INTELLIGENT CAR PARKING LOCATOR SERVICE

Ivan Ganchev, Máirtín O'Droma, Damien Meere

Abstract: This paper presents an InfoStation-based multi-agent system facilitating a Car Parking Locator service provision within a University Campus. The system network architecture is outlined, illustrating its functioning during the service provision. A detailed description of the Car Parking Locator service is given and the system entities' interaction is described. System implementation approaches are also considered.

Keywords: InfoStations, intelligent agents, multi-agent system, JADE, LEAP.

ACM Classification Keywords: H.3.4 Systems and Software, C.2.1 Network Architecture and Design.

I. Introduction

The InfoStations paradigm is an infrastructural system concept supporting "many-time, many-where" (Frenkiel and Imielinski 1996) wireless communications services. The InfoStation-based system outlined in this paper is established and operates across a University Campus area for the purpose of enhancing the mobile services experience. It allows mobile devices (mobile phones, laptops, personal digital assistants–PDAs) to communicate to each other and to a number of servers through geographically intermittent high-speed connections. In this paper, we detail the underlying network architecture and show how the different components within the architecture collaborate to facilitate one particular service, namely the Parking Locator service. This service allows registered users to locate available parking spaces throughout the campus.

The rest of the paper is organized as follows. Section II presents the InfoStation-based network architecture, illustrating how the architecture functions during service provision. Section III illustrates the Parking Locator service provision outlining sample interactions between system entities. Section IV outlines some implementation issues, and finally Section V concludes the paper.

II. InfoStation-based Network Architecture

The following InfoStation-based network architecture (Ganchev, O'Droma et al. 2003; Ganchev, Stojanov et al. 2006; Ganchev, Stojanov et al. 2006) provides access to a number of very useful services, for users equipped with mobile wireless devices, via a set of InfoStations deployed in key points around a University Campus. The 3-tier network architecture consists of the following basic building entities as depicted in Figures 1 and 2: user mobile devices, InfoStations and an InfoStation Center.

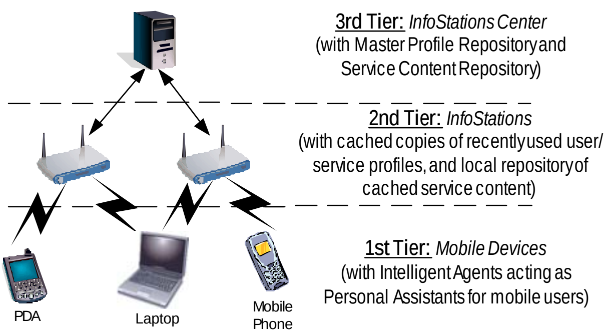

Figure 1. The 3-tier InfoStation-based network architecture

The users request services (through their mobile devices) from the nearest InfoStation via available Bluetooth (IEEE 802.15 WPAN), WiFi (IEEE 802.11 WLAN), or WiMAX (IEEE 802.16) connections. The InfoStation-based system is organized in such a way that if the InfoStation cannot fully satisfy the user request, the request is forwarded to the InfoStation Center, which decides on the most appropriate, quickest and cheapest way of delivering the service to each user according to his/her current individual location and mobile device's capabilities (specified in the user profile). Figure 2 illustrates some of the main components within each entity of the architecture.

