Bayes Net Based Combinatorial Prediction Markets

Robin Hanson

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Consensus Point

With: Charles Twardy, Kathryn Laskey, Wei Sun, Shou Matsumoto

Add an Assumption
You can drag questions into this area.

SEARCH CLAIMS: Enter a Keyword | CATEGORY: (All) | SORT BY: Default

359 Will a *significant Israeli military force invade or enter the Gaza strip between 19 November and 30 November 2012? (1175) — 20.0%

360 Will at least one Hamas rocket explode within Jerusalem's city limits between 19 November and 30 November 2012? (_1175) — 46.0%

346 Will Israel officially acknowledges responsibility for the Khartoum bombing of 23 October 2012, between 5 November 2012 and 31 December 2012? (_1166) — 2.0%

359 Category: Middle East

Will a *significant Israeli military force invade or enter the Gaza strip between 19 November and 30 November 2012? (1175)

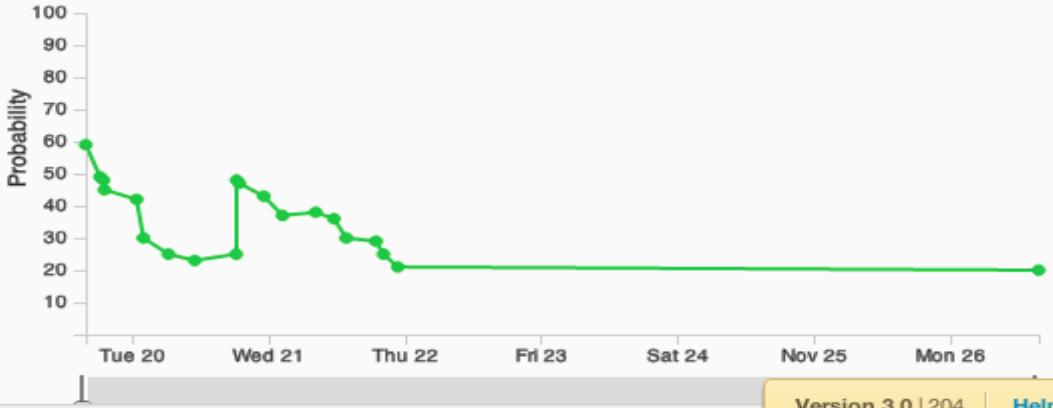
Current Estimate: – 20% +

1 edit this week. Last edit: Mon Nov 26

Question created Mon Nov 19 17:16:27 2012.
Settlement on Fri Nov 30 12:00:00 2012.

Show All Questions

Local Edit History



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Current Estimate

− 16% + | IF TRUE 1088 (-32.2) | IF FALSE 1127 (+7)

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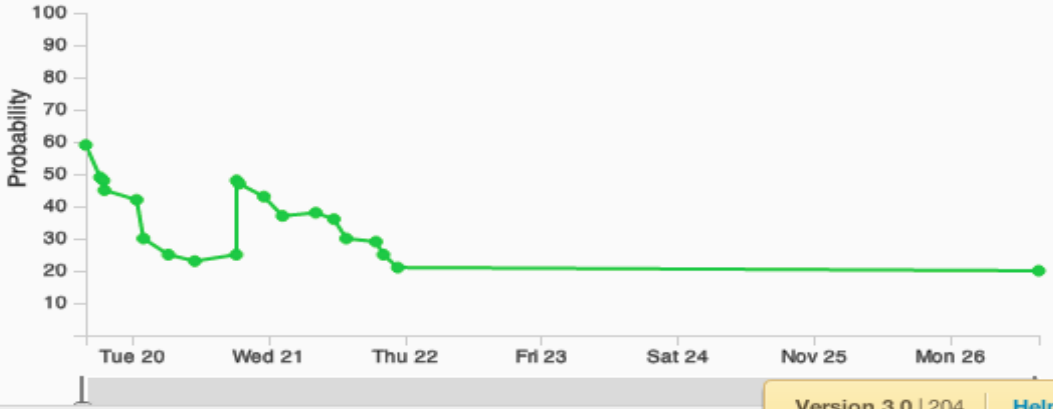

