Agents for Wireless Environments

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Abstract

The agent technology will have a role increasingly important in the telecommunications due to their properties, in particular, of autonomy, intelligence and/or mobility. The WLAN will also play an increasingly important role in offering an omnipresent access to the network, thus supporting the mobility of the user. In this context, we have identified some number of applicability of the agents in the WLAN. Then we have described an example of agents use by taking as scenario of reference a user of the 4th generation of mobile having at his disposal several technologies of wireless access. This user wants to be able to be connected in the best way, anywhere, any time and with any access network. Agent technology, in this case, is used to adapt the horizontal and/or vertical handover to the user's needs.

1. Introduction

Internet First Generation is based on simple principles, providing only one "best-effort" service, i.e. without any delay or packet loss guarantee. This service is sufficient for applications such as electronic mail which have no real time constraint [1]. However, with the considerable development of the Internet and multimedia applications that have real time constraints, a best-effort service is not yet sufficient. So the Internet New Generation has to support real time applications such as voice and video.
The current tendencies concerning the telecommunications can be classified into many fields [7]:
- *Solutions* : Searching for solutions for the electronic business, the mobile business and the company applications.
- *Services* : Increased personalization of the services.
- *Equipment* : Smaller and more powerful equipment.
- *Networks* : Convergence of the networks (telecommunication, Internet, TV and local area networks);

These tendencies reflect the increase of mobility in our surroundings: personal mobility, terminal mobility and code mobility.
The next generation of network will be omnipresent with a high throughput. However, some number of conditions must be satisfied:
1. To choose among the massive offers of service, the users need a personal help anywhere and any time.
2. To fully use the multimedia applications in a satisfactory way, the user must have an intelligent interface on his/her terminal.
3. Equipment must share personal information such as user profiles, and the terminals must be able to be transformed into suppliers of personal assistance able to carry out, in particular, commercial transactions. Powerful mechanisms of security must be added to the intelligent infrastructures of telecommunication.
4. networks becoming more complex and dynamic, new manners of conceiving and controlling them are necessary : network management must become distributed, proactive, and automated, while maintaining flexibility, scalability, and interoperability [2].

In this context, the agent technology will have a role increasingly important in telecommunications. It will be mainly used in:
- carrying out a high level of communication;
- personalising and integrating various services according to the negotiated QoS;
- treating the large quantity of information;
- allowing the self organization of the network [7];
- making a good modelisation of the real world;
- reducing the traffic in the network;
- carrying out a good exploitation of the resources [14].

In this paper we are interested, more particularly, with agent technology in the wireless networks. We start by reminding the main principles of the agent technology and the characteristics of the wireless networks. Then, we present the principal fields of agent application in the wireless that we have identified. Finally, we give an example of agent use that allows the adaptation of the handover to the need of quality of service of the user 's multimedia applications.

2. Agent technology

Since many years, the term "agent" is used more and more in the information technology as well as in the telecommunications. We can find several definitions concerning the agent which are different only in the type of application for which the agent is designed. H. Jens et all [3] gave the following definition: "an agent is a piece of software that can achieve a specific task in an autonomous way (for the sake of the user or the application)".
All the agents have the possibility of coordinating, communicating and co-operating with the system or with other agents. A common approach consists in defining the agent by its properties, such as autonomy, intelligence, mobility, etc...
T. Magedanz and all identify two principal types of agent [5]: mobile agents and intelligent agents.

2.1 Mobile agents

The principal attributes of a mobile agent are the mobility of the code, the data and the state (state of a process, a machine or a protocol). This makes it possible for software entities to move in an autonomous way through the network to achieve specific task, thereby taking advantage of proximity [3].
In[12], the authors present an analysis of the current tendencies concerning the Internet which in their opinion open the way for the deployment of "mobile agent" technology.
Many multi-agents platforms support mobility. We can quote the following platforms: Aglets Workbench of IBM[i], Voyager[ii], OMG-MASIF initiative[iii], Grashopper of IKV[iv], Semoa[v], Swarm[vi], MOLE[vii], Concordia of Mitsubishi Electric[viii], Agent TCL of Dartmouth College[ix], CyberAgent of FTP Softwareand[x] and JIAC of technical university of Berlin[xi].

