ITS Architecture - Implementation Issues

Roy Sumner and Gary Euler
PB Farradyne
3200 Tower Oaks Blvd.
Rockville, MD 20852 USA.
301.816.1854
301.816.1884
sumner@pbworld.com

Abstract

Agencies charged with implementing ITS projects have often wrestled with not only the form of architecture but also how far any particular system might extend. Some of the factors involved with such decisions include: complex layers of institutions; areas of operational responsibility; traffic homogeneity; communication networks extension throughout the proposed areas of influence; and inevitable budgetary constraints. Another major influence is whether public or private agencies are providing the funds or looking for revenue. This paper will examine the influence of such issues and provide examples of various applications.

INTRODUCTION

The US National ITS Architecture is defined as:

A common framework for planning, defining, and integrating intelligent transportation systems. It is a mature product that reflects the contributions of a broad cross-section of the ITS community (transportation practitioners, systems engineers, system developers, technology specialists, consultants, etc.) over a five year period. The architecture defines:

- *The functions (e.g., gather traffic information or request a route) that are required for ITS*
- *The physical entities or subsystems where these functions reside (e.g., the roadside or the vehicle).*
- *The information flows that connect these functions and physical subsystems together into an integrated system*

This is a noble goal, however, the reality of implementation issues does in many cases cause significant compromises to be made. This paper primarily addresses the architectural issues associated with the implementation of Advanced Traffic Management Systems (ATMS) and Advanced Traveller Information Systems (ATIS).

INFLUENCING FACTORS

The major factors affecting the type and extent of an ITS architecture include the following:

- Traffic homogeneity
- Institutional boundaries
- Operational responsibility
- Public or private ownership
- Operational elements such as ITS for management or information

These influences are discussed in the sections below. These influences are first considered in isolation and later in conjunction.

Traffic Homogeneity

The influence of incidents in one area of a particular region by incidents in another area is a function of the unique geographic features of the region and the distance between major population centres and traffic patterns. For example in the case of Washington, DC and Baltimore, with a combined population of 7.2 million, the two cities are each surrounded by a ring road that is separated by about 20 miles. The figure shows four areas: Washington, DC, Baltimore, Frederick, and Hagerstown. Although there are good traffic operational reasons for keeping Baltimore and Washington, DC together within one operational unit, the need is less obvious to include Frederick in the equation. This is effectively how the ATMS operations unit within the Maryland State Highway Administration controls these regions. However, if a broader view is taken, the major traffic flow in the Northeast corridor may well consider using routes through Frederick as an option. Frederick is about 40 miles from Washington, DC, and Hagerstown is another 20 miles from Frederick. Although there are separate operations centres for Baltimore and Washington, DC, these operators work in concert and have access to each other's real-time information. Therefore, an operator in Washington, DC can set a sign for traffic leaving Baltimore and provide information to drivers going south. Operators in Frederick will have limited use for information from Washington/Baltimore and operators in Hagerstown even less.

From an operational perspective, the implication for this region is that other control centres beyond 40-60 miles need not necessarily share real-time operational data in such a close manner that requires a single software application. This aligns with the commuting distance limits that are experienced in many metropolitan areas. Traffic homogeneity will undoubtedly impact decisions on the geographical extent of ITS architectures and will vary between locations, but there seems to be limited benefits extending architectures beyond commuting limits.

Institutional Boundaries

In the U.S., the various layers of Government: State, County, City, and other agencies, such as toll authorities and now some private roads, lead to a plethora of problems when an ITS architecture is under design. The geographical boundaries between institutions result from historical happenstance rather than coherent transportation planning. In some instances, boundaries are defined as centrelines of roads. In addition to the many layers of Government and their differing geographical areas, it is often the case that differing institutions cover different areas. For example, a State highway agency may cover all State funded roads, however, City roads will connect to State roads and both the City and State police have authority over certain operational aspects.

Institutional boundaries can create complexities that remain unresolved. There are examples of State and City control centres being installed in adjacent buildings because of unresolved institutional issues. Police, departments of transportation and emergency operations staff are regularly housed in differing locations causing inefficient and uncoordinated operations. Then, technological solutions for information sharing, video conferencing, etc., are used to provide the connectivity that memorandums of understanding cannot achieve. In these cases technology is used as a band-aid in attempt to provide integration of operations without having to accommodate good design.

