Temporale Partitionierung und Temporale Platzierung beim Entwurf Rekonfigurierbarer Rechensysteme

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Motivation

- Processing in space and time means
  - Multiple and different parts of algorithms with and without interdependencies are temporally present on the reconfigurable device

- Parts: modules, generations, etc...
  - Commonality: communication
    - Wire length is an issue

- Build parts w.r.t. optimization of the wire length
  - Appropriate partitioning of input graphs

- Instrument: spectral method
  - Quadratic optimization of the wire length
Motivation

- Reconfiguration costs time
  - Computation area must be prepared (reconfigured) before processing can start
  - Delay until processing on new area can start

- Several methods to cope with these challenges
  - Hide reconfiguration time: pipelined reconfiguration
  - Avoid reconfiguration: caching

- Means: Enhance spectral methods
  - Clustering methods
    - Weight of the nodes
    - Answering time optimized clustering
Agenda

- Motivation
- Retrospect (1\textsuperscript{st} period)
  - Spectral method
  - Modeling approach using the Y-chart
- Outlook (2\textsuperscript{nd} period)
  - Reconfigurable systems as pipelining systems
    - Temporal Partitioning
    - Phases of reconfigurable systems
    - Variations
      - Spectral methods and cluster building w.r.t. pipelining
      - Caching in reconfigurable systems
- Cooperation
- Conclusion
- References
**Spectral Method Objective**

- Spectral placement of input graphs w.r.t. wire length
  - Quadratic objective function
  - Nodes can be additionally weighted
    - Similar execution time
    - Communication ‘width’
    - Etc

- Method proposed by Hall (1970)
  - Input: LaPlacian Matrix
  - Output: spectral placement of nodes
  - Means: Eigenvectors etc.
  - Use: VLSI placement

- Allows effective cluster generation
**Spectral Method**

**Goal achieved**

- 3rd dimension for temporal domain
  - Can be built directly using Halls proposal
  - Cluster building along the time-axis \( t \)

- Alternative placement and partitioning principle
- Integrated concept to partition and place data flow graphs or task graphs on reconfigurable devices
Modeling Using the Y-chart
Challenges of Current Design Flows

- Model:
  - Dataflow/data stream
  - Spectral, temporal computation
  - Additional resource for OS

- Design challenges
  - Temporal and spatial dimension
  - See above (lack of model, technical difficulties)

- Practical examples
  - Vendor/device specific
    - Xilinx Virtex series (XAPP 290)
    - Atmel FPSLIC
Y-Chart Extension: Reconfiguration Level

- Summarizes properties of the reconfigurable system
- Only by considering the reconfiguration level, the system is a reconfigurable system
  - Without: not necessarily reconfigurable
- Encapsulation and collection of all important facts concerning the reconfiguration in one location
- Abstraction
Y-Chart Extension
Tool for Partial Bit-Stream Generation
Y-Chart Extension
UML Class Diagram Used in the Tool
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First Enhancement
From Temporal Partitioning to…

- First approach
  - Spectral methods: generations of DFG
  - Alternating execution of generations
  - Increase of the execution speed

- Avoid reconfiguration as much as possible (as it is costly)
- If necessary, reconfigure as smart (fast, etc.) as possible
  - Hide reconfiguration time

- Partitioning and Placement as key step towards above goals
  - Integrate pipelining in the partitioning and placement decisions
  - First: ways to describe reconfigurable systems w.r.t. pipelining
Reconfigurable Systems as Pipelining Systems … Abstracting Reconfigurable Systems

- Phases:
  - Run Time Reconfiguration: RTR
  - Execution: EX
Reconfigurable Systems as Pipelining Systems
Further Adaptations

- Multiple reconfiguration ports
  - Superscalar pipeline

- Adaptation of the sizes

- etc
Pipelining Spectral Methods

- Pipelining
  - Increase performance: maximize throughput
  - Constant pipeline clock

- Extend spectral methods to be usable for reconfigurable systems
  - Objective function to minimize wire length
  - Weight the nodes
  - Arrangement of nodes w.r.t. reconfiguration time, area, etc.

- Cluster generation
  - E.g. using simulated annealing
Caching Task Set

- Task Set
  - periodic
  - \#tasks > \#slots

- Run time environment
  - fixed and dynamic parts

![Diagram of caching process](image-url)
Caching Optimization

- Periodic execution
- Replacement strategy:
  - Best caching strategy
  - Realized with cut lines
  - Maximum distance
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Cooperation PadErOl (Erlangen & Oldenburg) “Durchgängiger Entwurfsfluss”

- Erlangen
  - High level design space exploration
- Oldenburg
  - OSSS+R
- Paderborn
  - Temporal placement on reconfigurable device

- Concrete case study
  - Tests
  - Improvements
  - Enhancement
  - Validation
- Generation of
  - Partial bit-streams
Multiple tasks scenario

- Combination of different alternatives (area + time trade-offs)
- Several Pareto-points
  - Partitioning method
- Caching
Conclusion

- Motivation
  - Wire length optimization → answering time optimization

- Retrospect
  - Spatial methods
  - Y-chart modeling

- New
  - Pipelining
  - Involving the spectral methods
  - Caching

- Cooperation
Meaningful References Since Last Workshop


- Dittmann, Florian and Bobda, Christophe: **Temporal Graph Placement on Mesh-Based Coarse Grain Reconfigurable Systems Using the Spectral Method** In: Int. Engineering System Symposium (IESS). Manaos, Brazil, 15 -17 Aug 2005
Thank you for your attention.

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