25   INTEROPERABILITY AMONG ITS SYSTEMS WITH ITS-IBUS FRAMEWORK

Osório, L., Barata M., Gonçalves C., Araújo P., Abrantes A., Jorge P.
ISEL, Instituto Superior de Engenharia de Lisboa, DEETC department, Lisboa, PORTUGAL
{lo, mmb, paraujo, aja, pmj}@isel.ipl.pt

Gomes, J. Sales, Jacquet G., Amador, A.
BRISA, Auto-estradas de Portugal, DID Innovation and Development Department, Carcavelos, PORTUGAL
{Jorge.Gomes, Gastao.Jacquet, António.Amador}@brisa.pt

This paper presents and discusses the extended Via-Verde business model from the point of view of the underlying requirements for the virtual business processes. The extension of Via-Verde concept to other services beyond the motorway toll collection has increased the number of independent companies involved. The complex networked scenario resulted on a proposal of an intelligent transport system – interoperability bus (ITS-IBus) (Gomes et. al. 2003) (Osorio, et. al. 2003-a) aiming to promote a generalized interoperability among heterogeneous (multi-vendor) technological subsystems. The ITS-IBus initiative has been developing since then, a reference implementation of a peer-to-peer service based framework with pluggable feature and a set of common agreed interfaces for coupling different technological systems. An important objective is to increase the quality of the offered services by establishing a flexible execution and coordination framework for the collaborative distributed business processes.

1. INTRODUCTION

There is a need for a continuous effort to promote interoperability among heterogeneous (multi-vendor) information and communication technology (ICT) systems. The fast evolution during the last three decades has contributed to a significant number of new products, some of them, unique solutions taking advantage of market opportunities. In several cases, costs reflect the low market scale if not "one-of-a-kind" solutions requiring extra-dedicated efforts. This leads to expensive management costs for a life-cycle solution justified by the lack of well-established technologies and methodologies (standards) and above all, a low reutilization level of components available in the enterprise.

This situation is common to scientific and technological areas in fast evolution processes, it happens until a generalized understanding of new concepts and technologies get somehow a consensus among the interested communities. In ICT area some important (ad hoc) normalization bodies like W3C, OMG, IETF and open source community like Linux, Apache, Java Community Process, has contributed with significant dynamics to the mentioned required consensus. Concepts like pervasiveness and ubiquity have their origins in the need for a generalized interoperability not only at technology level but also at process definition level. According to existing initiatives Brownsword (Brownsword, 2004) address interoperability from two perspectives: 1) establishment of enhanced software development engineering practices and 2) development of models like the North Atlantic Treaty Organization (NATO) C3 Technical Architecture (NC3TA) Reference Model for Interoperability (NMI). In our work, we are following the second perspective under a twofold approach. On the one hand individual systems supporting toll solutions are redesigned / (re)assembled based on open interfaces and on the other hand a service based model was adopted to offer flexible support to business distributed processes execution and coordination (Osório, 2003-a).

Two years ago, BRISA initiated this discussion when addressing new business challenges involving extended business models with the participation of different companies with complementary responsibilities. This inter company cooperation scenarios have established new requirements some from technological area and others from business process management domain. Considering a recurrent business level problem, associated with distributed information consistency, it was identified a need to move from file base information exchange to distributed business process integration. This distributed business process integration requires a different approach to the interoperability challenge among contributing technological subsystems as a consequence of the "disintegration" of monolithic systems into a group of specialized services "orchestrated" by some service specialized on business process execution based on its representation (Osório, 2003-a). Other strategies exist to redefine enterprise integration approaches considering reutilization of legacy systems associated to other more service or component oriented approaches like the programmatic integration servers as defined by Gartner (Pezzini, 2003).

Focusing on ITS domain, the interoperability among dedicated short-range communication systems (DSRC) have received several efforts, namely by European Committee for Standardization (CEN) through the technical committee TC-278 (Osório, 2003-b). Nevertheless, this area requires further investments considering the lack of interoperability among existing DSRC systems, situation that makes difficult to create a pan-European electronic fee collection system (EFC). Beyond different communication rates between the on board unit (OBU) and the road side equipment (RSE), low data rate (LDR) and a medium data rate (MDR) systems, the interfaces at fee collection application level presents minor differences considering message structure and the underlying technologies adopted by systems from different suppliers.

