Development of Dependable Network-on-Chip Platform

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Recent cars are equipped with many ECUs
  - Conventional ECU configuration

- CAN, FlexRay, etc.
Recent cars are equipped with many ECUs

- Centralized ECU approach
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- 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. [http://atc.ugr.es/recomp/](http://atc.ugr.es/recomp/)
      - Race: Robust and reliant automotive computing environment for future ecars. [http://projekt-race.de/](http://projekt-race.de/)
  - 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
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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

- Automotive Application
  - Integrated attitude control for four-wheel drive car
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♦ 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

V850E CPU cores

FPGA

External IO

D/A・A/D・etc

PC

Engine

Detectability

Vehicle Dynamics

Emission
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