

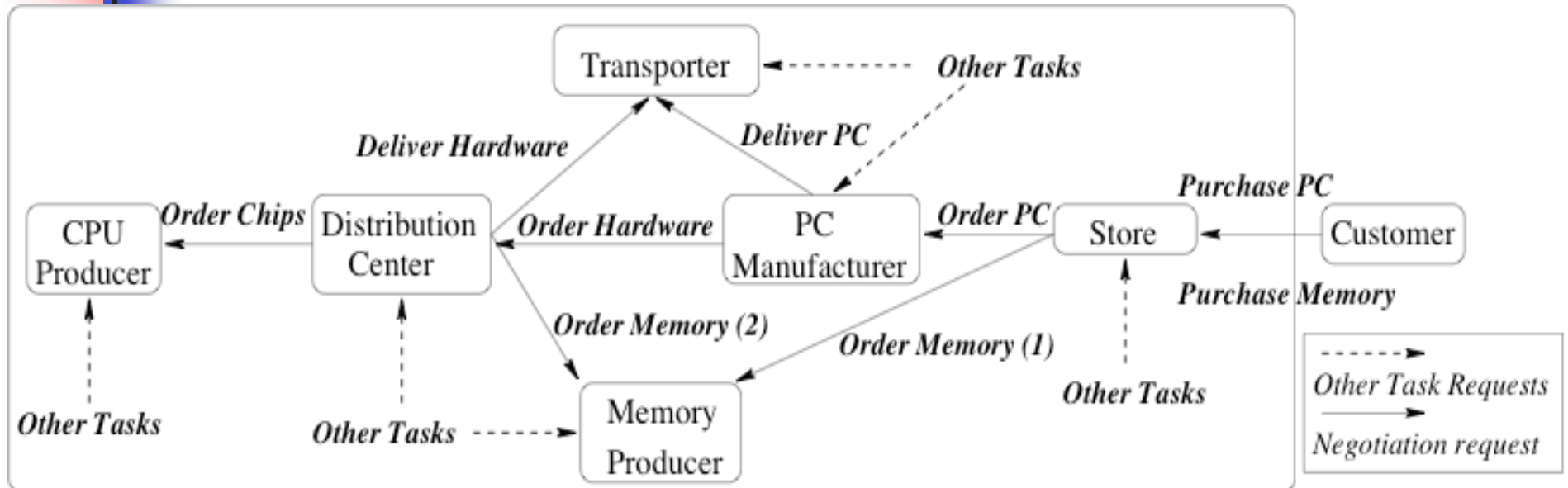
Meta-Level Coordination for Solving Negotiation Chains in Semi-Cooperative Multi-Agent Systems



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Negotiation chain/web



- Why MAS is complicated?
 - interactions/dependencies – Task, Resource
 - When, how, how much?
 - Dictator is not allowed/affordable
 - Butterfly effect



Negotiation is about

- Earliest start time (est)
- Deadline (dl)
- Promised finish time (ft)
- Reward
- Minimum quality requirement
- Early finish reward
- Decommit-ment penalty

