Algorithms for the partitioning of applications containing variable duration tasks on reconfigurable architectures

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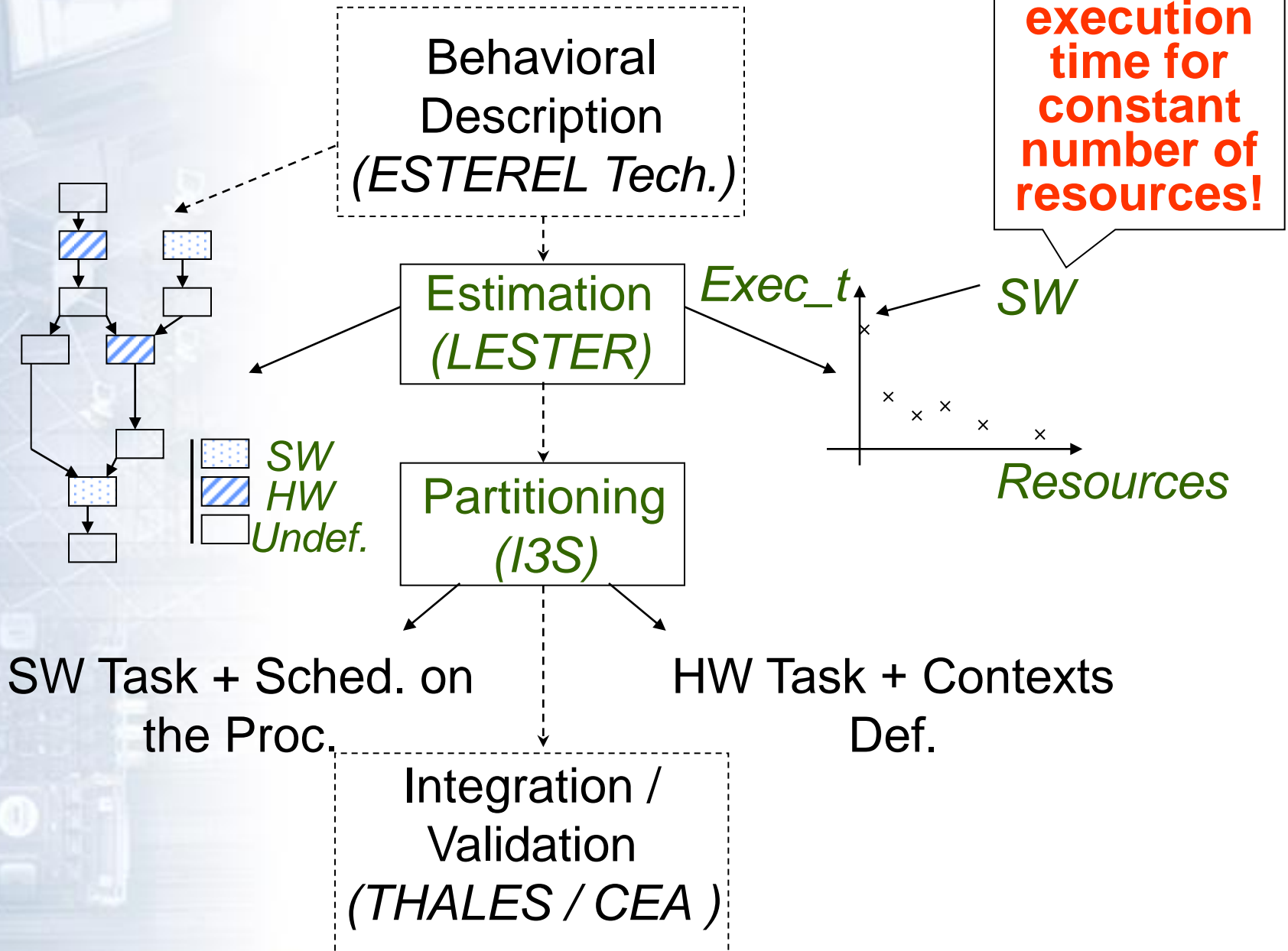{Email: ghaffari@i3s.unice.fr}

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AICCSA
2003

Outline

- Research context and problem formulation

- Partitioning of variable execution time

- Experiments and results

- Conclusion and perspective

EPICURE project flow

Behavioral Description *(ESTEREL Tech.)*

A fixed execution time for constant number of resources!

Estimation *(LESTER)*

Exec_t

SW

SW
HW
Undef.

Partitioning *(I3S)*

Resources

SW Task + Sched. on the Proc.

HW Task + Contexts Def.

Integration / Validation *(THALES / CEA)*

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Problem formulation

■ Applications with **hard** real-time constraints:

$$\text{Execution time} = \textbf{WCET}$$

■ Applications with **soft** real-time constraints:
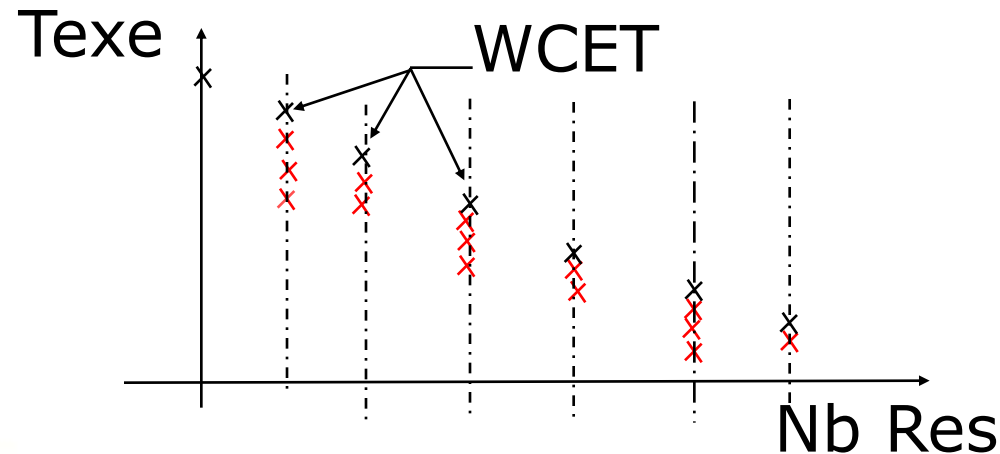
$$\text{Execution time} < \textbf{WCET}$$

➢ **WCET** case probability is very weak
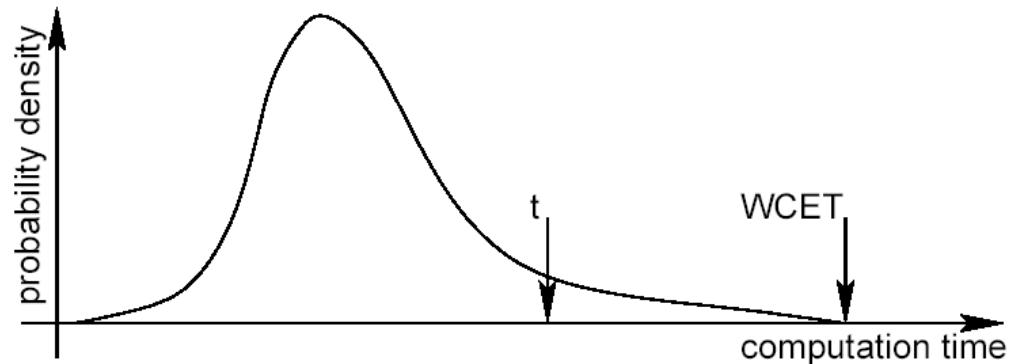
➢ Use of **WCET** =   - Excessive pessimism

