


MAPS: An Integrated Framework for MPSoC Application Parallelization

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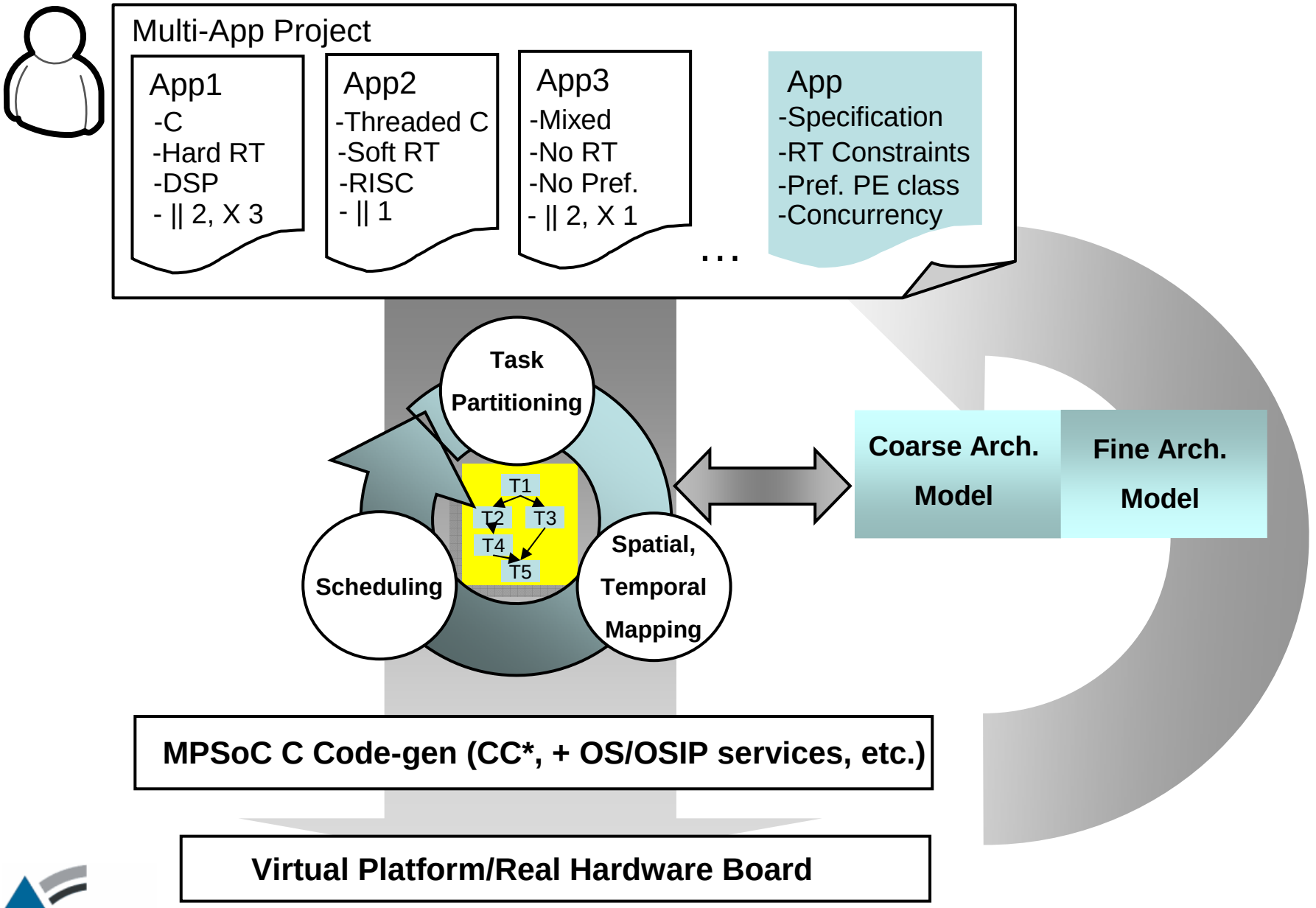
Agenda