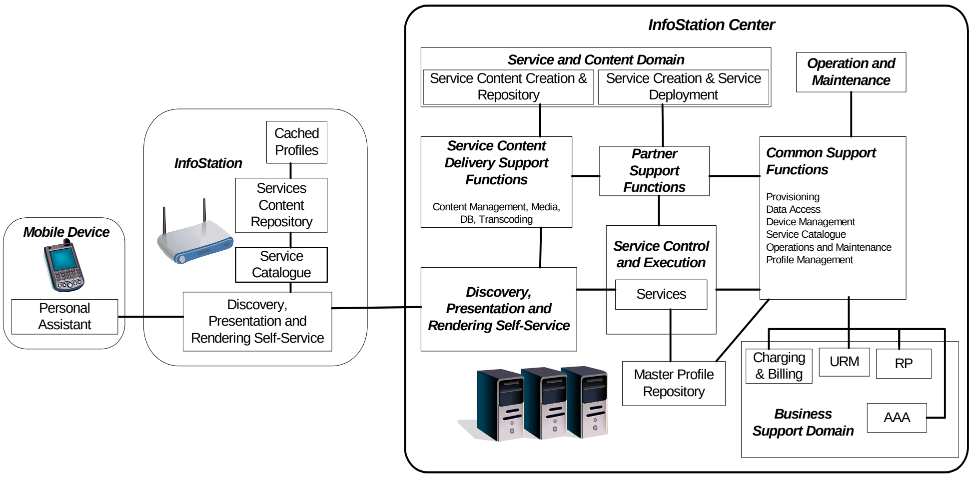

Figure 2: The InfoStation System Architecture

The *InfoStation Center* is concerned with the creation of service content and service creation, deployment, operation, maintenance, control and execution. In addition there are some common support functions that each service requires when initially created, for example device management, profile management, service catalogue etc. The InfoStation Center also houses a repository of all (up-to-date) master profiles relating to both users and services alike. Any changes made by the individual user to his/her own user profile and/or user service profile are forwarded on from the user mobile device, through an InfoStation to the InfoStation Center, where the repository is updated. (Each InfoStation keeps cached copies of all recently used, or updated by users, profiles.) The InfoStation Center also houses the Business Support Domain with a number of components relating to the charging and billing of users, User Relationship Management (URM), Resource Planning (RP) and indeed user Authentication, Authorization and Accounting (AAA).

When a mobile user enters within the range of an *InfoStation*, the Personal Assistant, installed in the user mobile device, and the InfoStation mutually discover each other. This process is facilitated through the Discovery, Presentation and Rendering Self-Service module within the InfoStation. The Personal Assistant sends a request to the InfoStation for user's Authorization, Authentication and Accounting (AAA). This request also includes a description of the mobile device currently being used by the user (or just the device's make and model) as well as any updates of user profile and user service profile (Figure 3). In particular with the Intelligent Parking Locator service, this process may occur a number of times as the user will, more often then not, pass through a number of InfoStation coverage areas with his/her vehicle.

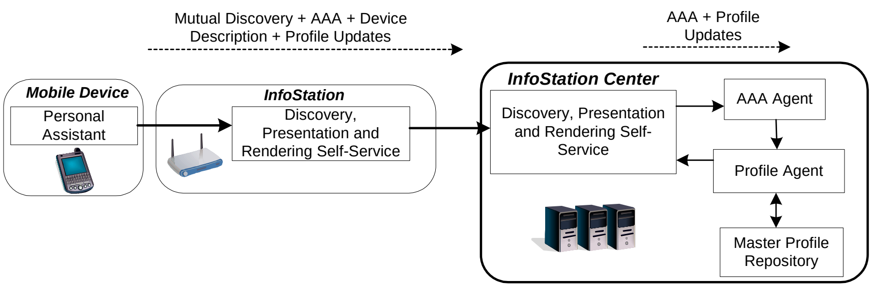

Figure 3: Step 1- Initial AAA and profile updates.

The InfoStation forwards this AAA request to the InfoStation Center along with the profile updates (Figure 3). If the user is successfully authenticated and authorized to utilize the services by the AAA module within the InfoStation Center, a new account record is created for the user. The user profile is analyzed by the InfoStation Center for current user preferences (e.g. applicable services) and device capabilities (utilizing the Composite

Capabilities/Preference Profile – User Agent Profile, UAProf). Then the InfoStation Center makes a service offer to the user in a form of a compiled list of applicable services from the Service Catalogue (Figure 4).