- Multiple step or single step protocol



Semi Cooperative System

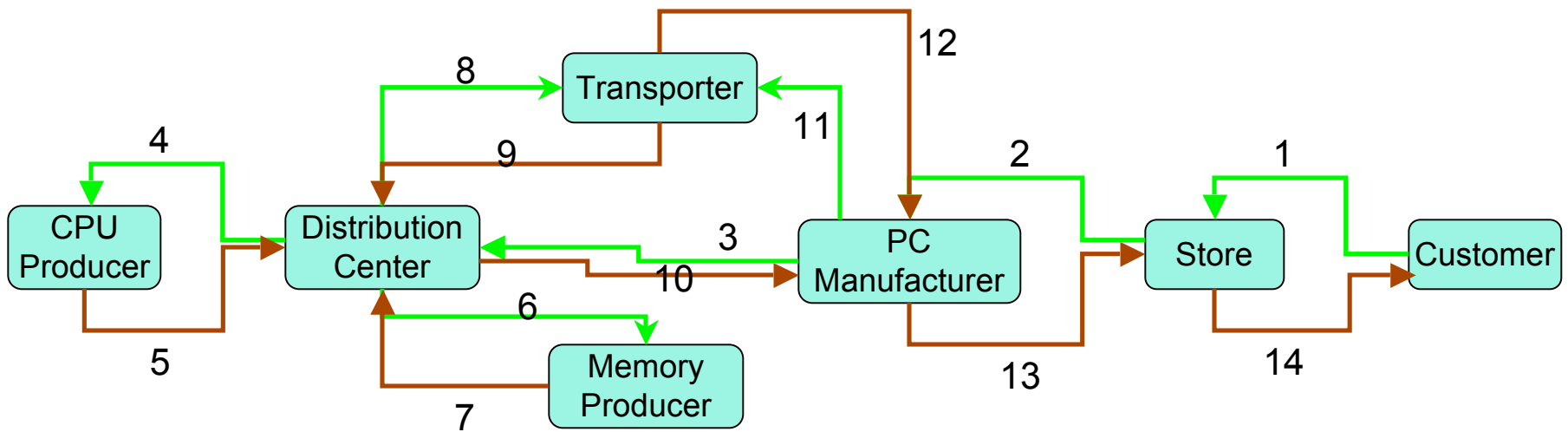
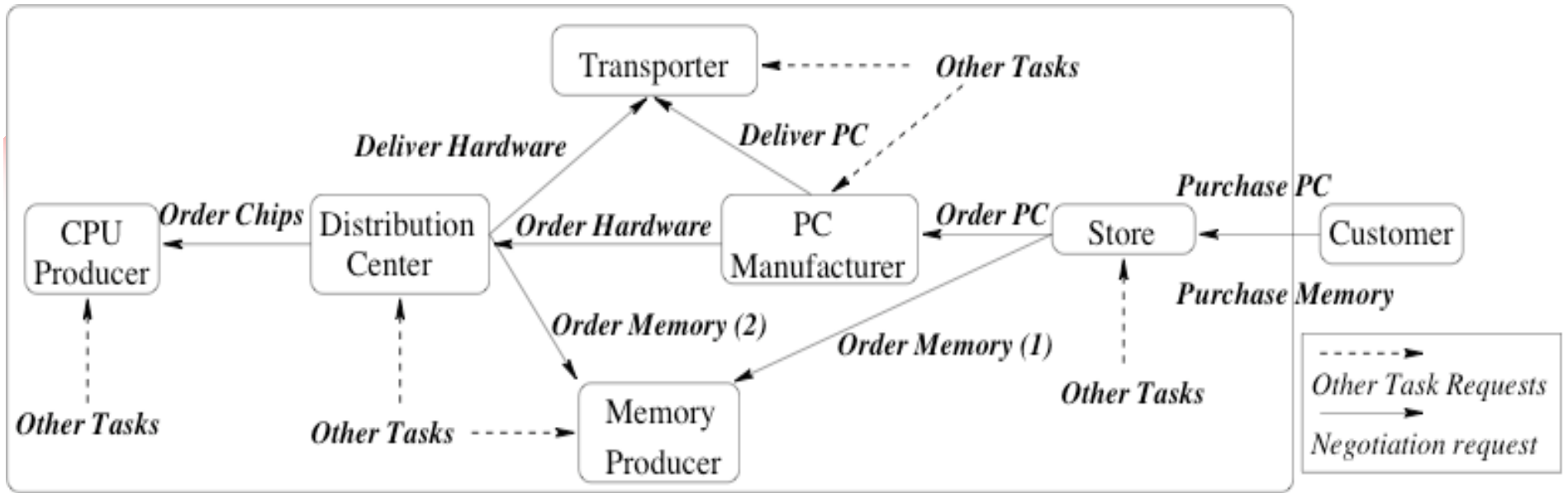
- Still self-interested agents
- Depends on others
- Cost of lying is high
- Multiple encounters

