Technische Universität Braunschweig

Effects of Dynamic NoC Resource Management for Mixed Criticality Applications

Rolf Ernst
TU Braunschweig
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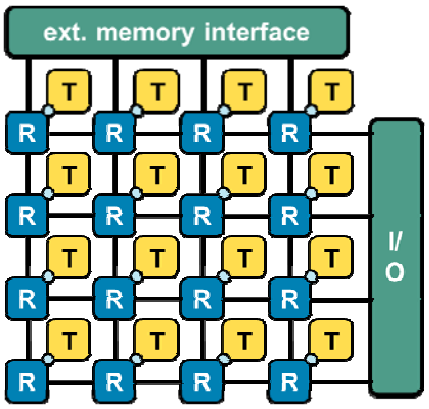
Motivation

IDA

- **many-core systems are reaching critical embedded systems**
  - sensor fusion and recognition in highly automated driving
  - avionics, space
- **limited power and cost budget**
  - compact solutions
  - higher systems integration
- **mixed criticality**

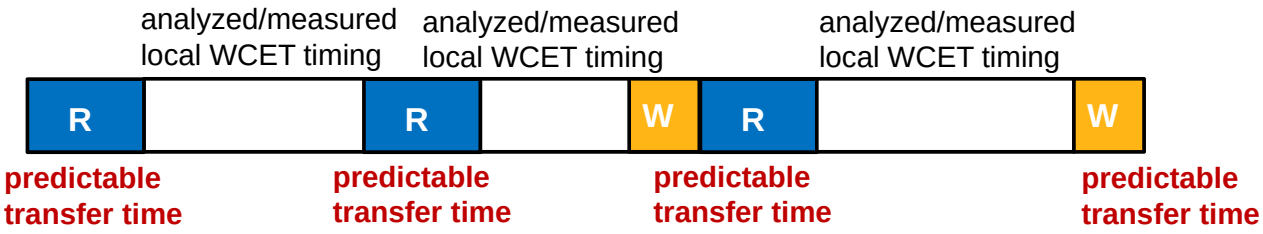
Mixed criticality challenge - Independence

- **safety standards require**
  - isolation of subsystems with different criticality levels
    (IEC 61508: sufficient independence; ISO26262: freedom from interference)
  - predictable timing where timing is relevant (almost every system)
  - error resilience
- **already challenging in current multicore implementations**
  - how to meet these challenges in many-cores?
  - main difference:
    Communication via Network-on-Chip (NoC)

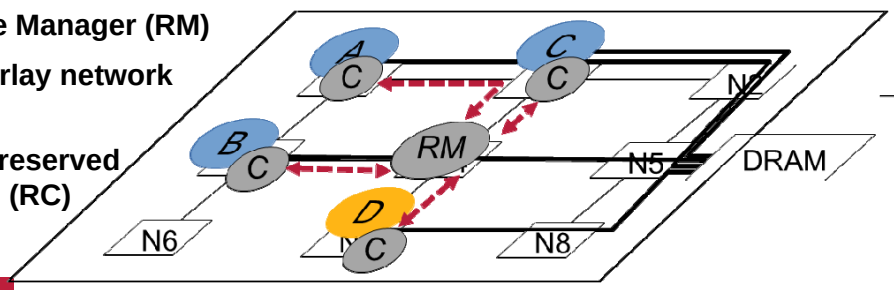


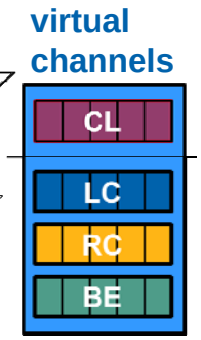
Last year: Predictable NoC transfer for critical app.

- **flexible block transfers**
- **resource management (RM) for predictable worst case (WC) timing**



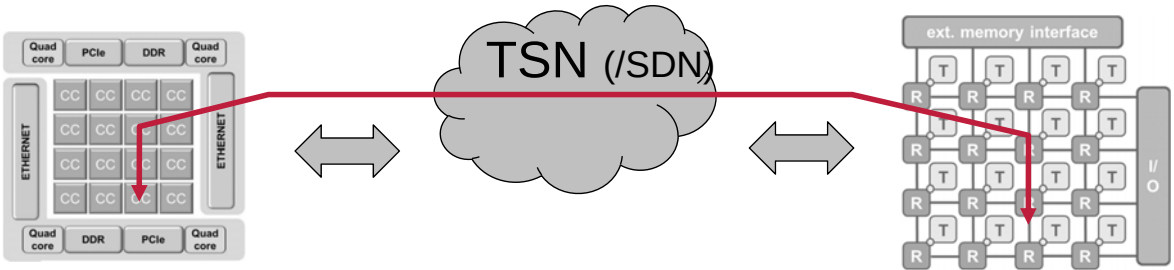
- **dynamic resource allocation**
  - **Resource Manager (RM)**
  - **uses overlay network (CL)**
  - **controls reserved channels (RC)**