2.2 Intelligent agents

An intelligent agent is a software entity which carries out operations for the account of the user (or for another program) with some degree of freedom and autonomy and which exploits knowledge or representations of the desires and the objectives of the user [6].
H. Jens and all [3] give the following definition: Intelligent agent are software entities that are able to perform delegated tasks based on internal knowledge and reasoning, where aspects such as inter agent communication and negotiation are fundamental. Usually mobility is not considered as an issue.
Another definition was given by N.R. Jennings and all [8]: "an intelligent agent is an information processing system, located in some environment, which is able to carry out flexible and autonomous actions in order to meet its aims of design".
A multi-agent system is a dynamic federation of agents connected by the shared environments, goals or plans, and which cooperate and coordinate their actions [9]. It is this capacity to communicate, to coordinate and to cooperate which makes interesting the use of agents in the telecommunication systems.

3. Wireless networks

the WLAN is on the way to become one of the principal solutions of connection for many companies. The large companies and many branches of industry such as health and education are concerned.

3.1 WLAN Advantages

The WLAN releases the user of its dependence on the cabled access to the backbone, offering a permanent and omnipresent access for him/her. This freedom of movement offers many advantages for the user such as:
- an omnipresent access to the network;
- a simple and real time access to the network;
- a faster and extended access to the data bases.

The WLAN also offers a greater flexibility and allows the installation of the transmissions in the places where the installation of cable is difficult, even impossible.

3.2 Problems related to the WLAN

Among problems related to the WLAN, we can quote:
- dynamic change of the network topology and resources;
- the complexity of the mobility management;
- specific characteristics of the radio channel;
- sudden and frequent disconnections;
- resources limitation for the terminal;
- the very variable delay and throughput because it is dependent on several factors such as the number of users, the interference, the multipath, etc.

4. Agent applications in wireless networks

Nowadays, few researches are based on the multi-agents systems in the wireless networks. However, the study of mobile agent communications in the Wireless can present some solutions [4]: the use of the intelligent agents for the management of the heterogeneous networks [2], the proposal of a multi-agents architecture to control the M-commerce [1], the definition of a reference scenario using the fixed and mobile agents to guarantee QoS between a server and a mobile terminal [13] and the implementation of an agent-based home banking service for a mobile network [14]. More generally, we identified five great fields for the application of agent technology in the wireless.

4.1 mobile terminal localization

In a few years, the wireless networks will provide to the multimedia applications, a large bandwidth with the necessary quality of service [15]. Thus, a method will consist in using the localization of the terminal and making forecasts to allocate the resources necessary to the terminals [16;17] and also for the re-routing of the traffic. The evaluation of the localization of the mobile terminal becomes, thus, an integral part of the wireless network management system.

Several methods are proposed to determine the localization of the mobile terminal in a wireless environment. They are based on the measure of AoA (Angle of Arrival), ToA (Time of Arrival), or RSS (Received Signal Strength) [18].

A simple method to locate the mobile terminal is to employ measurements to determine the "radio path loss". In [19], the localization of the mobile terminal is based on the measurement of the propagation of the "path loss" between the mobile terminal and the base stations (BSs) while being based on RSS measurements.

Agent technology can be used in this case to improve the results obtained and to support the mobility of the terminal, but it is necessary before to:

Predict:
1. future localizations of the terminal.
2. changes of the QoS.
3. disconnection moments.

Learn:
1. network connection characteristics.
2. user's behaviour models.
3. user's preferences.

4.2 Improvement of a mobility protocol

Agent technology can be used to improve the effectiveness of a mobility protocol such as Mobile-IP. This protocol was adopted by the IETF to ensure mobility in a IP network. However this protocol does not make it possible to perfectly maintain the performances of a connection in the case of a user's mobility. Indeed, the time needed to update the databases indicating the new position of the user can degrade the connection quality. Before the arrival of the localization request, several information packets can be lost after their sending towards the previous destination of the mobile.

4.3 Adaptation of the handover to the user's need

Agents can be used in the wireless network to support the vertical handover. An agent, having carried and deployed the software of an air interface for a radio technology, may autonomously request the software for another technology (according to the applicative needs of the user) before a vertical handover.

4.4 Signalisation control

Mobile agent can also be useful to control the signalisation [10;11]. The agents can also be used to dynamically negotiate the needs of quality of service, security and mobility for the user in the wireless network [21].

4.5 Reduction of the wireless access

The mobile agents can distribute the code on the wireless network equipment. The number of exchanges necessary to provide a personalized service can thus be reduced. This makes it possible to improve the performances of the wireless network by decreasing the consumption of bandwidth and by reducing the latency.

