SIP-based Architecture of Broadband Wireless Access Systems Inside the GSM/EDGE Network

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Abstract- **LCS (LoCation Services) [2] is a service concept in GSM and UMTS and specifies the network entities and elements that are necessary so that the cellular networks can support positioning functionalities. Broadband wireless access systems provide a mobile terminal with wireless access to a fixed infrastructure from a usually fragmentary coverage. Media Point [3], [1] is a service concept, which enhances the capabilities of the broadband wireless access systems in combination with a 2G or 3G system. This paper analyzes the way the location information of the LCS feature of GERAN could be used in order to push and cache personalized data to the Media Point component that is nearest to the mobile terminal before it reaches the coverage area of a Media Point. In this proactive way, the mobile user whenever inside the coverage area, will not need to wait for his or her data (e.g. e-mails) to be downloaded all the way from the Internet and thus increase the efficiency of the Media Point system.**

Index Terms- **Fragmentary broadband wireless access; GSM/EDGE; SIP; Media Point; LCS; integration; GERAN; location information; push service.**

I. INTRODUCTION

The integration of broadband wireless access systems in the public cellular infrastructure is currently one challenging systems integration issue. The creation of fragmentary broadband wireless access inside the cellular infrastructure is expected to provide broadband push services in specific geographical regions. These services could be accessed through so called Media Points, which are broadband wireless access points inside the cellular infrastructure of big cities where high-bit data rates are needed. This 'Media Point in city areas' scenario is presented in Figure 1.

The islands of fragmentary broadband wireless access created through the use of Media Points aim to balance the traffic in the whole network. For example, numerous mobile Internet users that regularly visit popular news sites could make use of broadband wireless access providing them by push services with their personalized information. Push services could also be used for the delivery of e-mail, music, and video.

Media Points have a coverage area with a radius between 50m and 150m. This radius depends on various conditions such as weather conditions and location of the Media Point. Weather conditions such as fog or rain cause more attenuation to the radio waves which results to a lower link budget when compared to weather conditions of low humidity.

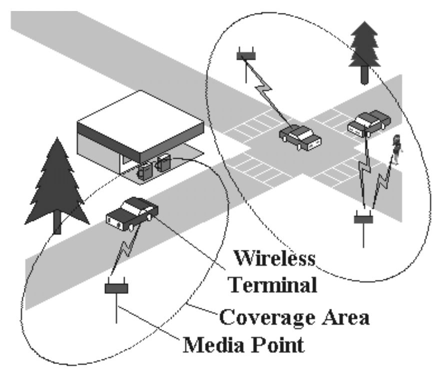

Fig. 1. The Media Point scenario.

It has to be noted that only stationary and low-mobility scenarios will be considered. Considering the scenario of stationary usage, we expect that mobile terminals remain in a certain locality during quite a long period of time. For the scenario of data transfer while walking, low-mobility of up to 5 km/h is considered. Finally, with the envisioned scenario of Media Point access in public transport, we could profit of the fixed routes of public transport. Mobile users could make use of Media Points installed in the bus stations while the bus halts.

II. MEDIA POINT OVERVIEW [1]

A. Logical Components

The logical components that can together form a Media Point can be identified as the Media Point Service Controller (MPSC), the Media Point Controllers (MPC), the Media Point Transceivers (MPT) and the Mobile Terminals (MT), as shown in Figure 2. The Media Point Service Controller is the central component of a Media Point network and provides the interface to the cellular network and the Internet. It supervises all Media Point Controllers belonging to that particular network.

Each of the Media Point Controllers administers a group of Media Point Transceivers, which are usually located in close geographical proximity. The Media Point Transceivers (Media Points) are mainly responsible to provide mobile terminals with wireless access to the Media Point infrastructure.

