Topology exploration for energy efficient intra-tile communication

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OUTLINE

- **Introduction**
- **Topology exploration**
  - **Impact of different topologies**
  - **OCST problem**
  - **Experimental results**
- **Conclusions**

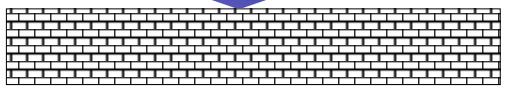
Low-energy operation should be targeted in all the design phases



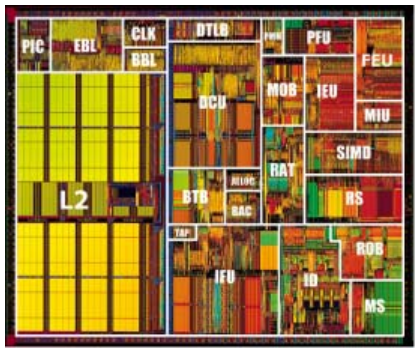

Battery Power driven

System-level design

Links between different design phases

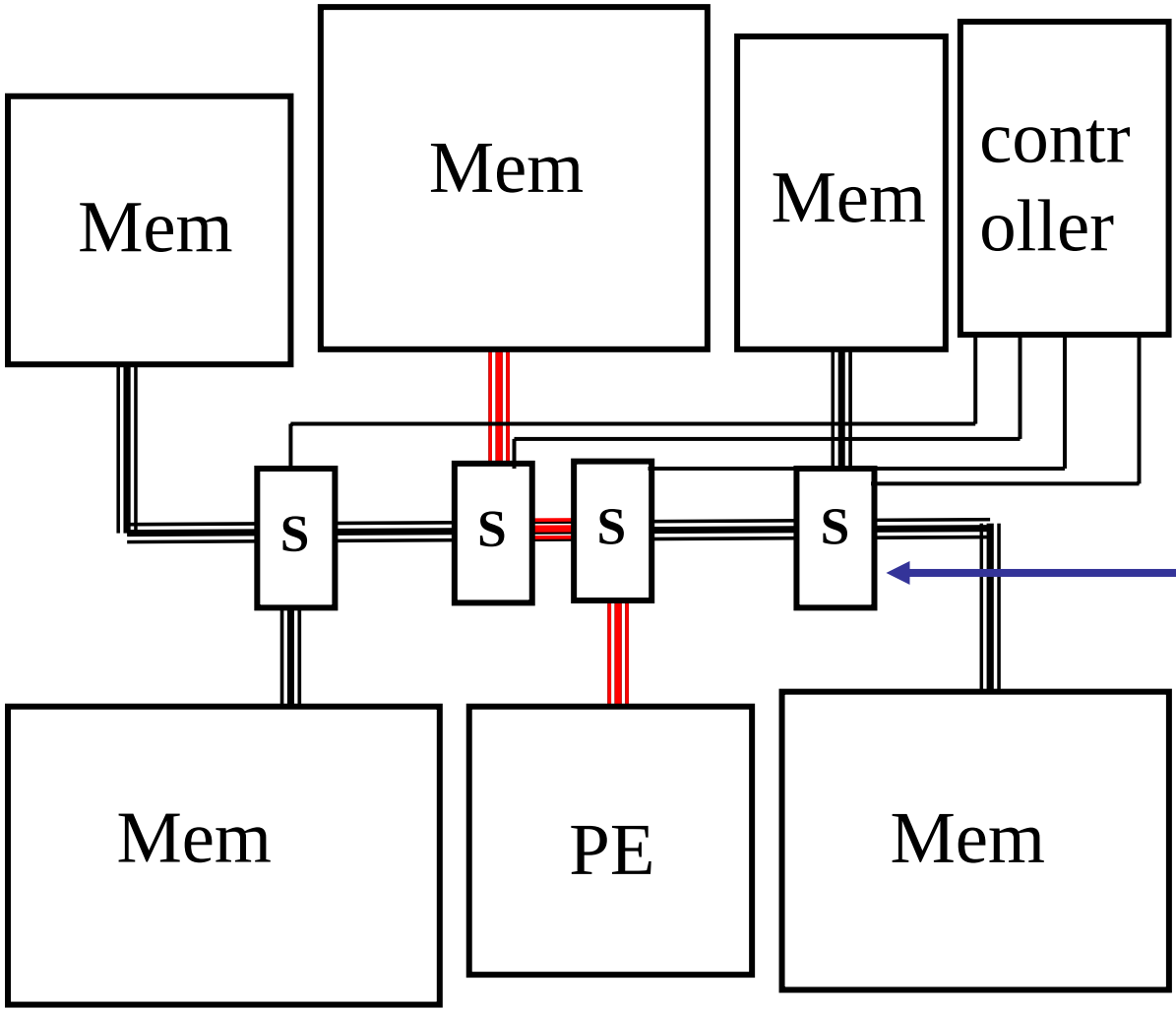


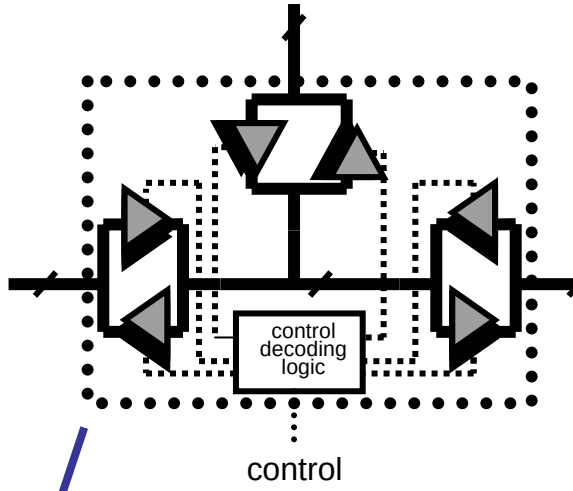
Physical design



Energy efficient operation is a key issue for embedded systems

Energy optimal sectioned bus (ESB) is an alternative for energy efficient communication

