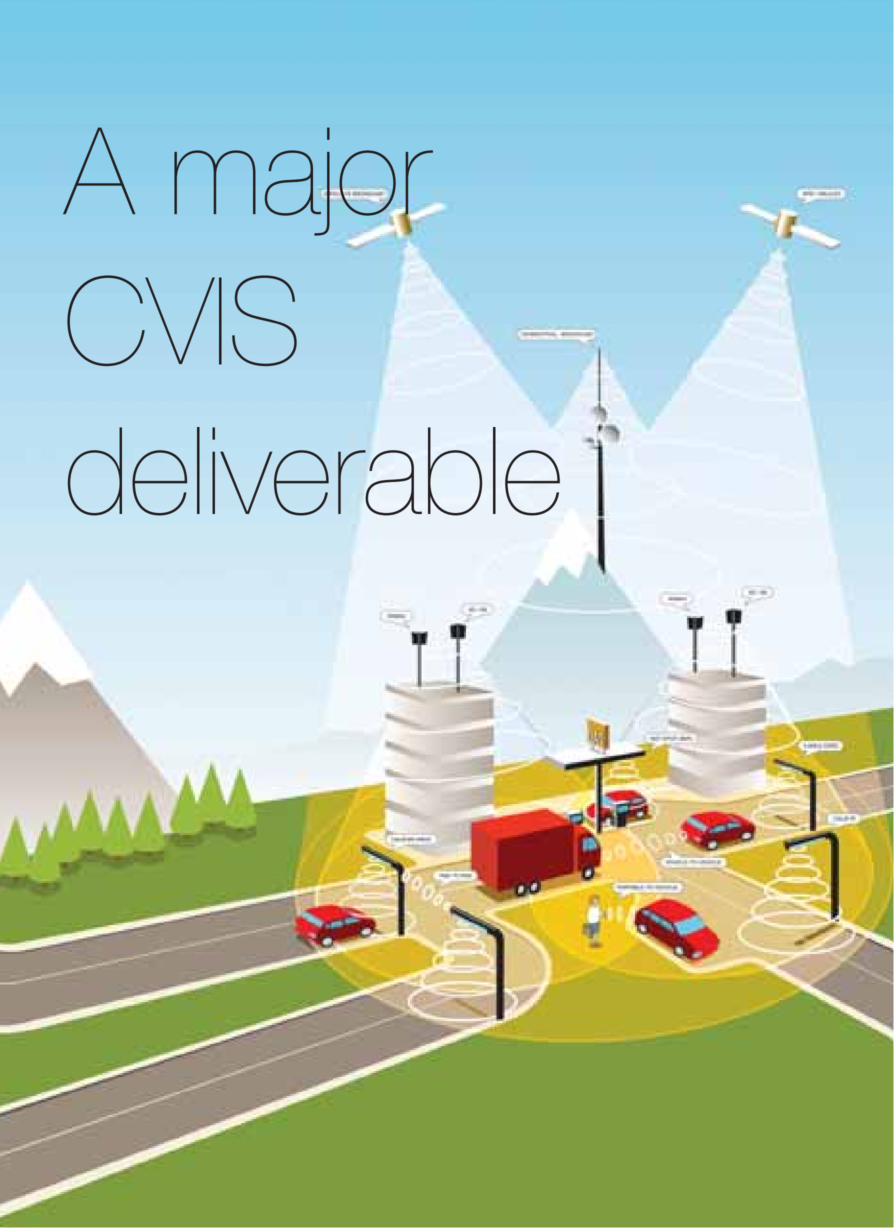
A major CVIS deliverable



Q-Free produced a booklet, 'CVIS - Helping vehicles and infrastructure co-operate' for the 2007 Aalborg ITS in Europe Congress. Copies are available from Marit Hammer, email Marit.Hammer@q-free.com

The CVIS (Co-operative Vehicle-Infrastructure Systems) project was launched in February 2006 to develop a platform which would allow vehicles to communicate and co-operate directly with other nearby vehicles and with roadside infrastructure. The first deliverable of this major endeavour, involving some 60 partners, is the publication of the CVIS high level architecture which, unlike many of today's information systems, will not become outdated when new technologies arrive.

A report by Andreas Schmid and Zeljko Jeftic

The classic road setting with which we are all familiar is furnished by roadside, vehicle and service ITS applications which have all been developed quite independently. If these ITS applications are to fulfil their potential in the future, however, a much greater degree of interactivity is required and that means initiating a common approach to transportation and safety issues.

