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Technical Summary

"Integration of In-Vehicle Electronics for IVHS and the Electronics for Other Vehicle Systems"

DEPARTMENT OF TRANSPORTATION
NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION

TECHNICAL SUMMARY

CONTRACTOR Stanford Telecommunications, Inc.	CONTRACT NUMBER DTNH22-93-D-07317
REPORT TITLE "Integration of In-Vehicle Electronics for IVHS and the Electronics for Other Vehicle Systems"	REPORT DATE March 1995
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Task Objective

The objective of this task was to identify and assess the main features of automotive computer architectures and electronic interfaces which could either facilitate or hinder the deployment of in-vehicle safety-related electronics for Intelligent Vehicle Highway Systems (IVHS). The key result sought from the task is a set of engineering assessments that evaluate the status of computer systems and electronic interface standards with regard to the potential for integration of the electronics for IVHS safety-related systems and the electronics for other vehicle systems.

Background

tie effort was guided by two goals defined by NHTSA: 1) to enable new and emerging safety-related automotive electronic technologies to be integrated into the framework of current and future automotive electronic systems; and 2) to help determine steps which may be necessary to ensure that lack of commonality in design and manufacture within the automotive industry does not impede deployment of the new technologies.

Task Approach

The task was divided into three primary subtasks as follows:

- Subtask 1: Identification of Automotive Computer Communications Network Architectures (CCNAs)
- Subtask 2: Development of criteria for assessing integration of safety-related IVHS systems
- Subtask 3: Engineering assessment of the alternative CCNAs with regard to integration of safety-related IVHS electronics

To ensure consideration of all potential automotive CCNAs, Subtask, included not only identification of computer systems and electronic interface standards, but also collection of information on current and future automotive practices obtained from manufacturers and technical committees. Subtask 3 included both initial engineering assessments and further organization of the assessments into summary evaluations suitable for use in defining recommendations relevant to deployment of IVHS safety-related systems.

(Continue on additional pages)

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Key Study Results

General Observations

- Automotive protocols are oriented toward sampled sensor data, "near real time" control, diagnostic codes, and short status reports; protocols having large packet sizes and unbounded latency behavior are not suitable for automotive applications,

- Automotive networks are constrained by control timing budgets, message latency requirements, electromagnetic interference environment, safety, reliability, and cost,

- Real time distributed control has not yet been implemented on production vehicles; a 1 Megabit per second (Mbps) Carrier Sense Multiple Access (CSMA) /Non-Destructive Arbitration (NDA) protocol can support approximately 25 kilobits per second (kbps) of real time message traffic, assuming 1 millisecond (msec) network latency at a 10^{12} assurance level, and 25% network utilization.

- Network throughput and latency performance are a function of several non-deterministic processes and cannot be computed analytically for most systems; few available studies address long term latency bound issues.

- CSMA/NDA is effectively limited to 1 Mbps by arbitration timing constraints; performauce of token passing and polling protocols in specific systems has not been adequately quantified.

- Most automotive protocols have adequate error detection capabilities, but do mot adequately address fault tolerance issues.

- "'Plug and play" is not yet feasible: physical layers are not fully specified, message types and addresses are tied to the arbitration scheme, application layer data is not standardized.

Near Term Systems (0 to 5 years)

- Most of the proposed IVHS systems are domimated by real time message traffic; this eliminates all except high speed (250 kbps and above) protocols from consideration.

- 1 Mbps CSMA/NDA protocols can support all proposed near term IVHS systems except for two which had high real time traffic loads (systems AC-l and AC-2 in the report); token passing and polling protocols could possibly support these two systems, but their performauce could not be quantified within the scope of this study.

- Below 1 Mbps, existing protocols can only guarantee latency and throughput for status and diagnostic systems, or lightly loaded "near real time" systems (e.g., systems SA-3, CR-2, DC-l, and the integrated Automatic Collision Notification/Collision Data Recorder system); buffer delays are significant for low speed protocols.

- Low speed protocols (below 20 kbps) are suitable for status and diagnostic systems, or Class A sensing and switching functions.

Mid-Term Systems (5 to 10 years)

- The proposed mid-term, fully integrated IVHS system could not be supported by the existing CSMA/NDA protocols because of high levels of real time message traffic.

- Token passing or polling protocol may be suitable for mid-term system; performance is difficult to assess without simulation.

- Mid-term system could be supported if latency constraints were relaxed; failure modes and effects are unknown and could be a vehicle safety risk.

Far Term Systems (10 years and beyond)

- Existing protocol standards do not appear adequate to support a future high capacity, real time, highly integrated in-vehicle network.

- Future networks may require real time subnets, a "near real time" backbone, hardware-based routing, or higher clock speeds.

- Feasibility of a high speed, low latency, "plug and play" network standard needs study.

- Fault tolerance (both in the network and in the attached nodes) and failure modes and effects will be major concerns in a highly integrated system; may require "firewall" concepts.

Potential Application of Study Results

This study identified some significant issues that may hinder timely, cost-effective deployment of such 'systems in the future. As a result, several key research topics requiring further study were identified. The findings of this study may be used as inputs to investigations of the following:

- Definition of performance benchmarking tests that allow protocols to be compared on a quantitative, objective basis. Should include light, moderate, and heavy traffic loads, a wide range of timing constraints, failure modes, and all classes of data.

- Definition of a broadly accepted, "plug and play" Class C networking standard that addresses issues such as fault tolerance, network and nodal failure modes and effects, long-term message latency requirements, and real time control timing constraints. Should also include full specification of the physical layer to facilitate cost-effective, third party development and integration of innovative IVHS technologies.

- A detailed analysis of network throughput and latency performance using specific protocol standards and system designs.

- Investigation of concepts such as inter-metworking, high-speed/low latency protocols, and firewalls to safely perform highly integrated distributed control, status monitoring, and diagnostics.

- Development of a prototyping or test bed laboratory capability to rapidly evaluate proposed IVHS technologies and interfaces.

- Development and evaluation of prototype IVHS systems usiwg primarily off-the-shelf technology and components. Early candidates for prototyping may include the Collision Data Recorder and the Automated Collision Notification System.