4.6 Problems related to the application of the MASs in the wireless

The main problems concerning the application of the agents in a wireless environment are related to the security, the cost, the compatibility and the implementation.

The access to internal network resources must be very well secured. Security has to play a major role in the design of the software environment supporting the agent deployment. Giving to an agent an important degree of autonomy and intelligence increases the risk of problems in case of an abnormal operation. A method to avoid the security attacks consists in authenticating the users, the agents and the terminals [1]. Cost in terms of agent migration and local processing needs also to be taken into consideration. The compatibility of agent platforms in terms of code and interfaces needs to be assured. Finally, implementing "mobile agent" technology in a wireless environment is a heavy task. However, displacement is, in certain cases necessary, for example, before the disconnection of the terminal on which it is located.

5 Scenario of reference

The user of the 4th generation of mobile (4G) has several wireless access technologies at his disposal. This user wants to be able to be connected in the best way, anywhere, any time and with any access network. For that reason, various wireless technologies, represented in figure 1, must coexist so that the best technology can be retained according to the user profile, the type of each application and the service required by the user.

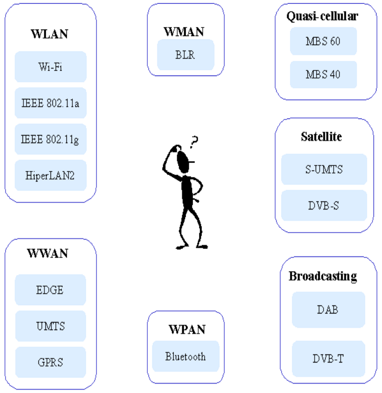

Figure 1: various wireless access technologies for the users of the 4G

In this context, the terminal equipment will have to permanently seek the best access network according to the user's needs. Agent technology can play a very important role in this choice. Figure 2 gives an example of network configuration offering several access technologies to the user. Agent technology is used to adapt the horizontal (change within the same access technology) and vertical (change of access technology) handover to the QoS needs of the user. The following example helps to illustrate this principle.

Example:

We take as example a Wi-Fi network deployed on a Campus (a university) and where agent technology is used to manage the mobility of the user in a dynamic way. In a Wi-Fi environment, the strategy of changing the access point requires 4 stages:

1. the discovery of a target access point,
2. the synchronization with the access point,
3. the sending of an authentication,
4. the establishment of the association.

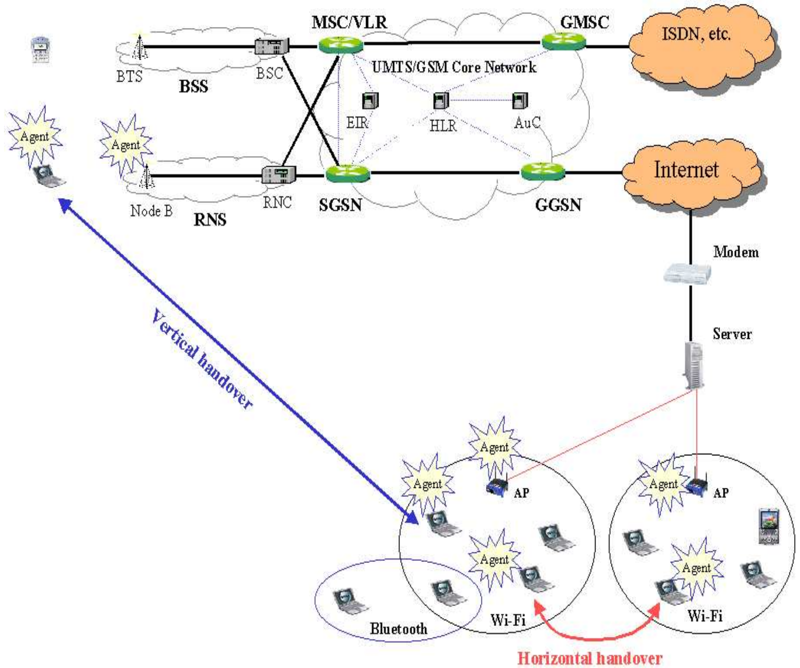

Figure 2: horizontal and vertical handover

This strategy, implemented in the network equipment (BSs and MHs), is static i.e. neither the service provider nor the customer can change the selection of the access point. However this selection can be bad in certain cases. In figure 3, the Mobile Host 5 (MH5) on which the user starts an application requiring a high level of QoS (a video application for example), receives the best signal of BS2; however, hand cell 2 is already very loaded and consequently QoS necessary for MH5 cannot be assured. A dynamic strategy consists in guiding the MH5 towards cell 1 which is empty and which can provide the necessary QoS.

