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A Conceptual ITS Architecture: An Atis Perspective

Foreword—This SAE Information Report describes a conceptual framework for Intelligent Transportation Systems (ITS) Architecture and Protocols. The emphasis is on communications between user equipment and the infrastructure, although the architecture is easily extendable to cover the vehicle-to-vehicle communications required for advanced vehicle control systems. This document will allow system developers and standards groups to identify specific interfaces and protocols within a larger conceptual framework.

The initial focus is to define a conceptual architecture that will support communications technologies and applications that are currently being deployed, while allowing room for expansion to accommodate new applications and new communications bearers. It is hoped that a single ITS media-independent application layer protocol can serve many services. The primary audience for this document includes systems developers of ITS products and services and international ITS standards bodies. The primary focus is on Advanced Traveller Information Systems. This architecture supports a variety of implementations that are based on current technology, while allowing for growth, change, and the ability to accommodate new components and technologies that have not yet been developed. This document is one of several substantial efforts to develop a national system architecture for ITS. Others include the FHWA ITS Architecture Development Program.

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1. ***Scope***—This SAE Information Report represents an information report on a conceptual ITS architecture and its accompanying protocols from the perspective of Advanced Traveller Information Systems providers and users. While a specific logical and physical architecture for ITS is still in the development stages, this conceptual architecture provides a robust general view of ITS functions and interfaces.

2. *References*

2.1 Related Publications—The following publications are provided for information purposes only and are not a required part of this document.

2.1.1 ANSI PUBLICATION—Available from ANSI, 25 West 43rd Street, New York NY 10036-8002.

ANSI D20.1 Standard—State's Model Motorist Data Base: Data Element Dictionary

2.1.2 ISO PUBLICATIONS—Available from ANSI, 25 West 43rd Street, New York, NY 10036-8002.

ISO 7498—Information processing systems—Open systems interconnection—Basic reference model
ISO 9735—Electronic data interchange for administration, commerce and transport (EDIFACT)—Application level syntax rules

2.1.3 TRANSPORTATION RESEARCH BOARD PUBLICATION—Available from Transportation Research Board, TRB, 2101 Constitution Avenue N.W., Washington, DC 20418.

Transportation Research Circular 412—ITS Primer

3. *Definitions*

3.1 System Architecture—A system architecture is a master plan that describes the fundamental components of the system and the information that is to be exchanged or communicated among the components. It provides guidance on how components interact and work together to achieve overall system goals.

3.2 ATIS—Advanced Traveller Information Systems. Systems that provide information to the traveller, usually the driver. Sources of information include the traffic management center and value-added service providers. User equipment includes in-vehicle navigation systems, interactive cable TV, wireless hand-held devices, and on-line information services.

3.3 Protocol—A set of rules and formats (semantic and syntactic) that determines the communications behavior of entities in the performance of functions within a system architecture.

3.4 Application Layer Protocol—The Open Systems Interconnect model contains seven layers. The highest layer is the application layer and it consists of the application entities that cooperate in the OSI environment. The only means by which user elements in different systems may communicate is through application protocol data units of finite size.

4. ***ITS Architecture***—The overall conceptual architecture is portrayed in Figure 1. Information sources and users of information are identified by the rectangular boxes; information flows (interfaces) are identified by the arrows. The information flows identified in this diagram include traveller information from both public and private service providers to a variety of applications and devices. The broad vertical lines indicate information networks such as Internet or the National Information Infrastructure.

