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A NEW APPROACH FOR THE RESOLUTION OF THE PROBLEMS OF OPTIMIZATION FOR MOBILE TELEPHONY OPERATORS

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ABSTRACT

The important success of the mobile systems of telecommunication motivates the suppliers of service to be reflected about enormous means of investments for infrastructures of network. The conception of big cellular networks is a complex problem, which turns around a big impact: the quality of the service and the cost of the network. With the continuous and fast growth of the traffic of communication, the large-scale planning becomes more and more difficult. This need is now more pointed with the evolution of phone networks (GSM), because of the biggest complexity of the system and the number of parameters which must be considered. In this subject, the solutions of the problems of dynamic optimization, Multicriteria associating the financial criteria (cost of the network), the technical criteria (insurance, availability) are developed in a context and the criteria of sale (quality of service). The interest of metaheuristiques (methods of optimization) is based on their capacity to find the effective solutions in a reasonable time. But with objective multi-problems, the efficiency of metaheuristiques can be compromised. Consequently, in this context it is necessary to integrate these methods into more general arrangements to develop more effective methods. For such reasons we are going to present an approach based on the multi-systems agents and the spatial ontologies, to conceive methods adaptive automobile which can react to the shape of the problem.

Keywords: *GSM network, Cellular Networks, Multi-Agents Systems, Spatial Ontologies, Dynamic Optimization.*

1. INTRODUCTION

During this last decade, the systems of communication knew an exceptional growth, that it is about systems of communication between mobile subscribers (GSM) or customers of phone replaced network (network RTC-fixes) [5]. At the same time, the techniques of radio communication dress henceforth a crucial importance for an increasing number of public utilities. It is necessary to be able to determine the technical characteristics and the ways of exploitation of these Hertzian services, always more numerous, while managing in an optimal way the radio spectre [4]. This last one is a limited natural resource which is always the object of more demands because of the fast development of new services of radio communication and of the phenomenal craze for the mobile techniques.

The cellular networks are systems with strong factors of tensions [6]. The real-time adjustment of the solution being at present impossible. The dynamic aspect adds a new dimension to the problem of conception (design) of the cellular networks. The optimization serves then for anticipating the modifications to be operated on the network to optimize the performances of the network during its evolution and to reduce the costs of its reorganization. The system not only has to supply a solution, but also be able to react to the

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breakdowns and to the chances by straightening its solution, Or still be capable of treating problems the data of which are only partially known, and for which the information arrives in time. The detailed and comprehensive analysis of the behaviour of the traffic in the time and in the space is an indispensable process for the planning of the systems radio motives. The static sizing of the network so as to offer a level of reduced service at the time of headland in for effect to waste the resources of the system when these are not well run.

Thus, the idea leads us to think about the development of a process of design capable of managing the changes arising on the network during its phases of growth and maturation. The demand in traffic varies in the time and in the space. The network is subject, besides, to changes long term, required by the rise of the traffic, Relative to the growth of the clientele, to the behavioural changes of the users as well as to the evolution of the cover. For landing in these requirements, the network is brought to adapt itself and to grow. However, according to the point of view of the researchers, the objectives of the supplier of the network and the specific conditions of the application, several models are to be considered, and thus, Several approaches are adopted to resolve them..

The call to a process of dynamic optimization seems a promising exit. This process is periodically launched during the points of decision, for objective the preparation of the system for the adaptation to the changes of the current period, While trying to take into account later periods, by predicting the zones where the increase of capacities is required and by realizing the necessary intelligent changes: (example: period of the holidays or the fairs, to strengthen the BTS " basic station receiving the appeals entrants and outgoing ", concerned zones). Because often, these changes lead a supplementary cost (new installations, hand of work), what prevents the system from adapting itself to the environment. Therefore, it becomes essential to integrate the knowledge about the structure of the problem. We can propose the ontologies at this level. So, to conceive methods automobile adaptive which can react to the shape of the problem and which require the cooperation of several methods, Will allow resolving the problem in its global nature. Reason for which, we meet ourselves in front of the need to bring in the multi-systems agents. A discipline which is interested in the collective behaviour produced by the interactions of several autonomous and flexible entities called agents, which these interactions turn around the cooperation, around the competition or around the coexistence between these agents.