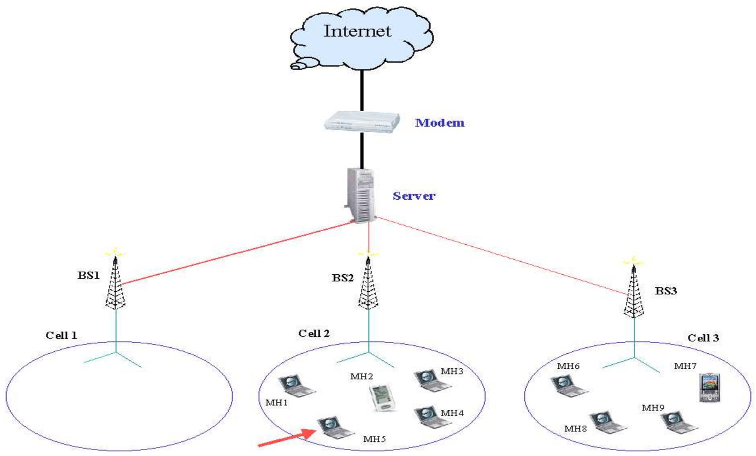

Figure 3: Example of Wi-Fi network

If all the cells are filled, the user must be able to use another access technology at his disposal which corresponds to his needs. In this example, it is the UMTS technology which will be used, the great number of users on the spot prevents the Wi-Fi from fulfilling the requirements of QoS for the required application. As soon as the user activates another less critical application in term of QoS or that the performance of Wi-Fi becomes acceptable for the application, the user must also be able to reconsider Wi-Fi technology (because of the high cost of the UMTS for example). Different vertical handover must be carried out in a completely transparent way for the user according to the applicative constraints and the user profile.

To provide quality of service on a Wi-Fi network, it is necessary to respect 3 principles [20]:

1. The number of hosts authorized to use the channel must be limited;

2. The geographical area inside which the users communicate must be limited so that all of them can use the highest throughput;

3. The sources must be limited by configuring the conditioners of traffic in the equipment.

In order to provide necessary QoS to a multimedia application, we will respect these three principles and we'll make three assumptions:

- From a certain number of users (N), gathered in the same cell, QoS necessary for a multimedia application will not be ensured any more and the cell will be considered as filled.
- Each access point contains a single "identifier of localization". From this identifier of localization, a user can connect himself to the cell allowing to ensure necessary QoS to the application.
- According to the work which was realized in [19], an estimate of the position of the MH is made and an application which gives the distribution of the cells in each room of the university (conference room, library...) is downloadable from the server.

Figure 4 represents the distribution of the cells and the associated identifiers, in a conference room having 3 access points.

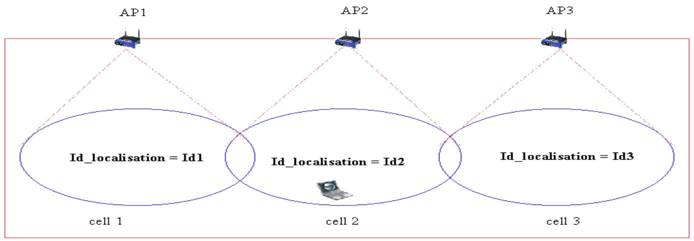

Figure 4: distribution of the cells in the room

6. Agent approach

The multi-agent system contains two agents:

1. Terminal Agent:

this agent is located on the MH, it establishes the connection between the user and the system, it can be graphic or in text mode. The Terminal agent is autonomous, it is activated by the user when starting a multimedia application. It communicates with another agent on the access point in order to find the state of the cell and the states of the cells in the neighbourhood. It asks for the deployment of another access technology if necessary.

2. State Agent:

this agent is located on the access point, it determines the internal state of the cell and the internal state of the neighbouring cells. From N users gathered in the cell, the state of the cell will be regarded as filled. To know the state of the neighbouring cells, the State agent contacts the same agents on the neighbouring cells, and thus it can recover their states.

Figure 5 represents the whole interactions in the system. In this example, the user is in cell number 2 of the conference room. He consults his emails or makes a transfer file. At the launching of a multimedia application, the Terminal agent is activated and sends a message (m1) to the State agent in order to know the state of the current cell, the State agent compares the number of users in the cell with the number N. If it is lower or equal to the number of users in the cell, it sends a message (m2) to the Terminal agent to indicate to it that the current cell is filled. At the same time the State agent contacts the same agents on the neighbouring access points (messages m3 and m4) in order to know the state of the neighbouring cells. Each agent answers by a message which contains the state of the cell or the number of users in the cell with the localization identifier of the cell (messages m5 and m6).

