Exploration of NoC Design & Management Concepts for MPSoC

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Computing Platform - Vision

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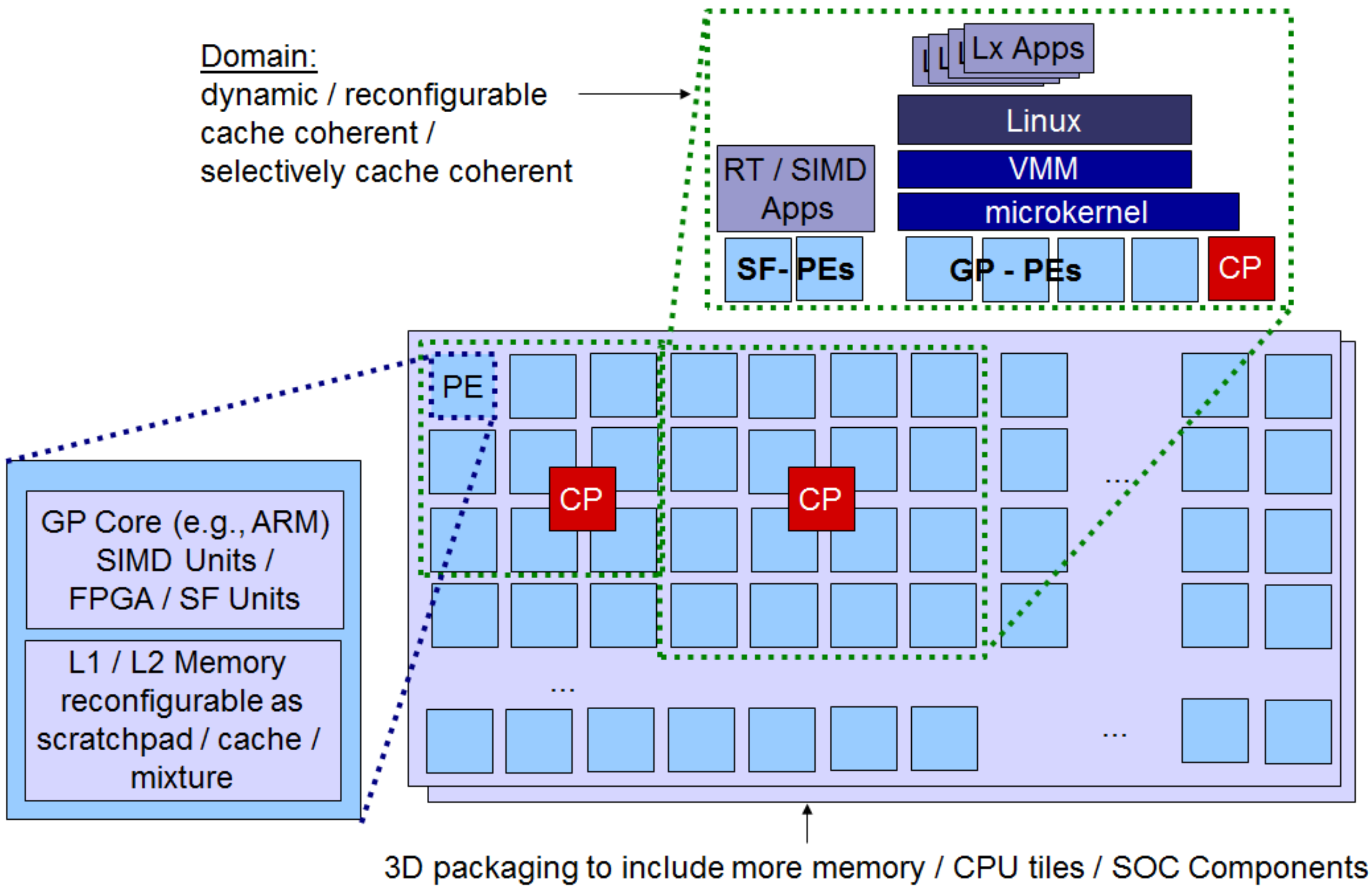
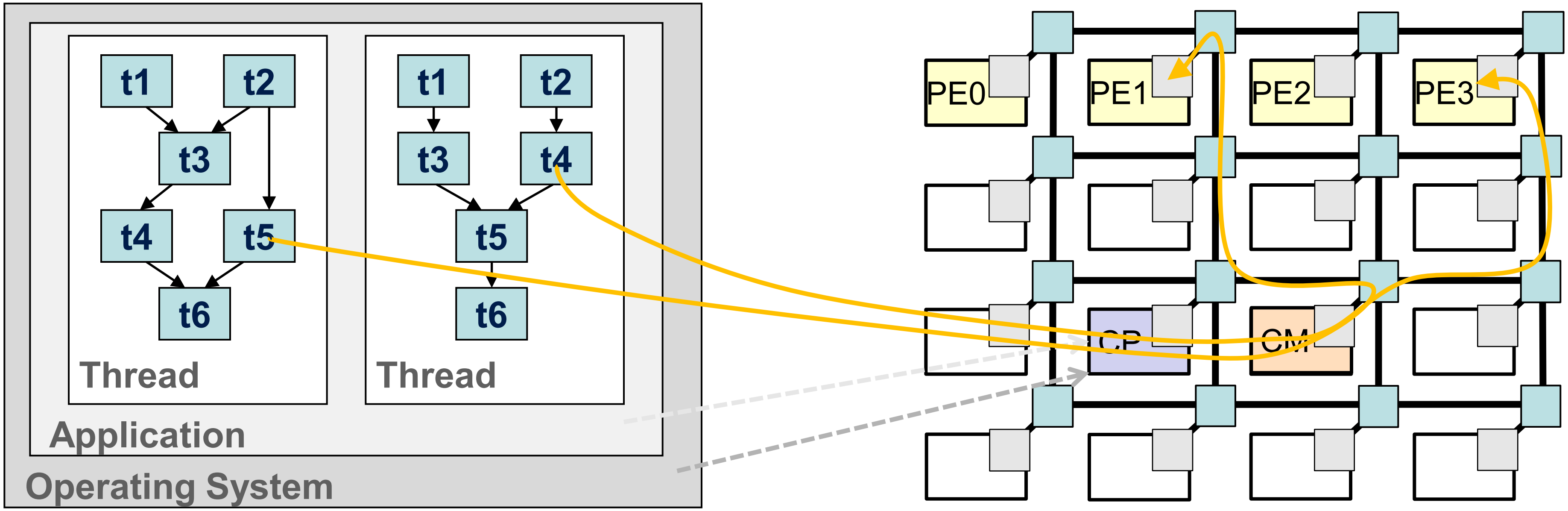
Our vision of an Embedded Supercomputing Processor 202x



