INStANT: A Dynamic Push Model for Mobile Architectures

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Abstract:

Satellite position based applications, Location based information services and communication infrastructures integrated in mobile distributed systems, has had a great influence on the development of new applications in various fields. One of them is certainly the Search and Rescue (SAR).

INStANT, "INfomobility Services for SafeTy-critical Applications on Land and Sea based on the use of iNtegrated GNSS Terminals for needs of OLYMPIC cities", will be based on state-of-art distributed software technologies (CORBA, DCOM or Microsoft .NET) providing safe, scalable and open systems and to build up tools for organizing centralized management services distributing mobile or located data.

The main innovations of the project will be the design and assembling of an integrated user terminal, based on integration of readily available COTS components capable of GNSS, mobile communications, visualisation, mobile internet applications and the development of a modular architecture, based on extensible components, that can be reused for different applications and allow usage of new terminals as they become cheaper and more powerful.

It should provide a logical and formal framework, with supporting infrastructure to use new approaches and models in which the concept of the data-driven or push models, an approach capable to provide a service with (near) real time response to emergency events, distributed over (mobile) communication infrastructures, dynamic and reusable, based on European/World equipment standards

Motivations

Satellite position based applications, Location based information services and communication infrastructures integrated in mobile distributed systems, has had a great influence on the development of new applications in various fields. One of them is certainly the Search and Rescue (SAR). One aim of the technological development in the search and rescue field, is certainly the minimization of the so called "time to arrival", i.e. the time between the emergency call and the arrival at the site where is the need of assistance, with a proper equipment and personnel. Other aims are related to the monitoring and management of fleet of vehicles, in terms of allocated resources, in order to maximize the coverage and efficiently plan emergency related activities.

These factors involve positioning systems based on Navigation Satellites (GNSS), Control systems, Decision support systems and Optimisation systems; and moreover require:

- User mobile terminals for localization and communication taking into account existing and future (satellite based) GNSS positioning systems such as EGNOS test-bed and GALILEO that is focused to guarantee its services for safety critical applications;
- Efficient infrastructures able to support communications and distribution over local/global networks;
- High efficiency, usability, scalability and manageability properties to accomplish efficient adjustment to the varying operative scenario;
- Dynamic distributed models to efficiently manage crisis events in near-real time fashion.

Bringing actual IT technologies into real operative environments, demanded by public/private services, is based on extensive validation by operative structures able to define and transfer their experience into application models and large-scale effective scenarios. This process goes

usually through a series of pilot projects by means of which the SAR-based management process can be defined and heavily structured on somehow standardized data upon which an effective distributed (and cooperative) software system can be modeled and implemented.

Global networked infrastructures (such as Internet and mobile computing) is moreover a real opportunity for global, information-based, mobile services whose main characteristic is to offer services to general public as well as provides the required level of security needed for proprietary systems. Global standardized infrastructures and frameworks for distributed and mobile computing (such as CORBA/DCOM and the new .NET technology) provides a way to ensure security, flexibility and reliability to build efficient, low-cost systems able to realize specific services (e. g. SAR based) to be integrated with services based on COTS and engineered to be used by Cellulars and Handhelds.

Web information and services are becoming accessible from a wide range of mobile devices, from cellular phones, pagers, and in car computers to palmtop computers and other small mobile devices. The technology to enable mobile access to the Web is still in the early stage, the main open questions regarding the languages and the formats.

Mobile equipments (GSM/GPRS/UMTS), Personal Digital Assistants (PDA) or Palmtops PCs and GNSS satellite location services, can be now easily integrated in the distributed scenario: mobile devices are rapidly converging in standards and components to meet the growing demands in terms of users and need of internet based services. To be truly useful, components and devices must be interconnected and interoperable: this will be more and more possible with the emerging standards on the fusion between higher order tools and markup languages (e.g. XML based):

- Location services are more and more available in low-cost devices and equipments (e.g. GPS and Handhelds or mobile communication terminals) that use (or are ready to use) communication protocols (e.g. WAP) and languages (e.g. WML) that allow an easy integration into Internet services.
- Geographical Information Services are furthermore converging to open standards: a remarkable approach is the OpenGIS project and the GML (Geographical Markup Language).
- Earth Observation services are also emerging in the Internet scenario, providing significant information services on local/global areas.
- WEB servers offers now a high level of security and reliability needed for sensible applications

