

Mapping Information Systems against Generic Freight System Architecture

Pekka Leviäkangas^{1*}, Anna-Maija Alaruikka²

1. Senior Research Scientist, VTT Building and Transport PO Box 18021, FIN-90571 Oulu, Finland; Tel: +358 40 561 6529; e-mail: pekka.leviakangas@vtt.fi
2. Research Scientist, VTT Building and Transport, Finland.

ABSTRACT

Systems architectures have been used to model comprehensive intelligent transports systems (ITS) and the services the systems are supposed to deliver. The aim of this paper is to demonstrate a use case of generic architecture and how existing systems which contribute to the architecture can be evaluated. The architecture can be used for “benchmarking” IT systems. If the architecture is based on business process descriptions and/or value chain descriptions, this mapping will position the system in the value chain.

KEYWORDS

System architecture, information systems, logistics, PolCorridor

INTRODUCTION

Systems architectures have been used to model comprehensive intelligent transport systems (ITS) and the services that the systems are supposed to deliver. Usually system architectures have been designed on national or sector-specific basis (e.g. road ITS architectures). Also the typical use case and viewpoint has been that of a sector authority, usually at national level. As far as the authors are aware, commercial use cases appear to have been rare. However, some examples do exist, such as projects financed by the Finnish Ministry of Transport and Communications, whereby common system architecture compatibility is required for all Ministry aided projects [1]. The same requirement set by Federal authorities applies to the US National Architecture for ITS [2]. In Japan, the architecture is seen as common platform for the automotive industry and service providers to facilitate services [3].

The question we are raising in this paper is whether commercial system providers can find architecture useful and if so, what are the prospective ways of utilization. We will use PolCorridor project [4] as an example, which has some interesting characteristics: it is an international intermodal project covering sea, rail and road transport. Furthermore it extends over several national borders. We will use the generic freight architecture TARKKI [5] as a generic architecture model and describe how commercial in-house or off-the-shelf systems

can be reflected and mapped against this architecture. The end result should show us how far the "ideal" world (described by architecture) is from the real world (defined by existing commercial systems). We shall point out the prospective cases for architecture utilization by commercial system and service providers. We also discuss the differences between "ideal" and "real" world. Our work has been reported in full detail by Alaruikka *et al* [6].

STRUCTURE AND AIMS OF THIS PAPER

The aim of this paper is to demonstrate a use case of generic architecture when we need to picture the ideal situation of having multiple IT systems working together in an international intermodal transport chain. In this ideal situation, the whole (i.e. the architecture) forms a seamless stream of information from one function or organization to another. But often the ideal situation differs from the real world. We describe how existing systems contribute to the ideal system as a whole. Finally, we evaluate the generic architecture's (TARKKI) usability for these purposes.

Our results, findings and conclusions should be interesting to those who

- justify the use of architectures and try to find use cases of architectures
- need to position their commercial or in-house systems as part of a wider value chain
- are keen to widen the range of IT services they currently provide and are looking for new user segments
- design architectures that aim to integrate (in functional sense) multiple individual systems.

Our paper starts with a review of different ITS architectures, the motivations behind them, as well as their primary use cases and restrictions of use. Then we proceed to case PolCorridor and show what kind of architecture is needed for international intermodal supply chain. Following this, the commercial and in-house systems that either already work on PolCorridor or are seen as prospective systems for PolCorridor are mapped against TARKKI architecture. Our mapping is done at conceptual and logical levels without going into technical details.

ITS architectures have currently involved transport services and applications such as traveler information and management of private traffic, public transport, delivery vehicles, information services, and freight and fleet operations. This paper attempts to add something new to the ITS architectures' traditional use cases.

SYSTEM ARCHITECTURES – MODELS FOR REAL OR IDEAL WORLD?

System architectures can be regarded as *descriptive* models of the ideal world with regard to information exchange and data processing. They *describe* how different systems should be organized and how services based on systems' capabilities should be produced. Architectures are also *deterministic* models; they assume that they describe the future of what is to come or which we are moving towards, especially the latter, which is a weakness of architectures because we are not living in a deterministic world. However, with right design and descriptive methods, architectures can with reasonable certainty be aimed to describe the world, the bundle of information services and systems, some time ahead. Also commitment to

architectures and making them mandatory will greatly increase the deterministic behavior of individuals and organizations working in the field of ITS. The risk in this kind of behavior is that possible unexpected evolutionary leaps could be hesitated because they do not fit into the deterministic pattern defined by architecture. Also architectures attempt to be somewhat *holistic* models, trying to capture a wider perspective. This is done by taking different viewpoints to ITS, like organizational, administrative, risk and deployment viewpoints.

