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# **Policies for Autonomy in Open Distributed Systems**



**Global InfoTek, Inc.**

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# Are policies a panacea?

# Are policies a panacea?

no



**IMHO**

**There are  
no panaceas**



**IMHO**

Except,  
maybe,

...



**IMHO\***

# the semantic web

*\*Disclaimer: this is MHO when  
I'm in one of my expansive moods.*

# Summary

- **Declarative policies** are useful for constraining autonomous behavior in open, distributed systems
- This enables **more autonomy**
- The **Rei** policy language and associate tools have provided a good base
- **Semantic web** languages (e.g., OWL) used, grounding descriptions in sharable, semantically rich, machine understandable ontologies
- We're evaluating and exploring the utility of policies through prototype **applications**
- In one, **Topsail**, policies guide agents to help form, operate and maintain teams of people.

# Policies for Autonomy

- Policies are rules of optimal behavior
  - Optimal? Policies are normative and describe what *should* be done in an ideal world.
- Policies provide high-level control of entities in the environment
  - Entities? These can be programs, services, agents, devices and people
- Using policies reduces the need to modify code in order to change systems' behavior
  - So? We assume modifying policies will be easier than modifying Java.



# Our Approach

- Declarative policies guide the behavior of entities in open, distributed environments
  - Positive and negative authorizations & obligations
  - Focused on domain actions
  - Policies are based on attributes of the action (and its actor and target) and the general context – not just on their *identity* of the actor
- Policies are applied at different levels
  - From OS and networking to applications

# Our Approach

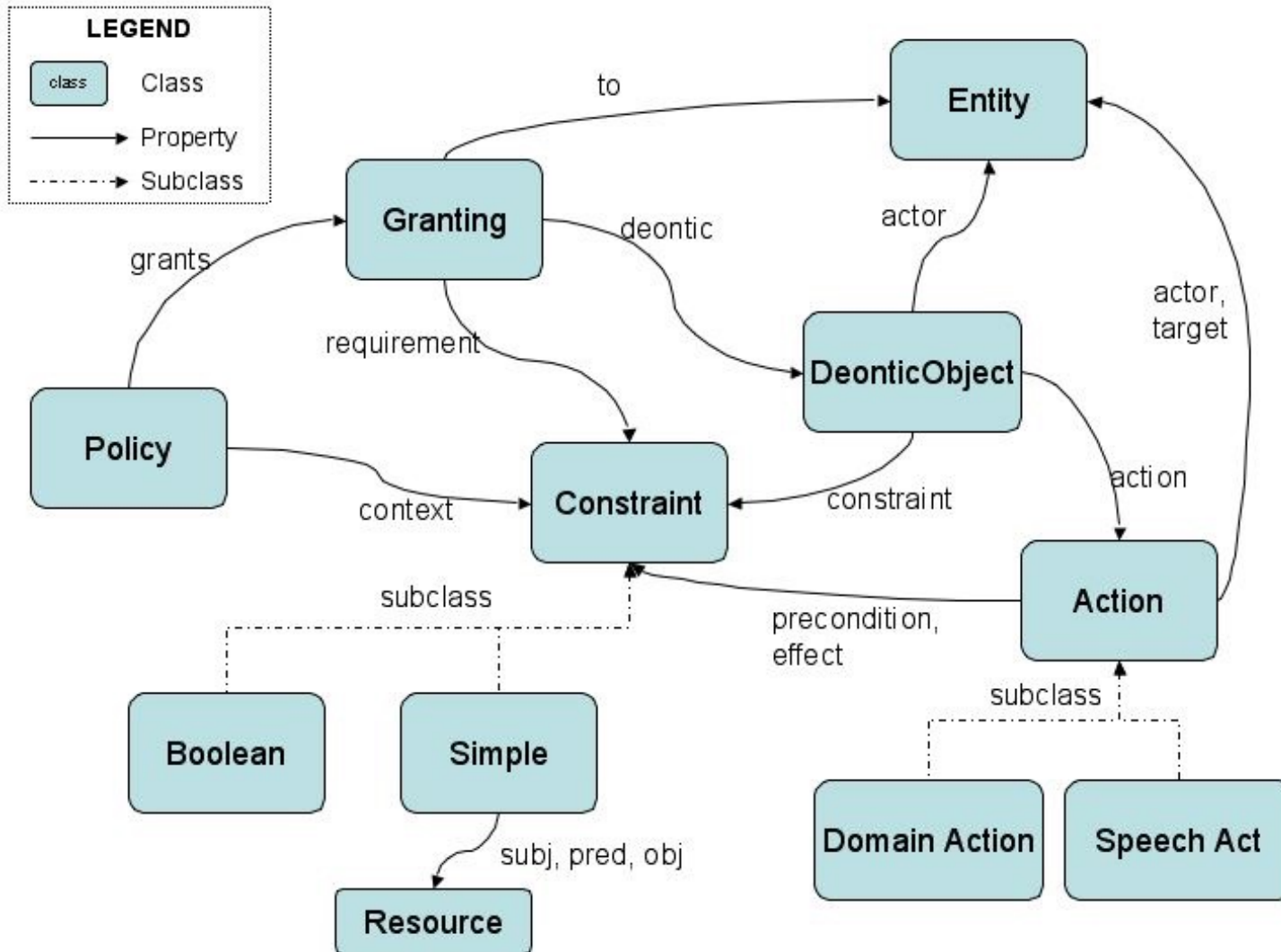
- Developed several versions of Rei, a policy specification language, encoded in (1) Prolog, (2) RDFS, (3) OWL
- Used to model different kinds of policies
  - Authorization for services
  - Privacy in pervasive computing and the web
  - Conversations between agents
  - Team formation, collaboration and maintenance
- Policies and attributes described in the web ontology language OWL