- The architecture is too large for it's required purpose

- Bad management of the resources

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Problem formulation

- Task execution time depends on:

  1. Application dependent (amount, type of input data)

  2. Platform dependent (type of processing unit)

  3. Environment dependent factors (communication time)

- In the case of HW/SW partitioning: new implementation lines

Texe · WCET · Nb Res

Chosen model

> DFGs are suitable models for an image processing application

> Granularity level: Coarse-grain
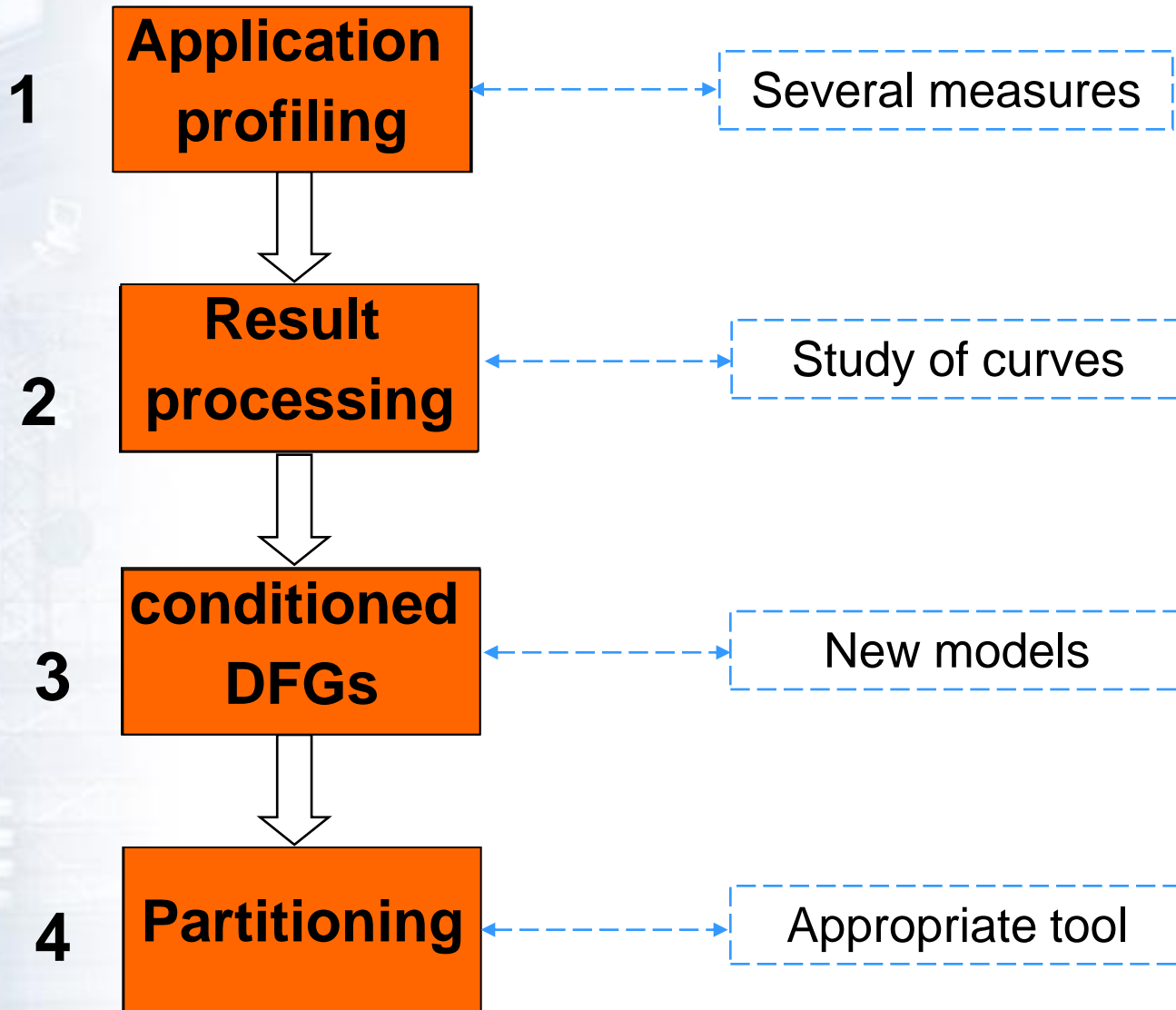
> Estimation: Execution time, communication

Task 1 (Processing)