Operational Responsibility

The most common institutional problems for ITS architecture implementations are as follows:

- Jurisdictional responsibilities between the various institutions – for example, the owning agency and the police may both have responsibilities related to incident clearance
- Boundary conditions where the ownership of the road changes and the owners on either side of the boundary have differing schedules, philosophies, and budgets.

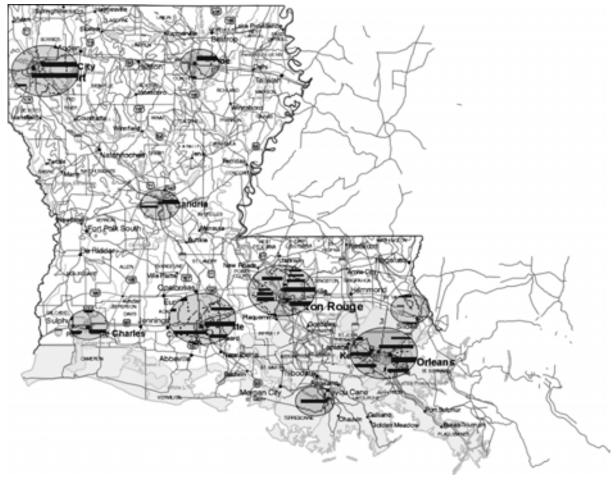
Agreements are often made to define the responsibilities, for example, the police may be responsible for what is on the road (vehicle clearance, enforcement, and emergency response) and the agency may be responsible for what is in the road (message signs, cameras, communication networks, etc.). These types of agreements have proven successful in several cases in the US, including Washington State and several locations in Florida.

Boundary conditions where the ownership of the roads changes within a metropolitan area cause multiple problems in architecture design. Ideally, the owners of the roads on either side of the boundary would institute a combined operation that would appear seamless both within the system and from the driver's perspective. Unfortunately, it is difficult to find examples of such cooperation and easier to find examples of discontinuities across boundaries. Such discontinuities include examples of ITS devices that stop where the boundary exists between jurisdictions. In others, the type of device or level of information will change when boundaries are crossed.

For the designer of an ITS architecture, the range of operational responsibilities needs to be clearly defined and documented. Where borders exist, every effort should be made to set up joint operations that treat the traffic within the region as one network rather than separate systems with discontinuities at the boundaries. Although these goals are likely to be hard to achieve, the savings in operations and manpower would be very substantial, as often one control centre rather than two would be required.

Public or Private Ownership

An example of the effects of ownership on ITS architecture can be found in Sao Paulo Brazil. Each of the various concessions that have won the rights to operate the toll roads radiating from the beltway (the Mini Anel) around Sao Paulo, are required to develop and install a traffic control centre with a range of ATMS functions. In addition, the State has plans for a control centre and the City already has three. All of these are well intentioned but do not represent good use of funds. Although the City is very large and the radiating roads are long, the coordination required between so many centres is a daunting task. Considering that one full-time operational seat required five employees plus supervisors and that most control centres have a minimum of two operators the costs for many control centres escalates very quickly.



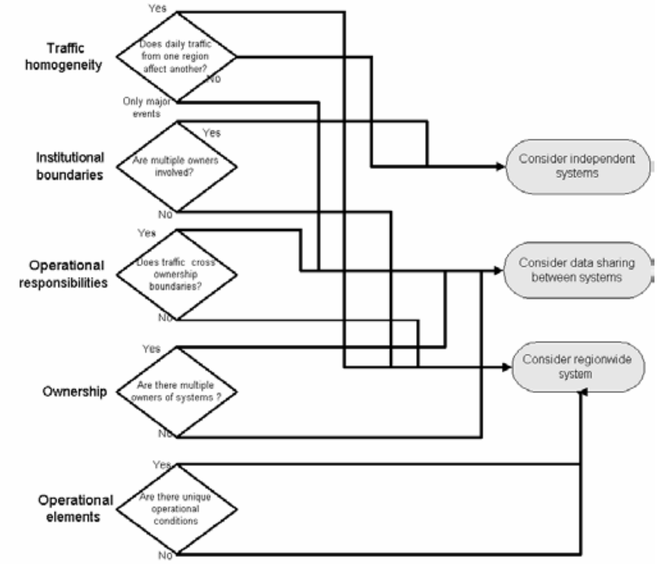
The private or public ownership of data also causes impacts on ITS architectures. In some instances projects have been abandoned as a result of the conflicts where the private investor wants exclusive use of his data and the public agency either needs the data for operational purposes or is legally obliged to give it to the public. Although several public agencies have approached the design of their ATMS with the view that they will sell the data to third parties and use the revenue to offset their costs, this approach has been unsuccessful to-date. The market in any one State or metropolitan area is too small to support a viable business model for an Advanced Traveller Information System (ATIS). There are no current examples within the U.S. where an ATIS system based on one State or metropolitan area has proven financially successful.