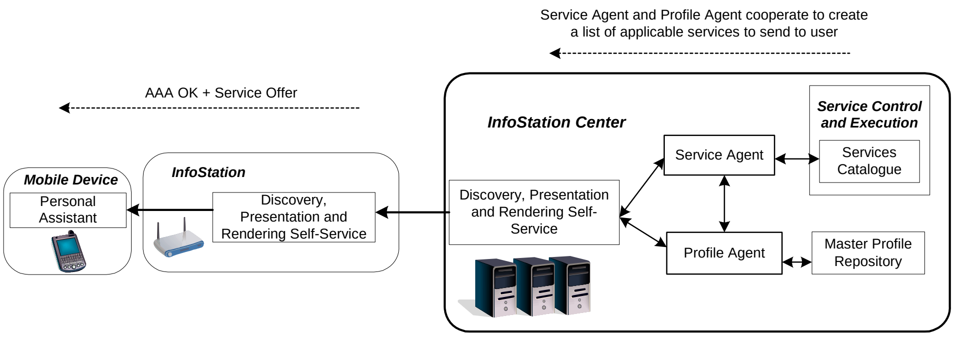

Figure 4: Step 2- Service Offer

This service offer is sent towards the Personal Assistant along with the AAA acknowledgment. The Personal Assistant displays the offer to the user who makes a choice and selects (makes a request for) the service s/he wishes to use. When the Personal Assistant forwards the user service request to the InfoStation, the latter checks its cache for the most up-to-date version of the requested service content (e.g. campus news bulletin). If the InfoStation is able to satisfy fully the user service request, it does so (Figure 5). Otherwise the InfoStation forwards this request to the InfoStation Center, which is better equipped to deal with it.

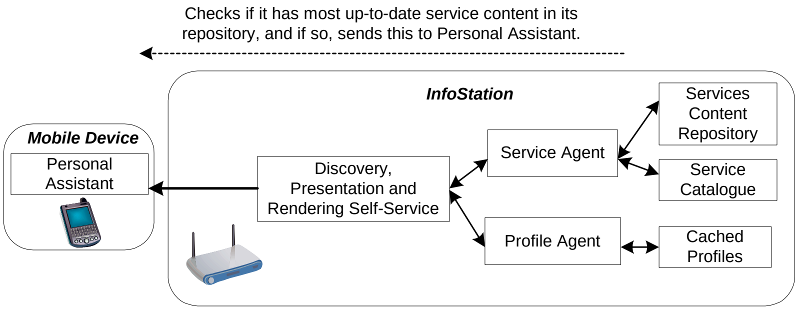

Figure 5: Step 3- Service request satisfied by InfoStation

On the user *mobile device*, the Personal Assistant (*agent*) facilitates the service utilization by the user. This is down to an agent-oriented approach to the implementation of the system. The service migrates onto the users mobile device, allowing the user unhindered access to the service even when out of range of the InfoStation. The Personal Assistant may make a service request while within the range of an InfoStation, then may pass out of the coverage area but will continue to work autonomously, adopting the functionality of the service until the user has completed his/her task. Once the mobile device comes within range of another InfoStation, the Personal Assistant updates and synchronizes the user service profile to reflect any work completed, or any new service requests made by the user while out of range.

In the following section we describe the provision of the Intelligent Parking Locator service in more detail.

III. Intelligent Parking Locator Service

A multi-agent approach (Carabelea and Boissier 2003; Ganchev, Stojanov et al. 2004; Stojanov, Ganchev et al. 2005; Adaçal and Bener 2006; Ganchev, Stojanov et al. 2006) is adopted as most suitable approach to structuring our system. In order to facilitate flexible and adaptable service provision, intelligent agents, residing within each of the three tiers of the system architecture must interact so as to satisfy, in the 'best' possible way, any user requests they might encounter. The following description outlines the entity interactions that take place during the Intelligent Parking Locator service provision. This service allows registered mobile users to gain access to information regarding available parking spaces on the University Campus and reserve a space that best suits them when approaching/entering the campus. However, visitors may also gain access to this service through prior temporary registration in the system for the duration of their stay. On accessing the service, these visitors would be directed to a visitor's car park.

In the delivery of this service, the content must be adapted and customized according to the capabilities of the user device and the user preferences. For example if the user has access to a resource-rich mobile device (e.g. a laptop or indeed a PDA), s/he may gain access to a graphical representation of the campus, which would greatly assist the user in finding the required parking space. If however the user only has access to a device with limited capabilities (e.g. a mobile phone), then the details of the available parking spaces would be specified in a simple format which 'best' suits the device (e.g. SMS/MMS). This trimming (adaptation) of the services is one way to address the shortcomings of some mobile devices, while still delivering the service.