Task 3

Task 2

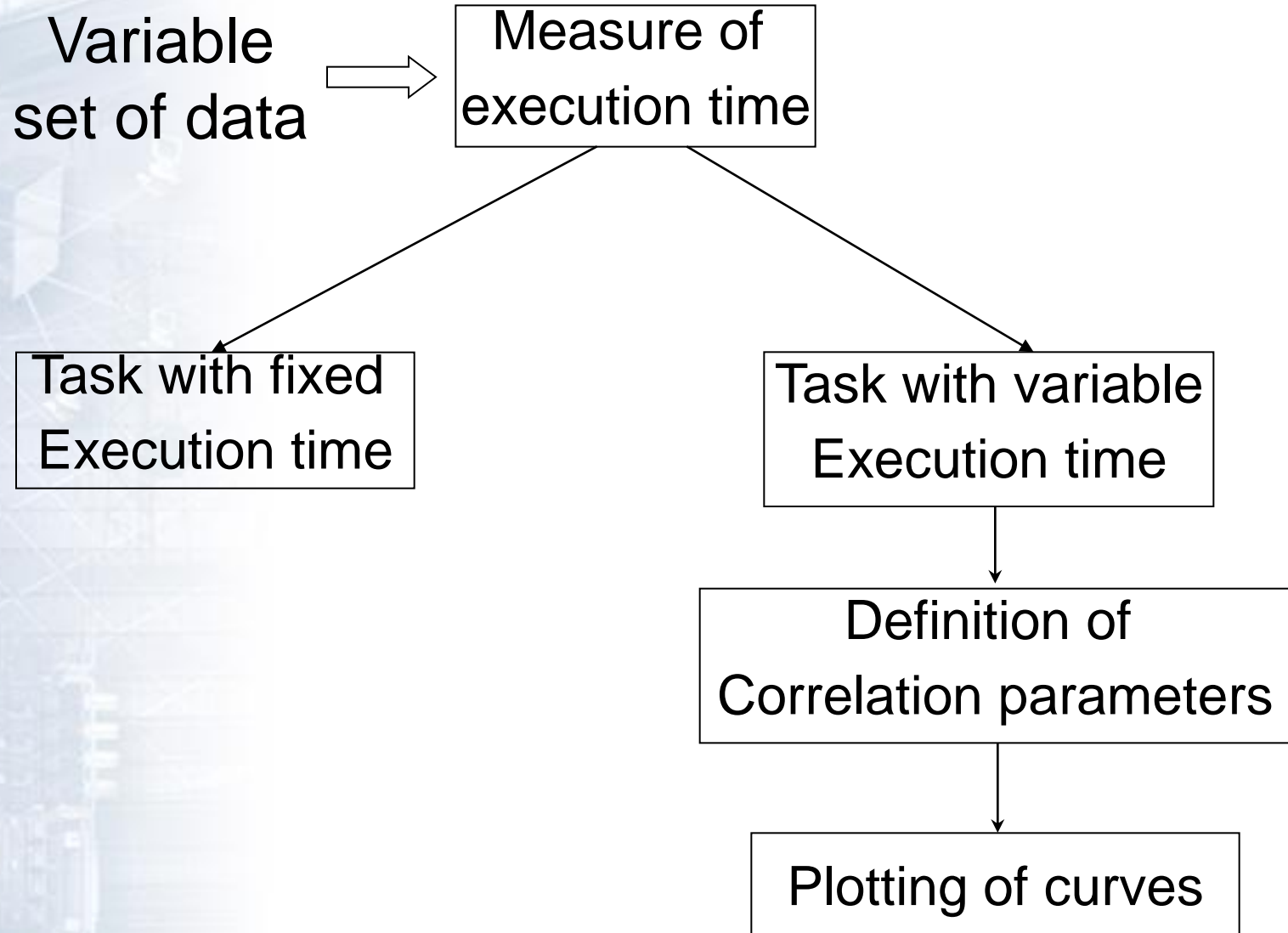Communication between tasks 1&2
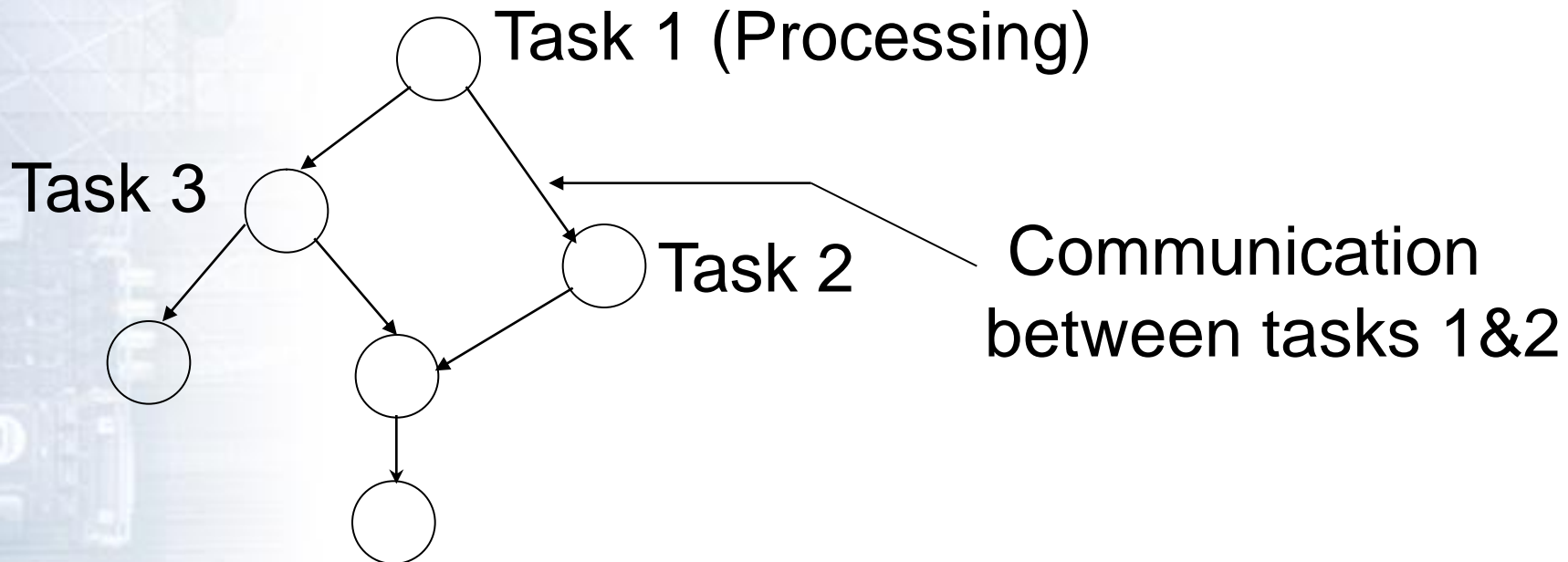
Target architecture

