Embedding Constraint Satisfaction using Parallel Soft-Core Processors on FPGAs

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Constraint Satisfaction with Finite Domain Constraints

• Problem
  – Consists of a set of Basic Constraints
  – Basic constraint: relation over set of variables
  – All variables assigned a domain (a subset of \( \mathbb{Z}^+ \))
  – Goal: bind a value to each variable such that all basic constraints are satisfied

• Solver: Propagation + Distribution + Search
  – Concurrent propagators implement basic constraints
  – Variables held in globally shared Constraint Store
  – Distributor inserts guesses when stuck, backtracks when disproven
Embedded Constraint Solver

FPGA-based Multi-soft-core architecture
- Collection of Xilinx MicroBlaze processors
- Local memory for data storage
- Fast interprocessor synchronization via interrupt-driven message passing

Distributed Constraint Store
- Variable set partitioned at design time
- Consolidator ensures only meaningful updates are kept
- “Shadow copies” maintained on remote nodes to minimize synchronization
Results

Evaluation: Mission Planning
- Synthetically generated task graph
- Constraints covering precedence, serialization over unary resource

Results
- Xilinx Virtex II Pro, 1, 2, 4 Microblaze processors
- Few processors increases local memory requirements,
- Many processors increases interprocessor synchronization
- Right balance depends on problem

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