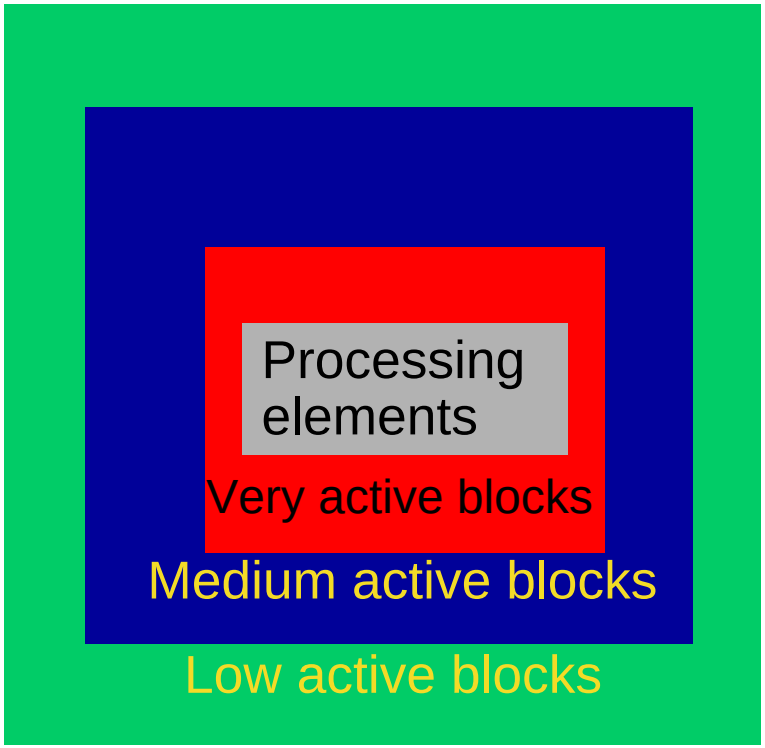


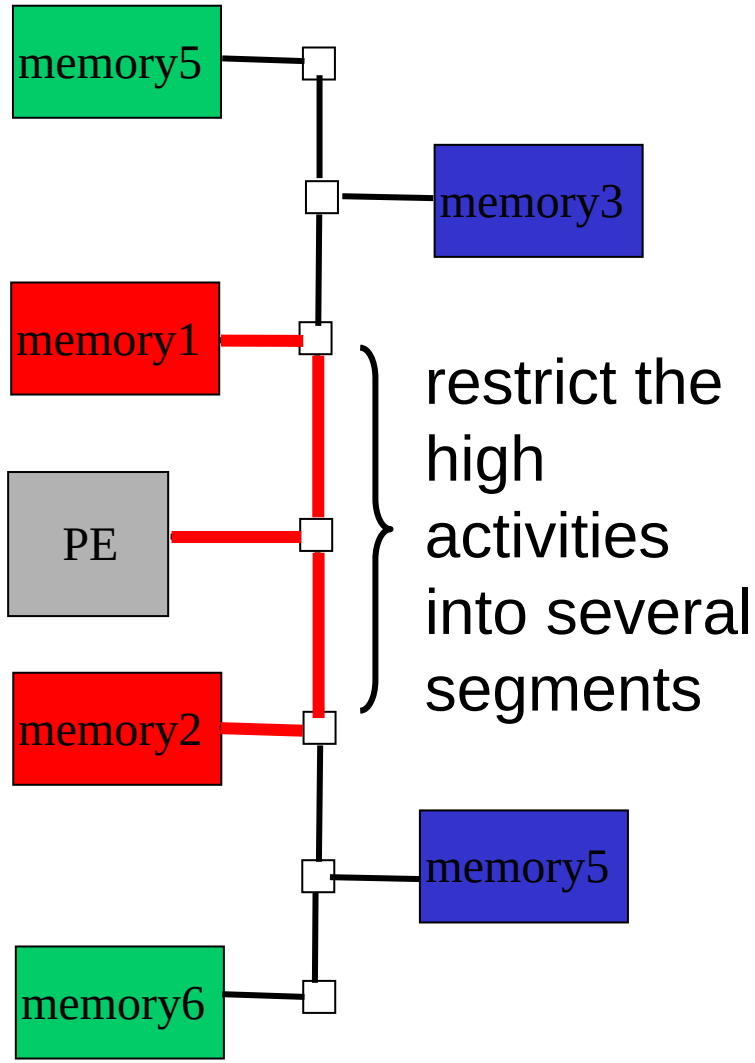


Switches

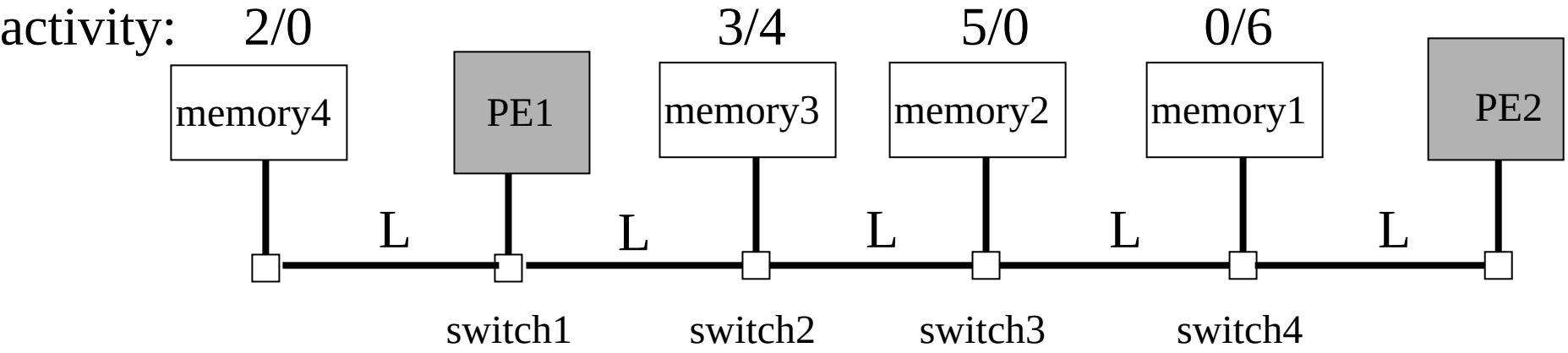
Activity-aware linear netlist for energy optimal solutions

Blocks that communicate very frequently should be ordered close to each other and vice versa



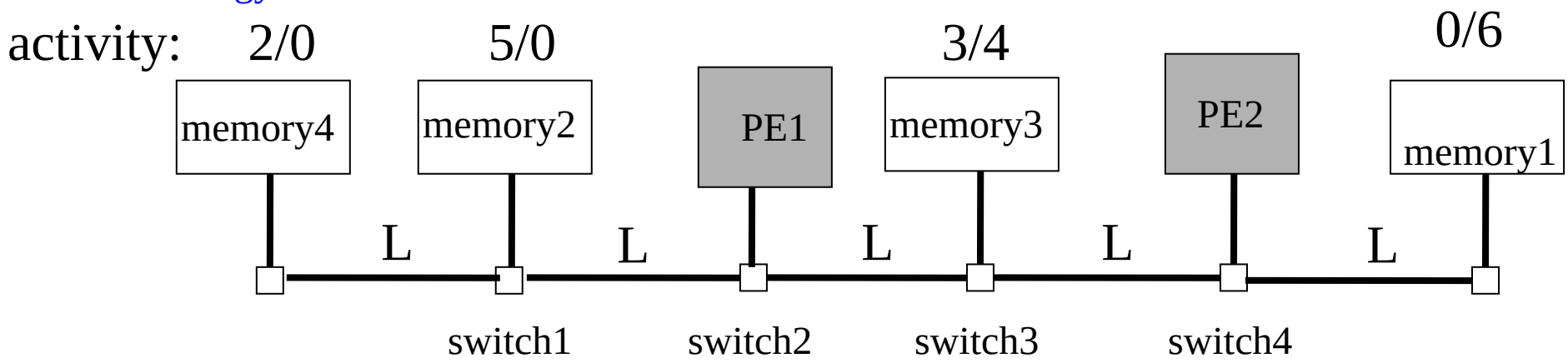


Block level netlist has a large impact of the energy consumption of segmented communication architectures



a. Activity blind block ordering decision

