Business Intelligence
and Mobile Technology Research
Business Intelligence and Mobile Technology Research:
An Information Systems Engineering Perspective

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In 2013, analytics and business intelligence, mobile technologies, and cloud computing were the top 3 priorities in the area of business and technology, according to a Gartner global survey of top 10 Chief Information Officers (CIOs). CIOs from 36 industries in 41 countries anticipate these information technologies to be a disrupting information technology that unexpectedly displaces an established technology over the next 10 years. Business intelligence systems consist of two major components, the data warehousing environment and the analytical environment. The latter is often further classified into two categories: reporting tools (dashboards and scorecards, reporting and query tools, etc.) and analytical tools. The analytical tools include decision support systems, executive support systems, online analytical processing (OLAP), and data mining.

All business organizations strive for increasing their growth by seizing new opportunities, reducing enterprise costs, attracting new customers and retaining old customers. In doing so, business intelligence and analytics allow business organizations to make better plans, informed decisions, and monitor their progress towards planned goals and objectives. The more disruptive power of IT technologies comes synergistically. Individual IT technologies do not work in isolation. Business intelligence systems are built on other digital technologies, such as mobile and collaborative technologies, cloud computing, virtualization, and enterprise resource planning and enterprise information systems. All of these IT technologies in combination bring forth their highest troublemaking forces to disrupt an existing market and seize new opportunities.

The Objective of this Book

This volume presents sixteen of the most insightful research papers amongst the various contributions accepted for presentations at the International Conference on Information Systems and Technologies (ICIST 2013) and International Conference on Software Engineering and New Technologies (ICSENT’12), held in Tangier, Morocco and Hammamet, Tunisia respectively. Two other papers originated from AMCIS (Americas Conference on Information Systems) 2012 Proceedings.
These papers truly represent what today’s CIOs see as the top priority disruptive IT technologies that will help business organizations seize digital opportunities to increase their growth and reduce operating costs. The effective design, development, and management of enterprise information systems require multi-disciplinary efforts from management information systems (MIS), information system engineering (ISE), information science, and other disciplines. This volume showcases exemplary ISE research in business intelligence and mobile technology. It is our hope that the sharing of these works with the IS community in other disciplines will help develop more synergy across areas. ISE aims to design, develop, and manage enterprise information systems. Recent years have witnessed a steady growth of ISE research in the IS discipline, and it has become an important theme at major IS conferences. Cross-disciplinary research in ISE is also increasing.

The Structure of this Book

The book has three sections: Business Intelligence, Mobile Technologies, and Miscellaneous Topics. The first section of the book introduces readers to emerging topics in business intelligence (BI). BI systems consist of three subsystems: data warehouses, business analytics, and performance management systems. BI systems enable users to access the data in data warehouses in real time, process the data to generate on-demand reports using online analytical processing, create decision alternatives using decision support systems/executive support systems, and predict future outcomes using data mining. BI systems utilize a wide range of management science and statistical models as well as visualization tools such as geographical information systems. Due to the breadth of BI topics, section 1 is further divided into three subtopics: decision support systems, data mining, and intelligent systems.

The decision support systems subsection includes the topics of negotiation support systems, decision support systems, and geographical information systems. Abroun and others propose a new concept and architecture of integrating wireless sensor networks within an enterprises information system into corporate data warehouses. They further discuss the benefits and different challenges for integrating wireless sensor networks into data warehouses. The next paper in this section presents a combination of psychological and rational approaches to simulate a complex negotiation behavior in the bilateral automated negotiation process. Autonomous agents could be intelligent software entities, distinguishable from a psychological character (such that conciliatory,
neutral or aggressive), and a rational reasoning to take part in the process of searching gain with eventual agreement.

The third paper in this subsection deals with the empirical testing of DeLone and McLean’s IS success model in the context of a Business Intelligence (BI) system in a police organization in Sweden. The last paper in decision support systems, modeling knowledge management systems for component-based software engineering, addresses modeling knowledge management systems for the component-based software engineering CBSE domain by using a popular knowledge Engineering technique.

The second subsection presents two chapters that focus on data mining. Data mining is the process of discovering knowledge in large databases. It aims to find meaningful insight and relationships among attributes in the large database using a wide range of tools and techniques in statistics, management science, information systems, and artificial intelligence. To derive previously unknown relationships and insight, data mining uses tools and techniques for the following.

