Mapping Asynchronous Iterative Applications on Heterogeneous Distributed Architectures

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Outline

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Parallel computing
Solving methods

Objectives

Solving large scale numerical problems

- **Direct methods**: solve the problem in a finite operations number
- **Iterative methods**: solve the problem by successive iterations and give the desired result's approximation

Solving methods
Why choosing iterative methods?

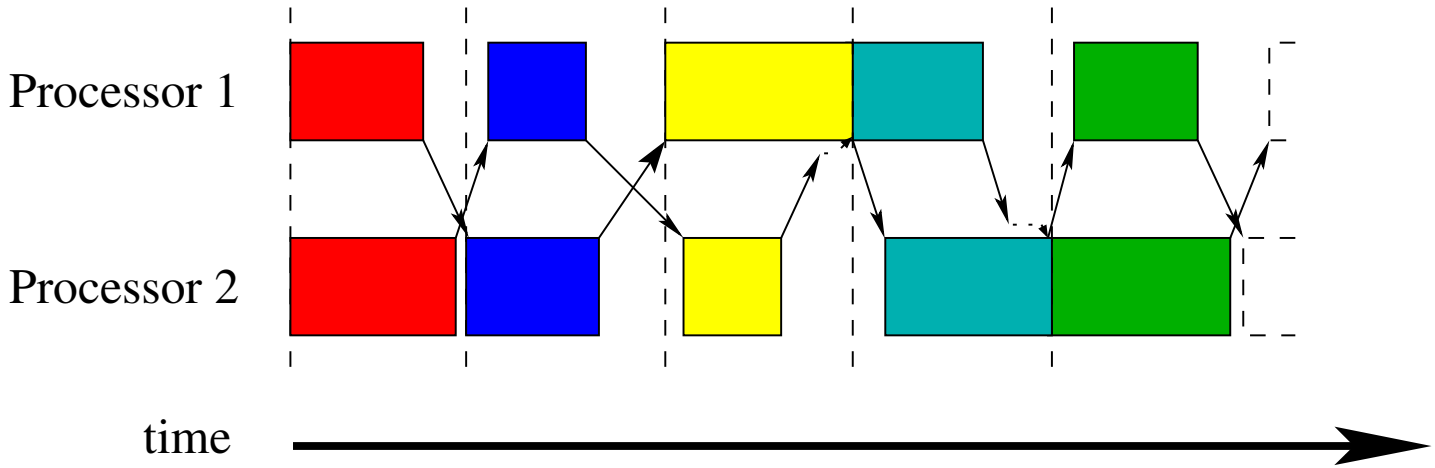
Advantages

- Some problems could not be solved by direct methods
- More simple to parallelize
- Could solve problems of a larger size