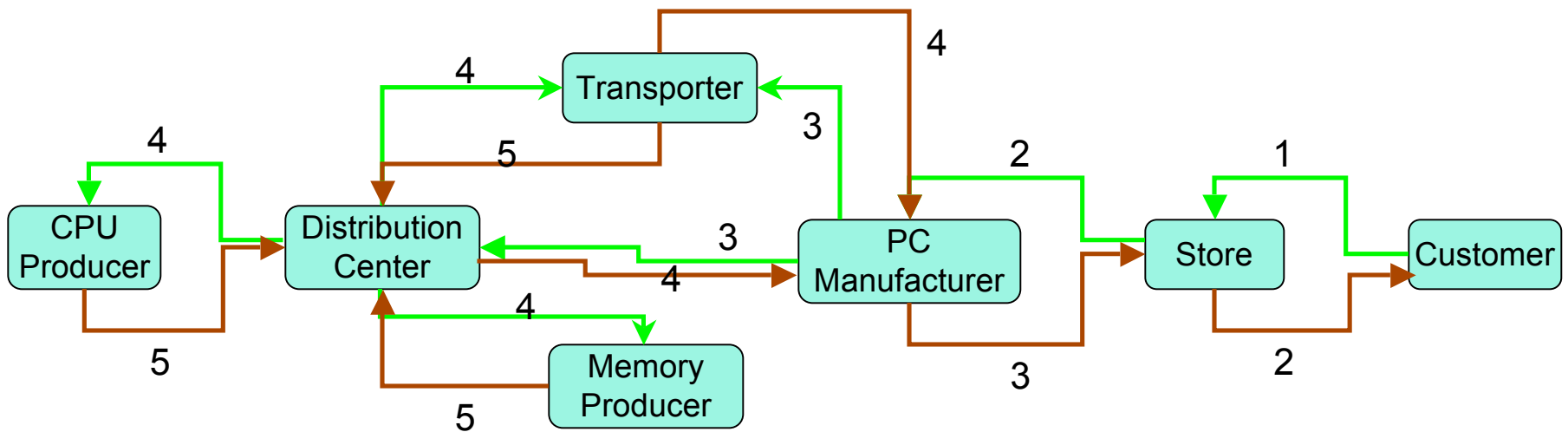
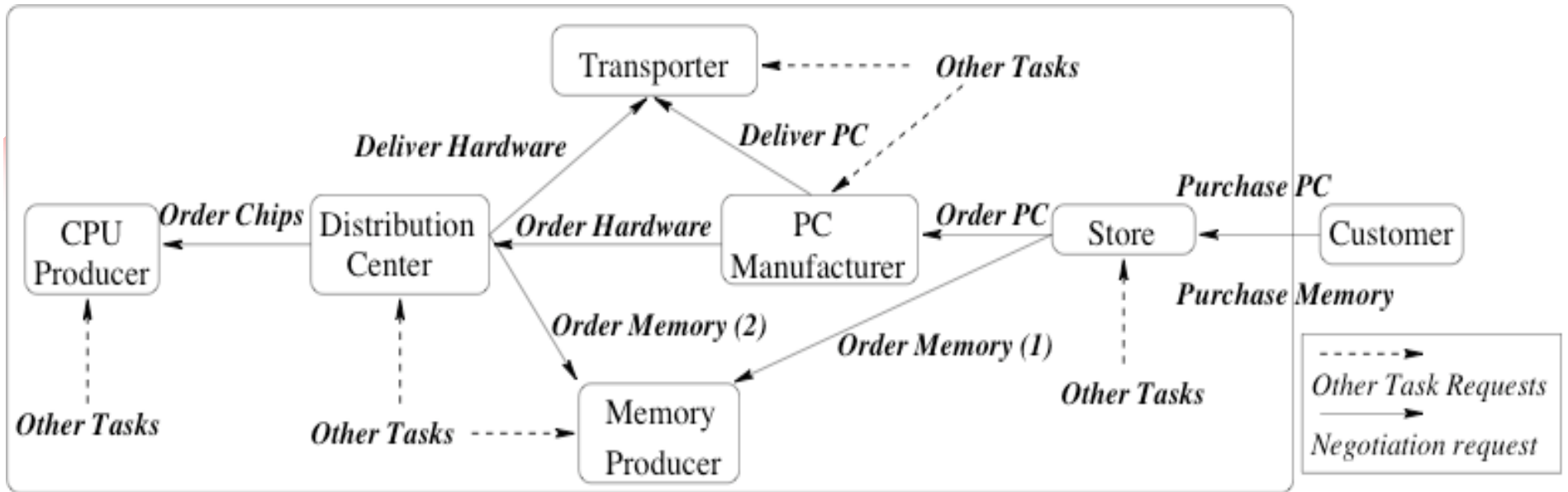
- Could be cooperative agents too
- Honest != telling the truth
- Thinks you know what is the best?

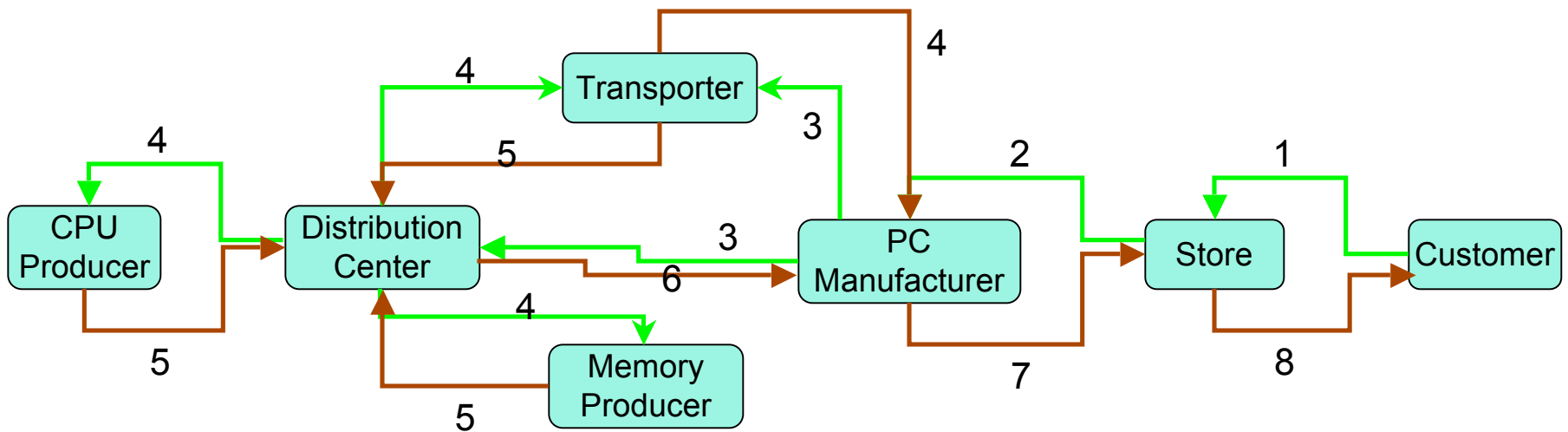
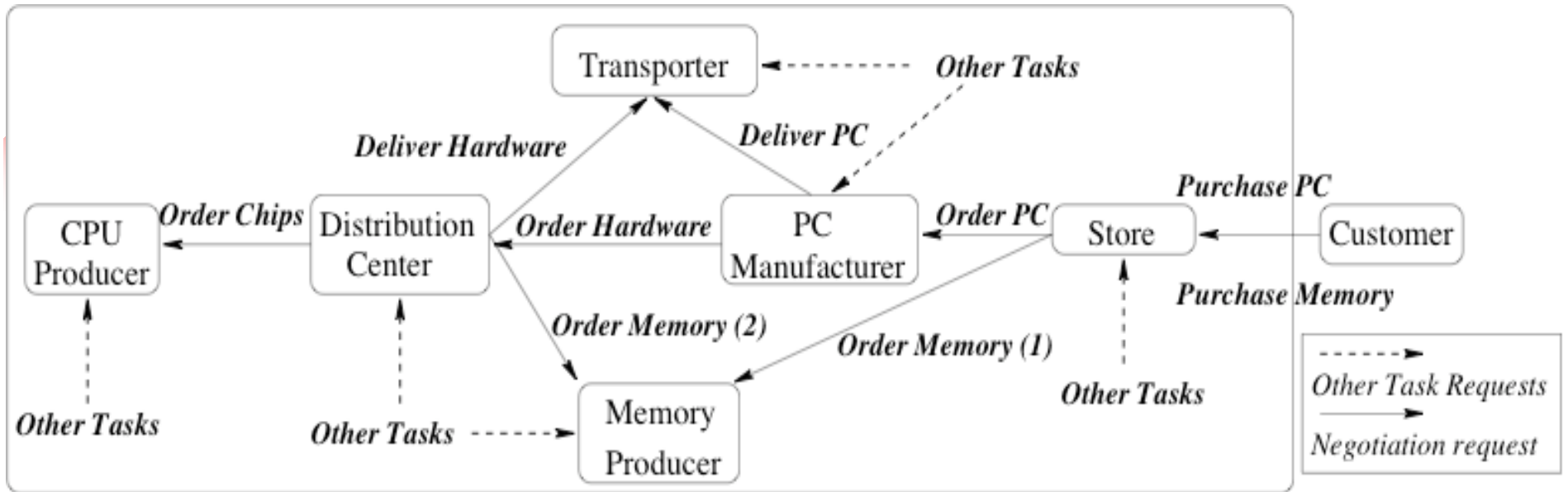


