map with material and surface normal information. However, RSMs do not provide a solution for secondary visibility: They allow computing surface elements that send the first bounce, but for every VPL (hundreds) another shadow map is required for secondary visibility.

The idea of Virtual Point Lights (VPLs) is to create a large number of point lights, each with a shadow map(SM), to simulate indirect illumination. So we need to render all these SMs for each vpl and this cause a big problem by choosing poor performance or temporal inconsistencies. Incremental instant radiosity [10] deciding which VPLs need to be removed and inserted to minimize temporal inconsistency. This approach allows for moving lights, but moving geometry leads to indirect shadows that lag behind the actual geometry. Depending on the frame rate and quality desired this can or cannot be acceptable.

The idea of IR was extended further by rendering so called imperfect shadow maps [13] for each VPL. Their idea is to create small and partial shadow maps for each VPL each frame, which they demonstrated gave little visual error. To do this, they created a point representation of the scene geometry, and for each imperfect shadow map they choose a subset of these points. This subset was then rendered to a texture, creating a coarse approximation of a shadow map, which was then improved in a push and pull step. By creating all these shadow maps in the same pass on the same texture resource, they were able to do this very quickly. These imperfect shadow maps were then used as shadow maps for the VPLs; in the same manner as the classical Instant Radiosity paper. This method can produce nice results in a few seconds but use hierarchy on light to reduce. Shading point or visibility testing problem was interpreted as a matrix problem. Matrix row column sampling ([5], [6],[12]) samples sparsely rows and columns of the lighting matrix to reconstruct the image (rows represents shading points and columns represents lights).

VPLs have two inherent limitations. First When connecting the camera to a VPL, the BRDF is much larger than the probability density of generating the path. This limitation leads to spikes ([6], [9]). The closer a VPL is, the more the artefact will be. Even it was treated by using clamping way but it causes energy lose, which means bias. [9] Introduced an unbiased path tracing approach to compensate for the loss of energy. However, large computation penalty was also introduced. The other limitation is the difficult path When glossy materials exist in the scene, S\*DS paths are inevitable since the paths are connected from a surface sample to a VPL. The main reason for these difficult paths is that the probability of generating a proper path is too small. By increasing the size of the path, we can increase the size of the path [3] or increase the size of the light [8]. Of course, bias is also introduced. These approaches considerably reduce the

computation cost, but are limited to a small number of VPLs and they are very inefficient at representing glossy light transport. It is only suitable for primarily diffuse materials; this is because a VPL on a glossy surface illuminates a small fraction of the scene only, and a huge number of VPLs might be necessary to render acceptable images.

### III. PROPOSED APPROACH

#### A. System Overview

This section provides an overview of our algorithm.

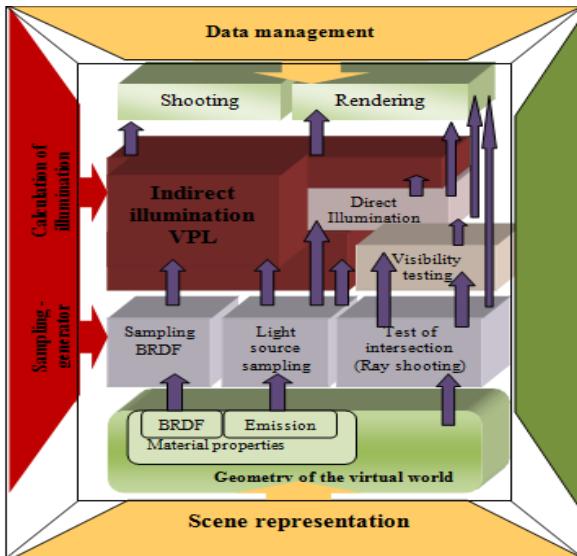


Figure 2. A scheme illustrates our system

Figure 2 illustrates the architectural of our system, an algorithm that is based on virtual point light to achieve smoothly indirect illumination, by tracing light paths starting from the primary light sources under the principal of random walks. The direct contribution of all these VPLs approximates the entire multi-bounce light transport in the scene, our system need **pre-computation data** to be taken for the **final gathering phase**.

- Scene representation :** All algorithms operate on a numerically defined virtual world that represent our scene, an internal model consisting of the geometry of the virtual world, optical material properties and the description of the lighting in the scene emission and reflection (BRDF) properties; Scene representation, which is described using Extensible Markup Language (XML) file. Sensors, light sources, objects and also the rendering technique (integrator) are described. In this way we are trying to make a standard script that model 3D scene which is alternate by the user in need.
- Basic operations:** The basic operations the virtual world representation has to support are light source sampling, directional sampling according to the reflection properties (BRDF sampling), and the computation of the intersection of a light ray with the geometry (ray shooting).
- Computation of illumination:** The computation of illumination can be separated into two parts direct and indirect. Direct illumination requires light source sampling and then a visibility test for every sample has to be performed.

Unlike, indirect illumination is computed by generating multi-bounce light paths using random walks. This requires light source sampling, directional sampling and ray shooting. And computation of direct illumination is also required. As indirect illumination is usually more expensive and the most consuming time to evaluate, this is the part that is typically pre-computed; we transform each indirect light to a direct inspired by the idea of vpl. The defiance is how identifying those parts of the computation that are constant, or can be rapidly adapted to changes happening in the virtual world (scene).

- Data management:** While finishing preparing all data (direct illumination evaluation, light tracing, ray shooting) that had been pre-computed which are needed to finally be gathering to render images. The main role of final gathering, however, is the validation and adaption of pre-computed information. This typically means checking whether a moving object has interrupted a light path: that is, visibility testing. This latter and other points are the most critical points that contribute to the image synthesis algorithm are ; approximation for visibility testing , ray shooting in general, ray tracing of visible reflective or refractive objects, improving sampling in random walk algorithms and in direct illumination, respectively should be evaluated efficiently to acquire a good, effective system to render smooth images .

#### B. Detailed description

##### I. Scene representation

Before light paths can be calculated, a scene and a viewpoint must be defined. Our scene is described using Extensible Markup Language (XML) file. Sensors, light sources, objects and also the rendering technique (integrator) are described. In this way we are trying to make a standard script that model 3D scene which is alternate by the user in need.

