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Modeling and implementation of geo-localized services equipped with self-adapting and self-organizing capabilities

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BIOGRAPHIES

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1. INTRODUCTION

In this paper, a platform of distributed location-based services based on mobile and embedded communications means, associated with positioning and navigation systems using Global Navigation Satellite System activities (GNSS) is presented. This work is a part of the project PM2G, Platform of Geolocalized Multi-Business Services, of the GSEM research group at Université de Technologie de Belfort Montbéliard (UTBM). The goal of PM2G is to model and implement a platform of coordinated and distributed location-based business services.

It should be noted that while the number of embedded applications has been growing rapidly in recent years, these systems are still restricted to specific business services. However, it is important to try to coordinate these services in order to maximize and improve their utilization. The project PM2G establishes the middleware needed for collecting, coordinating, aggregating, and scheduling services for shared use in a distributed-computing style. In doing so, we develop and implement TransportML, an extended XML platform to recognize, monitor and collect service information and description over the network. A prototype with the following business services that are Snow-clearing service for roads, the fire fighter service, emergency rescue service and public information service is being developed at UTBM. More precisely, TransportML is put in a concrete and experimentation way to ensure the coordination, the co-operation and the synchronization of location based services that are snow-clearing service for roads, the fire fighter and emergency rescue service.

This paper is organized as follows. Section 2 overviews related works and location based applications requirements. Section 3 describes the overall system architecture. Section 4 addresses issues regarding the design of the middleware TransportML. In section 5, a conclusion and future work directions are presented.

2. RELATED WORK

PM2G is a service oriented architecture in which business services can interact with one another via the middleware TransportML. Since it is essential to ensure information and process flows between and across heterogeneous business environments, an application's business logic has to be presented as a business service via a platform-independent XML interface. Service-oriented architecture (SOA) is a style of distributed computing that helps organizations share logic and data among multiple applications and usage modes. The basic architecture of SOA involves three fundamental pieces: service providers, consumers and a service discovery and composition system [BAK 07b].

By using the service oriented approach with an appropriate service discovery system, the platform can have a flexible infrastructure, which can easily adapt to user requirements and services' availability [BAK 07a]. More precisely, new services could be added, updated or removed dynamically, and users can discover services dynamically and on the fly to fulfill tasks in a way that suits users' current context best. In other words, the PM2G platform should exhibit self-adapting and self-organizing capabilities to be able, on one hand to cope with a dynamic environment that can evolve in unpredictable manner, and on the other hand, to adapt to situation and users' contexts.

Service oriented architectures are often designed according to the client-server paradigm. In its server-centric model version, there is a risk of single point of failure. In its peer-to-peer model version, the infrastructure and communication networks and all information about services are supposed stable and always available. Otherwise, in a dynamic environment, the overhead to continuously update information about services in registries could be huge. Moreover, the traditional client-server paradigm does not permit to take full advantage of ubiquitous and pervasive computing.

According to Gaber's classification, interaction paradigms can be classified into three categories: the traditional client to server paradigm (CSP) and two alternative paradigms, the Adaptive Services to Client Paradigm (SCP) and the Spontaneous Service Emergence Paradigm (SEP). SCP and SEP suits more ubiquitous and pervasive environments and requirements respectively [GAB 00, GAB 06, BAK 07a]. Recall that the main objective of Ubiquitous Computing (UC) is to provide users information and service accesses anytime and irrespective to their location, while in Pervasive Computing (PC), the main objective is to provide spontaneous emergent services created on the fly by mobiles that interact by ad hoc connections [GAB 00, GAB 06, BAK 07a]. In other words, SEP with Pervasive Computing may be viewed as a collective use and cooperation of mobile computers and wireless devices that exist and are available in the users' physical environment.

It should be noted that in the traditional client/server paradigm (CSP), the client is the one taking the initiative of requesting a service by first knowing its existence and has to provide its exact location. In the SCP alternative paradigm, which can be viewed as contrary to CSP; the service will go to the client, via an intelligent middleware, instead of the client taking the initiative and requesting an existing service and has the means to locate it. In SEP, a service can emerge spontaneously without any prior planning and according to ad hoc collective use and cooperation of mobile devices in the surrounding environment [GAB 00, GAB 06, BAK 07a]. SCP and SEP integrate self-adaptation and self-organization possibilities that enable the development of ubiquitous and pervasive applications.

