Knowledge Representation Tools for Electronic Commerce

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P2P EC — what this talk is about?

Peer-to-Peer Electronic Commerce
Peer-to-Peer Electronic Commerce (P2P EC) — what this talk is about?

Offers (supplies) requests (demands) services meet in Electronic Marketplace + trusted third party
Peer-to-Peer Electronic Commerce

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meet in

⇒

Electronic Marketplace + trusted third party

Marketplace: mostly, Web Site with human interaction
Peer-to-Peer Electronic Commerce

- offers (supplies)
- requests (demands)
- services

meet in

Electronic Marketplace + trusted third party

Marketplace: mostly, Web Site with human interaction

Renowned example: eBay
http://www.ebay.com
Some figures

Did you ever tried to find . . .

a used Fiat Panda gasoline: 109 offers on www.automobili.com
Some figures

Did you ever tried to find . . .

- a used Fiat Panda gasoline: 109 offers on www.automobili.com
- a room to share in Rome: 851 offers on www.easystanza.com
Some figures

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- a used Fiat Panda gasoline: 109 offers on www.automobili.com
- a room to share in Rome: 851 offers on www.easystanza.com
- a used Notebook PC: 2361 offers on informatica.ebay.it
Some figures

Did you ever tried to find . . .

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...how did you choose?
Some figures

Did you ever tried to find . . .

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- a room to share in Rome: 851 offers on www.easystanza.com
- a used Notebook PC: 2361 offers on informatica.ebay.it

... which reasoning did you employed?
P2P is not B2C

B2C: Business-to-Consumer  P2P: Peer-to-Peer
P2P is not B2C

B2C: Business-to-Consumer
usually, the seller owns the Web Site

P2P: Peer-to-Peer
the Web Site is of some third party
P2P is not B2C

B2C: Business-to-Consumer
usually, the seller owns the Web Site
the seller publishes offers

P2P: Peer-to-Peer
the Web Site is of some third party
both parties can publish on the Web Site
P2P is not B2C

- **B2C**: Business-to-Consumer
  - usually, the seller owns the Web Site
  - the seller publishes offers
  - the client browses...

- **P2P**: Peer-to-Peer
  - the Web Site is of some third party
  - both parties can publish on the Web Site
  - *Both* parties may take initiative (and browse...)
Thesis of the talk — why CILC should care?
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Semantic Annotation is making Electronic Commerce an arena for Knowledge-based applications
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Knowledge Representation tools can be used in *Logic-based Electronic Commerce* applications.
Outline of the talk —how I will try to argue?

1. ✓ P2P Electronic Commerce
2. *Enabling technologies*
3. General assumptions
4. Reasoning for Matchmaking
5. Reasoning for Negotiation
6. Languages and expressivity
7. What next?
Semantic Annotation

“The Semantic Web is a vision for the future of the Web in which information is given explicit meaning, making it easier for machines to automatically process and integrate information available on the Web.”
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— OWL - Web Ontology Language Overview
Semantic Annotation

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— **OWL** - Web Ontology Language Overview

**DAML** - DARPA Agent Markup Language
“The Semantic Web is a vision for the future of the Web in which information is given explicit meaning, making it easier for machines to automatically process and integrate information available on the Web.”

— **OWL** - Web Ontology Language Overview

**DAML** - DARPA Agent Markup Language

Web Services can be described through languages like **DAML-S, OWL-S**, ...
"On-sale PCs are ... home PCs with at most one OS, of type WinX"

```xml
<owl:Class rdf:ID="onSalePC"/>
<owl:subClassOf>
  <owl:intersectionOf rdf:parseType="Collection">
    <owl:Class rdf:ID="homePC"/>
    <owl:Restriction>
      <owl:onProperty rdf:resource="hasOS"/>
      <owl:maxCardinality rdf:datatype="&xsd;nonNegativeInteger">1</owl:maxCardinality>
      <owl:allValuesFrom rdf:resource="#winX"/>
    </owl:Restriction>
  </owl:intersectionOf>
</owl:subClassOf>
</owl:Class>
```
"On-sale PCs are ... home PCs with at most one OS, of type WinX"

