

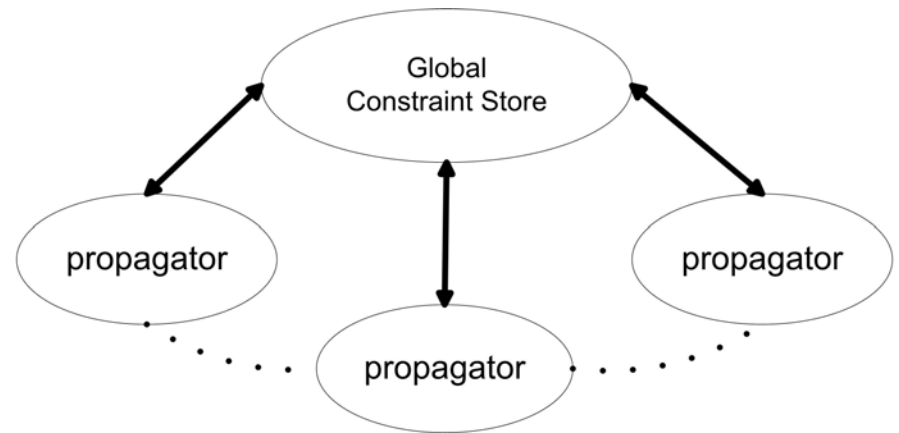
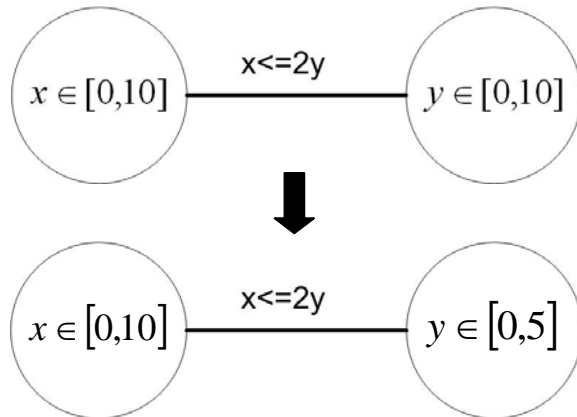
# **Embedding Constraint Satisfaction using Parallel Soft-Core Processors on FPGAs**

**Prasad Subramanian and Brandon Eames**

**Electrical & Computer Engineering  
Utah State University**

# Constraint Satisfaction with Finite Domain Constraints

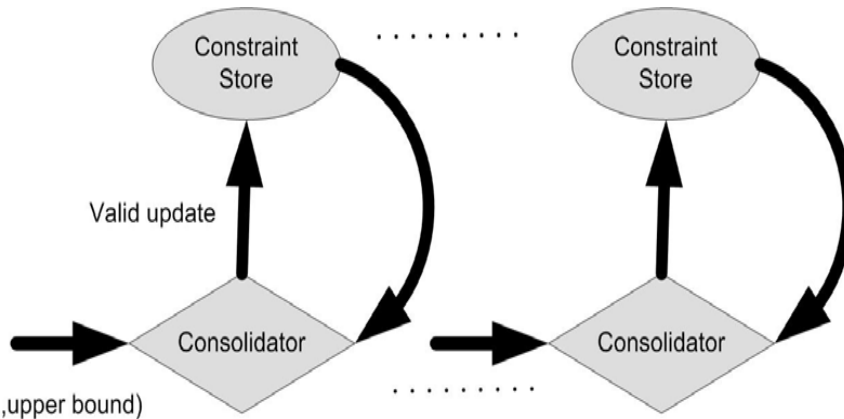
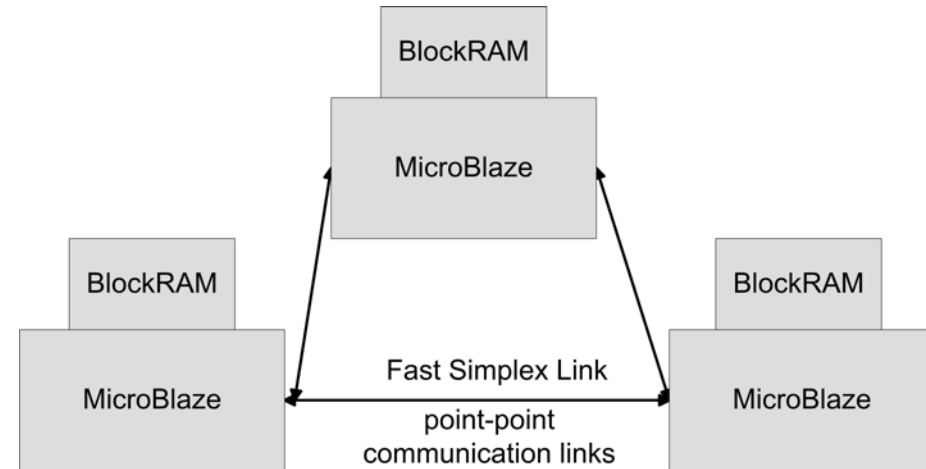
- **Problem**
  - Consists of a set of Basic Constraints
  - Basic constraint: relation over set of variables
  - All variables assigned a domain ( a subset of  $\mathbb{Z}^+$ )
  - Goal: bind a value to each variable such that all basic constraints are satisfied
- **Solver: Propagation + Distribution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