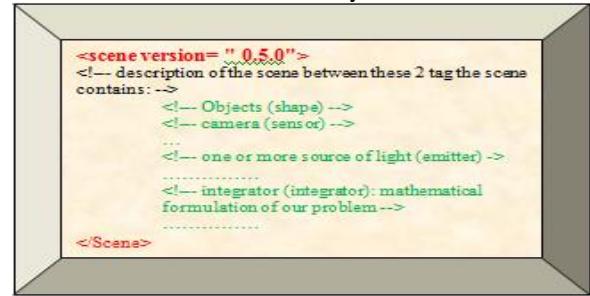


Figure 3. scene representation

After loading the scene which is well presented by an xml file, we trace rays from each light source to all of the scene objects, points, and creating virtual point lights (VPLs) at these points(**generating vpls**). Randomly choose one of the primary light sources in the scene, sample a random position x and direction w (create a VPL at this location if direct illumination is not handled otherwise).Trace the ray if it intersects a surface then create a VPL at this intersection location. Decide randomly whether or not to terminate the path using Russian roulette. If continued, sample outgoing direction, update path throughput based on BRDF and direction, and continue tracing.

Then, during the final shading pass, we evaluate each light (actual and virtual), calculating its weighted contribution to the scene, and shade the fragments appropriately .Every actual source of light will have unit intensity, which we distribute

equally to all of the virtual light sources created from it. Thus, we obey the principle of transfer of energy, which is the basis of radiosity. The intensity of each light dictates the share of its contribution to the final shading. VPL generation pre-process, is equivalent to the direct illumination of the first camera hit point by the VPLs.

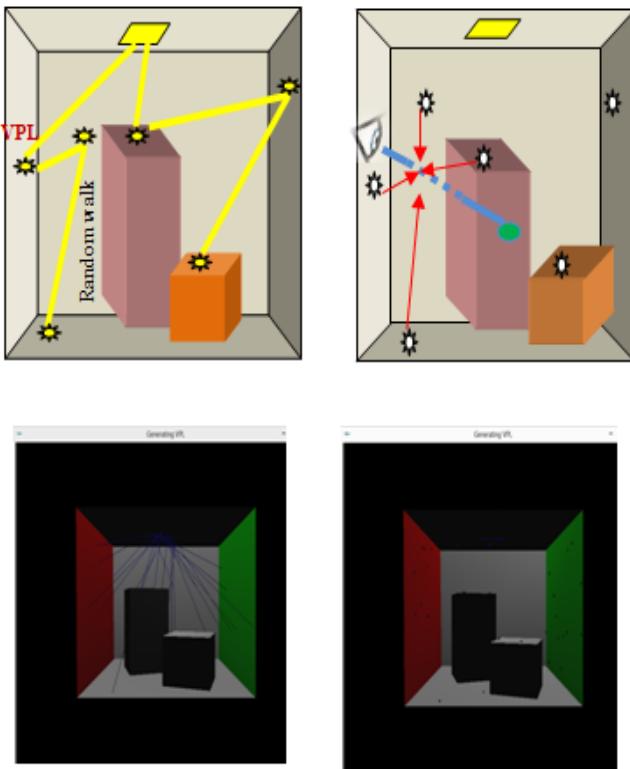


Figure.4 Generating VPL

## II. Basic operations

### a) Sample generator

When rendering a scene, we have to solve a high-dimensional integration problem that involves all properties that make up the scene; the geometry, materials, lights, and camera.

Because of the mathematical complexity of the integral used, it is generally impossible to solve them analytically, instead, they are solved numerically by evaluating the function to be integrated at a large number of different positions referred to as samples. Sample generators are an essential ingredient to this process: they produce points in a (hypothetical) infinite dimensional hypercube  $[0, 1]^\infty$  that constitute the canonical representation of these samples.

To do its work, a rendering algorithm, or integrator, will send many queries to the sample generator. (That is what arrows means in the diagram of our system that is mentioned before).

The gain by using Halton sequence QMC is to decreases the effect of clumping in samples by eliminating randomness completely. Samples are deterministically distributed as uniformly as possible that can lead to a higher order of convergence in renderings. Because of the deterministic character of the samples, errors will manifest as grid armoire

patterns rather than random noise, but these diminish as the number of samples is increased[12].we consider a set of points  $P$ . Consider each possible, axis-aligned box with one corner at the origin. Given a box of size  $B_{size}$ , the ideal distribution of points would have  $NB_{size}$  points.

The star discrepancy measure computes how much the point distribution  $P$  deviates from this ideal situation,

$$D^*_N(P) = \sup_B \left| \frac{\text{NumPoints}(P \cap B)}{N} - \text{Bsize} \right|$$

where  $\text{NumPoints}(P \cap B)$  are the number of points from the set  $P$  that lie in box  $B$ .

The Halton sequence (HS) in particular provides a very high quality point set that unfortunately becomes increasingly correlated in higher dimensions. HS based on the radical inverse function and are computed as follows. Consider a number  $i$  which is expressed in base  $b$  with the terms  $a_j$ :

$$i = \sum_{j=0}^{\infty} a_j(i) b^j$$

The radical inverse function  $\Phi$  is obtained by reflecting the digits about the decimal point:

$$\Phi_b(i) = \sum_{j=0}^{\infty} a_j(i) b^{-j-1}$$

### b) Ray shooting

Ray shooting is one of the expensive operations in the algorithm. The number of rays that needs to be shot in order to compute the distribution of energy in the scene to given accuracy with given confidence. In this case we refer to ray tracing is to trace many light paths using random walks starting from the sensor (camera). A single random walk entails casting a ray associated with a pixel in the output image and searching for the first visible intersection. A new direction is then chosen at the intersection, and the ray-casting step repeats over and over again (until one of several stopping criteria applies). At every intersection, the path tracer tries to create a connection to the light source in an attempt to find a complete path along which light can flow from the emitter to the sensor.

## III. Calculation of illumination

Always referring to the rendering equation to equate the contribution for all vpl using for the rendering. For estimating the radiance that represents the light transport from L lights to S surface samples.

$$L(x, w_o) = \sum_{x_i \in \Omega} g_{\text{hater}}.VPL(i) \quad (3)$$

$$L(x, w_o) = \sum_{s=1}^S C_{LS} \quad (4)$$

Each vpl is represented by its incoming light (L) to hit a surface (S).

