Branch-and-Bound Heuristics for Incomplete DCOPs

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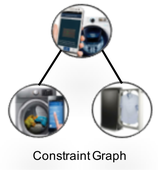
Problem Definition

Distributed Constraint Optimization Problems

Washer	Dryer	Discomfort
04:00	05:00	4
04:00	04:00	45
23:00	05:00	8
23:00	04:00	10

Constraint Cost Table



Constraint Graph

Dryer	Iron	Discomfort
05:00	05:00	15
05:00	06:00	11
04:00	05:00	21
04:00	06:00	30

Constraint Cost Table

Figure 1: DCOPs

Objective:
Finding an optimal solution that minimizes **constraint costs** (e.g. the best schedule for the devices that minimizes the users' discomfort)

Limitation of DCOPs:
Unrealistic assumption of apriori knowledge on all constraint costs

Model

To address the limitation of DCOPs:
we introduce Incomplete DCOPs (I-DCOPs)

Washer	Dryer	Discomfort	Elic
04:00	05:00	4	0
04:00	04:00	?	20
23:00	05:00	8	0
23:00	04:00	?	9

Dryer	Iron	Discomfort	Elic
05:00	05:00	15	0
05:00	06:00	?	3
04:00	05:00	?	29
04:00	06:00	30	0

Figure 2: Incomplete DCOPs (I-DCOPs)

I-DCOPs: constraints can be partially specified

- Unknown costs are denoted by '?'
- Eliciting unknown constraints incurs costs

Objective:
Finding a solution that minimizes both **constraint costs** and **elicitation costs**

What this Paper is About in 30 seconds!

Heuristics to elicit preferences from users in distributed multi-agent problems modeled with constraint optimization.

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Solving DCOPs

Distributed Synchronous Branch-and-Bound

		WD	WD-E	DI	DI-E
0	0	4	0	15	0
0	1	?	20	?	3
1	0	8	**0**	?	29
1	1	?	9	30	0

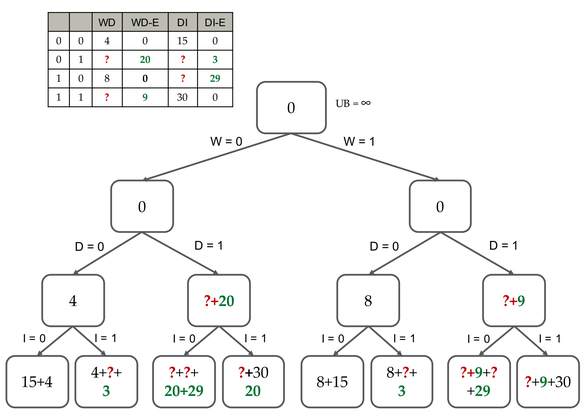

Figure 5: SyncBB Search Algorithm

- Variables/Agents: W, D, and I
- Values: 0 and 1
- Constraints: WD and DI

Branch-and-Bound Heuristics

We proposed distributed **heuristics**:

- CAC Heuristic:
  Child's Ancestors' Constraints:
  computes the estimated cost recursively and includes all **ancestors** costs
- ADC Heuristic:
  Agent's Descendants' Constraints:
  computes the estimated cost recursively and includes all **descendants** costs

To solve an I-DCOP, our approach:

- Employs SyncBB to interleave search with elicitation
- Applies heuristics to speed up SyncBB

Advantages SyncBB with heuristics:
as shown in Figure 4

- Smaller # of elicitations
- Smaller # of expanded nodes in the search tree
- Faster runtime
- Better quality solutions

		WD	WD-E	DI	DI-E
0	0	4	0	15	0
0	1	?	20	11	3
1	0	8	**0**	?	29
1	1	?	9	30	0

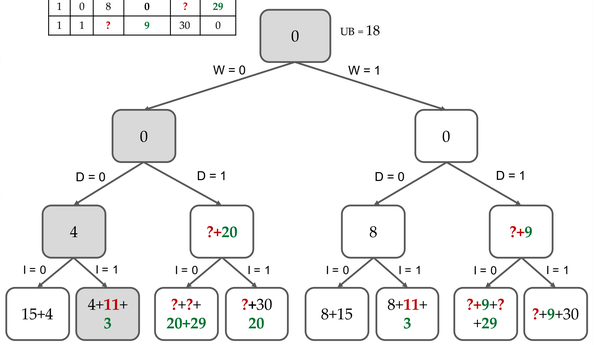

Figure 3: SyncBB with CAC Heuristic

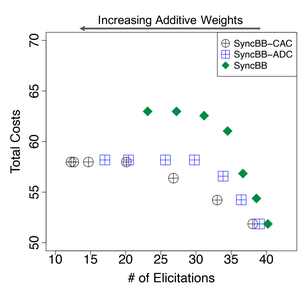

Figure 4: Performance of SyncBB w/o Heuristics

Applications

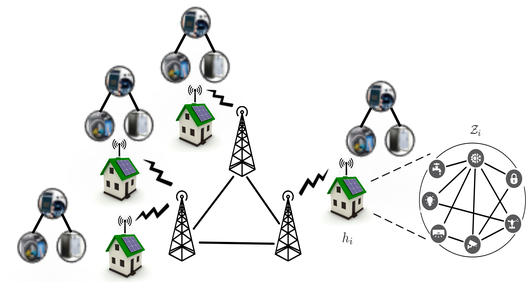

Figure 6: Smart Appliance scheduling [1]

Figure 7: Distributed Meeting Scheduling [2]

References

[1] Ferdinando Fioretto, William Yeoh, and Enrico Pontelli. A multiagent system approach to scheduling devices in smart homes. In *AAMAS*, 2017.

[2] Rajiv T Maheswaran, Milind Tambe, Emma Bowring, Jonathan P Pearce, and Pradeep Varakantham. Taking dcop to the real world: Efficient complete solutions for distributed multi-event scheduling. In *AAMAS*, 2004.

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