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Current Estimate	If True	If False
– 16% +	1087	1127

My Last Edit: 16%

2 edits this week. Last edit: Wed Nov 28

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Show All Questions | Equalize

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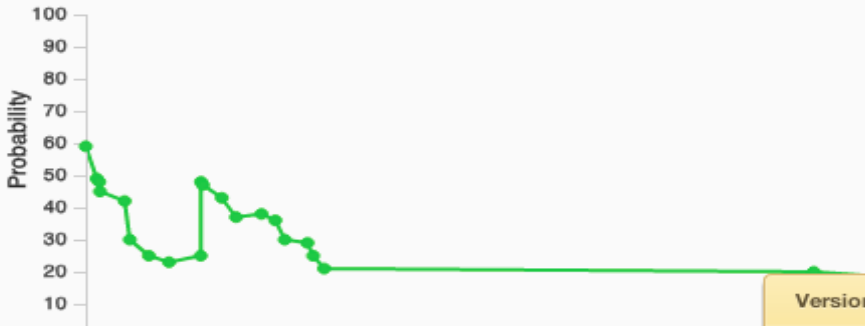

Assumption Set Probability: 46%

360 Will at least one Hamas rocket explode within Jerusalem's city limits between 19 November and 30 November 2012?

False | True

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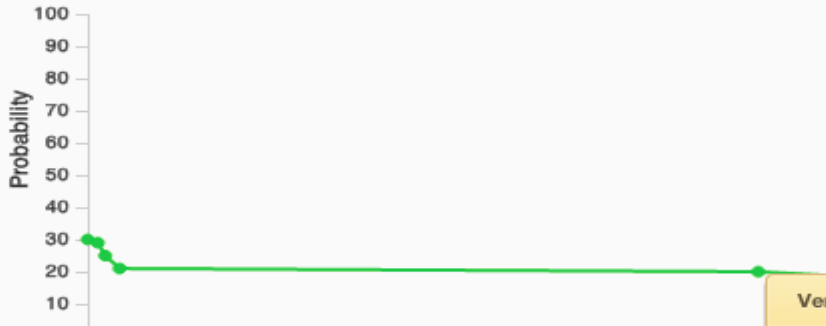


