Collaborative Hardware/Software Partition of Coarse-Grained Reconfigurable System Using Evolutionary Ant Colony Optimization

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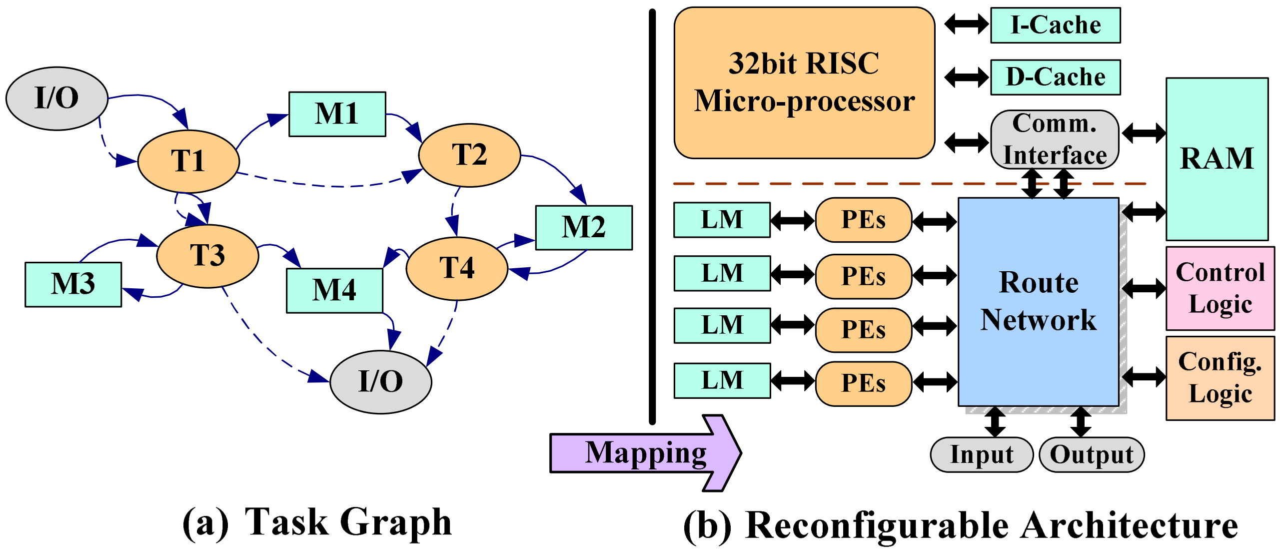
Outline

- ❖ Problem Formulation for Coarse-Grained Reconfigurable System Partition
- ❖ Collaborative Partition Framework
- ❖ eACOGA Algorithm
- ❖ Automatic Partitioning Flow
- ❖ Conclusions

Target architecture for partitioning



Task Graph
- Node - task
- Edge – channels or dependences

Reconfigurable Architecture
- RISC Microprocessor
- Reconfigurable PE Arrays

Problem formulation

- **Definition 1 (TG)** A task graph *TG = (T, E, C, P)* consists of a set of nodes *T*, a set of directed edges $E \subseteq (T \times T)$, configuration of nodes *C*, and a set of node ports *P*.

- **Definition 2 (rAG)** A reconfigurable architecture graph *rAG = (CP, CPE, CM, RN*) consists of microprocessor computation resources *CP*, reconfigurable computation resources *CPE*, memories *CM*, and route networks *RN.*

- **Definition 3 (k way partition)** For given a set of modules *M = {m1,m2,…,mn}*, a *k* way partition problem is to find a set of clusters *P = {p1,p2,…,pk}*, which meets:

$$\begin{cases} p_i \subseteq M, & 1 \le i \le k \\ \bigcup_{i=1}^{k} p_i = M & \\ p_i \bigcap p_j = \Phi, & 1 \le i, j \le k, i \ne j \end{cases}$$

