The Open ITS-IBus Service Oriented Middleware for ITS and Services: A Service Oriented ETC Solution

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ABSTRACT

An innovative electronic toll collection (ETC) solution, the SGMP system based on the service oriented architecture ITS-IBus, is presented and discussed. The open Intelligent Transport Systems Interoperability Bus (ITS-IBus) aims at establishing a multi-vendor technological infrastructure based on pluggable services implementing specialized functionalities like car identification, classification and enforcement. The ITS-IBus is a peer-to-peer service architecture where discovery and advertisement mechanisms and event registration and subscription are used to establish a community of peer services running on systems. These services implement specialized toll functionalities and present standard interfaces and contracts. The services run on systems that, beyond the functional services, implement specialized system services (core services) like administration, configuration, monitoring and security. The paper also discusses the adoption of a model driven development through a set of Eclipse

plug-in tools aiming to facilitate the development of ETC solutions in particular and ITS and services in general.

INTRODUCTION

Innovative integrated ITS solutions requires an advanced information and communication infrastructure and a new generation of tools able to cope with multi-supplier systems and multi competence developments. Innovative integrated solutions that are focused on advanced integrated business models, involves disparate systems from low level control units (road side equipments) to business intelligent tools, those that are mandatory to cope with the complexity of the emergent integrated (holistic) scenarios. A motorway management system, integrating toll infrastructure, traffic security, operations management and other subsystems requires holistic strategy involving a collaborative approach between technology and management areas. This requires common agreed concepts and standards mainly if the objective is to establish a competitive market of such a new generation of integrated solutions made of heterogeneous systems. This complex scenario has motivated the Intelligent Transport Systems Interoperability Bus (ITS-IBus) initiative (Gomes et. al. 2003), aiming to develop an open integration bus as a middleware based on services able to support complex and collaborative processes using open platforms and frameworks and standards. This paper describes a first implementation of a toll technological infrastructure, the SGMP system, by the Brisa's motorway concessionary in Portugal.

THE PROPOSED ITS-IBUS ARCHITECTURE

The ITS-IBus architecture (Gomes, 2003), (Osorio, 2004) was developed in Portugal in a join research project involving ISEL (an academic and research Institute), BRISA (the biggest motorway management company in Portugal) and WhatEverSoft (now ParaRede) (the first Sun Authorized Java Centre in Portugal) and other research groups and companies. The ITS-IBus is a peer-to-peer service architecture where discovery and advertisement mechanisms and event registration and subscription are used to establish a community of peer services running on systems (execution containers). These services present standard interfaces and contracts and implement toll specialized functionalities like car identification, car classification, and license plate recognition from others. The services run on systems that beyond the functional services, implement specialized system services (core services) like administration, configuration and security. The ITS-IBus was primarily motivated by the need for a

"plug-and-play" infrastructure where systems from different vendors can be integrated in an open toll management system. Another challenge was established by the need to construct a Pan-European motorway toll infrastructure where cars can use the same payment facilities across all European countries.

A toll ICT infrastructure (Figure 1) is made of panoply of systems some of them integrated by monolithic proprietary toll management systems. These systems evolve by their own and, in most of the cases, they follow a single vendor strategy what makes them far from an open innovation space. The Portuguese BRISA motorway company decided in 2002 to promote the development of a new strategy based on an open interoperability bus where multiple vendors of motorway toll systems were able to plug their systems. The main strategic goal was to create an open and competitive space where concurrent vendors were able to plug their systems. As a result, from the beginning of 2005, the ICT toll infrastructure evolved from a single vendor for the DSRD/RFID system where only the Norwegian Q-free where able to supply this kind of system, to a multi-vendor infrastructure where systems from both Q-free and Kapsch are now in operation. The alignment with an open service based architecture where specialized systems of a toll management infrastructure can be offered by more than one supplier has generated a significant cost reduction, not only on systems acquisition but also on system management and evolution. The work here presented is an innovative step from the early and innovative Via-Verde solution adopted in 1995 by BRISA. The Via-Verde tolling is based on the free-flow of cars equipped with an RF identifier. When cars cross a Via-Verde toll, without stop, a transaction is automatically generated and processed. The Via-Verde system is using a technology similar to the emergent RFID. In fact the DSRC is a kind of RFID where an active tag installed in the car, communicates with a toll antenna through a TC278 5.8 GHz wireless link (the rode side equipment reads and writes information to the tag).