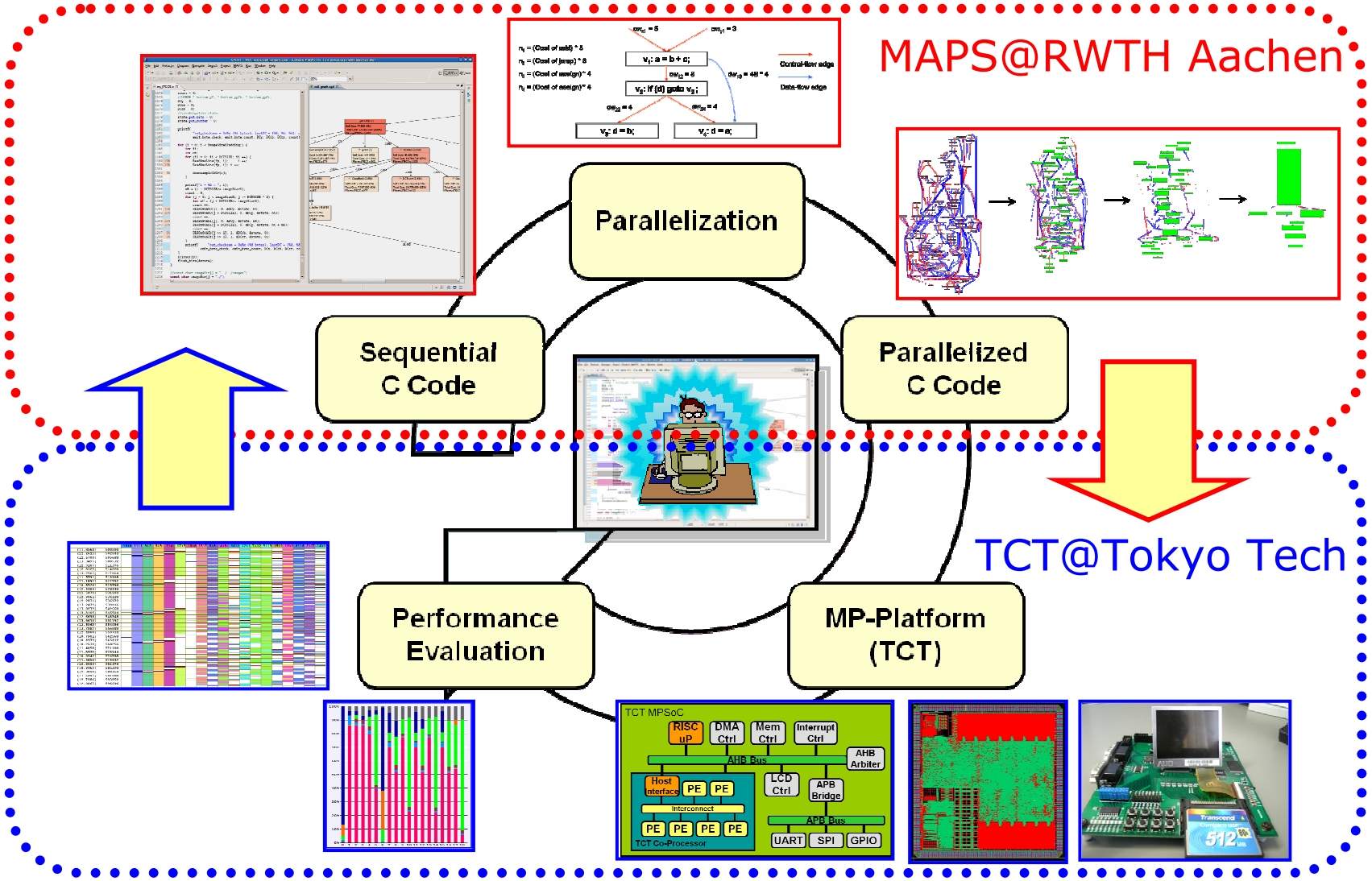
MAPS - MPSoC Application Programming Studio

- MAPS Project Overview
- MAPS-TCT Framework
- Summary/Outlook

MAPS Project Overview



MAPS-TCT Framework

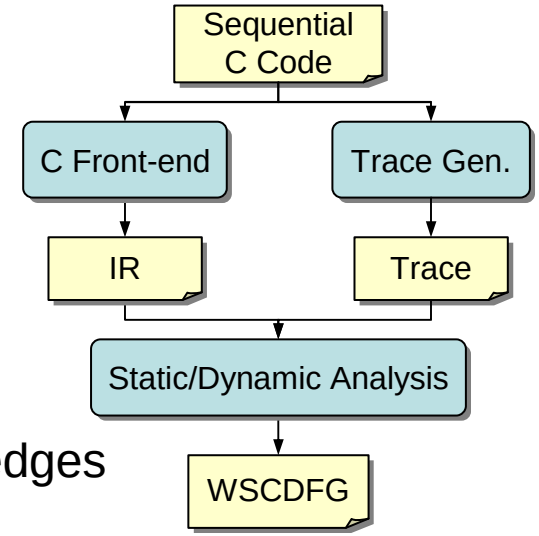


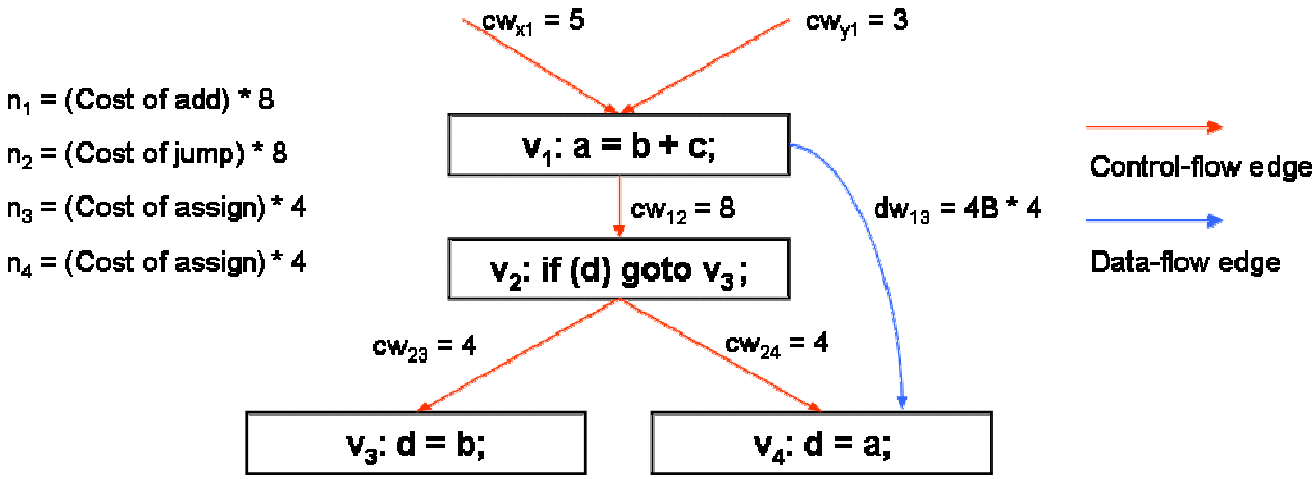
MAPS: MPSoC Application Programming Studio