Main drawback

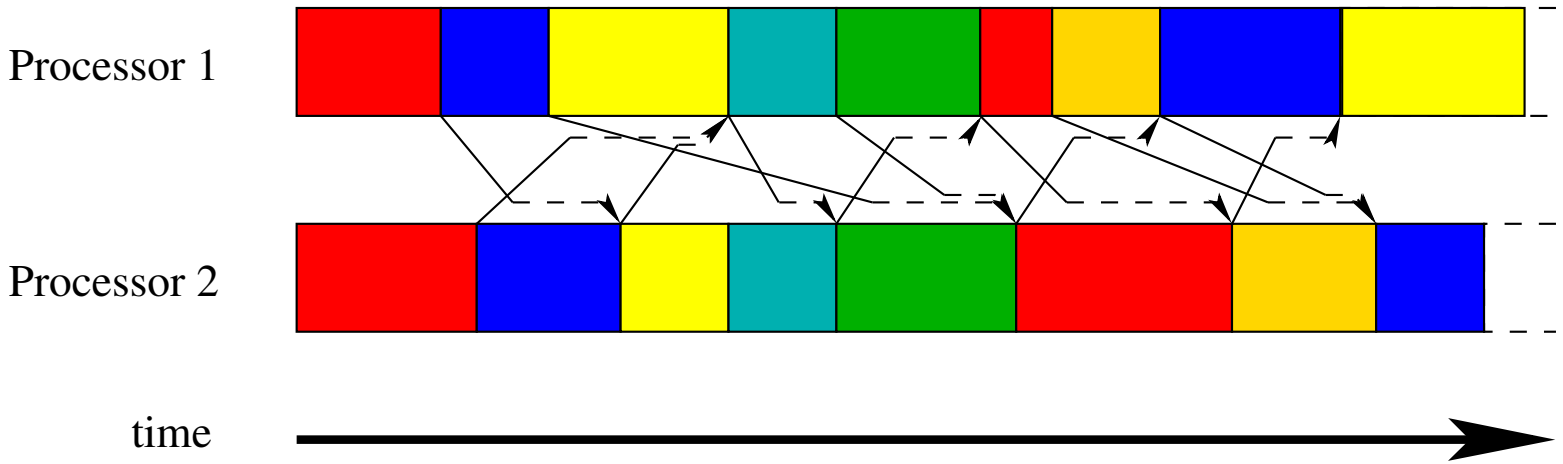
- Convergence study

Iterative computing
The synchronous model



- Iterations synchronizations
- Communications synchronizations (eventually)

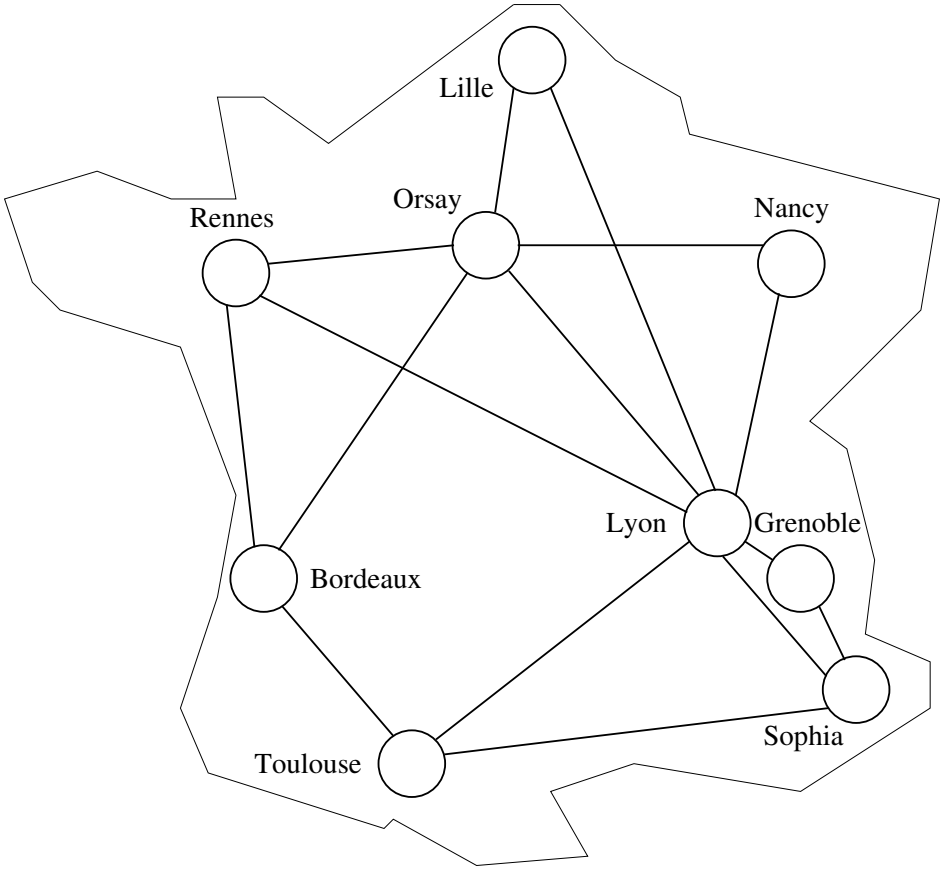
Iterative computing
The asynchronous model – AIAC



- No synchronization between iterations nor communications
- More iterations than synchronous model
- Not all algorithms can be transformed in asynchronous form