Today a growing number of ITS applications are available, and because we must be able to integrate separate systems, system implementation must be based on a strategic framework - System Architecture. We have learned that architecture can function as a basis for choices concerning design, deployment, and investment decisions of ITS applications.

ITS architecture covers not only technical aspects, but also organizational, legal, and social issues. ITS architectures ensure consistency of information and interoperability between components, they permit technology independence and provide the basis for a common understanding of the purpose and functions of the ITS. ITS architecture can be used to provide a preliminary cost benefit analysis, identifying main sources of costs and likely benefits and as a starting point for producing the component and infrastructure specifications for the ITS deployment. Architecture can also be used in identifying the organizational issues and potential problems that may affect the ITS deployment. ITS architectures give valuable support to decision makers by facilitating the discussion between the different parties involved. [7]

In [8] the potential benefits of ITS architectures are identified. However, the authors have not encountered published documentation on these benefits based on hard empirical evidence. The expected benefits are still based on intuition, logic and indirect observation. Yet there are sound reasons to believe that benefits are real. The same applies to costs.

An ITS architecture may include the following elements, for instance: [7]

- An overview (Conceptual model) – a top-level diagram showing the whole system and how it works
- Functional Architecture (Logical) – specifications for processes which are needed to satisfy the user's requirements
- Physical Architecture – specifications for physical components and their locations for a particular deployment
- Communications Architecture – an analysis of requirements for the links needed between the locations shown in the Physical architecture.

In Table 1, different existing architectures are briefly described as to their scope, level of technical detail, modal coverage, mandate, etc. This summary represents the views of the authors only.

It appears that the main problem with all these architectures is the commitment, or rather the lack of it, and getting different actors working together towards the state of the world the architecture describes. In other words, the deterministic behavior of actors – operators, system developers, service providers, authorities, vehicle industry, etc. – is not always ensured even if a mandatory, deterministic architecture is in place.

Table 1 - Different architectures and their characteristics (authors' assessment)

Architecture	Technical and geographical scope	Modal / sector focus	Owner / Host	Mandate	Driving forces, motivation
TelemArk – passenger transport [9]	Conceptual (business processes & services) and logical architecture (system entities) for passenger transport; Finland	Multimodal emphasis on road transport	Ministry of Transport and Communications Finland	Mandatory in Ministry aided projects	Interoperability of different operators' systems; choosing strategic projects which contribute most to the whole value chain
TelemArk TARKKI (freight)	Conceptual architecture for freight; Finland	Multimodal	Ministry of Transport and Communications Finland	Recommended in Ministry aided projects	Interoperability of different operators' systems; choosing strategic projects which contribute most to the whole value chain
MeriArkki [10]	Conceptual architecture for maritime ITS; Finland	Maritime	Finnish Maritime Administration (FMA)	Mandatory within FMA	Interoperability of different FMA systems; management of ITS within FMA
ArkTrans Norwegian System Framework Architecture [11]	Reference model, functional view, behavior view, information view; Norway	Multimodal	Norwegian Road Administration	Recommended	Interoperability of different operators' systems
FRAME – European Framework Architecture [12]	Functional (conceptual) and logical architecture; examples of physical architecture; deployment and other guidelines; European Union	Multimodal emphasis on road transport	European Commission	Recommended within EU	European Single Market; interoperability of systems and services cross the national borders
US National Architecture for ITS [13]	User services, logical and physical architectures; market packages; United States	Road transport	Federal Highway Agency	Mandatory for federal aided projects	Standardization, automotive industry; boosting of ITS
System Architecture for ITS in Japan [14]	User services, logical architecture and physical architecture; Japan	Road transport	Various national bodies, see [14]	Recommended	Standardization, automotive industry

In the PolCorridor project, we created an ITS architecture for an international supply chain. Along the chain there are many actors and numerous IT systems in use. As expected, these systems are far from being interoperable especially when taking a wider view of the supply chain. On the other hand, it was assumed that existing systems in operation and off-the-shelf systems which are already available can solve some of the problems encountered in seamless information flow from one actor to another. For this purpose we analysed how these systems covered different parts of the chain and what information services these systems could provide. When we concluded our analysis we discovered many other things that unexpectedly provided us with useful information. Architecture for PolCorridor includes a conceptual model and some parts of logical architecture.