So, in a first section of this article, we place the context of the networks of the mobile telephony, its problem, and the main concepts which refer to it. In a second section, we present the Multi-Agents systems. We grant a particular interest to the domain of the ontologies, notably the spatial ontologies, to arrive at the development of the approach proposed for this study. The last section will make the objective of a conclusion and a perspective.

2. MOBILE PHONES

We will first define the concepts of GSM mobile network, and then see its equipment and its hardware architecture.

2.1 GSM Network

A mobile network is a network that enables communication of individuals moving through a link or a radio channel. The general architecture of a GSM network [5], can be divided into three systems:

The radio subsystem (BSS): The radio subsystem consists of several entities: mobile, the base station (BTS) controller and a base station (BSC).

The network subsystem (NSS) : plays a key role in a mobile network, its components support all the functions of monitoring and analysis of information contained in databases needed to establish connection.

The system in operation and maintenance (OSS): it comprises three main activities of management: administration, business management and technical management.

2.2. Equipments of a network GSM

We can summarize the various components of the network through the following board:

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Component	Meaning	Function
BTS	Base Transceiver Station	• *Base Station receiving incoming and outgoing calls of ME*
BSC	Base Station Control	• *Controller base stations*
MSC	Mobile Switching Centre	• *Switch network.*
HLR	Home Location Register	• *Database on the identity and location of subscribers*
VLR	Visitor Location Register	• *Register database on visitors to the network.*
AUC	Authentication Centre	• *Authentication Centre of terminals on the network.*
OMC	Operation and Maintenance Centre	• *Centre operation and maintenance of the network operator.*
ME	Mobile Equipment	• *Terminal of the subscriber.*
SIM	Sim Identity Module	• *SIM card identifying the subscriber on a defined network.*

The material architecture of a network GSM, as well as the various existing streams of data between the previous equipments is illustrated by the figure1.

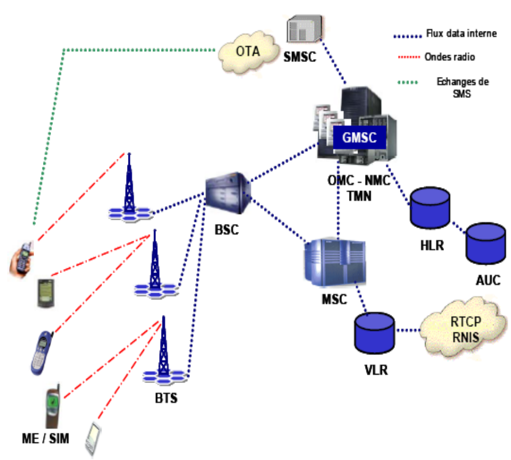

Figure1. Material architecture of a network GSM[5]

For our study we will look at radio subsystem and its main entities.

2.3. Material architecture of under system radio BSS

The BSS includes the BTS which are transmitter-receivers, but having a minimum of intelligence, and the BSC assures the control of a set of BTS.

2.3.1. Function of the BTS

The BTS is a set of transmitter-receivers called TRX. A BTS has for function the management of the transmissions radio (modulation, demodulating, equalization, coding and correction of errors). It also manages the coat connection of data for the exchange of road marking between motives and network infrastructure of the operator. So a BTS can manage at most hundred of simultaneous communications.

2.3.2. Function of the BSC

The BSC is the intelligent organ of under system radio. It has a relay role for the alarms and the statistics emanating from BTS towards the centre of exploitation and from maintenance. The BSC is a data bank for the software versions and the data of configuration downloaded by the operators on the BTS. The BSC pilots transfers between two cells (zone of the territory lit by an antenna" BTS "): it informs on one hand the new BTS who is going to take care of the subscriber “the mobile” while informing the back-end system (HLR) of the new localization of the subscriber.

We also think that the integration of the Multi-Agents Systems (MAS), will allow us to conceive methods adaptive automobile, this last idea will make the objective of the next section.

3. MULTI-AGENTS SYSTEMS

The subject of the Multi-Agents Systems (MAS), if it is not recent, is at present a very active field of research. This discipline is for the connection of several domains in particular of the artificial intelligence, distributed computer systems and software engineering. It is the discipline which is interested in the collective behaviour produced by the interactions of several called autonomous and flexible entities: "agents", whom these interactions turn around the cooperation, around the competition or around the coexistence between these agents.