We use the "Composite Capabilities / Preference Profile" (CC/PP) as the uniform format for the implementation of the user profiles. The master profile repository in the InfoStation Center contains descriptions of all registered user devices, i.e. their capabilities and technical characteristics. During the initial AAA request, the user's Personal Assistant sends as parameters the make and the model of the user device. An agent working on the InfoStation (or the InfoStation Center) reads the corresponding device's description from the repository and according to this, selects and forwards the best format of the service content. However a problem arises when a user uses a non-registered device as s/he might receive the service content in unsuitable format. Thus the user needs first to register any new mobile device s/he wants to use within the system. In this case, during the initial AAA request the Personal Assistant sends a full description of the user device's capabilities towards the InfoStation Center.

Figure 6, depicts a sample interaction between entities involved in the Intelligent Parking Locator service provision. As the user enters the campus area in a vehicle, s/he enters the coverage area of an InfoStation, positioned at the entrance to the campus. The Personal Assistant, installed in the user mobile device, and the InfoStation mutually discover each other. The Personal Assistant sends a request to the InfoStation for user's Authorization, Authentication and Accounting (AAA). During this initial AAA request, the user's Personal Assistant sends also the make and the model parameters of the user device, and any updates of user profile and user service profile. The InfoStation registers the user in its local Virtual Address Book and updates the profile, before forwarding the user request onto the InfoStation Center along with profile updates. In the case of successful AAA, the Profile Agent within the InfoStation Center (updates and) analyses the user profile stored in its Master Profile Repository. The Service Agent, in collaboration with the Profile Agent, creates a list of services applicable to the user and makes a service offer to the user.

However the user may specify in his/her profile that a request for the Parking Locator service be sent automatically after the successful AAA (and profile update) procedure. Or alternatively, if the user makes regular use of the service, the Personal Assistant could proactively anticipate the users request, i.e. once this service becomes available, the Personal Assistant automatically requests the location of parking for the user's vehicle. The InfoStation forwards on the user request to the InfoStation Center. Sensor networks within the car parks constantly update the InfoStation Center as to the availability of spaces. Different time periods of the day require more regular updates, especially from morning to mid-afternoon, as the user would require the information be as up-to-date as possible. However the updates can occur at much larger intervals during the evening and weekends when many more spaces would be available. In the case of Staff user's, the InfoStation Center discerns the location of the user's office from the user profile, and as such compiles a sorted list of available parking spaces according to their proximity to the user's office (desired destination). For Students and Visitors, the InfoStation Center locates parking spaces within the visitor and student car parks. In these cases, the InfoStation Center will also consult the user profiles to order the parking spaces according to criterion such as convenience to final destination and in particular for students, the cost associated with each parking space. The InfoStation Center then determines the approximate position of the user based on the location of the InfoStation from which the request was received. The InfoStation Center then discerns the best directions from user's current location to each of the available spaces.The Service Content agent and Profile Agent cooperate to adapt the content to the format that best suits the current user device capabilities and user preferences (i.e. graphical representation, audio description, text). Once the content is prepared for transfer, the InfoStation Center discerns the most suitable InfoStations to forward the data on to. As the user is most probably accessing the service whilst in transit, there is a good chance the user will pass through a number of InfoStation coverage areas. The InfoStation Center makes allowances for this and forwards the information on to a number of InfoStations in the