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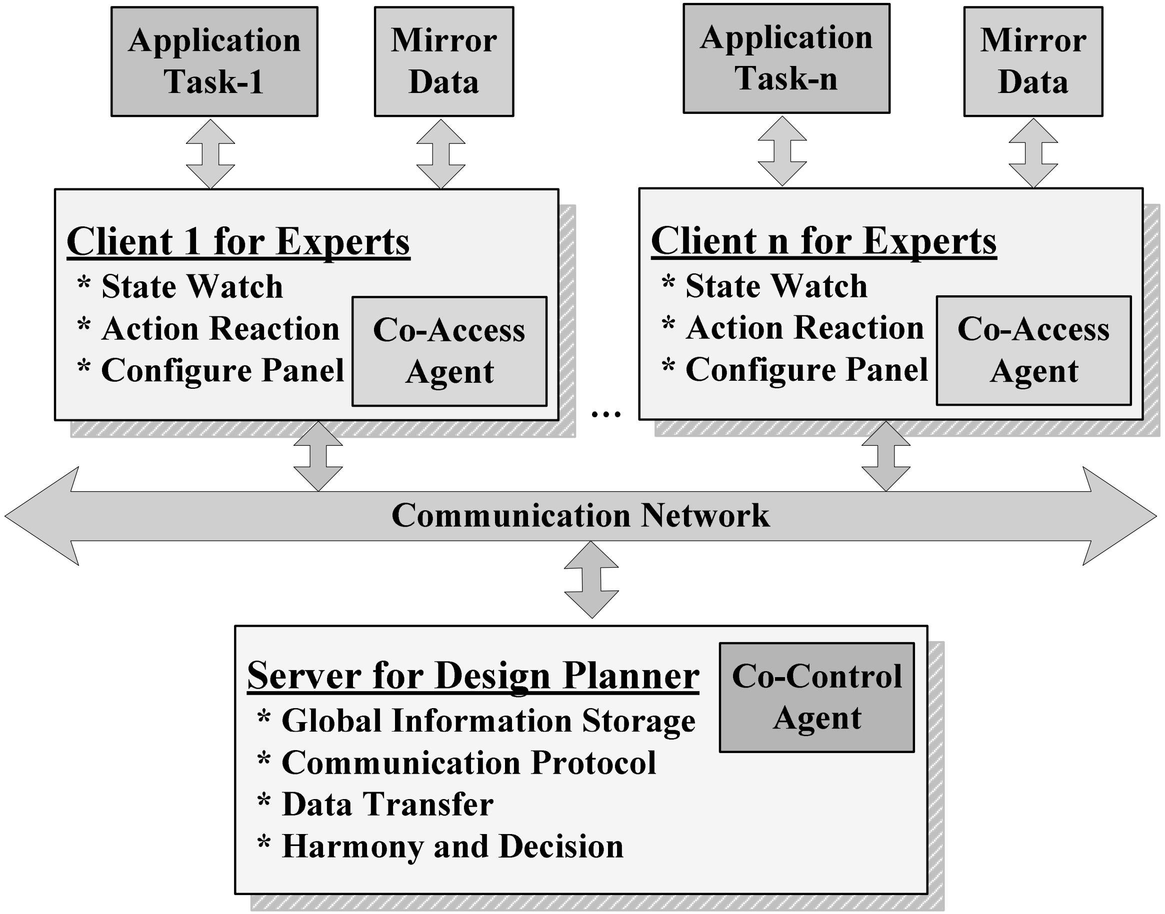
Collaborative Partition Framework



- ❖ Task protocol
- ❖ Data transfer protocol
- ❖ Parallel and cooperative control protocol
- ❖ Notification protocol

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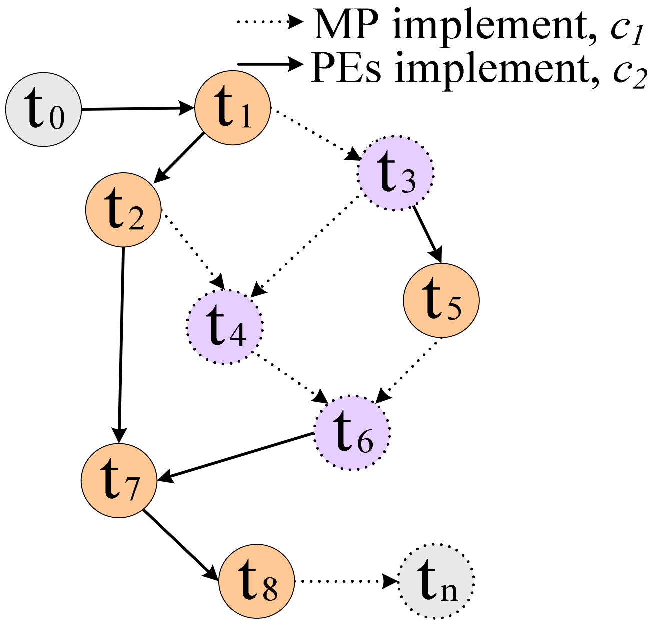
eACOGA algorithm