Processing Element (PE): FPGA / Special Function (SF) Units / General Purpose Cores / SIMD Units

Control Processor (CP): manages PEs; responsible for code / data transfers, NOC config, isolation

1. Realtime MPSoC Programming Model



- Distributing Jobs/Tasks onto Processing Elements (PE)
- “CoreManager” unit for run-time task scheduling (in about 100 clock cycles)
  - → Realtime constraints: deadline for threads, dynamic priority for tasks according to urgency
  - → Realtime constraints also for NoC: find&allocate GS channels in few dozen clock cycles

2. Realtime NoC via GS Routes

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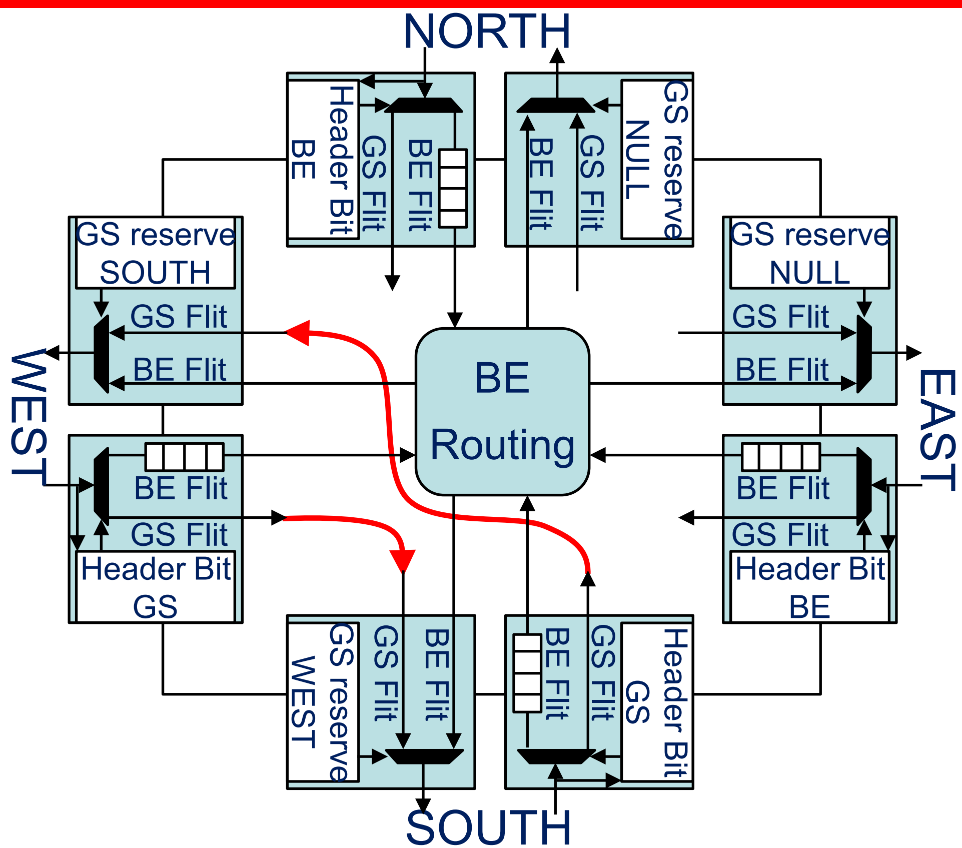