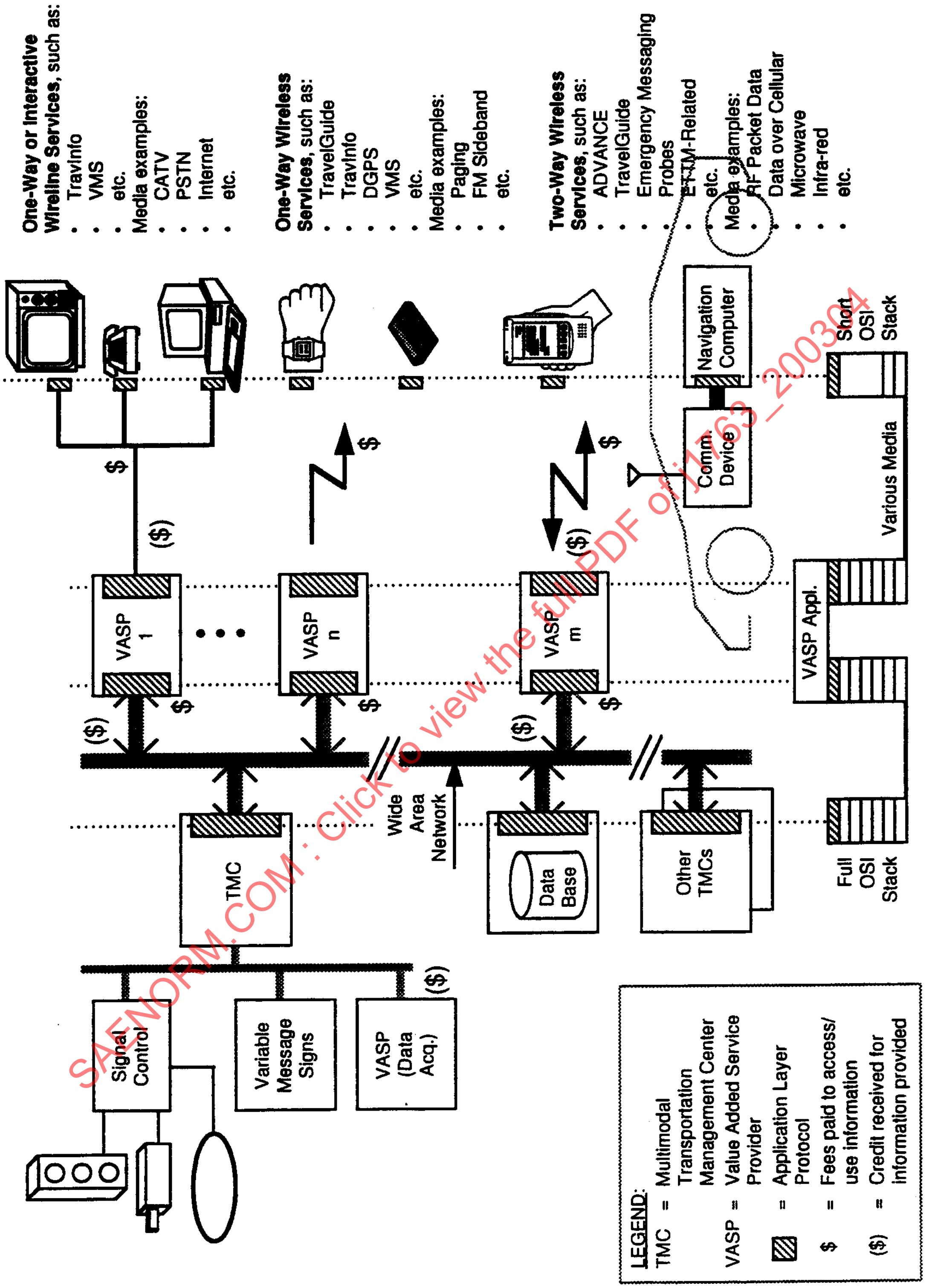

FIGURE 1—A CONCEPTUAL ITS ARCHITECTURE

At the bottom of the figure the seven layer OSI model is shown. It is expected that computers used by Traffic Management Centers and Value-Added Service Providers would contain the full seven layer OSI protocol stack, but due to limited computer power and memory in user equipment only the physical, link and application layers would be used (short OSI stack). It is hoped that a single application layer protocol will serve many ITS services.

5. Description of Modular Functions—The modular functions identified in Figure 1 include data acquisition, data fusion, data dissemination, value added services, and user applications. Key functions (processes) are described in detail in this section.

5.1 Data Acquisition—In the near future, the normal business of traffic surveillance and management will likely continue as it has to date, with the addition of more closed-loop signal control systems, more video-based systems, and more integration of multiple intersections. Software systems are being added to Transportation Management Centers (TMCs) for data fusion, transportation and network modeling, and multimodal management.

