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

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Outline

- Research context and problem formulation
- Partitioning of variable execution time
- Experiments and results
- Conclusion and perspective
EPICURE project flow

Behavioral Description (ESTEREL Tech.)

Estimation (LESTER)

Partitioning (I3S)

Integration / Validation (THALES / CEA)

A fixed execution time for constant number of resources!

SW Task + Sched. on the Proc.

HW Task + Contexts Def.

Resources

Exec_t

SW
Problem formulation

- Applications with **hard** real-time constraints:
  Execution time = **WCET**

- Applications with **soft** real-time constraints:
  Execution time < **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
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
Chosen model

- DFGs are suitable models for an image processing application
- Granularity level: Coarse-grain
- Estimation: Execution time, communication

![Diagram showing the chosen model with tasks and communication between tasks 1 and 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
Partitioning methodology

1. Application profiling
   - Several measures

2. Result processing
   - Study of curves

3. Conditioned DFGs
   - New models

4. Partitioning
   - Appropriate tool
Application profiling

Variable set of data

Measure of execution time

Task with fixed Execution time

Task with variable Execution time

Definition of Correlation parameters

Plotting of curves
Result processing and conditioned DFG

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

Construction of conditioned graph

On the processor

On the FPGA

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Partitioning and execution scheme

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

**Execution of the application**
- Processor
- Interface
- FPGA

Genetic algorithm

Partitioning solution of configuration 1

Partitioning solution of configuration n
Example of application

- Motion detection on a fixed image background

1. **Camera Images 256x256**
2. **Background Subtraction**
3. **Filtering (convolution 3x3)**
4. **Thresholding**
5. **Image labelling**
6. **Attributes computation**

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

✓ Maximum execution time for all the threshold groups
Experimental results

DFG with variable execution time tasks

Average of images
Subtraction of the image
Threshold
Morphological processing
Reconstruction 1,2,3
Dilation
Labeling 1,2,3
Covering envelope 1,2,3,4,5
Moving test

Total size of object
Number of objects
Total size of object

1,2,3,4,5
Threshold
Morphological processing
Reconstruction 1,2,3
Dilation
Labeling 1,2,3
Covering envelope 1,2,3,4,5
Moving test
Partitioning results

Total Texe = 72.455 ms

- Partitioning result of configuration 3

Total Texe = 82.659 ms

- Partitioning result of configuration 6
Total execution time

Execution time = WCET

Unused time during execution of the application

Processed image

Entry image

Partiti 1

Partiti 12

Partiti 8

Partiti 15

Total execution time

Texe (ms)

Different configurations
Total communication time

Different configurations

![Graph showing Tcom (ms) for different configurations]

Use of material resources

Different configurations

![Graph showing Nbr (LABs) for 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

DFG with variable execution time tasks

- Average of images
- Subtraction of the image
- Threshold
- Morphological processing
- Reconstruction 1, 2, 3
- Dilation
- Labeling 1, 2, 3
- Covering envelope 1, 2, 3, 4, 5
- Moving test