$L(x, w_o)$  is the outgoing radiance of sample point and  $C$  is the contribution of light L to sample S, which can be decomposed into  $C_{LS} = M_{LS} G_{LS} V_{LS} I_{LS}$  (5)

Where  $M_{LS}$ ,  $G_{LS}$ ,  $V_{LS}$ ,  $I_{LS}$  are material, geometry, visibility and intensity of light respectively.

To calculate the contribution for all vpls two operations should be done **sampling** and **shading** which need surface sampling, light and scene geometry. These are the main component that we are showed on our system which are represented by blocks. To fulfill a good process to create image with global illumination in real time, we are going to start with surface samples and light in which we use the best representation of lights for each sample, and then we prepare geometry to evaluate visibilities of sample-light (ray intersection), all these data are pre-computed for the final rendering (data management). To reduce the time in rendering pre-computation is needed, while loading geometry of the virtual world i.e. material properties (light, geometry) L and G, in relative to time we have the notation, TL and TG respectively.

$$\begin{cases} Light = L \rightarrow \sum L \\ Geometry = G \rightarrow \sum G \quad \text{including the factor of time} \\ \quad \begin{cases} L = \sum TL \\ G = \sum TG \end{cases} \end{cases}$$

Light and geometry are dependent to represent material properties (MP)

$$PM = \sum TL + \sum TG \quad (6)$$

The optimal data management is to minimize the time consuming we deal with  $MIN_{PM}$  (Eq. 7)

$$MIN_{PM} = min_{nL,nG} (\sum n_L TL + \sum n_G TG) \quad (7)$$

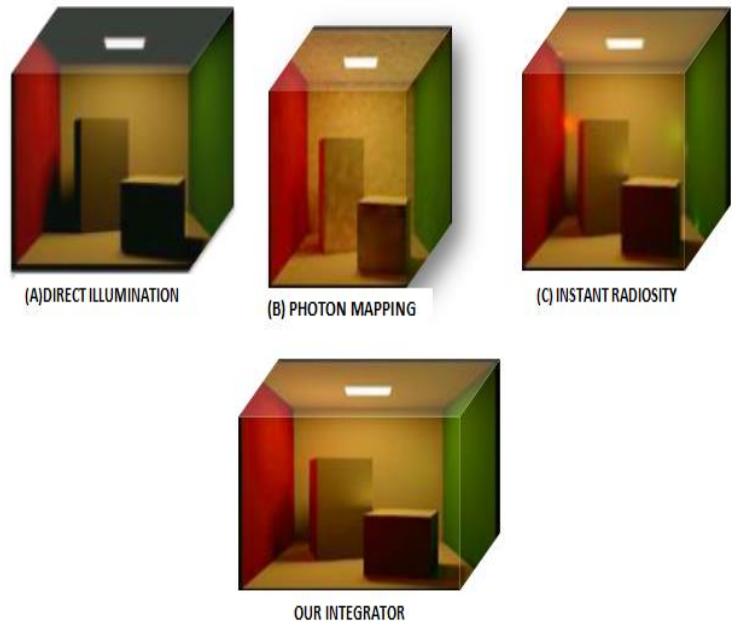
Where  $n_L$ ,  $n_G$  are the number of times that the algorithm loads light and geometry respectively . In order to achieve this we should take all computation with surface samples as well as all visibility tests before unloading it. Visibility testing may increase the occurrence of geometry because visibility is between geometry and light if G is visible or occluded from the camera point of view, it is preferable to test visibilities with as many sample-light rays as possible which will incur high number of light.

#### IV. RESULTS AND DISCUSSION

##### a) System used

The implementation of our model based on visual studio C++ language using the Visual Studio 2010 IDE and Python. Our system rendering output took place on a computer with i7-3517U processor with 4GB RAM and NVIDIA GT 635M/2GB. A table illustrates results of different integrator which is compared according to various property values

##### b) Results



##### c) Evaluation and discussion

###### 1. Used metrics

###### a) Shadow map resolution

Shadows are created by testing whether a pixel is visible from the light source, by comparing it to *depth* image of the light source's view, stored in the form of a texture

###### b) Maximum depth

Specifies the longest path depth in the generated output image (where -1 corresponds to  $\infty$ ). A value of 2 will lead to direct-only illumination.

###### c) Clamping factor

A relative clamping factor between [0, 1] that is used to control the rendering artifact discussed below

###### d) Sample

The number of samples per pixel specified to the sampler is interpreted as the number of VPLs that should be rendered.

###### e) Filter

Image reconstruction filters are responsible for converting a series of radiance samples generated jointly by the sampler and integrator into the final output image that will be written to disk at the end of a rendering process. This section gives a brief overview of the reconstruction filters that are available in Mitsuba. There is no universally superior filter, and the final choice depends on a trade-off between sharpness, ringing, and aliasing, and computational efficiency.

Desirable properties of a reconstruction filter are that it sharply captures all of the details that are displayable at the requested image resolution, while avoiding aliasing and ringing. Aliasing is the incorrect

leakage of high-frequency into low-frequency detail, and ringing denotes oscillation artifacts near discontinuities, such as a light-shadow transition.

**Gaussian filters (Gaussian):** this is a windowed Gaussian filter with configurable standard deviation. It produces pleasing results and never suffers from ringing, but may occasionally introduce too much blurring, when no reconstruction filter is explicitly requested.

Property value						
Shadow Map resolution	Maximum depth	Clamping factor	Sample /pixel 64	Filter	Time	
Only direct illumination	512*512		Low discrepancy	Gaussian	1.8m	
Photon mapping	512*512	$\infty$	Low discrepancy	Gaussian	24.6m	
Instant radiosity	512*512	$\infty$	0.1	Low discrepancy	Gaussian	1.07m
Our approach	512*512	$\infty$	0.5	Halton QMC	Gaussian	0.6m

## V. CONCLUSION

We have showed a detailed system aiming at approaching the various phenomena of interaction matter/light by inexpensive processing. As future work, we will investigate for improving other phenomena such us; if geometric simplifications can be included on top of the visibility approximations, the extension from one bounce to multiple bounces of light would be an interesting as well as the inclusion of highly complex materials.