To achieve this, two major barriers have to be overcome. The first is the fact that the emerging co-operative market, which spans all stakeholders, is expected to change more dynamically than any currently deployed roadside or vehicle hardware or software will. The second is that the specificities of regional markets will have to be recognised and managed.

To support both business and technical requirements, common ideas are needed. These are the concepts which are being addressed by the CVIS core technology sub-projects FOAM (Framework For Open Application Management) and COMM (Communication And Networking). They include:

- How to implement communication between mobile (vehicles) and non-mobile system parts, such as the road side infrastructure or service centres.
- How to achieve a flexible software deployment, which will support the life cycle management of software.

The CVIS communication approach

CVIS is developing technologies that link 'always on' communications partners over the IPv6 network, the new version of the Internet Protocol currently deployed. Since the mobile system parts may use different media (eg 3G communication, WiFi, DSRC, Infrared) the management of these 'channels' under the IPv6 communication layer is being built by COMM using the CALM specifications.

Special features are needed in a co-operative ITS environment. Besides peer-to-peer IP connections, in which the dedicated communication partner is known at system configuration time, dynamic approaches are also needed. Features such as broadcast or geocast allow a large, unspecified number of communication partners in a region to be addressed depending either on the broadcast channel reached or on the specified geographic area. However, more detailed capabilities are also needed to resolve an address for communication partners. A Distributed Directory Service allows similar applications to be discovered within a specific or neighbouring geographic region.

The CVIS approach for deploying software in the world of co-operative systems

Both mobile and fixed system parts are confronted with the need to adapt their capabilities either over time and/or over a greater geographic area when moving. Therefore, the software deployment technology must support the management of the software parts' life cycle more dynamically than is the case today - currently, changes after design time and implementation of hard and software are rarely possible.

Mechanisms for flexible software download and management as provided by JAVA/OSGi provide the basis of the solution developed by CVIS. This basis must be extended to fit the needs of co-operative systems. Arbitrary system changes through downloads would be a stakeholder's nightmare, so all system parts wishing to benefit from this flexibility – called 'CVIS host' in abstract – must participate with the help of their assigned host management centre. Stakeholders can operate host management centres, which allows them to influence the process according to their needs and constraints. Host management centres know the status of their assigned hosts and permit or deny software and configuration changes. CVIS also foresees dynamic mechanisms in which hosts can obtain updates or new software on the fly, remotely if needed (and permitted).

The following over the page shows three hosts; nomadic, roadside and in-vehicle, which usually communicate in the CVIS IPv6 way (blue lines symbolising the information flow). If needed, new software (applications) can be deployed through host management centres. Each host must be related to exactly one host management centre that is under the control of a governing organisation. The software applications may come from an ordered software supplier or – as shown – from a service provider wishing to deploy a new service.

JAVA/OSGi also figures as a "middleware layer" for applications, separating communication infrastructure and specific hardware from the applications themselves. CVIS extends this middleware with the basic functionalities (the project calls them 'facilities') needed inside cooperative systems such as the DDS or previously introduced remote management, or functions for communication, security etc.

Not all applications can be expected to be deployed as JAVA/OSGi bundles. Codes may already exist in native, or special real-time requirements which make it impossible to use JAVA. For such constellations native interfaces need to be integrated to allow other (JAVA) applications to use the native ones.

Many applications need to interface with the sensors and actuators of vehicles and roadside infrastructure. Therefore CVIS FOAM provides a mechanism called a 'local device tree'. This concept follows the specification of the open mobile alliance (OMA) device management tree. All status information is made available in a tree-structure which applications are able to browse through. To make this possible, vehicle OEMs and roadside system manufacturers can use this CVIS local device tree and implement it next to a gateway to their system.

Possible CVIS applications

Within CVIS, the CURB (Co-operative Urban Applications) sub-project is defining applications for the CVIS system focusing on urban areas. It addresses three main user groups, the driver ie the actual road user, the traffic manager or traffic operator and the public transport manager, and has identified three main areas of interest, traffic control applications, traffic management applications and public transport applications. The objective is to identify those applications which would benefit from enhanced co-operation between vehicle and infrastructure.