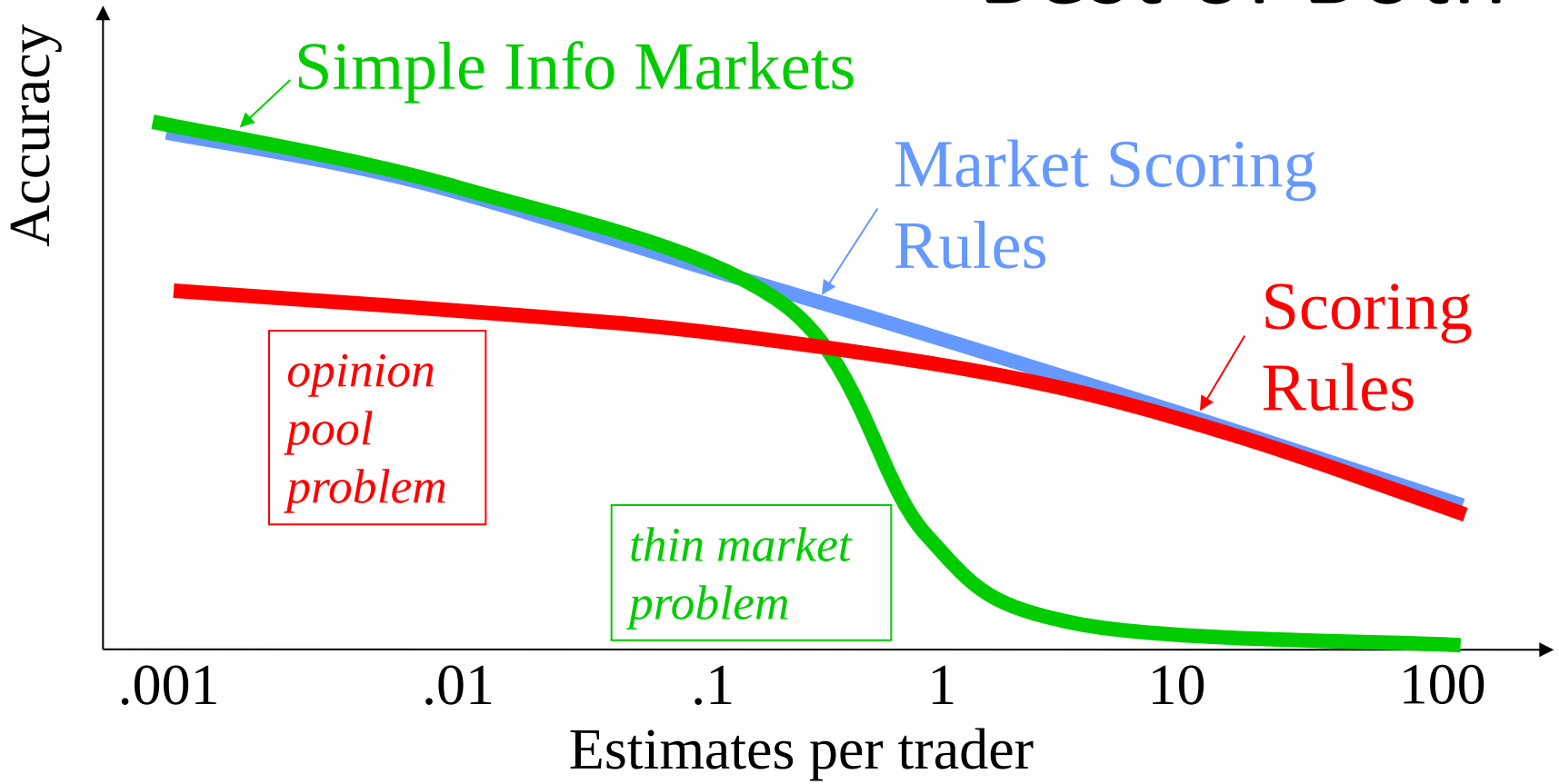
DAGGRE vs. SciCast

Same funder: IARPA

- ***DAGGRE***
- On foreign events
- Live 9/’11 to 5/’13
- ~100 claims at a time
- ~300 users/mo.
- Users paid $3000/mo.
- No performance pay

- ***SciCast***:
- On science, technology
- To go live ~11/’13
- ~1000 claims at a time
- ~3000 users/mo.
- No user pay

Best of Both


Accuracy
Simple Info Markets
Market Scoring Rules
Scoring Rules
opinion pool problem
thin market problem
.001
.01
.1
1
10
100
Estimates per trader

Market Scoring Rule (MSR)

- Scoring rule: if report **r**, state is x, get $s_x(\mathbf{r})$
  - Proper if: $\mathbf{p}$ in $\text{argmax}_{\mathbf{r}} \Sigma_x p_x s_x(\mathbf{r})$
- MSR: user t gets change $\Delta s_x = s_x(\mathbf{p}^t) - s_x(\mathbf{p}^{t-1})$

  "Anyone can use scoring rule if pay off prior user"
- Invert $s_x(\mathbf{p})$ for inventory market maker $p_x(\mathbf{s})$:
  - Tiny sale $\$ e_x$ if x fee: $p_x(\mathbf{s})\, e_x$ (s_x → s_x+e_x)
  - Big sale $\$ \mathbf{s}(1)-\mathbf{s}(0)$ fee: $\int_0^1 \Sigma_x p_x(\mathbf{s}(t))\, s_x'(t)\, dt$

Log Market Scoring Rule

- Log MSR: $s_x(\mathbf{r})=\ln(r_x)/\alpha$
- With log, cost bounded, changes uniquely modular
- Compute: state is probs p_x, assets S_x^u per user u
  - If u edits p_x -> p'_x , do $S'^u_x = S^u_x + \ln(p'_x/p_x)/\alpha$, **if** all ≥ 0
  - Helps to show market value of portfolio: $\underline{S}^u = \sum_x p_x S_x^u$
  - PROBLEM: If many vars, way too many states x!