3.1. Definition of an agent

According to an increasing number of researchers defines an agent, as being a computer system situated in an environment [7], of which it is capable of acting in perfect autonomy on its actions, with the aim of making meet the objectives of its conception, with the following characteristics:

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- An agent is an entity situated in a particular environment, which perceives the state of the environment through his sensors, and which acts on its environment through its effecters.
- It is conceived to carry out specific objectives, and it has particular purposes to be affected.
- It is autonomous, since it has the control of its internal state, and its own behaviour.
- It is capable of explaining and of producing solutions for flexible problems. It needs to be at the same moment reactive (capable of answering in opportunity, in changes which arise in the environment, it is capable of acting by anticipating the future purposes).

3.2. Models of existing agents

3.2.1. Reactive Agent

Architecture of reagent agent is architecture in which the decisions of action are taken at the time of the execution, from not enough information (information got at the present moment). The execution of these actions always follows the change occurring in the environment. The mechanism of decision is often very simple, the accent being put on the robustness rather than on the exactness and the optimum of the behaviour.

➢ **Remark:**

Concerning the reagent agent:

- No representation clarifies of the environment.
- No memory of its history, nor explicit purpose.
- Agents' large number (> 100), homogeneous in fine grain.

3.2.2. Deliberative Agent

This architecture contains a mechanism of decision consisting of a consideration explicit on the various possibilities of action by using, for example a generation of plans or by taking into account the utility hoped by the actions. The mechanism of decision which can be very complex, the accent is put on the optimum and on the exactness of the behaviour to the detriment of the robustness and of the time of execution.

3.2.3. Cognitive Agent

This type of agent possesses an explicit representation of its environment, so he can take into account his past, and he is complex in his conception. This type of agent when it exists in a system it is in small number.

3.3. Structure Believe Desire Intension

BDI approach is interested in the various stages of the process of reasoning which drives to choose an action to reach a fixed purpose. It is necessary to fix at first the purposes to reach (deliberation) that is to wonder what to make, then to look how to reach them (means-end reasoning). This approach has to allow the agents who use it to have stable and coherent behaviour even if the environment in which they evolve is unstable. The concept of intention is in the centre of this approach because he allows connecting the purposes with the faiths and with the commitments by having a theory of the passage in the act of the agents. The principle of reasoning of the agents BDI thus is to refine gradually the options in more and more concrete intentions (planning), which in the final will correspond to feasible actions. The agent plans his actions to satisfy his intentions.

3.4. Different types of interactions

The interaction is the mechanism which returns set existing agents in the more dynamic system, by the fact than it brings to light the mechanisms of communication and cooperation [8]. With the means of the interaction all the entities plunged into an environment, can interact according to various forms:

3.4.1. Interaction without communication

It bases itself on the inference of the actions of the others.

- ***Example:***

- Use of the theory of the games with matrices of gain.
- Updating of a constraint or an updating of dependence.

3.4.2. Interaction via the communication

It is a set finished by signals without interpretation and by fixed syntax.

- ***Example:*** multi-planning agents.

- ***Example:*** communication by the environment via tracks (signals) which leave the agents and who can be perceived by the other agents.

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3.4.3 Interaction via the sending of messages and plans

- The interaction is made by sending of messages, such as calls of methods of object-oriented languages.
- In the sending of plans, exchanges of partial plans are made so that one a knot of exchange of the partial plans of interpretation with the other knots of the system.

3.4.4 Interaction via a blackboard

The interaction via a blackboard is a technique which proved its efficiency in the conception of the systems, and this used type of technique so that the various existing agents in a given system can to communicate itself through a common space called " blackboard ", From which the mechanism and to deposit the information or the knowledge in this zone, the concerned agent will come to get back this information. We introduce this technique of communication, when all the agents are in centralized or distributed architecture. The main characteristics of this type of interaction (blackboard) are the following ones:

- ✓ No direct communication.
- ✓ Interaction via the sharing of the same space of work or system.

The figure 2 illustrates this mechanism. A system containing a set of agents based on this type of interaction possesses the following elements:

- The knowledge·
- The blackboard·
- The control mechanism.