- ***A practical MPSoC software development tool suite***
  - Sequential C (input) → "threaded C" (output)
  - Powerful analysis tools for providing rich feedback to the programmers
    - *Static dependence analysis*
    - *Dynamic profiling*
  - Powerful clustering method for extracting coarse-grain parallelism
    - *Weighted Statement Control Data Flow Graph (WSCDFG):* annotates dynamic profiling information on CDFG
    - *Coupled Block (CB):* subgraph of WSCDFG that is schedulable and tightly coupled by data dependence
    - *Constrained Agglomerative Hierachical Clustering (CAHC):* iterative clustering for building coarser graphs

Weighted Statement Control/Data Flow Graph (WSCDFG)

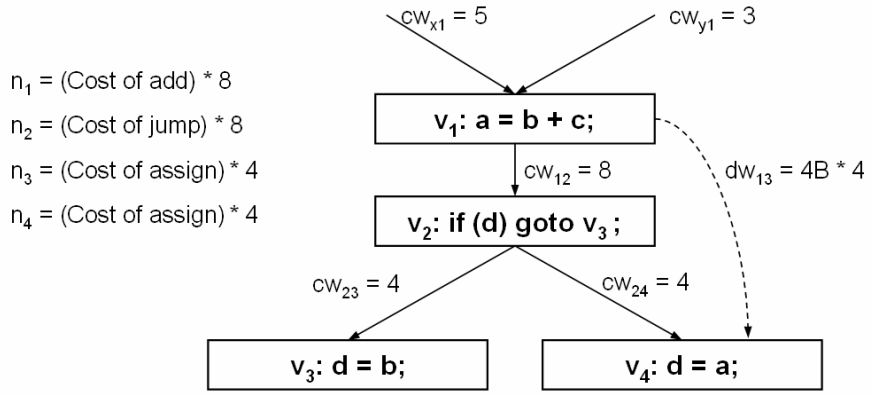
- **Definition: *WSCDFG* is a directed graph defined by G = (V,CE,DE,CW,DW,N), where:**
  - V: IR statement nodes
  - CE: set of control flow edges
  - DE: set of data flow edges
  - CW: weights (count) of control edges
  - DW: weights (amount of data, e.g. bytes) of data edges
  - N: weight of IR statement nodes (cost table)



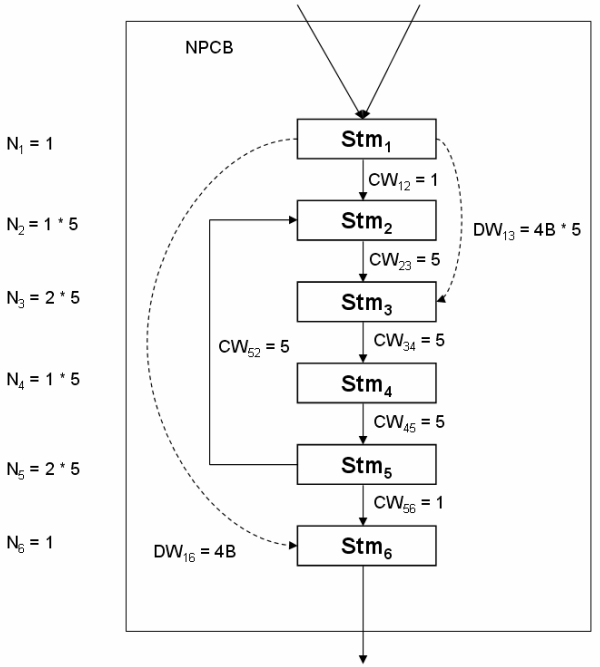


Parallelism Discovery: Granularity - Coupled Block (CB)

- **Coarse-grained Task Parallelism in C**
- **Based on Compiler IR (Intermediate Representation)**
- **Suitable Granularity of Codes as Atomic code blocks**
  - → ***CB*** *(Coupled Block)*
- **CB Design Criteria**
  - Tightly coupled by data-dependence
  - Schedulable



Weighted Statement Control/Data-flow Graph (WSCDFG)