Capable to provide sophisticated and realistic infrastructures for applicative solutions for:

- Managing vehicles equipped with communication terminals (GSM/UMTS) and GNSS positioning systems;
- Integrate, via mobile XML dialects, textual structured information in communication based mobile systems and distributed internet platforms based on open standards;
- Implementing models based on dynamic push technology (managing event based services);
- using geo-referenced OpenGIS products in an homogeneous framework;
- open new, general public, services based on the offered functionalities over the Internet (such as broadcasting of differential correction for GNSS equipments computed upon localised service areas).

This scenario can lead to explore the feasibility to reach highly integrated services with reduced development costs, in view of open tools and standards, with scalability and flexibility required in this context and efficiently integrated into the communication infrastructures.

GNSS framework: towards GALILEO services

There are currently two satellite navigation networks in the world, one developed and managed by United States (GPS) and the other Russian (GLONASS). Both have been designed to determine the position of military objectives, vehicles or units, with great accuracy. These networks can be used for civil purposes, and show several serious drawbacks, i.e. among others:

- no guarantee or liability cover is provided by their operators with all the implications that might imply in the event, for example, of air accidents;
- reliability which is uncertain: e.g. users are not informed immediately of errors that occur, and transmission is sometimes unreliable, particularly in towns and regions situated in the high latitudes of northern Europe;
- moderate precision for applications which require rapid positioning.

It is for these reasons that the European Union planned to develop by 2008, by way of the approved GALILEO project, a system which will control and which will meet its demands for precision, reliability and safety. The GALILEO system will enable each individual, by way of a small, cheap individual receiver, to know his position to within a few metres, as compared with tens of metres currently on offer from GPS. In addition, a guarantee of continuity of transmission of the signal will provide a fully reliable system, which the GPS does not. The European Union GALILEO project, supported by the European Space Agency, aims to launch a series of satellites monitored by a network of ground control stations, in order to provide world cover.

The INStANT project

INStANT, "INfomobility Services for SafeTy-critical Applications on Land and Sea based on the use of iNtegrated GNSS Terminals for needs of OLYMPIC cities", will be based on state-of-art distributed software technologies (CORBA, DCOM or Microsoft .NET) providing safe, scalable and open systems and to build up tools for organizing centralized management services distributing mobile or located data.

This project aims to set up, validate and demonstrate three pilot projects, based on the EGNOS System Test Bed with the view to develop a pre-operational service provision by the end of the project. By doing that the INStANT project will:

- accelerate the uptake of Galileo by the transport sector by exploiting and demonstrating the improved performances of EGNOS vis-à-vis GPS in targeted applications
- evaluate benefits and analyse economic viability from synergies with appropriate terrestrial infrastructures / services (terrestrial and/or satellite communications;)

These pilot projects focus on selected applications where the use of the EGNOS signal can prove superior to the use of GPS (in terms of required accuracy, integrity and/or guarantee of service). These pilot projects and respective applications are:

Pilot 1 (Rome)	Land / Urban	Fire Brigades / Route Guidance Fire Brigades / Pedestrian Resource Management Fire Brigades / Vehicle Resource Management
Pilot 2 (Athens)	Maritime / Confined Waters	Marine navigation (regulated) Marine surveillance Personal outdoor recreation (marine leisure vessels, yachts etc.)
Pilot 3 (Athens)	Land / Semi-urban	Lone worker protection Tracking of very valuable and dangerous goods Light Commercial Vehicles (LCV)/route guidance LCV/Emergency breakdown theft and recovery

All three pilot projects deal with safety of life applications (with the exception of personal outdoor recreation and LCV applications which are mass market). All applications introduce a unique opportunity for EGNOS/Galileo for different reasons:

- The high visibility and real needs in addition to the current lack of use of GPS by the Rome Fire Brigades (in the wider area of greater Rome).
- The maritime opportunities and operational needs in Athens (in the Aegean Sea and the Athens region) arising from the Olympic Games, 2004.
- The safety related land mobility opportunities and operational needs in Athens (in the wider Attica area) arising from the Olympic Games, 2004.

