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Class A Multiplexing Architecture Strategies

RATIONALE

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FOREWORD

There are generally three classes of multiplex application requirements within the vehicle. To cover these applications two prevalent multiplex architecture strategies have developed. The most popular is the Single Network Architecture. This architectural strategy sizes the network hardware to meet the requirements of the highest level application while maintaining the capability, where possible, of handling the lowest level application. The second strategy, Multiple Network Architecture, is to develop as many types of specialized network hardware components as required to efficiently handle each application and then gateway them together to have only one diagnostic service port. These two differing strategies are studied in detail and presented in this SAE Information Report.

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1. SCOPE

The subject matter contained within this SAE Information Report is set forth by the Class A Task Force of the Vehicle Network for Multiplexing and Data Communications (Multiplex) Committee as information the network system designer should consider. The Task Force realizes that the information contained in this report may be somewhat controversial and a consensus throughout the industry does not exist at this time. The Task Force also intends that the analysis set forth in this document is for sharing information and encouraging debate on the benefits of utilizing a multiple network architecture.

1.1 Three Classes Multiplex Networks

The Vehicle Network for Multiplexing and Data Communications (Multiplex) Committee has defined three classes of vehicle data communication networks.

1.1.1 Class A

Low-Speed Body Wiring and Control Functions, e.g., Control of Exterior Lamps

1.1.2 Class B

Data Communications, i.e., Sharing of Vehicle Parametric Data

1.1.3 Class C

High-Speed Real Time Control, e.g., High-Speed Link for Distributed Processing

1.1.4 Interrelationship of Classes A, B, and C

The Class B Network is intended to be a functional superset of the Class A Network. That is, the Class B Bus must be capable of communications that would perform all of the functions of a Class A Bus. This feature protects the use of the same bus for all Class A and Class B functions or an alternate configuration of both buses with a “gateway” device. In a similar manner, the Class C Bus is intended as a functional superset of the Class B Bus.

2. REFERENCES

2.1 Applicable Publications

The following publications form a part of the specification to the extent specified herein. Unless otherwise indicated, the latest revision of SAE publications shall apply.

2.1.1 SAE Publications

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

SAE J1850	Class B Data Communication Network Interface
SAE J2057-1	Class A Application/Definition
SAE J2058	Chrysler Sensor and Control (CSC) Bus Multiplexing for Class 'A' Applications
SAE J2178-1-2-3-4	Class B Data Communication Network Messages

2.2 Related Publications

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

Thomas R. Wroblewski, "A Multiplexed Automotive Sensor System," Sensors Magazine dated February 1989, Volume 6, No. 2

Thomas R. Wroblewski, "A CSC Bus Multiplexing Technique for Sensors and Actuators Which Allows Common Vehicle Electronic Control Modules," Paper #89123, 20th International Symposium on Automotive Technology and Automation, Florence, Italy, May 1989

3. DEFINITIONS

3.1 Event-based

The attribute of transmission of data on a manually triggered event or on change of parametric value.

3.2 Event-driven

The attribute of event-based network protocol.

3.3 Response-Type Messages

Messages that require Acknowledgement.

3.4 T-tap

A splice in a wiring harness forming a "T" connection. Sometimes this configuration is associated with automated insulation displacement type connection at a connector.

3.5 Time-based

The attributes of repetitive parametric data in a Class B Multiplex Network.

4. MULTIPLEX WIRING SYSTEM ARCHITECTURE STRATEGIES

It is a well-known fact that the cost of electronics is decreasing. More functions can now be integrated into fewer modules. The availability of Class B multiplexing now avails the automotive system designer with many new architecture partitioning options. The availability of customer-specific ICs to accomplish a function at a substantially lower cost is becoming a reality. On the other side of the equation is rising wiring and labor costs. Vehicle manufacturers have, in some instances, gone to off-shore or other countries to offset these labor-intensive assembly costs. However, the growth in size and complexity of wiring harnesses causes an ever-increasing investment in assembly facilities that overshadows these cost-containment efforts. These basic trends are projected to apply in the future and become our base assumptions.

4.1 Multiple Network Architecture Background

Initially, the Vehicle Network for Multiplexing and Data Communications Committee recognized the three different requirements for vehicle networking. A chart of these three vehicle multiplex networking typical characteristics is shown in Figure 1. This chart was presented late in 1986 to the SAE Truck and Bus Committee as the state of consensus by the Multiplexing Committee.

The chart shown in Figure 1 does not mean that three networks are needed to cover the multiplexing requirements, but that there are three different characteristic requirements within the vehicle that must be considered. Some of the entries in the chart such as "Status" and "Data Consistency" were not totally understood as noted by the missing entry under Class A. For example the "Status" entry was eventually recognized as the need for acknowledgement in a Class A Network. Some entries had slightly different meanings between committee members and, therefore, further development was dropped. The purpose of this document is not to explain all the characteristic requirements of vehicle networking, but to focus on the Class A and Class B interrelationship and, therefore, there will be no further discussion on Figure 1.

The decision to pursue a multiple network architecture strategy requires a careful study of the alternatives. This investigation of multiple network architectures begins with the assumption that a lower total vehicle system cost would result if one network were optimized around a data communications requirement and other networks were optimized around the sensor and control requirements.

Consider first the ramifications of optimizing a network around the data communications requirements, i.e., Class B multiplexing. Class B multiplexing interconnects intelligent modules such as the engine controller, body computer, vehicle instrument cluster, and other electronic modules. It normally does not affect the base vehicle wiring such as lighting, but it does affect wiring in that it may reduce the connections between sensors and modules. Class B Multiplexing in this case provides an intermodule data communications link for distributed processing. The parametric data shared between modules is almost exclusively repetitive in nature and rarely do these modules require handshaking or acknowledgement of data with other modules. Therefore, a network can be optimized around functional addressing. This is the result of handling the dominance of repetitive data and only a small amount of response type data, e.g., diagnostic data. It is consistent with this strategy to define a multiplex application so optimized by handling the dominance of time-based data communications requirements (see SAE J1850).

When physical addressing is required in a data communication optimized network, usually for vehicle diagnostics, it can be handled without reducing efficiency. The amount of safety type data that a data communications optimized network has to handle is negligible and can be very effectively handled by other means such as discrete hard wiring. Hard wiring of sensitive functions is considered an advantage because it is consistent with the present conservative method of handling these functions.

When the encumbrance of handling safety type data and most Class A (sensor and control multiplexing) functions are eliminated from the network requirements, a significantly simpler data communications network is the result. This multiple network architectural philosophy also results in a simpler and more effective method of handling sensor and control multiplexing.

The logistical size and complexity of the vehicle manufacturers' systems organization is another factor to be considered. The multiple network architecture is better suited to development and production by multiple sources: a situation that may be important to some vehicle manufacturers. The multiple network architecture requires only a moderate systems organization to insure compatibility because fewer messages would be supported by the data communication network. The sensor and control subsystem requirements can be handled by the product development organization with less direction from the system engineering group. This direction is possible because most of the subsystem would interface with their relevant sensors via their own dedicated Class A Network.

The multiple network architecture strategy should not be a hindrance to multiplex standardization because the Class B Network would be used to support diagnostics.