New approach to designing GPRS location Update function

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Wireless IP network has attracted significant interest due to their ability to support both voice and data transfer in mobile communication. One of the main issues concerning such network is the analysis and design of mobility function particularly the location management. In this paper, we focus on modelling location update function in wireless network standard GPRS (General Packet Radio Service) by using an agent approach [1].

1. INTRODUCTION

One of main advantages of wireless networks is the ability to provide mobile users versatile services when they are moving. To support mobility in wireless networks, two main tasks must be accomplished: handoff management and location management. In the last decade, cellular telephones have become prevalent due to the realization of mobility support in wireless cellular telephone networks. In recent years, wireless IP networks have attracted a lot of interest from both the business community and research organizations. It has been thought of as providing the foundation for m-commerce services.

There has been a lot of research into mobility support in wireless cellular networks [2, 3, 4, 5, 6, 7, 8]. One of the main issues is the design and analysis the function of tracking (that is, location update) mobile users as they are moving or after they have moved. Because there is a resource limitation in wireless environments, the cost of tracking mobile users has been considered as one of the most important factors affecting the performance of wireless networks.

In this paper, we use a Multi-Agents Reactive Decisional System (MARDS) tool to design the location update function.

This paper is organized as follows. Section 2 presents the architecture of GPRS network. The section 3 describes a GPRS location update scheme that we propose to model. In Section 4, a detailed description of MARDS model is presented, it's followed by modelling this kind of location update in section 5. Finally, conclusions are drawn in Section 6.

2. GPRS SYSTEM ARCHITECTURE

In order to integrate GPRS into the existing GSM architecture, a new class of network nodes, called GPRS Support Nodes (GSN), has been introduced [10, 11]. GSNs are responsible for the delivery and routing of data packets between the mobile stations and the external packet data networks (PDN). Fig. 1 illustrates the GPRS system architecture.

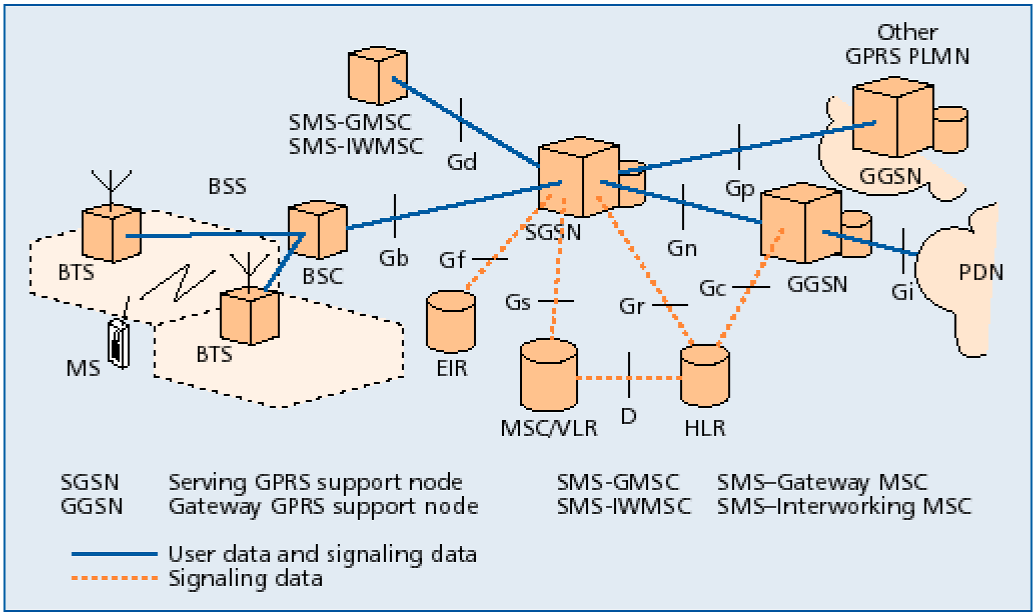

Figure 1. GPRS system architecture [9]