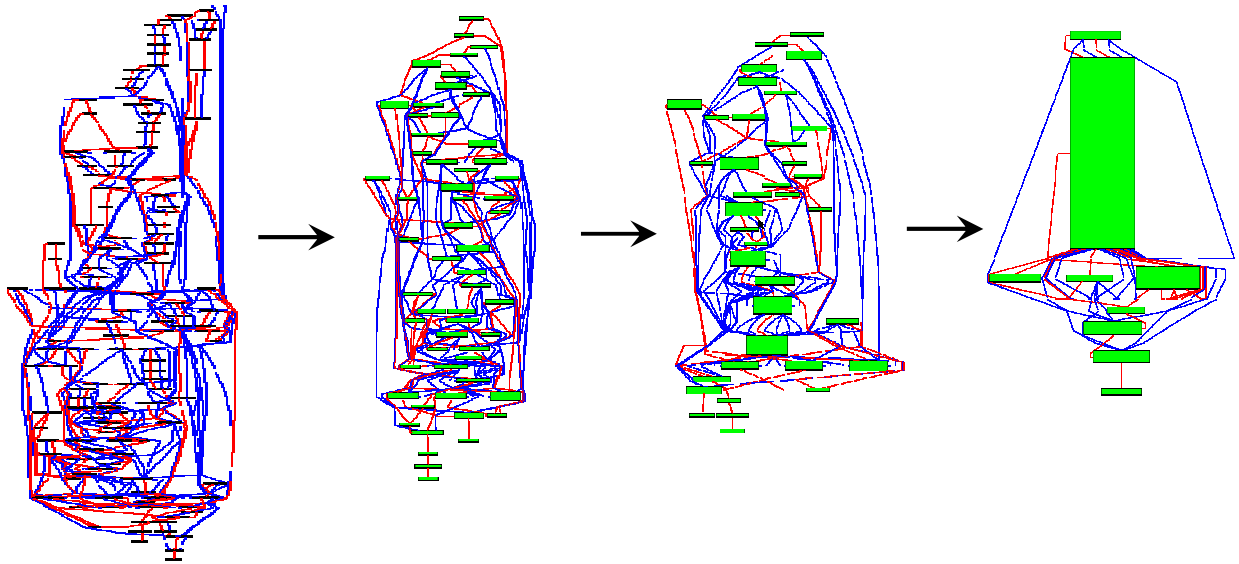


- $\forall v_i \in V', \frac{w_1 \cdot \sum_{cw_{ij} \in CW'} cw_{ij} + w_2 \cdot \sum_{dw_{ij} \in DW'} dw_{ij}}{D(v_i, V')} > T$