- Prediction
- Classification
- Segmentation/clustering
- Affinity analysis using association rules.

These data mining techniques can be broadly categorized into two groups: unsupervised and supervised. Amour et al. present a method of segmenting satellite images based on the vectors of the gray level. Their work proposes a new approach to segment satellite images, based on the statistics of ranks to distribute the image in homogeneous regions. This algorithm takes into account the relation which binds the spatial positions and the ranks of the gray levels in a given neighborhood. This study highlights the efficiency of the characterization of regions by means of the statistics of ranks of the grey level. To deal with the same line of research to develop data mining algorithms that aim to minimize the number of frequent item set, Selmi, Gammoudi, and Harrathi propose a Prime Number method for improving the performance of formal concept extraction algorithms. The use of prime numbers allows one to perform the run time of two operations: intersection and union between sets considering the assertion that the comparison of numbers is faster than the comparison between strings.

The third subsection of Section 1 addresses intelligent systems. Intelligent systems utilize a wide range of artificial intelligence tools and techniques to develop information systems that can mimic a human-being.
Intelligent systems have been developed to make information systems/computers/devices that use human knowledge and reasoning to solve problems (expert systems). Furthermore, intelligent systems are developed to understand human language (natural language processing systems), and human spoken language (speech understanding/recognition systems), perform a variety of manual tasks (robotics and sensory systems), and see and recognize objects (computer vision recognition systems).

Intelligent systems have been designed with several other advanced techniques such as the following.

- machine-learning techniques
- case-based reasoning
- genetic algorithms
- fuzzy logic and fuzzy inference systems
- support vector machines
- intelligent agents
- integrated advanced systems, which use a combination of individual intelligent tools.

Fuzzy neural networks: Neuro-fuzzy modeling (or fuzzy neural networks) is an example of integrated advanced systems. It refers to the method of applying the various learning techniques developed in the neural network literature to fuzzy modeling or to a fuzzy inference system (FIS). The basic structure of a FIS consists of three conceptual components as follows.

- A rule base, which contains a selection of fuzzy rules
- A database which defines the membership functions (MF) used in the fuzzy rules
- A reasoning mechanism, which performs the inference

Nahraoui, et al. developed a fuzzy neural network to predict the acoustic form function (FF) for an infinite length cylindrical shell excited perpendicularly to its axis. The Wigner-Ville distribution (WVD) is used like a comparison tool between the FF calculated by the analytical method and that predicted by the neuro-fuzzy techniques for a copper tube. This fuzzy logic system is able to predict the FF with a mean relative error (MRE) about 1.7%.

SVM and vision recognition system: Gattal and Chibani present another interesting example of an integrated advanced intelligent system that
combines support vector machines and a computer vision recognition system. Gattal and Chibani are interested in a particular and very serious aspect in the domain of automatic recognition of normalized and not normalized isolated handwritten digits. The latter concerns feature generation, which requires the collection of a large database of digits. As the objective is to improve the performance of our recognition system, they are focused on combining different pertinent features from the digits.

The steps of the proposed approach are as follows. First, they start by applying different structural feature generation methods which are extracted from each image of handwritten digits. Furthermore, they use the uniform grid technique to increase the recognition rate. Then, the classification is done using SVM. The proposed approach was tested, and the results achieved are very encouraging.

Machine Learning: Machine learning has become one of the major preoccupations of computer science and artificial intelligence. Members of commonality learning face the significant challenge of giving machines the ability to learn and generalize. However, these algorithms are participating in its structure to organize data, select, and change the type of kernel function implemented. First, feature selection can retain only the relevant attributes, such as maintaining performance. On the other hand, the choice of the kernel function and parameter settings affects this performance.

Youcef and Yamina provide a rigid theoretical basis of machine learning algorithms. They began their study in this context, and they were faced with a conundrum in respect to the wide range of machine learning techniques proposed in the literature. How does one create a generic structure for modeling a learning algorithm inspired by the queuing system to implement a dedicated system, for example the classification of medical images? This system allows the aggregation of the features or instances of learning/test that are out of the original set.