A serving GPRS support node (SGSN) is responsible for the delivery of data packets from and to the mobile stations within its service area. Its tasks include packet routing and transfer, mobility management (attach/detach and location management), logical link management, and authentification and charging functions. The location register of the SGSN stores location information (e.g., current cell, current VLR) and user profiles (e.g., IMSI, address(es) used in the packet data network) of all GPRS users registered with this SGSN. A gateway GPRS support node (GGSN) acts as an interface between the GPRS backbone network and the external packet data networks. It converts the GPRS packets coming from the SGSN into the appropriate packet data protocol (PDP) format (e.g., IP or X.25) and sends them out on the corresponding packet data network. In the other direction, PDP addresses of incoming data packets are converted to the GSM address of the destination user. The readdressed packets are sent to the responsible SGSN. For this purpose, the GGSN stores the current SGSN address of the user and his or her profile in its location register. The GGSN also performs authentification and charging functions.

In general, there is a many to many relationship between the SGSN and the GGSN: A GGSN is

the interface to external packet data networks for several SGSN; an networks for several SGSN, an SGSN may route its packets over different GGSN to reach different packet data networks. Fig. 2 also shows the interfaces between the new network nodes and the GSM network as defined by ETSI (European Telecommunication Standard Institute) in [10]. The Gb interface connects the BSC with the SGSN. Via the Gn and the Gp interfaces, user data and signaling data are transmitted between the GSN. The Gn interface will be used if SGSN and GGSN are located in the same PLMN, whereas the Gp interface will be used if they are in different PLMNs. All GSNs are connected via an IP-based GPRS backbone network. Within this backbone, the GSNs encapsulate the PDN packets and transmit (tunnel) them using the GPRS Tunneling Protocol GTP.

3. LOCATION MANAGEMENT

The main task of location management is to keep track of the user's current location, so that incoming packets can be routed to his or her MS. For this purpose, the MS frequently sends location update messages to its current SGSN. If the MS sends updates rather seldom, its location (e.g., its current cell) is not known exactly and paging is necessary for each downlink packet, resulting in a significant delivery delay. On the other hand, if location updates happen very often, the MS's location is well known to the network, and the data packets can be delivered without any additional paging delay. For the location management of an MS, a GSM location area (LA) is divided into several routing areas (RA). In general, an RA consists of several cells. The SGSN will only be informed when an MS moves to a new RA; cell changes will not be disclosed. To find out the current cell of an MS, paging of the MS within a certain RA must be performed. Whenever an MS moves to a new RA, it sends a “routing area update request” to its assigned SGSN. The message contains the routing area identity (RAI) of its old RA. The base station subsystem (BSS) adds the cell identifier (CI) of the new cell, from which the SGSN can derive the new RAI. Two different scenarios are possible:

• Intra-SGSN routing area update (Fig. 2): The MS has moved to an RA that is assigned to the same SGSN as the old RA. In this case, the SGSN has already stored the necessary user profile

and can assign a new packet temporary mobile subscriber identity (P-TMSI) to the user (“routing area update accept”). Since the routing context does not change, there is no need to inform other network elements, such as GGSN or HLR.

• Inter-SGSN routing area update: The new RA is administered by a different SGSN than the old RA. The new SGSN realizes that the MS has changed to its area and requests the old SGSN to send the PDP contexts of the user. Afterward, the new SGSN informs the involved GGSNs about the user’s new routing context. In addition, the HLR and (if needed) the MSC/VLR are informed about the user’s new SGSN. There also exist combined RA/LA updates. These occur when an MS using GPRS as well as conventional GSM moves to a new LA. The MS sends a “routing area update request” to the SGSN. The parameter “update type” is used to indicate that an LA update is needed. The message is then forwarded to the VLR, which performs the LA update.

To sum up, GPRS mobility management consists of two levels: Micro mobility management tracks the current routing area or cell of the mobile station. It is performed by the SGSN. Macro mobility management keeps track of the mobile station’s current SGSN and stores it in the HLR, VLR, and GGSN.