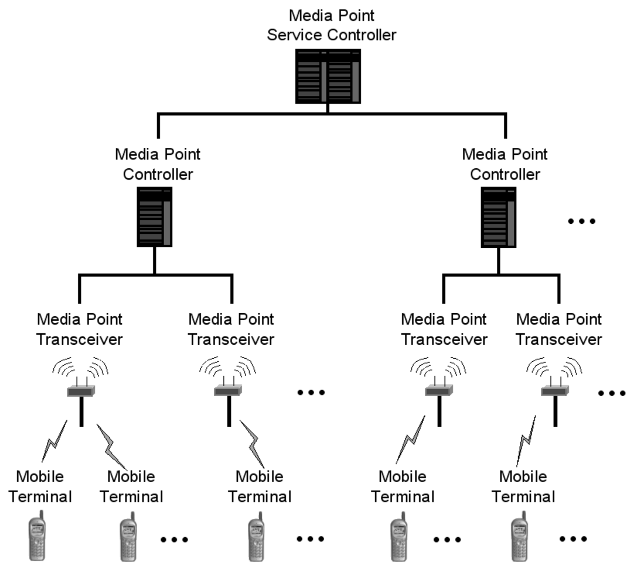

Fig. 2. Hierarchy of the Media Point system components.

B. SIP and push of data

SIP (Session Initiation Protocol) has the capability to include all types of information (e.g. a HTML page) in its body with use of the MIME format. This offers the opportunity of pushing a HTML page instead of the usual HTML pull concept [1]. SIP is also used for signaling in the Media Point scenario, hence it is worthwhile using the same protocol for the whole Media Point architecture for both pushing data and signaling. If different protocols had been chosen, compatibility problems might be faced between the different protocols while implementing the Media Point scenario in practice.

III. LOCATION TECHNOLOGIES SPECIFIED FOR GERAN

It is assumed that mobile terminals are ready for multi-mode operation, incorporating cellular as well as broadband wireless access technology. With a previous study [1] it was considered that whenever the mobile terminals detect a Media Point coverage area, they establish a connection. Within this study we are concentrating on how the positioning functions of the cellular network can contribute to increase the efficiency of the Media Point system. In the following sections the location estimation methods that could be used in the Media Point scenario are briefly described.

A. Cell Identity Method (Cell-ID)

The whole service area of a mobile phone network is divided to honeycombs of overlapping radio cells, in which a base station is centered where the radio antenna is installed. The dimensions of these honeycomb shaped areas, called cells, are dependant on the user traffic. They can vary from 300 meters in cities, to up 35 kilometers for thinly populated territories [7]. Each mobile user is singularly identifiable by this cell.

B. Enhanced Observed Time Difference (E-OTD)

This technique is involved with measuring the propagation time of signals received by the mobile terminal, between the base station of a radio cell and at least two other neighboring base stations. Then the corresponding results are compared. Because the coordinates of the base stations are known, the position of the terminal can be calculated either in the terminal itself or in the network by means of triangulation. The exactness of this method lies on 150 meters and under ideal conditions on a few meters [7].

C. Assisted Global Positioning System (A-GPS)

With the help of 24 Navstar satellites in orbit around the Earth, the Global Positioning System (GPS) has the highest positioning accuracy of between four and ten meters. By virtue of its satellite-based system, its performance depends on stable weather conditions. Signals have to be received from at least three satellites. The GPS receiver calculates the position independently. Disadvantage of this method is that it takes much time to perform the calculations needed for positioning [7]. As well as this, supposing that the GPS system positioning entities are located in the mobile terminal, a significant battery energy consumption is inevitable.

In A-GPS, some of the positioning parameters are achieved in advance through GPS receivers. This technique makes case-by-case calculation simple and reduces in this way the identifying time to a position to a matter of seconds.

IV. LOCATION ESTIMATING AND GERAN

The LoCation Services (LCS) feature in GERAN describes, according to the 3GPP [2], how the location of a mobile terminal can be specified through the measurement of radio signals. By using this location information, the data can be pushed proactively to the Media Point component that is nearest to the mobile terminal. In this way, the mobile user will not have to wait for his data to be downloaded all the way from the Internet and thus increase the efficiency of the Media Point system.