The ITS-IBus initiative aims to contribute to these interoperability obstacles by following an open initiative approach involving technological system suppliers and other end-user companies like Brisa. This paper discusses not only the underlying motivations for ITS-IBus but also the adopted strategy. The discussion, while centered on interoperability strategy and process modeling aspects aims also to

contribute to a balanced approach between technology and process expertise domains. There is a need to develop technological frameworks able to offer the process domain experts a set of flexible tools proper to help them to develop solutions answering to the (collaborative) business needs. The workflow model and more recently works on web services choreography address coordination of long-running interactions between distributed components (Muehlen, 2004).

2. DISCUSSING ITS-IBUS MISSION

There is an open discussion about the right strategy to address the new emergent complex challenges created by the crescent cooperation among companies when sharing common business objectives. This challenge is grounded on another unsolved but rather old set of problems related with the intra-company integration. From eighties, a growing investment has been done to understand the company as a holistic system based on processes and underlying technologies including social and organizational aspects (Vernadat, 1996). Several company models have been developed to abstract the complex systems, people and relations, some guided by researchers in management and others originated in different technological areas from manufacturing, engineering and computer science. These efforts have contributed with different formalizations to the innovation processes. In a broad sense, these were consequence of a continuous innovation in computer and communication infrastructures. Companies have been facing a dilemma when moving in to new systems in most of the cases to support more holistic approaches where it is required a higher level of integration among company information systems. There is a clear trend to move from an "island" based enterprise ICT systems' organization or technology systems' integration to a more process oriented integration (Depke, 2002). This is a result from a paramount effort led by companies like Sun, IBM, Microsoft, Oracle and SAP to contribute for an integration of different but similar methodologies, technologies and tools. These efforts are contributing to unify approaches promoting enhanced level of reutilization and a clearer and competitive industry of software components assembled to generate enterprise applications/systems.

The ITS-IBus is aligned to this strategy considering that it aims to promote a clear set of interfaces to be adopted in an OEM model (original equipment manufacturer). The objective is to facilitate the plug (assembling) of systems from different producers into complex integrated systems overall contributing to the enterprise business processes. More than another middleware bus, ITS-IBus is an open initiative to promote a generalized interoperability among ITS ICT subsystems in order to develop holistic intelligent transport systems. One example is the challenge to establish interoperability among electronic fee collection systems (EFC) in motorways from different countries. To achieve this goal there is a number of interoperability challenges that need to be solved. On the one hand, the communication between OBUs from different suppliers must interoperate with RSE installed in the involved country's motorways or in other facilities within a toll. On the other hand, the involved organizations need to establish complex collaboration processes able to offer car drivers a virtual toll service. In order to discuss the ITS-IBus strategy in this extended scenario the involved companies and some relations

among them are shown in (Figure 1). This is a simplified scenario from what we might see in a near future when all the motorways around the Europe implement similar solutions. In this scenario the questions are:

- What would be the global architecture of a pan-European EFC framework;
- Market strategy - Tier players from customers (ITS infrastructure users) to car embedded endpoint (OBU in the case of DSRC technology)
- Processes - Operators' and cooperative business processes and information models and management strategies
- Technology - Technological infrastructures, system components, quality of services and life cycle technology management.

Beyond the above dimensions, other not less important are not focused on this discussion like the social and organizational aspects.
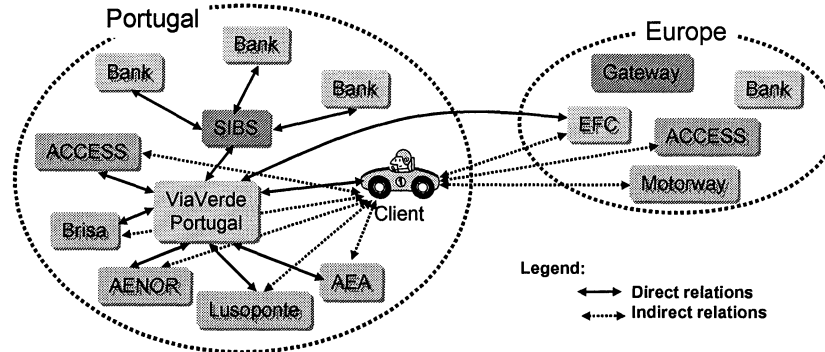