➢ Adaptable to many different types of applications

➢ Multiple tasks processing

➢ Important exchanges rate with memory

➢ Efficient solution in cost/performance

➢ General, flexible and reconfigurable

➢ FPGAs: assures accurate processing

Processor	Interface	FPGA

Partitioning methodology

1 → Application profiling ⇢ Several measures

2 → Result processing ⇢ Study of curves

3 → conditioned DFGs ⇢ New models

4 → Partitioning ⇢ Appropriate tool

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Application profiling

Variable set of data $\Rightarrow$

Measure of execution time

Task with fixed Execution time

Task with variable Execution time
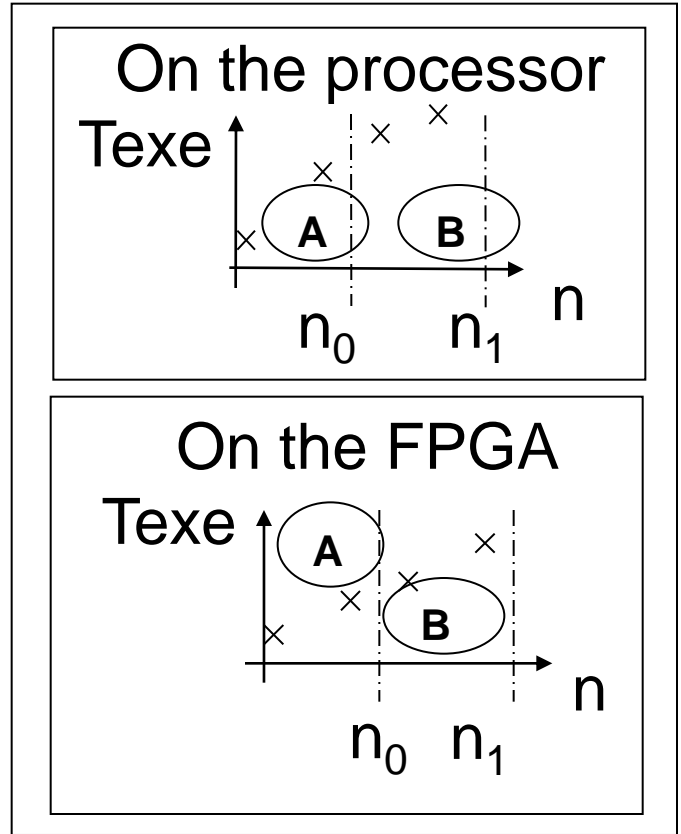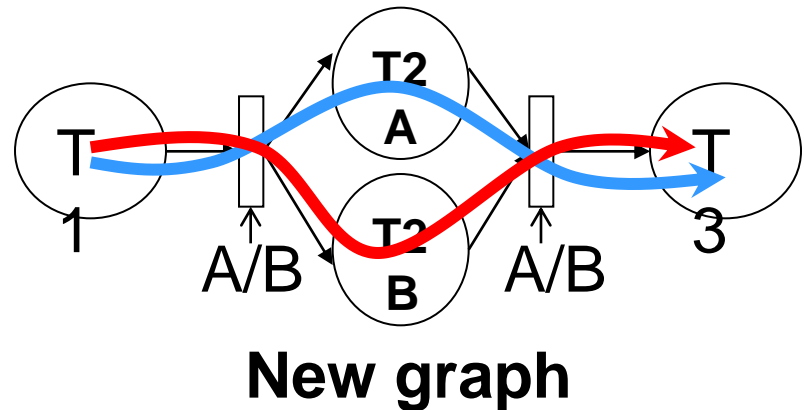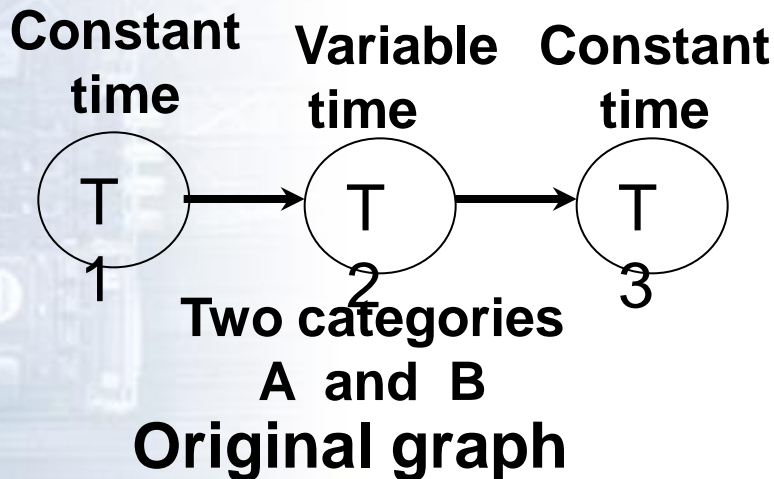
Definition of Correlation parameters

Plotting of curves

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Result processing and conditioned DFG

Execution time as a function of the number of objects in an image

On the processor

Texe ... A ... B ... n_0 ... n_1 ... n

On the FPGA

Texe ... A ... B ... n_0 ... n_1 ... n

■ **Construction of conditioned graph**

Constant time | Variable time | Constant time

T_1 → T_2 → T_3

Two categories A and B
Original graph

T_1 → [A/B] → T_2 A / T_2 B → [A/B] → T_3

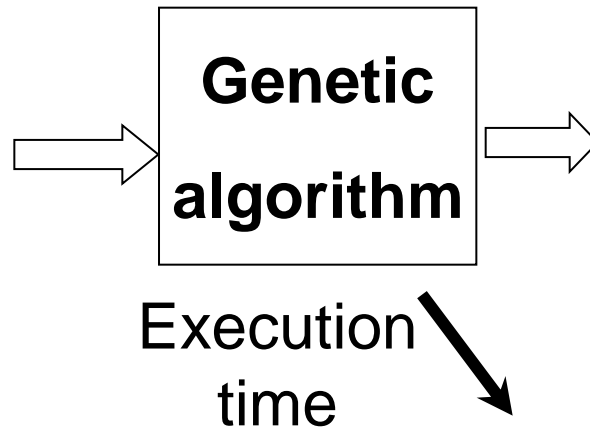**New graph**

Partitioning and execution scheme

■ Partitioning

- Couples (Texe, Nbre CLB)
- Graph of the configuration
- Characteristics of the architecture

Genetic algorithm

Execution time

- Partitioning solution of configuration 1
- ⋮
- Partitioning solution of configuration n