Genetic Algorithms: The Web services technology offers great potential to overcome the problems of interoperability. It is a promising framework for the integration of applications and for managing interactions between various partners in a distributed environment, which is the Web. In the basic infrastructure around the SOAP standard, WSDL, UDDI is sufficient to establish interoperable and integrated component. However, it is insufficient to make automatic and efficient multiple tasks at lifecycle of web services, for example, the composition and also the discovery of the required services.

Bekkouche, et al. focus on web service composition, where a set of services is composed to satisfy the user request, based on the semantic
descriptions of web services and their non-functional properties (QoS parameters). The user may also express its requirements through non-functional constraints (QoS constraints). The purpose of their work is to present an approach for web services composition based on a genetic algorithm that focuses on two aspects in order to find the optimal solution: the functional and non-functional aspects.

The second section of this book is titled, Mobile Technology. Mobile technology refers to the technology for wireless computing devices as well as wireless networking. The wireless devices include mobile phones, tablet computers, GPS navigation devices, etc. Mobile computing devices work with wireless networking technologies including virtualization and cloud computing. The first paper in this section discusses a key enabling technology, load balancing (LB), for virtualization and cloud computing. Cloud computing allows the user to virtualized network access to a service. It is load balancing that distributes and optimizes service requests to network resources using a scheduling algorithm. El Morabt et al. provide an overview of self-organization network (SON) mechanism. Load balancing in SON has been recognized as an effective means to increase network performance. The authors propose an algorithm which resolves the LB problem in the Long Term Evolution network.

The second paper, titled Cloud as a Major Catalyst of Change in Contemporary Business Environment, sheds light on the use of Service-Oriented Architecture (SOA) to design the services deployable in the Cloud. This is done using business process reengineering to simplify applications by both internal and external users of the organizations, which are interested to move to Cloud computing. The use of SOA in the Cloud provides services data abstraction. This abstraction can be understood as services messaging metadata, which can be in the shape of XML, XSD or other set industry standards providing interoperability to a user’s request. SOA eases the development of ever-changing applications that compare data with stationary applications while maintaining a decoupled relationship between these applications on a simultaneous basis.

The third paper, titled Security Attacks in Mobile Ad Hoc Networks, provides a comprehensive survey of the existent security threats that mobile ad hoc networks (MANETs) face. Abdelaziz, Nafaa, and Salim investigate selfish misbehaviors and malicious attacks through the different TCP/IP layers and discuss how these attacks affect the network. MANETs are wireless multihop networks that are dynamically constructed by autonomous mobile nodes without the support of any infrastructure or centralized administration. This new paradigm of wireless communication aims to make communication possible in some situations where the
services offered by both wired networks and WLAN are unavailable. However, the characteristics and structure of MANETs make them prone to attack using different techniques often used against wired networks as well as new methods specific to MANETs.

The fourth paper in this section is titled, “A Smarter Way to Implement Circuit Switch Fallback and Its Modified Call Flow to Reduce the Call Setup Time.” The long term evolution (LTE) is the newest mobile technology, dedicated mainly for high-speed data transfer. Because the LTE uses packet switching, voice calls in the global system for mobile communication, and universal mobile telecommunications system use circuit-switching technology, Operators/Carriers will have to take on adequate solutions to overcome the hurdle with the adoption of LTE. They include Voice-Over LTE, Circuit Switched Fallback (CSFB), and Simultaneous Voice and LTE. Jouihri and Guennoun propose a smart solution to implement CSFB as well as interesting recommendations to reduce the call setup time, which will result in a more comfortable user experience.

The last paper in this section is titled, An Architectural Framework to Design a Healthcare Information System. It presents an architectural framework for guiding the design of such systems. Following the best practices and guidelines of the most notable web developments processes, the framework in this chapter takes into account the recent advances in the Web and mobile technologies. Like any other information system in organizations, healthcare information systems are increasingly benefiting from recent advances in mobile technology and wireless networks. It seems to be self-evident to design a system that would support both patients and their healthcare providers in the process of treatment.