## REFERENCES

- [1] A.Keller. (1997, August). Instant radiosity. In *Proceedings of the 24th annual conference on Computer graphics and interactive techniques* (pp. 49-56). ACM Press/Addison-Wesley Publishing Co..
- [2] COHEN, M. F., WALLACE, J., AND HANRAHAN, P. 1993. Radiosity and realistic image synthesis. AcademicPress Professional, Inc., San Diego, CA, USA
- [3] Dachsbacher, C., Křivánek, J., Hašan, M., Arbree, A., Walter, B., & Novák, J. (2014, February). Scalable Realistic Rendering with Many-Light Methods. In *Computer Graphics Forum* (Vol. 33, No. 1, pp. 88-104).
- [4] Dachsbaucher,C. and Stamminger, M. (2005). Reflective shadow maps. In I3D '05: Proceedings of the 2005 symposium on Interactive 3D graphics and games, pages 203–231, New York, NY, USA. ACM.
- [5] Davidovič, T., Křivánek, J., Hašan, M., Slusallek, P., & Bala, K. (2010, December). Combining global and local virtual lights for detailed glossy illumination. In *ACM Transactions on Graphics (TOG)* (Vol. 29, No. 6, p. 143). ACM.
- [6] Hašan, M., Pellacini, F., & Bala, K. (2007, August). Matrix row-column sampling for the many-light problem. In *ACM Transactions on Graphics (TOG)* (Vol. 26, No. 3, p. 26). ACM.
- [7] Jensen, H. W. (1996). Global illumination using photon maps. In *Rendering Techniques' 96* (pp. 21-30). Springer Vienna.
- [8] Kajiya, J. T. (1986, August). The rendering equation. In *ACM Siggraph Computer Graphics* (Vol. 20, No. 4, pp. 143-150). ACM.
- [9] Kollig, T., & Keller, A. (2006). Illumination in the presence of weak singularities. In *Monte Carlo and Quasi-Monte Carlo Methods 2004* (pp. 245-257). Springer Berlin Heidelberg.
- [10] Laine, S., Saransaari, H., Kontkanen, J., Lehtinen, J., and Aila, T. (2007). Incremental instant radiosity for real-time indirect illumination. In *Proceedings of Eurographics Symposium on Rendering 2007*, pages xx–yy. Eurographics Association.
- [11] Ou, J. & Pellacini, F. (2011). Lightslice: matrix slice sampling for the many-lights problem. In *Proceedings of the 2011 SIGGRAPH Asia Conference*, SA '11, 179:1–179:8, ACM.37
- [12] P ,Dutre. Bekaert, P., Bala, K., & (2006). Advanced global illumination.
- [13] Ritschel, T., Eisemann, E., Ha, I., Kim, J. D., & Seidel, H. P. (2011, December). Making Imperfect Shadow Maps View-Adaptive: High-Quality Global Illumination in Large Dynamic Scenes. In *Computer Graphics Forum* (Vol. 30, No. 8, pp. 2258-2269). Blackwell Publishing Ltd.
- [14] T.Ritschel. C ,Dachsbaucher.T, Grosch, & Kautz, J. (2012, February). The state of the art in interactive global illumination. In *Computer Graphics Forum* (Vol. 31, No. 1, pp. 160-188). Blackwell Publishing Ltd.
- [15] Veach, E., & Guibas, L. J. (1997, August). Metropolis light transport. In *Proceedings of the 24th annual conference on Computer graphics and interactive techniques* (pp. 65-76). ACM Press/Addison-Wesley Publishing Co..
- [16] WALD I., KOLLIG T., BENTHIN C., KELLER A SLUSALLEK P.: Interactive global illumination using fast ray tracing In *Proc EGRW(2002)* pp15–24
- [17] Walter, B., Khungurn, P., & Bala, K. (2012). Bidirectional lightcuts. *ACM Transactions on Graphics (TOG)*, 31(4), 59.

## KNOWLEDGE CAPITALIZATION FOR MASSIVE OPEN ONLINE COURSES

NACERA HAMMID

Mouloud Mammeri University (UMMTO), Algeria, cilacila4@gmail.com

FARIDA BOUARAB DAHMANI

Mouloud Mammeri University (UMMTO), Algeria, faribouda@gmail.com

**Abstract:** Massive Open Online Courses (MOOC) are considered as the new e-learning generation. Consequently it's the most discussed subject in e-learning and higher education communities nowadays. The Most currents MOOCs are led by MOOC platform providers (like Coursera and Udacity) in partnership with universities. Hence, behind each MOOC, there are a large community of developers, teachers, facilitators and so one. Each delivered MOOC is the result of a collaborative contribution of these lasts. However, if massive open online courses are being a lifelong learning, the knowledge exchanged between the MOOC actors should be organized and managed so that it can be used and reused in a "massive" and "open" context. In this paper, we focus on the teachers' collaboration for capitalization of knowledge and its use for courses or another kind of learning activities generation in an open, online and massive context. We propose a knowledge capitalization model based ontology as a collaborative tool for disciplines in MOOC or any kind of massive and open online learning environment. The capitalization process is preceded by collaborators' prospecting and selection process. At this stage, the moderator is in charge of calling disciplinary experts over a certain *scope* (country, continent or over the world) to participate to the capitalization process. After that, experts interested to this call are invited to inscribe. Then they are classified according to their experiences in the disciplinary to capitalize. The first classified expert is selected as the organizer of the capitalization process (he will be the expert moderator). We propose two kinds of knowledge capitalization. The first one is related to the disciplinary ontology (as disciplinary meta model) capitalization. In this process, knowledge engineers are invited to validate or propose disciplinary domain ontology elements (concepts, semantic associations and rules). The second kind of capitalization concerns the disciplinary knowledge capitalization. Here, disciplinary experts, who are experienced teachers of the given discipline, are invited to give their suggestions by proposing or updating instances for the domain ontology elements. In this paper we recommend that the disciplinary domain ontology is Onto-TDM proposed and evaluated in our precedent works.

**Keywords:** E-learning, collaboration, knowledge capitalization, Massive Open Online Courses (MOOC), educational ontologies.