< owl:Class rdf:ID = "onSalePC" />
< rdfs: subClassOf >
  < owl:intersectionOf rdf:parseType = "Collection" >
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    < owl: Restriction >
      < owl:onProperty rdf:resource = "hasOS" />
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        1
      < /owl:maxCardinality >
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An Example in OWL — more precisely, OWL-Lite

"On-sale PCs are ... home PCs with at most one OS, of type WinX"

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General Assumptions

Based on Semantic Annotation, we assume that Offers, requests, services are logic formulas $O, R, S, \ldots$
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- The marketplace ontology is a \textit{logic theory} $\mathcal{T}$
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- Offers, requests, services are logic formulas $O, R, S, \ldots$
- The marketplace ontology is a logic theory $T$
- An agreement between $O$ and $R$ is either a...
General Assumptions

Based on Semantic Annotation, we assume that:

- Offers, requests, services are *logic formulas* $O, R, S, \ldots$
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General Assumptions

Based on Semantic Annotation, we assume that

- Offers, requests, services are *logic formulas* $O, R, S, \ldots$

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- an agreement betw. $O$ and $R$ is either a...
  - model of $\mathcal{T} \cup \{O, R\}$, or a...
  - set of models of $\mathcal{T} \cup \{O, R\}$, or a...
  - formula consistent with $\mathcal{T} \cup \{O, R\}$
Most of the talk — the past is the prologue

1. ✓ P2P Electronic Commerce
2. ✓ Enabling technologies
3. ✓ General assumptions
4. *Reasoning for Matchmaking*
5. Reasoning for Negotiation
6. Languages and expressivity
7. What next?
What’s Matchmaking?

First phase in a Bilateral Commercial Transaction:

1. *Matchmaking* (find counterpart)
2. Negotiation (agree/tradeoff details)
3. Exchange (goods, services, money)
An Example — a cognitive experiment

From *Sunday Times, online marketplace*

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- Offer: 2000/V FERRARI 360 Modena F1 Argento Nurburgring with Bordeaux Leather 22,700 £65,000 NE England
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Do they match?
An Example — a cognitive experiment

From *Sunday Times, online marketplace*


- Offer: 2000/V FERRARI 360 Modena F1 Argento Nurburgring with Bordeaux Leather 22,700 £65,000 NE England

*How well* they match? (compared to other offers/requests)
Aim: less browsing in P2P EC

Solution: move the reasoning methods from persons browsing ads into a *facilitator* system

—But: which reasoning?
Aim: less browsing in P2P EC

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*Compare* (possibly with deduction)
Aim: less browsing in P2P EC

Solution: move the reasoning methods from persons browsing ads into a facilitator system

—But: which reasoning?

- Compare (possibly with deduction)
- Posit missing information
Aim: less browsing in P2P EC

Solution: move the reasoning methods from persons browsing ads into a *facilitator* system

— But: which reasoning?

- *Compare* (possibly with deduction)
- *Posit* missing information
- *Revise* conflicting issues
A first classification based on \( \models \)

An offer \( O \) and a request \( R \) match...

\[ \text{exactly if } \mathcal{T} \models O \equiv R \]
An offer $O$ and a request $R$ match...

- **exactly** if $T \models O \equiv R$
- **potentially** if $T \not\models \neg(O \land R)$
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  - significant if only some details conflict
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- “plug-in” (w.r.t. $R$) if $\mathcal{T} \models R \Rightarrow O$
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- **“plug-in”** (w.r.t. $R$) if $\mathcal{T} \models R \Rightarrow O$
- **fully** (w.r.t. $R$) if $\mathcal{T} \models O \Rightarrow R$
Evaluating the match


Offer: 2000/V FERRARI 360 Modena F1 Argento Nurburgring with Bordeaux Leather 22,700 £65,000 NE England
Evaluating the match


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conflicting info: 430 vs. 360 (different models)
Evaluating the match

- Request: Ferrari 430 \textit{Coupe/Spider urgently required}. Best prices paid. Immediate decision.