The third section of the book includes three chapters that discuss miscellaneous topics, such as ontology evaluation and e-learning. Ontology evaluation, from a logical and empirical perspective, has been recognized as a critical phase in an ontological engineering research field. Most well-known ontology development methodologies include evaluation as their part, either at the end or through the whole ontology development process. However, the profusion of methodologies has made it difficult for researchers to develop generic approaches for evaluating the ontological quality that are independent of any specific methodology. One of the most well-known ontology assessment approaches is the one achieved by humans, who attempt to assess how well the ontology fulfills its predefined criteria, standards and requirements. Chapter 16 by Zemmouchi-Ghomar and Ghomari propose a methodological baseline for
ontology assessment by humans (domain experts and end-users) via a questionnaire. It aims to support a component-based evaluation.

The next chapter in the third section, Ontology–Driven MVC: A Variant of MVC architectural style by Chaturvedi and Prabhakar, highlights the drawbacks of the MVC architectural style and proposes an ontology driven solution to address these problems. Despite the separation of concern provided by the MVC architectural style, some inter-component dependencies, which constitute the liabilities of the style, still remain. In this paper, the proposed solution of the ontology is used as an active run time component. The ontology is generic and can be used for any application that is based on MVC style. The authors demonstrate the usage of this style through an example implementation based on both the traditional MVC style and the ontology–driven MVC style.

The final chapter by Eom et al. empirically tested the DeLone and McLean model of information systems success model in a university e-learning context using structural equation modeling. The results indicated that system and information quality both affected the two mediating constructs, system use and user satisfaction. These, in turn, influence the e-learning systems success. The nature of e-learning systems is fundamentally different from the environment in which the DeLone and McLean model is developed and tested, either voluntary or quasi-voluntary environments. However, e-learning systems are to be used in a mandatory environment. For that reason, the DeLone and McLean model has a limited explanatory power for explaining the role of e-learning systems on the outcomes of e-learning. Consequently, we conclude that the primary focus of the empirical research of the e-learning system should shift from the system factor toward human and design factors. E-learning systems empirical research is focusing on the critical success factors of e-learning outcomes that are comparable to or superior than traditional face-to-face learning system.

The Audience of this Book

This book is for practitioners, researchers, managers, and graduate students in computer science, information systems, information science, and computer engineering. Moreover, libraries in university, profit and non-profit organizations around the world will be potential customers. We believe that information systems researchers within the other disciplines will benefit from more dialogues and collaborations with each other. Greater synergies will promote and further advance the IS field as a whole.
PART I

BUSINESS INTELLIGENCE
CHAPTER ONE

TOWARD THE INTEGRATION OF WIRELESS SENSOR NETWORKS INTO AN ENTERPRISE INFORMATION SYSTEM’S DECISION-MAKING MODEL

O. ABROUN, A. TAHIRI, N. AKNIN AND K. E. EL KADIRI

Wireless sensor networks (WSN) are a new technology that opens new opportunities for data retrieval, and with its different and multiple real-world applications it takes information access to an advanced level. Due to the importance that information has today, benefits that WSN brings to information technologies might be described as overwhelming.

Moreover, within the world of enterprise information (EIS), information has a special value as the backbone of daily decision making systems. The importance of information in decision making represents a motivation that pushes organizations to the continuous development of their decision models.

Accordingly, the progress of both WSN and Information Technology (IT) within the context of EIS inspired us to suggest a new model that aims to integrate WSN within EIS. However, we believe that such integration is not free of challenges.

In our research, we introduce the main concept of WSN integration within the EIS decision model, and we discuss the different challenges that face this incorporation.

Introduction

Information and information technology witnessed a very significant development recently, especially in the Enterprise world, where they (Information and Information Technology) have a huge influence on
Enterprises structures and play an important role in their development. For this reason, we consider Enterprise a very sensible field where information becomes very important, especially in decision making.

On the other hand, a source of very valuable information that we find still is neglected in the enterprise world has made an explosive evolution during the last decade, i.e., a set of small, autonomous devices working together to solve different problems named Wireless Sensor Networks (WSN).

Based on this powerful evolution, we aim to discuss how WSN can be integrated to EIS, and also to study the difficulties that this kind of incorporation may face.

To achieve this goal, we first discuss the main concepts of information systems, and their role and influence on the EIS structure. Then we introduce WSN technology basics. Finally we discuss the different challenges to be faced when WSN technology is integrated to the world of EIS.