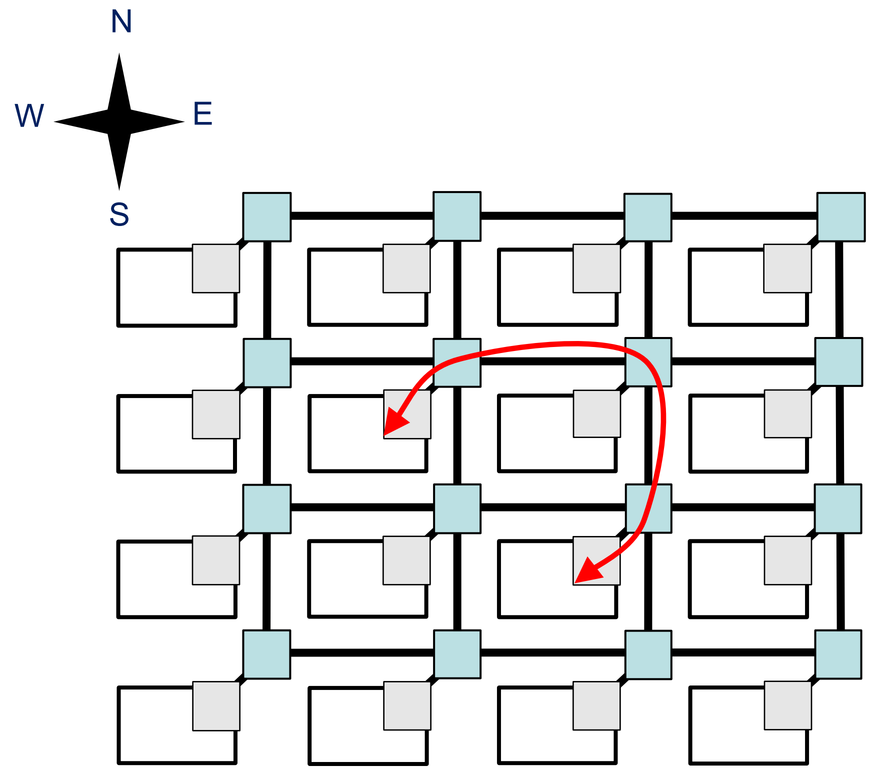

- GS route reservation: corresponding ports (south-west) get entry
- GS flit directly forwarded to corresponding output (routing bypassed)
- If no GS route or no GS flit: BE flit forwarding → Use free link

3. Guaranteed Service Allocation – Principles

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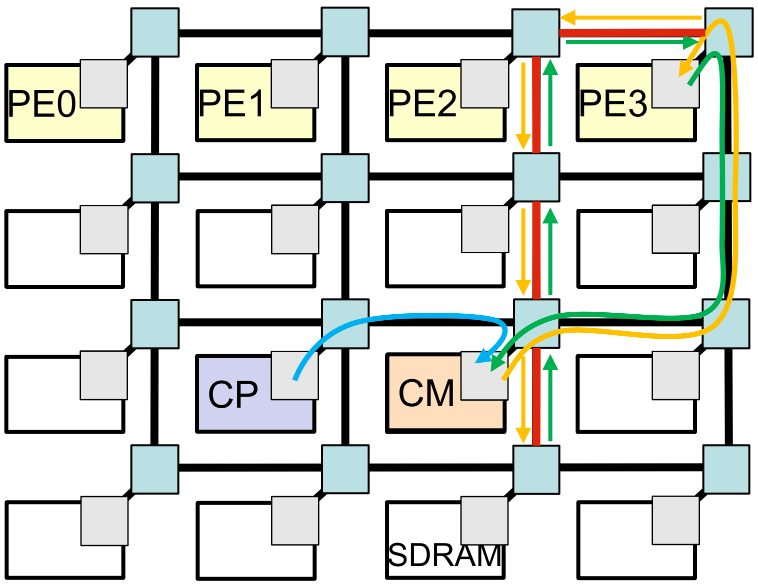
Distributed Allocation