Prediction Market Issues

- **Problem**: What we know depends on context
- *Solution*: Let tell relational, conditional info
- **Problem**: Too many combos to store/update
- *Solution*: Bayes nets store/update probs well
- **Problem**: Also need store/update assets, find expected assets, ensure assets not go negative
- *Solution*: In Bayes net LMSR, ways to store/update/find-min for probs also does assets

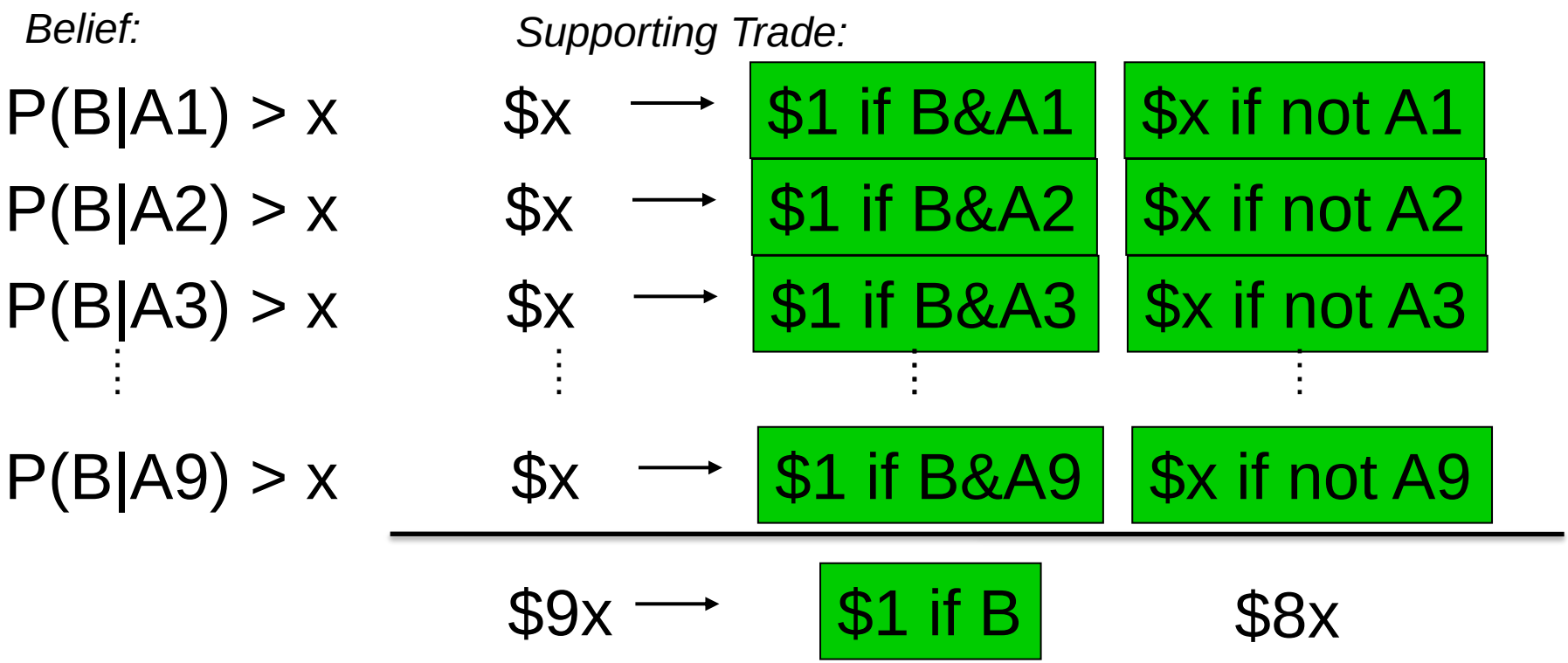
Edit-Based Combo System Needs

1) User u chooses assumptions A, target event T
2) Find & show to user u (who has assets S^u):
   a) Current consensus $p(T|A)$
   b) Now long/short? Via: $E_p[S^u|A\&T]-E_p[S^u|A\&notT]$
   c) Limits [min,max] of new $p'(T|A)$, to ensure $S^u \geq 0$

