Standardized datacommunications and information exchange;
a requirement for the integration of Motorway Management Systems.

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SUMMARY

The term "islands of automation" applies to the present generation motorway managements systems. From a users point of view the need for system integration on the short term is identified. It is emphasized that standardized communications and information exchange between systems is a key factor for both the integration of present systems and the migration to a new generation systems that will comply with an ITS architecture. Industrial automation had gone through a similar path ten years ago. It is indicated what lessons can be learnt from that field concerning the development and deployment of communication standards. Finally the OM/RR-protocol is described. This protocol is based on current standards but is less complex and easy to adopt without doing concessions to flexibility. It will be used for the integration of Dutch motorway managements systems in the first place.

INTRODUCTION

Present motorway management systems show typical characteristics of island automation: it concerns application specific system development, resulting in single vendor solutions with no provisions and support for inter system communications. This applies to systems for automatic incident detection, early ice warning, route information, parking management and so on. From a historical point of view the development of dedicated systems is understandable, since there was no common architecture as basis for application development. Anticipating to the adoption of an ITS architecture a long migration period must be faced because of the economic depreciation of current systems and the time to market for the new generation systems.

The first section of this article identifies the need for integration of motorway management systems from a users point of view. A distinction is made between functional and lateral integration.
Development and use of communication standards is a key factor for successful systems integration on the short term, and for adoption of an ITS architecture on the long term. The second section of this article identifies similar developments in the field of industrial automation. In this field the limitations of island automation had already been recognized in the early eighties, but the adoption of open concepts and solutions is still not widely spread amongst users. It is indicated what factors contribute to a slow and uncertain adoption process and what can be learnt from it.
The third section describes a communications protocol for the control of, and information exchange between motorway management systems. The protocol is based on object oriented application protocols such as ROSE, CMIP and MAP/MMS, but it is much simpler and will be implemented on top of proven TCP/IP networks.

FUNCTIONAL AND LATERAL INTEGRATION

In the present situation motorway management systems are each equipped with operator interfaces tailored for the specific purpose. One management area is covered by several system types and consequently traffic operators and managers have to be acquinted with several user interfaces for system control and information display. A common user interface concept is missing.
It is expected that management areas will become larger in the near future. Overviews of these areas will be needed (by means of digital maps), and meanwhile operators must be able to zoom in at smaller selected areas. Unfortenately these areas will be beyond the scope of the individual motorway management systems, while digital maps are vendor specific and cannot be exchanged between systems.
A solution for these problems requires an integration system that offers access to the functionality of individual motorway management systems via one uniform user interface (functional integration), and that provides one view on the motorway network without the revealing the geographical boundaries of the individual systems (lateral integration).

The Operator Support System (1) will provide the desired integration. Basis for optimal flexibility is an open protocol for communications between the OSS and the individual motorway management systems. It is called the OM/RR-protocol. Currently this protocol is in development at the Dutch Rijkswaterstaat. However, it is known that protocol development and deployment is no sinicure and that it should not be underestimated. Therefore the next section first presents a flash back to similar experiences in the past, and it is summarized what can be learnt from them.

RELEVANT DEVELOPMENTS IN THE PAST

The construction process of international and industry standards

International standards tend to be comprehensive and complex. Many bodies have to agree on offered services, consequently resulting in a slow process of standardization during which the draft standard only on exists on "paper". The process can be characterized as top down with initially no feedback from pilot implementations. The resulting standards are conceptually better, provide sophisticated services, and are more flexible than industry equivalents. Although users appreciate these advantages, they are finally in favour of industry standards because of the availability of tested products, full vendor support, and short system integration periods. Industry as well as de-facto standards arise bottom up from a direct and practical need. From the early start implementations are available and the construction process is iterative.

When planning to construct a new standard one should apply both a top-down and a bottom-up approach. First establish a flexible but simple concept by focussing on what is really required in practice, rather than on what can be required in principle. The concept should be generic, not deterministic. Next define pilot-projects in operational environments which aim at filling in the details, user participation and demonstration. The advantages of early adoption are two-fold;

- Attention focusses on fulfilling user needs rather than on construction of a perfect standard in the first place.
- An installed base with actively involved users is created from the start which will benefit the adoption of the future standard.

Industrial automation

Industrial process and production automation are sectors with a history of island automation. Early eighties General Motors recognized the need for communication standards as a means to achieve system integration and to overcome the islands of automation. Final goal was to achieve communications between multivendor industrial systems (computers, robots, numerical controllers etc). This would be the basis for an open system market, in contrast with the current market of vendor specific total solutions.

Initially GM put much effort in specification of the Manufacturing Automation Protocol (MAP). On one hand this standard prescribed the use of an expensive and unknown local network in a time in which computer networking was still evolving. On the other hand MAP specified a set of complex and comprehensive communication services, called the Manufacturing Message Specification . Evaluating the history of MAP over the past fifteen years, it can be noted that both aspects slowed down the adoption of MAP amongst users and vendors. Moreover the MAP-community did not recognize the need for a gradual migration path in time, i.e. the path to migrate from a current situation of island automation to open system environments. In a technical perspective the gap between proven vendor specific systems and open MAP-systems had to be filled in with migration products. It was not until both suppliers and users faith in MAP was already declining that those products became available. Current investments were not preserved in time, and up to now it can be observed that the world wide installed base of MAP/MMS-networks is relatively small.

