Optimal Runtime Task Mapping to a Partially Reconfigurable Coarse-Grained Array

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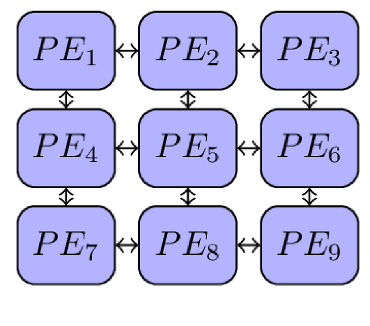
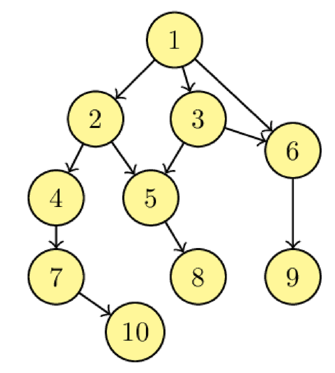
Introduction

If area (and power) is a constraint in mapping, then tiles may be reused to temporally pipeline the processes. Significantly, using active partial reconfiguration allows the dynamic balancing of the compute pipeline on the basis of space limitation on fabric.

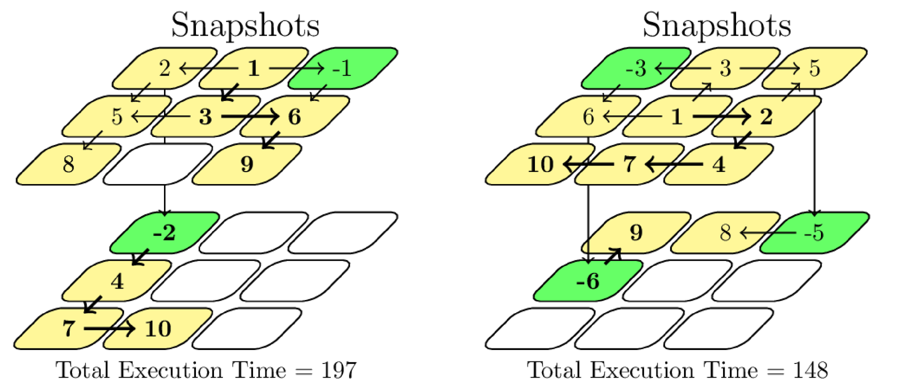
Motivation Example



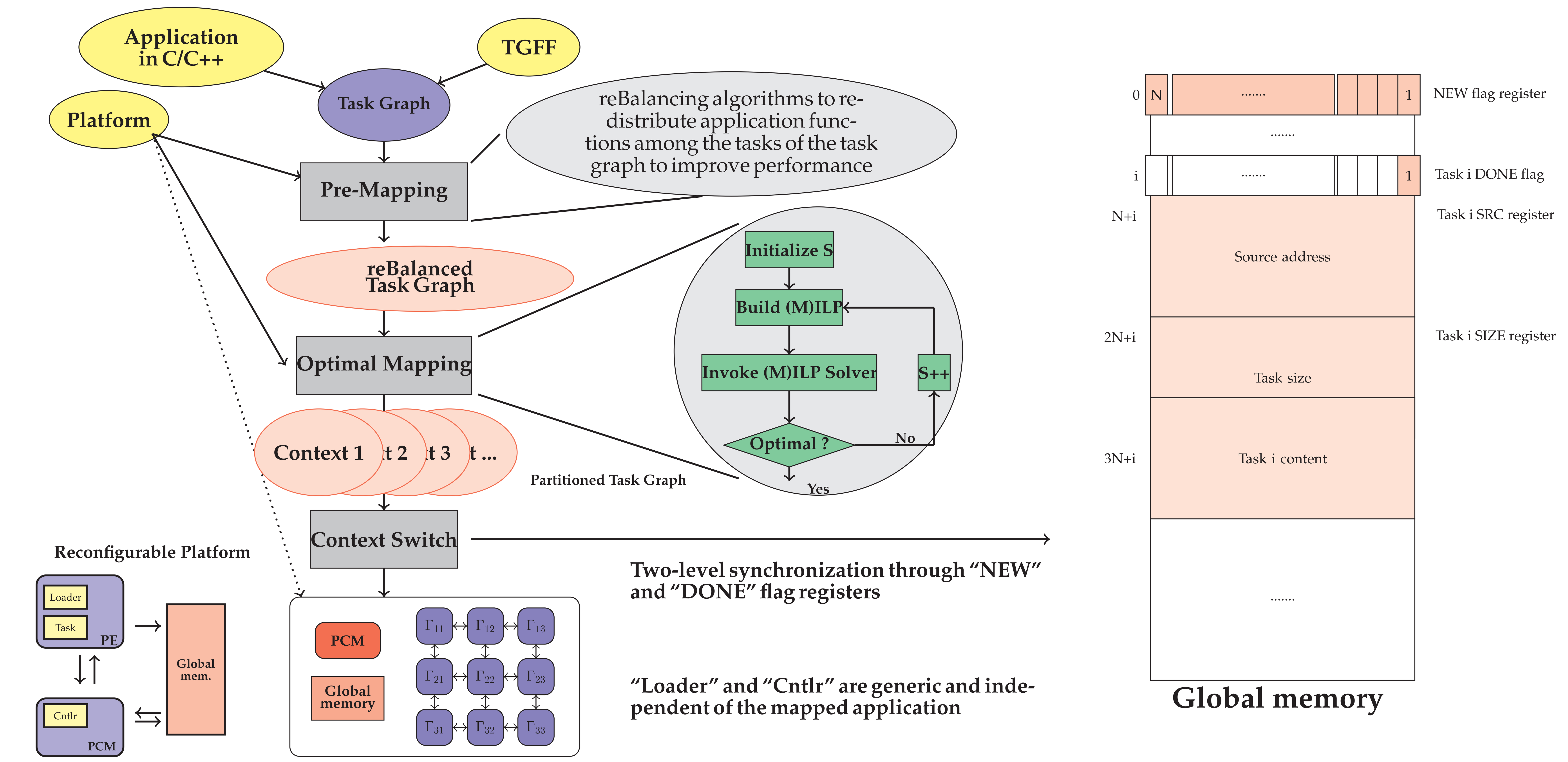


Task	Runtime
1	10
2	20
3	60
4	50
5	10
6	10
7	10
8	10
9	20
10	10

r_t=2, r_e=1, C_e=5



Overall Flow



Mapping

Goals:

- Map a large application with more tasks than the PEs available on the fabric
- Map more than one application onto the fabric

Objectives:

1. minimizing total reconfiguration cost
2. minimizing the application's total execution time

Formulated for:

1. Mapping acyclic task graphs onto 2D mesh platform
2. Mapping cyclic task graphs onto 2D mesh platform
3. Mapping onto 3D mesh platform
4. Mapping onto any arbitrary interconnect

Future Work:

- Proof of Optimality
- (M)ILP formulation for *"heterogeneous"* platforms
- Integration into Daedalus Framework

Mapping: Formulation

Some of the rules in our (M)ILP:

- Each task can be mapped onto one and only one tile.
- Each tile can be assigned to one task or any number of edges originating from the same source task.
- If source task of an edge is mapped to a tile, destination task can be mapped to any neighbouring tile in the same snapshot or to a tile in the next snapshot.
- If an edge is mapped to a tile, destination task of the edge can be mapped to any neighbouring tile in the same snapshot or to to a tile in the next snapshot.