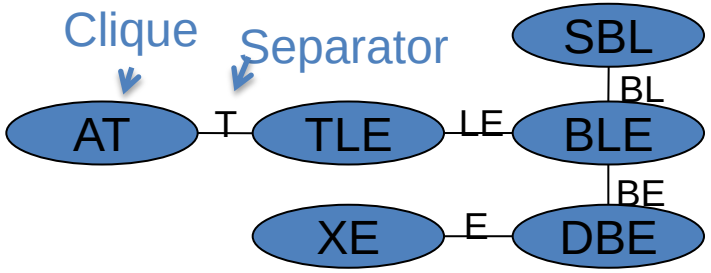
If raise p: *win* / *lose*

3) User u aborts or picks a $p'(T|A)$ in [min,max]
4) Update p to reflect $p(T|A) \rightarrow p'(T|A)$
5) Update assets S^u to reflect bet for p' over p
6) Periodically show how $\underline{S}^u = E_p[S^u]$ vary with u

Reusing Assets



Bayes/Markov Nets

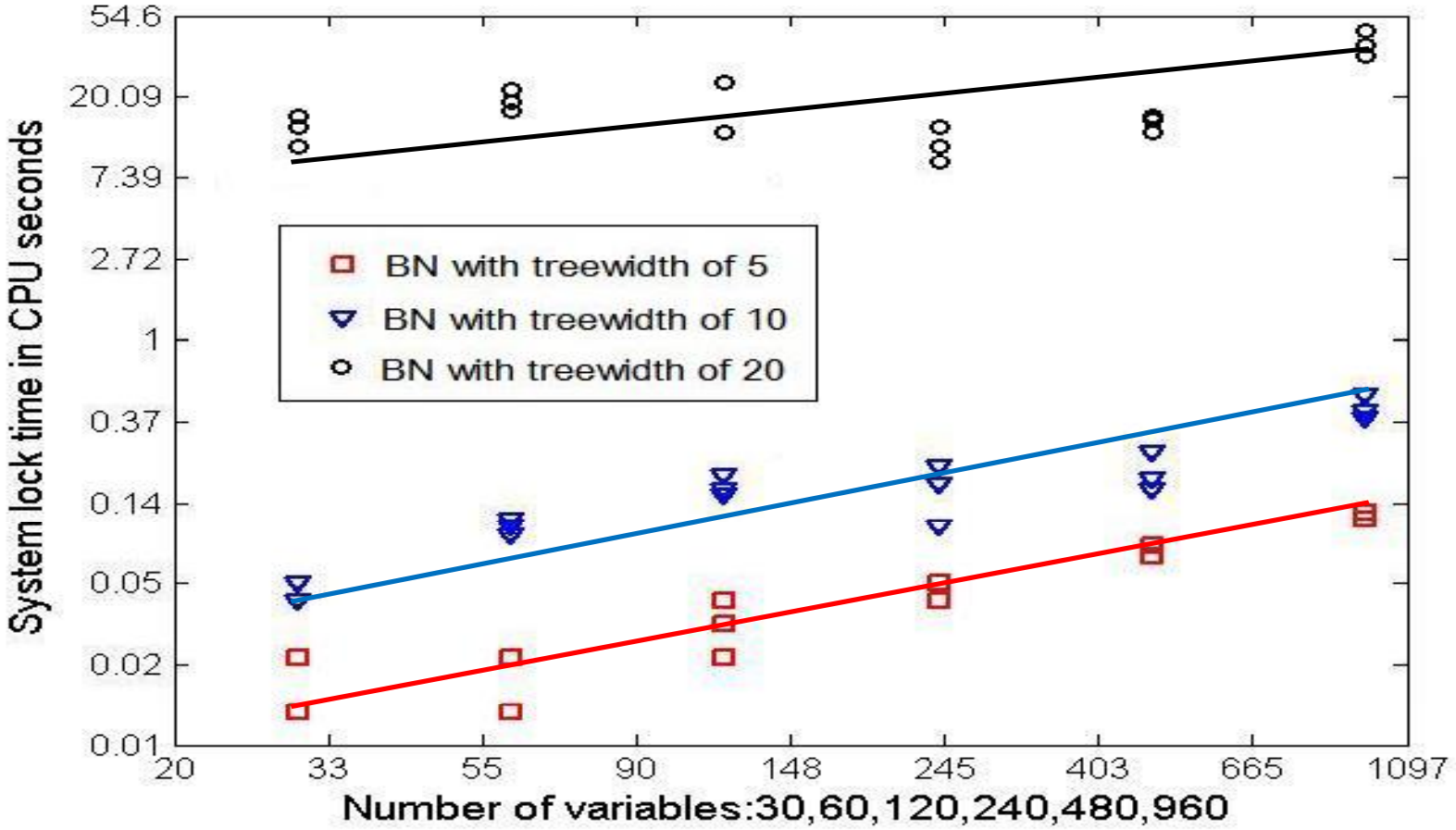


P(Clique | Rest of Net) =
P(Clique | Its Separators)

$x = <x_A, x_B, x_C, \ldots>$

- $p_x = \prod_c p_c(x_c) / \prod_s p_s(x_s)$ lets update p(x), find mind, via JT alg
- Let $q_x^u = \exp(S_x^u/b)$, so $q'_x/q_x = p'_x/p_x$, q_x^0 = constant
- $q_x = \prod_c q_c(x_c) / \prod_s q_s(x_s)$, so can update q(x), find min, via JT alg
- Implies $S_x = \Sigma_c S_c(x_c) - \Sigma_s S_s(x_s)$, $\underline{S} = \Sigma_c \underline{S}_c - \Sigma_s \underline{S}_s$
- If edit p(T|A) -> p'(T|A), need T,A in same clique
- [min,max] = [$p/\min_{(x \text{ in } A\&notT)} q_x$, $1-((1-p)/\min_{(x \text{ in } A\&T)} q_x)$]

Markov Engine Scalability Test



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6) Periodically show how $\underline{S}^u = E_p[S^u]$ vary with u

