INFORMATION SYSTEMS INFRASTRUCTURE -

ENABLING THE DEVELOPMENT AND USE OF ITS

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SUMMARY

Intelligent Transport Systems and Services (ITS) is the concept used in the transport sector to describe how the new mobile information technology can be used to support the mobility of people and goods. An important feature of ITS-applications is their strong dependency of an infrastruture in order to be developed and used. This infrastructure can be divided into a technical part and an information systems part. The technical part consists of a wide range of technical equipment. The information systems part of the infrastructure is a network of actors, a number of information systems and communication standards. The aim of the paper is to describe the information systems part of the infrastructure and its enabling role for the development and use of ITS.

INTRODUCTION

Today there is a rapid development of information technology which can be used to support the mobility of people and goods. We have a rapid technological development which makes it possible to send and receive information to and from different mobile units, e.g. cellular phones and PDAs. The technology makes it possible for people who are on the move to use advanced IT-systems and services. These systems can be used in different mobile situations and for mobility management, i.e. for transport- and travel-management, and they are of interest because travel and transport activities are becoming increasingly important for industry and society.

Intelligent Transport Systems and Services (ITS) is the concept used to describe how the new mobile information technology can be used in the transport sector (1). The idea with ITS is that the services should bring extra knowledge to travellers and operators in order to improve transport activities. In cars, ITS is used to help drivers navigate, avoid traffic hold-ups and collisions. On trains and buses ITS is used for managing and optimising fleet operations and to offer passengers automatic ticketing and real-time traffic information. At the roadside ITS is used for co-ordinating traffic signals,

detecting and managing incidents and to display information for drivers, passengers and pedestrians. An important feature of ITS-applications is their strong dependency of an infrastruture in order to be developed and used.

The term infrastructure (2) is normally used for the stable structure of roads, harbours, railroads, airports, energy systems and telephone networks. This implies that the concept of infrastructure is often used for describing a basic physical and technical foundation for the production and distribution of products and services in a society. If we analyse the infrastructure needed to produce and distribute ITS-services we can see that it consists of a *technical part* which consists of a wide range of equipment e.g.:

- mobile units for communication, e.g. units which are built into vehicles, cellular phones and PDAs;
- wireless telecommunication, e.g. telecommunication and radio communication;
- positioning, e.g. Global Positioning Systems (GPS) and cellular phone triangulation;
- GIS-technology.

However an important part of the infrastructure consists of an *information systems part*, which consists of:

- information and databases;
- functionality that is used for accessing, manipulating and organising information;
- communication standards that facilitate the communication between different actors and information systems;
- actors who supply and distribute information and their responsibilities and roles.

I will refer to this second part of the infrastruture as the *information systems infrastructure (ISI)* in the paper, and the ISI should have an enabling function and be shared by a number of users and user groups. This means that the ISI should be designed to support a number of ITS-applications, it should not be tailored to one type of application or the needs of a particular user group. The aim of the paper is to describe the information systems systems part of the infrastructure and its enabling role for the development and use of ITS.

INFORMATION SYSTEMS INFRASTRUCTURE (ISI) – AN EXAMPLE

An example of an important part of the information systems infrastructure in the ITS-sector in Sweden is the National Road Database (3) which is known by its swedish abbriviation NVDB. In a research project we have evaluated and analysed the NVDB (4), and the analyses show that there are already a number of databases, both at the local and national level, that contain information about the road network:

- The municipalities of Sweden store information about the roads and streets in the cities.

- The SNRA keep information about the national roads that connect the cities.
- The National Land Survey Administration (NLS) keep information about the national roads and location based information.
- The forest industry keeps information about the forest roads.

The problem is that these databases contain only bits and pieces of the road network information needed in order to develop ITS-applications. For example, a service provider who wants to develop a navigation system or a fleet management system got to have access to information about all types of roads. This implies that there is a need for integrating data about all roads in the NVDB-database. To accomplish this the road network information has been standardized with the help of the road network model (see figure 1 below). The road network model describes the roads in terms of nodes and links, and the structure of the NVDB-information is based on this topological description of the road network.