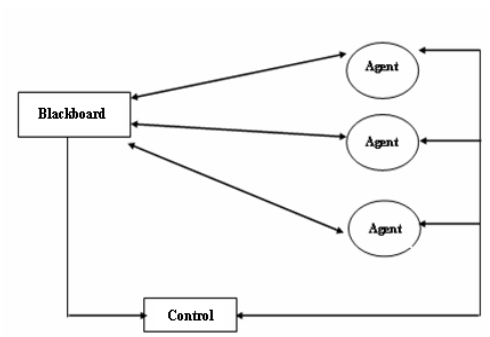

Figure2. Agents' interaction by the blackboard

The next section presents the domain of the ontologies, while showing the type the most suitable to our problem that is the spatial ontologies.

4. THE ONTOLOGIES

By definition ontology is a representation of a consensus enters a community of persons who can be brought to complete or to modify this ontology even if it already contains authorities. Ontology has vocation to describe the real world and to make the modelled information accessible and devisable. The ontologies are a promising way to describe and share information please by a community of persons, Accessible on Web. However various types of ontologies can be considered according to their contents and their uses. In our study we are going to be interested in a consequent type that is the spatial ontologies.

4.1. The spatial ontologies (or spatiotemporal)

Ontologies are the concepts of which are localized in the space. A temporal constituent is often necessary in complement for the modelling of the geographical information, because the geographical applications handle so very often temporal data, to see spatiotemporal [10]. The spatiotemporal ontologies are typically descriptive and can apply to any contents requiring a modelling localized in the space and the time.

4.1.1. Constituents of the spatial ontology

The spatial ontology has four constituents, among which each in its own primitive and its own relations, and is in interaction with the others:

- ***The mereologie.***
- *The topology.*
- *The localization.*
- *The morphology.*

The Mereologie is traditionally considered as the theory of the parts and whole, but if it allows to report the notion of part, it does not manage, for lack of the notion of connection, to make sense of the notion of a connected whole (vs. A scattered whole) where from the necessity of the topology. The primitive of the Mereologie is the notion of part, some basic principles [1] of which we can call back:

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1. Every thing is a part of itself.
2. Two different things cannot be parts one of the other one.
3. Any part of a thing is it even, a part of this thing.

4.1.2. The needs of the spatial ontologies

The spatial ontologies have specific needs which are connected to the following needs:

- Define the spatiality by means of spatial types of data varied (line, simple surface …), by types of spatial objects (that is having spatial attributes), of relations spatial as the topological relations and\or continuous fields raster).
- Define deliberately spatial concepts by means of axioms containing spatial predicates.
- Argue about the spatiality of the authorities that is deducing from the spatial described relations all the valid relations.

As any ontologies, the spatial ontologies can be used for the exploration, but also the extraction of information and beyond for the inter operability of Geographic Information Systems (GIS) [2].

4.1.3. Specificities of the spatial ontologies

The specificities of the spatial ontologies can be identified according to four points:

1) The modelling of the information and their semantic which requires rich enough models and for the geographical information, the concepts of description of the spatial characteristics at the same moment under discreet and/or continuous shape.

2) The reasoning to be capable of deducing/classifying information and of verifying coherence of the descriptions.

3) The authorities for management of the data if the ontology contains it.

4) The requests to question the ontology as well at the level of the authorities as at the level of the plan.

The objective of the next section will concern the development of our contribution, while calling back essential left of the composed problem.

5. PRESENTATION OF THE APPROACH

A BTS is an element of emission and reception, having a minimum of intelligence, which has for function the management of the transmissions radios. It is the first component of the network, Person in charge on the coverage of the request of a broadcasting subscriber. So that another BTS which will be informed to take care of the receiving subscriber. The relative load of a cell corresponds to the report between the demand in traffic on this cell and its actual capacity [9]. A cell which serves many motives sees its coverage area being reduced, thus holes of cover appear and appeals will be thrown back. To avoid this type of problems, connected to the increase of the traffic, the resource BTS must be exploited in a reliable way (increase its intelligence).
Cells having a load approaching the 100 % see each other applicants of help of the other nearby BST having no load “cells candidates”. What can lead an automatic reorganization of the plan of frequencies, without the attribution of new cards TRX or the insertion of new BTS. A mobile becomes attached to the cell which offers him the best quality radio on the experimental canal (see figure 3: cell with intermittent line).