It is worth noting that context representation and manipulation are important issues in PM2G. In particular location information, as fundamental context information, which is used to index entities in the environment, depends on the space representation model and the level of required information details [ROX 07]. The variety of positioning technologies and short-range networking technologies continue to improve in their reliability and accuracy. An extensive review of location systems for ubiquitous computing is given in [ROX 06].

To address services' access issues, it is necessary to guaranty the user access to utilize the allowed and available services. More precisely, an access control must be granted to services in order to regulate their usage. the main problem resides in managing access policies to disparate services that are not under the control of a single system designer/administrator. The computational contract model presented in [NAI 07], which defines an exchange process between clients and service providers of is used in PM2G. It should be also noted that security is one of the fundamental issue in PM2G

2.1. LOCATION INFORMATION

The implementation of geo-localized services depends mainly on the reliability of location information. Hence, the positioning technology used must ensure the relevance, the continuity and the availability of the information. Indeed,

location-based applications can be indoor, outdoor, or supported both within buildings and outdoors. Depending on the positioning technology used, location information can be represented in different ways and in different granularities [ROX 07]. Recall that the granularity of location information might be within centimeters, meters, or greater. For example, the global positioning system (GPS) uses satellites to determine the position of a GPS receiver within an accuracy of several meters.

Location information representation models are an important issue to index entities in the environment. Recently, Roxin et al. have proposed in [ROX 07] three types of spatial models: a flat graph model, a hierarchical graph model and a real-time graph model. Each model provides a given level and granularity of information details to location based applications.

2.2. ASYMMETRIC CRYPTOGRAPHY AND ELECTRONIC SIGNATURE

TransportML messages must intrinsically include security information used to verify their integrity, authenticity and perform access rights checks. Historically, modern asymmetric cryptography is based on {public key, private key} keypairs. Electronic signatures generation and verification is basically digital signatures processes along with digital certificates integration [COT 03]. The aim of electronic signature is to verify signed contents integrity and authenticity rather than searching for information confidentiality.

Since XML is imposed as a standardized way to formalize networked communications, it has enlarged its usage to cryptography and digital signature encoding formats [EAS 02] and tends to replace the ASN.1 BER and DER encodings, although it suffers from many security weaknesses (e.g., infinite loops in DTDs, multiple DTD conformant XML encodings for same information, etc.) [GAL 06].

2.3. GNSS APPLICATIONS TO TRANSPORTATION AND MOBILITY WITH PM2G

The use of information and communication technologies associated with GNSS systems and embedded systems represent a primordial task for development of innovating solutions for mobility management and for quality of service improvement in transportation domain. In this framework, GNSS systems can provide vehicle positioning information and/or state of infrastructures, which can be accessed by service providers and users.

It is important to notice that among the main applications of GNSS systems so far, in particular in the framework of real time vehicles management, most applications are oriented to a specific service. Although most research works are carried out to answer transportation needs, many research efforts are still necessary in order to use GNSS in multi-business services' context with multiple actors. Moreover, most current developed applications to transportation are devoted to locating systems. For example, a real time embedded locating system using 3D multi sensors fusion is presented in [ABU 05]. In [ELE 06, STE 00], GNSS systems are used for road applications, in particular for traffic information. In [ROX 07], representation models for location information are proposed for context-aware applications.

3. PM2G ARCHITECTURE

The platform architecture developed in this paper is constituted of two layers: a vertical layer which contains different business services to be coordinated (snow clearance, emergency services, firemen services, etc.), and an horizontal layer composed of a middleware or a service bus called "TransportML". The main objective of this middleware is to allow coordination, cooperation and synchronization between all business services of the vertical layer by exchanging information and enabling resource sharing. These operations are ensured by an horizontal communication layer composed of communication networks and positioning systems. Figure 1 shows the overall architecture of PM2G platform.

The implementation of the platform handles communications security, actors authentication, access rights management, time stamping and tracability and manage different interactions between users. Specification and modeling of the platform functionalities are carried out using the formal method (Max, Plus) algebra [NAI 03]. This part of work is not presented in this paper.