CONSTRUCTING POLCORRIDOR ARCHITECTURE

PolCorridor architecture is based on the transport system concept visualized in Figure 1. It shows geographical connections and the scope of the system. The concept core is the "Blue Shuttle Train" across Poland and Czech Republic between the hubs of Swinoujscie and Vienna. This system bypasses the heavily loaded German road and rail networks and serves the trade between Scandinavia and Southeastern Europe. Transport models show that PolCorridor is underutilized and has the capacity to serve the aforementioned markets [15].



Figure 1 - PolCorridor Supply Chain System (Source: PolCorridor consortium)

The process of constructing PolCorridor architecture was as follows:

- 1) Generic freight architecture TARKKI was assumed to represent the future desired state-of-the-world with regard to ITS and international intermodal supply chain
- 2) TARKKI was supplemented by MeriArkki, the maritime ITS architecture because the transport concept included several critical maritime links, especially between Finland and Poland
- 3) Relevant services listed by these architectures were chosen for PolCorridor; the parts that included authority activities or infrastructure related issues were paid less attention.
- 4) Conceptual architecture was drafted for the whole chain so that all modes were present: maritime – rail - road; in fact, this was considered to represent all the needs and events that could be identified in this corridor.

The final outcome of the conceptual architecture, which is in fact a business process description, is shown in Figure 2 (only a clip of the process can be shown; this is a part of the road transport process).

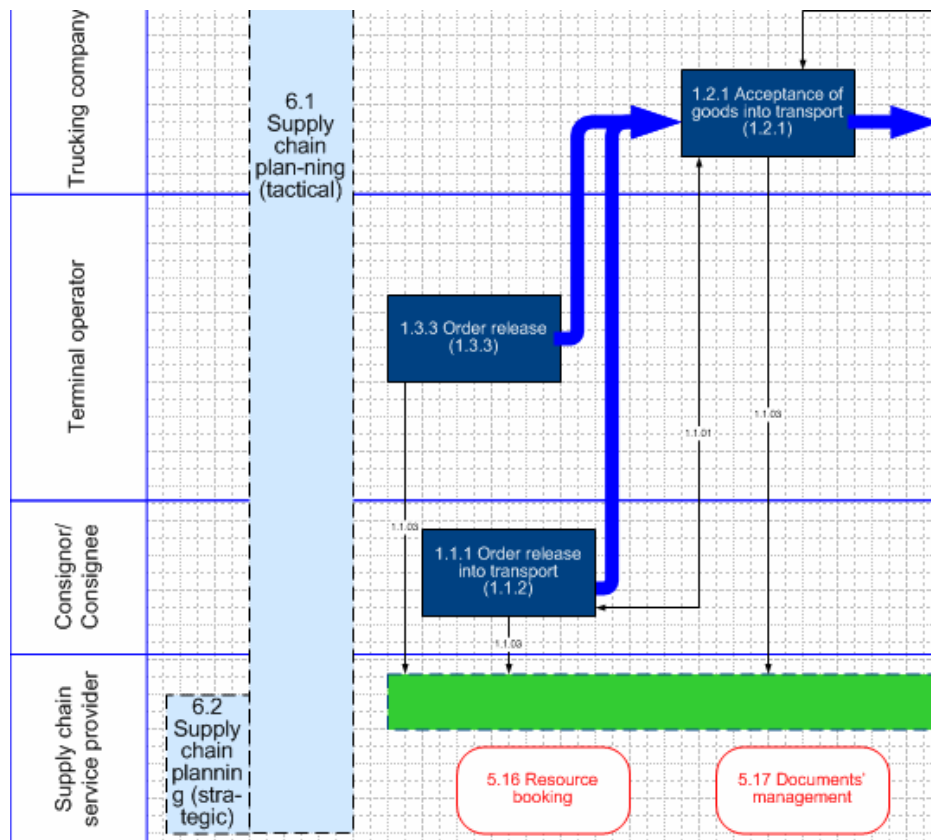


Figure 2 - A clip from the road transport process [6]

The number of information services that are produced within the whole intermodal process was quite extensive. After focusing on the most relevant services, some 40 of them were chosen for PolCorridor architecture from a commercial freight point of view (Table 2).