Energy ~ 2*L+3*L+4*3L+5*2L+6*L=33L



b. Activity aware block ordering decision

Energy ~ 2*2L+5*L+3*L+4*L+6*L=22L about 33% cost saved

Topology design is very important!!

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Block level netlist based on activity information

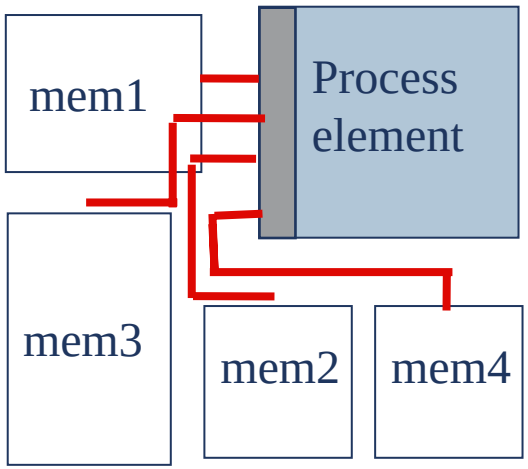
1. P2P style:

Memory1 ---- PE;

Memory2 ---- PE;

Memory3 ---- PE;

Memory4 ---- PE;



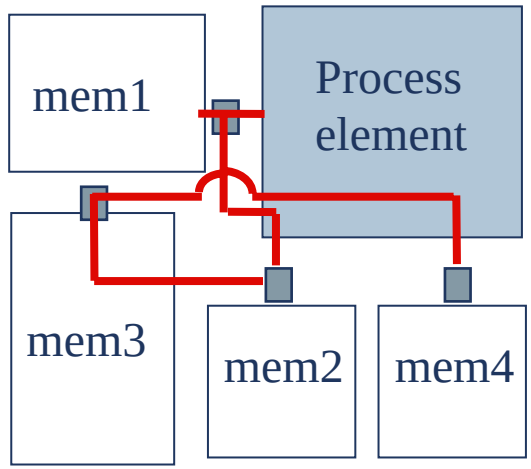
2. Linear connection

Only Activity:

According to the memory access frequency and neglecting layout geometry

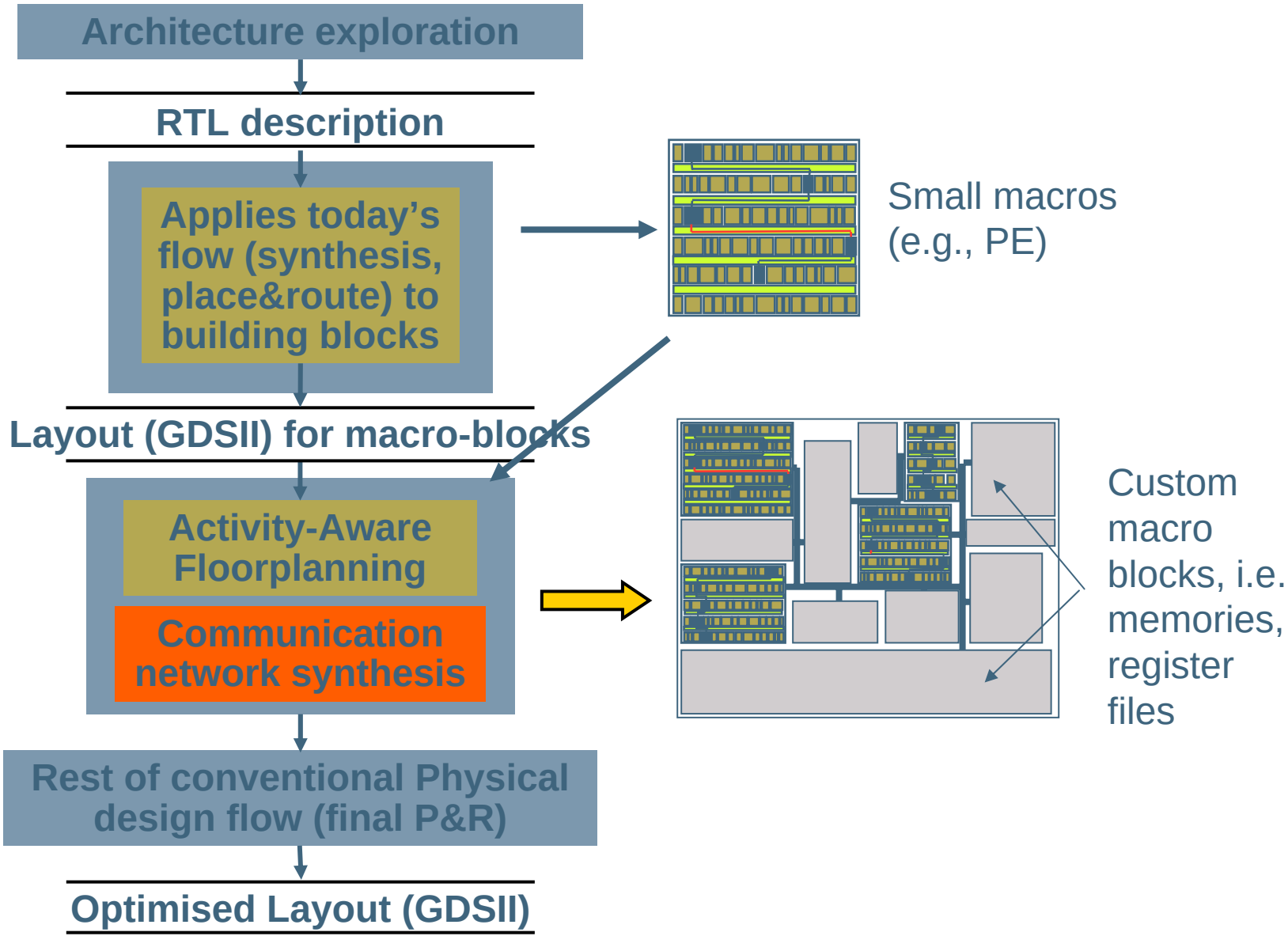
PE ---- Mem1 --- Mem2 --- Mem3 --- Mem4

High active ⟶ Low active



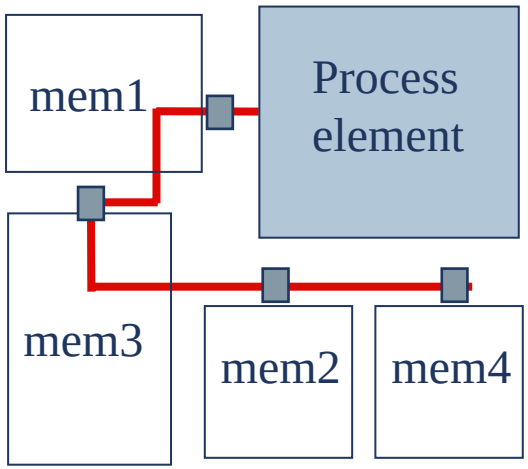
Too restrictive for physical design

Introducing a floorplanning estimation step before communication synthesis enables energy optimization