### 1. INTRODUCTION

The online learning (E-learning) is one of the most remarkable events in the learning history. Thanks the internet and mainly the web, the information becomes accessible shareable and questionable over the globe. Nowadays, many educational institutions (mainly universities), are open to the web. As an example, a website or web portal of a university is generally composed of a description and some important information about it, its offered programs classified by department and faculties and the most of them give a restricted access to pedagogical resources (courses tutorials ...). We can also find programs which are available for distance learning under specific conditions. Out of those sites we find other sites in the web which offer (payable or no) online trainings. Several offline courses and tutorials are distributed online which are edited either by teachers or anyone who wants to share his learning experience. The forums and Wikis are very effectives for collaborative learning. In the forums, a topic is exposed which can be a problem and then the intervention should be a suggest solution, or an introduction of debate, so the interveners are invited to give their point of view. In the Wiki technology, the participation can be open or restricted on a group of

collaborators aims to capitalize their knowledge. It is a set of pages which can easily be edited and modified by members. The resulting pages constitute a knowledge book which can be used and reused later. In this kind of collaborative spaces, moderation is required to validate the result and avoid any senseless interventions. These two technologies are also can be integrated in learning environments as learning activities, those last are called Learning Management System (LMS or CMS for Content Management Systems) like MOODLE [1], Claroline [2]. We find in an LMS different learning resources (courses, tutorials, assessments, exercises, practicals...) and activities (forums, blogs, quizzes...). It is mostly used by universities on the Intranet (locally) or on the web to improve the students learning experience.

Massive Open Online Course (called MOOC) is the most recent phenomenon in the online learning. It includes the most important features offered separately by the previous online learning generations like the openness and the accessibility online with the characteristic of massiveness and interaction with social networks. It is considered as the sixth e-learning generation [3]. A MOOC platform is generally composed of LMS including other extensions (like Coursera [4], Moodle MOOC [5], OpenClassroom [6], FuterLearn [7]...). Each MOOC is realized by a large community of teachers designers and developers. However, the MOOC platform doesn't provide a

collaborative environment where those members can share and exchange their knowledge and built a common knowledge base for MOOC.

In this paper, we are interested on the teachers' collaboration for capitalization of knowledge and its use for courses or another kind of learning activities generation in an open, online and massive context. We suggest a knowledge capitalization model based ontology as a collaborative tool for disciplines in MOOC or any kind of massive and open online learning environment. In what follows we will first introduce an overview about MOOCs, after that we define the context and objectives of our research. The third point will give details about the proposed capitalization process stages. The fourth and the last point will be an overview of our future first validation of our proposition. This validation is about an application of the capitalization process for a discipline from the standardized LMD licence training program of our country.

## 2. MASSIVE OPEN ONLINE COURSES:

The term MOOC was coined in 2008 by Dave Cormier. The first MOOC 'Connectivism and Connective Knowledge' (CCK08) was led by George Siemens of Athabasca University and Stephen Downs of National Research Council [8].

**Massive course:** refers to the massiveness of number of the participants on this course. **Open course:** means that everyone from anywhere can access to this course without any fees. **Online course:** means that the course is distributed online. 'Openness also means that novices and experienced people are able to merge together in the same space and communicate and interact with each other. And this is one of these things that you can do online that you can't really do offline' [9].

The Connectivism and connective knowledge course was about and based on the limits of previous learning theories and the idea that the knowledge is constructed by communication, collaboration and interaction between learners using technology (blogs, wikis...) and social network. After his first mooc experience in the fall of 2011 with Peter Norvig (Director of research at Google) offering an open enrollment of their Artificial Intelligence (CS 271) course, Sebastian thrun (a professor at Stanford University) started Udacity (a mooc platform). After soon, Daphne Koller and Andrew Ng launched Coursera.

Concerned about the commercialization of online education, Massachusetts Institute of Technology (MIT) created the not-for-profit MITx. The inaugural course, 6.002x, launched in March 2012. Harvard joined the group, renamed edX [8]. In 2013, the the Open University built its own MOOC platform, Futurelearn led by universities from the United Kingdom. Many others moocs initiatives was followed (like Open2Study, Iversity, FUN, OpenHpi...) and others stilling launched. Many types of moocs exist in the literature [10] [11] [12], we retain two types of them: those that emphasize the connectivist philosophy, and those that resemble more traditional courses. To distinguish the two, Stephen Downes proposed the terms "cMOOC" and "xMOOC"[13]. In Connectivist MOOCs (cMOOCs), courses organized by group having the similar specific

focus, encourages participants to collaborate, share and contribute in building a creative knowledge. Extended MOOCs (xMOOCs), mostly led by universities, courses look like traditional courses, videos lectures and online interactive exercises (tests and quizzes) and home works, and learners are expected to duplicate what they are taught.

many discussions have been animated toward this emergent trend, most of them treat the impact of moocs on higher education, the role of instructors (educators/facilitators) in moocs, the learner profile, the design and the constitution of courses. Iqbal & al [14] mentioned that most of the opportunities which MOOCs gave to education become inevitable challenges. MOOCs offer us a new learning dynamic based upon learning analytic but with limited assessment methods, a lifelong learning without learner profile personalization and authentication, collaborative, social and peer to peer learning with lack sufficient teacher-learner interaction. Koutropoulos & all [15] listed fifteen main problems and challenges for MOOC design and evaluation, the most of them are the design of mooc , the learner engagement , motivation and satisfaction, and assessments challenges. They also called to rethink and reconsider teaching approaches and keep an open mind to various aspects of teaching, such as facilitating, monitoring, coaching, peer teaching and so on.