The services are based on the generic services introduced in TARKKI. Wireless channel and Wireless device have been combined into Wireless IT. The services are sorted according to different phases of the process.

Table 2 - Services selected for PolCorridor [6]

Support Process	Contracting Phase	Preparational Phase	Operational Phase
EnvDataMgmt	LicenceMgmt	TimetableMgmt	TimetableMgmt
MapServ	ContractMgmt	TransportPlanMgmt	GoodsAcceptanceMgmt
TrafficData	ResponsibilityMgmt	LogisticsOperatorMgmt	VehiclePositioning
RoadMaintTasks		RouteMgmt	VehicleMonitoring
RiskTrLicenseMgmt		ResourceMgmt	VehicleIdentification
RiskTrTracking		OrderMgmt	HandlingInstructionsMgmt
VehRegisterServ		OrderReceipt	WirelessChannel
			WirelessDevice
			LoadingMgmt
			VAServicesMgmt
			GoodsReleaseMgmt
			ShipmentMgmt
			PartyIdentityMgmt
			ExceptionMgmt
			ExceptionReceipt
			UnloadingMgmt
			ReclamationMgmt
			TrackingTargetCreation
			TrackingDataMgmt
			TrackingDataMonitoring
			ParcelHierarchyMgmt
			SupplyChainMgmt
			ProductionMgmt
			ProductIdentification
			ProductListMgmt
			WarehouseMgmt
			TransshipmentMgmt

} WirelessIT

SYSTEMS MAPPING AND THE STORY IT TELLS

In order to find out which IT systems and services there are in place today, which systems have potential, and what kind of systems are missing, we "mapped" the existing and prospective systems to PolCorridor architecture. This effort served the following two purposes:

- The IT companies involved in the project wanted to see how their systems fitted into this extensive intermodal architecture and which parts of the business process, actors and functions they could potentially serve with their products
- The research consortium wanted to test the applicability of generic architectures to serve commercial product planning and strategic marketing

decision making (whom to market the system, which markets and what parts of value chain).

The mapping process consisted of several sub-processes mentioned in Figure 2. The services different information systems provided were collected from every system provider/owner and these services were listed, i.e. the IT systems were mapped against generic services. The relation between the actors and the process components was clarified in order to find what kind of services each actor requires. This information was crucial in defining potential customers, whose service demands are not currently fulfilled. This resulted in the Service Distribution Map. Finally, information gathered was visualized by mapping the available information systems onto the process map. If the system was able to provide services related to a process component, the component was highlighted and the ability of the system defined by using the following categories:

- Totally => system provides all of the services related to the process component
- Mostly => system provides extensively (roughly more than 50 %) the services related to the process component
- Partly => system provides some (clearly less than 50 %) of the services related to the process component.

This assessment was done by researchers and was of course subjective and qualitative.