**Information Systems and their Impact on Organizations**

Davis (2000) defined the components of information systems:

The Information System or Management Information System of an organization consists of the information technology infrastructure, application systems, and personnel that employ information technology to deliver information and communications services for transaction processing/operations and administration/management of an organization. The system utilizes computer and communications hardware and software, manual procedures, and internal and external repositories of data. The systems apply a combination of automation, human actions, and user-machine interaction.

In addition, the importance of information systems can be seen in its influence on many levels, for example in the sensitive field of stock markets where it drives different transactions. We believe that the development of every system today hardly is related, on many levels, to the use of information technology.

Furthermore, as specified by Mousavi and BadrAbady (2008), the influence of information systems on EIS can be on the following levels:

- Operations: improves the efficiency of the main business operations, regardless their nature.
- Transactions processing: manages different transactions.
• Decision support: provides relevant information for decision making.
• Employees monitoring and performance evaluation: offers the possibility to follow employees’ presence and performance.
• Documentation and Communication: conserves the main work status of business.

Therefore, we see that an organization’s success is dependent on many levels on the use of information technology, and its influence is overwhelming, especially on the decision-making level.

**Wireless Sensor Networks**

WSN can be defined as a set of small, autonomous devices working together to solve different problems. It is considered to be a new technology that has been experiencing significant growth during the last decade. As time passes, people are becoming more aware of the important role that those microcontrollers may play in many aspects of their lives.

Navneet Kaur (2013) defines WSN major components as:

**Sensor Field:** An area in which the nodes are placed.

**Sensor Nodes:** Sensor-nodes are the heart of the network. They perform collecting and routing of data back to a sink.

**Sink:** A sink is a sensor node with the specific task of receiving, processing and storing data from the other sensor nodes. It serves to reduce the total number of messages that need to be sent; hence reducing the overall energy requirement of the network. The network usually assigns such points dynamically. Regular nodes can also be considered as sinks if they delay outgoing messages until they have aggregated enough sensed information. Sinks are also known as data aggregation points.

**Task Manager:** The task manager also known as base station is a centralized point of control within the network, which extracts information from the network and disseminates control information back into the network. It also serves as a gateway to other networks, a powerful data processing and storage centre and an access point for a human interface. The base station is either a laptop or a workstation. Data is streamed to these workstations either via the internet, wireless channels, satellite etc. So hundreds to several thousand nodes are deployed throughout a sensor field to create a wireless multi-hop network. Nodes can use wireless communication media such as infrared, radio, optical media or Bluetooth...
for their communications. The transmission range of the nodes varies according to the communication protocol in use.

Thanks to this easy-to-deploy infrastructure especially since it does not have a strict topology (instead of being ad hoc), WSN can be deployed everywhere. Consequently, we consider the world of EIS to be full of precious data-retrieval opportunities. Also we believe that WSN integration into EIS is a very useful process that is full of advantages.

**WSN Integration Within Enterprise Information System**

EIS is composed of many connected information-based systems. The idea of integrating WSN to this information system is founded on adding a new member to the EIS body, or even feeding base systems with raw data coming from the outside world, in order to prevent accidents, to wisely manage human resources, to allow a data-based warehouse remote control, to monitor products quality and for many other practical applications.

Based on those potential applications on the one hand, and the different advantages that WSN have as a new data source on the other, we assume that EIS will take the following form after integrating WSN:

Figure 1: The Suggested Information System Model
As indicated on the above figure, the different components of an information system, as previously defined, will have a new member represented by WSN systems. By communicating to those components, WSN are going to feed the system with data about the outside world (e.g., temperature, humidity, CO₂ levels, etc.). However, as the addition of a new member to an existing system may result in different changes. The integration of WSN into EIS presents many challenges. These challenges are discussed in the next section.

**Integration Challenges**

Based on the Middleware concept definition discussed by Gomez et al. (2008), we find that adding WSN to the EIS body needs to consider the following principles:

**Heterogeneity**

Every manufacturer in the market of wireless sensors provides data in its own format. As a result, the multitude of data formats is an important challenge to be faced, especially when EIS applications need to acquire data in a unified format.

**Interoperability**

The Enterprise Information System contains a large number of applications, which may be working in different environments. Consequently, WSN data should be accessed in the same way and with the same quality, regardless of the access environment.