Node
A
B
C

Link ID	Start Node	End Node
Link 1	A	B
Link 2	B	C

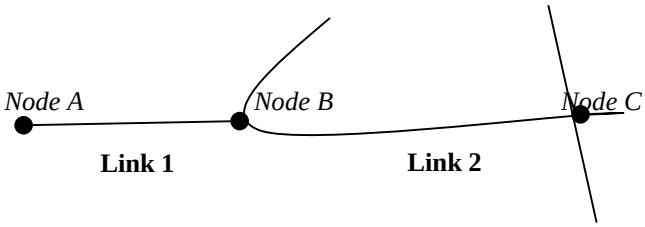

Figure 1 The road network model

The road network model is the bases for a national standard for exchange of transport network and location based information that will enhance the possibilities integrate the road work information and to relate the NVDB-information to other information in a standardised way. This is important because virtually all transport and traffic information is dependent of location, and the NVDB-information has to be combined with other information systems and databases to really be useful. For example a fleet management system used by a truck driver could contain information which is described in figure 2 below.

Transport order

No : 1987987

Customer: Lars Ek

Delivery address: Kungsgatan 50

Town: Stockholm

Traffic message

Date: 2001-11-14 Time: 12:01

Type: Accident

Place: E 4 on Essingeleden Stockholm between Fredhäll and Stora Essingen.

Message: Traffic accident, one lane closed in direction Stora Essingen.

Figure 2 A fleet management system which combine business information, transport networks and traffic, based on location.

In this case we have:

- a transport order which tells the truck driver where to deliver the goods*;*
- transport network information which show information about the roads;
- a traffic message which tells the driver that there has been an accident.

This implies that a service provider who wants to develop this system have to combine the transport order of the freight company where the truck driver is employed, with NVDB-information, address and traffic information.

Figure 2 also illustrates that information about locations is a very important for ITS-applications. In this case we have a transport order which tells the truck driver the *location where to deliver the goods, the location is also represented with a cross on the map*. We have transport network information which is *location based* because the road is located in the landscape. Furthermore there is a traffic message which tells the driver that there has been an *accident on a certain location on the road.* From the figure it is important to notice that information about locations is not only something that has to do with coordinates (5). We also use geographical identifiers (6), e.g. names of places and addresses. In figure 2 above we can see that adress information, e.g. "Kungsgatan 50" and names of places, e.g. "Essingeleden", "Fredhäll" and "Stora Essingen" are used.

"Essingeleden" is a road in "Stockholm" and "Fredhäll" and "Stora Essingen" are names which are related to certain places on that road.

This implies that the NVDB together with a number of other databases, e.g. databases which contain information about names of places, postal and street addresses and traffic information constitutes an important part of the ISI in the ITS-sector in Sweden.