Figure 1 – Pan-European EFC infrastructure

The global architecture of a pan-European EFC framework is considered as a top-level goal to motivate the need for a holistic approach pointing to a tight collaboration among European ITS players. The second vector aims to discuss market strategy considering company arrangements according required services to commit global EFC framework. This involves players from ITS operators (Brisa, Aenor, AEA, Lusoponte), car parking infrastructures (Access), payment gateways (SIBS) and bank service providers, important to consolidate payment operation with ITS customers. In Portugal the car driver (Client) has a business relation with Via-Verde Company. The Via-Verde offers access services to different motorways, car parking and to other facilities (services) on the behalf of the various infrastructure operators (indirect relations). In the future, a European car driver might drive through European countries crossing motorways from different operators and parking in different areas without care about local payment. It will be invoiced in a month basis with a detailed report of all transactions. To achieve this there is a need to understand the collaboration model among the involved companies in order that each one can comply with a predefined and agreed quality of collaborative services. This involves different type of services from money transference involving payment gateways and banks, motorway toll transactions, car parking transactions from others. To achieve this purpose, the normalization forums are of paramount importance because they are contributing to standardize information models and

more recently service interfaces based on the web services definition language (WSDL) and XML schema for the underlying data types involved. The interactive financial exchange (IFX) forum is an example of such an initiative to promote interoperability among payment service providers and users. Another forum, the open financial exchange (OFX) is also promoting interoperability through a specification for the electronic exchange of financial data using the Internet as communication platform. Nevertheless these and other initiatives are somehow divorced from others with similar objectives but in other application domains like the information exchange between business applications hosted by open application group (OAG), the object management group (OMG) for a more ICT oriented standards, from many others.

There is a lack of interoperability between technology and business areas partially explained by the fast evolution of ICT during the last decades. Even for ICT experts it is not easy to make decisions about the operating system to adopt (Linux or Windows), the runtime framework for distributed applications (Java/JVM or C#/CLR) from other more specialized frameworks, most of them presenting complex challenges when necessary to integrate them towards more holistic solutions. Even if the W3C XML framework that has emerged from the largest interoperable platform the World Wide Web (WWW or Web) has contributed to facilitate interoperability at process and technological levels, many obstacles exist.

Beyond this more technology oriented discussions, there is also a paramount effort to unify organizational (business) processes as a key measure to make possible enterprise collaboration. An important contribution is the process handbook under development at MIT as a comprehensive framework for organizing large amounts of useful knowledge about business (Malone, 2003).

Under these challenges, the ITS-IBus open initiative aims to contribute to promote interoperability at both technological and process level through a flexible and advanced interoperability framework based on existing open standards. The strategy is not to force a fast change from existing solution and well established system providers but rather involves them in the definition of common interfaces and promoting the reutilization of open frameworks able to assemble a diversity of systems to develop solutions easier to project, develop, maintain and evolve. These more technical requirements follows other more business ones those that must guide the design of a successful holistic technological infrastructure. Actually, the business models are the prime discussion in order to establish the underlying trusted business relations from which the collaborative relations are derived. The collaborative relations can be formalized through specific contracts that regulate all the collaborative processes specifying also the information exchange and auditing procedures.

As an example, we can consider a motorway operator responsible for an infrastructure with a number of electronic fee collection tolls. When a car crosses, a toll (entering or leaving it if in a closed infrastructure) the operator registers the transaction and, as soon as possible, delivers it, possibly in a lot, to the client's service provider. For the client's service provider, there is a need to access all the transactions (client's identification, a location and a time stamp). This information will support client's invoicing with a detailed report explaining each transaction. For conflict resolution, some evidences are necessary to consolidate the stored transactions even if in some circumstances it might be necessary to make a deeper

information analysis considering an extended time window to detect exceptional client's patters. This is what happens with other services offered in a diversity of domains. There is a need for entities, the client and the service provider to establish a clear and trusted framework. To guarantee this it is also necessary to extend trustiness to all the intervening partners. If something goes wrong, the client claims to the service provider and he must receive from it all the answers to the open questions. Even if some information is missing it is important to consider that all the responsibility is of the service provider.