- Offer: 2000/V FERRARI 360 Modena F1 Argento Nurburgring with Bordeaux Leather 22,700 £65,000 NE England

in $R$, not in $O$: \textit{Coupe/Spider, urgently required}
Evaluating the match


Offer: 2000/V FERRARI 360 Modena F1
Argento Nurburgring with Bordeaux Leather
22,700 £65,000 NE England

in $O$, not in $R$: color *Argento, Bordeaux Leather*
seats, 22,700 miles, ...
Abduction (history)

- C. S. Peirce (1839–1914)
- From $A \Rightarrow B$ and $B$, *abduce* $A$

Abduction was the first step of scientific reasoning, the other two being
  - Deduction
  - Induction

since Pople [1973] has been used to formalize Diagnosis in AI
Abduction for P2P EC

- Let $\mathcal{L}$ be a logic language
- $R$ a request in $\mathcal{L}$
- $O$ a possible offer for $R$ in $\mathcal{L}$
- $T$ be a domain ontology
Abduction for P2P EC

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find a hypothesis $H$ such that
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find a hypothesis $H$ such that

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$\mathcal{T} \models H \land O \Rightarrow R$
Intuition

When $R$ evaluates its possible transaction with $O$, before concluding the transaction, $R$ and $O$ should agree on $H$. 
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- When \( R \) evaluates its possible transaction with \( O \), before concluding the transaction, \( R \) and \( O \) should agree on \( H \).

- Will \( O \) accept \( H \)?
Intuition

- When $R$ evaluates its possible transaction with $O$, before concluding the transaction, $R$ and $O$ should agree on $H$.
- Will $O$ accept $H$?
- Vice versa for $O$, with a different $H'$ such that $T \models R \land H' \Rightarrow O$.
What Abduction is good for?

- compute a \textit{score} for each counteroffer
What Abduction is good for?

- compute a *score* for each counteroffer
- *e.g.*, number of hypotheses in best $H$
What Abduction is good for?

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  - *e.g.*, number of hypotheses in best $H$
  - *e.g.*, expected utility from $H$’s
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- compute a *score* for each counteroffer
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  - *e.g.*, expected utility from $H$’s
- construct an *explanation* for match suggestions
What Abduction is good for?

- compute a **score** for each counteroffer
  - *e.g.*, number of hypotheses in best $H$
  - *e.g.*, expected utility from $H$’s

- construct an **explanation** for match suggestions
  - *e.g.*, a facilitator that suggests “Offer 213 seems to be the best, supposing your requests \textit{color:blue} and \textit{Credit Card Payment} are satisfied”
Best hypotheses

Different criteria:

- shortest $H$ — fewer issues to be set
Best hypotheses

Different criteria:

- **shortest** $H$ — fewer issues to be set
- **maximally ignorant** $H$ — minimal consequences
Best hypotheses

Different criteria:

- *shortest* $H$ — fewer issues to be set
- *maximally ignorant* $H$ — minimal consequences
- language-specific
Best hypotheses

Different criteria:

- **shortest** $H$ — fewer issues to be set
- **maximally ignorant** $H$ — minimal consequences
- language-specific
  - *e.g.*, minimal conjunctions if $\lor, \neg \notin \mathcal{L}$
Comparing criteria

\( R = \text{FiatPanda} \land \text{radio} \land \text{fogLamps} \)
Comparing criteria

\[ R = \text{FiatPanda} \land \text{radio} \land \text{fogLamps} \]

\[ O = \text{FiatPanda} \land \text{year2000} \]
Comparing criteria

\[ R = \text{FiatPanda} \land \text{radio} \land \text{fogLamps} \]

\[ O = \text{FiatPanda} \land \text{year2000} \land \text{radio} \land \text{fogLamps} \]

radio \land \text{fogLamps} is a \textit{maximally ignorant} \ H
Comparing criteria