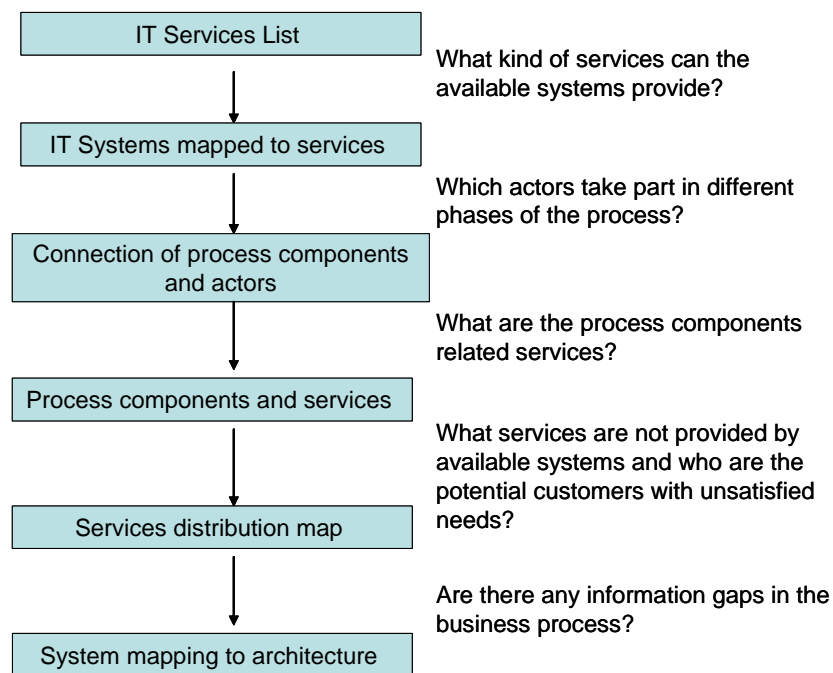


Figure 3 - Mapping process [6]

Examples of the mapping results are shown in Figure 4 and Table 3. Figure 4 visualizes the final outcome of the system's coverage with regard to process and Table 3 shows an excerpt of the Service Distribution Map. Both descriptions worked surprisingly well. We were actually able to position each system (existing or prospective for PolCorridor) and to point out which parts of the architecture, or rather business process, were or

could be covered by these systems. Where white spots were discovered, i.e. parts of the process where no services or systems could be found, we considered this to be a noteworthy result, especially for the hands-on development of intermodal supply chain information services and products. We were able to inform IT developers where new systems and services are required and operators of the supply chain where to find systems that could fill the "information gaps" in the business process.

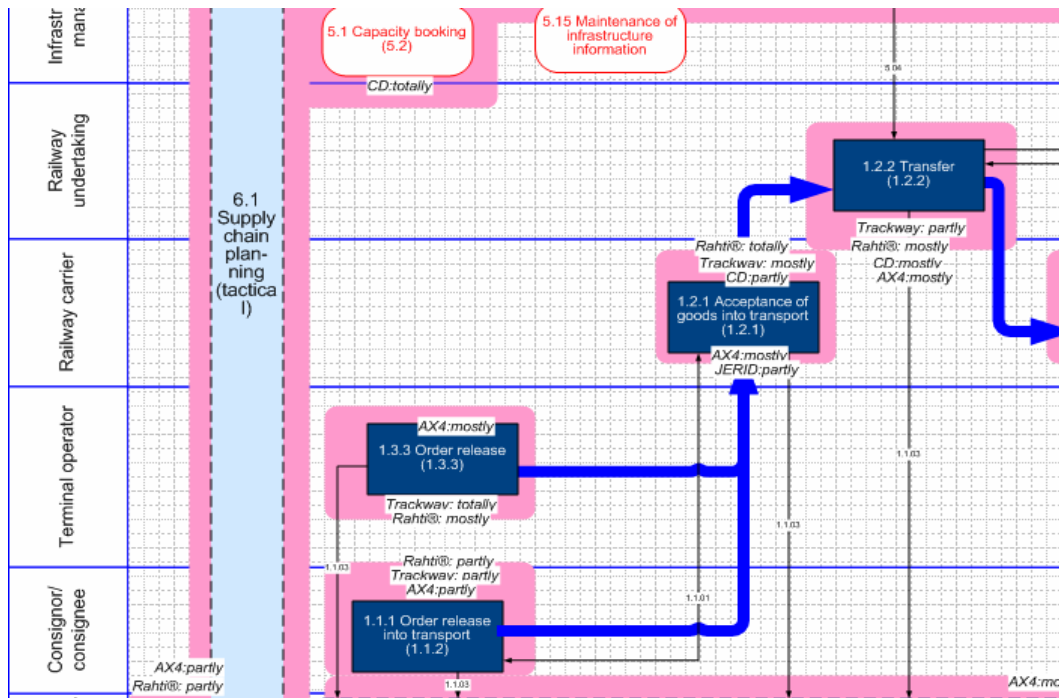


Figure 4 - Systems' coverage of business process – a clip [6]

Table 3 - Service Distribution Map - an excerpt; each character refers to a particular system [6]