Emphasis is put on the adoption of international standards. The proposed techniques push for assessment and spread of standards in the area of emergency services management and applicative

representation. A specific objective is actually devoted to a leading role in the definition and consolidation of international standards, technologies and products which will orient most of the design choices in order to stress the sharing of such standards among the user and technology developers.

Among the applications that can be targeted by the project results:

- Marine navigation
- Surveillance navigation
- Personal outdoor recreation (yachting, sailing etc.)

the fist one is related to the on board navigation of different kind of vessels (trader, ferry boat, etc.). The second one involves the surveillance of marine traffic from a shore based VTS centre. During the Olympic Games the sea borne mobility towards the port of Piraeus as well as the wide area of Attica will be increased. Therefore the precise measurement of the vessel's position and its broadcasting together with related information to the VTS centre, is of great importance.

The proposed system contains in fact an EGNOS receiver (which performance is equivalent to Galileo) and a transponder on-board the vessels. The recorded vessel's position/route will be transmitted to the centre. The centre awareness of the precise location of the vessels as well as their course and speed will contribute to efficient fleet management by:

- Avoiding grounding and collision by maintaining a safe distance to known obstacles (e.g. wrecks, other vessels, etc.)
- Skipper's conforming to local instructions
- Assessing the safety margins for performing manoeuvres

Regarding the third application, it involves the navigation and surveillance of leisure vessels, yachts, etc. During the Olympic Games many visitors are expected to come to Athens by their yachts. These vessels will be also used for accommodation purposes. So, the above mentioned sea borne mobility will be, even more, increased.
The evolution of the technologies applicable to the products, the availability of standards to integrate the different services in the same mobile terminal is moreover taken into account, to follow the evolution of commercial mobile terminals that will be available at the moment of the service verification activity. Extensible component design technology will be capable to update identified components of the system to meet the specifications of the mobile terminals evolution.

INStANT Objectives

The main objectives of the INStANT project are targeted to:

- Design/simulate and integrate, at a conceptual as well as operative level, the components that are necessary to build a mobile user terminal, at a European level, that consists of the integration of the following services:
    - GNSS navigation and positioning, based on EGNOS receivers (towards a GALILEO platform);
    - GSM/GPRS/UMTS cellular communications, with particular emphasis on new 2.5/3rd generation equipments;
    - smart and capable interfaces that are tuned to reach high level of usability in the domain of SAR applications.
- Deliver a Service Control Centralized Infrastructure (SCCI) capable of the service functionalities and thus equipped with a:
    - GIS Database server containing Local Routes (in raster/vector forms) and Geo-referenced data with interesting point and data for suitable location based services.
    - Web/WAP server to enable mobile internet connection
    - Application server equipped with Data exchange management capabilities (SMS, Vector data in XML packets, Raster image processing) to serve a dynamic push model management for emergencies control (Events to mobile equipments) and management of mobile equipments under critical alerting constraints. The synchronisation between central/local databases containing information on mobile position and sensible data (such as equipments,

water level, intervention state, resources, machine conditions) and the management of (optimal) route planning of vehicles within service areas.

- Monitor standards, technologies and products to effectively operate on the evolving scenario in which the project will perform the activities; the monitoring and the link with other GALILEO funded projects, such as GEMINUS, GENESIS, GUST and SARGAL will be also a key activity.

The hereafter listed items, such as the:

- Design of an integrated user terminal capable of GNSS, mobile communication and handheld capabilities that is exclusively originated from European companies, under the GALILEO framework, and that is based on the standardization activities of the current EC pilot projects,

- Development of an highly integrated infrastructure, based on extensible components, that can be reused for different emergency, fleet management and terminal based services,

- Specification at a conceptual as well as at the applicative viewpoint, of a model of a real, user based, validated emergency service, under a the guidance of relevant users and organisation of major urban areas of Europe,

- Development of a scalable and interoperable core system with superior processing power, GIS/LBS based database integration, real time object oriented and distributed technologies

are to be considered major objectives pursued by the INStANT project.