**Security**

Information in general, especially when transported between two separate sides, needs to be secure in order to guarantee a high level of data trust. In the EIS world, information is very sensitive, so security is also another important challenge that the integration of WSN within EIS must overcome.

On the other hand, when data is available, another issue needs to be addressed when integrating WSN into the information system – the data access modes. A multitude of data modes is very important in the world of EIS, because the questions that need to be answered by decision-makers vary depending on the situation. Therefore we see that data collecting,
which is the main function of WSN, should allow data access in the following modes:

- **Raw Data Access:**
  The data, as collected by the sensors can be accessed without any filtering or preprocessing.

- **Process Data Access:**
  Data, which after being processed by sensors, have the capability of executing such tasks, should be presented to the EIS.

- **Historical Data Access:**
  Data history is one of the most important data access modes since many data mining techniques, e.g., prediction algorithms, are based on the collected data over time. Additionally, a degree of control over the system is needed in order to allow EIS administrations to configure WSN sensing based on their needs.

  Therefore, the different challenges that WSN integration into EIS presents are reflected in the following figure:

Figure 2: Integration Model Middleware Architecture

Conclusion

As we consider the process of incorporating WSN into EIS, we find that information systems in particular still is neglected by researchers. The different concepts discussed in this work will take decision making within EIS to an advanced level. However, due to the many challenges that such incorporation presents, bringing the benefits that WSN provide to the EIS
world requires careful planning. When done successfully, however, this process creates a framework that can open up a myriad of possibilities for increased productivity in any workplace that employs any variation of the EIS model.

References


CHAPTER TWO

PSYRATIONAL STRATEGY
TO SIMULATE NEGOTIATORS’ BEHAVIOR
IN BILATERAL AUTOMATED NEGOTIATION

DALEL KANZARI AND KHALED MELLOULI

The negotiation process aims to find an agreement between players (Fisher 2000) that satisfies their private requirements before reaching the negotiation deadline (Jennings et al. 2001). The latter have generally conflicting interests and try to acquire a compromise, even with incomplete information about the opponent’s strategies, by using concession strategies. Many studies like the time-dependent strategy (Faratin et al. 1998), Bayesian learning (Zeng and Sycara 1998), reasoning based on constraints (Luo et al. 2003), and game theory (Binmore and Vulkan 1999), deal with agents’ behaviors used to reach final agreements on matters of mutual interests. They focus only on one agent character that can influence the negotiation process and achieves results without combining diverse behaviors. Our motivation is to combine the following two characteristics: (a) the rational character that leads the agent to take into consideration the opponent’s preferences when making a decision, and (b) the temperamental character that leads the agent to accept only the opponent’s offer that ensures him a satisfied profit.

Our approach integrates psychological analysis (El-Nasr et al. 1998) (study of temperamental behavior during the negotiation process) and the rational decision-making process (study of reasoning to predict the adversary’s strategy) in order to provide a methodological support to negotiation players.

Psyrational Negotiation Strategy

Given a round, composed of an offer and a counter-offer, and given the adversary’s last action, the psyrational agent’s reaction (choosing a
suitable answer) is based on its internal “temperament” (conciliatory, aggressive, or neutral) and on its rational negotiation behavior. “Temperament” defines the psychological aspect of the agent’s personality that plays an important role in determining the negotiation results:

- If the “temperament” is conciliatory, then the psyrrational agent is more co-operative in reaching a final agreement.
- Otherwise, if the “temperament” is aggressive, the psyrrational agent is more competitive and the negotiation might fail.

On the other hand, rational negotiation behavior aims to reach an agreement with mutual satisfied interests. The principle is to resolve the conflicts between competitors by considering the opponent’s preferences in each decision. The model represents a win-win strategy modeled by a sequential game of decision-making.

**Psyrational Agent Model**

A psyrational agent is based on 4 interdependent subsystems organized in layers (see Figure 1):

- Communication and data representation: presentation of internal comprehensive data.
- Temperamental Behavior: study of cooperative, competitive, and neutral behavior.
- Rational Behavior: study of rational reasoning in decision-making process.
- Negotiation Behavior: study of the combination of Temperamental Behavior and Rational Behavior.

Figure 1: Psyrational Structure
Rational Behavior

Rational Behavior leads the psyrational agent to take into consideration the other’s aims and preferences when making a decision (Pruitt 1981, Osborne and Rubinstein 1994). It forms the collaborative side of the negotiation process, between players, in order to reach a final agreement with shared utilities.