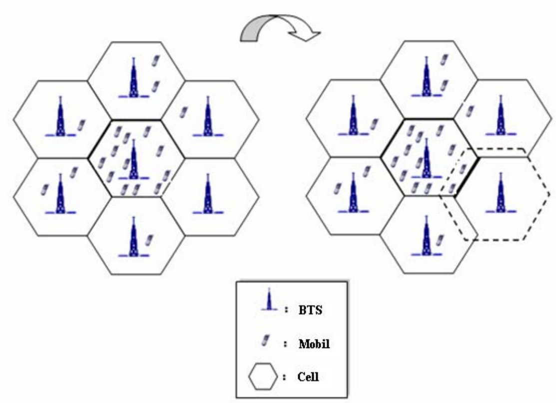

Figure3. Process of optimization of the cellular network

When a mobile passes from a cell to the other one, he sees the pilot of the first cell weakening, and that of second to grow gradually. The affectation of an appeal of a mobile to a BTS is a process which involves several parameters (ex: azimut, tilt, power pilots) [3].

- **Tilt:** angle of inclination of an antenna in a vertical plan. The zone covered by the antenna decreases and the intensity of the power averages received in the cell increase.

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- **Azimut:** orientation of the main lobe of the antenna in the horizontal plan. A modification of the angle azimut can be useful further to an effect of mask connected to the landscape or to the buildings (problem of interferences).
- **Power of the pilots:** indicate to the mobile the cell with which he has to be connected (the extent of the cell).

The objective of the proposed process of optimization is to supply from the beginning, a plan of expansion of the cellular network spreading out over several periods, according to the received changes. So, as shows it the figure 4, the system receives as entered an initial configuration of the network and elaborates an optimized network. To maintain a collection of diversified solutions (history) will allow a better and faster adaptation of the network to the registered changes, during the next phases.

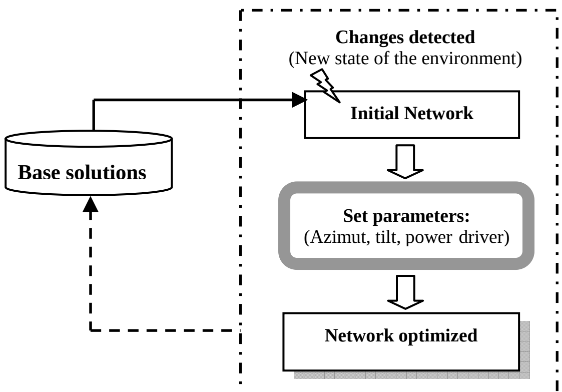

Figure 4. General principle of the process of optimization

The adjustment of the solution is begun only in the recording of the changes on the environment. The approach is defined by a succession of states of the environment E = {state 1, state 2, state n}. Every state is characterized by:

5.1. General architecture of the system

The general architecture of the system of optimization consists of agents' various types. Every agent is responsible on the resolution of a problem or the execution of a particular task.

- **Cell Agent:** this agent is in charge of by the detection of the overload of a cell (reactive agent), through the calculation of the following function:

$$L = \frac{A}{C}$$

With:

- ***L:*** Load with the cell.
- ***A:*** Demand in traffic on the cell.
- ***C:*** Actual capacity of the cell.

If the load affects the 100 %, the cell is declared "Applicant" otherwise it is declared "Candidate" with a degree of participation (number of communications to be able to take care).

- **Supervisor Agent:** the role of this agent (deliberative agent) is to list every time which are the cells of type: "applicant" and "Candidate". After collaboration with GIS Agent, Supervisor Agent will decide what is the nearby cell (the closest in the localization of the subscriber) which has to cover the zone of overload. And delegate to the Evaluator Agent the task to calculate the necessary parameters (azimut, tilt, power of the pilots). These last ones will be again sent to the Supervisor Agent to assure a remote customization of the BTS (regulation of antennas) of the concerned cell. And demand for Historic Agent to make a saving of this configuration of the network (solution) according to the state registered by the environment.

- **GIS Agent:** this agent (cognitive agent) possesses a geographical representation of the region of the cellular network (line, surface, dimensions), with its various changes (in case of appearance of obstacles or new constructions).

➢ **Remark:**

GIS Agent possesses a geographical representation in the form of cells in 3D, for every moment t. what we call: *cell3D - t.*

- **Evaluator Agent:** according to the dimensions of the zone to be covered, this agent takes the initiative to calculate the necessary parameters at the level of: the azimut, the tilt and powers of the pilots. It sends these parameters to Supervisor Agent.

