Claspar
A Distributed Conflict-Driven Answer Set Solver

Martin Gebser   Roland Kaminski   Benjamin Kaufmann
Torsten Schaub   Bettina Schnor

University of Potsdam

Outline

Outline

Overview *claspar*

- Is a parallel answer set solver based on MPI and *clasp*
- Builds upon *clasp*'s interfaces
  - Incremental interface
  - Extensible propagation
  - No changes to the *clasp* library itself!
- Supports a subset of *clasp*'s reasoning modes
  - Enumeration
  - Optimization
- Inherits all of *clasp*'s options related to search strategies!
- Offers different search topologies
  - Search space splitting using guiding paths
  - Competitive search using solver portfolios
  - Combinations of both
- Configurable knowledge exchange between solver instances

Outline

Search Topologies

- **Master Worker Topology**
  - Master divides search space among workers using the guiding path technique
  - Solver instances work on disjoint search spaces
  - Maximum work sharing

- **Competition Topology**
  - Extends master worker topology
  - Worker and a set of competitors solve the same subproblem
  - Different search strategies for workers and competitors
  - More robust

- **Hierarchical Master Worker**
  - Extends master worker topology
  - Superior master controls set of inferior masters
  - Inferior masters control workers
  - Better scaling than master worker topology

Search Topologies

- Master Worker Topology
    - Master divides search space among workers using the guiding path technique
    - Solver instances work on disjoint search spaces
    - Maximum work sharing
- Competition Topology
    - Extends master worker topology
    - Worker and a set of competitors solve the same subproblem
    - Different search strategies for workers and competitors
    - More robust
- Hierarchical Master Worker
    - Extends master worker topology
    - Superior master controls set of inferior masters
    - Inferior masters control workers
    - Better scaling than master worker topology

Experiments

	1+2 (1)	6+2 (1)	30+2 (4)	62+2 (8)
Guiding Path				
ASP	174,661 (24)	154,504 (22)	103,283 (14)	85,578 (11)
SAT	89,428 (8)	42,491 (5)	38,293 (6)	30,515 (4)
Uniform Portfolio				
ASP	174,661 (24)	149,157 (17)	133,147 (18)	113,309 (16)
SAT	89,428 (8)	57,694 (3)	40,555 (2)	31,734 (2)
Non-uniform Portfolio				
ASP	174,661 (24)	141,890 (16)	98,160 (11)	92,331 (11)
SAT	89,428 (8)	52,739 (3)	37,772 (3)	30,739 (1)

Machines 28 × two quadcore Intel Xeon E5520, 48GB memory

ASP benchmark consisting of 68 ASP instances

SAT benchmark consisting of 78 SAT instances

Header solver instances + control processes (machines)

Cells time (timeout)

Experiments

	1+2 (1)	6+2 (1)	30+2 (4)	62+2 (8)
Guiding Path				
ASP	174,661 (24)	154,504 (22)	103,283 (14)	85,578 (11)
SAT	89,428 (8)	42,491 (5)	38,293 (6)	30,515 (4)
Uniform Portfolio				
ASP	174,661 (24)	149,157 (17)	133,147 (18)	113,309 (16)
SAT	89,428 (8)	57,694 (3)	40,555 (2)	31,734 (2)
Non-uniform Portfolio				
ASP	174,661 (24)	141,890 (16)	98,160 (11)	92,331 (11)
SAT	89,428 (8)	52,739 (3)	37,772 (3)	30,739 (1)

Machines   28 × two quadcore Intel Xeon E5520, 48GB memory
ASP   benchmark consisting of 68 ASP instances
SAT   benchmark consisting of 78 SAT instances
Header   solver instances + control processes (machines)
Cells   time (timeout)

Experiments

	1+2 (1)	6+2 (1)	30+2 (4)	62+2 (8)
Guiding Path				
ASP	174,661 (24)	154,504 (22)	103,283 (14)	85,578 (11)
SAT	89,428 (8)	42,491 (5)	38,293 (6)	30,515 (4)
Uniform Portfolio				
ASP	174,661 (24)	149,157 (17)	133,147 (18)	113,309 (16)
SAT	89,428 (8)	57,694 (3)	40,555 (2)	31,734 (2)
Non-uniform Portfolio				
ASP	174,661 (24)	141,890 (16)	98,160 (11)	92,331 (11)
SAT	89,428 (8)	52,739 (3)	37,772 (3)	30,739 (1)

Machines $28 \times$ two quadcore Intel Xeon E5520, 48GB memory
ASP   benchmark consisting of 68 ASP instances
SAT   benchmark consisting of 78 SAT instances
Header   solver instances + control processes (machines)
Cells   time (timeout)

Outline

Knowledge Exchange

- No nogood exchange per default
- All-to-all Nogood Exchange
  - No scaling
- Local Nogood Exchange
  - Exchange depends on topology
    - Competition Worker + associated competitors
    - Hierarchical Workers sharing a Master
    - Master Worker Equivalent to all-to-all exchange
  - Localize exchange
- Hypercube Nogood Exchange
  - Solver instances organized in hypercube
  - Exchange along edges
  - Better scaling/ still some locality
- Nogood Filtering Heuristics
  - Nogood length
  - Literal Blocking Distance

Knowledge Exchange

- No nogood exchange per default
- **All-to-all Nogood Exchange**
  - No scaling
- **Local Nogood Exchange**
  - Exchange depends on topology
    - Competition Worker + associated competitors
    - Hierarchical Workers sharing a Master
    - Master Worker Equivalent to all-to-all exchange
  - Localize exchange
- **Hypercube Nogood Exchange**
  - Solver instances organized in hypercube
  - Exchange along edges
  - Better scaling/ still some locality
- Nogood Filtering Heuristics
  - Nogood length
  - Literal Blocking Distance