Computing environments

- Clusters
- Distributed clusters
- Computing grids



Outline

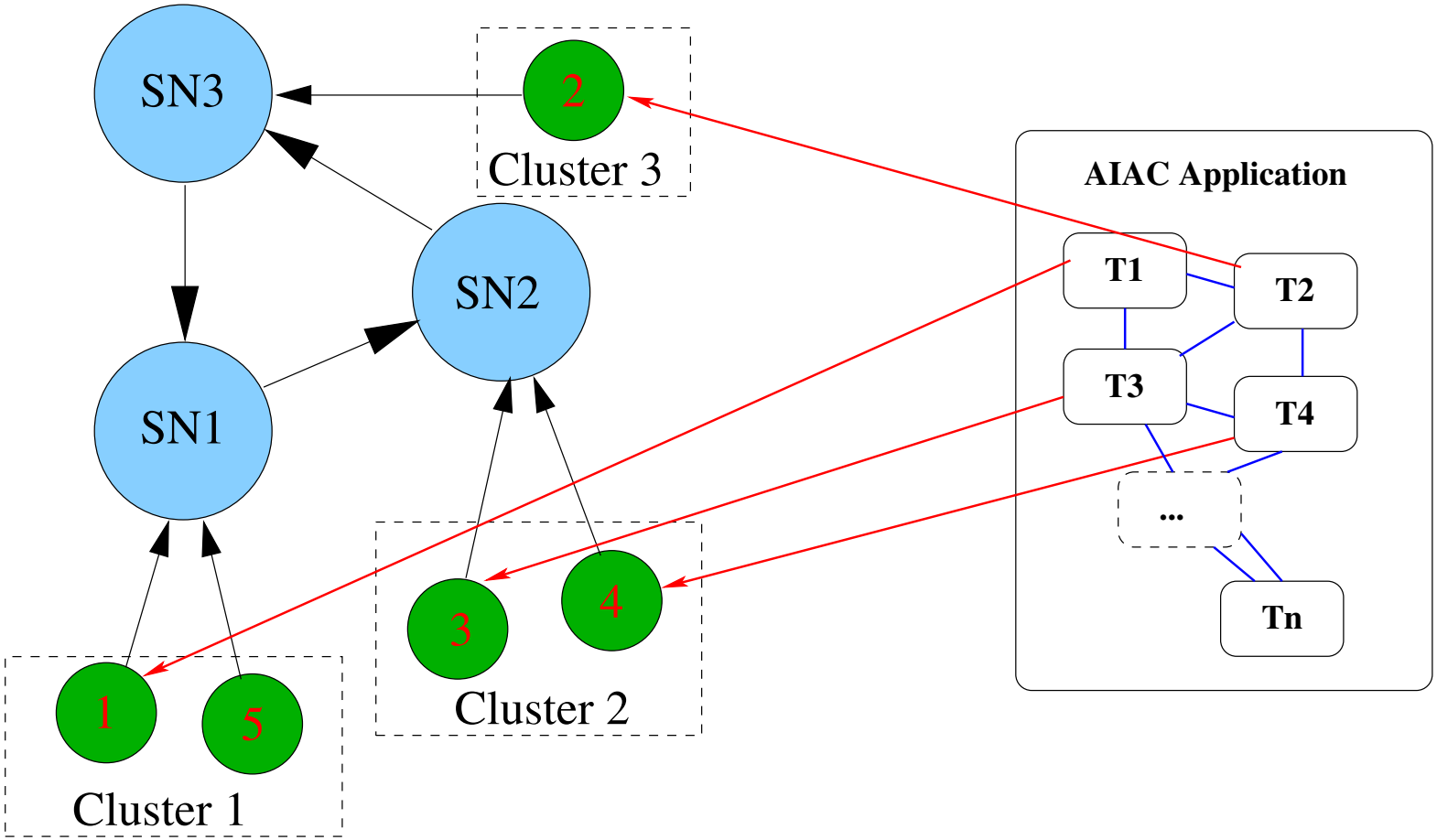
The JaceP2P-V2 platform

- Execution platform and programming environment
  - Platform: daemons, super-nodes, spawners
  - Functions library
- Designed for AIAC model
- Fully fault tolerant