Roles	EnvDataMgmt	MapServ	TrafficData	InfrastructureMaintTasks	RiskTLicenseMgmt	RiskTTracking	VehRegisterServ	LicenseMgmt	ContractMgmt	ResponsibilityMgmt	TimetableMgmt	TransportPlanMgmt	LogisticsOperationMgmt	RouteMgmt	ResourceMgmt	OrderMgmt	OrderReceipt	TimetableMgmt	GoodsAcceptanceMgmt	VehiclePositioning	VehicleMonitoring	VehicleMgmt	VehicleIdentification	HandlingInstructionsMgmt	WirelessIT	LoadingMgmt	VA Services Mgmt	GoodsReleaseMgmt	ShipmentMgmt	PartyIdentityMgmt	ExceptionMgmt	ExceptionReceipt	UnloadingMgmt	ReclamationMgmt	TrackingDataMgmt	TrackingDataMonitoring	TrackingTargetCreation	ParcelHierarchyMgmt	SupplyChainMgmt	ProductionMgmt	ProductIdentification	ProductListMgmt	ProductMgmt	WarehouseMgmt	TransshipmentMgmt	
Consignee							P	X	T R C A	T R	R P	T R A	R P C	R C				T A						T R P A				T R A	T P R A	T R A	R A	T R A							A	R				X		
Consignor	T	R	J	X			P	X	T R C A	T R	R P	T R A	R P C	R C				T A										T R A	T P R A	T R A											A	R			X	
Authorities			P	C	R	T	C	P	X	T R C A	R P	T R A	R P C	R C				R	C	J	R	P	C	A	T R P C A	R P A			T R A					T R A							A	R		R	A	
Infrastructure manager (road)			X	X				X	T R A	R	T R A	R	R						R	J			T R A					T R A												A	R					
Terminal operator (truck)									T R A	T R	R	T R A	R	R				T A									T A	T R A	T R A	T R A									T A	A	R			X	A	
Trucking company									T R A	T R	R	T R A	R	R	R				R	J	R	A	T R A			R		T A	T R A	T R A	T R A										A	R				

In Table 3 the characters refer to particular systems as follows: T = Trackway, R = Rahti®, A = AX4, P = PortNet, C = CD Telematika (the IT subsidiary of the Czech Railways that provide a range of system modules), X = no system available for mapping. Some quite relevant systems, such as JERID's [6], are not visible in the clip in Table 3.

CONCLUSION

Our first and foremost finding is that architecture can be used for commercial system “benchmarking”. Systems may be mapped and positioned in the architecture. If the architecture is based on business process descriptions and/or value chain descriptions, this mapping will position the system in the value chain. This is invaluable information to IT companies and system designers who can benefit from architectures in strategic ways, for example by

- seeing who are the potential users or beneficiaries of their system
- seeing how well the system satisfies different parts of value chain and business process
- identifying extension or focus needs in the functionality of their system
- identifying co-operation requirements or possibilities when other system providers offer supplementary systems.

Mapping proved that viable information systems, which can take care of intermodal logistics processes, do exist. The challenge is how to integrate different systems and make them inter-operable between different countries and operators. The fact that many times these actors have varying incentives and motives, does not make this task any easier. It is here where the difference between “real” and “ideal” world are to be found. However, “ideal” can be made “real” if actors clearly find common interests – this usually requires a strong champion to lead the work. This type of solution can already be found, e.g. the PortNet system of Finnish Maritime Administration that produces benefits for its multiple users and stakeholders [16].

On the basis of our use case, we believe that architectures have a clear *instrumental* function and value for commercial system providers as well as information service providers along intermodal chains. It appears that the public bodies should assume responsibility of building the architectures, as commercial actors are not benefiting from them very fast and the mandatory nature of architectures would not be emphasized if they were provided by commercial actors. However, sometimes large companies may enforce their architectures onto their suppliers and subcontractors.

For architecture people, especially the Finnish architecture owners (the Ministry and FMA), this case analysis of PolCorridor showed that architecture can be utilized also in ways that were not foreseen when e.g. TARKKI was built. The experience from the PolCorridor case also confirms the above conclusion that commercial actors seldom do this work by themselves, particularly when it comes to multiple actor IT problems. There needs to be an impartial party who is willing to study the system as a whole, such

as the PolCorridor supply chain, and then analyze how different parts fit into the whole architecture.

ITS policy and strategy implementation is easier with the help of architecture. Strategic investments in system development should be based on recognized needs for particular applications and how they are able to contribute to the value chain in a pioneering manner. Our use case implicitly shows evidence that there is a wide international need for certain systems.