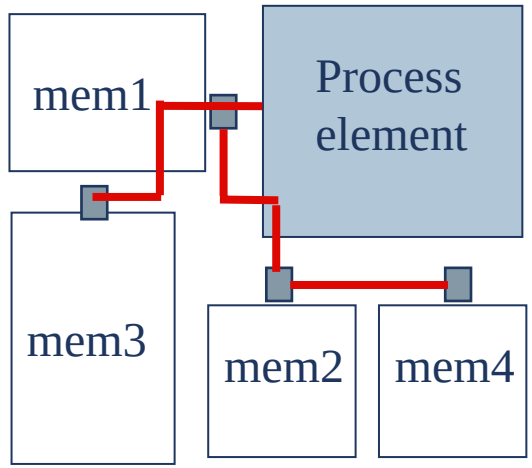


Block level netlist definition combining activity and geometry introduction

3. Linear connection



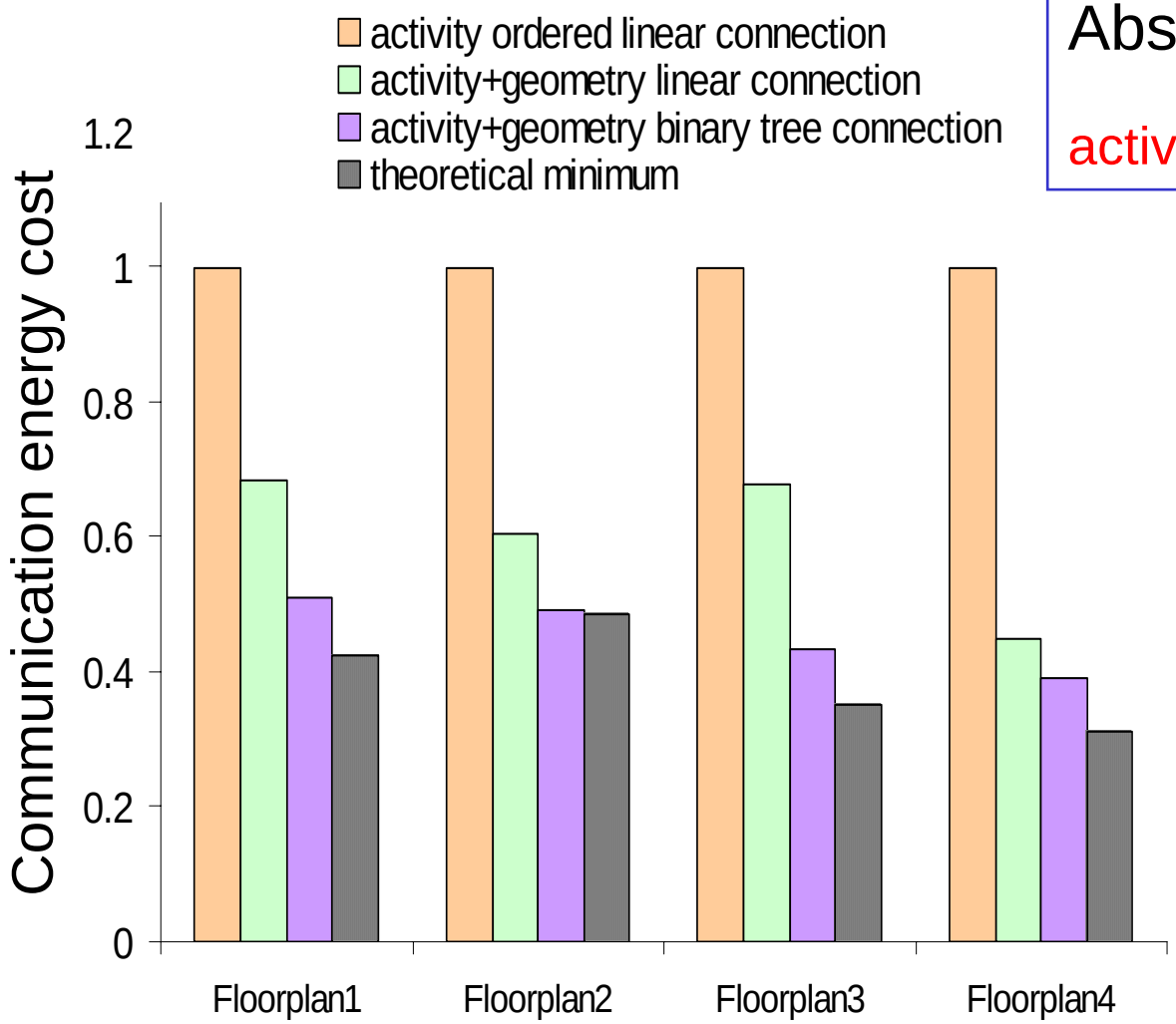
4. Binary tree



More freedom

Netlist is decided according to the floorplanning + memory activities information (geometry is considered)

Communication cost for different netlist topologies at high level



Abstract energy metric::