3. INTEROPERABILITY STRATEGY

There is a complex challenge which companies are facing when their business processes depend on multiple partners with competing business interests. On the one hand, the underlying business processes need to be unified or at least, some mapping needs to be established. On the other hand the technological framework considering all the ICT infrastructures from operating systems, middleware and networking systems, even if interoperability is being facilitated by some convergence achieved from a set of open initiatives, it continues to be a real problem when ICT life cycle management costs are considered. From different authors, the right strategy to cope with interoperability is not to promote radical substitutions but rather promote smooth transitions where legated systems are considered as valuable assets; at least until an accepted migration road map is established.

Therefore, the ITS-IBus open initiative is grounded on the following premises:

- Systems exist in different technological stages and forms, with focused objectives and other overlapping different application domains;
- Systems based on standard software or based on software and dedicated hardware establishes groups of heterogeneous systems overlapping or not relevant functionalities and characteristics.

We define a system as an ICT unit based on software or software and dedicated hardware able to work standalone or as an assembled component of a more complex system. This definition of system aims to unify in a broad sense to other concepts that fall in our system's definition. A system can be either an EIS (Enterprise Information System), an application, a software component, any piece of software or software and hardware able to be considered as a closed box with a clear behavior (outputs) under different environment conditions (inputs), (Figure 2).
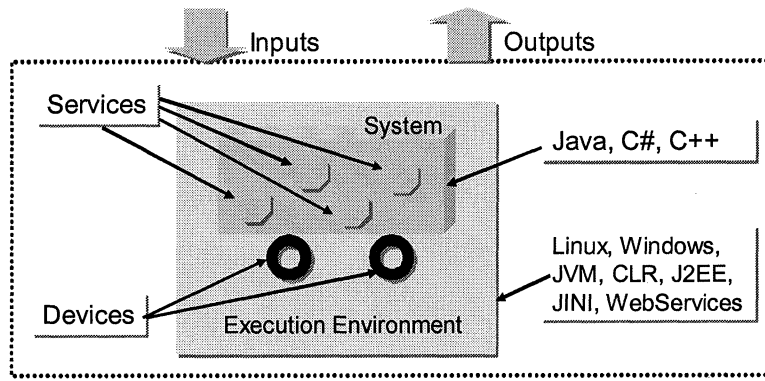
Figure 2 – General model of a company ICT system

The inputs can be configuration variable, information from sensors, user inputs, any information that might contribute to condition system's behaviour. The output can be any information that is needed by other system or user to realize some activity or task. In some extent, the proposal follows the service-oriented architecture (SOA) where all the execution units take the aspect of services with predefined contracts. In addition, in ITS-IBus the toll technological system at different levels are invited to adhere to such a service based framework. From our experience, there exist measurable advantages for both toll technology providers and motorway manager companies as end-users to adhere to a common interface. Furthermore, the strategy might be extended to a set of secondary business processes involving the collaboration with other companies. As an example, a motorway company might need to collaborate with a bank to make electronic payment cards debits to common customer accounts. Nowadays this collaboration is being done with a technology not adapted to the new collaboration needs mainly those related with time. It is not acceptable that some change in customer payment card like revocation or information update, take more time than a few minutes or at maximum a few hours to get information updated in all the tolls requiring such information.