However, the advent of high-speed data networks has caused a significant change in the architectures for ATIS. Generally, the successful applications cover an entire country. Private ATIS applications are not constrained by institutional boundaries or disputes over responsibilities. The ability to provide the service to the entire country and provide data from one location is the ultimate in efficiency. The GM OnStar system and the Metro/Etak model in the U.S. and the Trafficmaster in Europe provide examples of how extending the architecture for ATIS provides sufficient customer base for a financially sustainable system. The relationship between public and private architectures seems a lost opportunity for information sharing from the perspective of the public agency. However, the view from the private agency is that they have succeeded in developing a business without being dependent on bureaucratic institutions beyond their control.

Operational Elements

Although particular architectures, such as the USDOT's National Architecture, intend to accommodate all applications into one major framework in each region, it is unlikely that such a system will be built in its entirety. The developers of architectures have to consider the fact that the scope of specific applications has very different reaches. CVO applications extend out through interstates and cross boundaries. Transit applications extend into residential areas where most traffic control systems do not. The utility of close-coupled integration needs to be examined according to the individual operational elements to be installed.

For example, advanced passenger transit systems are an off-the-shelf item and, as such, do not conform to the internal specifications of an ITS regional architecture. However, the systems may provide useful real-time data with the transit vehicles acting as probes. The architectural issues can be confused by the overlapping boundaries whe
re the transit agency's area of responsibility is different from the ATMS operator. An example is Louisiana where there is little operational need for the ATMS operators in Baton Rouge and Shreveport to share information due to the 240 miles between them. However, this is an area subject to major evacuations due to hurricanes and flooding of the Mississippi. Under these circumstances, there is a big need to share real-time operational



data across the entire state. This results in having differing architectural needs for some functions during limited time periods, for example during an evacuation

INTEGRATION ISSUES

The level of integration between the architectural elements in the U.S. National Architecture indicate that very close coupling of the applications is required to achieve some level of harmonious operations. The reality is that many successful applications are being developed with little coupling between them. This is particularly the case between ATMS and ATIS applications.

The Figure illustrates some of the major issues that can impact the direction any particular architecture can take. The questions asked are those that need to be considered during the planning phase. They should first be considered in isolation and then in conjunction with one another to anticipate problems of interrelationships. For example, if part of the system is privately owned are there may be differing and conflicting operating procedures, for example, for disabled vehicle clearance. Adjacent jurisdictions that agree to work together and lay out common procedures need to consider the simplest of things, such as operational hours to prevent implementation issues from occurring.

The indications are that ATIS may be left to the private sector to develop. If this is the case, then this approach has ramifications for those that develop architectures and plan systems. The operator must consider the data ownership issues and the fact that those businesses that want to distribute the data for profit are assisting in the network operations by communicating with drivers. The current examples of successful private ATIS have no relationship with the Public ATMS's beyond the fact that the agencies may subscribe and use the data for operational reasons.

ARCHITECTURAL RECOMMENDATIONS

The normal architectural development process is to:

- Define needs
- Develop user services
- Select market packages and
- Develop an plan for implementation, operations and maintenance

This is logical and guides the process of development. However, the planning process needs to consider the impacts of the additional issues defined above. The following steps can guide the developer of an architecture toward a solution:

- Define the business of the buyer, e.g., is it a public agency with network operational needs, transit operations, or a private company in search of profit. Segment the solutions according to the business type.
- Look for geographical definition using traffic homogeneity and business issues not just political jurisdictions.
- Develop "over the border" long-term operational agreements, if required.
- Define responsibilities to match the needs.
- Determine what is public and private industry and how and if they should interact.

- Utilize communication resources, particularly shared resource opportunities both within and outside of public agencies.

The indications are that a centrally imposed architecture does not work as intended when business issues intrude. Allowances need to be made to accommodate these forces that are generally beyond the control of public agencies.