activity × Manhattan wire length

Binary tree topology is a good candidate for energy optimal communication

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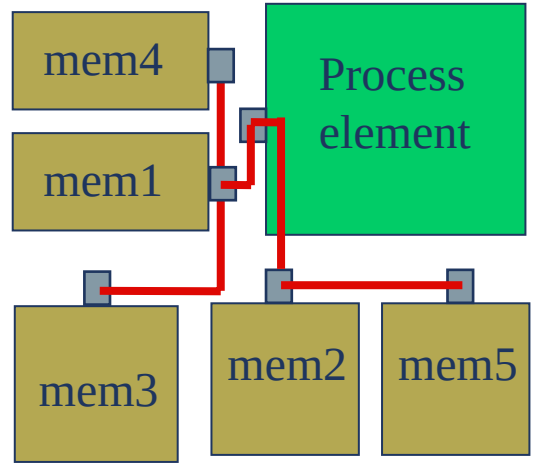
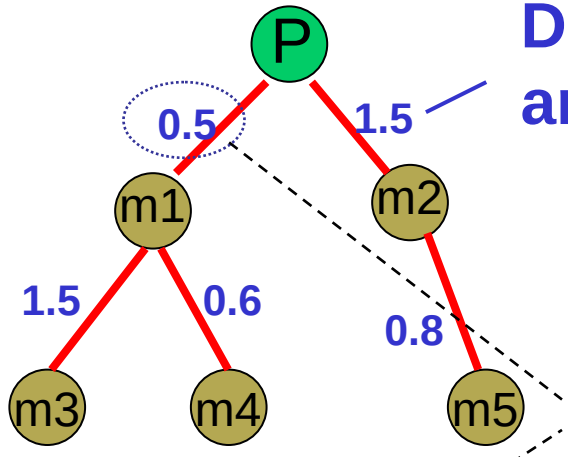
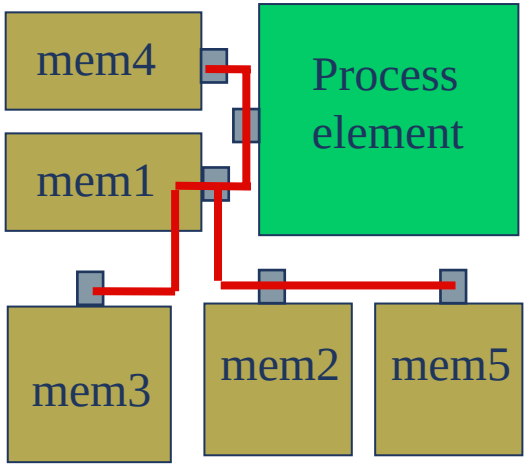
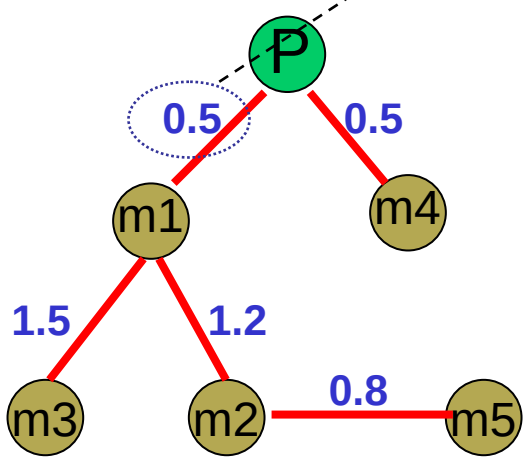
The floorplanning estimation stage determines the distance annotation for the block-level netlist





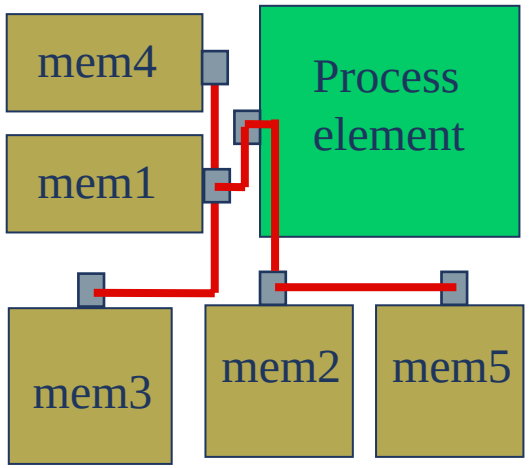
Distance annotation



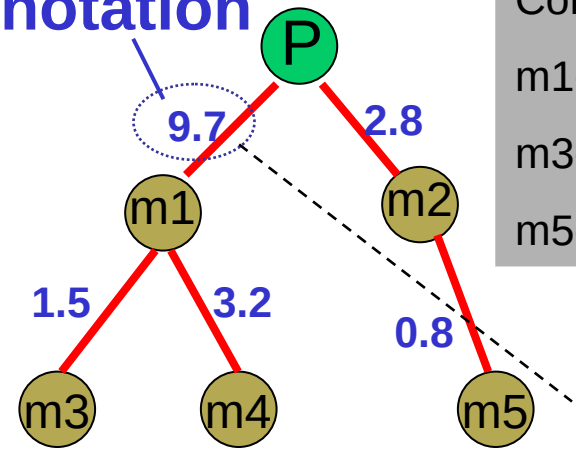


The distance annotation is the same for the same edge in different topologies (the floorplan is the same)