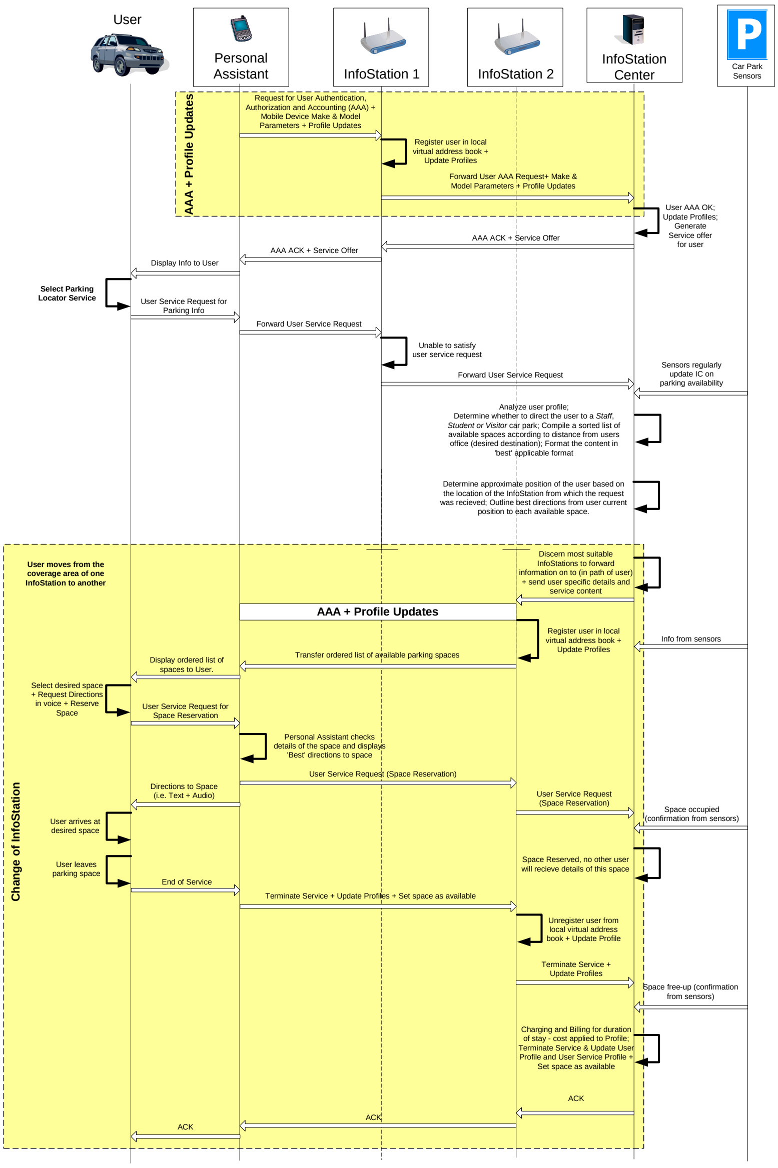

Figure 6: Intelligent Parking Locator Service: Entity Interactions

path of the user (Borràs and Yates 1999; Yuen, Yates et al. 2003), along with specific user details.

As the user moves from the coverage area of one InfoStation to another, AAA and profile update procedures are executed first. The approached InfoStation will have already received information about the user from the InfoStation Center, along with requested service content. As such the InfoStation can account for the user and immediately forward on the requisite content. This reduces the time taken for the InfoStation to provide the service content. This process may happen with a number of InfoStations as the user drives through the campus. As the user leaves the coverage area of an InfoStation, the user service profile is updated, specifying how much of the service content was transferred (if the transaction was not completed). This information is circulated around the InfoStation network, so as to ensure the user's Personal Assistant does not receive the same information a number of times.

Once the user receives the ordered list of parking spaces, s/he chooses a particular parking space, reserves it and request directions to that space. Once a space is chosen, the Personal Assistant examines the details of the space and displays precise directions. An audio explanation accompanying the text description would be best suited to this service, as it would provide the least distraction, allowing the user to concentrate on driving.

The Personal Assistant also forwards on a parking space reservation request to the InfoStation Center. Once the space has been reserved (and it's occupancy confirmed by the sensor network), no other users will be supplied with details of that space. The InfoStation Center monitors the duration the user occupies the parking space for charging and billing purposes.

When the user leaves the parking space, the sensor network confirms this to the InfoStation Center. The Charging and Billing Module within the InfoStation Center accounts for the duration of the user's stay. A corresponding charge related to parking in that car park, is charged to the user account. Once the user/ service profiles have been updated, the service is terminated.

Another issue to be taken into account is that of Staff specific parking spaces. Certain Staff members (e.g. University President, Vice-Presidents, etc) will be allocated their own specific private parking space. If perhaps an unauthorized user enters the space, the sensors in the car park will alert the InfoStation Center. If this unauthorized user is registered, the InfoStation Center will, if possible, forward on a notification to the user to vacate the space and perhaps provide the location of and available space nearby. If the unauthorized user happens to be unregistered and un-contactable, campus security may be notified.