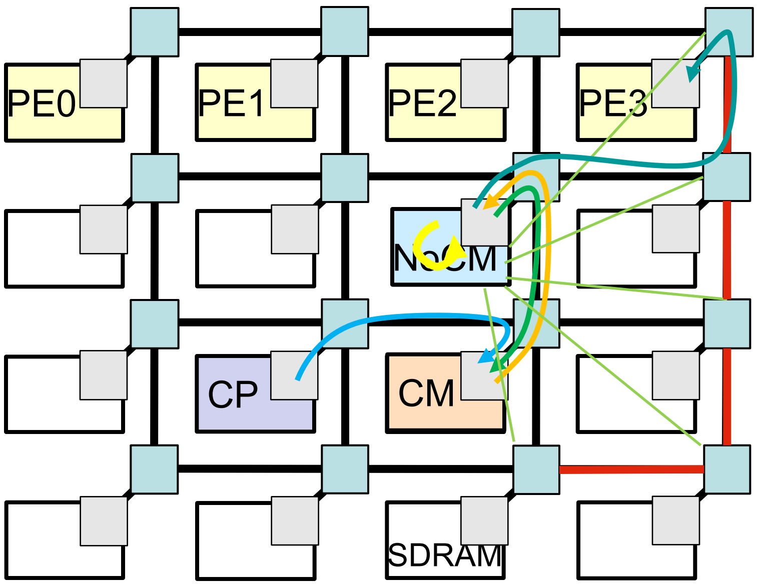
CoreManager informs PE

→ PE sends Setup-Flit

→ Routers used for allocation

→ Distributed algorithms (x-y, flood, flood minimal path)

Central Allocation



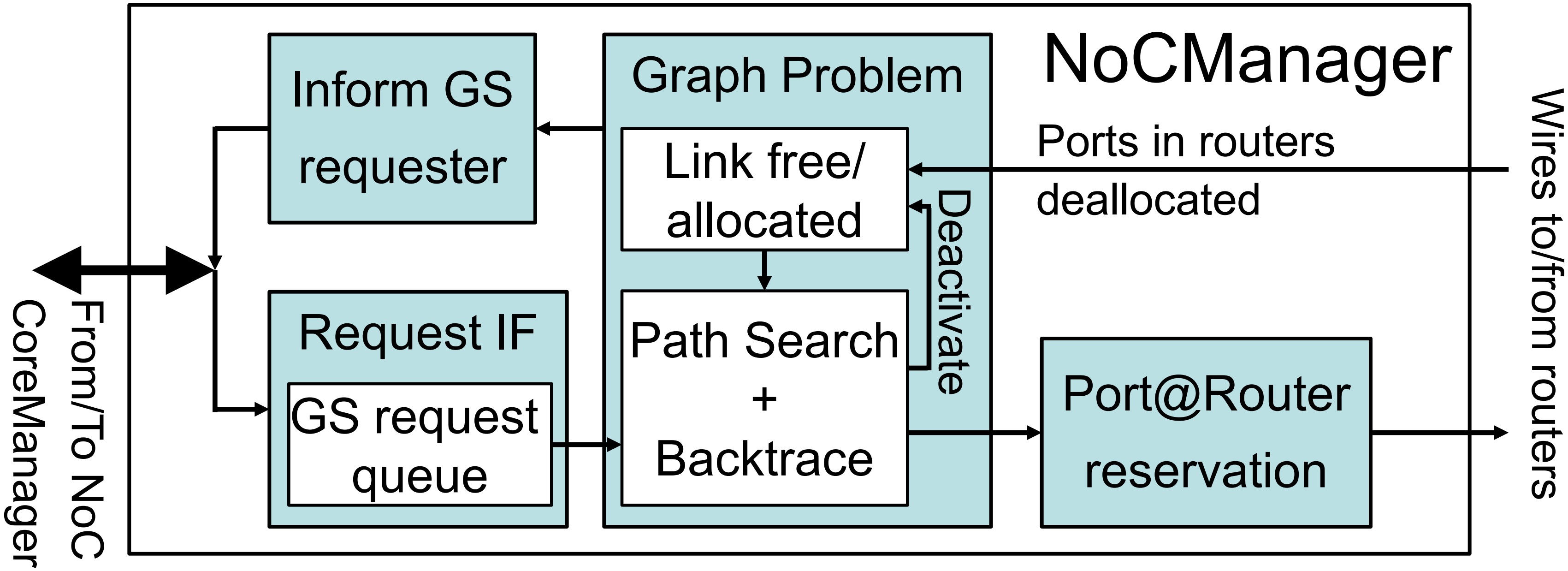
CoreManager informs NoCManager

→ NoCM solves shortest path problem

→ NoCM allocates routers (direct wires)

→ NoCM informs CoreManager+PE

3. QoS Allocation – Central NoCManager



- Path Search + Backtrace can be done by different “shortest path” algorithms
- Keep actual state of link (allocated/free) for next route search
- Allocate routers (ports) via dedicated control wires to each router
- Search and allocation in few dozen clock cycles → hardware unit