Lessons learnt from standardization efforts in the production industry in the past, may also apply to the field of traffic management (systems) in the near future;

- Keep communication services as simple as possible, and base their specification on what is really needed.
- Concentrate on the upper protocol layers by selecting proven and well supported networks for the lower layers.
- Consider protocol development as an iterative process with feedback from operational sites from the start.
- Identify a migration path to preserve current investments cq. systems.
- Hurry up! The construction and adoption process of a (potential) standard is not only a technical issue. It is also a matter of driving force and faith. Suppliers and users will be patient, but when this process takes too long the wheel won't start running.

THE OM/RR-PROTOCOL

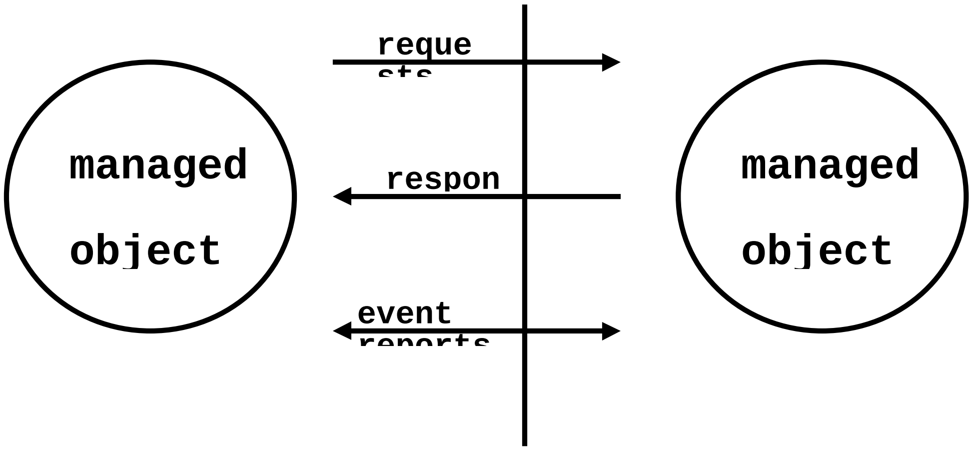
The Request Response (RR) protocol is based on an object oriented communication model. The Object Management (OM) protocol is specified on top of the RR protocol. The OM protocol enables a managed object in one system to consult and to control managed objects in another system, and it enables the exchange of event reports. This section describes the object model and the concepts of OM/RR layering.

The object model

From a conceptual point of view, a managed object in one system looks at another system as to a collection of objects which it has to manage. Managed objects in different systems communicate via one or more associations (in popular terms: network links).

Via the OM protocol managed objects can be dynamically created, deleted and manipulated, such as the retrieval and setting of object attributes. Furthermore, managed objects can issue event reports (e.g. state change reports or alarm reports). In principle the communication is symmetrical as is illustrated in figure 1.

Figure 1
Communication between objects.



Layered specification

The OM/RR-protocol is a two layer protocol that fits within the application layer of the ISO-OSI reference model as is illustrated in figure 3. The upper layer offers object management (OM) services to applications. The OM-layer relies on the services of the request response (RR) layer. This section is restricted to the basic OM/RR concepts. The full OM/RR protocol and service specification is available on request (2). This specification clearly distinguishes definition of RR and OM services, and the associated protocols which are specified using the ASN.1 syntax (5).