The State agent in the current cell makes a comparison between a number of users in the neighbouring cells or between their states. If there is at least a cell which is not filled, he sends the localization identifier of the chosen cell to the Terminal agent (m7), and sends an ACK message (m8) to the State agent in the chosen cell.

At present, the Terminal agent sends a request to the server in order to download the application which will enable the user to know the place of the concerned cell in the room.

On the other hand, if all the cells are filled, the State agent contacts the Terminal agent (message m9) which will require the deployment of the UMTS.

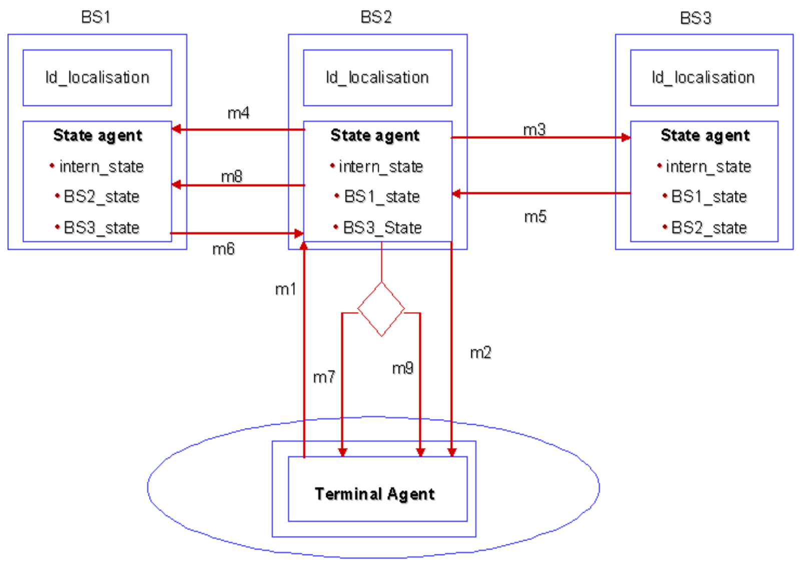

Figure 5: interactions between the agents

7. Particular cases

In absence of the second principle (The geographical area inside which the users communicate must be limited so that all of them can use the highest throughput) the users use different throughput.

In the literature, we find the following proposed solution named FTS [22], it aims to avoid the performance degradation caused by one or more slow hosts in a 802.11b hot spot. In this solution, each host calculates a proper time according to the bit rate shaping the bandwidth. In the Access Point, the FTS Server stores the MAC address and the bit rate of the active hosts, broadcasts the number of active hosts and the maximum bit rate in the hot spot. In the Client station, the FTS Client receives the number of active hosts and the maximum bit rate in the hot spot from the FTS Server, it calculates the accorded time, if its own bit rate is smaller than the max bit rate then it calculates its allowed bandwidth and configures its traffic shaper with its allowed bandwidth.

We suppose that the number of users in the cell is **nbr** and the max bit rate is 11Mbps. In this case, the QoS is always assured for the hosts which are connected at 11Mbps, we seek to satisfy the other hosts which are connected at 1, 2 or 5.5 Mbps. To satisfy an voice application in term of QoS, the cell can support n1 users connected at 11Mbps, n2 users connected at 5.5 Mbps, n3 users connected at 2 Mbps and n4 users connected at 1 Mbps.

Generally, a voice application needs 64 kbps. So, to satisfy this application, the condition for each host is: **useful throughput ≥ 64 kbps.**

we remember that if the bit rate is 1, 2, 5.5 or 11Mbps then the useful throughput is set to 0.892 Mbps, 1.68 Mbps, 3.81 Mbps or 6.08 Mbps respectively. Consequently and according to the work realized in [22], if the bit rate is 1, 2 or 5.5 Mbps then the condition is (0.892 Mbps/nbr) ≥ 64 kbps, (1.68Mbps/nbr) ≥ 64 kbps or (3.81 Mbps /nbr) ≥ 64 kbps respectively.

$$(0.892\ Mbps/nbr) \geq 64\ kbps \rightarrow nbr \leq 14 = n4$$

$$(1.68\ Mbps/nbr) \geq 64\ kbps \rightarrow nbr \leq 27 = n3.$$

$$(3.81\ Mbps /nbr) \geq 64\ kbps \rightarrow nbr \leq 61 = n2.$$

n1 determines the number of users connected at 11Mbps (their traffic shaper is not configured because 11 Mbps is the max bit rate in the hot spot [22]).