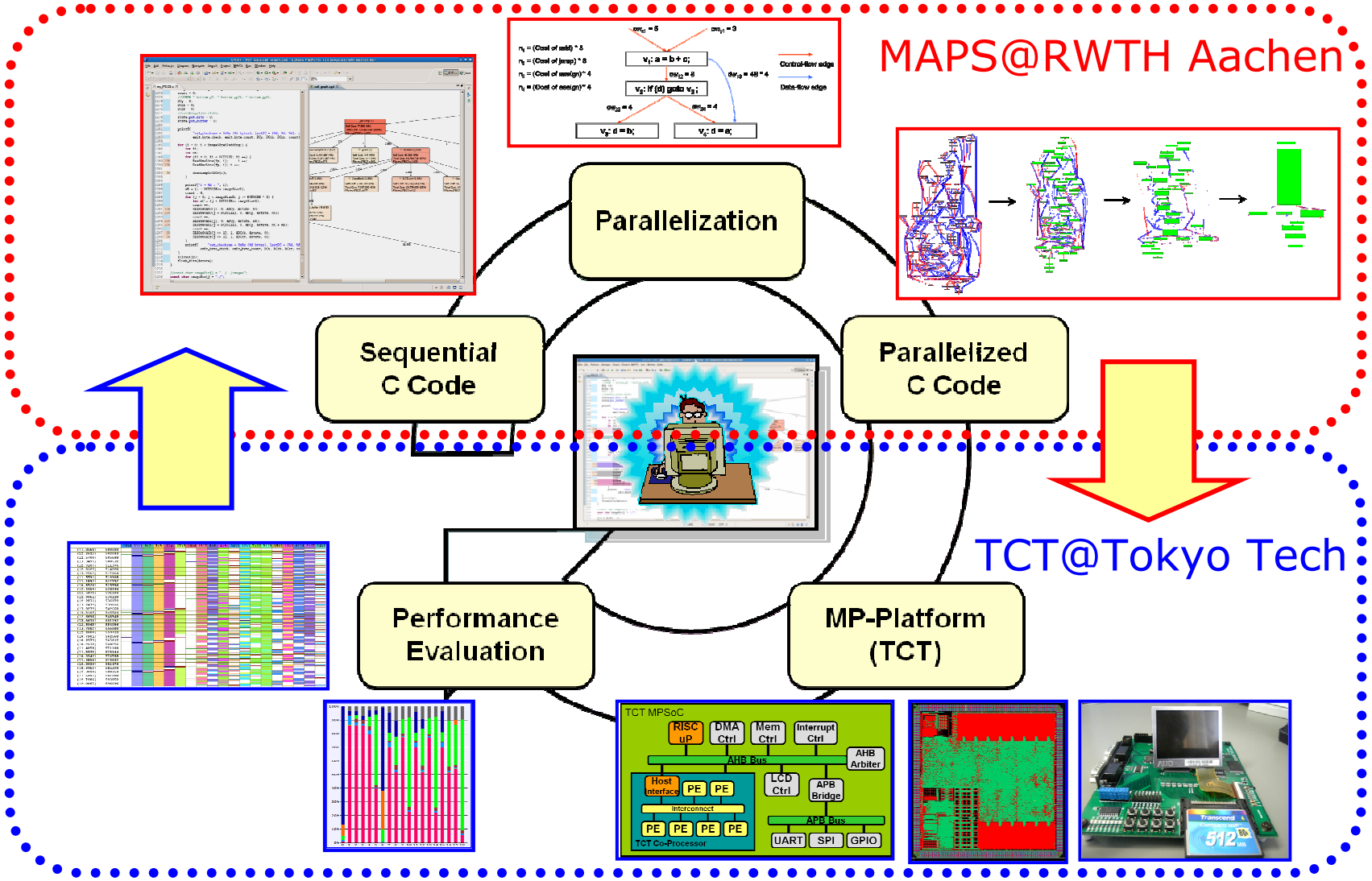
CB Example in WSCDFG

Parallelism Discovery: CB Generation – CAHC Algorithm

- **Optimal generation of CB: Heuristics needed**
- **Based on Density Boundary Scan algorithm (DBSCAN) for knowledge discovery in data bases**
- ***Constrained Agglomerative Hierarchical Clustering* – CAHC**
  - Constrained: maintain schedulability of CBs
  - Hierarchical: several clustering levels with different granularities
  - Agglomerative: build coarser graphs iteratively