MS	*BSS*	*SGSN*	*New MSC/VLR*	*HLR*	*Old MSC/VLR*	*Exchanged Messages*
						Routing Area update request
						Security functions
						Location updating request
						Update location
						Cancel Location
						Cancel location Ack
						Insert subscriber data
						Insert subscriber data Ack
						Update location Ack
						Location updating accept
						Routing area update accept
						Routing area update complete
						TMSI reallocation complete

Figure 2. Intra-SGSN Update location Procedure

4. Description of MARDS model

The Multi-Agent Reactive Decisional System (MARDS) [1] constitutes an approach among the newest and most useful ones for reactive system modeling. Its main components are a Decisional Reactive Agents (DRA), which are interconnected with them by communication interfaces.

In this section, we are going to define, formally, all components constituting a MARDS.

4.1 Formal description of a DRA model

A DRA (Decisional Reactive Agent) can be used to define an autonomous and independent agent. The obtained agent receives actions and can act in an autonomous way until their realization in the adequate deadlines. To reach a given goal, we need to define an objective or a sequence of objectives ordered in a certain proposed way, which we propose in order to resolve this problem. The formal description of a DRA consists of the formalization of the various constituents of a decisional organ introduced into ADMDOOS (Analysis and Design Method of Decisional Oriented Object Systems) [7].

Formally, a decisional reactive agent is a 10 uplets Ag = <A, D, S, E ', O, E, O', Act, Dec, Sig>, where:

A : Set of actions performed on Ag,

D : Set of decisions generated by Ag,

S : Set of signalizations received by Ag,

E' : Set of external states delivered by Ag,

O : Set of internal objectives of the Ag,

E : Set of internal states of the Ag,

O ' : Set of external objectives of the Ag,

Act : Function that interprets an action, performed on Ag in one external objective,

Dec : Function that describes the agent reaction generated by a decision toward its environment.

Sig : Function that receives a signalization and generates an external state toward its environment.

For a DRA, the events that come from (respectively send toward) the environment can be only actions or signalizations (respectively decisions or external states).

4.2 MARDS Model

A Multi-Agent Reactive Decisional System (MARDS) [1] is a software structure characterized by a set of agents, interconnected by communication interfaces.

4.2.1 General architecture

The internal structure of a MARDS is based on a two-level tree (Fig 3), consisting of DRA Supervisor (DRAS), two or several possible sub-agent components ($MARDS_i$) and communication interfaces (Decisional Interface and Signalization Interface) that interconnect the supervisor with its sub-agents

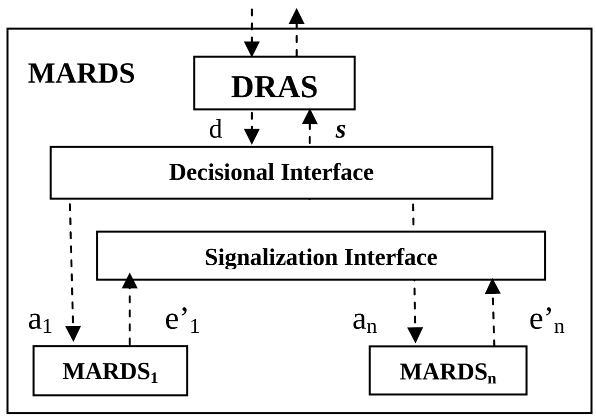

Figure 3. Internal Structure of a MARDS

A $MARDS_i$ can be either a simple DRA or an MARDS

4.2.2 Formal description of a MARDS

The formal description of an MARDS refers simply to the formalization of the basis components described in Fig 3. The DRA component is described in section A, it is stills to define, formally, the Decisional and the signalization interfaces.

Formalization of the decisional interface

Definition:

Formally, a decisional interface is an uplet

DI =<DI_Input, n, DI_Output, TradDec>, where:

- DI_Input : inputs of DI (decision)
- n : dimension of DI (the number of channels that constitute the outputs of DI),
- DI_Output : outputs of DI (set of actions),
- TradDec : translation function of a decision into several parallel

actions, each of these actions is led to an inferior sub-agent level.