Considering [22], the client configures its traffic shaper with its allowed bandwidth. If its throughput is lower than 64 kbps, the Terminal agent is activated and sends a message (m1) to the State Agent in order to inform it that its requirement in term of QoS cant be assured (figure 6).

The State agent contacts the same agents on the neighbouring access points (message m2 and m3) in order to know the state of the neighbouring cells. Each agent answers by a message which contains the number nb1 of users connected at 11Mbps, the number nb2 of users connected at 5.5Mbps, the number nb3 of users connected at 2Mbps and the numbers nb4 of users connected at 1Mbps with the localization identifier of the cells (message m4 and m5).

For the neighbouring cells, the State agent in the current cell makes the following treatment:

If (min (nb1(cell1,cell2)) ≤ n1 or min (nb2 (cell1,cell2)) ≤ n2 or min (nb3 (cell1,cell2)) ≤ n3 or min (nb4(cell1,cell2)) ≤ n4)* **then**

it sends the localization identifier of the chosen cell to the Terminal agent (m6), and it sends an ACK message (m7) to the State agent in the chosen cell.

At present, the Terminal agent sends a request to the server in order to download the application which will enable the user to know the place of the concerned cell in the room.

Else the State agent contacts the Terminal agent (message m8) which will require the deployment of the UMTS.

*: To provide the QoS requested, State agent seeks to find an connection at 11Mbps in a neighbouring cell, if not it tries to find a connection at 5.5 Mbps or at 2 Mbps or finally at 1 Mbps. To do that, it compares the number of users in the 2 neighbouring cells connected at the same bit rate (cell1 and cell2) with the max of users accepted in the cell and connected at the same bit rate.

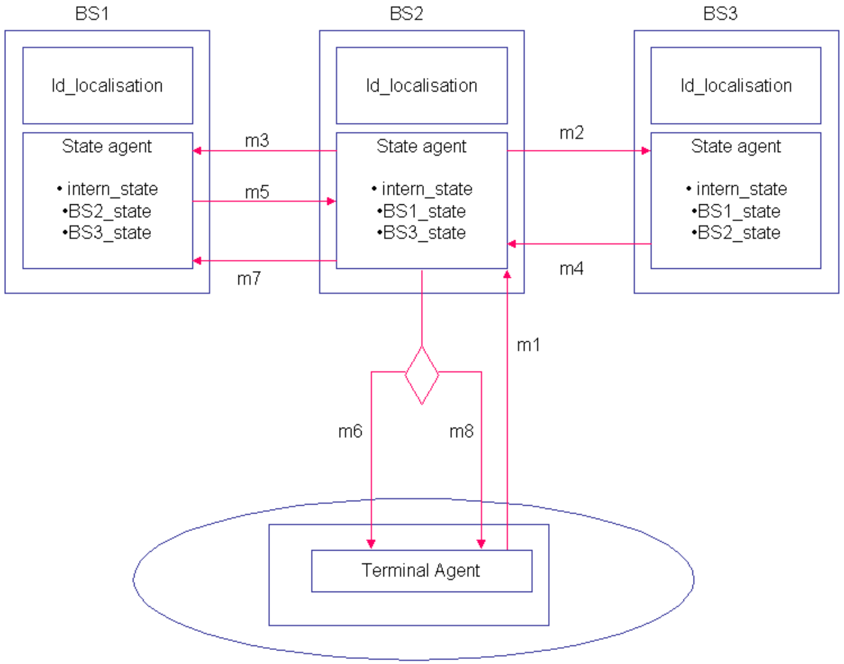

Figure 6: interactions between the agents

8. Conclusion

The agents will be mainly used in the wireless networks to improve the methods of localization and the existing protocols of mobility, to control the signalisation on the network, to reduce the accesses and to adapt the handover to the user's needs. The latter point was detailed by taking as scenario of reference the 4th generation of mobile and the provision of several wireless access technologies. Agent technology, in this case, makes it possible for the user to change access point or access network according to his needs. Other applicability of the agents in telecommunications is also important such as the proposal or the dynamic composition of personalized services to the users. In this case, wireless technologies can still play an important role as an access network.

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