Dynamic architecture for solving optimization problems of operators of mobile telephony

Chaker MEZIOUD  
Department of Computer Sciences.  
University Mentouri of Constantine.  
Constantine. ALGERIA  
cmezioud@yahoo.fr

Mohammed Khireddine KHOLLADI  
Department of Computer Sciences.  
University Mentouri of Constantine.  
Constantine. ALGERIA  
kholladi@yahoo.fr

Abstract — The operators of the mobile telephony are more and more demanding towards their applications. They wait for a big reliability, for a number ceaselessly increasing of services, the respect for the constraints of conviviality, for cost, etc. Therefore, the size and the complexity of the applications increase. The current techniques do not allow protecting us from problems of conception. That is why we need a high-level modelling, which will allow us to analyze the organization between the various elements of the system and the interactions between these elements. The interest of the systems multi agents ensues from collective behaviour produced by the interactions of several autonomous and flexible entities called agents, whom these interactions turn around the cooperation, around the competition or of her(it). However techniques come from this domain, concentrate more on the expression of the relations inter-agents. The expression of the mobility from the point of view of the distributed systems is not described. A property acquired time, will allow processes to choose themselves to move on the sites of a network to work locally on a point of view of the distributed systems is not described. A property acquired time, will allow processes to choose themselves to move on the sites of a network to work locally on the resources and be exchanged their interactions. Reason for which, we are going to propose in this paper a formalization which appeals to an algebra of process, which is \( \pi \)-calculus, for its capacity to be able to conceive systems automobile adaptive which can react to the shape of the problem.

Keywords: GSM, Cellular Networks, Multi Agents systems, Algebra of process, Dynamic Optimization.

I. INTRODUCTION

In recent years, communication systems have experienced tremendous growth in terms of communication systems between mobile subscribers (GSM) or subscribers to the switched telephone network (PSTN fixed network) [7]. Cellular networks are systems with high stress factors [8]. The real-time adaptation of the solution being at present impossible and 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. Reason for which we met ourselves in front of the need to bring in the multi-systems agents. The general architecture of the system of proposed reorganization, bases itself on a set of agents of various types. We thought afterward, that the integration of the notion of mobility, in terms of process or interactions at the level of the architecture of the proposed system, will allow ending in better results. The composed question was to find the adequate executive explicit, for the specification and the conception of the system. The choice was made for the algebra of process \( \pi \)-calculus , for its capacity to be able to develop dynamically the topology of the applications. In a first part of this article we place the context of the networks of the mobile telephony, its problem, and the main concepts which refer to it. A brief section will be intended for the presentation of the Multi- Agents Systems. We grant a particular interest to the algebra of process \( \pi \)-calculus , in particular the most suitable versions for our study. To arrive at the development of the proposed approach and that optimized through the integration of the concept of mobility. The last section will make the objective of a conclusion and a perspective.

II. MOBILE PHONES

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

A. GSM Network

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.

B. Equipments of a network GSM

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](image-url)
For our study we will look at radio subsystem and its main entities.

C. 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.

- **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.

- **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.

Integration of the world of the agents, will allow us to conceive methods adaptive automobile, this last idea will make the objective of the next section.

III. 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.

A. 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:

B. Mobile Agents

The pattern of mobility of mobile agents is derived from two different domains, the agents coming from the artificial intelligence with the multi-systems agents [3] and systems distributed with the migration of process [2]. To simplify, we can say that the plan to mobile agents is a generalization of the migration of process where the movement is for the initiative of the code. We speak then about a proactive migration. The main characteristic of a mobile agent is to have certain autonomy thanks to the proactive migration.

IV. PRESENTATION OF $\pi$-CALCULUS

To develop safe software, it is necessary to manage at first at the good to formalize it, that's why it makes use of formal languages as $\pi$-calculus. This last one who allows us to establish a mathematical model to verify certain properties expected from the software (safety, non-blocking, liveliness). The algebras of process are adequate executives for the specification and the check of reagent systems. This domain knew various approaches: CSP [1], CCS [4], $\pi$-calculus [6]. The fundamental abstraction is that we are interested in the behaviour of a process only through a certain number of points of interaction called "canals". $\pi$-calculus allows furthermore describing systems of mobile processes that are systems links of communication between processes of which the processes as well as can change place in time. The purpose looked for by $\pi$-calculus is the introduction of the concept of mobility, in order to authorize the dynamic reconfiguration of the topology of the applications.