- "Multi-threaded"
- Java language (portability)
- AND Team (*Jean-Claude Charr*)

The JaceP2P-V2 platform

Default "mapping"



Mapping relevance

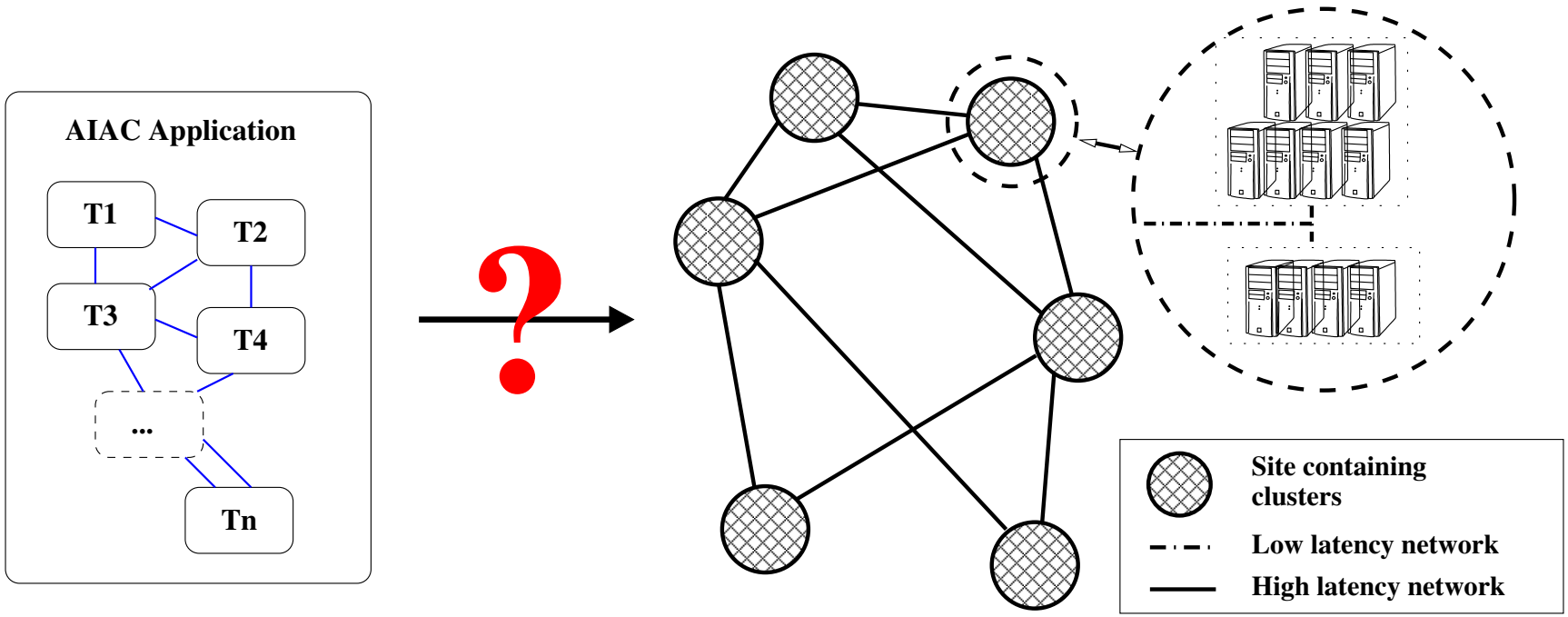
Conditions

- Grid'5000 platform – 200 computing nodes
- Simple Mapping algorithm (SMa)
- Application using the Multisplitting CG
  - Problems sizes : 550'000 and 5'000'000

Results – Gains in execution time

- For 550'000: 30% faster than without mapping algorithm
- For 5'000'000: 40% faster than without mapping algorithm