■ Execution of the application

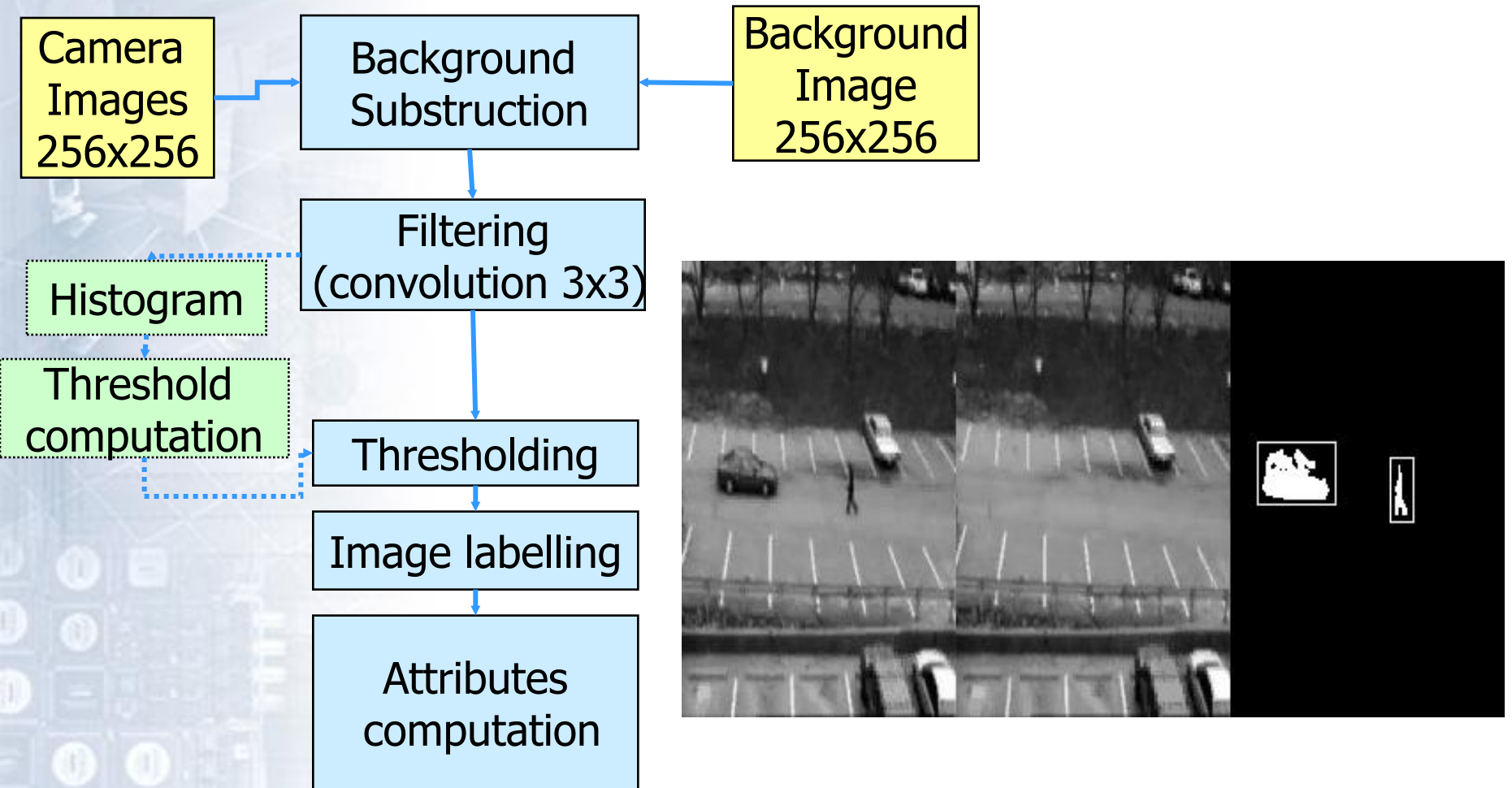**Processor**

address

data

Interface

FPGA
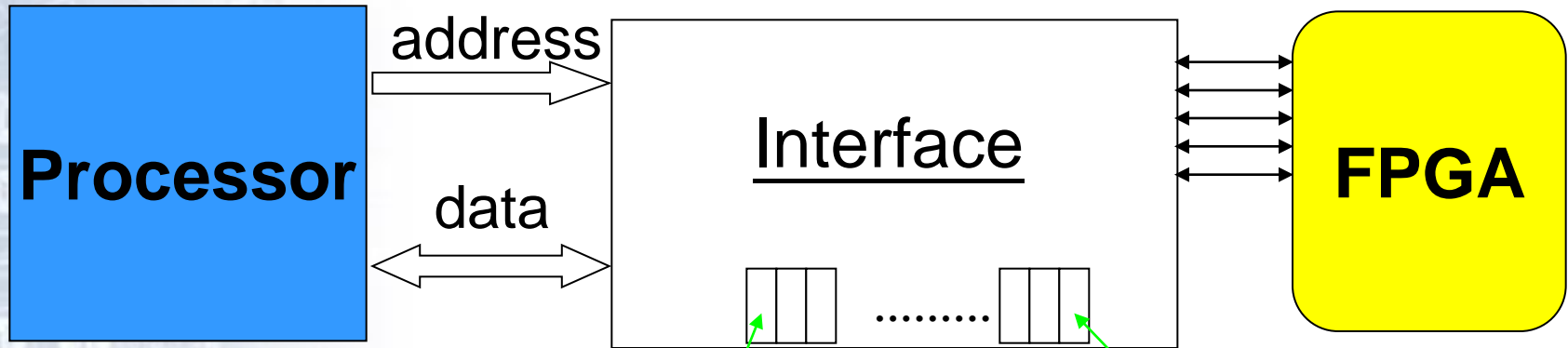
- Partitioning solution of configuration 1
- Partitioning solution of configuration n

Example of application
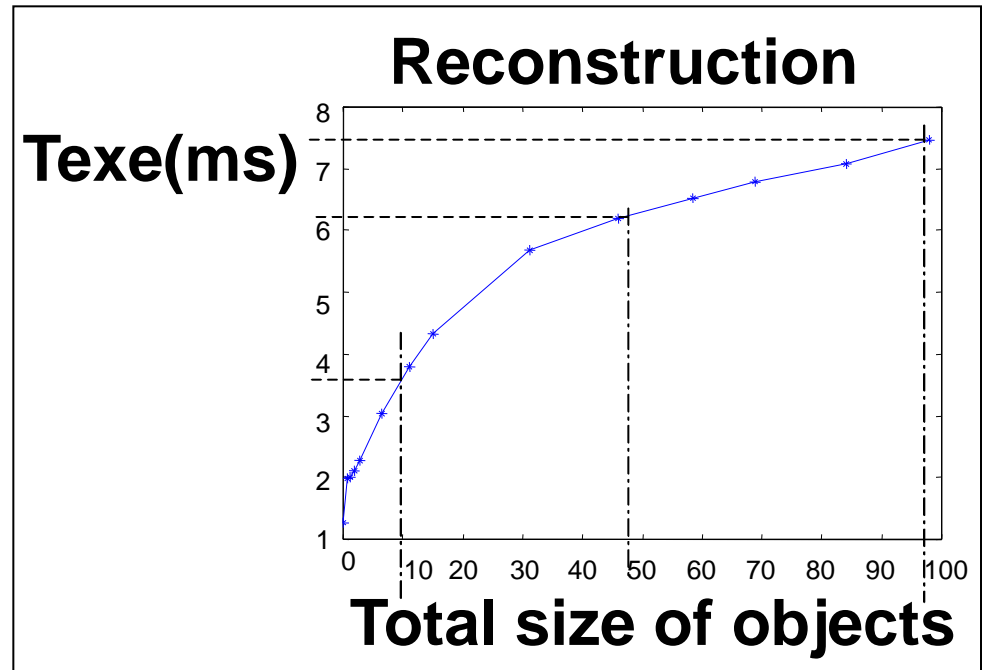
- Motion detection on a fixed image background

Camera Images 256x256 → Background Substruction ← Background Image 256x256

Background Substruction → Filtering (convolution 3x3)

Histogram

Threshold computation

Filtering (convolution 3x3) → Thresholding → Image labelling → Attributes computation

Object list with : (x,y) co-ordinates of the center of gravity, surrounding envelop