## 3. KNOWLEDGE CAPITALIZATION BASED ONTOLOGY IN MOOCS:

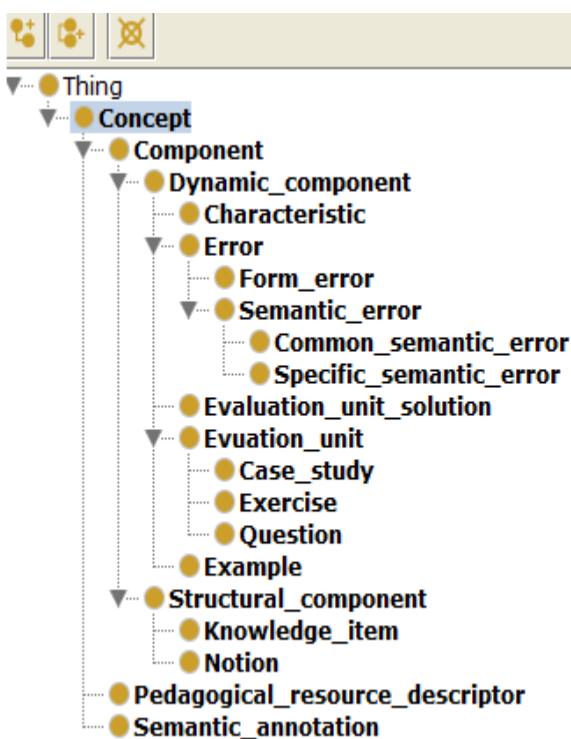
Knowledge capitalization is a process based on knowledge management methods aiming to collect and organize the know-how and experiences feedbacks so it can be used and reused. The knowledge is firstly collected then formalized so that it can be accessible. Knowledge capitalization is mostly used by enterprises in fact of expert's retirement, the loss of acquired knowledge from previous projects and the need of facilitating the integration of new employees. Ontology is one of the knowledge formalization methods. a domain ontology consists of a representation of concepts of a domain and the relation between those lasts.

The use of ontologies is efficient for sharing a common knowledge , treating and automating reasoning of/about knowledge and the reusing of this last. Thus several works are opted for the use of ontologies as knowledge modeling for knowledge capitalization. As examples of those works; Lahoud and all [16] proposed a semantic web service to extract knowledge in E-groupwares called OCEAN (Ontology Creator Extractor Annotator & Knowledge) to enable engineers to capitalize their know-how by using ontology. Dai and all [17] suggested a cooperative knowledge discovery model for design project as a cooperative knowledge management method based ontology. In e-learning domain, Zouaq and all [18] proposed a framework for e-learning resources capitalization as an alternative of Learning Object Repository (LOR) approach (used to store resources annotated with standard metadata such as the Learning Object Metadata and SCORM) by representing learning object content and generating a domain ontology associated to this content. Berkani and all [19] defined

CoPE (Communities of Practice of E-learning) as a virtual space where e-learning actors can share and exchange their knowledge and know-how using an ontology based framework structured on three layers: 1) the ontology layer defining a common vocabulary to facilitate knowledge sharing between CoPE members, 2) the semantic annotation layer as a semantic support to annotate the CoPEs' knowledge assets for facilitating its retrieval and reuse and the asset layer providing means of storage and indexing its different assets.

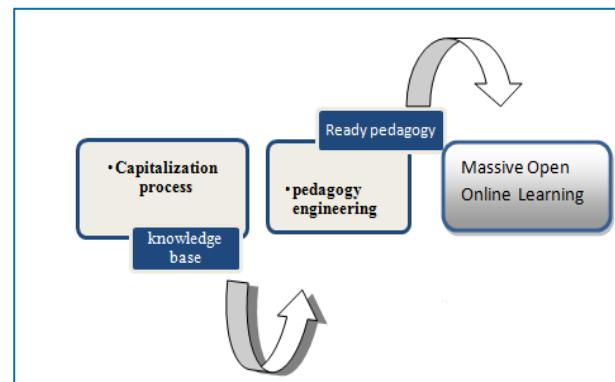
Our proposition consists of a knowledge capitalization process for disciplines based on the Onto-TDM domain ontology already proposed and evaluated in our precedent work [20]. This last represents a discipline as set of concepts (notions, knowledge items, evaluation units, errors ...) and a set of semantic links. As shown in figure 1, a concept can be a component, a description of a pedagogical resource or a semantic annotation. A component can be a dynamic or structural one. This last is composed of Knowledge item which is the most elementary knowledge of a discipline, and notion which is a set of knowledge items. The dynamic component is represented as characteristic, evaluation unit, evaluation unit solution, error and example. An evaluation unit can be an exercise, a case study or a question. For errors we distinguish two kinds of them, the form errors and the semantics ones. These lasts are separated on semantics errors which can be common for different exercises, and specific semantics errors that are particular for a given exercise but related to the use of a notion or a knowledge item in this exercise.

During the knowledge capitalization process collaborators are invited to express their knowledge of a discipline as a set of notions and suggest evaluation units, pedagogical resources and a set of frequently errors according to their experience in teaching.



**Fig 1:** ONTO –TDM domain ontology concepts seen with the Protégé tool

This disciplinary knowledge got from this knowledge capitalization process can be the knowledge base of engineering pedagogy (PE) of different learning activities in different computer based learning particularly for the online, massive and open ones. Hence the PE module can be integrated in a Massive Open Online Courses platforms (where courses are difused) or Massive Open Online Learning (MOOL) platform where different kind of learning activities (more than courses) are proposed (see fig 2).



**Fig 2:** the use of disciplinary knowledge in massive open online environments.

#### 4. THE PROPOSED KNOWLEDGE CAPITALIZATION PROCESS BASED ONTOLOGY

The capitalization process is composed on six stages (as shown by fig3):

##### 1) Project announcement :

The moderator chosen in collaborators' prospecting and selection process make a broadcast call to the others collaborators, the capitalization is then started.

##### 2) Project initialization :

The moderator adds the first suggestion which is an instance of the domain ontology (instances of notions, knowledge items, examples exercises...) and activates the collaborators participation.

##### 3) Propositions collection :

Each one of the expert add his proposition. This last can be a modification of the existing one or a new suggestion.

#### 4) Synthesis :

The moderator analysis the expert's suggestions and. After that he builds a temporary version of the knowledge base.

#### 5) Rebroadcasting and opinions collection :

The moderator exposes the temporary version and collects the expert's opinions about it. This step is iterated until getting a version on which the majority of collaborators agree.

#### 6) Project closure :

The moderator validates and rebroadcast the final version and the close the capitalization process.