The ITS-IBus architecture is organized around executive systems made of a set of "pluggable" services. To achieve this goal, three concepts were defined. The system concept identifies an execution container holding a set of services (the second concept). These services are the implementation of functionalities grouped on a fine-grained based strategy. The third concept is related with the standardization of the execution container, the service definition and deployment framework. Beyond the "plug-and-play" service, a system (service execution container) holds also a monitoring and a security service. The monitoring service is an important piece to contribute to the management of the quality of the services (QoS) and also to contribute to coordinating decisions when fault tolerance is required to comply with critical processes. The security services are necessary considering that a toll infrastructure is a distributed system with Internet access for administrative and management tasks.

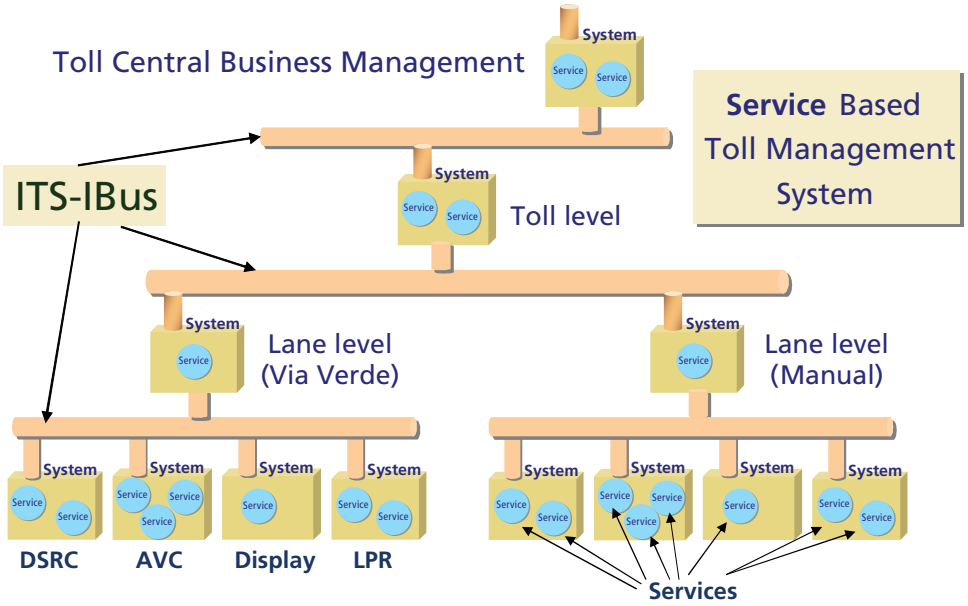

Figure 1 – Toll technological infrastructure based on ITS-IBus

The developed systems range from DSRC/RFID transaction coordinators, car classification and license plate recognition systems. All these systems hold services positioned on a peer-to-peer basis on the infrastructure. The services know each other through discovery and advertising mechanisms. Services can access other services following a synchronous or an asynchronous call; the asynchronous scenario are based on an event subscribe mechanism for managing call-backs. The ITS-IBus architecture for a toll management system is a hierarchical coordination system based on a lane management system (LMS) with a lane coordination service, a tool plaza management system (TPMS) holding a coordination service for a set of lanes and finally a toll central coordination system holding a service to coordinate all the TPMS systems. The LMS system type can hold services to coordinate Via-Verde (DSRC/RFID like) lanes, manual lanes based on an operator (tollbooth) and the electronic lanes (eTOLL) based on bank card or other automatic payment mechanisms. All the services follow an open interface defined by ITS-IBus project and available for suppliers to incorporate into their systems.