A. Polyadic $\pi$-calculus

It allows the transmission of a tuple of values during an interaction. We use in our study this version of $\pi$-calculus to benefit from an important property that is the parameterization, through the simultaneous emission of a consecutives series, in an order given to a process. The reserved syntax is the following one:

$$P ::= \alpha | P \parallel Q | P \parallel Q | \alpha \cdot P | P \cdot Q | P \cdot P | P \cdot \pi$$

Where prefixes $\alpha$ (actions) are defined as follows:

- $\alpha (u) ::$ reception of a list of variable $u$ on the canal $\alpha$
- $\alpha <u>: $ emission of a list of variable $u$ on the canal $\alpha$

B. $\pi$-calculus higher order

It can not only provide variables and channels but also the process [10].

Example :

$$P | \alpha \cdot P \quad \text{avec} \quad P = \alpha (x,y,z)\parallel 0 \quad \text{et} \quad Q = \alpha (u,v,R)\parallel v (u)\parallel R$$

In the example above, the $S$ was transferred from the process $P$ in $Q$.

V. PRESENTATION OF THE APPROACH

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 2: cell with intermittent line).
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: azimuth, 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.
- Azimuth: orientation of the main lobe of the antenna in the horizontal plan. A modification of the angle azimuth 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).

A. 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.

- 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 (azimuth, 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).

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

B. Dynamic Architecture

If we want to give a model of the previous architecture, in terms of process. It will be illustrated in Figure 4.

One of the issues:

- In the event of a loss of a link between the agents. How can we intervene?
- And if we talk in terms of value, is there a way to reduce the communication time between these agents?

On the basis of \(\pi\)-calculus as language, in the formal specification of agents of the previous system, we will certainly lead to better results. For example: if the Supervisor Agent loses its communication link with the GIS Agent, but the expected optimization process will not be achieved. The answer to such a concern; \(\pi\)-calculus as formal language provides a dynamic reconfiguration to the topology applications. It means that Supervisor Agent may delegate its link to one of his agents to complete the task required (see Figure 5).
We can translate this mobility of links in $\pi$-calculus, as follows:

$$S \equiv b \cdot a \cdot S'$$  
and  
$$G \equiv a(x) \cdot G'$$  
and  
$$E \equiv b(x) \cdot a(x) \cdot E'$$

With:  
$S$ : Supervisor Agent  
$G$ : GIS Agent  
$E$ : Evaluator Agent

A second opportunity to be able to negotiate, it is in case the Evaluator Agent can move to the Cells Agents, which surround the overloaded cell, to intervene in every detected saturation. The nearby cells deliver their three parameters: azimuth, tilt, power signal, to be able to assure with regard to their current loads. In that case, the Evaluator Agent possesses the update to be applied and is going to move from a cell to the other one (by crossing six cells), and by getting back three parameters of every cell. As shows it the following figure:

![Figure 6. Movement of the Evaluator Agent](image)

C. Advantages

Through this new approach of dynamic architecture, various advantages will be gained, we quote the most essential:

- The first advantage to be quoted, it is the decrease of the intensity of information exchange between the various agents.
- The second considerable advantage is the decrease of waiting times. It happens frequently that the waiting time of the answer of a request is longer than the time of treatment necessary for the realization of the service.
- We decrease considerably the cases of problems of connection (breaks of links), and in case of a break, the agent can delegate his link to another agent.

VI. CONCLUSION AND PERSPECTIVES

Through this paper, we presented a new solution of a problem which enough took time researchers, in the field of optimization and which was the major concern of mobile phone operators. A solution of agents' base, which assures revisions and recycling of the network through an effective cooperation with various agents, where every agent is responsible on the resolution of a problem or the execution of a well determined task. Our work knew several stages. Having spoken about the domain of the networks of the mobile telephony and its main concepts, we thought of a presentation of domain of the multi-systems of agents and the formal language $\pi$-calculus. To arrive at the nucleus of our work that is the description of the solution proposed with its main points, in particular the presentation of the general architecture of the proposed system. We are not satisfied to us with the solutions acquired through this approach; we thought that the integration of the notion of mobility, at the level of the architecture of the proposed system, will allow ending in better results. Reason for which we appealed to the algebra of process $\pi$-calculus, for its capacity to be able to develop dynamically the topology of the applications. As perspectives, we think that the development of a software which bases itself on a method of optimization, which supports the important concepts and the techniques already revealed through our study, guide the mobile network to improve network quality optimized manually, and a reduction in the time required for this repetitive task for experts radio. The gain in performance is also reflected in the reduction for the operator investments in infrastructure.

REFERENCES