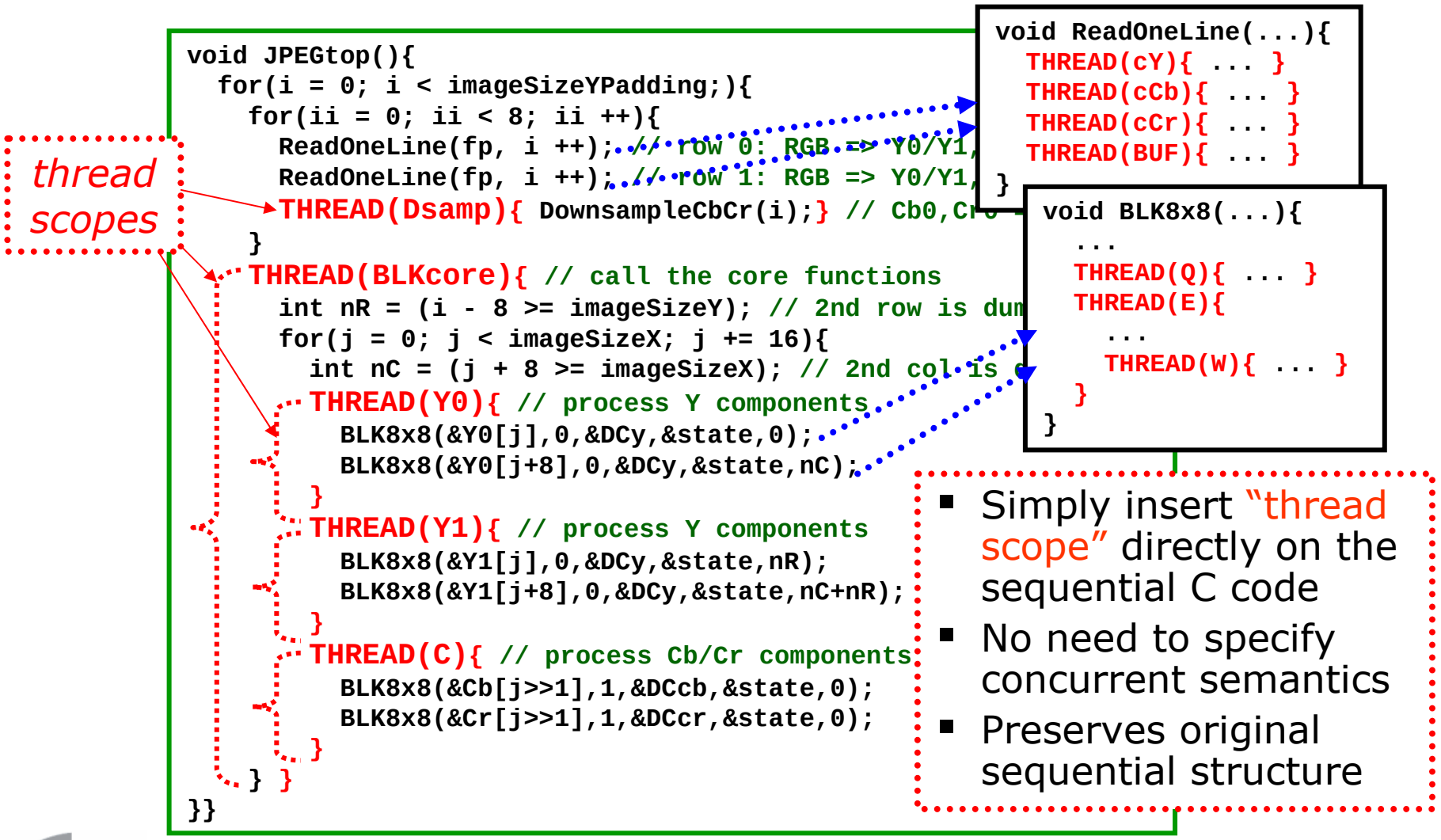


MAPS-TCT Framework



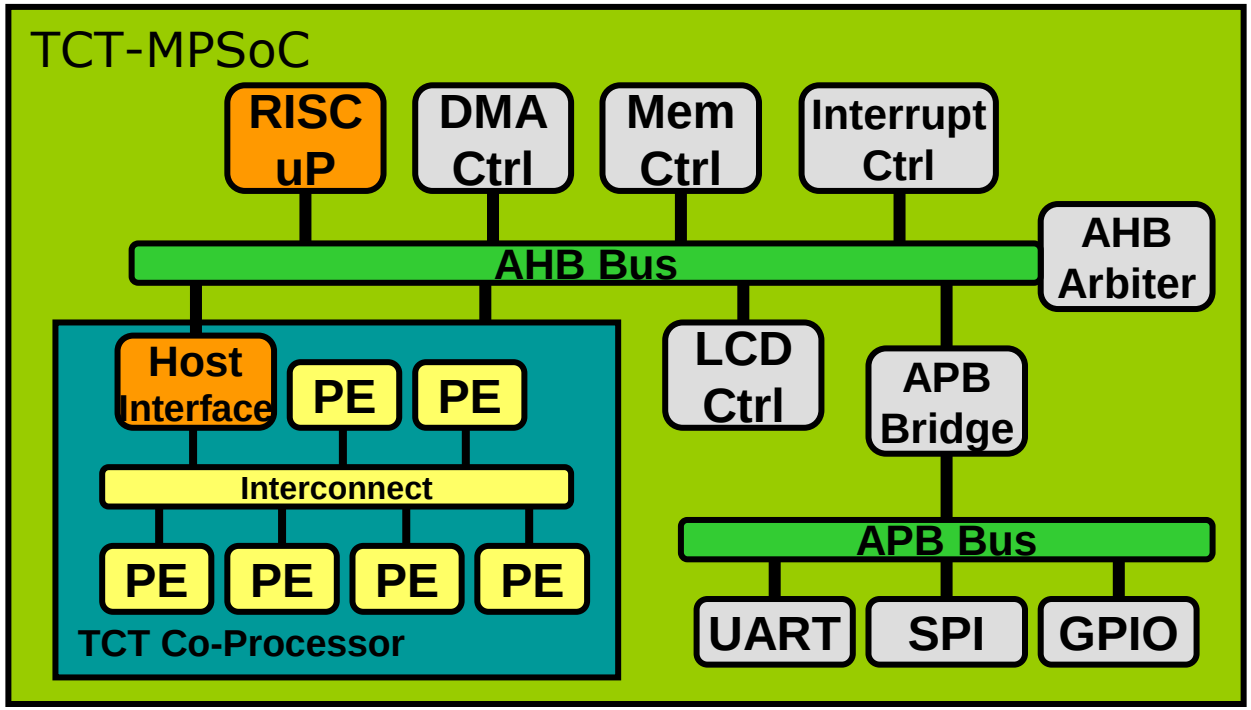
Tightly-Coupled Thread (TCT) Programming Model