This year:
Integration with end-to-end network traffic

- **manycore-to-manycore over TSN (Real-time Ethernet)**
  - **matches block transfer**
  - **large packets – NoC peak loads in competition with NoC traffic**
  - **can be combined with software defined networking (SDN)**



- **applications**

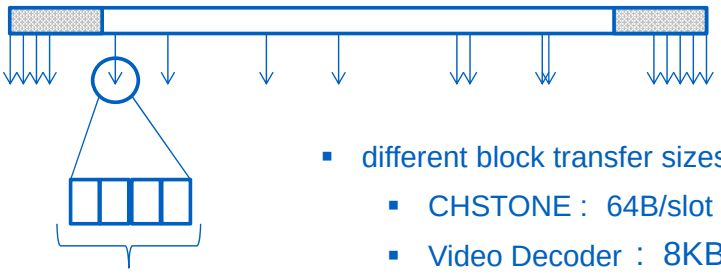
Avionics
- communication in ARINC653 scheduling
- pipelining of computation and communication

Media
- predictable communication integration

Automotive
- predictable integration of network traffic
- handling dynamic communication patterns
- dynamic adaptation for Adaptive AUTOSAR
- dynamic transmission error handling

Experiments

- **analytical WC experiments**
  - pyCPA analysis framework
- **simulations**
  - OMNeT++ event-based simulation framework
  - HNOCS library
- **input data**
  - memory access traces

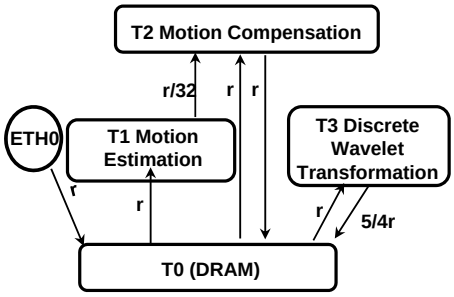


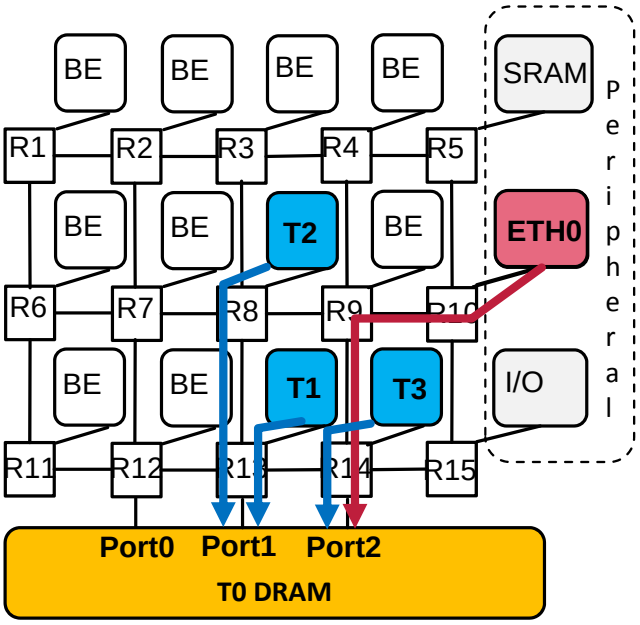
block transfer

- different block transfer sizes
  - CHSTONE : 64B/slot (4 packets)
  - Video Decoder : 8KB/slot (125 packets)
    Ethernet Packets

Experiment: Real-Time Video Denoising [Kostrzewa2016b]

