Applicability of data distribution technologies within ITS

# Scope

A variety of general-purpose data distribution technologies have emerged within the Information and Communications Technologies (ICT) industry. These technologies generally provide services at the Open System Interconnect (OSI) Session, Presentation, and Application Layers (i.e., Layers 5-7). Within Intelligent Transport Systems (ITS), these layers roughly correspond to the Facilities Layer of the ITS station architecture, as defined within ISO 21217.

This Technical Report investigates the applicability of these data distribution technologies within the ITS environment.

# Normative references

# Terms and definitions

facilities layer

ITS station architecture

# Symbols and abbreviations

ICT

ITS

OSI

# Transitioning from traditional to cooperative thinking

## General

ITS is heavily dependent upon the exchange of varied types of data between and among disparate types of physical objects. Physical objects include:

* Centres (e.g., fixed-location facilities, cloud-based back-office services)
* Field devices (e.g., along the roadside)
* Vehicles
* Travelers (e.g., personal devices)
* Support systems (typically fixed or back-office, that provide services enabling ITS, but do not directly provide ITS)

The data that these systems exchange include:

* Live elemental data (e.g., vehicle speed, location, signal timing information, etc.)
* Live aggregated data (e.g., average speeds, rain rates, etc.)
* Status information (e.g., status of reversible flow lanes)
* (Relatively) static data (e.g., map information)
* Exceptional reports (e.g., information on traffic incidents, realignment of lanes due to incidents or road work, etc.)
* Configuration data (e.g., certificate revocation lists, traffic regulation information, software configuration, etc.)
* Software updates (e.g., for on-board applications)

The varied data exchanges among the different physical objects also has various needs for data distribution. For example, software updates might be intended for specific vehicles. Traffic regulation data is likely intended for all vehicles within a jurisdiction. Exceptional reports might be intended for vehicles approaching an incident. And finally, there is an increasing appreciation that some of the information exchanged might be useful to support ITS services other than the ITS service for which the data was originally intended.

There are a variety of technical and institutional challenges in successfully sharing data in a timely and secure manner. Challenges include:

* Acquiring the data (e.g., through sensors)
* Defining ownership and access rights for the data
* Securing the data (e.g., authentication, authorization, confidentiality, integrity, availability, etc.)
* Achieving adequate market penetration of lower-layer communication technologies
* Agreeing on the upper-layer protocols for exchanging the data over the communication technologies
* Standardizing the definition of data for use in various contexts
* Defining performance criteria for different uses of the data
* Maintaining the interface over the life cycle of the involved physical objects. Operational lifetimes for ITS devices vary radically; field devices often have lifetimes of 15-20 years, vehicles closer to 10 (though often much longer), and smartphones merely 18-24 months.

This technical report focuses on the upper-layer protocols (i.e., the Facilities Layer along with its management and security) while recognizing that this layer will need to provide adequate services to support the other issues. For example, part of our analysis of the data distribution technologies considers the ability of each technology to provide authentication services that meet rigorous ITS demands as well as an analysis of the performance implications of each technology (e.g., processing and bandwidth requirements). Other issues listed are largely left to other stakeholders in the ITS community.

The systems engineering approach to designing any complex system is to work with the relevant stakeholders, including service providers and system integrators, to develop a “Concept of Operations”, or ConOps. This involves describing in detail the service (the “why”), the actors participating in the service (the “who”), and the requirements on information that must be generated and exchanged by entities engaged in the service (the “what”).

Once agreement is reached on the ConOps, the implementers work together to develop a high-level design (i.e., an architecture) that defines the means by which the service will be implemented (the “how”), which must (directly or indirectly) define the details of how the information is encoded and transferred between physical objects. If the system is intended to support an open interface (i.e., so that competing manufacturers can interoperate); these design details should be defined within open standards and developed with broad-based consensus.

Once the architecture is developed, each interface is designed by its own group of experts to meet the defined needs. However, this division of effort tends to produce “silos” of thought that can often result in four major problems:

1. **Competing protocol selection:** Different silo efforts are likely to select different approaches to exchanging data. There are many off-the-shelf protocols that can be extended to support most ITS data exchange needs and some experts may wish to develop their own protocols to optimize performance in certain cases. While each decision may be reasonable in isolation, each protocol adopted by the ITS industry has costs associated with stakeholders learning the technology, implementers programming with the technology, testers verifying conformance to the technology, and maintenance issues with maintaining backwards compatibility, as well as memory and processing issues within devices that have to support multiple technologies. Ideally, the ITS community as a whole should attempt to identify a suite of preferred protocols that meet industry needs so that the variability in systems is minimized.
2. **Competing data definitions:** Different silo efforts are likely to produce different data definitions to describe the same real-world conditions. This greatly complicates data sharing, increases potential translation errors, and increases integration costs. Ideally, all ITS data definitions should be developed in a cooperative fashion.
3. **Limited scope and lack of forwards compatibility:** Engineers within the silo teams will often attempt to “optimize” their design; however, without a complete knowledge of how data might be used, it is impossible to know if a design is truly optimal or not. This can partially be overcome by ensuring that the reference architecture is developed with a broad as scope as practical, but since innovations occur over time, it must be understood that no effort will ever be omniscient about how the data might be used; we can only attempt to consider as much data as possible.
4. **Competing architecture efforts:** A final challenge facing any development team is that there is often different competing and/or overlapping efforts across the world. Once standards are developed, it is often difficult and expensive to harmonize the results after the fact.

This technical report attempts to address the first issue by identifying different protocols that have been suggested for use within the ITS industry, comparing their respective characteristics, and suggesting a preferred set of protocols for future use.