The main users identified by the CINT (Co-operative Inter-Urban Applications) sub-project, include the driver and traffic manager but also the traveller who has yet to start their journey and focuses on trip planning applications and 'ghost driver' detection where vehicles are travelling in the wrong direction through the road network. Once again, the emphasis will be on establishing reliable and accurate communications between vehicle and road infrastructure as well as service providers and central services such as the traffic management centre.

CF&F (Cooperative Fleet and Freight Applications) is a sub-group which has been set up to assess and demonstrate the benefits of co-operative systems between vehicle and infrastructure for traffic efficiency and road safety in the field of freight transportation and fleet management. Three priority applications have been identified, dangerous goods applications including monitoring and guidance, parking zones applications including urban load and highway parking slot management and access control applications relating to sensitive infrastructure.

CVIS Communication and Networking (COMM)

The scope of the COMM sub-project comprises the communication-relevant components and protocols in CVIS. COMM is ensuring seamless and continuous communication from the vehicle towards the infrastructure and other vehicles. The connection is transparent to the applications and supplies socket communications for more demanding applications. Assignment and management of the communication media should be completely beyond the responsibility of the applications. COMM is developing the CVIS communication system based on the new standards for hybrid mobile networking from ISO, IEEE, IETF and ETSI.

The CVIS COMM air interface is based on several communication channels such as GPRS, UMTS, M5 (mobile Wi-Fi) and IR (Infrared). The technology will use policy-based rules to select the optimal communications channel at any time and place. COMM is a network concept in which all CVIS devices both in the vehicle and in the infrastructure are connected via the mobile version of the newest Internet Protocol (mobile IPv6).

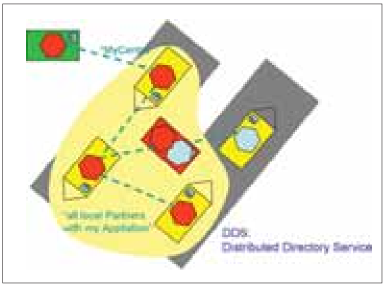
The three main objectives of COMM are to:

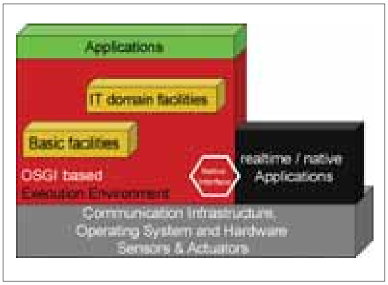
- Specify and implement a communication system that fulfils the requirements set by the community of co-operative systems developers and users. The communication subsystem mainly consists of vehicle and roadside CVIS wireless routers with the necessary air interfaces, including software for operation and management.
- Make the communication system available as a prototype device to the various test beds and field trial sites during the project, and later as open reference designs through open source IPR agreements. This portable prototype device is called the Integrated Communications Execution Reference Platform.
- Provide a continuous two-way contact with the relevant ISO, ETSI, IEEE and IETF standardisation groups so that by the end of the CVIS project, European and global standards are matched as closely as possible to the CVIS open reference designs.

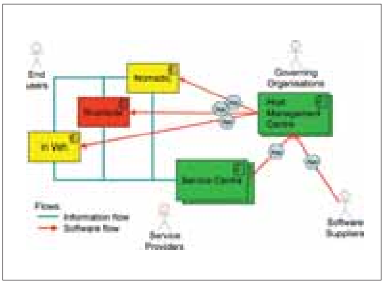
COMM proposes the creation of a fully open reference communication system that can be optimised or directly ported into commercial products for vehicles and roadside systems. This reference communication system should also form the basic communication platform for other European ITS projects (SAFESPOT, COOPERS, SISTER), and close coordination with these projects is necessary!

CVIS Framework for Open Application Management (FOAM)

The FOAM sub-project aims to create an open execution environment in which CVIS telematics applications can be developed, delivered, implemented and maintained. For this, FOAM has defined an architecture that connects in-vehicle systems, roadside infrastructure and back-end infrastructure. In this architecture, applications can be deployed remotely to the execution environments on the different hosts in the vehicles, roadside units and central loca-







From the left: Distributed Directory Service; managing the interface with native applications; and the fact that all hosts must be related to exactly one host management centre

tions. The execution environment is an OSGi environment enriched with additional services that are necessary for co-operative management of transport safety and efficiency. In the near future, working reference implementations will be developed and put to the test in several test sites running different applications. These demonstrations will show that the FOAM architecture forms a solid basis for development and deployment of cooperative ITS applications.