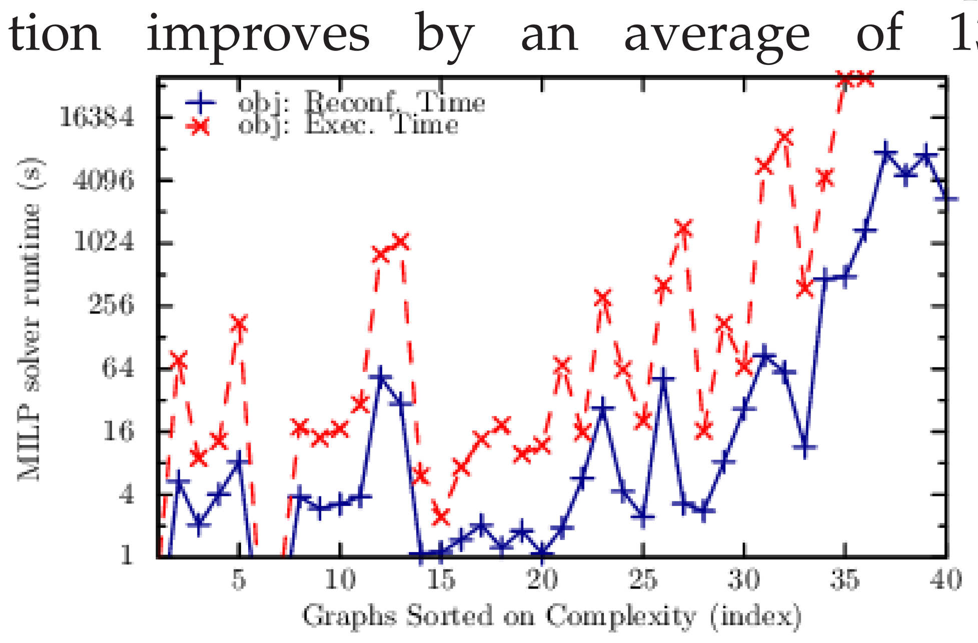
U: number of iterations
V: number of iterations for each snapshot
s: snapshot index
S: number of snapshots
h_s: highest latency task in snapshot s
γ_s: reconfiguration cost of snapshot s
δ_s: computation cost of snapshot s

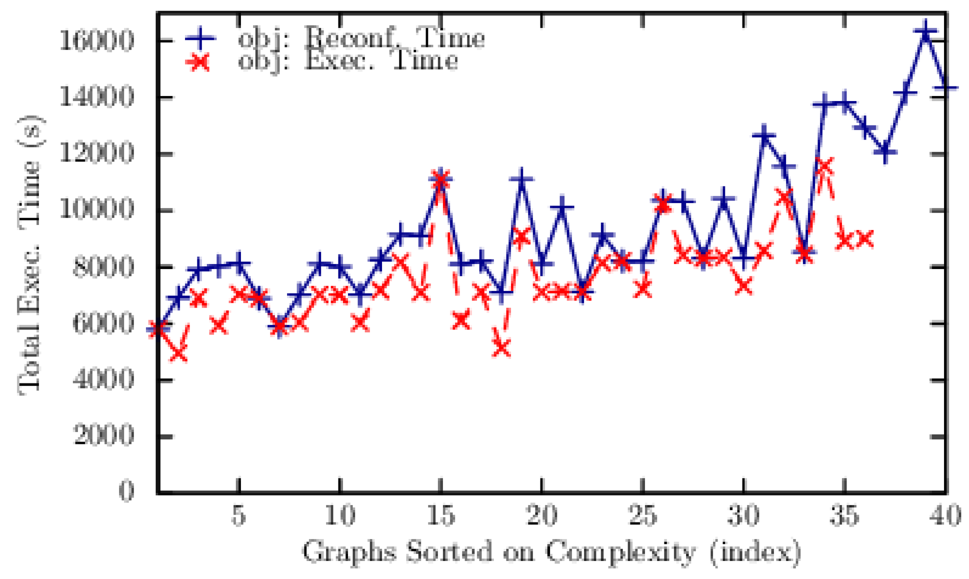
Total execution time of the application:

$$\tau = \left\lceil \frac{U}{V} \right\rceil \times \sum_{s=1}^{S} (\delta_s + (V-1) \times h_s + \gamma_s) \quad (1)$$

Mapping: Results

When objective is "min-execution", solver requires 31.1X more time than when it is "min-reconfiguration" while the total execution time of the application improves by an average of 13.97%.





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