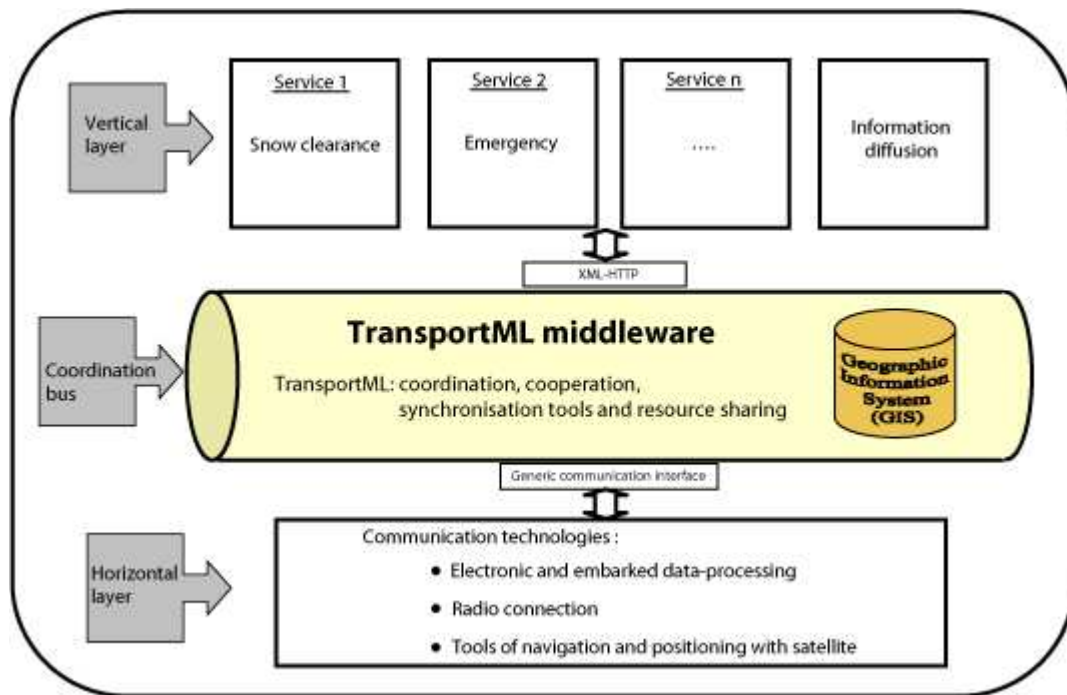


Figure 1: The PM2G platform architecture

TransportML-compliant services are known as information providers. They make information available to clients (information requesters), mentioning the required credentials to access the service. This publication does not contain the whole information but a small description so that requesters are able to determine the information relevancy.

The UML use-case model illustrated by figure 2 describes the main information providers and requesters actions. Providers publish information summaries made visible to requesters (using a lookup process). Providers can then send information when requesters ask for them, providing the required credentials. This operation can be compared with RSS feeds syndication.

