Simulation Based Automotive Communication Design using MATLAB- SimEvent

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Agenda

• Introduction

• Different Analysis Methods

• Analytical vs. Simulation Approach

• Why and when to use Simulation Based Approach

• Use cases

• Q&A
Exponential Increase in Bus Bandwidth Capacity

Caveat: This is assuming that the same architectural pattern is maintained in the future.
Emerging Technical Challenges

• Exponential increase in communication bus and computing processor requirements
  • Broadcast communication and synchronization
  • Increase in supervisory control layers and distributed closed loop control
  • Heterogeneity in transmit models

• Move from 1 function – 1 ECU paradigm to up-integration of functions
  • Reduce No of ECUs

• Move from fail safe towards fail operational
  • Active Front steering to Steer by Wire
  • Federated vs. integrated fault tolerant devices
Architectural Patterns

• Some of the potential network architectural patterns

  • Isolated Backbone
    - Use a public bus as a high speed, high bandwidth means to share data between domain gateway modules and support some modules directly

  • Utilized Backbone
    - Use a public bus as a high speed, high bandwidth means to share data between domain gateway modules

  • Router
    - Use a router as a means to share data between domain busses

  • Grid
    - Use Multiple Buses to contend with needed bandwidth

  • Linear
    - Single CAN bus. Features are added as needed as new modules, or integrated into existing modules

Public Bus

- DLC
- P/T
- EBCM
- BODY
- SDM
- INF/TEL

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Complexity in satisfying the architectural needs

- Low Infrastructure Cost
- Expandability
- Flexibility
- Low Cost to Add Features
- Safety
- Energy Efficiency
- Domain Isolation
- Re-use
- Timing - Jitter
- Timing - Latency
- Packaging
- Maintainability/serviceability

Requirement exceeds capability
Capability exceeds requirement

Mid Content
Isolated Backbone
What methods and tools will assist the system architect to come up with an architecture that meets these challenges?
System level performance analysis

Analytical approach
“Mathematically represent the system for worst case and best case scenario for a given design”

Simulation approach
“Simulates the system for a given scenario and is time based to predict best design”
<table>
<thead>
<tr>
<th>Metric\Approach</th>
<th>Analytical</th>
<th>Simulation</th>
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</thead>
<tbody>
<tr>
<td>Latency</td>
<td>Y (Worst case)</td>
<td>Y (Average)</td>
</tr>
<tr>
<td>Load (CPU or Network)</td>
<td>Y (Worst case)</td>
<td>Y (Average)</td>
</tr>
<tr>
<td>Buffer Management</td>
<td>Y (Worst case)</td>
<td>Y (Average)</td>
</tr>
<tr>
<td>Jitter</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>Initialization Time</td>
<td>N</td>
<td>Y</td>
</tr>
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Why Simulation Approach

• Study the behavior of a system without building the real system.

• Find un-expected phenomenon, behavior of the system.

• Easy to perform "What-If" analysis.

• Simulations take the building/rebuilding phase out of the loop by using the model already created in the design phase.

• Simulation testing is cheaper and faster can be done at very early stage of development.

• Simulators can be used as an effective means for teaching or demonstrating concepts of a real system.
SimEvent Toolbox Library set

- SimEvents provides a discrete-event simulation engine and component library for Simulink
- Enables modeling event-driven communication between components to analyze and optimize end-to-end latencies, throughput, packet loss, and other performance characteristics
- It has Libraries of predefined blocks, such as queues, servers, and switches, which enables to accurately represent actual system
- SimEvents can design distributed control systems, hardware architectures, sensor and communication networks etc...
**Introduction to CAN Protocol**

- **CAN bus** *(Controller Area Network)* is a vehicle bus standard designed to allow microcontrollers and devices to communicate with each other within a vehicle without a host computer.

- CAN features an automatic arbitration-free transmission. A CAN message that is transmitted with highest priority will succeed, and the node transmitting the lower priority message will sense this and back off and wait.
CAN Frame Format

**Standard Format**

- **Arbitration Field**
  - 11 bit IDENTIFIER
  - RTR
  - IDE
  - r0

- **Control Field**
  - DLC

- **Data Field**

**Extended Format**

- **Arbitration Field**
  - 11 bit IDENTIFIER
  - SRR
  - IDE
  - 18 bit IDENTIFIER

- **Control Field**
  - RTR
  - r1
  - r0

- **Data Field**
CAN Network Simulation Model
Bus load vs Time

Load vs Time in (ms)
Histogram if Inter-arrival Time of a Message

No of occurrences

Time in (ms)
Conclusions

• Simulation based approach can help us in verifying the design without actually building it.

• It can be used to re-create field issues including boundary conditions, which is not possible using analytical method.

• Many design alternatives can easily be compared.