IV. Implementation

The system is implemented in an agent-oriented manner utilizing the Java Agent DEvelopment (JADE) (JADE; Bellifemine, Poggi et al. 2001; Anghel and Salomie 2003; Bellifemine, Caire et al. 2003; Bellifemine, Caire et al. 2005; Bellifemine, Caire et al. 2006) framework. This allows for the flexible development of multi-agent systems and applications for management of network resources in compliance with the FIPA specifications. The JADE architecture is completely modular and as such, by utilizing specific modules, can be configured to adapt to the requirements of a number of different deployment environments. Within our JADE implementation, one of the most useful modules is the Lightweight Extensible Agent Platform (or LEAP) (Moreno, Valls et al. 2003; Caire and Pieri 2006) Module. This module, or add-on, replaces some parts of the JADE kernel, providing a modified run-time environment, which facilitates the implementation of agents on mobile devices with limited resources. Another very useful aspect of JADE-LEAP is its ability to support split-containers (split run-time environments) on resource-thin devices. The container can be split into two separate sections, a FrontEnd (running on the mobile device itself), and the BackEnd (running from a fixed network entity - a mediator) as illustrated in Figure 7.

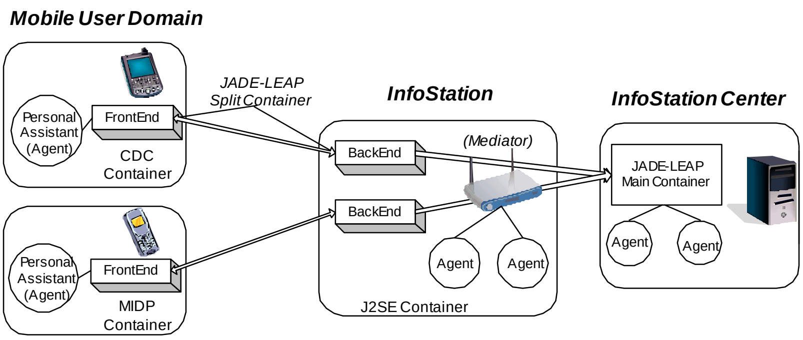

Figure 7. JADE-LEAP split-container execution

This mediator is charged with instantiating and maintaining the BackEnds. In our system, the InfoStations deployed throughout the campus take on these mediator roles. Each FrontEnd is connected to each BackEnd through a bi-directional connection. The splitting of the container into two separate, yet connected, entities is particularly useful in the realm of resource-constrained devices, as the FrontEnd of the container is far more lightweight in terms of the required memory and processing power then the entire container. Due to the geographically intermittent nature of the InfoStation connection, the FrontEnd and the BackEnd may undergo a loss of connection, however the Front-End can detect this and re-establish the connection as soon as possible. Any messages not transmitted due to this temporary disconnection can be buffered and delivered when the connection is re-established. This store-and-forward mechanism (implemented in both the FrontEnd and the BackEnd) is especially important to the efficient facilitation of the Parking Locator Service, where the user will pass in and out of coverage range of a number of different InfoStations, and as such data will have to be buffered and transmitted after a period of time by another InfoStation.

Figure 8. Screenshots of service execution on devices with varying capabilities.

The splitting of the container has no bearing on us, as the same functionality and set of APIs are available to an agent, whether it is contained within a full container or the FrontEnd of a split container. The JADE framework also serves to shield us from the complexity of the distributed environment, allowing the concentration of our efforts on developing the application logic, rather then worrying about middleware issues such as discovery and communication of entities within the system.

The following are two sample screen shots of how this service will appear on two different mobile devices with different capabilities. The screen shot on the left represents a device with the capabilities to show complex graphical information. In this case the device shows a map of the campus and graphically illustrates the path for the user's vehicle to follow, in order to reach the reserved destination parking space.

The device on the right illustrates how a device with more limited capabilities may convey the same information to the user. That particular device's profile will specify its capability to only handle text information during its communications with the InfoStations. As such the InfoStation will provide only the requisite text information.