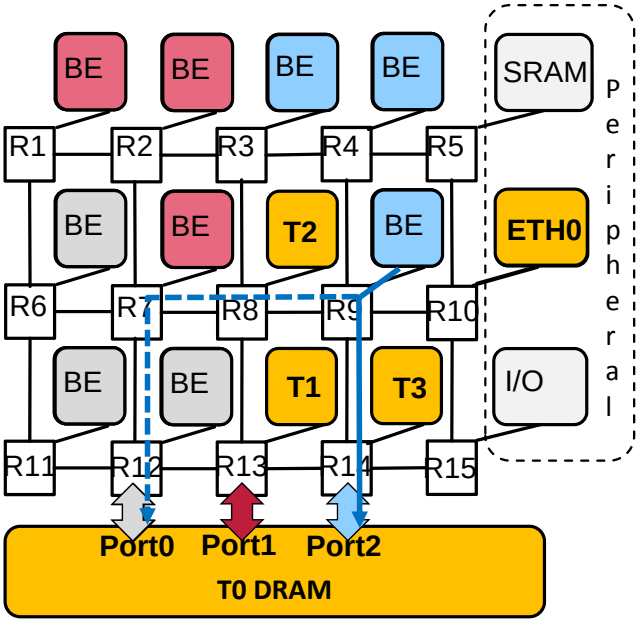
Mixed Criticality
- **Ethernet communication**
- **Real-Time Video Denoising**
- Best Effort applications (CHSTONE)



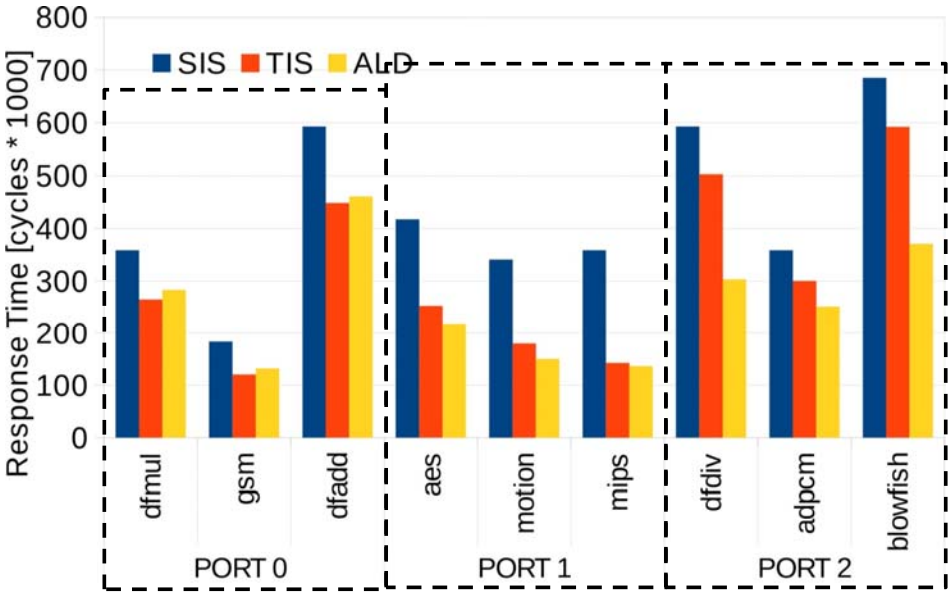


Comparing different schedules

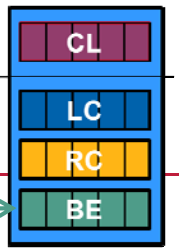
- **spatial isolation (SIS)**
  - all BE senders must use Port0
  - no link shared between BE and SC
- **temporal isolation (TIS)**
  - priority assignments for VCs
  - distribute the load between ports (group of 3 applications per port)
  - BE blocked when SC are active
- **adaptive communication load distribution (ALD)**
  - each BE has a detoured path to Port0 (blue and dotted line)
  - when SC sender is active load is detoured



Benchmark-based results for best effort tasks (BE)



Performance of CHSTONE benchmarks (BEs) in the use case.



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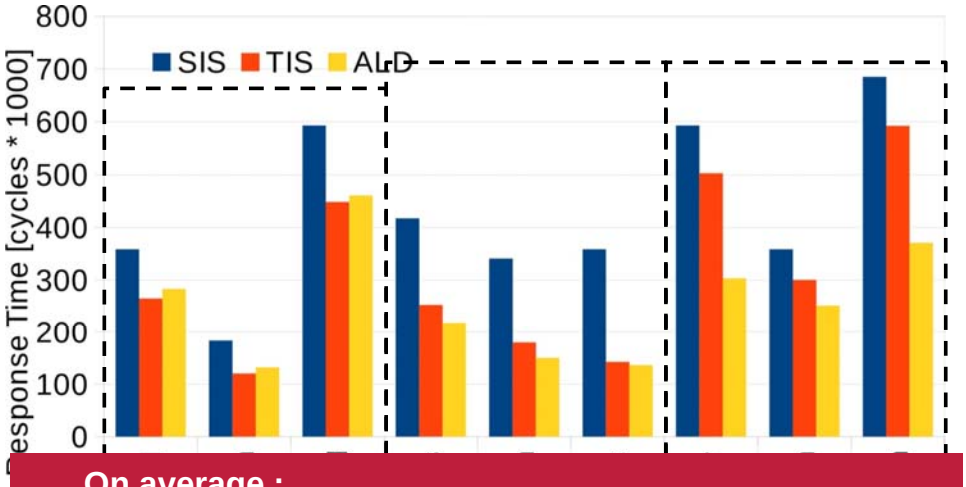
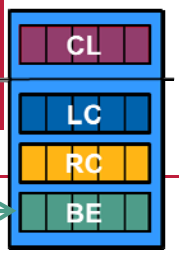