Formalization of the signalization Interface

Definition:

Formally, a signalization interface is an uplet SI =<SI_Input, n, SI_Output, TradSig> where:

- SI_Input : inputs of SI (Set of external states),
- n : dimension of SI (the number of channels that constitute the inputs of SI),
- SI_Output : outputs of SI (signalization),
- TradSig : The traduction function of several external states into one and only one signalization

Formalization of a MARDS

Definition:

A Mutli-Agent Decisional Reactive System (MARDS) is the uplet S defined by: <DRAS, DI, SI, E-MADRS>, where:

- DRAS: An agent of DRA type that supervises S,
- DI : Decisional Interface of S,
- SI : Signaling Interface of S,
- E-MADRS: Set of MARDS components S. It can be empty.
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5. Modelling intra-SGSN Location update function

5.1 General description

The location update function involves a set of entities able to communicate and collaborate among them through exchanging messages. A message can be either a request or an acknowledgement of service. The entities involved in this function are modeled by DRAs. The messages that every entity can emit or receive will be actions or signalizations in the reception case, decisions or external states in the emission case. The DRAs will be grouped together to form the MARDS RA that will model the function itself. The communication between the DRAs is made by communication interfaces. The MS is modelled by MS_RA and will be considered as a supervisor agent of the MADRS RA. SGSN is modelled by SGSN_RA, whereas, the BSS (respectively MSC) will be modelled by BSS_RA (respectively MSC_RA1 and MSC_RA2).

5.2 Specification of intra-SGSN entities

In his specification, messages exchanged in an intra-SGSN function (Fig. 2) will be prefixed by A, XO, XS, IO, IS, D, or S corresponding respectively to an action, eXternal Objective, eXternal State, Internal Objective, Internal State, Decision, or Signalization.
To simplify, we focus on masters agents: MS_RA, BSS_RA and SGSN_RA.

Associated actions and external states:

In this section, actions and external states associated to masters agents are described. Table 1 shows Act function of these agents.

Agent	Action	External states
MS_RA/BSS_RA	A_Routing_Area_Update_Request	XS_Routing_Area_Update_Request
MS_RA/BSS_RA	A_Routing_Area_Update_Accept	XS_Routing_Area_Update_Complete
SGSN_RA	A_Routing_Area_Update_Complete	XS_TMSI_Reallocation_Complete

Table 1. Act function for agents: MS_RA, BSS_RA, SGSN_RA

Associated Decisions and signalisations:

The agents reactions are specified by two functions Dec and Sig which are represented in tables 2 and 3.

Note that IS_C is the initial state of each external objective.

Agent	External Objective	Internal State	Decision	Internal Objective
MS_RA	XO_Routing_Area_Update_Request	IS_C	D_Routing_Area_Update_Request	IO_Routing_Area_Update _Request
BSS_RA	XO_Routing_Area_Update_Accept	IS_C	D_Routing_Area_Update_Accept	IO_Routing_Area_Update _Accept
SGSN_ RA	XO_Routing_Area_Update_ Complete	IS_C	D_TMSI_Reallocation_Complete	IO_TMSI_Reallocation_ Complete

Table 2. Dec functions associated to agents: MS_RA, BSS_RA, SGSN_RA

Agent	Signalisation	External Ojective	Internal Objective	External State
MS_RA	S_Routing_Area_ Update_Request	XO_Routing_Area_Update_ Request	IO_Routing_Area_Update_ Request	XS_Routing_Area_ Update_Request
BSS_RA	S_Routing_Area_ Update_Request	XO_Routing_Area_Update_ Request	IO_Routing_Area_Update_ Request	XS_Routing_Area_ Update_Request
SGSN_ RA	S_location_updating_ Accept	XO_Location_Updating_ Accept	IO_Location_Updating_ Accept	XS_TMSI_Reallocation_ Complete

Table 3. Sig functions associated to agents: MS_RA, BSS_RA, SGSN_RA

Architecture of RA agent

The global architecture of RA agent is presented below, every entity named X in GPRS is modelled by X_RA corresponding agent, for example the Mobile Station (MS) is modelled by MS_RA agent.

