AAAI-16 Tutorial

CP-nets

- Thomas E. Allen
- Judy Goldsmith
- Francesca Rossi
DOMINANCE

Judy Goldsmith
Simple CP-net: Monday Reception Food

- Pasta
  - Penne > Bowtie
- Sauce
  - B: White > Red
  - P: Red > White
- Cheese
  - R: Yes > No
  - W: No > Yes
Bowties, Red, NoCh < Penne, Red, Cheese
Bowties, Red, NoCh < Bowtie, Red, Cheese

- Cheese: No
  - Pasta: Bowtie
  - Sauce: Red

- Cheese: Yes
  - Pasta: Penne
  - Sauce: Red

Penne > Bowtie

B: White > Red
P: Red > White

R: Yes > No
W: No > Yes
Bowties, Red, Cheese < Penne, Red, Cheese
Preference Graph as (Hyper-)Cube

- Penne, White, Cheese
- Penne, Red, Cheese
- Penne, White, NoCheese
- Penne, Red, NoCheese
- Bowtie, Red, NoCheese
- Bowtie, Red, Cheese
- Bowtie, White, Cheese
- Bowtie, White, NoCheese
Preference Graph (almost planar layout)

- Penne, Red, Cheese
- Penne, Red, NoCheese
- Penne, White, Cheese
- Penne, White, NoCheese
- Bowtie, Red, Cheese
- Bowtie, Red, NoCheese
- Bowtie, White, Cheese
- Bowtie, White, NoCheese
Dominance in the Preference Graph

- Bowtie, Red, Cheese
- Penne, Red, Cheese
- Penne, White, Cheese
- Bowtie, White, Cheese
- Penne, White, NoCheese
- Bowtie, Red, NoCheese
- Penne, Red, NoCheese
- Bowtie, White, NoCheese
Bowties, Red, NoChe < Penne, Red, Cheese
Bowties, Red, NoCh < Penne, Red, Cheese
Notice that B,R,N is incomparable to B,W,C
Finding Flipping Sequences

- Dominance as graph search
Complexity

- Dominance is NP-hard
  - Boutilier, et al. 2004

- For trees and polytrees, Dominance is in P
  - Boutilier, et al. 2004

- In fact, for trees, it’s linear
  - Bigot, Zanuttini, Fargier, Mengin, UAI, 2013
Complexity

- Flipping sequence search over multi-valued CP-nets with partially specified preferences is not in NP.
  - Boutilier, et al. 2004

- In generalized CP-nets, Dominance is PSPACE-complete
  - Assumes cycles allowed, multi-valued variables, succinctly represented CPTs; Goldsmith, Lang, Truszczynski, Wilson, JAIR, 2008
Boutilier, Et Al. Heuristics

- “Ordering queries”: \( o >_d o' \) iff for every \( x \), if
  - \( o[\text{Pa}(x)] = o'[\text{Pa}(x)] \) and
  - \( o[x] \neq o'[x] \)
  - \( O[\text{Pa}(x)]: o[x] > o'[x] \)
- If \( o > o' \) then \( o >_d o' \)
- \( o >_d o' \) can be determined in polynomial time
Ordering Query Example

- Hunh?
- Consider the comparison $a_2b_1c_1d_1, a_2b_2c_1d_2$. We know that we can’t have $a_2b_1c_1d_1 > a_2b_2c_1d_2$ because $a_2: b_2 > b_1$.

- Thus, this the ordering query returns “No.”
Boutilier, Et Al. Heuristics

- Suffix fixing (leveraging topological ordering of nodes)
- Least-variable flipping
- Forward pruning
Reduction to Planning

<table>
<thead>
<tr>
<th>Sauce</th>
<th>Mushrooms</th>
<th>Cheese</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Red</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>White</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>White</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

BECOMES 4 STRIPS OPERATORS:

Red and Mush
Not(Cheese)

Red and not(Mush)
Cheese

White and Mush
Not(Cheese)

White and not(Mush)
Not(Cheese)
Ganesh Ram Santhanam’s Approach

- Reduction to model checking: CRISNER
  - Santhanam, Basu, Honavar, AAAI ’10; KR ‘10; AAAI ‘14 tutorial
Li, Vo, and Kowalczyk’s Approach

- DT*: an A*-like search algorithm
  - Li, Vo, and Kowalczyk, AAMAS 2011
Domshlak, Prestwich, Rossi, Venable, and Walsh

- Soft constraints (for acyclic CP-nets)
Dominance Testing Contest

- Coming soon, to an AI meeting near you
- [http://cs.uky.edu/~jcsi225/dtcompetition.html](http://cs.uky.edu/~jcsi225/dtcompetition.html)
- Cory Siler will be managing the contest