Figure 3 shows the general organization of the Location Service entities, that is the relationship between LCS and GERAN [2]. The positioning functions, shown in Figure 4, are comprised of coordination, measurement and calculation functions, important for the location estimation of the mobile terminal.

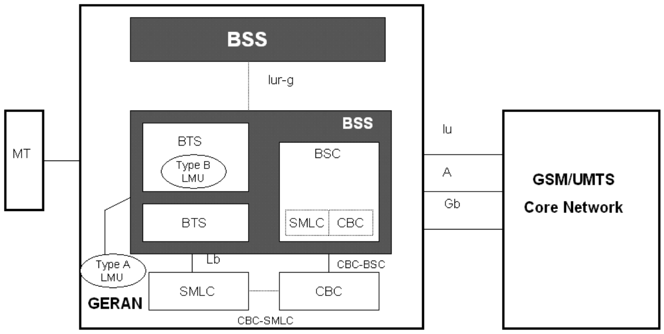

Fig. 3. Functional LCS Architecture in GERAN.

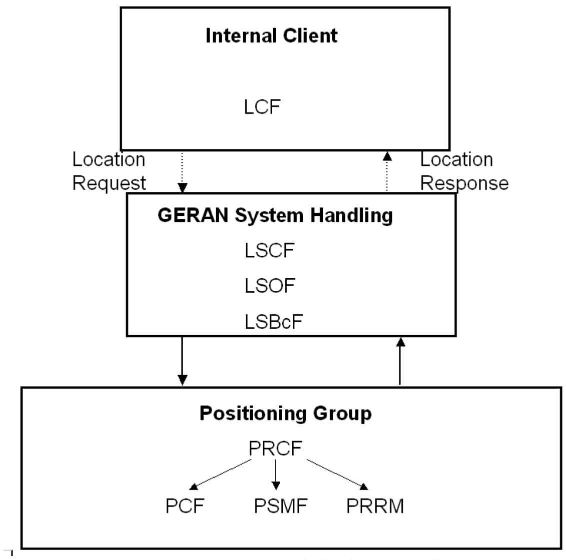

Fig. 4. GERAN LCS capability functional diagram.

V. THE COMBINED MEDIA POINT AND GSM/EDGE ARCHITECTURE

The signaling between the different Media Point components as well as the push of data is based on the Session Initiation Protocol (SIP) [1], [4], [5]. Most of the signaling process shown in Figure 5 as well as the push of the personalized data could be accomplished before the mobile terminal enters the coverage area of a Media Point with the help of the positioning functions of the cellular network.

Instead of installing just a Presence Server [6] in the Media Point system, a SIP Gateway with Presence Server capability should be installed in the cellular network in order to make use of the location information provided by the GERAN positioning functions. The SIP Gateway installed in the cellular network will make use of the location information provided by the GERAN location entities. By specifying the location of the mobile terminal, the Media Point system will be able to push the data to the Media Point Controller that is nearest to the mobile terminal. The Media Point Service Controller will be notified in advance about the existence of the mobile terminal user. Thus much of the signaling of Figure 5 as well as the push of data will be accomplished in advance, that is before the mobile terminal enters the coverage area of a Media Point.