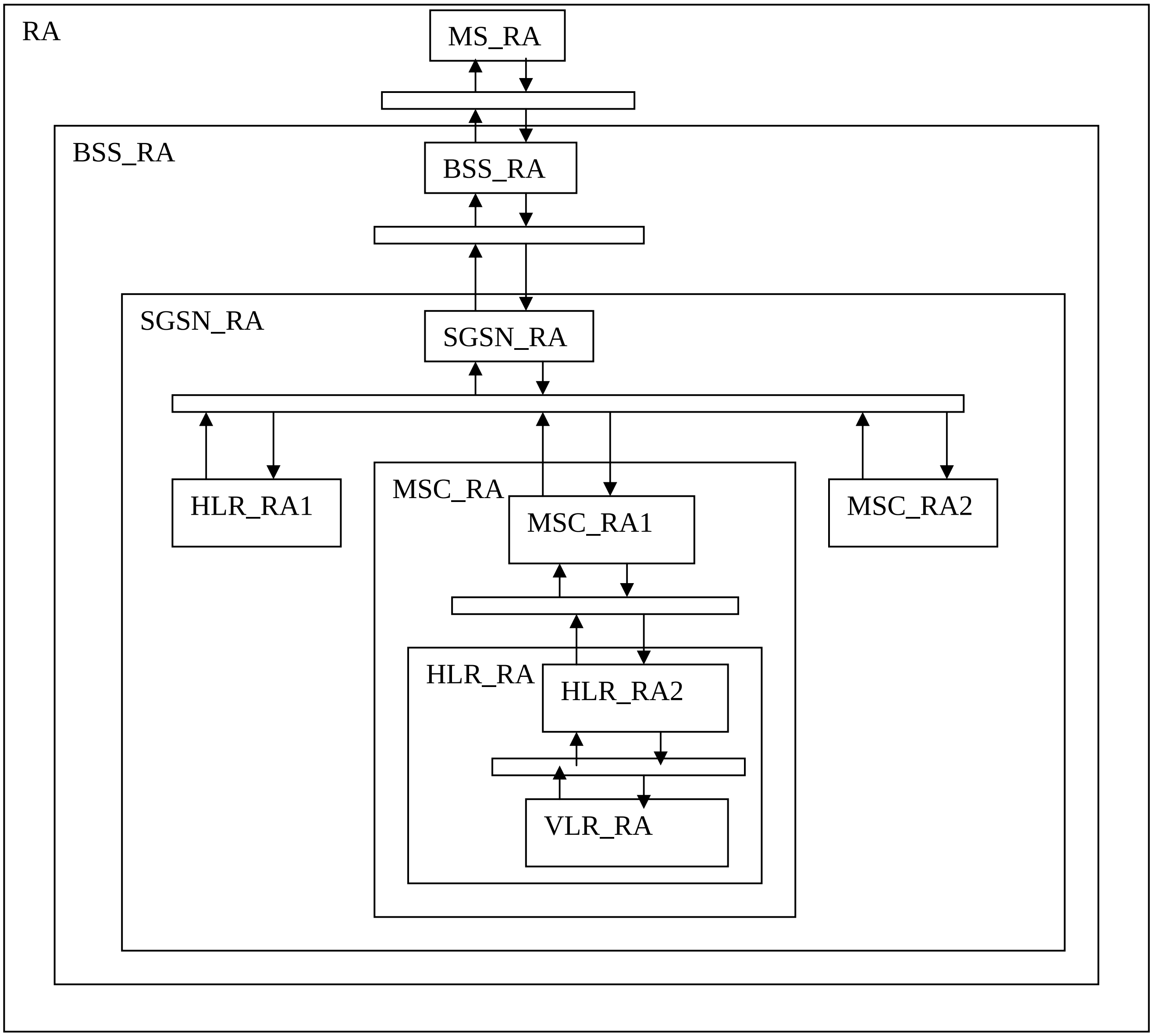

Figure 4. An intra-SGSN Location update agent

Figure 4 presents the RA agent that models an important function of GPRS: Location management.

6. Conclusion

In this paper, a new method based on agent approach is used and applied to an intra-SGSN location update. By this work, we contribute in validating GPRS mobility management. The simulation and the evaluation of results will be done in a future work.

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Biographies

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