Marco strategy for negotiation

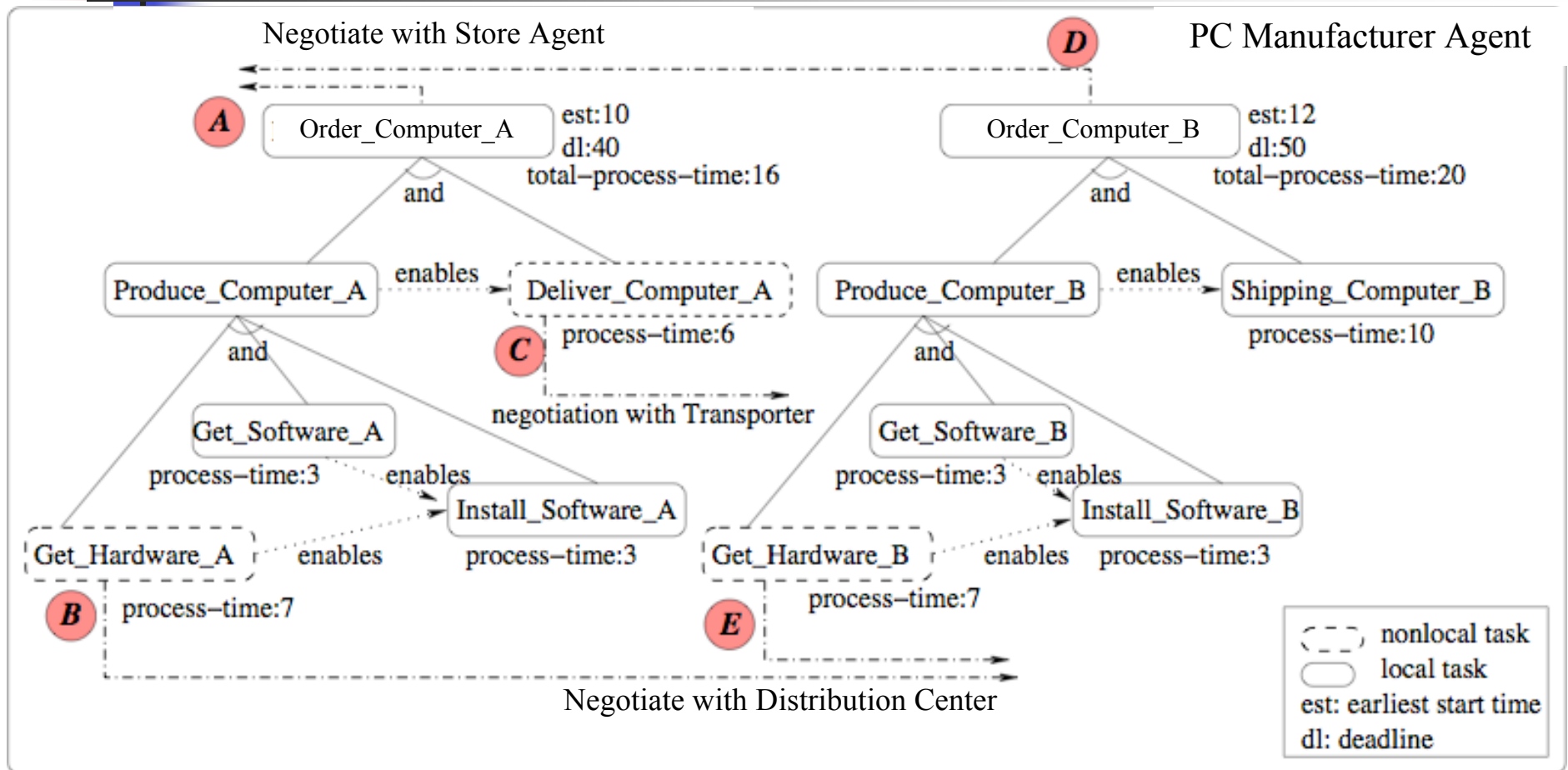
- Management of multiple related negotiation sessions
 - In what order to do?
 - How much time to spend on each one?
 - Maximum acceptable value ranges for features
 - Time
 - Price
- Not the (micro) “negotiation strategy”