# Rei Policy Language

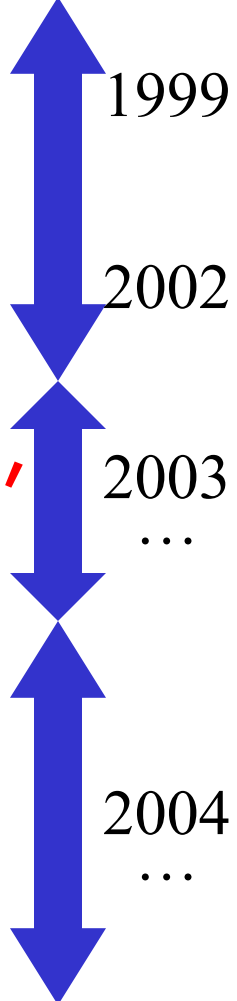
- Rei is a declarative policy language for describing policies over actions
- Reasons over domain dependent information
- Currently represented in OWL + logical variables
- Based on deontic concepts
  - Permission, Prohibition, Obligation, Dispensation
- Models speech acts
  - Delegation, Revocation, Request, Cancel
- Meta policies
  - Priority, modality preference
- Policy tools
  - Reasoner, IDE for Rei policies (Eclipse), ...

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# Rei Specifications (partial)



# Applications – past, present & future

- Coordinating access in *supply chain management system*
  - Authorization policies in a *pervasive computing environment*
  - **Policies for team formation, collaboration, information flow in *multi-agent systems***
  - Security in *semantic web services*
  - Privacy and trust on the *Internet*
  - Privacy in a *pervasive computing environment*
- 



# pervasive computing

# Authorization policies in pervasive computing environments



# Problems

- Highly distributed, open and dynamic
- Users and resources are neither pre-determined nor permanent
- No central repository or control



# Authorization policies

- Every entity describes its own authorization policy that defines security requirements for its access
  - E.g.. The grad fax machine states that only UMBC graduate students can send faxes
- No central policy or control
- Authorization is formulated as verifying that the credentials of the requesting user meet the requirements of the requested object

# Meeting Room Example



Client's Meeting Room

John wants to use the printer in the meeting room



John, Consultant

(John Requests to use printer)  
Signed with private key + credential from John's office saying he is a consultant