In order to cope with distributed business requirements, ITS-IBus framework proposes a service-based environment where each functionality or group of functionalities are available through services. In the general architecture of a typical toll infrastructure (Figure 3) a lane management system (LMS) coordinates a group of systems through their services. A toll is managed by another system, the toll plaza management system (TPMS) responsible for all the operations management at toll level. The overall tolls are coordinated by a toll management system responsible for the supervision of the entire motorway technological infrastructure. All the systems implement specialized services plugged through an open interoperability bus made of a set of open frameworks offering reusable services like directory, publish and discovery, messaging, authentication and authoring, information security, persistency, user presentation facilities, from others.
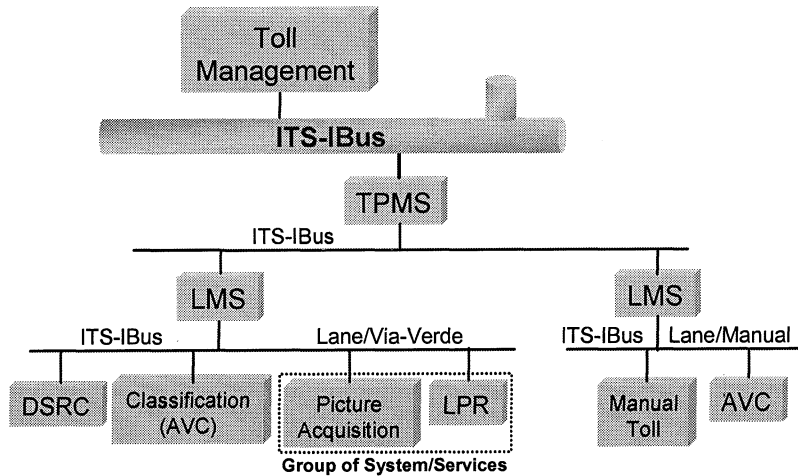
Figure 3 – General architecture of a toll technological infra-structure

There is an ongoing effort from Brisa and involving potential technology suppliers to promote an open framework and service interfaces as an open initiative. This might contribute to enforce a convergence of the presentations or interfaces for systems belonging to a same class. It does not make any more sense to admit that competitive factors are on systems' interfaces or in specific functionalities not available in any other competing system. The trend for companies, willing to adopt well established and proved technologies (some open technologies) under the crescent pressure to get more integrated (holistic) infrastructures, is contributing to support such necessary consensus.

As an example for a Via-Verde lane a DSRC collects car identifiers and according classification and a validation of contractual conditions the LMS decides for the collection of a picture of the car and the plate character string if available the LPR service. On a toll, the DSRC (Dedicated Short Range Communication) system is the component that is responsible for controlling the communications with the vehicles where an on board unit is installed to enable motorway client identification (Osorio, 2003). Both DSRC and LPR system services follow an open interface developed under ITS-IBus initiative. For the license plate recognition where there is a lack of standards applied to this problem, a research activity is being conducted to promote an open standard interface for an automatic vision system (Broggi, 2000). The main objective is to develop a special class of systems offering different automatic vision related services namely long-term traffic statistics (Abrantes, 2002), the detection of dangerous car maneuvers, license plate recognition (Chang, 2004), obstacle detection on high speed railway lines or in risky motorway or rout sectors.

To integrate all these dedicated systems the ITS-IBus adopts a peer-to-peer strategy considering that (business) processes are executed into systems that present services to other processes or service implementations (Figure 2). Everything requiring computational actions is represented by services presenting an open interface and following a set of rules that make them ITS-IBus enabled. The services

are plugged into systems that behave like an execution containers presenting a minimal set of service to the ITS-IBus (Osorio, 2003). A system might implement at least the "plug and play" service in order to be identified by other ITS-IBus enabled peers.

A first prototype of a lane management system (LMS) and a toll plaza management system (TPMS) was developed. This first approach uses the JINI framework to create the service community. Following a previous work, the JXTA is also being evaluated to extend the service community to Internet domain getting advantage from the mechanisms offered by this framework to cross firewall and routers/NAT company barriers.

4. CONCLUSIONS

The ITS-IBus initiative involves different projects aiming to create the necessary consensus in different but complementary application domains. The initial focus was on toll technologies namely at those supporting the Via-Verde service model. In this area an effort was done to develop a peer to peer framework based on services implementing specialized functionalities of a toll infrastructure involving systems like a DSRC for car automatic identification and a LPR to automatic plate recognition as an enforcement system. Nevertheless, the extension of the Via-Verde model and services to other facilities like car parking and gas stations added new challenges namely those related with the involved companies that indirectly contribute to the Via-Verde pervasive services. These companies use different technological systems and processes organization what is contributing to a number of difficulties to establish an advanced collaborative model based on distributed business processes. In some areas like car parking infrastructures, there is a need to further normalization efforts in order to promote the adoption of open solutions and a shift to ITS-IBus peer service strategy. There are a number of monolithic and proprietary solutions to manage car-parking infrastructures that need to move to open solutions in order to get pluggable to the ITS-Ibus and to cope with Via-Verde business model requirements.