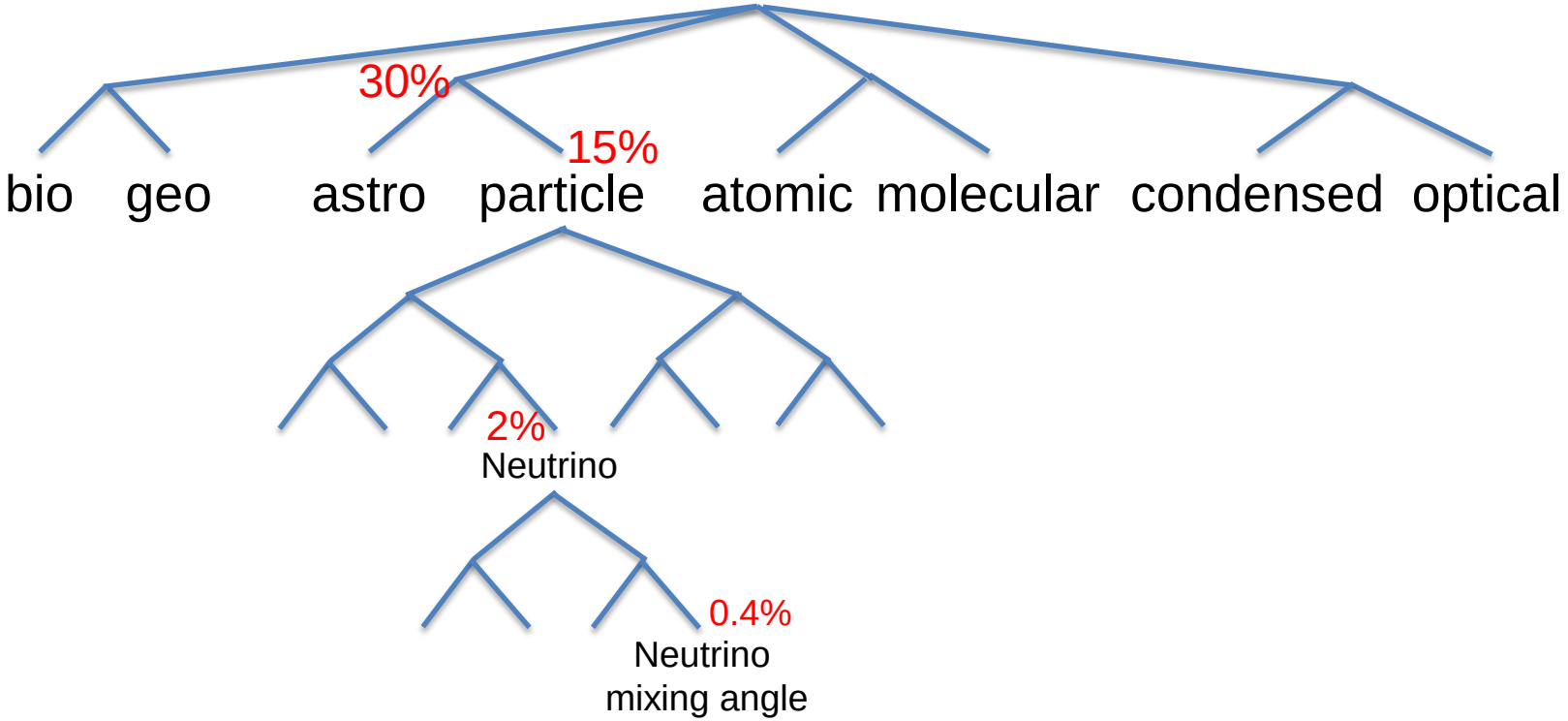
If raise p → *win* / *lose*

DAGGRE vs. SciCast

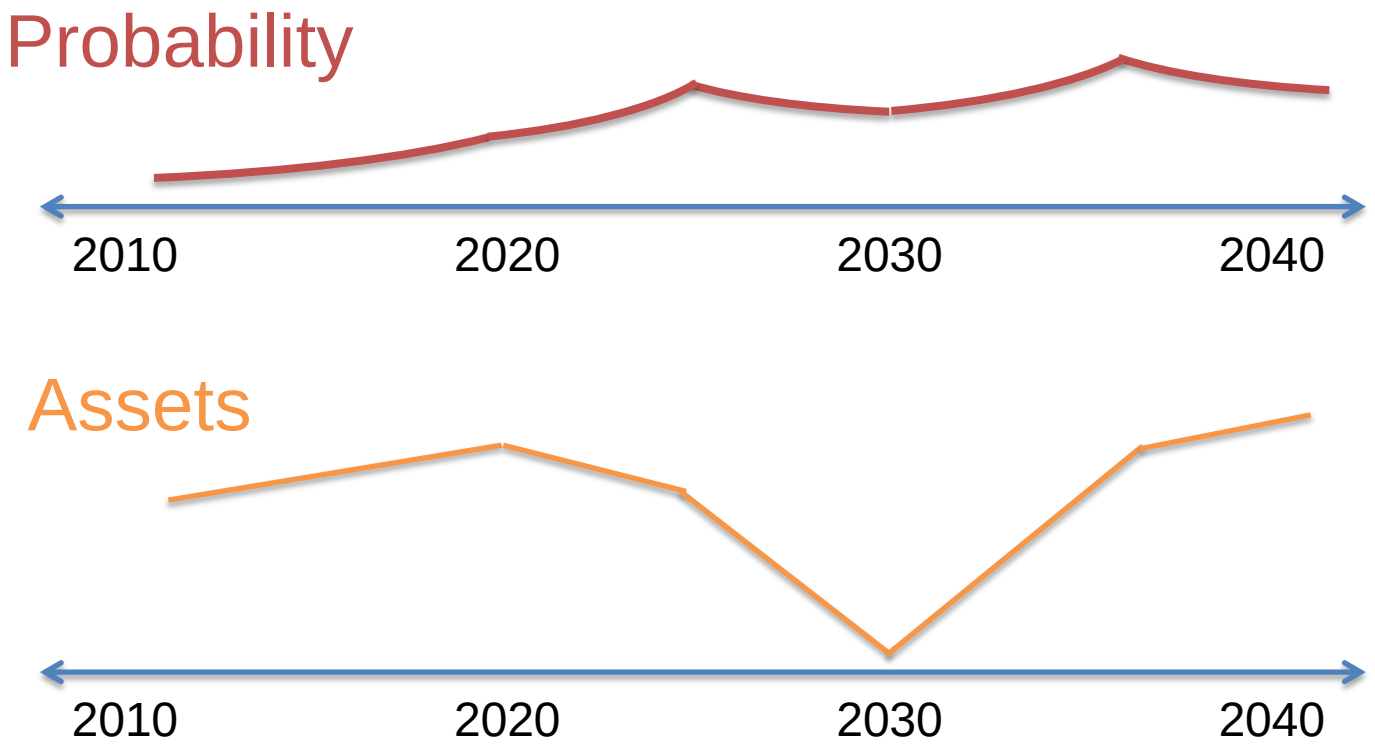
- ***DAGGRE***
- ~100 claims at a time
- Network treewidth ~5
- Show expect long/short
- Only local edits allowed
- < 5 values per variables

