Development of Dependable Network-on-Chip Platform

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Recent cars are equipped with many ECUs

- Conventional ECU configuration

![Diagram of ECUs and sensors/actuators connected via CAN, FlexRay, etc.]
Recent cars are equipped with many ECUs

- Centralized ECU approach
Recent cars are equipped with many ECUs
- Centralized ECU approach

Any ECU can access any sensors/actuators

ECUs efficiently used by balancing loads
Tasks continuously executed even if some ECUs become faulty
(i.e., faulty ECU does not result in malfunction of its specific functions)
Backgrounds

- **Centralized ECU approach**
  - **NoC (Network-on-Chip) based**
    - Some European projects
  - **Multi-Chip NoC based** [Yoneda, et al. PRDC2012]
    - Multiple NoCs are connected via off-chip links
      - On-chip networks seamlessly extended to multi-chip networks
    - Advantages
      - Cost-effective: small NoC chips are cheap, and various sizes of configuration are possible (without developing different sizes of NoCs)
      - Chip-level redundancy: tolerate a chip fault
Backgrounds

- Centralized ECU approach
  - NoC (Network-on-Chip) based
    - Some European projects
      - Recomp: Reduced certification costs for trusted multi-core platforms. [Atc page]
      - Race: Robust and reliable automotive computing environment for future ecars. [Project page]
  - Multi-Chip NoC based [Yoneda et al. PRDC 2012]
    - Multiple NoCs are connected via off-chip links
      - On-chip networks seamlessly extended to multi-chip networks
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Our Project

- **Hardware platform**
  - Multi-Chip NoC
    - Dependable, adaptive, deadlock-free routing
    - Efficient inter-chip communication technology
  - Evaluation board

- **Task execution**
  - Pair & Swap
  - SmartCore

- **Task allocation**
  - Redundant allocation, redundant scheduling
Our Project

♦ Automotive Application
  - Integrated attitude control system for a four-wheel drive car
    - Torque, brake, and steering control of 4 wheels performed by ECUs
  - Highly cooperative process needed by each ECU
    - Integrated Control ECU
    - 2 Electric Power Steering Control ECUs
    - Brake Control ECU
    - Battery Management ECU
Our Project

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Our Project

- Characteristics of this application
  - Stopping control is very dangerous
    - Higher availability is required
Experimental system

Base chip × 4

HILS (Hardware In the Loop Simulation) system

Base chip

- Routers
- H.W. accelerator
- V850E CPU core

- Routers
- V850E CPU cores

- External IO
- D/A • A/D • etc

- FPGA

- PC

- Engine

- Detection

- Vehicle Dynamics

- Environment
Ongoing work

- Evaluation kit
  - NoC implementation
    - 4 Multi-Chip ASICs
    - Vertex7(XC7VLX690T)
  - HILS interface
  - Pseudo HIL-plant models (executable on PC)
  - Redundant task allocation tool
    - Input: (Simplex) Simulink model for application
    - Output: Executable codes for redundant cores