- **Strategy of Render to DAG**

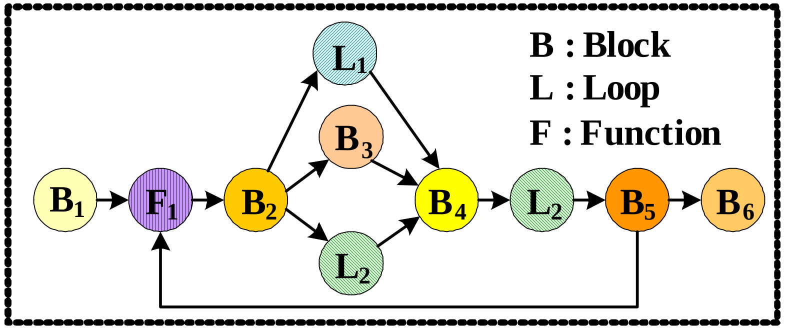
$$p_{ij}(k)=\frac{\tau_{ij}(k)^{\alpha}\eta_j(k)^{\beta}}{\sum_{l=1,2}\tau_{ij}(l)^{\alpha}\eta_j(l)^{\beta}}$$

$$\eta_j(k)=1/((w_t * time_t(k))+(w_a * area_j(k)))$$

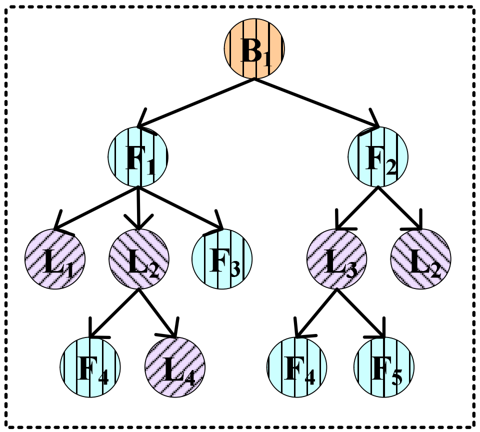
- **…**

Direct acyclic graph based bi-coloring model

Generate test DAGs



Three type of code block in DAG



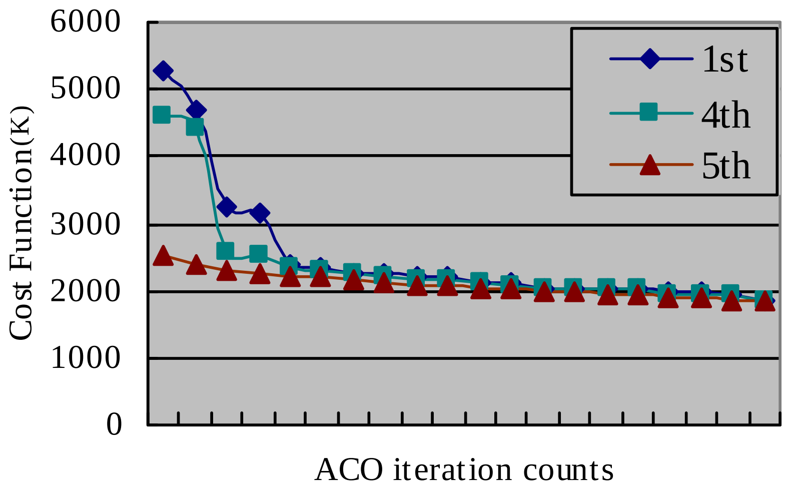
Hierarchical view of critical block in DAG

- **Application Profiling**
  - Basic Block
  - Critical Block
  - Task Flow Graph
- **Basic Block**
  - Blocks
  - Loops
  - Functions