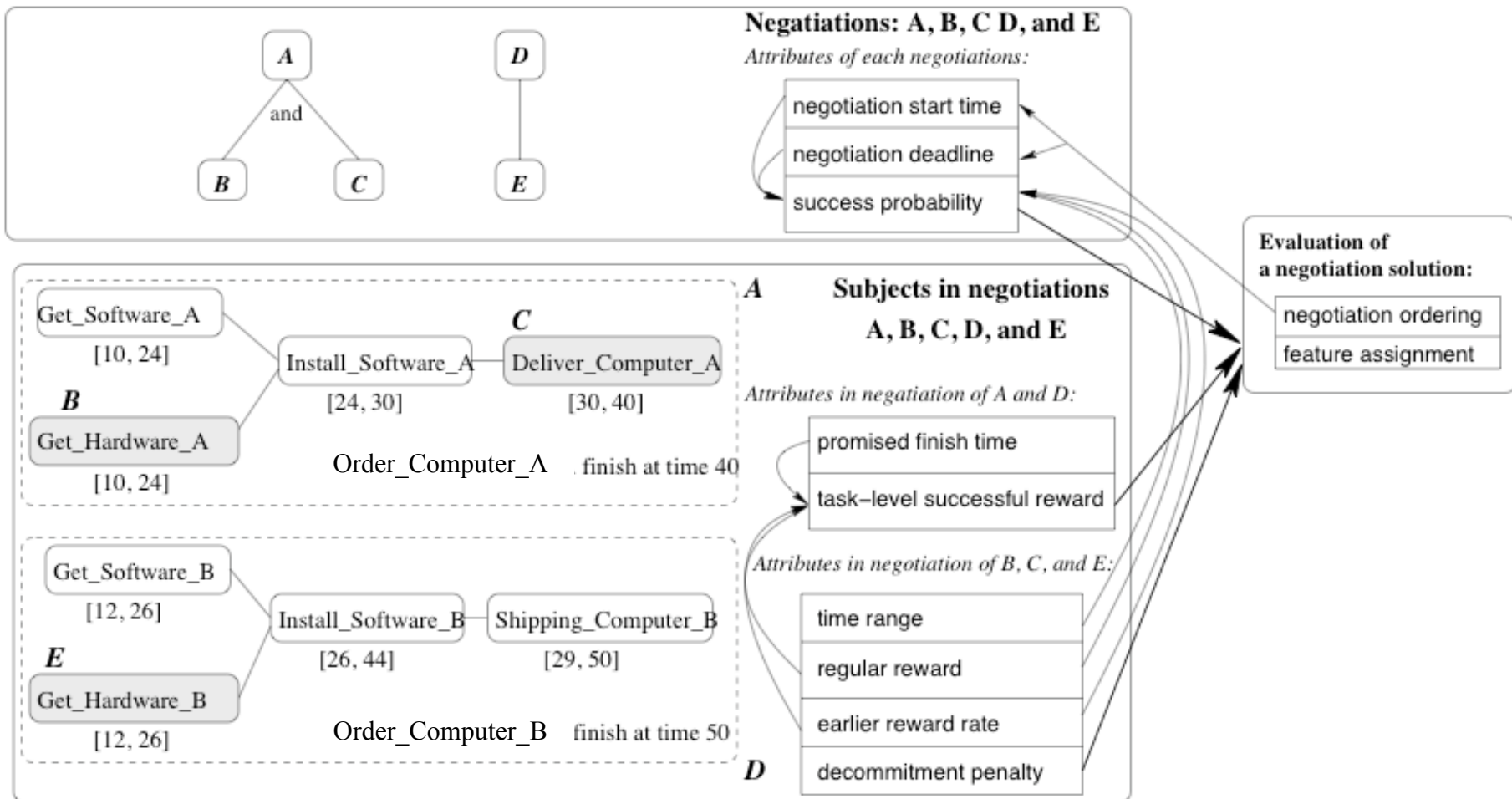




Local Tasks and Negotiations



Single agent's multi-linked negotiation problem





A negotiation solution is:

- An arrangement of local negotiations
 - Ordering of negotiations
 - The acceptable value ranges
- To Maximize the reward
- Minimize the decommitment penalty
- Given - local model
 - Negotiation duration, deadline
 - Success probability function



In global context ...