Experimental results

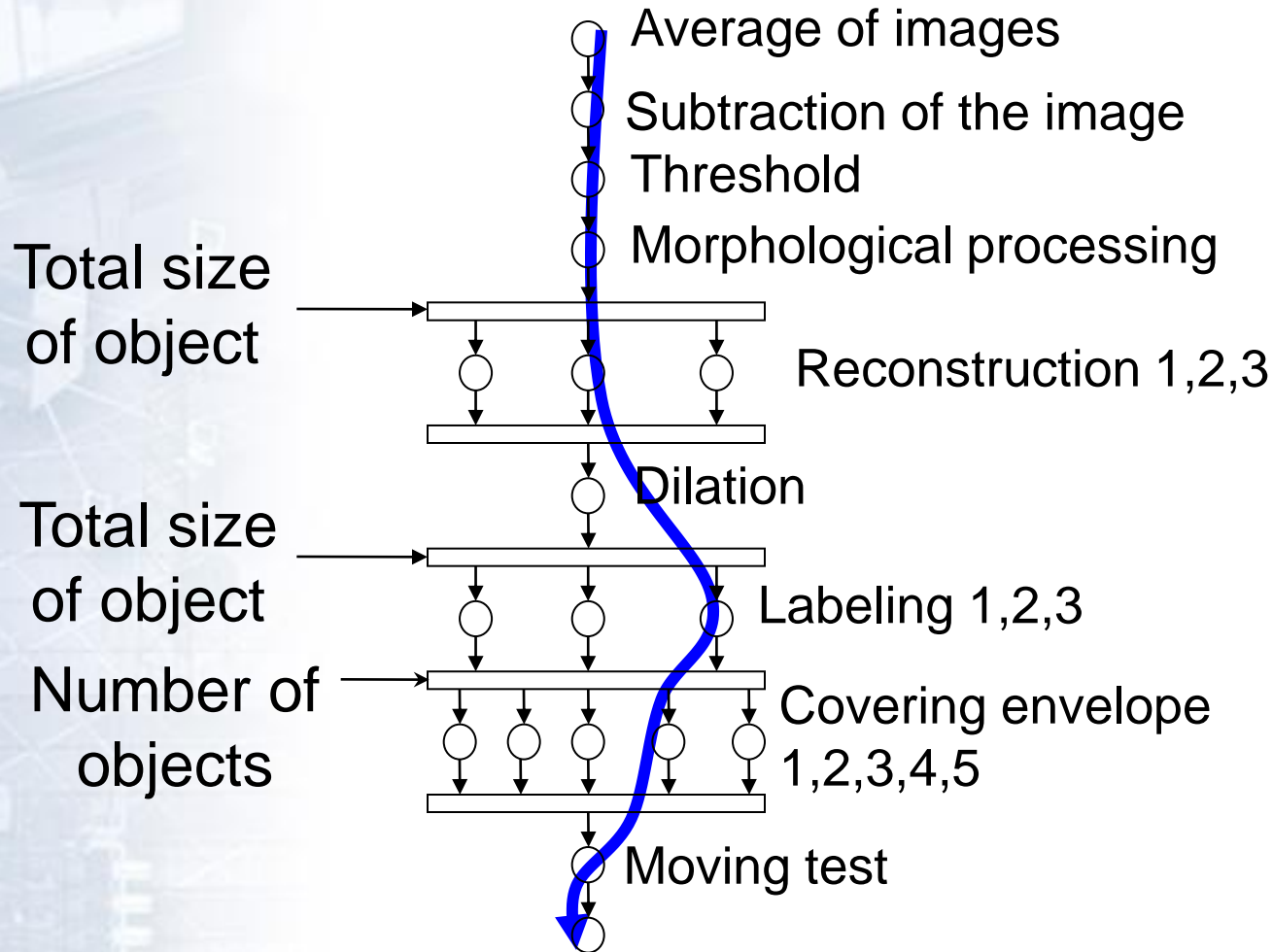■ **Profiling results**

• **Choice of thresholds :**

➤ the value of the gradient

➤ number of possible configurations to consider

(total design time, memory space)

➤ same thresholds for

processor and FPGA

Reconstruction

Texe(ms)

Total size of objects

✓ Maximum execution time for all the threshold groups

Average of images

Subtraction of the image

Threshold

Morphological processing

Total size of object

Reconstruction 1,2,3

Dilation

Total size of object

Labeling 1,2,3

Number of objects

Covering envelope 1,2,3,4,5

Moving test

DFG with variable execution time tasks
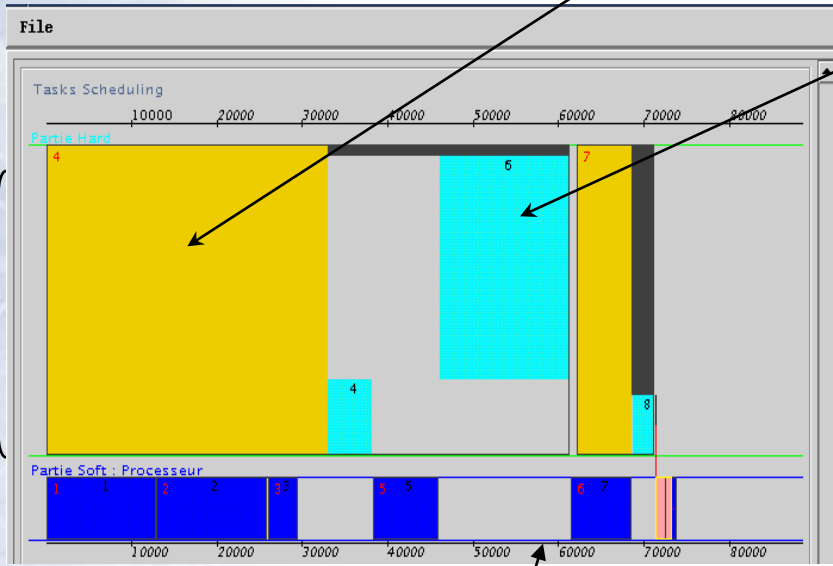
Partitioning results

FPGA

CPU
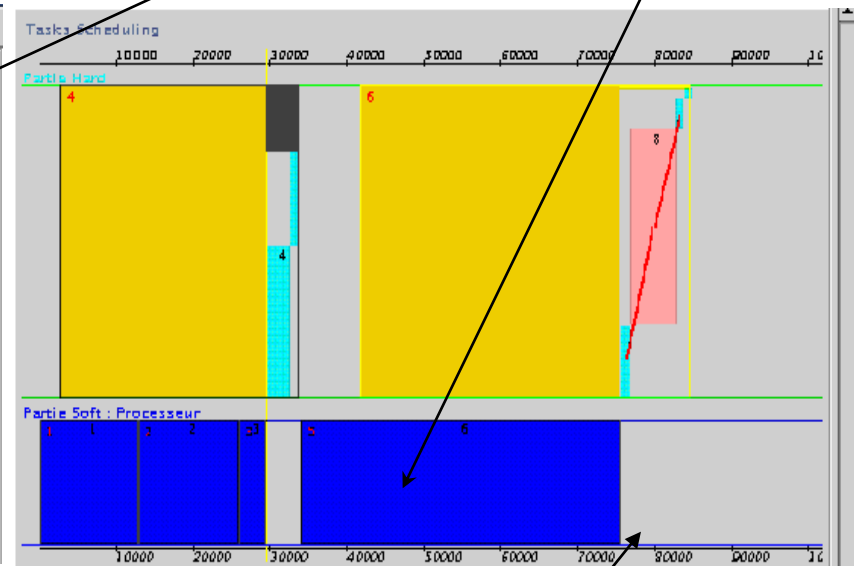
Reconfiguration time
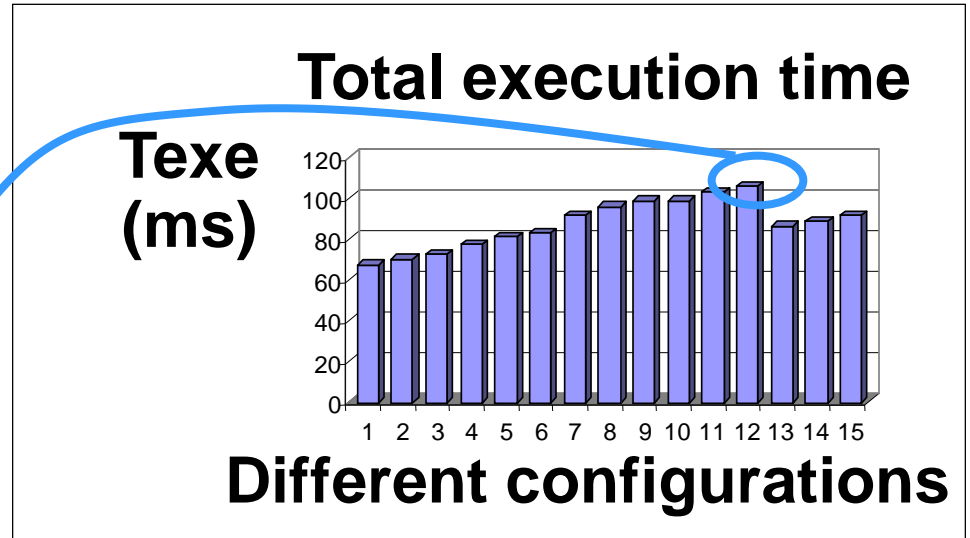
HW task