This requires the development of specialized systems as open components pluggable to an open infrastructure and able to support the execution of the (business) processes at different levels of the ICT framework. At company interoperability level, more efforts need to be done to establish a common understanding for related processes and an execution model able to cope with collaborative business model requirements.

5. ACKNOWLEDGMENTS

contributions from Miguel Machado, Bruno Basílio, Rui Lopes, Joaquim Pereira, Rui Gonçalves, Francisco Monte and Ricardo Cruz.

6. REFERENCES

1. Abrantes A., Marques J., Lemos J., Long Term Tracking Using Bayesian Networks, IEEE International Conference on Image Processing (ICIP), Rochester, 609-612, vol. III, S, 2002.
2. Beymer D., McLauchlan P., Coifman B., Malik J., A Real-time Computer Vision System for Measuring Traffic Parameters, In Proc. Computer Vision and Pattern Recognition (CVPR), 1997.
3. Broggi, A., Ikeuchi, K., Thorpe, C., Special issue on Vision Applications and Technology for (Broggi, 2000) - Intelligent Vehicles, IEEE Transactions on Intelligent Transportation Systems, June, 2000.
4. Brownsword Lisa L. Carney D. J., Fishe D., et al - Current Perspectives on Interoperability, Technical Report, CMU/SEI-2004-TR-009, 2004.
5. Chang, S., Chen, L., Chung, Y., Chen, S., Automatic License Plate Recognition, IEEE Transactions on Intelligent Transportation Systems, March 2004.
6. Depke R., Engels G., Langham M., Lütkemeier B., Thöne S. - Process-Oriented, Consistent Integration of Software Components, Proc. of the 26th Int. Computer Software and Applications Conference (COMPSAC) 2002, Oxford, UK, IEEE, Aug. 2002.
7. Gomes J. Sales, Jacquet G., Machado M, Osório A. Luís, Gonçalves C., Barata M. - An Open Integration Bus for EFC: The ITS IBus, in ASECAP2003, 18 - 21 May 2003 in Portoroz, Slovenia
8. Malone, T. W., Crowston, K. G., Herman, G. (Eds.) - What Is In the Process Handbook? Chapter in: Organizing Business Knowledge: The MIT Process Handbook. Cambridge, MA: MIT Press, September 2003.
9. Muehlen M., Nickerson, J.V.; Swenson, K.D.: Developing Web Services Choreography Standards – The Case of REST vs. SOAP. Decision Support Systems 37, Elsevier, North Holland, 2004.
10. Osório A. L., Abrantes A. J., Gonçalves J. C., Araújo A.; Miguel J. M., Jacquet, G. C.; Gomes, J. S. - Flexible and Plugged Peer Systems Integration to ITS-IBUS: the case of EFC and LPR Systems, PROVE'03 – 4th IFIP Working Conference on Virtual Enterprises, published by Kluwer Academic Publishers, ISBN: 1-4020-7638-X, pages 221-230, 2003-b.
11. Osório, A. Luís; Barata, M. Martins; Abrantes, A. Joaquim; Gomes, J. Sales; Jacquet, G. Costa - Underlying ITS Business Processes with Flexible and Plugged Peer Systems: the Open ITS IBus approach, PROVE'03 – 4th IFIP Working Conference on Virtual Enterprises, published by Kluwer Academic Publishers, ISBN: 1-4020-7638-X, pages 221-230, 2003-a.
12. Pezzini M. - Leveraging Legacy Assets: Web Services Through Integration, in the Gartner European Symposium, Fortezza da Basso Florence Italy, 10–12 March 2003.
13. Roy T. Fielding, Richard N. Taylor. Principle design of the modern Web architecture. ACM Transactions on Internet Technology (TOIT), pp. 115-150, May 2002.
14. Vernadat, F.B. - Enterprise Modelling and Integration: Principles and Applications. Chapman & Hall - London, 1996.2. Smith, Adam. "An Inquiry into the Nature and Causes of the Wealth of Nations". In Classics of Economics, Charles W. Needy, ed. Oak Park, IL: Moore Publishing, 1989.