- Everybody computes its local optimal solution given
 - Imperfect model of others
- Local optimal + local optimal + local optimal = ???
- Better local optimal
- Best local optimal
- Globally local optimal

- Improve the model !



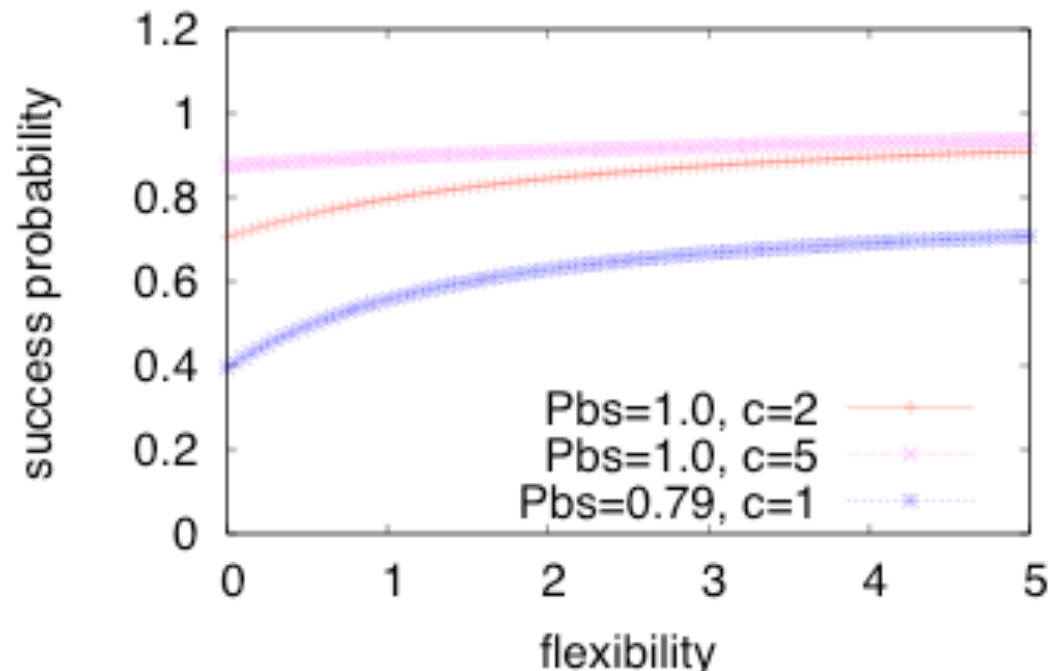
Meta-level Coordination

- Pre-negotiation phase
 - Negotiation count
 - Likelihood of conflict with competing tasks
 - Learn the statistical distribution of est, dl
 - Update periodically

Flexibility and Success Probability

$$flexibility(t) = \frac{dl - est - process_time(t)}{process_time(t)}$$

comparison of different success probability function



$$p_s(v) = p_{bs}(v) * (2/\pi) * (\arctan(f(v) + c))$$



Adjusting success function

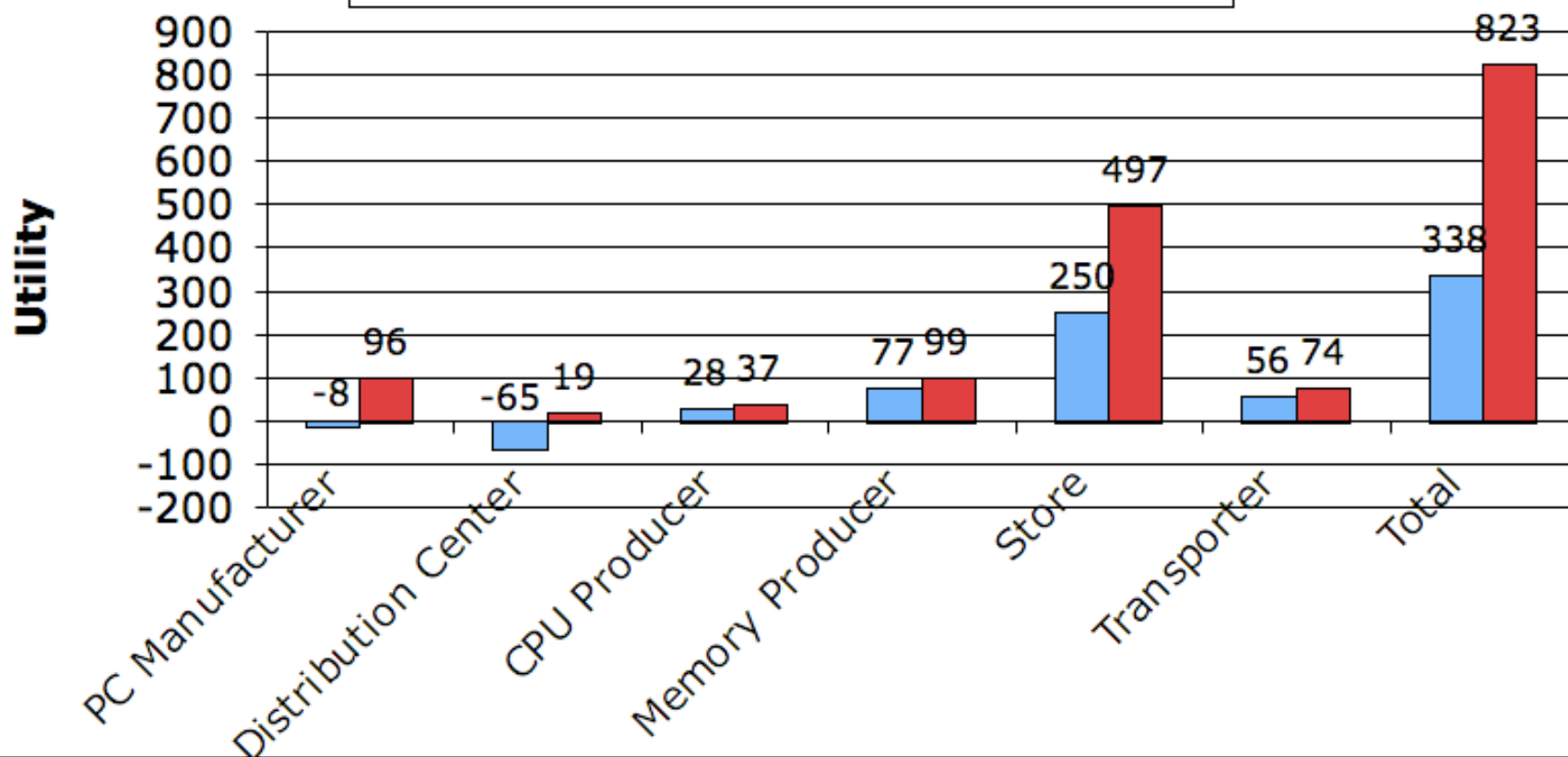
```
if( $P_{noConflict} > 0.99$ ) // no other competing task  
     $c = C_{large} - negCount$   
else // competing task exists  
     $c = C_{small}$ 
```