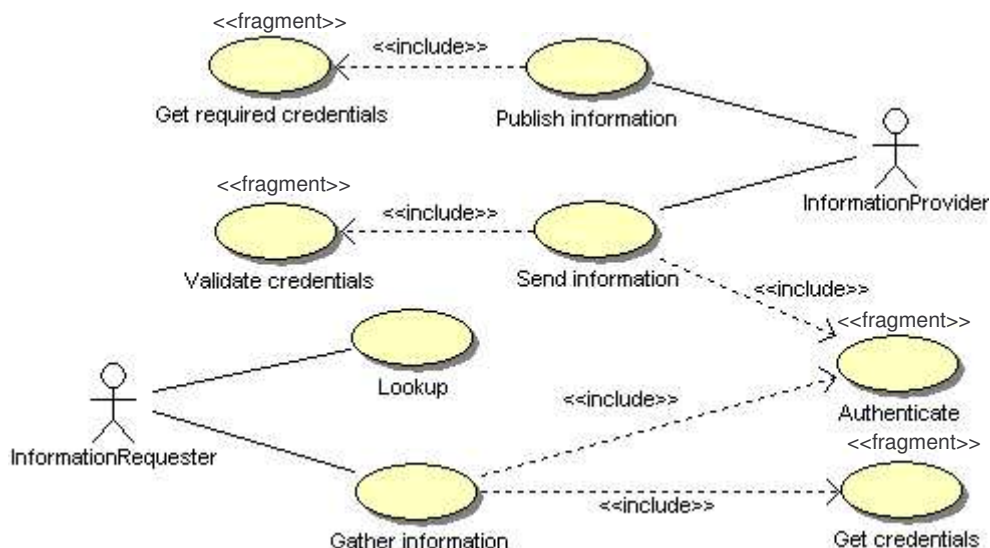


Figure 2: TransportML main use cases

4. TRANSPORTML COMPONENTS

As depicted by figure 3, information providers publish information summary using naming services or in a local public area to be consulted by mobile agents. This information is associated with required credentials known as publication rules represented by a set of excepted credentials. This access rules information is given to requesters so that they can check that they own the appropriate credentials to satisfy the information access requirements. When asking for a given

service available on an information provider, a requester provides the set of required credentials and creates a published information request. This request is digitally sign by the requester's security manager before being sent to the information provider to get the published information. The information provider verifies the requester's digital signature and checks the credentials validity and matching with the expected credentials by means of its own security manager. The whole information is then digitally signed and sent back to the requester as far as the latter's credentials are sufficient.

Each information and information summary holds an obsolescence delay which indicates that a new request must be performed to get up-to-date information after this maximum amount of time.

Independently from the network layer (TCP/IP), TransportML derives from web services Simple Object Access Protocol exchange format and adds authentication information provided by XML-based electronic signatures [EAS 02].

Within PM2G, a generic format to represent information summaries and whole information based on existing formats (such as RSS syndication feeds) is being developed.