- \( R = \text{FiatPanda} \land \text{radio} \land \text{fogLamps} \)
- \( O = \text{FiatPanda} \land \text{year2000} \)
- radio \land \text{fogLamps} \text{ is a maximally ignorant } H
- \( T = \{ \text{bundleOffer} \Rightarrow \text{radio} \land \text{fogLamps} \land \text{alarm} \} \)
Comparing criteria

\[ R = \text{FiatPanda} \land \text{radio} \land \text{fogLamps} \]

\[ O = \text{FiatPanda} \land \text{year2000} \]

radio \land \text{fogLamps} is a \textit{maximally ignorant} H

\[ T = \{ \text{bundleOffer} \Rightarrow \text{radio} \land \text{fogLamps} \land \text{alarm} \} \]

\textit{bundleOffer} is a \textit{shortest} H
Comparing criteria

\[ R = \text{FiatPanda} \land \text{radio} \land \text{fogLamps} \]

\[ O = \text{FiatPanda} \land \text{year2000} \]

\[ \text{radio} \land \text{fogLamps} \text{ is a } \text{maximally ignorant} \]

\[ T = \{ \text{bundleOffer} \Rightarrow \text{radio} \land \text{fogLamps} \land \text{alarm} \} \]

\[ \text{bundleOffer is a } \text{shortest} \]

\[ \text{neither solution is in the other set.} \]
Intermezzo
Abduction could formalize reasoning on missing information for P2P EC
Abduction could formalize reasoning on missing information for P2P EC
what about conflicting information?
Belief Revision (history)

Gärdenfors [1988], among many others: Revise Knowledge $\mathcal{K}$ with new info $A$ by:

1. **contracting** $\mathcal{K}$ into $\mathcal{K}_{\neg A}$ such that $\mathcal{K}_{\neg A} \not\models \neg A$

2. **adding** $A$ to $\mathcal{K}_{\neg A}$

Intuition: contract the least
Let $\mathcal{L}$ be a logic language

$R$ a request in $\mathcal{L}$

$O$ a possible offer for $R$ in $\mathcal{L}$

$\mathcal{T}$ be a domain ontology
Contraction for P2P EC

- Let $\mathcal{L}$ be a logic language
- $R$ a request in $\mathcal{L}$
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- $\mathcal{T}$ be a domain ontology

find a pair $\langle G, K \rangle$ (Give up, Keep) such that
Contraction for P2P EC

- Let $\mathcal{L}$ be a logic language
- $R$ a request in $\mathcal{L}$
- $O$ a possible offer for $R$ in $\mathcal{L}$
- $T$ be a domain ontology

find a pair $\langle G, K \rangle$ (Give up, Keep) such that
- $T \models R \equiv G \land K$
Contraction for P2P EC

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find a pair $\langle G, K \rangle$ (Give up, Keep) such that

- $\mathcal{T} \models R \equiv G \land K$
- $O \land K$ is satisfiable in $\mathcal{T}$
Contraction for P2P EC

Let $\mathcal{L}$ be a logic language

$R$ a request in $\mathcal{L}$

$O$ a possible offer for $R$ in $\mathcal{L}$

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find a pair $\langle G, K \rangle$ (Give up, Keep) such that

$\mathcal{T} \models R \equiv G \land K$

$O \land K$ is satisfiable in $\mathcal{T}$

$\langle G, K \rangle$ is a contraction of $R$ w.r.t. $O$
Best contractions

Different criteria:

- shortest $G$ — fewer issues to give up
Best contractions

Different criteria:

- *shortest* $G$ — fewer issues to give up
- *maximally ignorant* $G$ — minimal consequences
Best contractions

Different criteria:

- **shortest** $G$ — fewer issues to give up
- **maximally ignorant** $G$ — minimal consequences
- maximal knowledge for $K$
Example

\[ R = \text{flat} \land (\text{lift} \lor \text{firstFloor} \lor \text{secondFloor}) \]
Example

\[ R = flat \land (lift \lor firstFloor \lor secondFloor) \]

“I want a flat which either has the lift, or it is a low floor”
Example

$R = \text{flat} \land (\text{lift} \lor \text{firstFloor} \lor \text{secondFloor})$

"I want a flat which either has the lift, or it is a low floor"

$O = \text{firstFloor} \land \text{lastFloor} \land \text{garden}
Example

- $R = \text{flat} \land (\text{lift} \lor \text{firstFloor} \lor \text{secondFloor})$
  - “I want a flat which either has the lift, or it is a low floor”

- $O = \text{firstFloor} \land \text{lastFloor} \land \text{garden}$

- $T = \begin{cases} 
  \text{firstFloor} \land \text{lastFloor} \equiv \text{house} \\
  \text{flat} \equiv \neg \text{house} 
\end{cases}$
Example

\[ R = \text{flat} \land (\text{lift} \lor \text{firstFloor} \lor \text{secondFloor}) \]

“\text{I want a flat which either has the lift, or it is a low floor}”

\[ O = \text{firstFloor} \land \text{lastFloor} \land \text{garden} \]

\[ T = \left\{ \begin{array}{c}
\text{firstFloor} \land \text{lastFloor} \equiv \text{house} \\
\text{flat} \equiv \neg \text{house}
\end{array} \right\} \]

\[ G = \text{flat} \]
Example

\[ R = flat \land (\text{lift} \lor \text{firstFloor} \lor \text{secondFloor}) \]

“I want a flat which either has the lift, or it is a low floor”

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\text{flat} & \equiv \neg \text{house} 
\end{cases} \]

\[ G = \text{flat} \]

\[ K = \text{lift} \lor \text{firstFloor} \lor \text{secondFloor} \]
Logic-based ranking

suppose a buyer enters the marketplace with request $R$
Logic-based ranking

- suppose a buyer enters the marketplace with request $R$
- the facilitator ranks all offers $O_1, O_2, \ldots, O_n$ based on a pair of scores:
suppose a buyer enters the marketplace with request $R$

the facilitator ranks all offers $O_1, O_2, \ldots, O_n$ based on a pair of scores:

a score for a best contraction $\langle G, K \rangle$ of $R$ w.r.t. $O_i$
Logic-based ranking

- suppose a buyer enters the marketplace with request $R$
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  based on a pair of scores:
  - a score for a best contraction $\langle G, K \rangle$ of $R$ w.r.t. $O_i$
  - a score for a best abduction $H$ on $O$ w.r.t. $K$
suppose a buyer enters the marketplace with request $R$

the facilitator ranks all offers $O_1, O_2, \ldots, O_n$

based on a pair of scores:

- a score for a best contraction $\langle G, K \rangle$ of $R$
  w.r.t. $O_i$

- a score for a best abduction $H$ on $O$ w.r.t. $K$

- an explanation $G, K, H$ of the rank of each offer
Logic-based ranking

- suppose a buyer enters the marketplace with request $R$
- the facilitator ranks all offers $O_1, O_2, \ldots, O_n$ based on a pair of scores:
  - a score for a best contraction $\langle G, K \rangle$ of $R$ w.r.t. $O_i$
  - a score for a best abduction $H$ on $O$ w.r.t. $K$
  - an explanation $G, K, H$ of the rank of each offer $\leftarrow$ trust!
Variable-strength \textit{preferences} [Lukasiewicz & Schellhase KR-06]
Alternatives to Belief Revision

- Variable-strength preferences [Lukasiewicz & Schellhase KR-06]

- syntax: \((\alpha > \beta | \phi)[x]\)
Alternatives to Belief Revision

- Variable-strength preferences [Lukasiewicz & Schellhase KR-06]