Seamless transition from *sequential C codes*

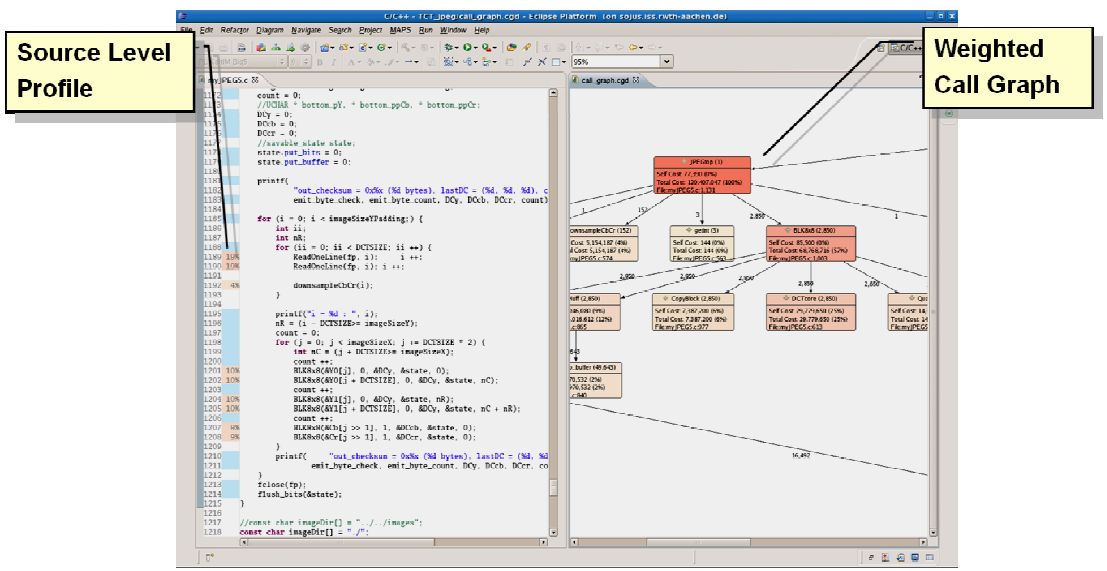


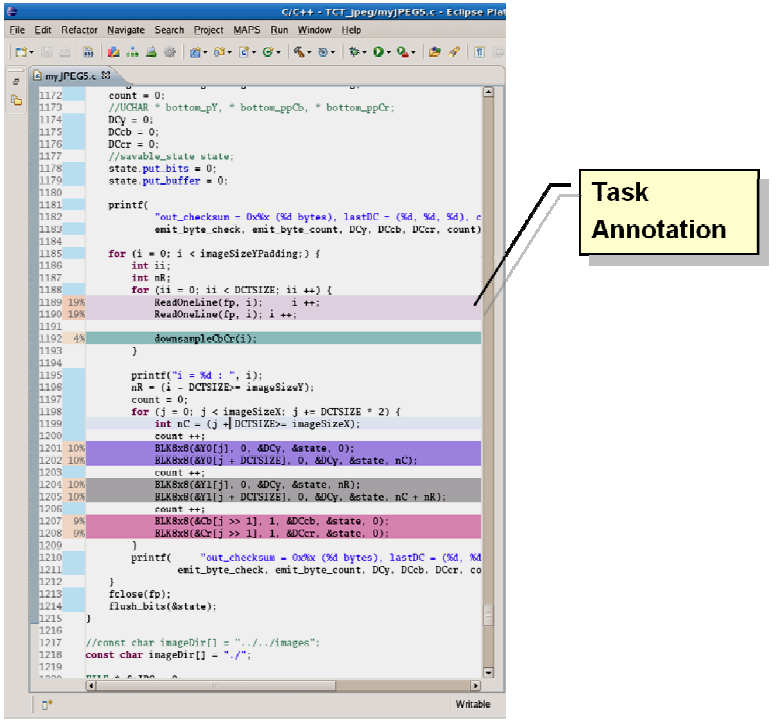
TCT-MPSoC Prototype Chip

- **TCT Coprocessor (TCoP): 6-PE array @ 100 MHz**
  - Full crossbar interconnect
  - Dedicated comm. module in each PE
- **Host RISC core: JANUS200 @ 200 MHz (ARMv4T ISA)**
  - Can be configured as the 7th PE on the PE array interconnect