In addition, Value Added Service Providers (VASPs) will emerge that will either make a business of acquiring transportation related information, or will do so as part of a larger business scope, such as from their customers or other sources. VASPs will provide data to the TMCs for a fee, or for a rebate against fees paid to use the disseminated TMC data (reflected by the $$ labels in Figure 1). (Another common term for VASP is ISP - Information Service Provider.)

5.2 Data Dissemination—The TMCs will acquire, fuse, and disseminate traffic, transit, weather, and other transportation-related data. The distribution may occur over the National Information Infrastructure or some other wide area network. The concept here is that these data would be available to any other TMC or licensed VASP anywhere on the continent or anywhere connected to the National Information Infrastructure. This allows a traveller embarking on a trip to determine conditions or transit schedules at the destination regardless of the length of the trip, or the mode of travel.

As described previously, VASPs may license their data for further dissemination to their customers, or may provide additional data, acquired from their customers or other means, back to the TMC. The wide area network is therefore a two-way network providing an opportunity for continuous improvement of the data and expansion of the coverage.

Additional databases, accessible via dedicated servers or other gateways, may also appear on the National Information Infrastructure or some other wide area network, providing additional traveller information such as restaurants, hotels, and driving directions.

5.3 Value Added Services (VASPs)/Information Service Providers (ISPs)—A Value Added Service Provider (VASP) will first decide on the nature of the service it wishes to provide to its customers. (Information Service Provider is another name for the same function/type of organization.) Based on customer requirements, the VASP/ISP will select the data set (available on the National Information Infrastructure) it wishes to license and the medium it wishes to use to deliver this service to its customers. In some cases, a VASP/ISP may already have access to a communications channel (and media) and will define the data set according to the capacity of the available channel. A VASP/ISP may also use multiple media to deliver its services to a wider selection of users.

For example, a VASP/ISP decides to offer a "Mobile MLS" to realtors. It licenses from the TMC the data set that includes traffic and weather information, and combines this information with access to the Multiple Listing Service. The VASP then licenses capacity from an appropriate carrier or carriers for the communications link to its users' equipment. Its customers, the realtors, can then request a list of the homes for sale in a given area, in a given price range, with particular features such as three bedrooms and two baths, and then have their in-vehicle navigation system plan the quickest route to each of the homes in the list. If this VASP's in-vehicle equipment is capable of providing probe data as well, then the probe data can be sold back to the TMC for a rebate or credit on license fees.

The conceptual framework accommodates the full spectrum of these possibilities.

5.4 User Applications/Equipment—ITS user equipment will include devices with a variety of types and levels of functionality. In some cases, user equipment will be tightly coupled with and dedicated to a VASP's service. In other cases, user equipment will be a standard device with a standard communications interface running an application provided by the VASP.

In either case, to foster interoperability across the nation and to encourage greater market penetration, some standard media will be essential. As shown in Figure 1, these standard communications media may be grouped into: one-way or interactive wireline services, one-way wireless services, and two-way wireless services. In addition, a standard application layer protocol (ISO OSI Layer 7) developed especially for ITS or adapted from an existing protocol will help ensure widespread use of the data while still allowing the VASP or equipment supplier to add value. Such a standard application protocol may be carried over multiple communications technologies and media. ISO TC 204 WG 16 (an ISO working group whose mission is wide area communications standards for intelligent vehicle highway systems) is currently developing such a protocol.

Each of the components and functions in Figure 1 is defined in the paragraphs that follow. A large variety of devices and communications media can be used to transmit and/or receive ITS information using this conceptual architecture and a standard application layer protocol. Due to the nascent nature of the ITS industry, the applications/equipment described below include commercial products, emerging products, and field tests.

5.4.1 SIGNAL CONTROL—Control of traffic signals in real time using loop detectors, video cameras, etc., and driven by traffic models in the TMC.

5.4.2 VARIABLE MESSAGE SIGNS—Message signs for travellers that are controlled by the traffic management center.

5.4.3 TMC—Transportation Management Center. The TMC collects and fuses data and distributes it via a wide area network. The TMC can also purchase data from a value-added service provider and in some cases may be a value-added service provider.