Our overall conclusion underlines the managerial role of architectures. Architectures are not only the tools for “bit-wizards” but rather the contrary. Architectures are the tools to create deterministic behavior patterns for operational actors and they may be used in managerial target setting and performance evaluation processes. Our use case particularly demonstrates the usefulness of architecture to the “commercial IT manager” working in or providing services to international intermodal logistics.

ACKNOWLEDGEMENTS

We thank our project promoters in Finland: Ministry of Transport and Communications, Finnish Technology Agency, Ports of Helsinki, Turku, Hamina and Kotka, ProComp Solutions Ltd, Stockway Ltd and AtBusiness Communications Ltd. We also thank our partners in PolCorridor consortium and those companies who actively took part in PolCorridor IT work. Our good colleague, Research Scientist, Mr Jyrki Haajanen is acknowledged for useful comments on this paper.

REFERENCES

- [1] http://www.aino.info/haku1/AINO_Haku_Liite_3_040601.pdf. A contract clause, appendix 3 for AINO program projects (Liite 3 - Hankkeiden yleiset velvoitteet). In Finnish only. Read in November 12th 2004.
- [2] United States Federal Register: Rules and Regulations. Vol. 66, No. 5 / Monday, January 8, 2001
- [3] Highway Industry Development Organization. ITS Handbook 2004-2005.
- [4] <http://www.toi.no>, PolCorridor Project’s home page. Read in November 12th 2004.
- [5] Granqvist, J., H. Hiljanen, A. Permalä, P. Mäkinen, V. Rantala, A. Siponen (2003). Freight transport telematics architecture, final report. *FITS publications 25/2003*. Ministry of Transport and Communications Finland.
- [6] Alaruikka, A-M., P. Leviäkangas, J. Haajanen, J. Huotari, J. Kanninen (2005). Pol-Corridor – IT Systems. *VTT Research Notes 2302*. VTT, Finland.
- [7] *Planning an intelligent transport system – A guide to system architecture*. Why you need one and how to create it. Issue 2. <http://www.frame->

online.net/Brochures/ITS%20Planning%20Guide%20Issue%202%20.pdf. Read in December 13th 2004.

[8] Perrett, K. E. & Stevens, A. 1996. *Review of the potential benefits of Road Transport Telematics*. Transport Research Laboratory. TRL Report 220.

[9] Mäkinen, P., K. Ruoti, J. Lähesmaa, M. Lehtonen, J. Oinas, T. Ristola, K. Appel (2001). The National Transport Telematics Architecture – TelemArk. Description of the Architecture. *Reports and memoranda of the Ministry of Transport and Communications B 6/2001*. Ministry of Transport and Communications Finland.

[10] Mäkinen, P., J. Levo, J. Lähesmaa, P. Rautiainen (2004). Maritime ITS Architecture, Core Processes and Development Plan (Merenkulun telematiikka-arkkitehtuuri. Pääprosessit ja kehityssuunnitelma). *FITS publications 34/2004*. Ministry of Transport and Communications Finland.

[11] Natvig M., H. Westerheim (2004). ARKTRANS, The Norwegian system framework architecture for multimodal transport systems supporting freight and passenger transport. Version 3.0. *Sintef Report 2004-01-29*.

[12] <http://www.frame-online.net>. Mizar's home page. Read November 12th 2004.

[13] *National ITS Architecture* <http://www.iteris.com/itsarch/> and <http://www.its.dot.gov/arch/access.htm>. Read in November 12th 2004.

[14] *System Architecture for ITS in Japan* (1999). National Police Agency, Ministry of International Trade and Industry, Ministry of Transport, Ministry of Posts and Telecommunications, Ministry of Construction. November 5th 1999. http://www.its-jp.org/english/arch_e/index.htm Read in November 12th 2004.

[15] Leviäkangas, P., J. Lehtinen, I. Berg, A-M. Alaruikka. Pol-Corridor – Assessment of Demand for the Blue Shuttle Train's Services in North and South European Markets. *VTT Research Notes 2293*. VTT, Finland.

[16] Leviäkangas, P., R. Hautala (2002). Impact Evaluation of Maritime ITS – Case PortNet. *9th World Congress on ITS*, Chicago, October 14-17, 2002.