Parallelization Experiment: JPEG Encoder

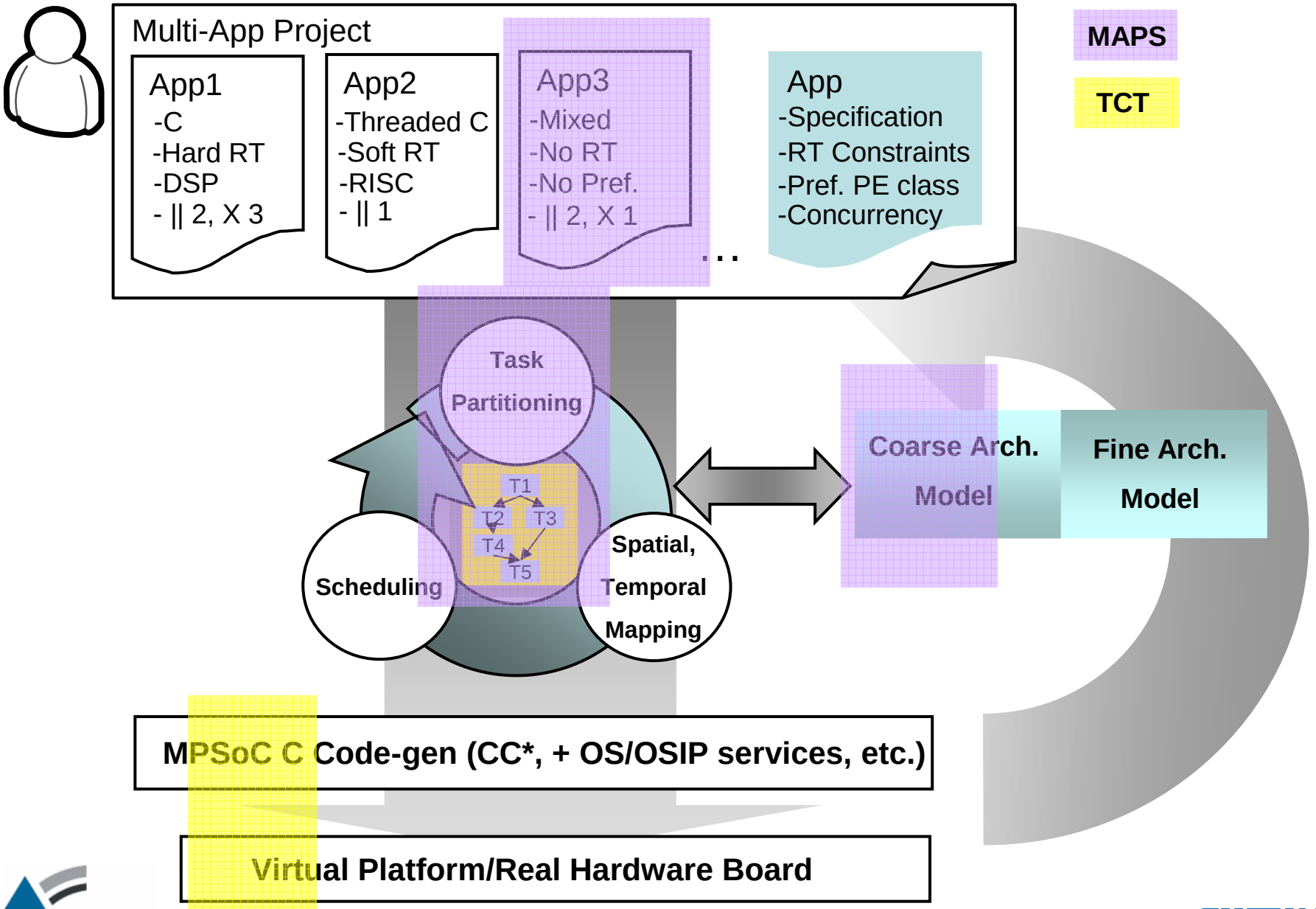




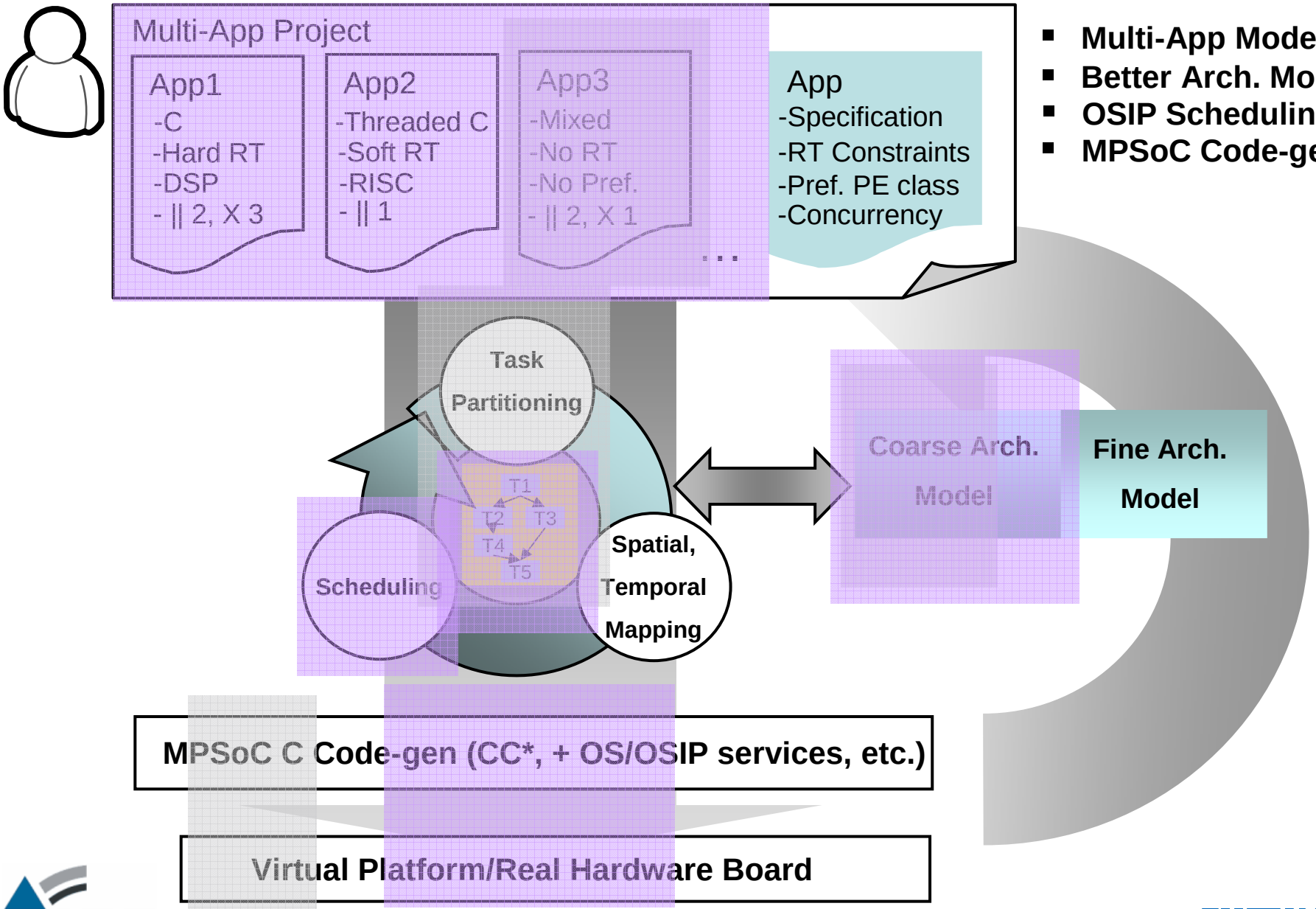
Speedup & efficiency

Step	Speedup	No. of PEs	Parallel Efficiency
1	3.61x	16	22.58%
2	5.48x	17	32.3%
3	5.48x	16	34.3%
manual	9.43x	19	49.6%

Summary: MAPS work-in-progress



Outlook



- **Multi-App Model**
- **Better Arch. Model**
- **OSIP Scheduling**
- **MPSoC Code-gen**

Thank you!