The activity annotation is not static --> OCST problem



Activity annotation

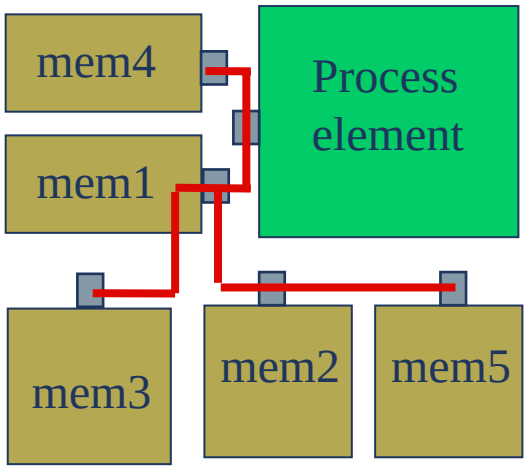


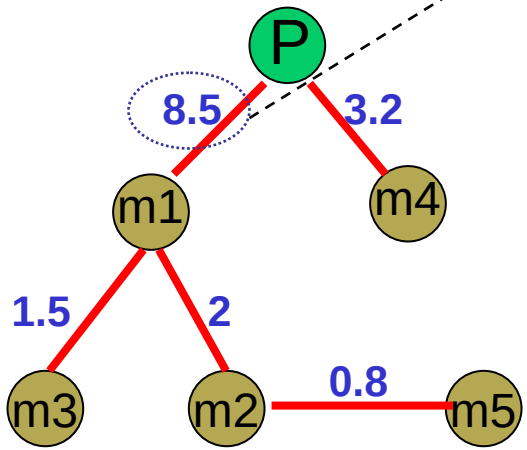
Communication acitivity assumption

m1-->PE: 5 m2-->PE: 2

m3-->PE: 1.5 m4-->PE: 3.2

m5-->PE: 0.8

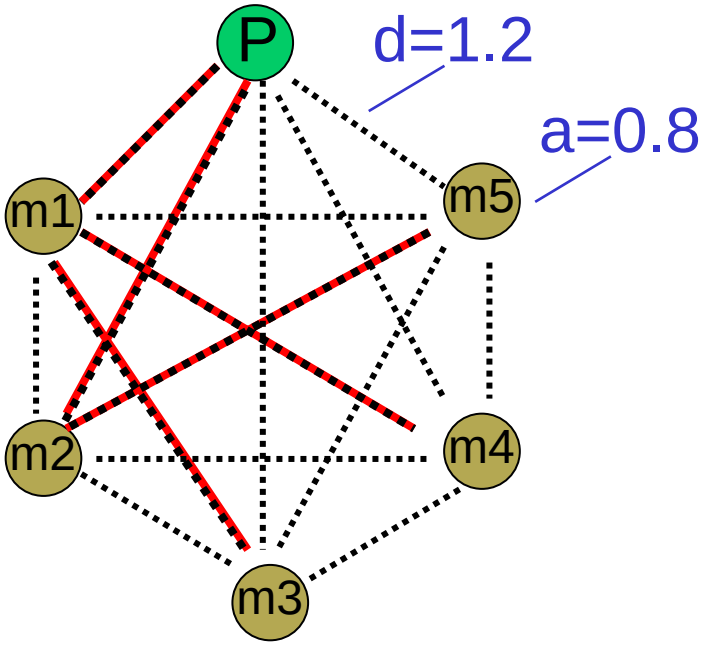




The activity annotation is dynamic. It is decided only after the topology is fixed (Different from the normal Spanning Tree problem!!).

It is an Optimal Communication Spanning Tree problem (OCST)

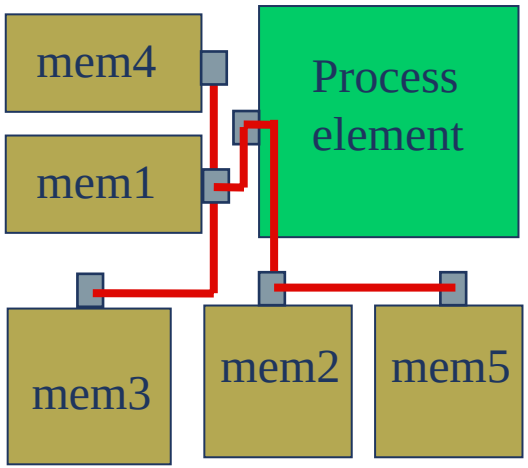
Greedy approach to solve the OCST problem



Communication Cost=

$$\sum activity \times dis\tan ce$$

GA: each iteration, the two nodes which have the minimal value=distan./activ. are connected.



The greedy approach has less than 5% overhead in average compared to the optimal results obtained by the exhaustive approach for small scaled designs