- syntax: $\left( \alpha > \beta \mid \phi \right)[x]$

- formula $\alpha$ is preferred to formula $\beta$ in the context $\phi$ with weight $x \in \mathbb{N}$
Negotiation

Second phase in a Bilateral Commercial Transaction:

1. ✓ Matchmaking (find counterpart)
2. Negotiation (agree/tradeoff details)
3. Exchange (goods, services, money)
Logic-based negotiation

- each agent puts utilities on formulas

\[
\begin{align*}
U_R(price2000) &= 2 \\
U_R(1YearGuarantee) &= 15
\end{align*}
\]
Logic-based negotiation

- each agent puts utilities on formulas
  \[ U_R(price2000) = 2 \]
  \[ U_R(1YearGuarantee) = 15 \]

- some formulas are strict requirements
e.g., FiatPanda
Logic-based negotiation

- each agent puts utilities on formulas
  
  \[ \begin{align*}
  U_R(\text{price2000}) &= 2 \\
  U_R(\text{1YearGuarantee}) &= 15
  \end{align*} \]

- some formulas are strict requirements
  \[ \text{e.g., FiatPanda} \]

- additive utilities
  
  \[ U_R(\text{price2000} \land \text{1YearGuarantee}) = 2 + 15 \]
Example: buyer

Utilities for $R$:

<table>
<thead>
<tr>
<th>formula</th>
<th>$U_R(\cdot)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>FiatPanda</td>
<td>strict</td>
</tr>
<tr>
<td>$fogLamps \land radio$</td>
<td>strict</td>
</tr>
<tr>
<td>price2000</td>
<td>2</td>
</tr>
<tr>
<td>price1000</td>
<td>5</td>
</tr>
<tr>
<td>1YearGuarantee</td>
<td>15</td>
</tr>
</tbody>
</table>
Example: seller

Utilities for $O$:

<table>
<thead>
<tr>
<th>formula</th>
<th>$U_O(\cdot)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>FiatPanda</td>
<td>strict</td>
</tr>
<tr>
<td>$1\text{YearGuarantee} \Rightarrow price2000$</td>
<td>strict</td>
</tr>
<tr>
<td>$price2000$</td>
<td>10</td>
</tr>
<tr>
<td>$price1000$</td>
<td>2</td>
</tr>
</tbody>
</table>
Agreements as models

Utilities $U_O(m), U_R(m)$ of a model $m$ of $\mathcal{T}$
Agreements as models

utilities $U_O(m), U_R(m)$ of a model $m$ of $\mathcal{T}$

$= \sum$ utilities of satisfied formulas in $m$
Agreements as models

utilities $U_O(m), U_R(m)$ of a model $m$ of $\mathcal{T}$

search for optimal agreements:
Agreements as models

- utilities $U_O(m), U_R(m)$ of a model $m$ of $\mathcal{T}$
- $\sum$ utilities of satisfied formulas in $m$

search for optimal agreements:

max-sum: $\max_m \{U_O(m) + U_R(m)\}$
(welfare)
Agreements as models

- utilities $U_O(m), U_R(m)$ of a model $m$ of $T$

  - $= \sum$ utilities of satisfied formulas in $m$

- search for optimal agreements:
  - max-sum: $\max_m \{U_O(m) + U_R(m)\}$ (welfare)
  - max-product: $\max_m \{U_O(m) \cdot U_R(m)\}$
Example, cntd.: agreement

<table>
<thead>
<tr>
<th>satisfied formulas</th>
<th>$R$</th>
<th>$O$</th>
</tr>
</thead>
<tbody>
<tr>
<td>FiatPanda</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>$\text{fogLamps} \land \text{radio}$</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>1YearGuarantee</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>price2000</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>1YearGuarantee $\Rightarrow$ price2000</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td><strong>total utilities</strong></td>
<td>17</td>
<td>10</td>
</tr>
</tbody>
</table>
Preliminary results — see next ECAI-06

- Integer Linear Programming can be used, also for max-product
Preliminary results — see next ECAI-06

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- any other methods provably better?
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- No: finding an optimal agreement is NPO-complete
Preliminary results — see next ECAI-06

- Integer Linear Programming can be used, also for max-product
- any other methods provably better?
- No: finding an optimal agreement is NPO-complete
  tailored approximation algorithms unlikely to exist, unless APX = NPO
Rest of the talk — do you need a coffee?