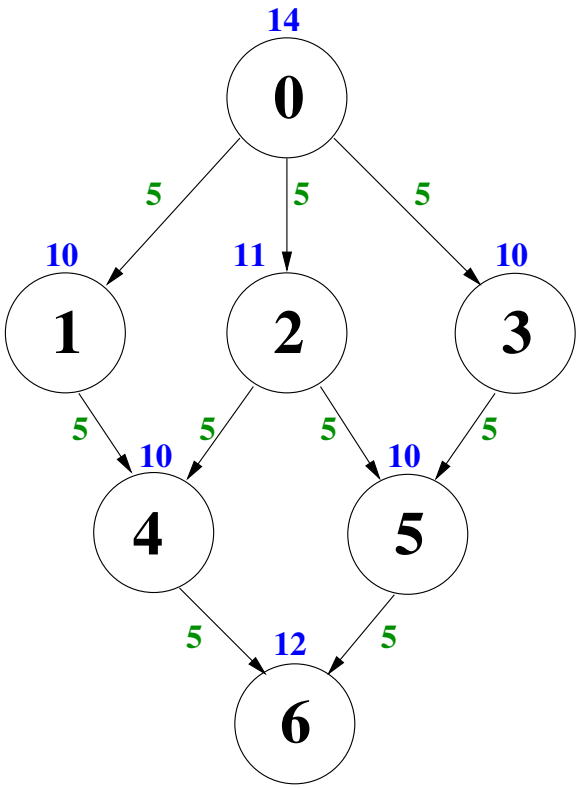
Problematic



Outline

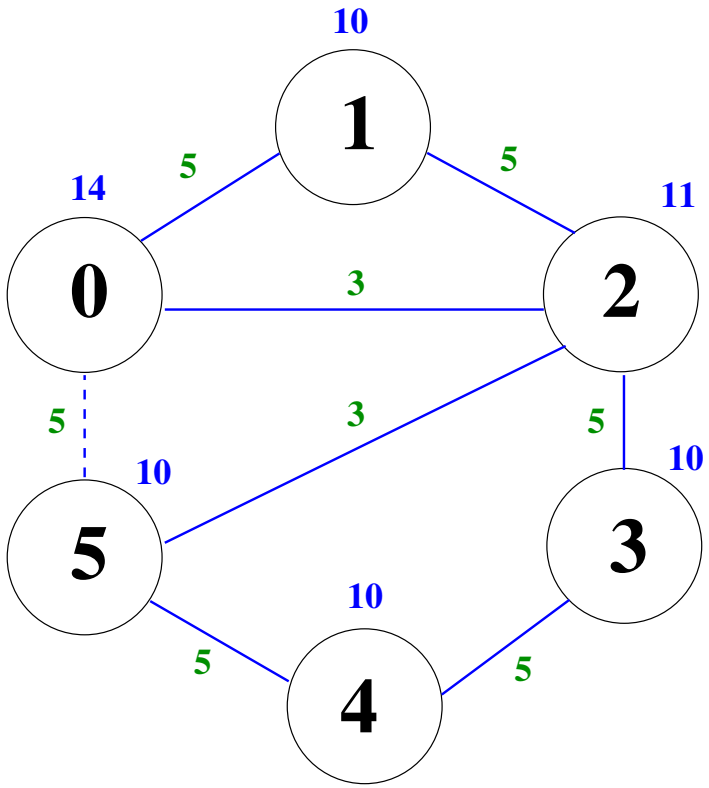
Application modeling

(fit with synchronous model)