$$p_{bs}(v) = \min(1.0, P_{noConflict}(v) * (\pi/2) / (\arctan(f(v)) + c))$$

Different Flexibility Policies

fixed-flex

meta-info-flex





Negotiation duration and deadline

- Meta-info-deadline policy

```
if(negCount(v) >= 3) // more additional nego-  
tiation needed
```

```
     $\delta(v) = (\textit{negCount}(v) - 1) * \textit{basic\_neg\_cycle}$ 
```

```
else if(negCount(v) > 0) // one or two addi-  
tional negotiations needed
```

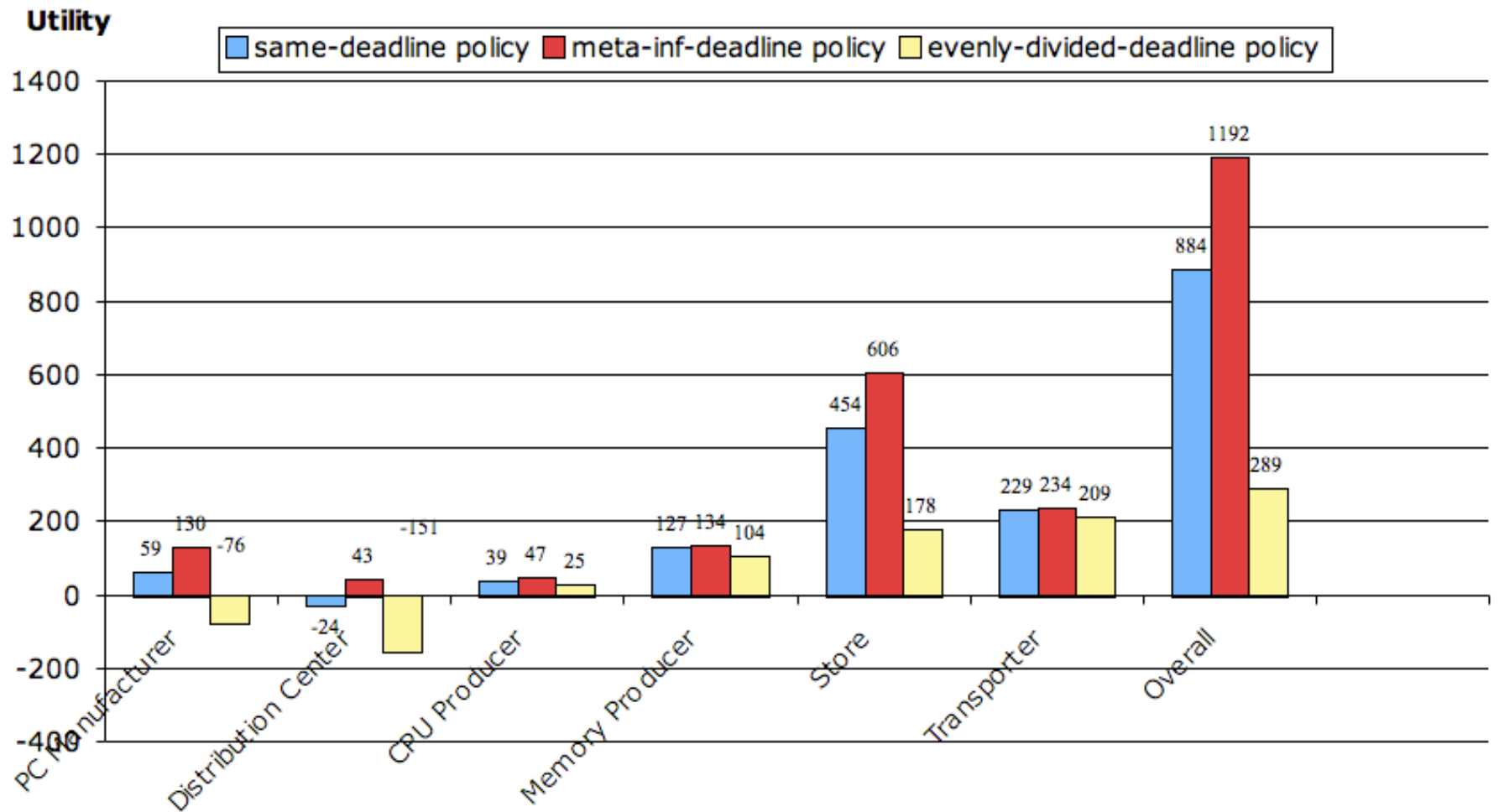
```
     $\delta(v) = 2 * \textit{basic\_neg\_cycle}$ 
```

```
else //no additional negotiation
```

```
     $\delta(v) = \textit{basic\_neg\_cycle} + 1$ 
```