4. GS Allocation Success in 6x6 NoC

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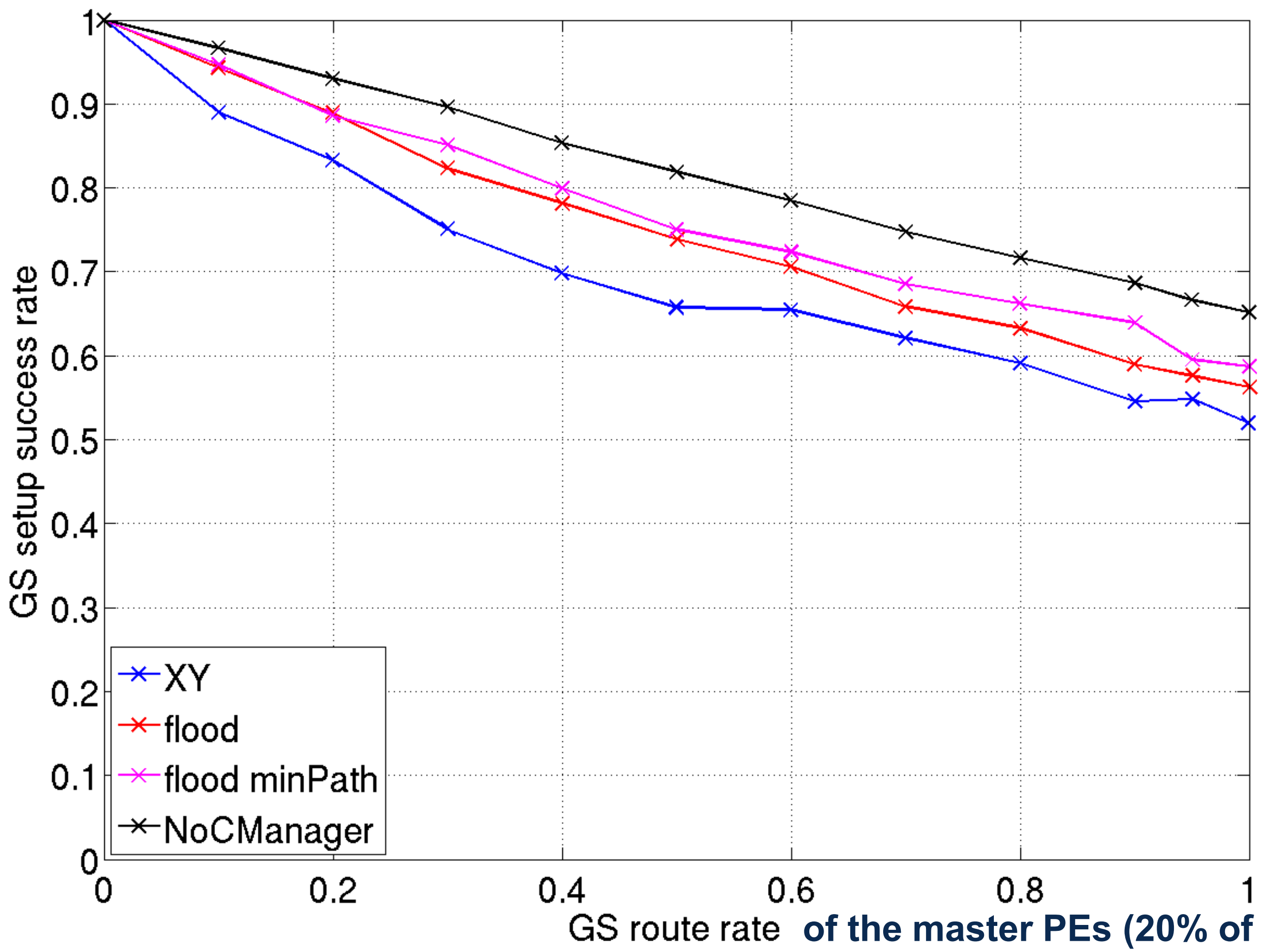

of the master PEs (20% of 6x6)

➔ Centralized NoC management achieves better performance results (at few traffic scenarios, flood along minimal path superior)