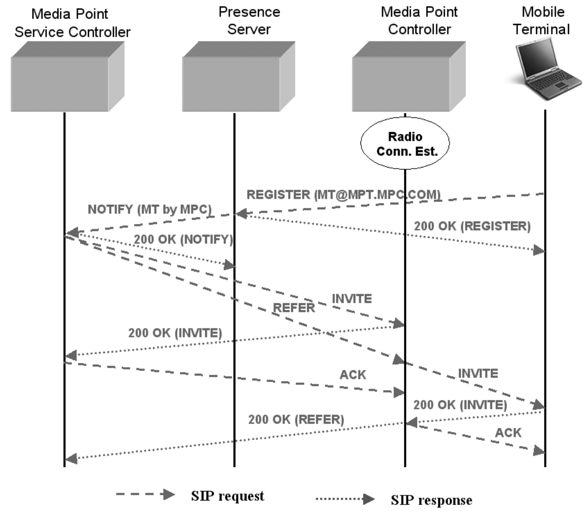

Fig. 5. The signaling process between the Media Point components [1] after the mobile terminal enters the coverage area of a Media Point without the help of the cellular network.

VI. SIGNALING SCENARIOS AND THE COMBINED ARCHITECTURE

In the combined infrastructure there are different types of protocols, one in the core network for location estimation signaling and one for the signaling between Media Point entities. In order to convert the information of the RRLP message to information compatible with the SIP protocol a SIP Gateway [8] is needed.

The hardware side of the SIP Gateway comprises a SS7 Interface-Card which is able to process the signaling information of the SS7 standard. The software side is able to communicate with the SS7-Interface-Card and the SIP device. The SIP Gateway could be located in the hardware where the MSC software is installed.

In the following paragraphs, the different signaling scenarios of the integrated Media Point architecture in the cellular network are presented.

A. Location prediction and the corresponding Media Point system signaling

The signaling process is presented in Figure 6. We assume that the Mobile Terminal is out of any Media Point coverage area. The MSC sends the BSSAP Perform Location Request message to BSC and the BSC forwards it to the SMLC. Then the SMLC sends a BSSAP-LE Connection Oriented Information message to the BSC with a content embedded in the BSSAP MT Position Command together with a RRLP message parameter.

The BSC sends the embedded RRLP message to the MT as well as a RR Application Information message. In case that the MT has the positioning information to send back to the SMLC, it sends a RR Application Information message to the BSC containing an embedded RRLP message. After this and provided that the positioning supervision timer has expired, the BSC rejects the RRLP message received in the last step. Otherwise the BSC sends this message to the SMLC.

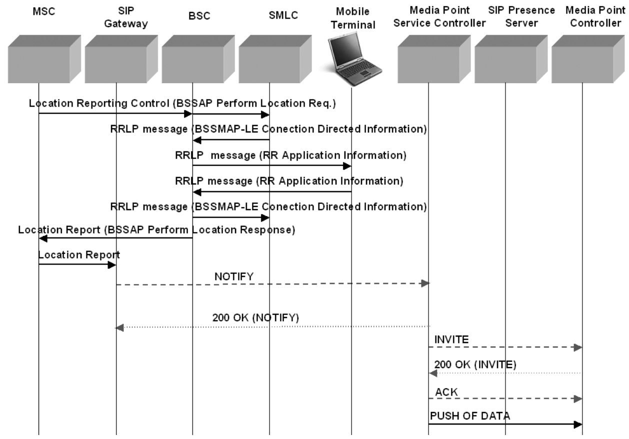

Fig. 6. The signaling process between the Media Point components and the cellular network before the mobile terminal enters the coverage area of a Media Point.

After this the BSC sends the BSSAP Location Response to the MSC. The MSC sends the Location Report message to the SIP Gateway in order to convert its information into a message compatible with the SIP protocol. The SIP Presence Server entity of the SIP Gateway sends a NOTIFY message to the Media Point Service Controller. With this message the Media Point system is informed about the possible location of the target MT. Then a SIP connection is established between the MPSC and the MPC. As a result, the personalized data can be pushed proactively to the MPC.

B. Signaling process when the prediction of the location of the MT has been successful

We assume that the MT enters a Media Point coverage area. The location information of the MT has already been estimated from the cellular network and sent to the MPSC. The procedure to produce a Location Report is the same with that described in the previous paragraph. The MT establishes a radio connection with the broadband access network (e.g. IEEE 802.11a/e or HiperLAN/2) and then establishes a SIP connection. The signaling process is presented in Figure 7.