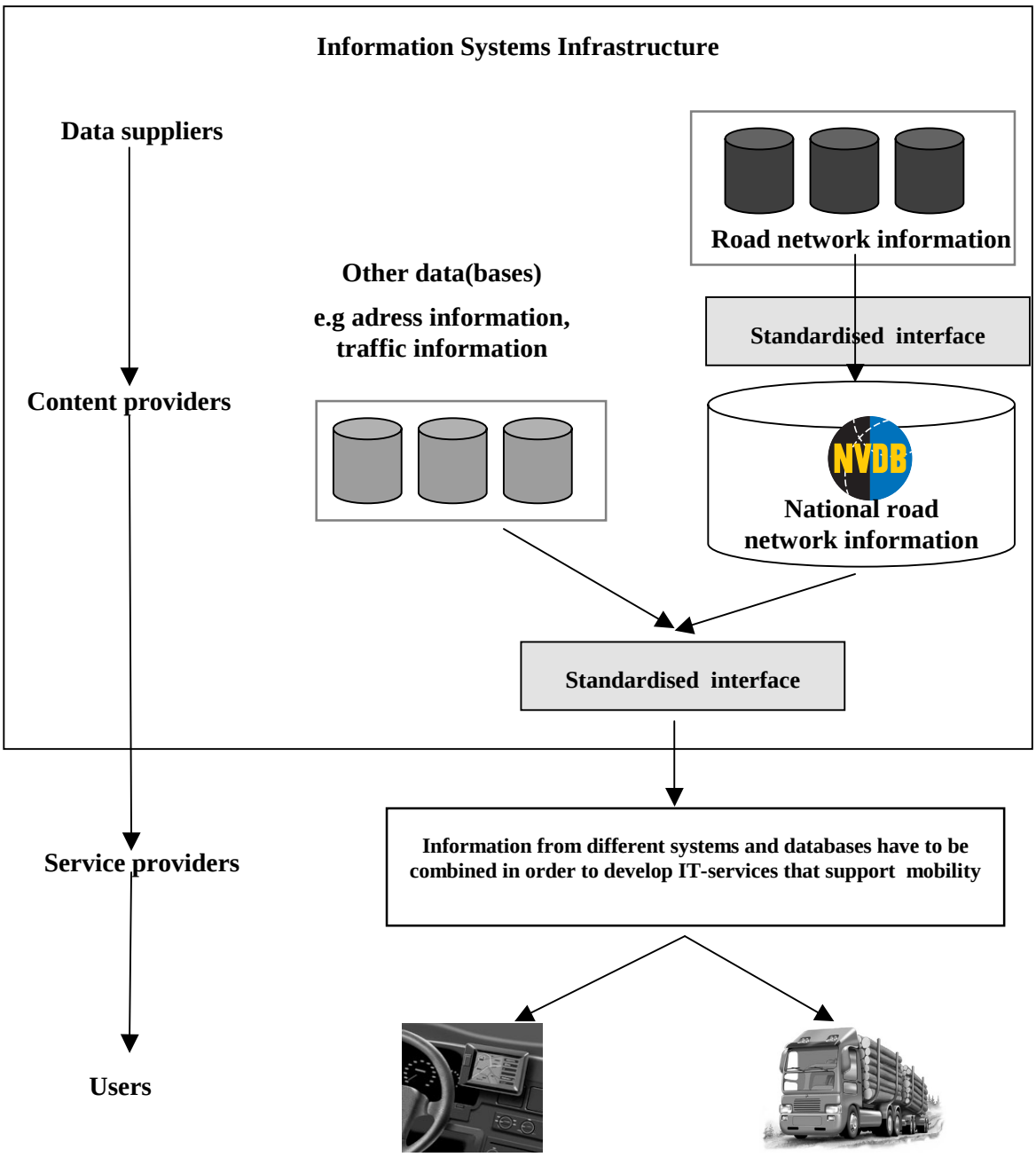

Figure 3 The NVDB is a part of an ISI that is a prerequisite for a number of ITS-services

This means that the ISI is composed by a number of subinfrastructures which should be connected and interrelated. The things listed below are important features of the ISI (see also figure 3 above):

1. Information about the road network, address and traffic information.
2. Functionality used for communicating the information between the data suppliers in the data acquisition process.
3. Functionallity used for communicating the information to service providers and users.
4. Standards, e.g. the network road model, which are used to facilitate the communication of information between different actors, business units and information systems.
5. The responsibilities and roles of people, business units, organisations and institutions who supply and distribute information, e.g. data and content suppliers.

The ISI is important for the development and use of ITS because without such an infrastructure it will be difficult to develop applications in an efficient way, and to get services which contain high quality information.

ORGANISATIONAL NETWORK CO-OPERATION

The development and maintenance of information systems infrastructures implies that a number of actors have co-operate because there is not a single actor who got access to all the resources needed. This implies that a typical feature of information systems infrastructures is that several private companies and authorities have to co-operate in a network organisational context. Co-operation in such a context is built on communication and relationships between different actors (7). This implies that the development and maintenance of the ISI has to be understood as acts of co-operation in a large and complex organisational network. Such processes can be coordinated (the SNRA in the case of the NVDB), but not controlled, by a single actor as the driving force, and the expected effects from these types of processes are more problematic to anticipate. Another important aspect to consider is that it takes time to develop large infrastructures, and as time passes new requirements appear, and it is important that the ISI is organized in a way that it can adapt to new requirements (8).

This implies that the network cooperation has to be organised based on an evolutionary long-term perspective and a number of basic principles and responsibilities. For example, the *data aquisition process* of the NVDB is built on the basic idea that the core NVDB-organisation has the responsibility to standardize, receive, store, and integrate data in the NVDB-database. The NVDB-organization is also responsible for making formal agreements with the data suppliers that govern the data acquisition process. But the NVDB-organisation does not have their own personal to perform the data acquisition process, this is the responsibility of the data suppliers which are the road managers, and involve people at the SNRA, the NLS, the municipalities and the forest industry.