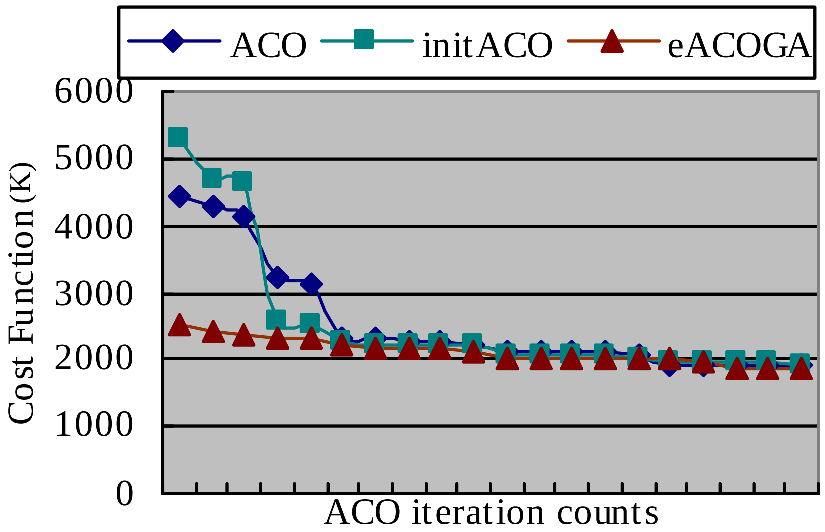
Performance of typical algorithms

Typical Algorithms	**Execution Time**		**Resources** *(cPE mPE)*
	Estar *(Mcycle)*	***LEAP*** *(Kcycle)*	
512 point FFT	32.320	6.721	10c4m
1024 point FFT	72.353	12.802	10c4m
Edge Detection (320x240)	39.720	216.958	16c7m
Edge Detection (480x360)	87.898	474.205	16c7m
Median Filter (320x240)	1580.368	220.010	30c7m
Median Filter (480x360)	3590.500	478.792	30c7m
Matrix Multiply (64x64)	54.315	79.141	30c10m
Matrix Multiply (128x128)	2522.258	318.901	30c10m
FDCT	2433.389	2838.905	30c10m
IDCT	2437.417	2839.044	30c10m

Hw/Sw Partitioning with eACOGA



The evolution curve of eACOGA



Comparing eACOGA with ACO

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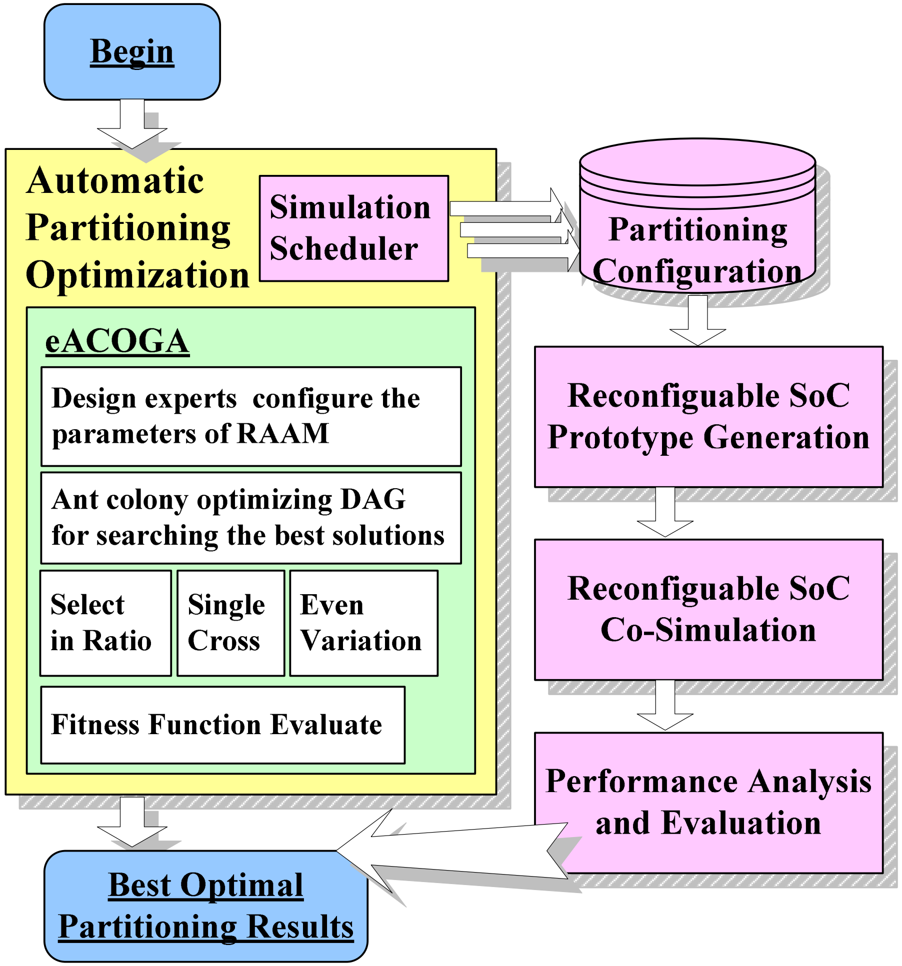
Automatic partitioning flow



- For each individual of generic population in eACOGA, the flow of partition and reconfigurable SoC co-simulation can run automatically. When some constraints cannot be met, experts can request to stop the simulation.

- Transaction level simulation in SystemC can describe various behaviors of reconfigurable SoC with faster speed and nicer accuracy. Architecture template enhances reuse of existing SoC design and achieves exploration speedup well.

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Conclusions

- Collaborative hardware/software partition approach of coarse-grained reconfigurable system supports both human-computer and human-human interaction well.
- Automatic collaborative partition flow can not only reduce time of waiting for simulation, but also provide convenient collaborative framework for multi-field experts to work.
- The algorithm of eACOGA can evolve the main control parameters (α, β, ρ, Q) of ACO, so that it can find global best optimal solutions efficiently and rapidly.

Thank you !