The MT sends a REGISTER to the MPC. After the MT has registered, it receives an OK response. The SIP Presence Server then sends a NOTIFY message, encapsulating the location information registered by the MT and receives an OK. The MPSC compares the two location entries of the MT, the one received as a location prediction from the cellular network and the other by the registration of the MT. Considering that these two entries match, the location estimation was successful. After this, the MT can establish a SIP connection with the MPC and receive its data that are waiting there cached.

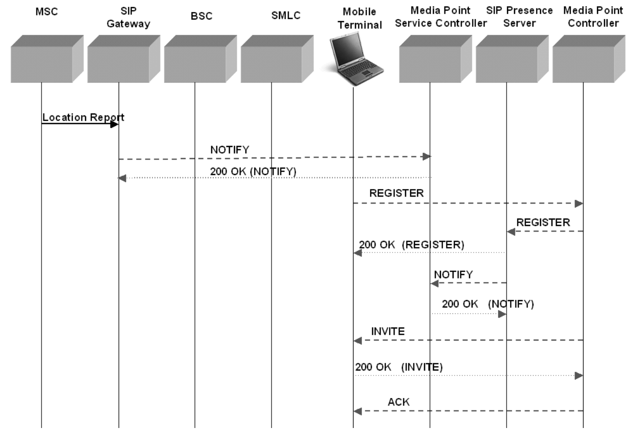

Fig. 7. The signaling process between the Media Point components and the cellular network in case that the location estimation has been successful.

By comparing the signaling in Figures 5 and 7 it becomes obvious that less signaling is needed after the mobile terminal enters the coverage area of a Media Point. In this way, the idle time before the mobile terminal obtains the first packets of data is reduced.

As well as this, the personalized data (e.g. e-mails) are pushed and cached in the Media Point component that is nearest to the mobile terminal. In this way, they should not be downloaded all the way through the Internet and thus increase the efficiency of the Media Point system.

C. Signaling process when the location prediction of the MT has not been successful

Figure 8 presents the corresponding signaling process.

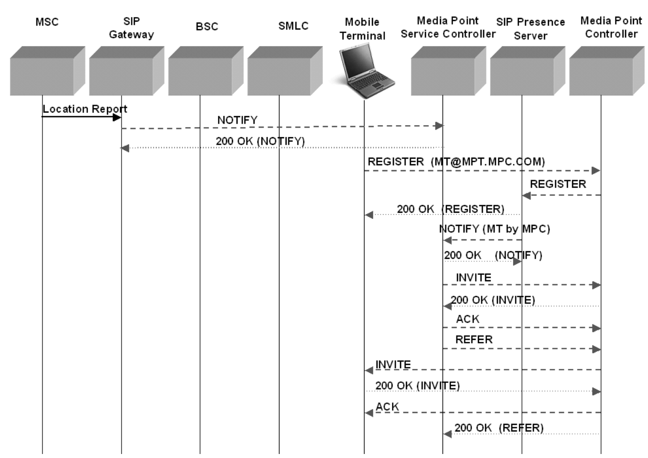

Fig. 8. The signaling process between the Media Point components and the cellular network in case that the location estimation has not been successful.

We assume again that the MT enters a Media Point coverage area. The procedure is the same with that of the previous paragraph with the difference that the cellular network did not predict successfully the Media Point coverage area that the MT has entered. As a result, the whole signaling has to be repeated and the data have to be pushed to the correct MPC. This signaling is presented in Figure 8 and is actually the signaling that should be performed when no prediction of the location of the MT is available. As a result, the inaccuracy of the location estimation methods may result in unnecessary overhead. This overhead could be minimized with the appropriate Media Point network planning, of which a brief introduction is presented in the following paragraph.