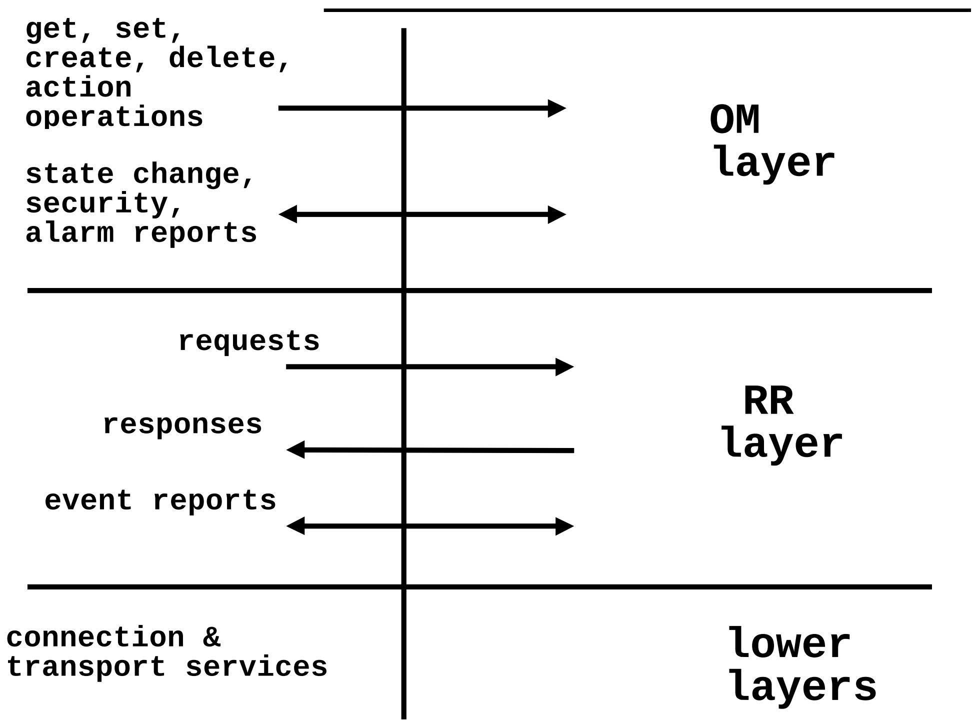
The RR protocol layer offers its service user the possibility to request the invocation of an operation at a peer service user by sending a Request message. The result of the request is returned to the service user as a Response message. At the same time, service users can send event reports to each other in an asynchronous way. The RR protocol enables the service user to include type information in the Request and Event messages in order to specify types of requests (operations) and events by the higher OM protocol layer. The RR services and protocol are modeled after the ISO-OSI Remote Operations service and protocol standard (3), but they are much simpler.

The OM protocol layer enables the user to create, delete and manipulate objects at a peer service user. The OM services are defined in terms of the generic RR services. The OM services and protocol are modeled after the ISO-OSI standards CMIS and CMIP (4) but, again, they are much simpler. The OM layer supports the following operations;

- Get: to retrieve the value of one or more attributes of a (remote) object.
- Set: to modify an attribute value.
- Action: to request the invocation of an action e.g. to open or close a barries.
- Create: to create an object of a certain type..
- Delete: to delete an object.

The next figure illustrates the relation between the RR protocol layer and the OM protocol layer.

Figure 2
The RR and OM layers



As shown in figure 3 the OM/RR layers are using standard TCP/IP services;

Figure 3: The OM/RR protocol stack.

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••••••••••••••••••••••••••••••
• User (application process) •
••••••••••••••••••••••••••••••
• 7b OM      •  7c           •
• reports &  •  association  •
• operations •  management   •
••••••••••••••               •
• 7a RR      •               •
••••••••••••••••••••••••••   •
• 6  Presentation: ASN.1 •   •
••••••••••••••••••••••••••••••
• 5  Session: stream sockets •
••••••••••••••••••••••••••••••
• 4  Transport: TCP          •
••••••••••••••••••••••••••••••
• 3  Network: IP             •
••••••••••••••••••••••••••••••
• 2  Datalink                •
••••••••••••••••••••••••••••••
• 1  Physical                •
••••••••••••••••••••••••••••••
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CONCLUSIONS AND PLANS

History has shown that standardized communications and information exchange are key factors in system integration and architecture development, but one should not underestimate the complexity of developing new standards. A top-down approach often leads to powerful but comprehensive and complex protocols which are difficult to adopt. A practical bottom-up approach solves short term needs but may lead to unwanted islands of automation on the long term. A trade-off between both approaches seems the best guarantee for success: start with a well considered concept, put it to test in operational environments, and consider further development and refinement as an iterative process. Development of the OM/RR-protocol is an example of such an approach.

The OM/RR-protocol has been specified in 1997. The specification will be available to industry for development of distributed applications. The first operational system using the OM/RR-protocol will be the Operator Support System (1). This system will realize the forementioned integration of motorway management systems. The protocol will be used for inter systems integration between the OSS and existing heterogeneous motorway management systems, while it will also be used for communication between the OSS subsystems.

In parallel projects the relation with communication protocols for other application domains is being investigated. This concerns DATEX, an EC initiative for inter center data exchange (6) and NTCIP, a US industry initiative (7) initially for road side communications now being extended for inter center data exchange. The results are expected late 1997.

REFERENCES

(1) Operator Support System, Operational Concept Document
Version 1.0, 16 June 1997
Rijkswaterstaat AVV

(2) OM/RR Service, Protocol and Association Management
Specifications
Version 1.2, 3 June 1997
Rijkswaterstaat AVV

(3) Remote Operations
ISO/IEC 13712, 15 September 1995
International Organization for Standardization

(4) Common Management Information Service and Protocol Definition
ISO/IEC 9595 & 9596, 7 Januari 1991
International Organization for Standardization

(5) Abstract Syntax Notation One (ASN.1)
ISO/IEC 8824, 1994
International Organization for Standardization

(6) DATEX-Net Specifications for Interoperability
Version 1.1, December 1996
DATEX Task Force

(7) National Transportation Communications for ITS, Protocol
NEMA Standards Publication TS3.x, 1996
NTCIP Steering Group