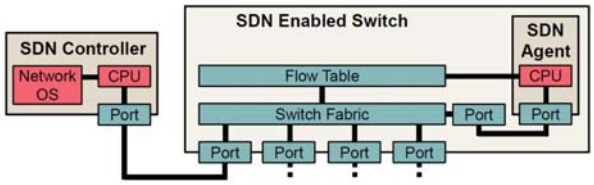
On average :

- **~ 50% improvement in comparison with SIS**
- **~ 35% improvement in comparison with TIS**

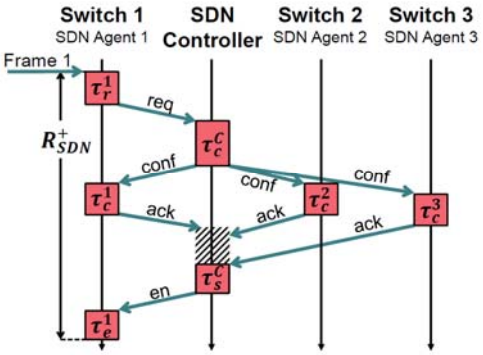


SDN for TSN - Principle

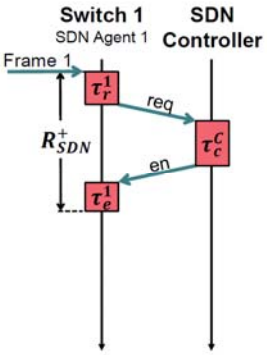
- **SDN uses network for switch configuration**
  - access control, reconfiguration, ...
  - explicit control or preconfigured
  - control redundancy *must be added*
- ***applications***
  - *security, safety, availability (fail operational)*



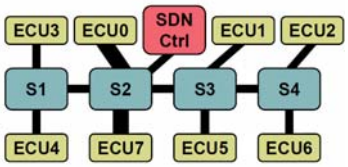
SDN architecture



explicit flow configuration



preconfiguration



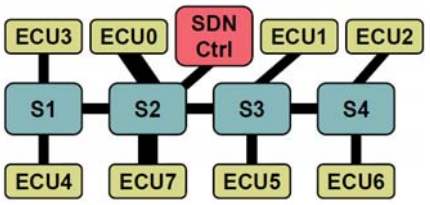
example topology

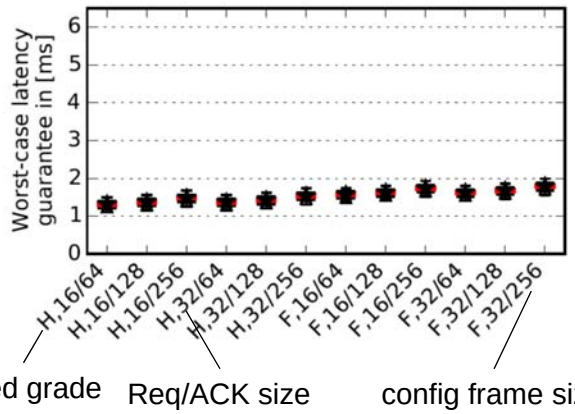
protocols (proposed)

Feasibility study SDN for automotive TSN [Thiele2016]

- **protocol timing for access control**
  - **depends on load, number conf. requests**
  - **explicit configuration: 1ms ...6ms**
  - **preconf: < 1.3ms**
  - **feasible approach for automotive**
- **more research needed**
  - ***H2020 project, www.safure.eu***

SAFURE





Conclusion

- **NoC based many-cores are entering safety critical system design**
- **mixed criticality is result of function integration**
- **dynamic resource management using a research manager is a highly efficient NoC control mechanism for such NoCs providing worst case guarantees**
- **this year: coupling with global network traffic**

Thank you!

Acknowledgement: Some of the slide contents have been provided by Adam Kostrzewa and Daniel Thiele

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