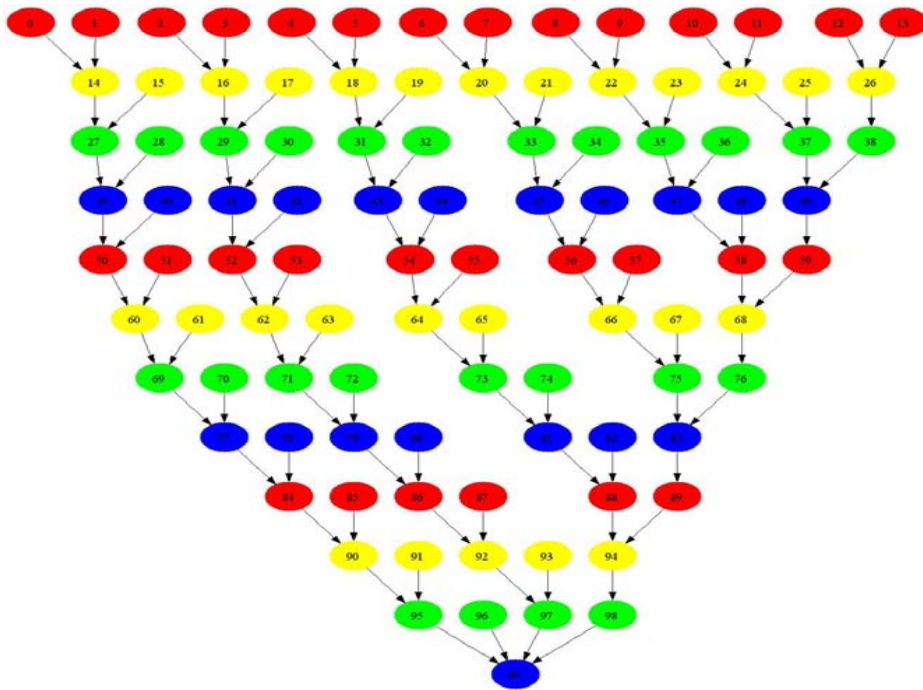


## Distributed Constraint Store

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

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# 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

# uPs	Propagation (ticks)	# dist. steps	1st soln (ticks)	Propagation speed-up	% stack usage
1	310209	60	FAILS	1	167.98
2	159608	47	2632804	1.94	68.99
3	109971	43	1668505	2.82	44.41
4	85914	65	2360598	3.61	53.00