4. GS Allocation Success in 12x12 NoC

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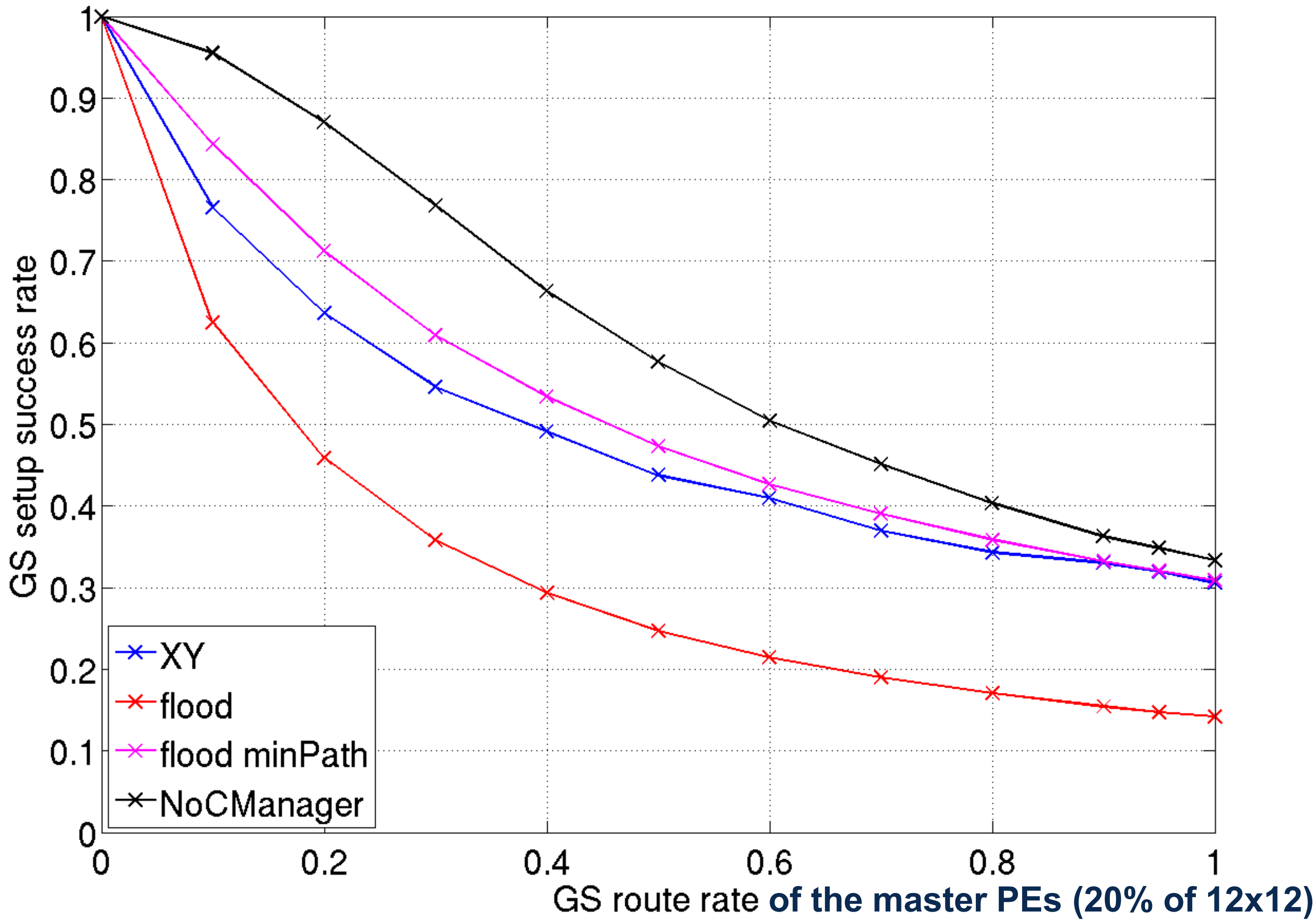