It is important to learn more about how information systems infrastructures should be developed and maintained because these are complicated cooperative processes. To be able to understand the complexity of these co-operative processes it can be fruitful to analyse them from a network organisational perspective which is discussed in network relationship theory (9). In this theory it is emphasized that business processes are per-

formed in a complex network of interorganisational relationships between several interacting companies and organisations. The network theorists also claim that actors can influence the development of the network but that the network is too complex to be controlled by a single actor. This implies that the development processes that take place in a network organisational context cannot be seen as a structured design process that is controlled by a single company or actor. It can be better described as a process of *evolution* and *dynamics*.

If we consider the *evolution aspect*, it is important to realise that evolution takes time and that the effects from a specific development activity is not possible to fully anticipate. This means that it is important to emphasise the long term perspective of the development and use of the ISI. The *dynamic aspect* of the development process concerns the web of actors and their interests, which can influence the development and maintanence of the ISI. The development of the ISI will e.g. depend on how many actors that are interested to partcipate in the network cooperation, and the more actors who partcipate in the development and maintanence of the ISI the more valuable it will be. This can be exemplified with the NVDB. If only a few of the 278 municipalities will deliever data, and adopt the standards which is used for communicating the road network information, the value of the NVDB will be limited.

STANDARDISATION

Standardisation is a very important part of developing an ISI, because different elements are integrated through standardisation (8). In the ITS-sector the use and implementation of standards is important because there is a need for standards that promote high quality and effective communication between actors, companies and information systems. This implies that communication standards are a necessary constituting element of the ISI. In order to develop ITS-applications it will be important to be able to combine information from different systems and databases. To be able to do this it will be necessary to standardise the interfaces between different systems and databases. This is the reason why a lot of money and work have been spent on the development of standards in the ITS-sector.

For example the NVDB-project is not only a project where a database is developed. The project has also has made an effort to standardise the information management of road network information. This standardisation effort includes both a common information structure, the road netork model, and methods for managing changes of network based geographical information.

Examples of other standardisation initiatives in the ITS-domain are the KAREN-project (10), the work done by the ISO/TC204 (11). The KAREN and ISO/TC204 initiatives are focused on how to promote information exchange between information systems, people and organisations.

Within the area of location based and geographical information standardisation projects are conducted by ISO/TC211 where e.g. standards for geographical identifiers and location referencing have been developed (6). The standards in the area of location

based information is of great interest for the ITS-sector. The reason for this is that ITS-applications are heavily dependent of location based information and how to make geographical references.

The development, use and implementation of standards is essential in order to develop an ISI. However the development of standards can be quite complex, the network of actors have to negotiate and make agreements which can be a slow and complicated process. There is also a tendency of trying to build to global standards which tend to be to complicated to understand and use. In two research projects we have investigated the use of national and international standards in the ITS-sector (12, 13), and we found that there is a lack of knowledge how to use and implement the standards. One problem is the lack of knowledge of how to implement standards in the practical business and systems development process. Another problem is that standards are quite comprehensive and that the support for implementing them can be rather limited. There is e.g. a lack good handbooks and IT-tools to support the use of standards. It is important to solve these problems because the value and adoption of a communication standard is to a large extent dependent of the number implementations and users of the standard. The fundamental mechanism supporting this adoption process is that a large installed base makes the standard cumulative more attractive. The more installations the more users and information systems can communicate with the help of the standard, and this will be attractive for new users. This positive feed-back loop is illustrated with figure 4 below.

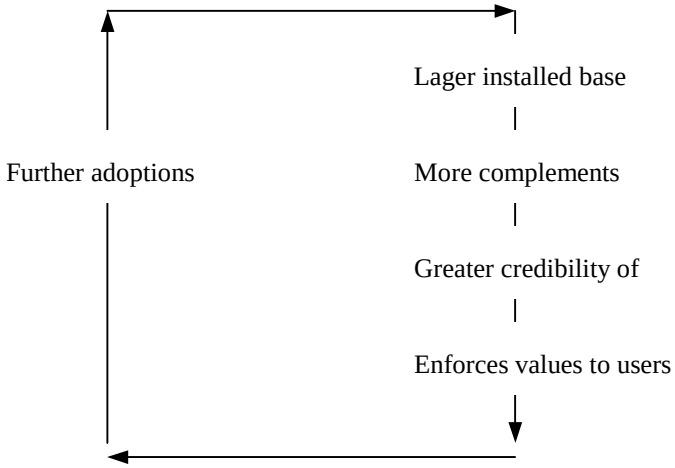

Figure 3 Standards reinforcement mechanism (14)

CONCLUSIONS

In the paper the concept of information systems infrastructure in the context of ITS has been discussed. When we talk about transport and travel activities the term infrastructure is normally used for the physical structure of transport network. However ITS requires an infrastructure which consists of the information about the transport network and information which is related to the transport network. The ISI is a network of actors, a number of information systems and communication standards.