DAG

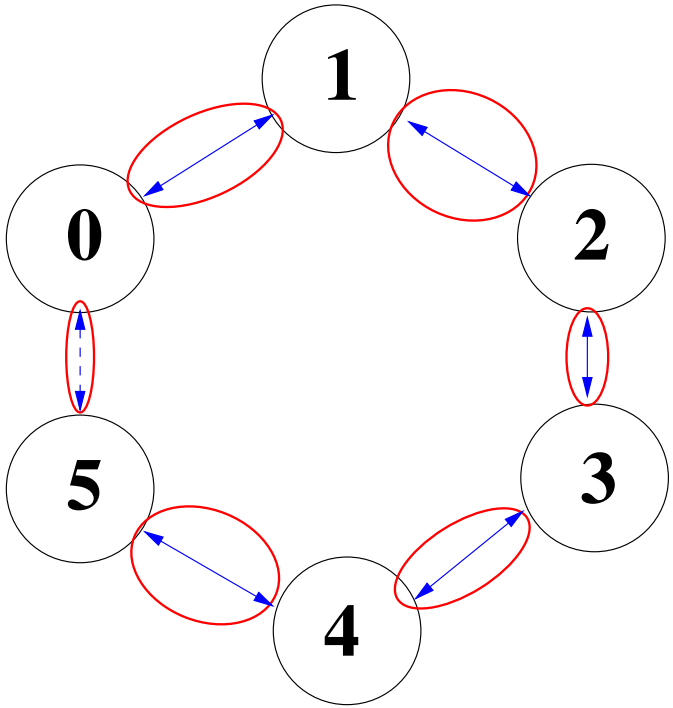
(fit with asynchronous model)



TIG

Existing mapping algorithms

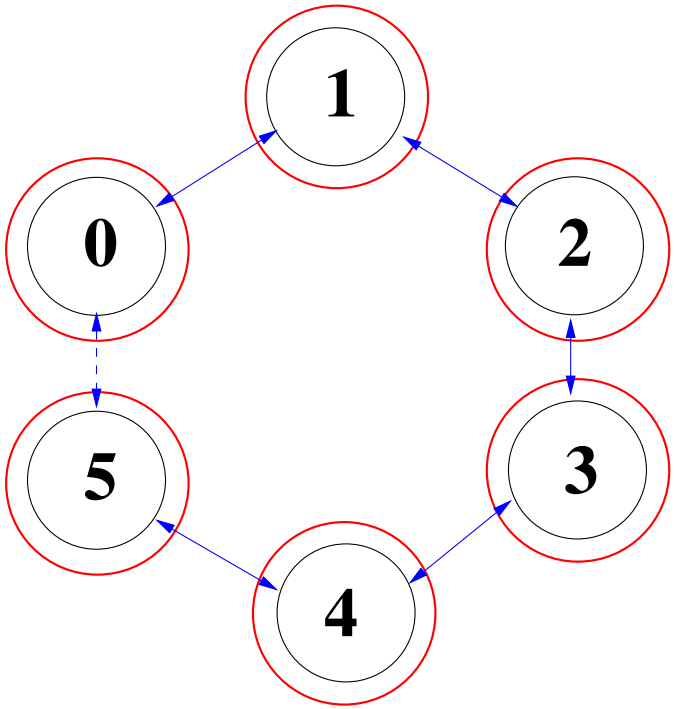
Minimization of external links – *edgecuts*



- Goal: avoiding penalizing communications
- Algorithms: Metis[1], Chaco[2]...

Existing mapping algorithms

Minimization of execution time



- Goal: reducing the application execution time
- Algorithms : QM[3], FastMap[4], MiniMax[5]...

Specificities of the AIAC model and JaceP2P-V2

Specificities due to the AIAC model and JaceP2P-V2

- Only one task per computing node
- *No task precedence*

Specificities due to the targeted architecture

- Computing node volatility
- Tasks state save
- Heterogeneity in computing nodes
- Heterogeneity in networks

AIAC-QM algorithm

Quick Quality Map (QM) [3]

- Optimization of the execution time of each task
- Execution time taking care of computation and communication
- Does not satisfy model's constraints

Evaluation of AIAC-QM

- Adaptation and implementation of QM in JaceP2P-V2 $\rightarrow$ AIAC-QM
- Introduction of a little part of *edge-cuts*