VII. MEDIA POINT NETWORK PLANNING: A BRIEF INTRODUCTION

With the prediction of the location of the MT the personalized data of the MT user can be pushed proactively to the corresponding MPC and thus increase the efficiency of the Media Point system. But still, a significant amount of overhead can be produced in the core network if the Media Point system architecture is not carefully planned.

Let us consider the case when the estimation of the location of the MT is being made with the use of the cell ID method. In this case, the cell where the MT is located contains many Media Points. If these Media Points belong to different MPCs as shown in Figure 9, then the data should be pushed, according to our analysis, to all the corresponding MPCs. This unfortunately creates a significant amount of overhead. Another possibility could have been to push the data to randomly one of these MPCs but this would have decreased the efficiency of the Media Point system as well as again increased the overhead if the prediction has been unsuccessful.

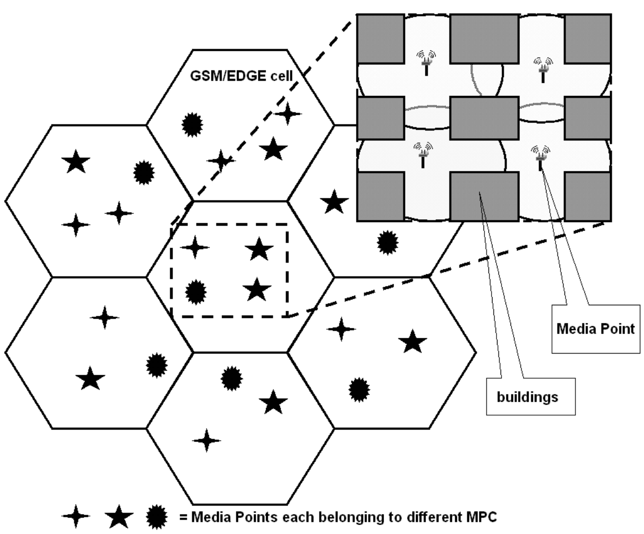

Fig. 9. Case of Media Points inside the cellular network causing significant overhead to the core network when the cell ID location prediction method is used.

On the other hand, if the Media Point network is carefully planned, then this problem can be eliminated. A simple solution could be to place in each cell Media Points that belong to only one MPC, as shown in Figure 10. A related and more thorough analysis could be made for the other location estimation methods as well as for the corresponding performance but is beyond the scope of the present paper.

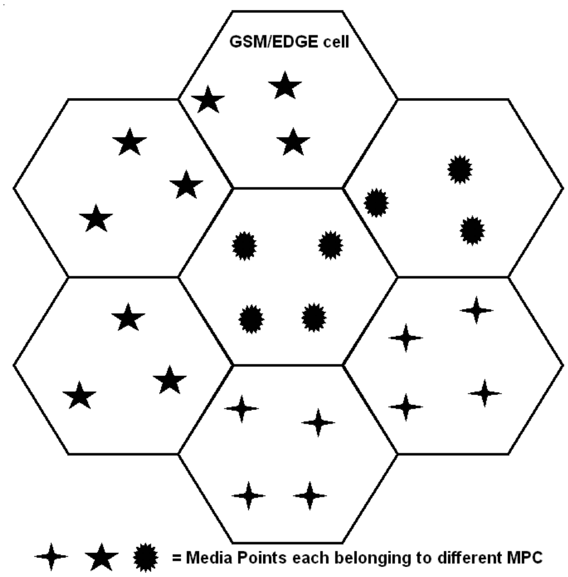

Fig. 10. A proposal for a Media Point network planning when the cell ID location prediction method is used.

VIII. CONCLUSIONS

We presented the way the location information of the positioning functions in GERAN could be utilized in order to integrate the Media Point system in the cellular infrastructure as well as increase its efficiency. Furthermore, a thorough description of the combined cellular network and Media Point system infrastructure was provided, as well as a solid description and presentation of the message flow charts. Finally, suggestions concerning the efficient Media Point network planning were provided.

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