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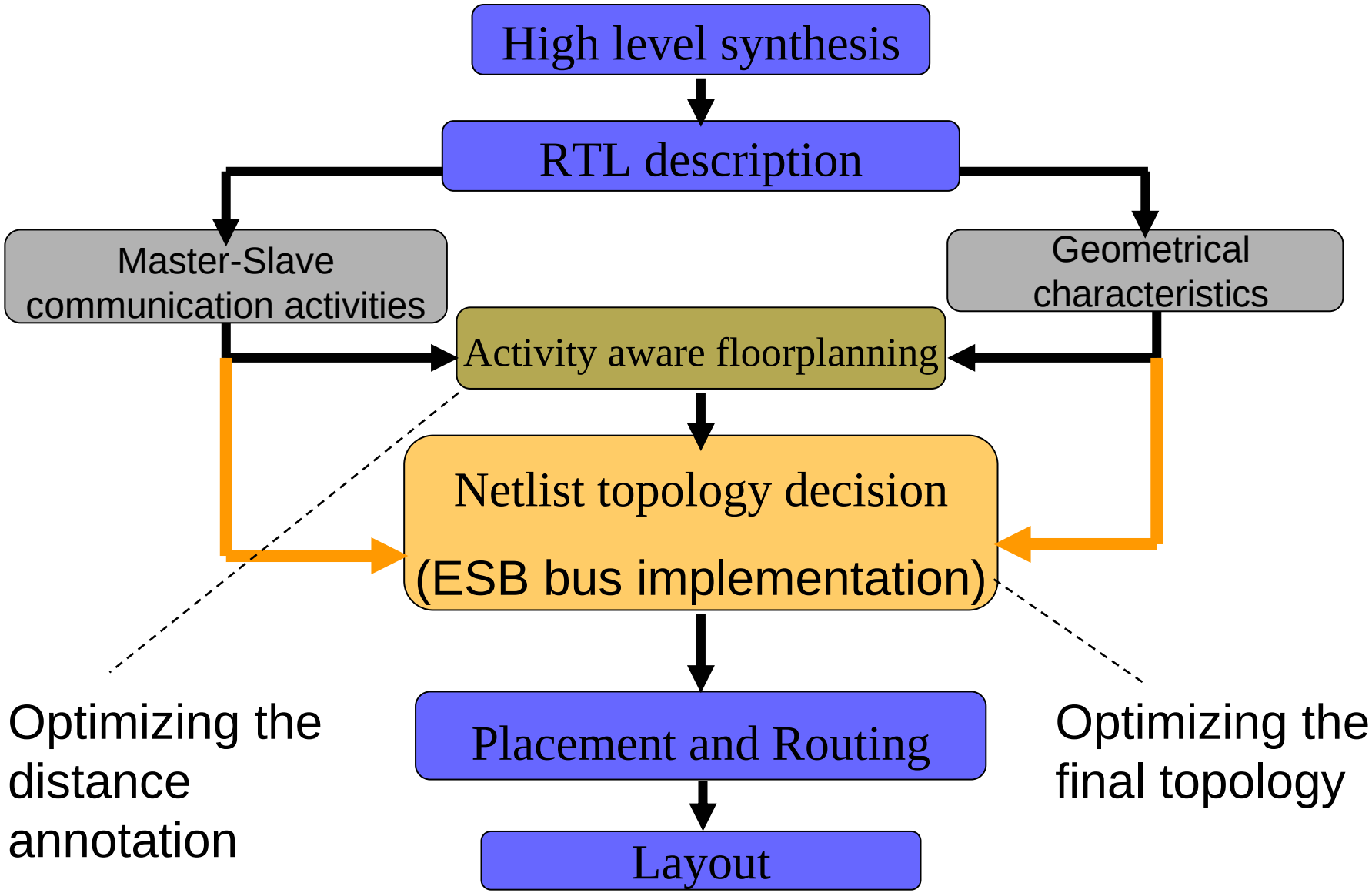
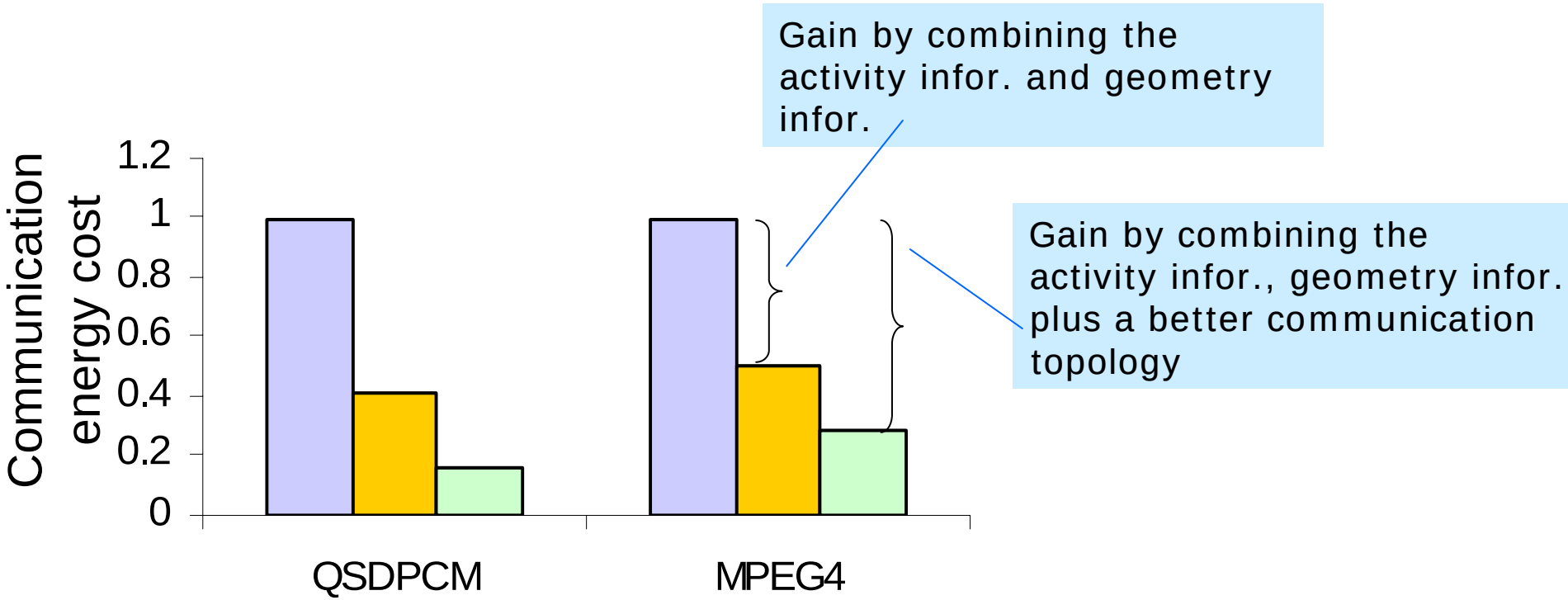
The framework of the netlist optimization for ESB bus architecture



Energy comparison of linear connection and binary tree connection

- Area optimized floorplanning & activity aware linear netlist
- Activity aware floorplanning & linear netlist using geometry&activity information
- Activity aware floorplanning & binary tree netlist using geometry&activity information



Conclusions

- ESB bus can significantly improve network energy consumption

- Together with the initial floorplanning stage, our methodology can generate an energy efficient block level netlist. This netlist can improve energy efficiency by a factor of 4 compared to standard linear bus topologies.