Experiments

	1+2 (1)	6+2 (1)	30+2 (4)	62+2 (8)
Without Nogood Exchange				
ASP	174,661 (24)	141,890 (16)	98,160 (11)	92,331 (11)
SAT	89,428 (8)	52,739 (3)	37,772 (3)	30,739 (1)
Local Nogood Exchange				
ASP	174,661 (24)	93,166 (11)	75,678 (13)	58,747 (7)
SAT	89,428 (8)	29,067 (0)	28,324 (3)	14,373 (1)
Hypercube Nogood Exchange				
ASP	174,661 (24)	92,108 (10)	82,388 (13)	64,028 (9)
SAT	89,428 (8)	27,245 (0)	33,602 (4)	24,099 (2)

Machines	28 × two quadcore Intel Xeon E5520, 48GB memory
ASP	benchmark consisting of 68 ASP instances
SAT	benchmark consisting of 78 SAT instances
Header	solver instances + control processes (machines)
Cells	time (timeout)

Experiments

	1+2 (1)	6+2 (1)	30+2 (4)	62+2 (8)
Without Nogood Exchange				
ASP	174,661 (24)	141,890 (16)	98,160 (11)	92,331 (11)
SAT	89,428 (8)	52,739 (3)	37,772 (3)	30,739 (1)
Local Nogood Exchange				
ASP	174,661 (24)	93,166 (11)	75,678 (13)	58,747 (7)
SAT	89,428 (8)	29,067 (0)	28,324 (3)	14,373 (1)
Hypercube Nogood Exchange				
ASP	174,661 (24)	92,108 (10)	82,388 (13)	64,028 (9)
SAT	89,428 (8)	27,245 (0)	33,602 (4)	24,099 (2)

Machines	28 × two quadcore Intel Xeon E5520, 48GB memory
ASP	benchmark consisting of 68 ASP instances
SAT	benchmark consisting of 78 SAT instances
Header	solver instances + control processes (machines)
Cells	time (timeout)

Experiments

	1+2 (1)	6+2 (1)	30+2 (4)	62+2 (8)
Without Nogood Exchange				
ASP	174,661 (24)	141,890 (16)	98,160 (11)	92,331 (11)
SAT	89,428 (8)	52,739 (3)	37,772 (3)	30,739 (1)
Local Nogood Exchange				
ASP	174,661 (24)	93,166 (11)	75,678 (13)	58,747 (7)
SAT	89,428 (8)	29,067 (0)	28,324 (3)	14,373 (1)
Hypercube Nogood Exchange				
ASP	174,661 (24)	92,108 (10)	82,388 (13)	64,028 (9)
SAT	89,428 (8)	27,245 (0)	33,602 (4)	24,099 (2)

Machines 28 × two quadcore Intel Xeon E5520, 48GB memory
ASP benchmark consisting of 68 ASP instances
SAT benchmark consisting of 78 SAT instances
Header solver instances + control processes (machines)
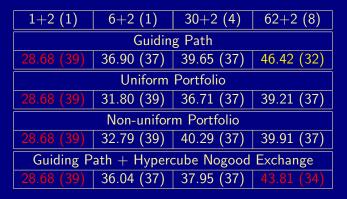Cells time (timeout)

Outline

Optimization

- Branch and bound optimization
  - Lower bounds sent to dedicated process
  - Then broadcasted and incorporated if relevant
  - Lowest reported bound corresponds to optimum
- Compatible with all search topologies

Experiments

1+2 (1)	6+2 (1)	30+2 (4)	62+2 (8)
Guiding Path			
28.68 (39)	36.90 (37)	39.65 (37)	46.42 (32)
Uniform Portfolio			
28.68 (39)	31.80 (39)	36.71 (37)	39.21 (37)
Non-uniform Portfolio			
28.68 (39)	32.79 (39)	40.29 (37)	39.91 (37)
Guiding Path + Hypercube Nogood Exchange			
28.68 (39)	36.04 (37)	37.95 (37)	43.81 (34)

Machines   28 × two quadcore Intel Xeon E5520, 48GB memory
Benchmark   53 ASP instances
Header   solver instances + control processes (machines)
Cells   score (timeout)

Experiments

1+2 (1)	6+2 (1)	30+2 (4)	62+2 (8)
Guiding Path			
28.68 (39)	36.90 (37)	39.65 (37)	46.42 (32)
Uniform Portfolio			
28.68 (39)	31.80 (39)	36.71 (37)	39.21 (37)
Non-uniform Portfolio			
28.68 (39)	32.79 (39)	40.29 (37)	39.91 (37)
Guiding Path + Hypercube Nogood Exchange			
28.68 (39)	36.04 (37)	37.95 (37)	43.81 (34)

Machines	28 × two quadcore Intel Xeon E5520, 48GB memory
Benchmark	53 ASP instances
Header	solver instances + control processes (machines)
Cells	score (timeout)

Outline

Summary

Available at

- http://potassco.sourceforge.net

- *claspar* is adjustable to various physical architectures through
  - different search topologies and
  - configurable nogood exchange
- *claspar* might be valuable to solve challenging problems
- *claspar* supports most of the reasoning modes and configurability of *clasp*

But Still needs research to improve its efficiency

Summary

Available at

- `http://potassco.sourceforge.net`

- *claspar* is adjustable to various physical architectures through
  - different search topologies and
  - configurable nogood exchange
- *claspar* might be valuable to solve challenging problems
- *claspar* supports most of the reasoning modes and configurability of *clasp*

But Still needs research to improve its efficiency