- ***SciCast***
- ~1000 claims at a time
- Network treewidth 50?
- Show min long/short
- Allow arbitrary edits?
- Value trees, cont. distr.

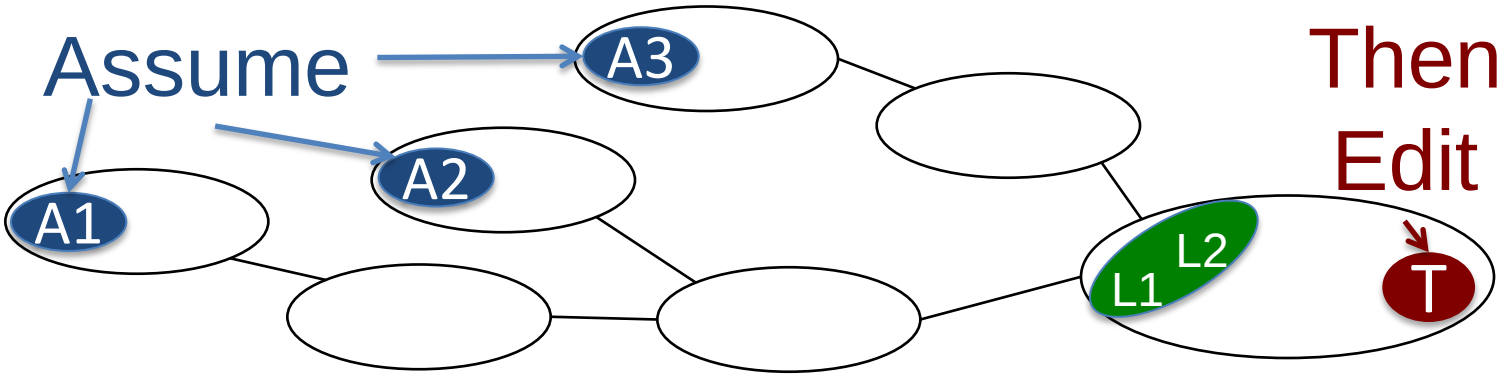
What Field 2013 Physics Nobel?



When 1000 qubits?

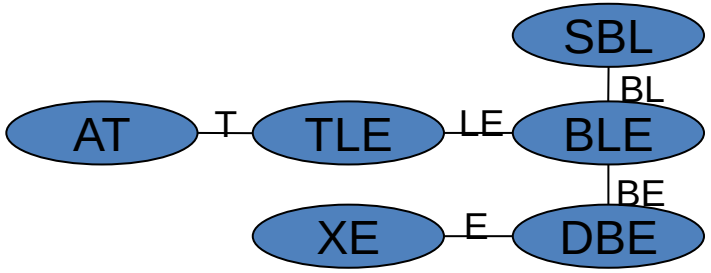


What If A Is Far from T?



- *Option 1:* Find nearest changes to ideal LMSR edit of P(**T**|**A**) that fit network constraints.
- *Option 2:* Translate far assumptions **A** into local clique assumptions **L**, let user edit P(**T**|**L**).

Can Users Edit Links?



- Add link => bigger cliques
  - Costs system more space/time to store/update
  - Allow if users willing to make big supporting edit?
- Delete link => some old assets can't be sold
  - Allow if edit creates conditional independence?
- How control compute costs while allowing structure changes?
  - Require combine add, delete links so same cost?