INSTANT project main technical achievements will moreover be:

- At the beginning of the project: to deliver a set of documents that provides user demands and requirements for emergency service consortium users, targeted to the terminal manufacturers and to the service components that are provided by the INStANT technology providers,
- At the end of the first year of the project: the design and the delivery of service based components to be used in the integrated user terminal,
- After the mid assessments of the project: the installation and validation of two pilot applications to be tested in the specified urban areas,

At the end of the project: a realization of a pilot and a pre-operational application to demonstrate the feasibility of the project results to be used.

INStANT innovations

The main innovations of the project will be:

- Design and assembling of an integrated user terminal, based on integration of readily available COTS components capable of GNSS, mobile communications, visualisation, mobile internet applications.
- Development of a modular architecture, based on extensible components, that can be reused for different applications and allow usage of new terminals as they become cheaper and more powerful. It should provide a logical and formal framework, with supporting infrastructure, to bring the following benefits:
- Easy expansion to new application areas, leading to:
    - increased take-up of satellite based technology
    - reduced cost of equipment with expanding markets
- Faster time to market for new applications built on this infrastructure
- Big advantage of component based approaches.
- Open architecture, in line with emerging technologies and standards.

- Scaleable (cities {particularly at high density times like Olympics}, Provinces, Countries, the Med {Islands}, EU)

- Will assist with definition of new standards and expansion of application areas and increased take-up of the technology.

- Extensive Demonstrations of the EGNOS Signal, for the first time in the world (building on the results of one-off trials of Turin, Aegean Sea). There are benefits given the improved integrity and accuracy of the signal, which should give a competitive advantage over GPS / DGPS. Particular benefits can be listed:

    - Route matching is more consistent and reliable. Increases acceptability of the technology and dependence on it.

    - An ability to give better route guidance (more cheaply) particularly if linked to other traffic management systems. (Existing map matching techniques depend on many different sensor and data inputs for accuracy).

    - Importance of event monitoring, which is **critical** for security personnel and related applications. Eg. **Accurate** security alerts **must** get through otherwise personnel are at risk.

    - Integrity increases acceptability. This leads to an increased reliance on single mechanism approaches, reduces complexity, reduces cost, provides openings for new application areas.

- The concept of the data-driven or push models, an approach capable to provide a service with (near) real time response to emergency events, distributed over (mobile) communication infrastructures, dynamic and reusable, based on European/World equipment standards

- Integration of EGNOS information in suitable (service and user oriented) data structures in an efficient and easily manageable way, e.g. textual structured data (such as XML dialects) with high level of flexibility and self-structure (Data Type Definition and schemas).

Other innovations pursued: towards the Dynamic model

In the following sections we will describe a structured approach to applicative oriented modelling that will allow to deploy software environments based on extensible (operative) models based on data exchange mechanism.

Several disciplines, elucidated in current research and applications, may help thus to figure out an effective way to use different paradigms and modelling techniques to design complex Object based Architectures (OA) in which adaptability, extensibility and modularity are demanded to face SAR domain activities: consider a basic paradigm (e.g. Object Oriented) to build abstract structures with simple compositional mechanism (i.e. restricted to well defined and simple interfaces) and use a design scheme, a là Design Pattern, to "envelope" other paradigmatic modelling issues on top of object orientation (i.e. borrowed from constructing extensible data processing patterns).

The construction of the appropriate applicative as well theoretical constructions to reach an effective kind of "paradigmatic encapsulation" is therefore one of the aims of our research. Main objectives were in fact to model Objects/Components, within a suitable compositional mechanism, in a distributed (realistic) scenario and to supply appropriate theoretical model of distributed (CORBA/XML) architectures with particular emphasis on extensible design disciplines.

Among other innovative concepts we should also focus on new sophisticated ways to accomplish the dynamic requirements of an effective scenario is in fact to shift the paradigm used in the service management to the concept of the data-driven or push models. Such approaches are capable to provide, with the additional and above mentioned capabilities offered by the integrated user terminal, a service with the following characteristics:

- (near) real time response to SAR events to manage emergency operations,
- extensible on high efficient designed components,
- dynamic distributed over (mobile) communication infrastructures,

- reusable to a large extent, being based on extensible component technologies, for different similar applications,

Here data structured in an efficient and easily manageable way, e.g. textual structured data (such as XML dialects) with high level of flexibility and self-structure (Data Type Definition and schemas), can be effectively used to drive efficient systems that responds to event mechanism required by SAR applications.