There are three important features which characterize the ISI:

- it should be integrated with the help of communication standards;
- it should be shared by a number of users and user groups;
- it should have an enabling function.

It is important to emphasize the importance of the ISI for the development and use of ITS because without such an infrastructure it will be difficult to develop ITS-applications in an efficient way, and to get services which contain high quality information. The information structures and the communication standards of the ISI will also be sustainable over a long period of time which implies that they will influence how applications can be developed and used although the technology changes. It is also important to focus on the ISI because the development and use of ITS is often discussed from a technical perspective, and focused upon the technical infrastructure. Although the technical part of the infrastructure is important, and the technical part and the information systems part are interdependent of each other. It is essential to acknowledge that problems concerning the development of the infrastructure needed for ITS to a large extent is a business, organisational and institutional issue. This is also something which have been experienced in the NVDB-project. A key issue to succeed with this project is to be able to motivate all the actors which have to cooperate to really make a cooperative effort, and to create the institutional prerequisites and principles to enable the network cooperation which is needed.

REFERENCES

(1) Ertico (2001) *What is ITS* [WWW document] www.ertico.com/what_its/what_is.htm.

(2) Gurlanik D. B. (ed., 1970) *Websters New World Dictionary of the American Language*, New York: The World Publishing Company

(3) Lundgren, M-L (2000) The Swedish National Road Database – Collaboration Enhances Quality, *Proceedings of the Seventh World Congress on Intelligent Transport Systems*, 6-9 November, Turin, Italy

(4) Eriksson O., Axelsson K. (2001) *The Swedish National Road Database – Analysing governing principles for an Information Systems Architectures*, *Proceedings of the Eight World Congress on Intelligent Transport Systems*, 30 Sep – 4 Oct, Sydney, Australia

(5) Couclelis C. People Manipulate Objects [Cultivate Fields] : Beyond the Raster-Vector Debate in GIS, *Theories and Methods of Spatio-Temporal Reasoning in Geographic Space : proceedings / International Conference GIS - From Space to Territory: Theories and Methods of Spatio-Temporal Reasoning*, Pisa, Italy, September 21 - 23, 1992

(6) ISO/DIS 19112. *Geographic information- Spatial referencing by geographic identifiers.* [WWW document], URL http://www.statkart.no/isotc211/scope.htm#19112

(7) Hanseth O. (2000) Infrastructures- From systems to infrastructures, In Braa K., Sörensen C., Dahlbom B. [eds.] *Planet Internet*, Studentlitteratur, Lund, pp. 179-216

(8) Hanseth O. (2000) Information Technology as Infrastructrure, Doctorial thesis, Deaprtment of Informatics, Göteborg university, Sweden

(9) Håkansson H., Snehota I. (eds, 1995) *Developing Relationships in Business Networks*. Routledge, London

(10) Bossom R.A.P., Jesty P. H., Shultz H-J., Avontuur V., Galliet J-F, Franco G. (1999), *KAREN Framework Architecture – Overview, D3.6*

(11) ISO/PDTR 14813-1 Transport Information and Control Systems – Reference Model Architecture(s) for the TICS Sector – Part 1: Fundamental TICS Services

(12) Eriksson O. Axelsson K. (2000) ITS Systems Architectures - From Vision to Reality, In *Proceedings of The Seventh World Congress on Intelligent Transport Systems*, Turin, Italy, November 6-9, 2000.

(13) Forsman A. (2001) *Standardisering som stöd för informationssamverkan i samband med trafikinformation*, In Swedish, Högskolan Dalarna, Borlänge.

(14) Grindley P. (1995*) Standards, Strategy and Poli*tc., Cases and Stories New York: Oxford University Press.