5.4.4 TRAVINFO—Intermodal Traveller Information System currently being field tested in the San Francisco Bay Area under the FHWA's Field Operational Test program. This system collects, integrates and disseminates traffic and transit information, and makes it available to travellers through kiosks, cable TV, personal computers, and hand-held devices. Participants include the Oakland Metropolitan Transportation Commission (MTC), Caltrans, the California Highway Patrol, FHWA (Federal Highway Administration), FTA (Federal Transit Administration), PATH, and multiple private companies. In Figure 1, TravInfo is an example of the kind of integrated wireline services that will use this conceptual architecture.

5.4.5 CATV—Cable television. Used for disseminating real time traffic information to end users.

5.4.6 PSTN—Public switched telephone networks. Many transportation management centers offer dial-in travel and weather information.

5.4.7 INTERNET—Global network of packet-switched wireline networks that communicate using the Transmission Control Protocol/Internet Protocol (TCP/IP). TCP is a transport layer protocol (level 4 of OSI) and IP is a network layer protocol (layer 3 of OSI). Several service providers offer travel and weather information on the Internet.

5.4.8 TRAVELGUIDE—A palm-top portable traveller information system currently in development by the Ministry of Transportation Ontario. In Figure 1, TravelGuide is an example of the kind of one-way wireless services that will use this conceptual architecture. Two-way communications using wireless hand-held devices such as PDAs are also possible. With two-way communications capability, an inexpensive hand-held device can become a full-function traveller information system.

5.4.9 DGPS—Differential Global Positioning System. GPS is a system of 24 satellites deployed by the U.S. federal government for positioning via triangulation. For reasons of national security, the signal is distorted so that the positioning information provided is accurate only to within 30 to 100 m (100 to 300 ft). Differential GPS (DGPS) systems attempt to correct this distortion by measuring the GPS signal at a known location, calculating differential correction factors which remove the distortion for a certain geographic area, and transmitting these to the user equipment. DGPS signals could be broadcast using one-way wireless technologies, allowing a variety of portable devices to perform location and navigation functions.

5.4.10 PAGING—One-way wireless data communications devices. A one-way, non-speech personal selective calling system with alert, without message or with defined message such as numeric or alphanumeric. Several companies are experimenting with providing travel information to paging devices.

5.4.11 FM SIDEBAND—FM Sideband technologies are broadcast technologies which involve modulating the frequency and using the subcarrier(s) for traveller information or station ID. A common form of FM sideband technology in Europe is RDS-TMC. AM sideband technologies are also being tested in the U.S., although the data rate is very low.

5.4.12 ADVANCE—The ADVANCE (Advanced Driver and Vehicle Advisory Navigation Concept) is a demonstration of dynamic route guidance in the Northwest suburbs of Chicago. The traffic management center will gather, fuse, and disseminate traffic information to 75 vehicles equipped with route guidance systems. In Figure 1, ADVANCE is an example of the two-way wireless services that will use this conceptual architecture to provide adaptive, real-time route guidance. Other projects of a similar nature will be demonstrated at the Atlanta Showcase and in the FastTrac project in Michigan.

5.4.13 EMERGENCY MESSAGING—Services which provide the ability to request emergency road or medical service, and receive an acknowledgement that the message has been received and help is on the way.

5.4.14 RF PACKET DATA—A method of transmission in which small blocks of data called packets traverse in a store-and-forward method from source to destination. Packet switches package the data into packets and transmit these packets, along with an error checking code, over a communications link that is shared with other packet users. An RF packet is sent via wireless communications. Packet data technology allows large blocks of data, such as maps or driving directions, to be sent inexpensively.

5.4.15 DATA OVER CELLULAR—Data sent over a mobile cellular network in roughly the 800 to 900 MHz range. New cellular modem technologies allow data traveller information over cellular links.

5.4.16 MICROWAVE—Radio communications sent at frequencies at roughly 3 to 300 GHz, at wavelengths between 1 mm (0.039 in) and 1 m (39.37 in). A promising technology for traveller information due to its large information carrying capacity.