Structured data, together with associated data formats communicated by standard technology (e.g. WAP and WML), can be managed in a sophisticated model were the data will flow from mobile (located) devices, with appropriate structure (using well defined DTDs), to reach event data service embedded in the centralized management.

Model dynamics based on data driven approach

Focusing on the operational "role" of active entities of the distributed (Object based) Architecture (OA) we observe that:

- A set of objects play the role of "functional" objects in a distributed environment, that is they are responsible essentially of processing "data": such objects can be identified as the "core" processing units in the dynamics of the OA.

- other objects in the OA play the role of "Data" objects that are "arguments"/"results" (i.e. values) for the above processing objects.

We can decide thus to split the set of all OA objects in two main, non-intersecting subsets, the "functional" subset and the "argument"/"results" subset. The objects in our OA are maintaining their own "object" nature but are tagged and used within a functional or data nature.

The Functional Objects (FO) will be realized by distributed (e.g. Java/CORBA) objects that are chosen to be the necessary and sufficient entities for the overall OA functionality.

The Data Objects (DO) are then XML structures equipped by suitable schemas/DTDs used as "arguments"/"results" or "values" by the functional objects in the overall processing dynamics and can be stored in the (e.g. unique and centralised) Database Management System .

Data interact with the persistent service management of a dedicated server, via suitable XML based DBMS with event notification services (commercial tools are in this field available as COTS components but can be easily emulated by standard tools). Data act thus to drive in (actively or in push-mode) SAR events by means of software components embedded in a centralized Service managers.

Data will infact flow from mobile (located) devices, with appropriate structure, to reach event data service embedded in the centralized management: interoperability of formats and standards (e.g. HTML vs WML) can be used to make simple and homogeneous a replacement of service to agree with new standards and data structures. Here the meta-level description of structure, detailed by embedded DTDs in XML data, can easily respond to data-interoperability demands.

We propose hence to use an applicative model, that we may call a Functional Design Pattern System, to model highly reactive distributed Object Oriented systems as hybrid architectures where, in a suitable (meta)model design context, the main entities are:

- Localised Client/Servers that act as main processing units as objectified "functions". These "Functional Objects" have well defined and standard IDL interfaces that reflects signatures of functions. They behave effectively as pure localised (Java/CORBA) objects as well as (objectified) functions in an abstract model of the system.

- Data, as Persistent Objects, move along localised sites and gives to the servers a way to realise the desired (distributed) computation.

The abstracted information flow process, together with the data realizes a processing schema based on data event models and specifically oriented to XML Schemas or DTDs encapsulated in an overall XMI mechanism[1].

[1] remember that the operational model itself can be specified by XMI models.

Event notification mechanism

The notification of data related to vehicle management (location, identification, data related to on-board equipment, status of personnel, status of supplies, etc.) via mobile terminals (e.g. GSM equipped with GPS, laptops with GSM/GPS cards) and structured in textual XML form (e.g. in a suitable markup dialect) are notified to the central service via standard wireless platform (i.e. WAP protocol) and GSM public service[2].

Such data interacts with the persistent service management of a dedicated WEB server, via suitable relational XML database with event notification services (commercial tools are in this field available as COTS components but can be easily emulated by standard tools). Data received acts now to drive SAR events by means of DB manager that notifies to a centralised Service manager (connected to Java/XML dedicated servers).