➔ Centralized NoC management achieves better performance results

4. Area Consumption on Chip

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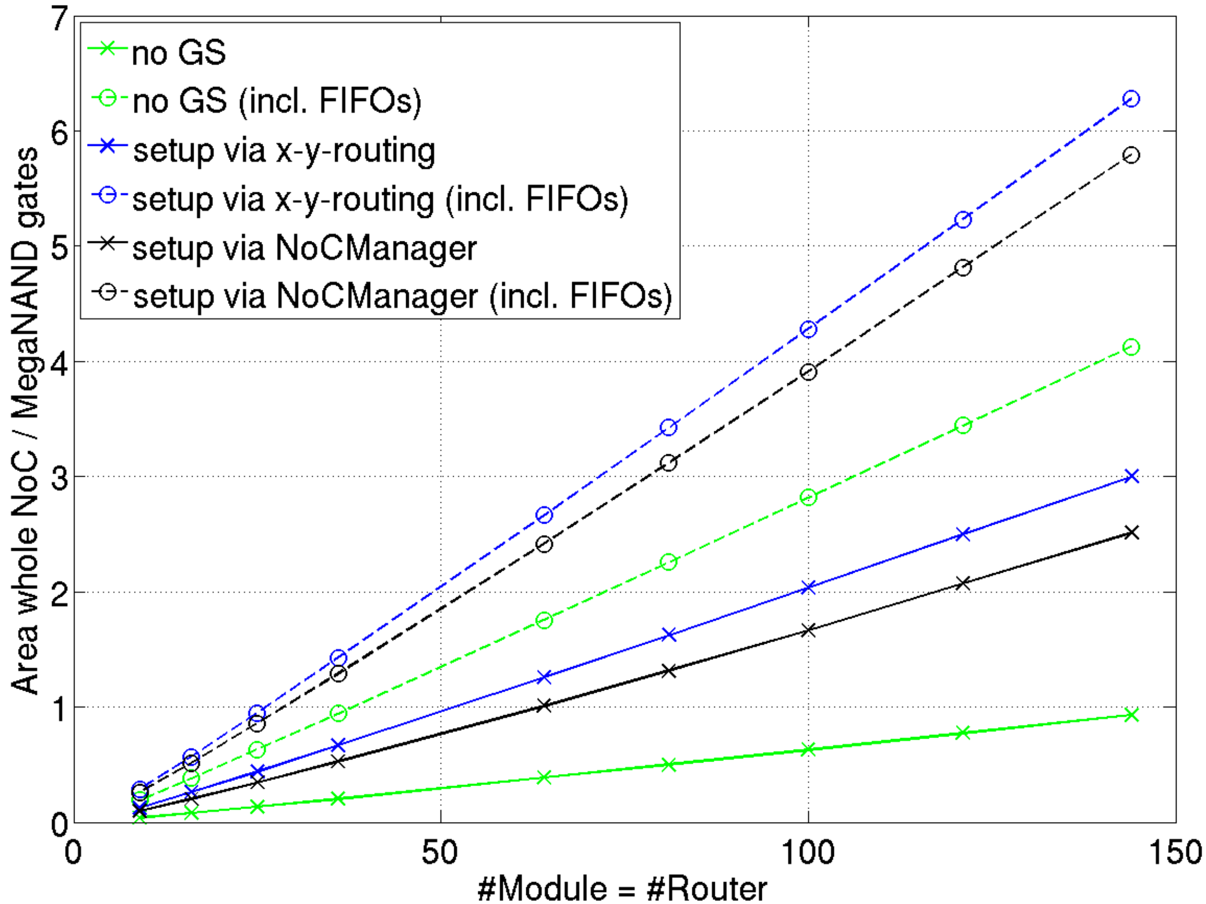

Area: area for routers + area of GS allocation scheme

➔ Centralized NoC management requires less area than distributed

5. Clustered NoC Motivation – Performance

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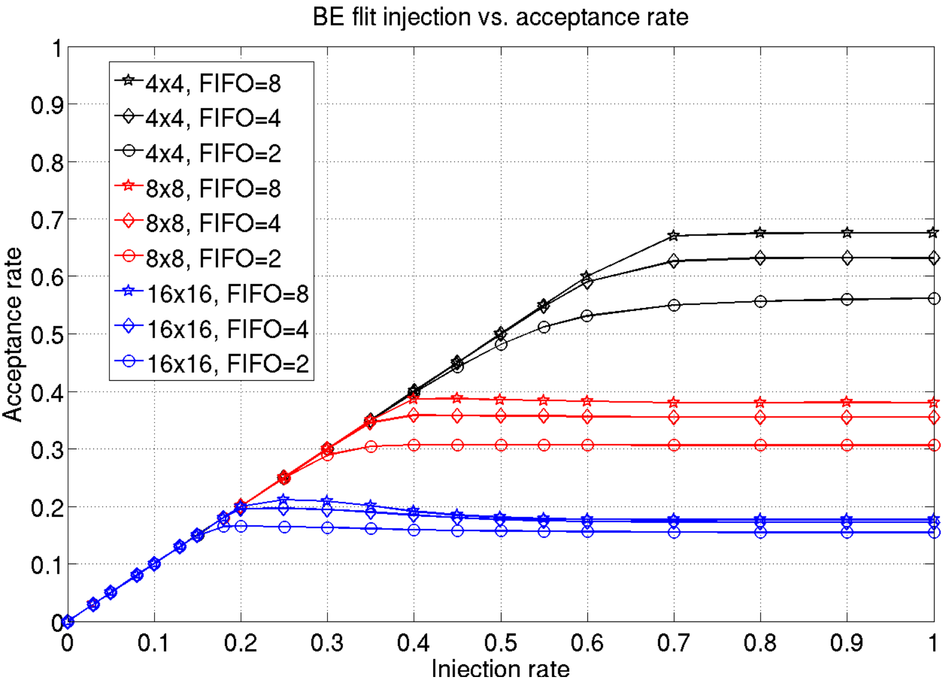