CVIS Cooperative Monitoring (COMO)

The COMO sub-project aims to deliver a specific set of traffic related data to any CVIS application. A selection of possible applications is described by the CINT (Cooperative Inter-Urban Applications), CURB (Cooperative Urban Applications) and CF&F (Cooperative Fleet and Freight Applications) sub-projects (see box). The idea is that due to the defined availability of specific data sets, the development of a market for traffic services in an open systems environment can be strongly supported, due to the fact that the technical conditions under which data can be accessed have already been defined.

According to the current status, COMO will provide the following data groups:

1) Vehicle sensor and/or processed data (such as XFCD/EFCD)
2) Roadside Unit (RSU) sensor and/or processed data (such as loop or weather sensor data)
3) RSU local traffic status overview for the geographical area around a given RSU
4) Traffic centre traffic status overview for the geographical area covered by a given centre

COMO is set to furnish high-quality data to provide information with a high trust value. Thus, the core of COMO will be data fusion processes which guarantee that, wherever available, data from different sources – such as vehicles passing an RSU – will be used to provide the best possible quality of information.

In addition, COMO will provide information on different levels, such as for the RSU and centre. As an example, a given RSU will provide a local traffic status overview that contains more detailed information than the traffic centre's overview of the relevant area. This could concern traffic queues at the stoplights or turning rates at intersections that are provided by the local traffic status overview of an RSU. In comparison, the traffic centre's overview might not contain data at a per-lane level.

Due to the IPv6 functionality provided by the COMM sub-project, it is generally irrelevant where COMO data sets are physically stored, since they can be accessed from any platform, anywhere, at anytime. Nevertheless, COMO makes the distinction between specific platform types – namely vehicle, RSU and centre – to illustrate the different types of COMO information available to CVIS applications. As mentioned above, COMO will fuse data from different sources and provide different data sets according to each platform type.

Because the COMO data set defined within CVIS is based on the requirements of the applications at hand, the COMO data set will be extensible in order to cover future sensors and information. In addition, CVIS allows for a wide area of applications to be defined in the future.

COMO architecture

The most important challenge for any CVIS application is how to access the COMO data. COMO will provide all data sets via a standard query interface that can be accessed by the CVIS applications. This application programmer's interface (API) is connected to the local dynamic map (or a similar data base and/or data tree) which holds the COMO data. The local dynamic map (or LDM) is a concept of the SAFESPOT project which focuses on safety relevant data sets and could be used by both projects. The LDM will be enriched by COMO data to form the bridge between the concepts of both projects. Additionally, CVIS applications can rely on subscription mechanisms which will provide COMO data according to specific rules, ie if new data sets of a specific kind become available.

Another aspect to be addressed is how the data is 'produced' by COMO. Within CVIS, COMO will implement processes to produce COMO information from the sensor data provided on the platforms from the vehicles, RSUs and, possibly, traffic centres. In addition COMO data sets may be provided by the existing systems directly, such as by EFCD messages. It is, however, up to each OEM to decide which sensor and processed data will be made available on its specific platform - such as a specific vehicle model - once the system is widely deployed on the road. COMO will also provide specific data fusion processes for various data sets, for example to fuse EFCD messages with each other or EFCD messages with local traffic information in a RSU. These algorithms will further be exchangeable, since new algorithms may arise in the future and could benefit the quality of the COMO data even further. Thus, COMO will clearly define the interfaces towards those algorithms.

As liability aspects are crucial for certain applications that access the functionalities of the existing systems, for example if the green-time-cycle were to be changed, it is specifically foreseen that the owner of the existing system is responsible for the connection between the relevant CVIS application and the existing system, such as an RSU. Concerning the data structure and methodologies, existing and emerging standards will be considered in order to guarantee a wide applicability of COMO data without re-inventing the wheel.

Conclusions

Since the CVIS project originates from the transport sector, COMO is a logical conclusion for the CVIS system given that it provides traffic-related data sets on which applications can rely. However, COMO is only relevant for transport sector applications, and CVIS is supplying much more than that! Its potential for fields of applications in the entertainment, communication and convenience sectors, just to name a few, is still to be explored once CVIS is more widely available.

CVIS is a four-year European ITS project with a budget of €41 million, roughly 50% funded by the EU. CVIS is co-ordinated by ERTICO – ITS Europe. You can visit the CVIS project website at www.CVISproject.org

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