- **Historic Agent:** this agent preservation the history of the previous solutions, according to the arisen events. What will allow the re-use

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of the good solutions for a better and faster adaptation of the network during the future phases.

➢ **Remark:**

Once the overload is crossed (the subscriber moved towards another cell, either decrease of the communications), the network returns again to its initial configuration.

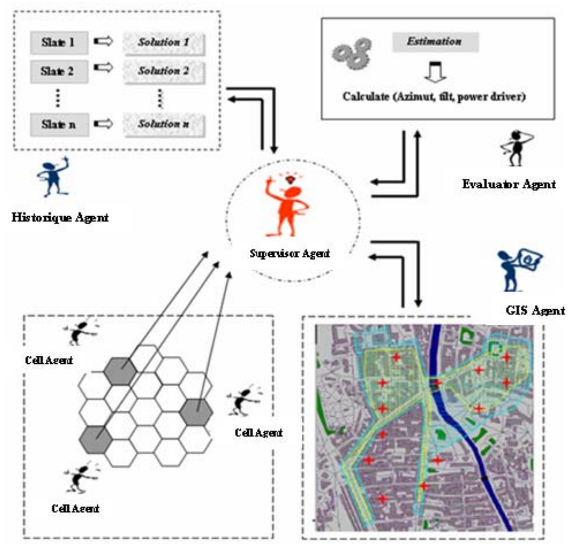

Figure5. General architecture of the System

5.2. Overview of the Mereologie:

To demonstrate the presence of this important function of the spatial ontology during our study, we thought of a decomposition of the system presented previously. For reasons of simplicity, we are going to content with giving just a global sight of every type of Mereologie and with showing briefly its presence in our study.

a. Mereologie Structural

Its presence was concretized, when we decided to decompose the territory (the environment) into cells *(Cell3D l-t)*, where:

- One under environment is a part of the environment.
- A cell is a part of under environment.
- Every cell is served by a basic station.
- All the cells form a single network.

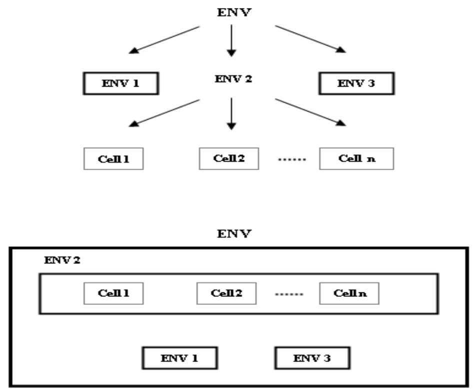

Figure6. Decomposition of the Environment

b. Mereologie Functional

➲ ***Goal:*** *" Do, physical role "*

Example: calculate, rate of load of the cell.
This agent is in charge of calculating the rate of load of his cell, in case of overtaking or achievement of 100 %, he communicates the information to another agent to take the necessary initiatives. In our system it was the case of Cell Agent which supplies the information of its cell to Supervisor Agent.

c. Mereologie Compartmental

☞ Order / planning

It is the case of Supervisor Agent, who gives orders to his agents by sending it's under requests, also by following a chain (sequence of movements) of stages ordered well before taking the initiative.

6. CASE STUDY

To illustrate our approach we thought that its application in our real lives, we give more benefits. This is a new formula called Milinum, launched recently by a telephone operator and whose principle is to speak for free every day for the same operator from 21:00 until 06:00. Faced with this opportunity irresistible the number of communication subscribers of this operator has increased remarkably, which has caused many problems with the telephone network in terms of quality saturation in some areas. " This concern has awakened the optimization services, and research has begun to be launched, whose main objective is to save the honour that ensure a minimum quality of the telephone network. The first solution: when we control the time of saturation, trying to detect areas (zones) affected by this problem. An

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analysis found that areas with the category of young age between 20 to 30 years are most affected. Why the idea has led to a geographic research and the use of geographic information systems (GIS) was essential. For example, areas where there are university students, or places of residence were a concern among others. This configuration will give us more illustration of the problem:

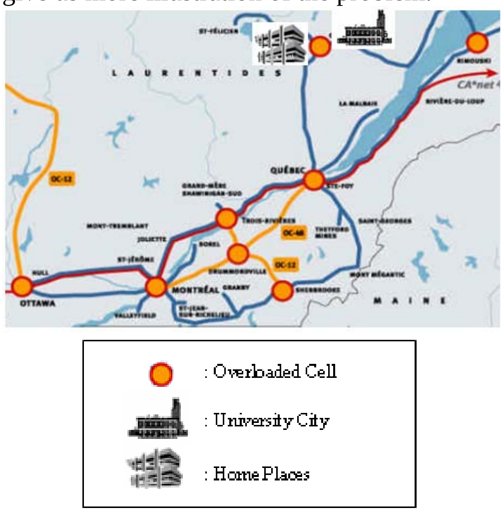

Figure 7. Example of detection of overloaded zone

At first the solution was:
By using GIS, we have detected areas of cells affected by the saturation (see Figure 7, "overcrowded cells). So, to raise the issue of strengthening the BTS overload, through maps TRX (transceivers), or by adding a mobile BTS in the area could solve the problem.

This solution has proven its profitability until the summer period (holiday period), where subscribers located in areas well defined (example: dormitories) are no longer in their places, they are dispersed in different areas. Repeat the same procedure using GIS to locate new areas is no longer an overcrowded recommended solution, especially when we know that these subscribers will move again just after the holiday period, or to their former places or to other places. So, the idea guides us towards finding a suitable solution and not a periodical. Why we believe that the appeal process dynamic optimization introduced by the previous approach, seems a promising outcome to this problem.

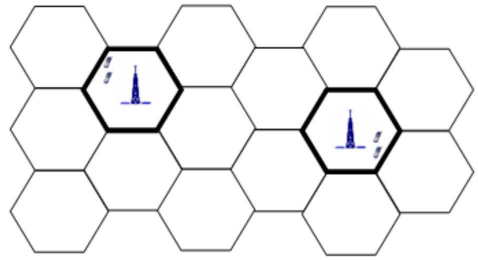

Figure 8. Configuration of initial network

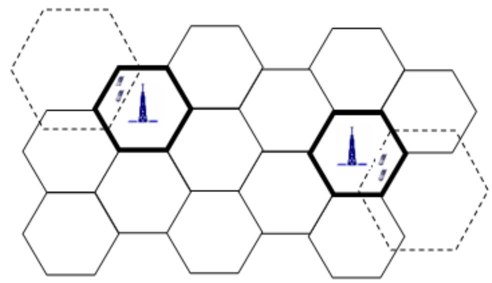

Figure 9. Configuration of **optimized network**

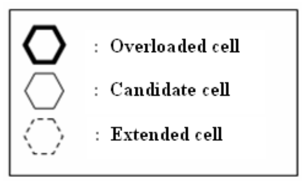

Figure 8 shows the case of two crowded areas at a given time *(t).* Knowing that the time *(t+1)* configuration may change, acquiring new cells overloaded. By the call to the process of upgrading automatic frequency plan, presented through the previous approach, we will get the configuration shown in Figure 9.

So the network has to adapt and grow, providing at the outset, a plan of expansion of the cellular network spanning several periods, according to the changes earned.

7. CONCLUSION AND PERSPECTIVES

We presented through this article a new solution of a problem which enough took time of researchers and which was the major concern of mobile phone operators. An approach that is based on new techniques, which are multi-agent systems and ontologies space for the implementation of a process of optimization of the cellular network. The role is to provide retraining and redesigns the network through effective cooperation with different agents, where each agent is responsible on solving a problem or complete a job well determined. Our work has gone through several stages. After

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discussing the field of mobile telephony and its main concepts, we thought about the integration of ontologies in a space-based agents, which will lead to better results, why we are found to need to present a section on the world of agents, and another on ontologies. To arrive at the description of the proposed solution with its main point, in particular the presentation of the general architecture of the proposed system. In such a context, we thought that the exploitation of our approach in a case study of a real problem, we will put forward good reasons for choosing this approach. Why we opted for a final section, which has been a case study of a problem statement by a mobile operator.
Hence the important concepts and techniques already revealed through our study, we believe that the development of software that is based on a method of optimization, which supports the important concepts and techniques already revealed through this study will guide the mobile network towards a comprehensive solution or a good local optimum. At each iteration, a rapid assessment of the GSM network calculates the new settings. This will improve the quality of network optimized manually, and reduce the time required for this repetitive task for experts radio.

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