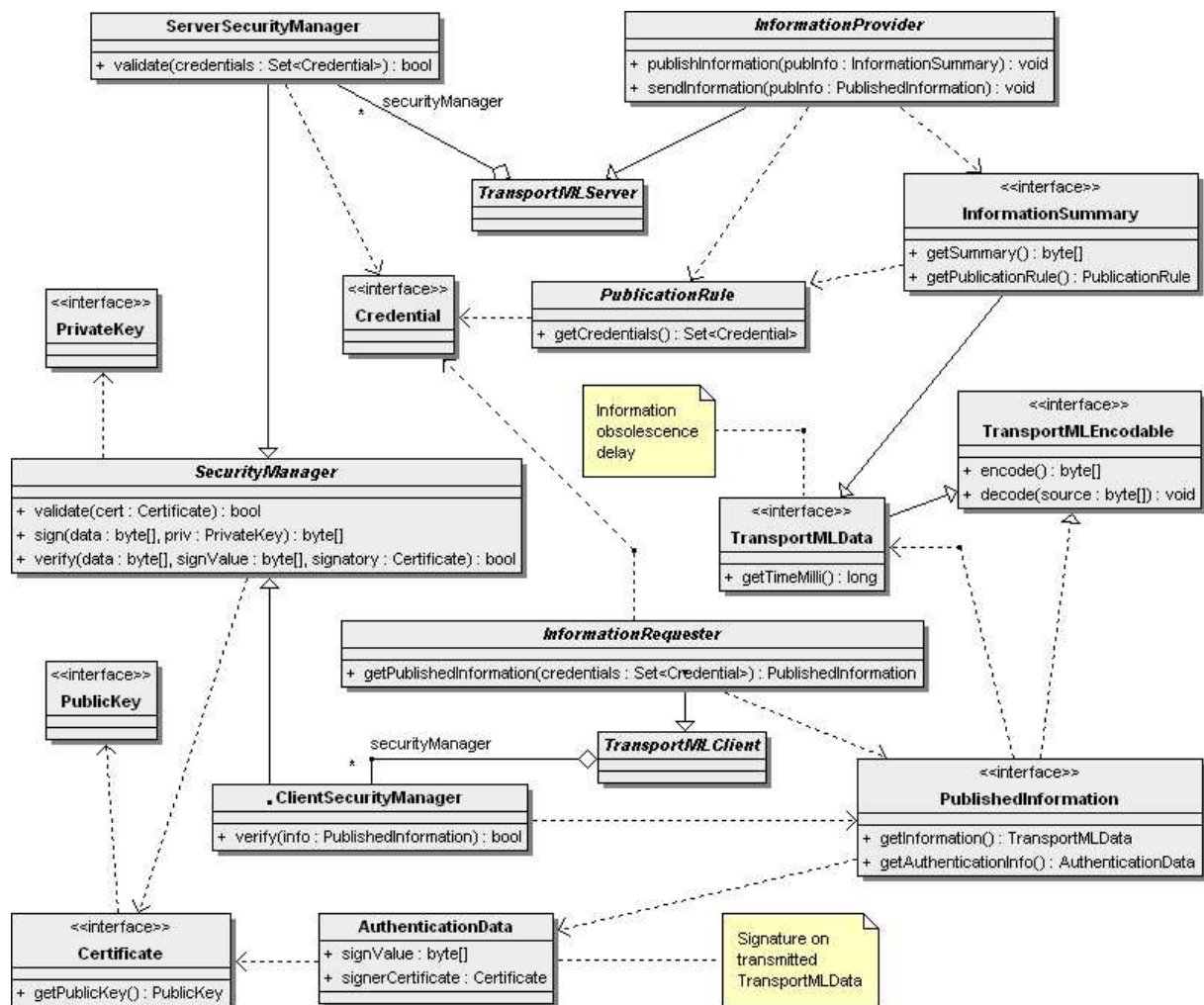


Figure 3: TransportML components organization

4.1. SECURITY HANDLING

4.1.1. Security Manager presentation

TransportML takes advantage of an internal security manager which allows applications security and TransportML services security separation. TransportML security manager is composed of client-side and service-side modules.

The client-side module makes sure that the outgoing request satisfies a-priori the corresponding service execution. The request can be cancelled in case the requester does not hold the mandatory credits or does not support required security protocols or algorithms.

The service-side security manager first verifies that the incoming request conforms to the expected XML format (according to DTD, XML Schema and Schematron constraints for example). The manager then checks that the request digital signature is valid and that the signatory has the necessary credits to ask for the service.

4.1.2. Digital signature creation and validation processes

Messages authentication and integrity relies on digital signatures along with X.509 version 3 public key certificates (modeled using "Certificate"). Digital signatures are associated with messages (requests – responses) so that receivers can verify their integrity and validity using revocation lists [HOU 02] or on-line protocols [MYE 99].

Messages can be wrapped into secured communications protocols such as TLS to ensure confidentiality. Client-side TransportML security manager is composed of two complementary layers: requester's signature creation layer and accreditations gathering. Accreditations composition is performed as defined by [COT 03]. Server-side TransportML security manager is also composed of two layers: the first layer aims at verifying the requester's digital signature and the second layer validates the requester's signature associated accreditations (credentials) by means of Access Control Lists [COT 03]. It globally considers all digital signatures to allow or deny accessing the service.

4.2. COMMON HORIZONTAL FACILITIES

TransportML benefits from PM2G common facilities such as discovery service systems, information availability and transactions management. Furthermore, TransportML includes complementary facilities related to vertical business services interactions such as information publication and security.

The information publication facility allows vertical services sharing part of their proprietary information along with visibility. This visibility flag depends on requesters' credits and make the information opaque or unavailable to non-authorized third parties.

Getting access to the whole protected information may require complementary credentials held by other requesters. These credentials can be obtained my means of a security and composition facility. This facility is provided to help requesters gather credentials and therefore allow services composition. A possible implementation may derive from [COT 03].

5. CONCLUSION AND FUTURE WORK

In this paper, the Platform of Geolocalized Multi-Business Services PM2G has been presented. The goal of PM2G is to model and implement a platform of coordinated and distributed location-based business services. PM2G is a service oriented architecture in which business services can interact with one another via the middleware TransportML. The main objective of this middleware is to allow coordination, cooperation, synchronization and resource sharing between diverse business services. A prototype with the following business services, Snow-clearing service for roads, the fire fighter service, emergency rescue service and public information service is being developed. Future work on TransportML will concern the extension of TransportML to perform service composition and service emergence. A location-aware security issue will also be addressed.

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