- Same deadline
- Evenly-divided-deadline

Different Negotiation Deadline Policies



How close to global optimal?

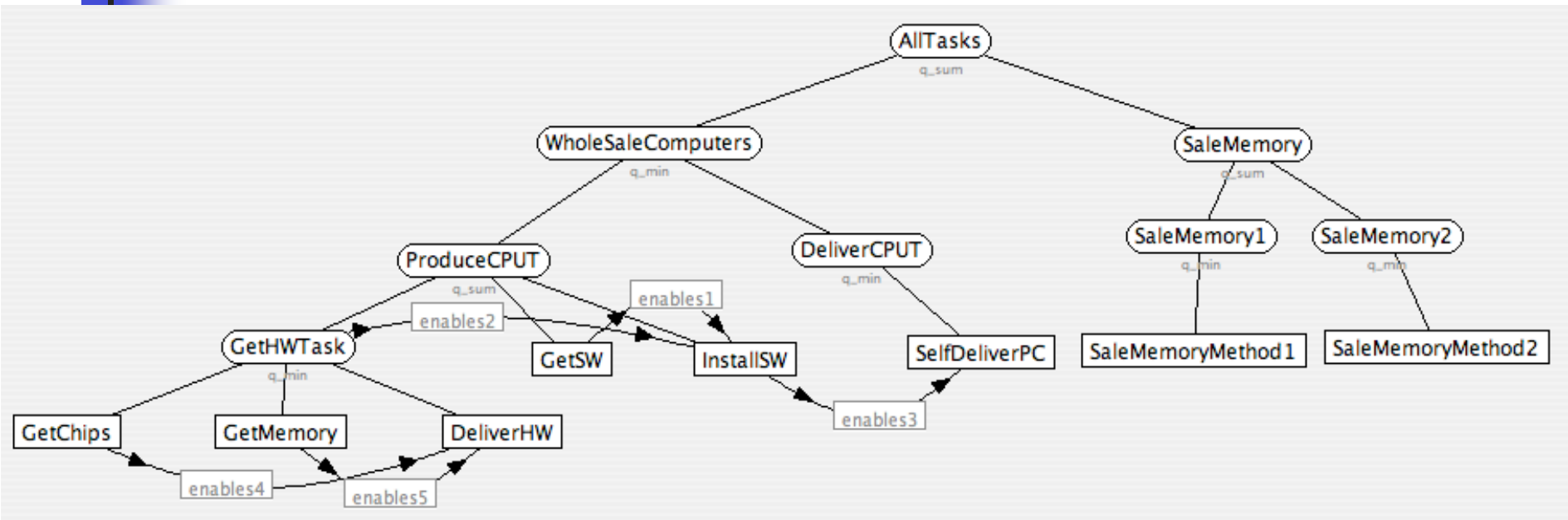


Table 3: Comparison With Centralized Approach

Centralized	fixed-flex	%	meta-info-flex	%		
1106	338	30.6 %	823	74.4 %		
Centralized	same-deadline	%	meta-info-deadline	%	evenly-divided-deadline	%
1308	884	67.6%	1192	91.1 %	289	22.1 %



How general is it?

- No decommitment penalty, no early reward?
- Cooperative system?
- uncertainty

Table 4: Detailed Comparison of Different Negotiation Policies

Policy	task received	task accepted	task cancelled	penalty paid	early reward	utility	w/o penalty	w/o early reward	w/o both
fixed-flex	123	109	90	144	189	338	482	149	293
meta-info-flex	123	103	16	24	370	823	847	453	477
same-deadline	220	148	40	92	319	884	976	565	657
evenly-divided-deadline	220	154	100	253	157	289	542	163	415
meta-info-deadline	220	141	13	15	436	1192	1206	755	770