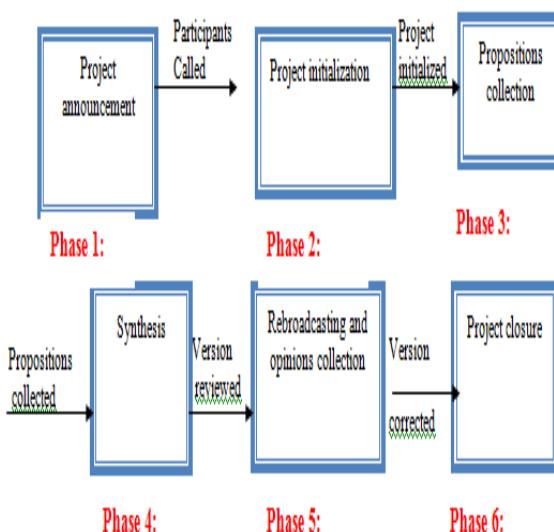


Fig 3: The knowledge capitalization process main steps.

## 5. CASE STUDY

This section describes an overview of our future first validation of our proposition. This validation is about an application of the capitalization process for a discipline from the standardized LMD licence training program of our country. The application of our proposed approach is not yet implemented; it is at the design stage.

The discipline chosen in this case study is the algorithmic program for Computer Sciences Licence training in Algerian universities. The result got from this capitalization project will be a national knowledge base of this discipline.

According to the **Knowledge Capitalization Process (KCP)** detailed in the previous section, we define two kinds of actors in our collaborative application, the moderator and the disciplinary experts. As we mentioned previously in the collaborators' prospecting and selection process, the moderator is the best classified in the disciplinary experts list (according to his experience in teaching the disciplinary to capitalize and writings about this last). Thus, in this case all the collaborators are

algorithmic experts. The following table (see table1), lists the role of each actor in the capitalization process. In what follows, we give details about “adding a proposition” use case.

Table1: Actor's use cases in KCP.

Use case	Actor
Calling laborators	Moderator
Editing the first suggestion	Moderator
Editing new suggestions or modifying previous ones	Disciplinary experts
Suggestions analyse and building a revision version	Moderator
Defusing the revision version and collecting opinions	Moderator and disciplinary experts
Validation and diffusion of the final version	Moderator

#### 1) Adding a proposition :

Adding a new proposition is to give a set of algorithmic notions, couples of evaluation units and solution, examples and pedagogical resources.

First, the user must specify the elementary type of the concept which can be a knowledge item (KI), notion, exercise, case study, question, example, common semantic error, specific semantic error, form error, example, semantic annotation or pedagogical resource descriptor. Type the title of the concept and specify the location of the pedagogical resource (see fig 4). Next, in the case of adding a KI, the user must indicate the notion which this KI is part of. When adding an evaluation unit (exercise, question or case study), the user have to mention the notions (one or more KI will be consequently concerned) to be evaluated. In the case of adding an error (semantic or form error), the KI to miss once making this error must be specified. If the concept type is example the user must indicate the notion and/or KI concerned.

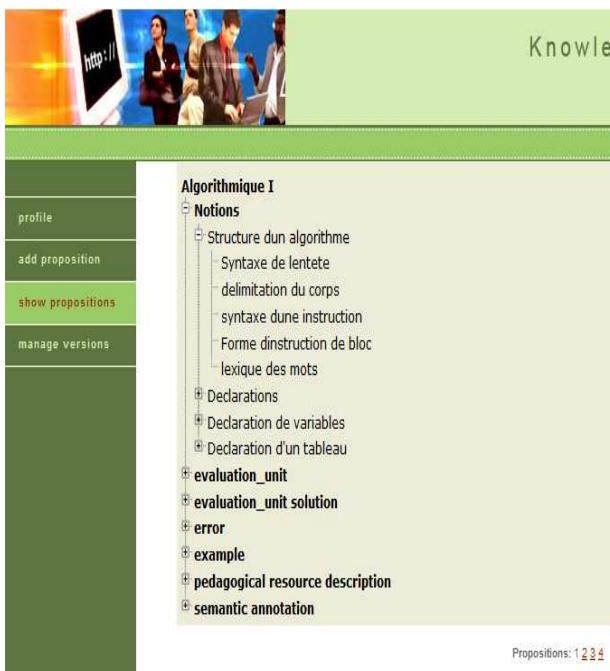


**Fig 4:** Adding a proposition

The first proposition is added by the moderator. The following propositions are added by the Disciplinary Experts (DE). The figure 5 shows a tree view of the collaborator's propositions.

## 2) *Modifying a proposition :*

DE can add a new proposition or building a proposition from modifying an existing one. This second type of adding a proposition is also used by the Moderator (M) to build a synthesis version. To modify a proposition, the user (DE or M) select the basic version to use from the propositions list (shown in fig 6), and modify its elements described in the previous cases as shown in figure 7.



**Fig 5:** A tree view of propositions

profile	proposition range	Autor name	time and date		
add proposition	1	Bouareb.F	10.08.2015 10:20	<a href="#">View</a>	<a href="#">use</a>
show propositions	2	Amirouche.F	10.08.2015 11:00	<a href="#">View</a>	<a href="#">use</a>
	3	Berkane.T	14.08.2015 12:30	<a href="#">View</a>	<a href="#">use</a>
	4	Ait Elhadj.F	14.08.2015 13:00	<a href="#">View</a>	<a href="#">use</a>

**Fig 6 :** Propositions' list shown in DE space.

**Fig7 :** The modification of a proposition

## 6. CONCLUSION

In this paper we suggest a collaborative tool for discipline knowledge capitalization. This tool aims to provide a consensus about what to teach in a given discipline. We project particularly to use this capitalized knowledge for MOOC engineering. We gave an overview about our first validation of our proposals. The case study concerned the algorithmic discipline from Algerian university licence training. We expect in next works to finalize other experiments about the tool and its use for capitalization of different disciplines of common licence training from universities of our country.

