Inertial Sensor Cluster for Adaptive Path Prediction
AReComP – Automotive Reconfigurable Computing Platform

Zorawar Bhatia[1], Elie Sarraf[2], Scott Miller[1], Mihai Sima[1], Michael McGuire[1]
[1]University of Victoria, [2]University of British Columbia

Project: **F304-FIS**

ReCoEng Lab

Our task / goal and problem difficulty

- Build a reliable, performant, flexible, and cheap computing platform that is suitable to be deployed on-chip together with sensors and analog electronics.
- Warning: these are typically opposite requirements.

Fundamental Trade-off in Computing

- General-Purpose Processor – implement in software
  - Flexible, can be reused
  - Cheap but slow, might not be appropriate
- Application-Specific Integrated Circuit – implement in hardware
  - Not flexible, cannot be reused
  - Fast but expensive, might not be appropriate

Polymorphic Hardware

- Fine-grain: Field-Programmable Gate Arrays (FPGA).
  - Based on Look-Up Table (LUT) and rich Interconnect
  - Not a cheap solution, but general-purpose platform
- Coarse-grain: RaPiD, PipeRench.
  - Based on Multiply-and-ACcumulate (MAC) units
  - Cheaper, but good for Digital Signal Processing (DSP)
- **ShEERA**: Shift Enabled Embedded Reconfigurable Array.
  - Based on Shift-Enabled Interconnection Network
  - Cheaper, but good for transcendental functions

Reconfigurable Computing Approach

- Polymorphic Hardware + General-Purpose Processor
- Hardware-like performance with software-like flexibility
- Allows debuging and updating after fabrication
- No commercially available reconfigurable platforms

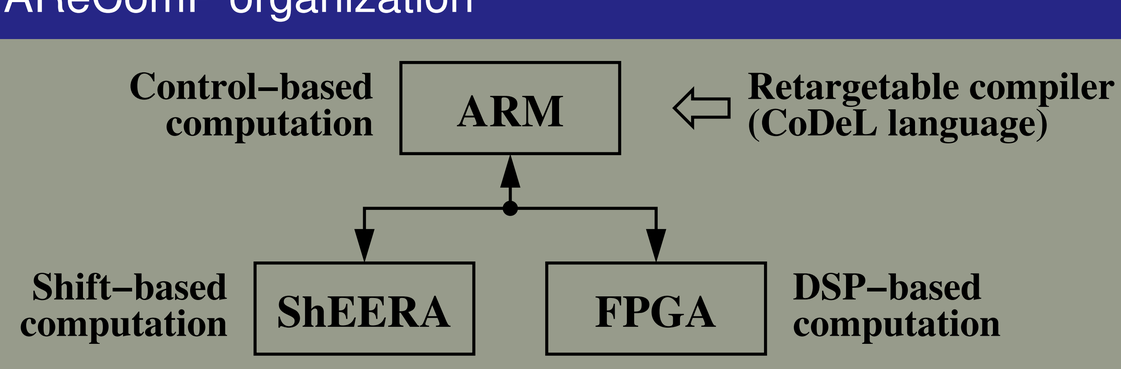
Automotive Requirements

- **Low time-to-market** – short design and fabrication cycle
- **Flexibility** – reuse and fast iterative improvements
- **Adaptability** – many car makers and vendors
- **Cost effective** – sharp competition

AReComP – Automotive Reconfig. Computing Platform

- Based on ARM processor for which a large amount of software (including Linux operating system) is available.
- A coarse-grain reconfigurable fabric (ShEERA) attached to ARM.
- A fine-grain reconfigurable fabric also attached to ARM.
- The hybrid is called ***AReComP***.
- Software tools need to be improved – CoDeL language (UVic).

AReComP organization



Promising Applications for AReComP

- Improved communications based on existing setup.
- Control system with real-time response for sensors on chip.
- Kalman filtering for optimal estimations.
- Post-fabrication adjustments!

Achievements

- Reconfigurable Kalman filters on FPGA for target tracking for navigation (GPS/Galileo), radio channel estimation, and echo cancellation in hands-free cellular telephone operation.
- FPGA implementation of the control-feedback loop of the Digital Accelerometer for better stability and linearity.
- Reconfigurable solutions for Orthogonal Frequency-Division Multiplexing (OFDM) over fast-fading radio channels.
- Transcendental functions and matrix operations on FPGA.
- Two-stage implementation of shift operation on FPGA.
- ShEERA (our coarse-grain reconfigurable array) prototype.

To do

- Integrating AReComP with A/D converter and sensors on chip.
- Control algorithms based on transcendental functions.
- Rapid prototyping methodology for accelerometers on FPGA.
- Speech recognition with arrays of wireless microphones in automotive environments.

References

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