SW task

Total Texe = 72.455 ms

- Partitioning result of configuration 3

Total Texe = 82.659 ms

- Partitioning result of configuration 6

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Total execution time

Total execution time

Texe (ms)

120
100
80
60
40
20
0

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

Different configurations

Execution time = WCET

Entry image → | Partiti 1 | Partiti 12 | Partiti 8 | Partiti 15 | → **Processed image**
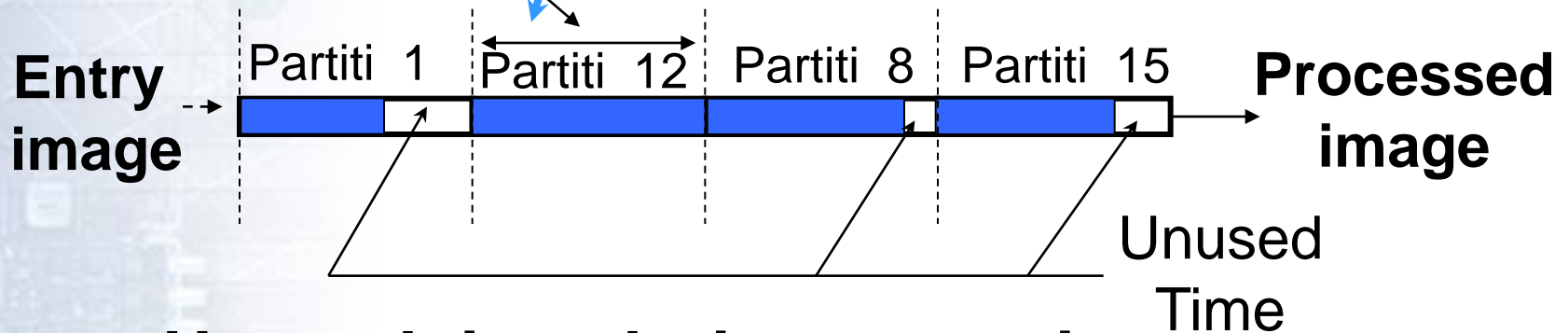
Unused Time

Unused time during execution of the application

Total communication time

Total communication time

Tcom (ms) — Different configurations
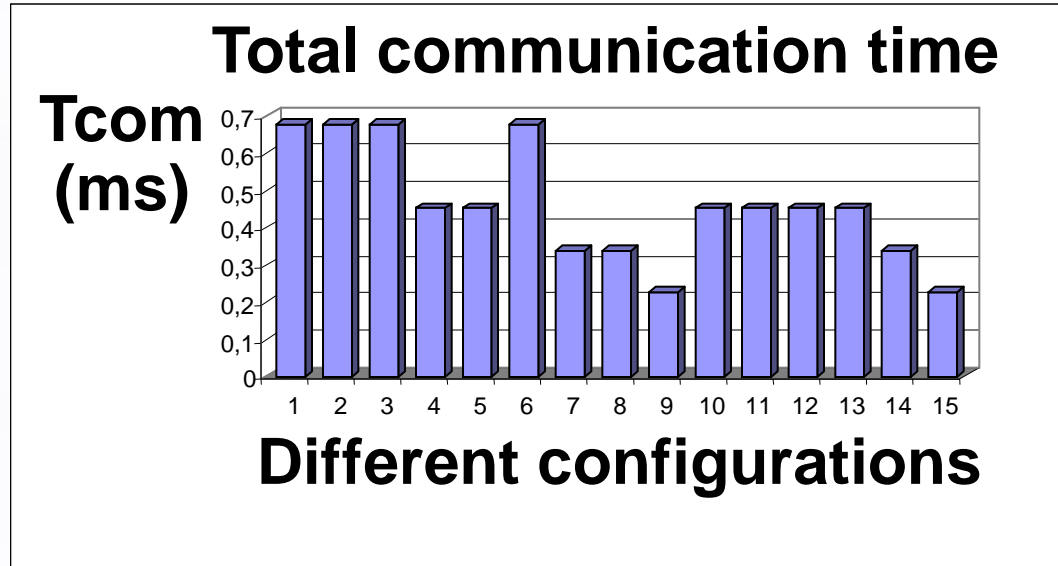
Use of material resources