AN ITS-IBUS ETC SOLUTION IMPLEMENTED WITH JINI

Even if the ITS-IBus specification is technology independent an implementation was developed to the JINI 2.0 platform. Other technologies were considered to map

ITS-IBus concepts like SOA/Web Services and JXTA. Nevertheless, JINI (Newmarch, 2000) was considered as the most stable and reliable technological platform to cope with real-time constraints, mainly when considering the Via-verde lane (free-flow) were cars are identified and classified at high speed. A set of adapters were developed to integrate existing systems to the ITS-IBus infrastructure while it is expected that in the future toll system vendors might adopt ITS-IBus specification making their system ITS-IBus enabled. An ETC based on ITS-IBus is organized around a hierarchy of services starting at lane level with the LMS – Lane Management System (price management for the different vehicle types and origins and adapters to the RF Readers); the TPMS - Tool Plaza Management System runs a service responsible for the coordination of a plaza and finally the CCS – Central Coordination System responsible for the operation of a complete motorway. The same underlying architecture supports automatic and manual tool collection, depending on the services that are "plugged" into the lane. From the point of the ITS-IBus architecture there is no limitation on the adopted technology; a broker concept offers virtual access to ITS-IBus services from any service independently of its underlying technology; web services can be provided to integrate services developed in other technology.

An implementation of ETC management system, the SGMP – Toll Management and Monitoring System), following ITS-IBus architecture was developed (Figure 1).

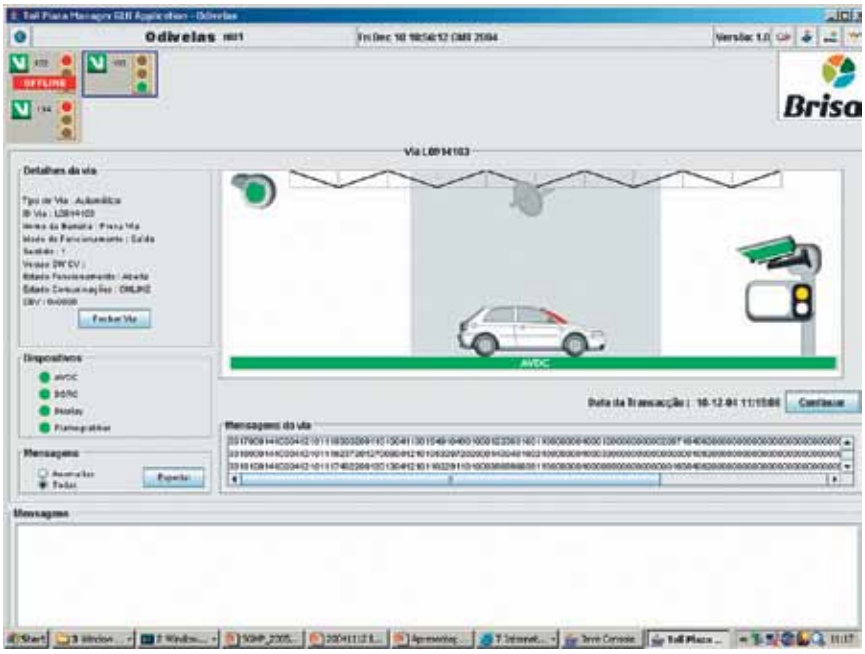

Figure 2 – The interface of the SGMP system

This ETC solution makes possible the development and integration of new services be them implemented in JINI or other technology. If another technology is necessary to by integrated, a wrapper adapter have to be developed.

INTEGRATED SOLUTIONS WITH MODEL DRIVEN DEVELOPMENT

Since the beginning of the ITS-IBus project a special concern was dedicated to the "leaning curve" required adopting advanced systems and concepts like those proposed by ITS-IBus and associated to the underlying technologies. Even if JINI is not a complex platform it embeds a number of new concepts and a complex framework requiring specialized knowledge do deal with. To facilitate service development, it is being developed a plug-in for the Eclipse platform specialized to guide toll management system developers to create systems, services and client applications. The client application was established as a special service used to test ITS-IBus services to be used during developments. The main expected goal from developing such a workshop to create new systems and services is to focuses developers on service business logic, on the solutions. The objective is to offer experts on toll management an advanced tool where services and services integration on complex systems (integrated solutions) can be developed from models, reducing to a minimal the code needed to be written. With ITS-IBus development workshop a developer does not need to be an expert on JINI or in any other underlying technology selected to support ITS-IBus concepts.

