Center for Embedded Systems (CES)

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Distributed Run-Time Management for a Multi-Agent System

In today's automotive environments, embedded electronic control units (ECU) are customized, each handling pre-specified inputs and services. However, multiple ECUs with different non-transferable functions result in highly failure-susceptible systems. This unpredictability is aggravated by the scalability of the interconnected components, by the increased complexity of their interactions, and by the potentially serious risks consequences posed by the unpredictability. Software errors, aging, security, legacy software, and increased performance requirements add to the complexity required for maintaining reliable real-time car systems. Taking into account all the aforementioned characteristics and the specific automotive requirements and standards, distributed resource management becomes the most promising solution to these problems.

The proposed on-vehicle multi-agent system can offer smarter and more secure communications between vehicles' numerous electronic control units, thus making possible improved distributed error recovery, safety, and functionality transfer.

Consumer surveys indicate that more than a quarter of car buyers consider Internet connectivity more important than other key auto features such as engine power and economy. Because it will generate huge quantities of data, this new interconnectivity will interact with and impact the entire world in many ways. As smart cars continue to evolve new applications and services will build upon communications between cars, smart buildings, news and alert services, weather and security interests, and smart cities. From navigation services to "mobile" office environments, modern smart-car systems need to be capable of automatically and dynamically integrating and supporting almost all user-end devices. Thus, distributed run-time management and distributed ECUs will prevail as the key multiple integrated technology to efficiently and effectively address all the aforementioned issues.

Integrated multi-agent software components are no longer bound or confined to specific hardware. They can now be executed on various embedded units in support of all types of run-time service migrations. Each embedded ECU can act as run-time replacements for other ECUs, thus resulting in lower susceptibilities to failure.

In this project, CES researchers at Southern Illinois University coupled multi-agent systems with run-time resource management to develop a distributed framework for run-time management of multi-agent systems. The framework is based on the idea of distributed co-operative agents. These provide self-management functions while maintaining system requirements. Some of the framework's distributed functionalities include dynamic resource mapping task and management, error management, node discovery and service migration.

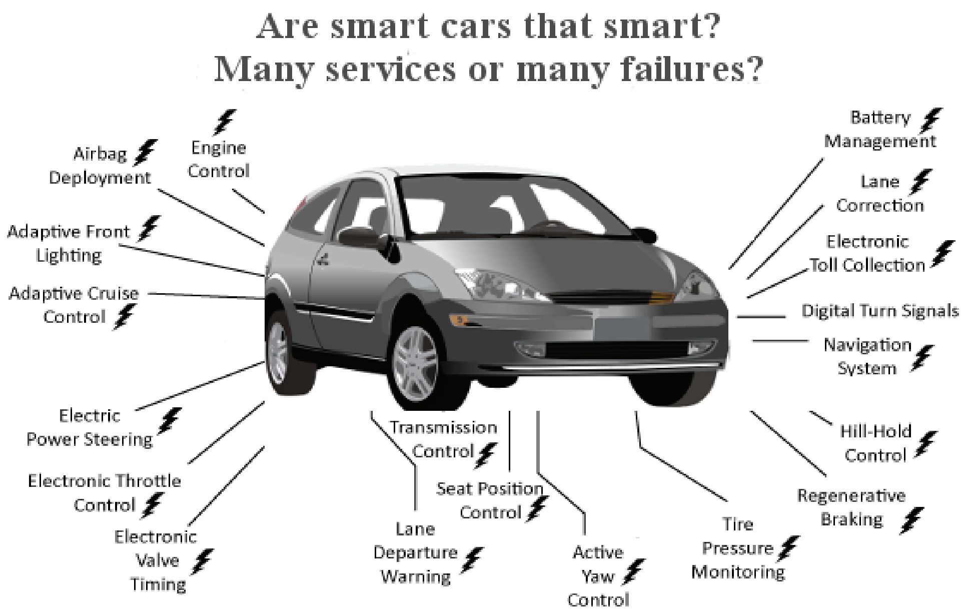
This work brings extended innovation to the field of "smart" cars by combining state-of-art technologies and integrating distributed run-time services for multi-agent systems. The resulting services offer improved real-time support, more powerful fault tolerance and intelligent decision making along with improved overall system monitoring.

Previous methodologies have suffered from central points of failure. They typically have had limited scalability; meaning that decisions could not be easily made at run-time. This CES/SIU/C breakthrough combines reactive and co-operative communication schemes. Resulting systems are therefore capable of making more reliable decisions and predictions by employing improved methods for self-management.

This work complies with a consideration number of automotive industry and standards. Automobile navigation, car security, infotainment requirements, travel information, cruise control etc. are a few of many examples of services that are highly depended on ECUs. This breakthrough's framework offers unprecedented integrated diagnostic opportunities because it deploys targeted diagnostic agents to deep-dive potential error states within automobiles. The distributed approach also offers improved uptime and reliability through the redeployment of tasks to available nodes for processing. Moreover, it enables leaner on-board microcontroller platforms by triggering executable agents when needed, as opposed to executing them continuously in the background.

This work and its improvements and new solutions for self-management, will result in better control and security. Cars will become more capable of adapting to the driver. Principles and techniques employed in this breakthrough may be adapted and integrated with other systems that require distributed control and communication.

Economic impact: Automobiles are well on their way to becoming the most sophisticated of all connected devices. The smart car market is expected to be worth $274 billion by 2017. Across the world, roughly 23 million cars on the road today are connected to the Internet, and that number is expected to soon increase to over 150 million. The number of connected cars may soon exceed a quarter of a billion worldwide. Projections indicate that by the year 2020, 16 billion dynamic-networked devices will be deployed.



Smart cars contain multiple embedded electronic control units. The concern is that multiple ECUs that have different non-transferable functions result in highly failure-susceptible systems.

This breakthrough's automatic node discovery functionality will allow vehicles to more easily adapt to new technologies and communication protocols with the outside world. The constraints of the harsh and demanding environment inside vehicles and real-time application requirements are more easily integrated and taken into consideration by the proposed framework. Instead of having continuous monitoring, resource management is achieved more efficiently than was possible with previous state-of-art methodologies. Because the multi-agent system will more seamlessly integrate new features, it will be more feasible to launch and download smart car monitoring services with minimal modifications in software and hardware architectures.

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