1. ✓ P2P Electronic Commerce
2. ✓ Enabling technologies
3. ✓ General assumptions
4. ✓ Reasoning for Matchmaking
5. ✓ Reasoning for Negotiation
6. *Languages and expressivity*
7. What next?
Which language for P2P EC?

Propositional
Which language for P2P EC?

- Propositional
  - useful only for theoretical purposes
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- Propositional
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- Description Logics (DLs)
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  - useful only for theoretical purposes
- Description Logics (DLs)
  - OWL-DL *is* a DL
Which language for P2P EC?

- Propositional: useful only for theoretical purposes
- Description Logics (DLs): OWL-DL is a DL
- many papers already
Which language for P2P EC?

- Propositional
  - useful only for theoretical purposes
- Description Logics (DLs)
  - OWL-DL *is* a DL
  - many papers already
- why not Logic Programming?
Example, revisited  — just an idea

\[ R = \text{FiatPanda}, \text{radio}, \text{fogLamps} \]

\[ O = \text{FiatPanda}, \text{year2000} \]

\[ T = \begin{align*}
\text{radio} & :\leftarrow \text{bundleOffer}.
\text{fogLamps} & :\leftarrow \text{bundleOffer}.
\text{alarm} & :\leftarrow \text{bundleOffer}.
\end{align*} \]

\[ R \text{ can be derived from } T \cup \{O\} \text{ if } \text{bundleOffer is abducible} \]
$O, R$: conjunctions of atoms
$O$, $R$: conjunctions of atoms
$\mathcal{T}$: a logic program
\( O, R \): conjunctions of atoms

\( T \): a logic program

Find a set of abducibles \( H \) such that

\[
T \cup \{O\} \cup H \vdash R
\]
$O$, $R$: conjunctions of atoms
$\mathcal{T}$: a logic program
Find a set of abducibles $H$ such that
$\mathcal{T} \cup \{O\} \cup H \vdash R$
+ representation & programming in one language
$O$, $R$: conjunctions of atoms

$\mathcal{T}$: a logic program

Find a set of abducibles $H$ such that $\mathcal{T} \cup \{O\} \cup H \vdash R$

+ representation & programming in one language

+ enabling technologies exist (RuleML)
$O, R$: conjunctions of atoms

$\mathcal{T}$: a logic program

Find a set of abducibles $H$ such that $\mathcal{T} \cup \{O\} \cup H \vdash R$

+ representation & programming in \textit{one} language

− limited expressivity

agents carry both an offer and a request
Future issues

- agents carry both an offer and a request
- “Award-winner chinese calligrapher seeks flat in London” — Sunday Times, August 2002
Future issues

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- Dating services
- specialized comparisons *e.g.*, price, color, delivery time
- epistemic statements
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“Award-winner chinese calligrapher seeks flat in London” — Sunday Times, August 2002

Dating services

e.g., price, color, delivery time

epistemic statements

“Best prices paid”
Future issues

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- Dating services
  - e.g., price, color, delivery time
- epistemic statements
  - “Best prices paid”
  - “smokers allowed”
Acknowledgements

All people at SisInfLab, Politecnico di Bari
But especially...

- Eugenio Di Sciascio
- Tommaso Di Noia
- Simona Colucci
- Azzurra Ragone
- ... among many others
An invitation — among many other conferences

- next *ACM Symposium on Applied Computing* (SAC-2007)
- track on Semantic-based Resource Discovery, Retrieval & Composition (SDRC)
- papers welcome!