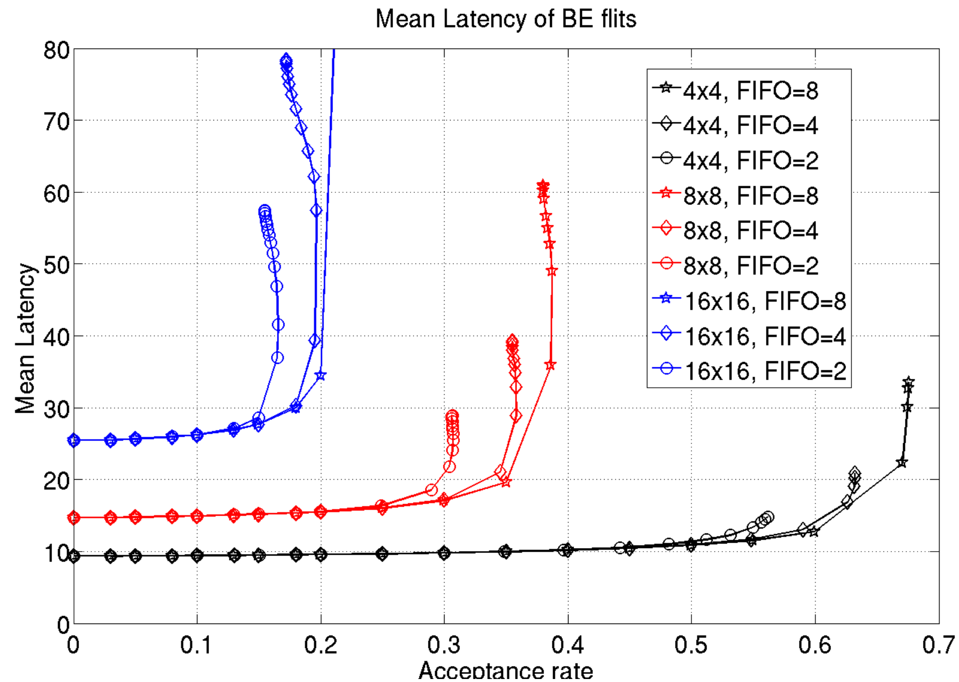

➔ Significant decrease in throughput (saturation point) with growing NoC size! → **Open Point**

(Constraints: 4x4, 8x8, 16x16 2D-mesh, uniform traffic in space, POISSON stream in time, 500.000 cycles where upper+lower 10% were ignored)

5. Hierarchy in NoCs - Architectures

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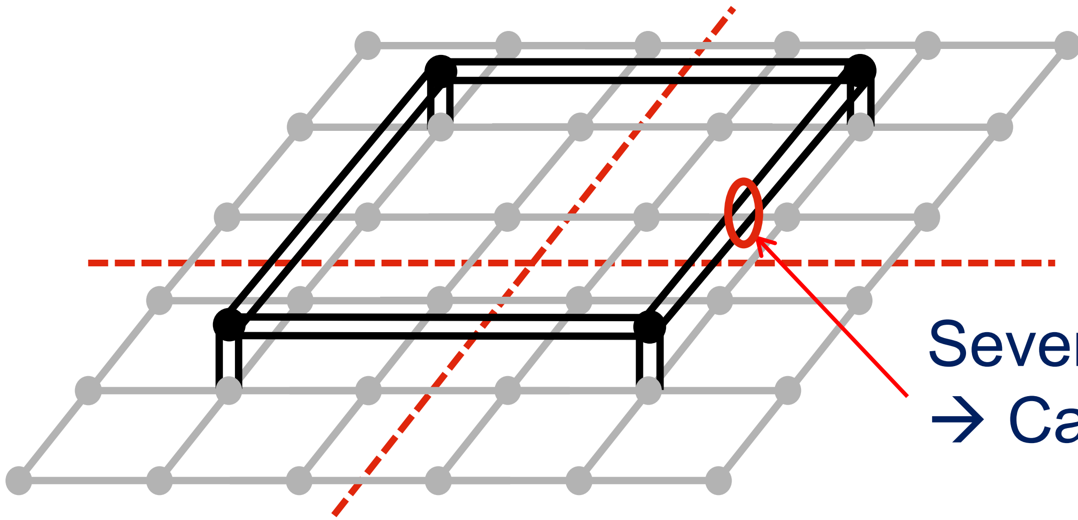

Several links on high-level mesh
→ Carry concentrated traffic

Cluster Architecture:

- Divide NoC in Clusters
  → Communication between clusters across high-level NoC
  + Shorten long distances
  + Deadlock-free routing
  - Flits to neighboor travel longer ways

Conclusions

Results: NoC with NoCManager a big step forward

NoC Challenges

- Service classes
- Hierarchy
- X-lock free routing and scheduling

The MPSoC Challenge

- One integrated concept for managing NoC, space/time scheduling of HW/SW tasks, and memory/buffers needed!