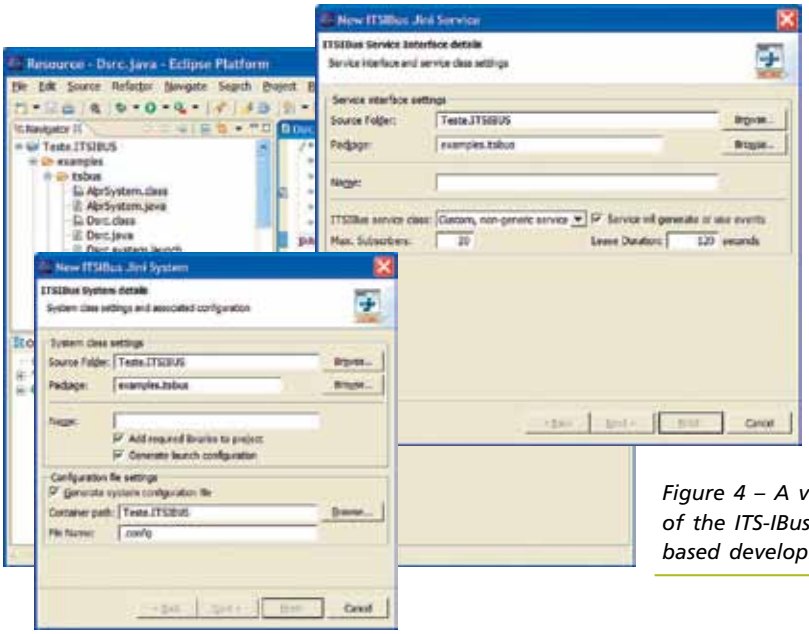

Figure 4 – A view of the ITS-IBus Eclipse based development framework

A version of an ITS-IBus tool suite (ITS-IBus workshop) considers a guided (automatic) generation of Systems, Services and a Client application. The concept of client application was introduced to make developments easier by facilitate tests and debugging.

The main objective of this tool suite is to contribute to reduce complexity when integrating systems based on different underlying technologies. Even if some technologies are being considered as a way to plug disparate systems like what is happening with Web Services, there is a generalized consensus that evolution will not happen under technology uniformity.

Some specific requirements like those related with real-time systems, the reutilization of acquired knowledge and experience, cultural factors and other aspects, are some of the motivation contributing to accept the diversity of technologies beyond methodologies and tools. This perspective points to an increasing complexity on the development of integrated solutions. The integrated solutions require a diversity of competencies along the life cycles from design, development, deployment, management to evolution, difficult to coordinate without a set of tools able to guide the multiple competence contributions.

CONCLUSIONS

The ITS-IBus architecture is based on a community of peer-to-peer services what facilitates the development and integration of new functionalities. The services are dynamically recognized based on an advertisement and discovery mechanism avoiding the rigid approaches usually utilized and based on configuration files. If independent of physical constraints like hardware in a specific system, the services can be running in any other computer accessible by the discovery mechanism.

The developed SGMP system, operating since the beginning of 2005, proved to be an interesting open approach for a new generation of ETC solutions. The need for a new generation of interoperable, agile and flexible technological platform makes the ITS-IBus a good strategy to develop integrated solutions for the ITS domain.

Furthermore the development of a framework where repetitive and complex tasks are automated through wizards helps the adoption of ITS-IBus by ITS systems suppliers. The adoption of Eclipse follows a crescent consensus around the need for a common development platform extensible and used along the technological systems life cycle. The available tools present uniform concepts along the conception, design, development, deployment and operation cycles what might help to get a holistic perspective of enterprise ICT systems. This enterprise consistency is a key step for companies to get involved in collaborative networks on a wide service based collaborative infrastructure.

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