Total resources number
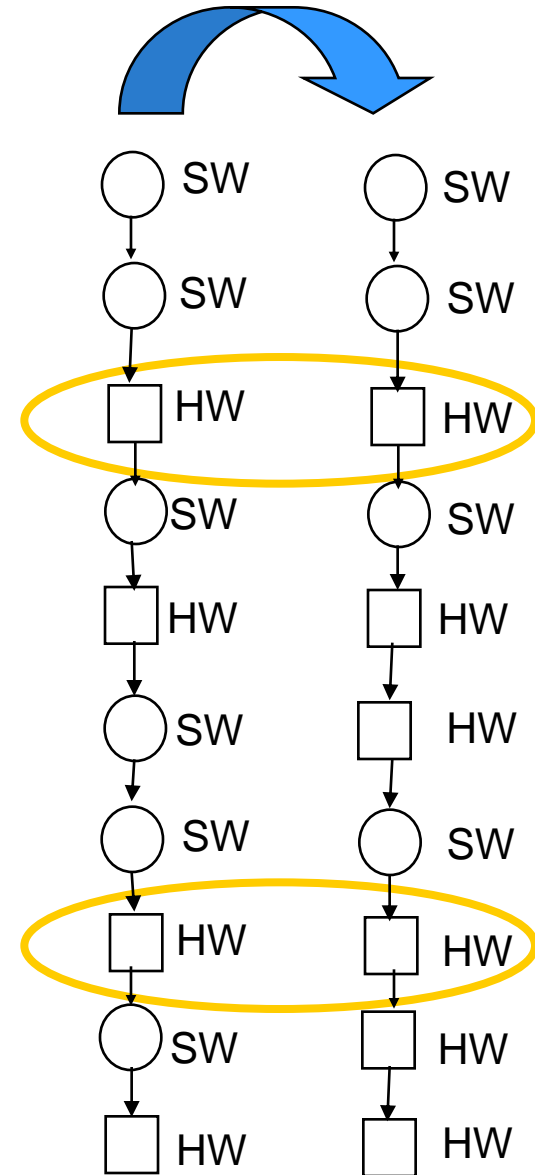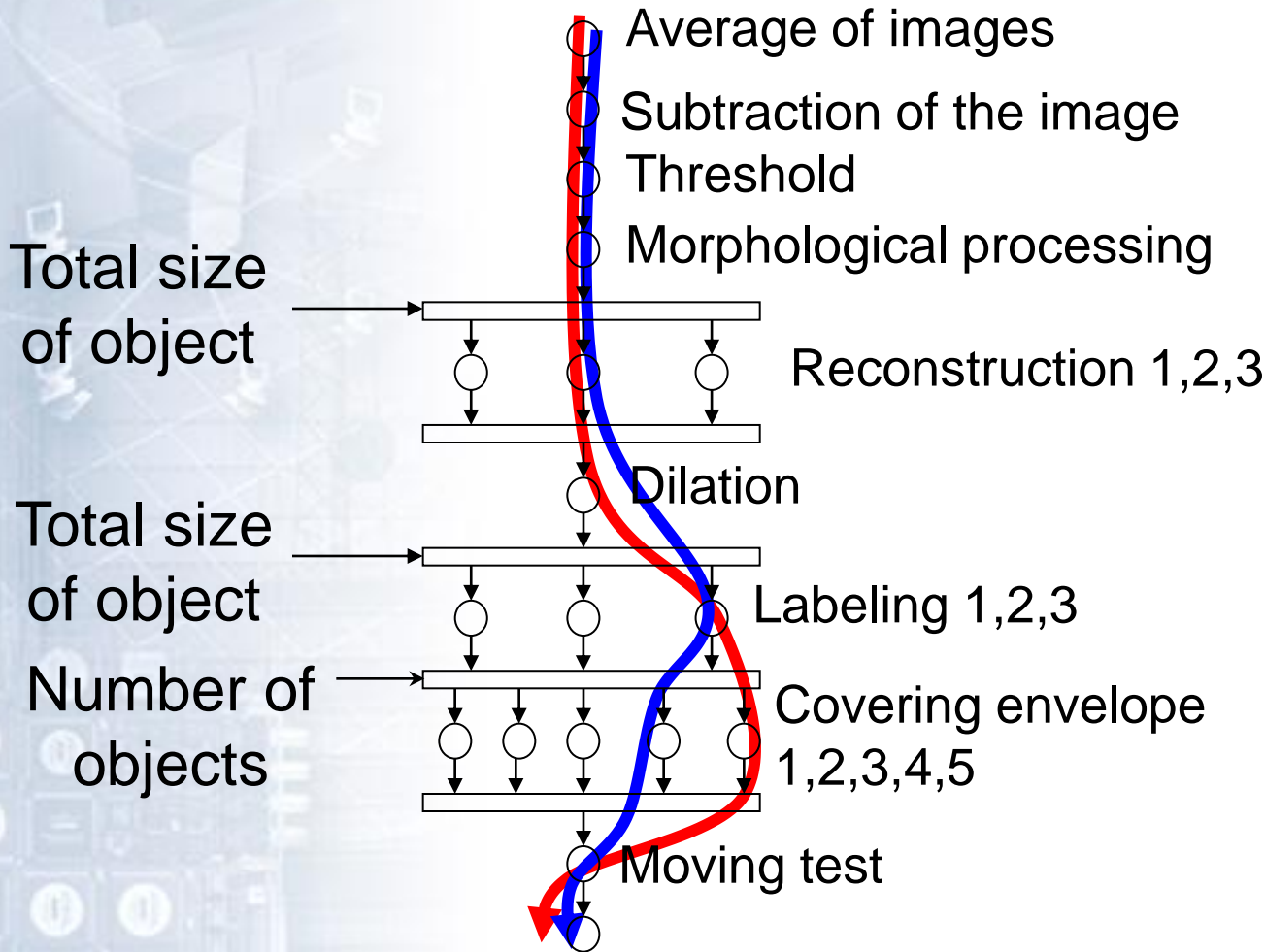
Nbr (LABs) — Different configurations
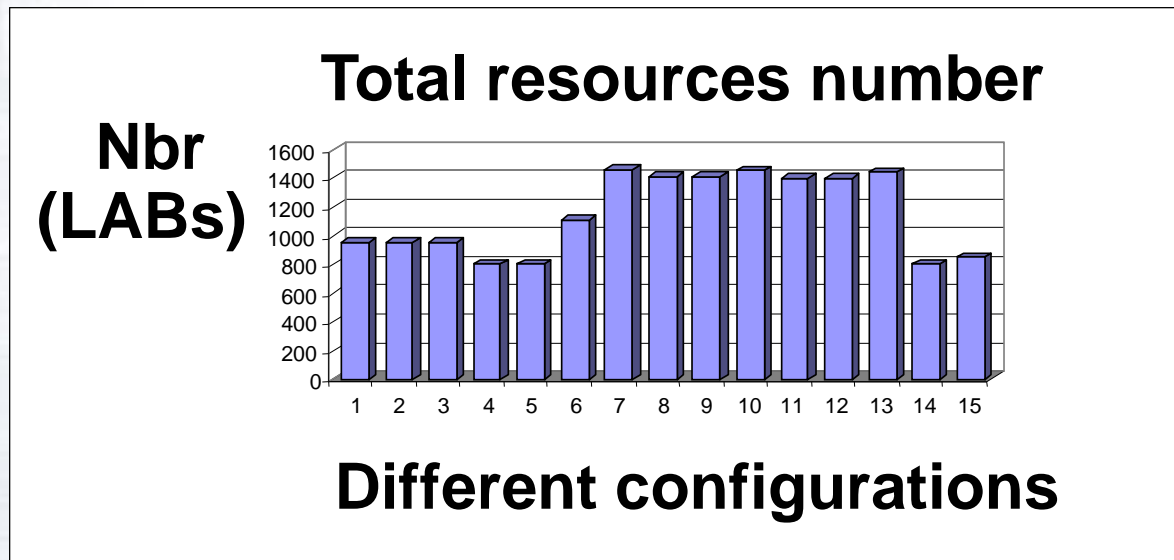
Conclusions

➢ Better exploitation of architectural hardware resources

➢ Profiling results give configurations which reduce the pessimism of the worst case

For certain data set we gain:

- An unused time and/or resources that can be exploit by optimizing other criteria such as the consumption

- A decrease of communication time

Perspectives

- Optimization of partitioning results

Average of images

Subtraction of the image

Threshold

Morphological processing

Total size of object

Reconstruction 1,2,3

Dilation

Total size of object

Labeling 1,2,3

Number of objects

Covering envelope 1,2,3,4,5

Moving test

DFG with variable execution time tasks

SW
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