## 7. REFERENCES

- [1] Moodle site at : <https://moodle.com/?gclid=CKLFpbao3scCFYccGwodjwsGrw>
- [2] Caroline site at :<http://www.claroline.net/>
- [3] Stephen Downs blog, 2012, “e-learning generations” at:  
<http://halfanhour.blogspot.com/2012/02/e-learning-generations.html>.
- [4] Coursera site at :<https://fr.coursera.org/>
- [5] Moodle MOOC site at:<https://learn.moodle.net/>
- [6] OpenClassrooms site at: <https://openclassrooms.com/>
- [7] FutureLearn site at:<https://www.futurelearn.com/>
- [8] Wikipedia: Massive Open Online Course at:  
[http://en.wikipedia.org/wiki/Massive\\_open\\_online\\_course](http://en.wikipedia.org/wiki/Massive_open_online_course).
- [9] Stephen Downs blog,2012, “education as platform mooc experience” at: <http://halfanhour.blogspot.com/2012/03/education-as-platform-mooc-experience.html>.
- [10] Lane, L., 2012. Three kinds of MOOC, Lisa's (online) teaching blog (blog post), at :<http://lisahistory.net/wordpress/2012/08/three-kinds-of-moocs/> .
- [11] Clark, D, 2013. MOOC: taxonomy of eight types of MOOC (blog post), Donald Clark Plan B (blog post), at :  
<http://donaldclarkplanb.blogspot.co.uk/search?q=MOOCs:+taxomy>.
- [12] Gilliot, J.-M., Garlatti, S., Rebai, I., & Belen-Sapia, M, 2013. “Le concept de iMOOC pour une ouverture maîtrisée “. at :  
<http://ateliermoocieah2013.wordpress.com/>  
Siemens, George. ["MOOCs are really a platform"](#) at :
- [13] <http://www.elearnspace.org/blog/2012/07/25/moocs-are-really-a-platform/>
- [14] Iqbal.S, Zang.X Zhu.Y, Yan Chen. Y Zhao.J , 2014 "On the Impact of MOOCs on Engineering Education“ at:  
<http://ieeexplore.ieee.org/xpl/articleDetails.jsp?reload=true&arnumber=7020249>.
- [15] Koutropoulos.A Zaharias.P , 2015,“Down the Rabbit Hole: An initial typology of issues around the development of MOOCs “ at:<http://scholarworks.umb.edu/cgi/viewcontent.cgi?article=1011&context=ciee>
- [16] Lahoud I , Monticolo D, Gomes S, OCEAN: a semantic web service to extract knowledge in E-Groupwars, sixth international conference on Signal-image technology and internet based systems, 2010.
- [17] Dai X , Matta N, Ducellier G, CKD: a Cooperative Knowledge Discovery Model for Design Project, Proceedings of the Federated Conference on Computer Science and Information Systems pp. 1363–1369, 2014.
- [18] Zouaq A, Nkambou R, Frasson C, A Framework for the Capitalization of e-Learning Resources, 2006.
- [19] Chikh A., Berkani L., Sarirete A, Modeling the Communities of Practice of E-learning – CoPEs. In LINC, 4<sup>th</sup> Annual Conference of Learning International Networks Consortium, pp.428-441. 2007.
- [20] Bouarab-Dahmani F, Si-Mohammed M., Comparot C & Charrel P. J (2010). Automated Evaluation of Learners with the ODALA Approach: Application to Relational Databases E-learning. International journal of computational intelligence systems, IJ CIS, Vol.3, N 3, (September 2010), 357-369, published by Atlantis press.

## Author Index

Abdelmoumene, Zerari	95
Ait Oubelli, Lynda	1
Amira, Foughali	9
Amirat, Abdelkrim	1
Ayoub, Benayache	89
Azeddine, Bilami	89
Belaoued, Mohamed	36
Belkadi, Khaled	31, 70
Benayache, Ayoub	17
Besma, Senaï	26
Bilami, Azeddine	17
Bouarab-Dahmani, Farida	101
Bouatouche, Mourad	31
Boucheham, Bachir	36
Boufaida, Mahmoud	42
Bougueroua, Salah	36
Boukli Hacene, Sofiane	78
Chehili, Hamza	42
Cheraitia, Meryem	47
Cherroun, Hadda	57
Guessoum, Fatima	52
Haddadi, Salim	47, 52
Hameurlaine, Messaoud	57
Hammid, Nacera	101
Hidouci, Adenane	63
Khiat, Salim	26
Lebsir, Rabah	63
Miroud, Mohammed El Mustapha	70
Mohamed Chaouki, Babahennini	95
Mohammed, Azza	78
Moussaoui, Abdelouahab	57
Nacer Eddine, Zarour	83
Naima, Bahi	95
Rahal, Sid Ahmed	26
Sabrina, Mehdi	83
Sami, Barkat	17, 89
Sarra, Khemliche	95
Zizette, Boufaida	9

## Keyword Index

Actuator node	17
Agile Development	42
Algorithm Génétique	31
alignement	9
AMQP	89
Analyse de risques	70
Application Layer Protocols	89
Apriori algorithm	26
Association Rule	26
CBIR	36
change impact analysis approaches	63
CoAP	89
collaboration	101
combinatorial optimization	52
community	83
Component	42
composition	83
Contiki	78
COOJA	78
correspondances sémantique	9
discrete wavelet	36
E-learning	101
E-santé	70
E-Tourism	31
EBIOS	70
educational ontologies	101
EMF compare	1
Energy efficiency	17
ETX	78
Exam timetabling	47
Framework	42
global illumination	95
Haar basis	36
HEEP	17
Heterogeneous WSN	17
heuristic	52
high availability of web services	83

Image Mining	26
Image Reconstruction	57
image retrieval	36
Internet of Things (IoT)	89
interreflection effects	95
Inverse Problem	57
IOT	78
 knowledge capitalization	101
 light source	95
 M2M	89
Magnetic Resonance Imaging	57
Massive Open Online Courses (MOOC)	101
medical imaging	26
metaheuristic	52
Metaheuristics	47
Mobile Application under test(MappUT)	1
model	42
model driven engineering (MDE)	1
MQTT	89
multi agent system	83
 Neighborhood	47
Nurse rostering	52
 Objective Function	78
OF0	78
ontologies multi-points de vue	9
 personnel scheduling	52
planning	83
Problème de Planification Touristique	31
Protection des données personnelles	70
Publish/Subscribe	89
 Request/Response	89
RESTful	89
Routing	17
RPL	78
 SCA	42
Simulated annealing	47
skewness	36
SOA	42
software evolution	63
Software evolution	1

Software maintenance	63
statistical moment	36
Super-resolution	57
Sécurité	70
Test case adaptation	1
TIC	31
timetabling	52
virtual point light(vpl)	95
web service	83
Weighted Support.	26
Wireless Sensor Network	17
XMPP	89