V. Conclusion

The effectuation of the InfoStation-based Parking Locator service in a University Campus area has been outlined in this paper. The underlying network architecture has been described along with an illustration of how each of the different components within the architecture collaborates to facilitate mobile services. The Parking Locator service has been considered as an example. This service allows registered users to locate available parking spaces throughout the campus and reserve a space that best suits them when approaching/entering the campus area. Details of how service content is tailored to specific devices and how the duration of the user's stay affects the charging and billing for utilization of the service have been outlined.

The multi-agent structure, implemented by means of the Java Agent DEvelopment (JADE) software framework utilizing its Lightweight Extensible Agent Platform (LEAP) module in particular, has been discussed in detail due to its suitability to the proposed system. The benefits of this implementation have been also outlined in detail.

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Bibliography

Adaçal, M. and A. Bener (2006). "Mobile Web Services: A New Agent-Based Framework." IEEE Internet Computing Vol. 10(no. 3): pp. 58-65.

Anghel, C. and I. Salomie (2003). JADE Based solutions for knowledge assessment in eLearning Environments, TILAB & University of Limerick.

Bellifemine, F., G. Caire, et al. (2003). "JADE: A White Paper." exp, Telecom Italia Lab Volume 3(No. 3,).

Bellifemine, F., G. Caire, et al. (2005). JADE Programmers Guide, TILab.

Bellifemine, F., G. Caire, et al. (2006). Jade Administrator's Guide, TILab.

Bellifemine, F., A. Poggi, et al. (2001). JADE: A FIPA2000 Compliant Agent Development Environment. AGENTS '01, Montreal, Quebec, Canada.

Borràs, J. and R. D. Yates (1999). Highway InfoStations. WPMC'99, Amsterdam.

Caire, G. and F. Pieri (2006). LEAP User Guide, TILab.

Carabelea, C. and O. Boissier (2003). Multi-agent platforms on smart devices: Dream or reality? Smart Objects Conference (SOC03), Grenoble, France.

Frenkiel, R. H. and T. Imielinski (1996). "Infostations: The joy of `many-time, many-where' communications." WINLAB Technical Report(WINLAB-TR-119).

Ganchev, I., M. O'Droma, et al. (2003). A model for integration of electronic services into a distributed eLearning center. 14th EAEEIE International Conference, Gdansk, Poland.

Ganchev, I., S. Stojanov, et al. (2006). An InfoStation-Based Multi-Agent System for the Provision of Intelligent Mobile Services in a University Campus Area. IEEE-IS'06, London.

Ganchev, I., S. Stojanov, et al. (2006). An InfoStation-Based University Campus System for the Provision of mLearning Services. IEEE-ICALT '06, Kerkrade, The Netherlands.

Ganchev, I., S. Stojanov, et al. (2004). Enhancement of DeLC for the Provision of Intelligent Mobile Services. 2nd International IEEE Conference on Intelligent Systems (IS'2004), Varna, Bulgaria.

JADE Java Agent Development Framework Project - http://jade.cselt.it.

Moreno, A., A. Valls, et al. (2003). "Using JADE-LEAP to implement agents in mobile devices." TILAB "EXP in search of innovation", Italy.

Stojanov, S., I. Ganchev, et al. (2005). An Approach for the Development of Agent-Oriented Distributed eLearning Center. International Conference on Computer Systems and Technologies - CompSysTech, Varna, Bulgaria.

Yuen, W. H., R. D. Yates, et al. (2003). Effect of Node Mobility on Highway Mobile Infostation Networks. ACM MSWiM 2003, San Diego.

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TRAFFIC OFFERED BEHAVIOUR REGARDING TARGET QOS PARAMETERS IN NETWORK DIMENSIONING

Emiliya Saranova

Abstract: *We consider a model of overall telecommunication network with virtual circuits switching, in stationary state, with Poisson input flow, repeated calls, limited number of homogeneous terminals and 8 types of losses. One of the main problems of network dimensioning/redimensioning is estimation of traffic offered in network because it reflects on finding of necessary number of circuit switching lines on the basis of the consideration of detailed users manners and target Quality of Service (QoS). In this paper we investigate the behaviour of the traffic offered in a network regarding QoS variables: "probability of blocked switching" and "probability of finding B-terminals busy". Numerical dependencies are shown graphically. A network dimensioning task (NDT) is formulated, solvability of the NDT and the necessary conditions for analytical solution are researched as well.*