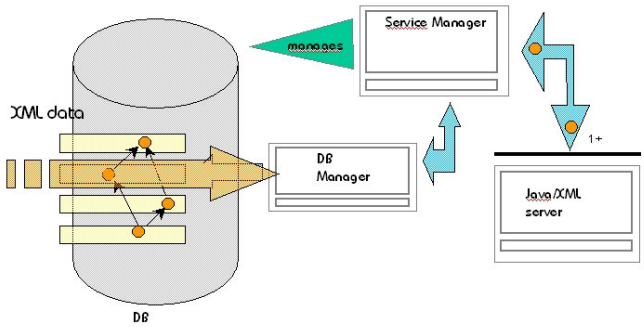

Figura 1 - Data Driven Model

Here the high level of:

- Data structure
- Data compactness
- Data driven architecture

gives a way to reduce communication constraints and to reach high level of system sensibility to alerts.
The generality of the definition will give us the possibility to build simple architectures, in a top-down approach, incrementally building more complex systems using reuse in a simple fashion and also at a level of design.

Further possibilities offerred by this approach are related to the use of standards and open technologies in terms of:

- Open standards: XML, WML, OpenGIS GML
- Open tools: Java, Enterprise JavaBeans, JEEE with CORBA, Apache Web server and XML processors
- Automatic generation of interface layouts, with the use of XSL ans XSST, can be moreover applied to give the possibility to reach the level of customizabilty required.

APPENDIX: INStANT Consortium

Analytically, the consortium consists of:

The Co-ordinator and Principal Contractor, **NEXT Ingegneria dei Sistemi S.p.A.**: a Small Medium Enterprise, as of the definition presently in force at the Agency.
The company provides systems and services of Information Technology. The global solutions developed by NEXT are focused in the areas of Business Transformation, like Management Consulting and Organization, and System Development. In particular the competencies that NEXT is able to offer are oriented to the Consultancy, IT Strategy and selection and realization of IT solutions in the markets of Space, Defense and Telecom. NEXT, in the mentioned markets, provides services such as systems development and integration, project management and application development based upon standard packages; Information Systems Management, both centralized and distributed, Application Management, Network Management, complete solutions, based upon Internet/Intranet projects, integrated in a wider Information Technology project.

The Principal Contractor **KTIMATOLOGIO S.A.** is a Hellenic public company responsible for the design and implementation of the Greek Cadastre (a 3 billion EURO project). In the consortium, it has the roles of the Digital Map Provider. It will also be co-ordinating work on the user requirements, testing and demonstration (most

[2] If higher level of reliability of the service, in a real scenario, is required then we can choose (being constant the functionalities offered, to use GALILEO receivers and custom communication media.

other industrial partners are also involved in this activity). Finally, KTI is responsible for the Pilot Projects in Athens (Land/maritime) and the exploitation of the results.

The Assistant Contractor **Vernicos Yachts** is a Hellenic Maritime Vessel Operator which will provide information for User Requirements in maritime sector, provide vessels for the testing and demonstration, evaluate and assess the results and participate in the exploitation activities.

The Assistant Contractor **Karakitsos Security** is a Hellenic Security Service Provider which will provide information for User Requirements in security sector, provide vehicles for the testing and demonstration, evaluate and assess the results and participate in the exploitation activities.

The Automatic Vehicle Location, GIS Mapping solutions and Mobile Data Communication systems provider contractor of the consortium is the **TERRAFIX**. Since its formation in 1983, Terrafix has been at the forefront of Mobile Data Automatic Vehicle Location, and GIS Mapping Systems. These comprise a unique integration of navigation, communications and display technology providing benefits and improvements in operational efficiency across a broad spectrum of mobile environments worldwide. Terrafix is a SME and is based in an 'Objective 2' region with 'assisted area' status

LEAT, beloging to Vitrociset Group, is an avionics and aeronautical telecomunication systems engineering installation and maintenance Company Associated to the AIAD (Aeronautical and Defense Industries Association) is member of the CIRA (Italian Center for Aerospatial Research). It operates since 1962 and is ENAV's (National ATC Board) and European Union's partner in the implementation of experimental in-flight national and european satellite navigation and telecomunication systems (EGNOS - GBAS - Electromagnetic Interferences - Signal Monitoring): LEAT will provide the consortium with the necessary skill to build an integrated EGNOS receiver component in the user terminal.

Main customers of the project's services are entities of the public and private sector. These include the Organising Committee of the Olympic Games 2004, Fire Brigade and Civil Protection authorities, marine and yachting companies, security services companies, delivery companies etc.