Rational Behavior analyzes the complex problem of negotiation in several sequential sub-problems or sub-games composed of an offer and a counter-offer (Kanzari and Mellouli 2011) (See Figure 2.). A sub-game is a well-defined separate game that contains an initial node, and all the moves and information sets from that node remain in the sub-game. Each sub-game contains an equilibrium offer that can satisfy the both agents’ goals.

Figure 2: Sequential Negotiation Strategies
Figure 2 highlights the following notations:

- \( i, j \): the players
- \( U^i_p \): the \((i)\) player’s utility by accepting the offer \( p \)
- \( U^j_p \): the \((j)\) player’s utility by accepting the offer \( p \)
- Each node represents a player that has two choices:
  - Accept the adversary’s offer \( (p) \) and then the negotiation process ends with the pair of utilities \( (U^i_p, U^j_p) \)
  - Refuse the adversary’s offer and propose a new offer if the negotiation deadline cannot be reached.

The aim of the rational approach is to resolve the conflict between players by finding the equilibrium offer that fulfils their preferences on each sub-game, before the negotiation deadline.

**Temperamental Behavior**

Temperamental Behavior reasoning integrates a fuzzy logic approach to control character variation influenced by the adversary proposal and to generate a related counter-proposal (See Figure 3.).

Figure 3: Temperamental Behavior
Given the last offer, and current psyrational agent’s characteristic (conciliatory, neutral, and aggressive), the temperamental behavior model allows the update of these characteristics and the generation of an adequate counter-offer. This model emphasizes the influence of the negotiator’s personality in sense of “temperament” in order to update the answers during the negotiation process. The characters’ evaluation and the proposal updates are modeled by means of Mamdani’s fuzzy systems (Liu 2002).

**Negotiation Survey**

The negotiation survey studies potential offers (Rosenschein and Zlotkin 1994) supplied from the temperamental reasoning and the rational reasoning, to elaborate the final system’s decision making (See Figure 4.).

This module negotiation combines the outcomes of the strategies based on the agent’s temperamental and rational reasoning to generate a personal-rational behavior endowed with both personal and rational characters.

Let $P$, defined in $P = \delta P_r + (1-\delta)^\eta P_t(1)$, denotes the final counter-proposal:

$$P = \delta P_r + (1-\delta)^\eta P_t(1)$$

$P_r$: the rational reasoning’s output

$P_t$: the temperamental reasoning’s output

$\delta \in [0, 1]$: denotes the rationality degree:
- if $\delta \in [0.5, 1]$, then the system’s response is more rational.
- Otherwise, the system’s response is more temperamental.

$\eta \in [0, 1]$: denotes the degree of influence by the agent’s personality:
- if $\eta \in [0, 0.5]$, the agent’s temperamental characters have great influence on the final decision making.
- Otherwise, the temperamental agent will have less influence on the final decision.

This module analyzes the two sub-systems (psychological and rational) results to find a suitable solution that satisfies the agent’s objectives and guarantees a final compromise with the opponent before the negotiation deadline.
Experimental Evaluation

The aim of experimentation is to evaluate the psyrational strategy by comparing the latter to the time-dependent strategy and to create a simulation of a bilateral negotiation process between a psyrational buyer and a time-dependent seller (Faratin et al. 1998), for the price of a commodity.

The offer of a time-dependent seller is defined by (2):

$$P_s' = \min_s + \left(1 - \alpha_s(t)\right) \cdot \left(\max_s - \min_s\right) \quad (2)$$

$$\alpha_s(t) = \left(\frac{t}{T}\right)^{1/\beta}$$

: The time-dependent function that determines the offer’s concession speed according to the value of $\beta$, so if $\beta < 1$, then the agent is aggressive. Otherwise, the agent will be conciliatory (Gratch and Marsella 2004, Raiffa 1982).

- **T**: The negotiation deadline
- **mins**: The minimal seller’s price (reserved value)
- **maxs**: The maximal seller’s price

To evaluate agent strategies, we use the following measures:

- **Buyers’ Utilities**: $U_b = \max_b - P^*$
- **Sellers’ Utilities**: $U_s = P^* - \min_s$