AIAC-QM algorithm

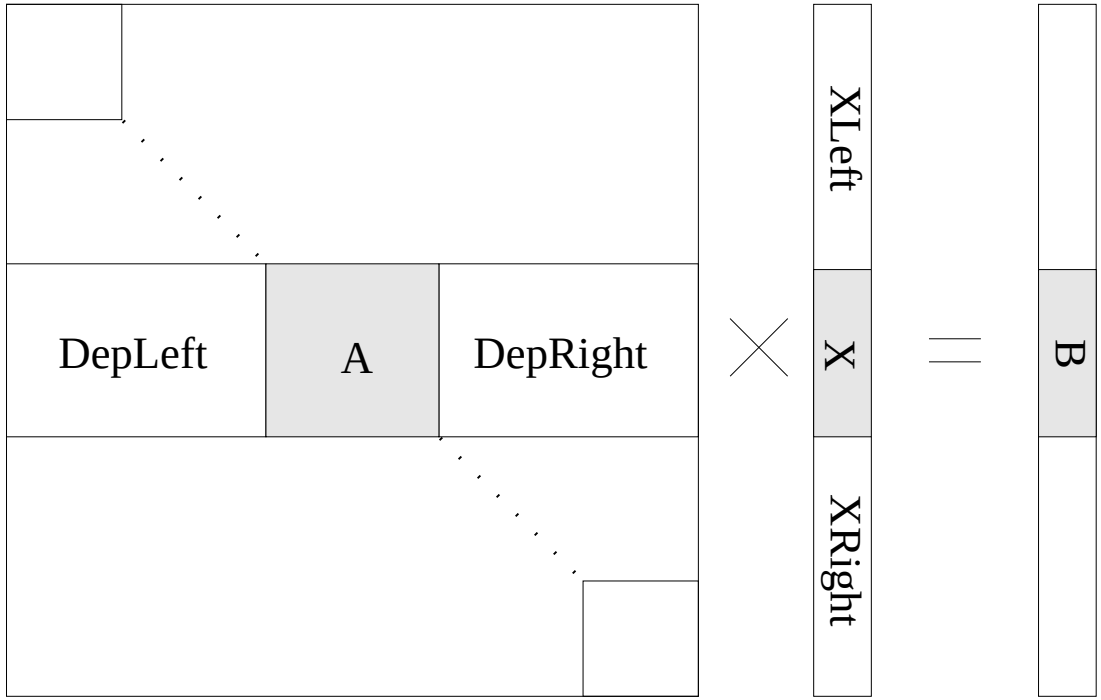
Principles

- Sort computing nodes by computation power
- Iterate on each task for searching a better node
- Limited number of rounds
- Execution time computation based on:
  - Computing node power
  - Locality with task's neighbors

Outline

NPB – Multisplitting Conjugate Gradient

- Nas Parallel Benchmark
- Conjugate Gradient matrix computation
- Asynchronous version using the multisplitting method[6]



Conditions of the evaluations

Application and architectures

- Multisplitting CG (E : 550'000 and F : 5'000'000)
- 64 (for E) and 128 (for F) computing nodes
- Homogeneous architectures
  - Architecture 1: 113 nodes – 440 cores
  - Architecture 2: 213 nodes – 840 cores
- Heterogeneous architectures
  - Architecture 3: 112 nodes – 394 cores
  - Architecture 4: 212 nodes – 754 cores
- No computing node failure

Results 1 – Homogeneous Architectures

Algorithm	No	SMa	AIAC QM	F-EC
Execution time	150s	110s	101s	90s
Gains	–	27%	33%	40%

Table: Multisplitting CG 550'000 – Architecture 1

Algorithm	No	SMa	AIAC QM	F-EC
Execution time	403s	265s	250s	218s
Gains	–	34%	38%	46%

Table: Multisplitting CG 5'000'000 – Architecture 2

Results 2 – Heterogeneous Architectures

Algorithm	No	SMa	AIAC QM	F-EC
Execution time	498s	341s	273s	385s
Gains	–	32%	45%	23%

Table: Multisplitting CG 550'000 – Architecture 3

Algorithm	No	SMa	AIAC QM	F-EC
Execution time	943s	594s	453s	660s
Gains	–	37%	52%	30%

Table: Multisplitting CG 5'000'000 – Architecture 4

Outline

Conclusion & Future works

Conclusion

- Mapping is essential for JaceP2P-V2
- Adaptation of existing mapping algorithms
- Considerable gains on application execution time

Future works

- Designing a hybrid algorithm
- Mapping tasks' saves
- Take care about nodes capacities
- Fault tolerance in mapping algorithms

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