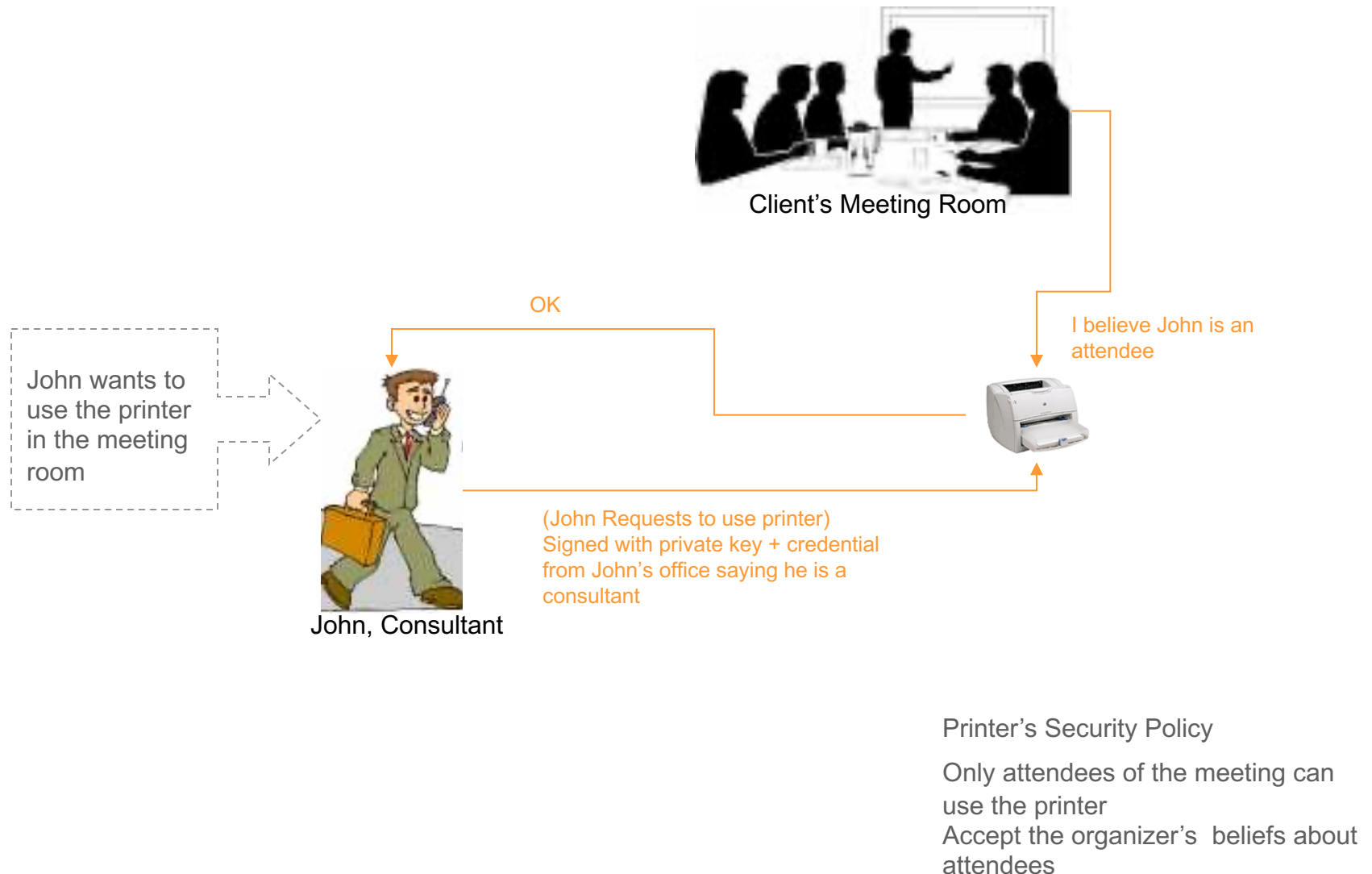


What are your beliefs about John

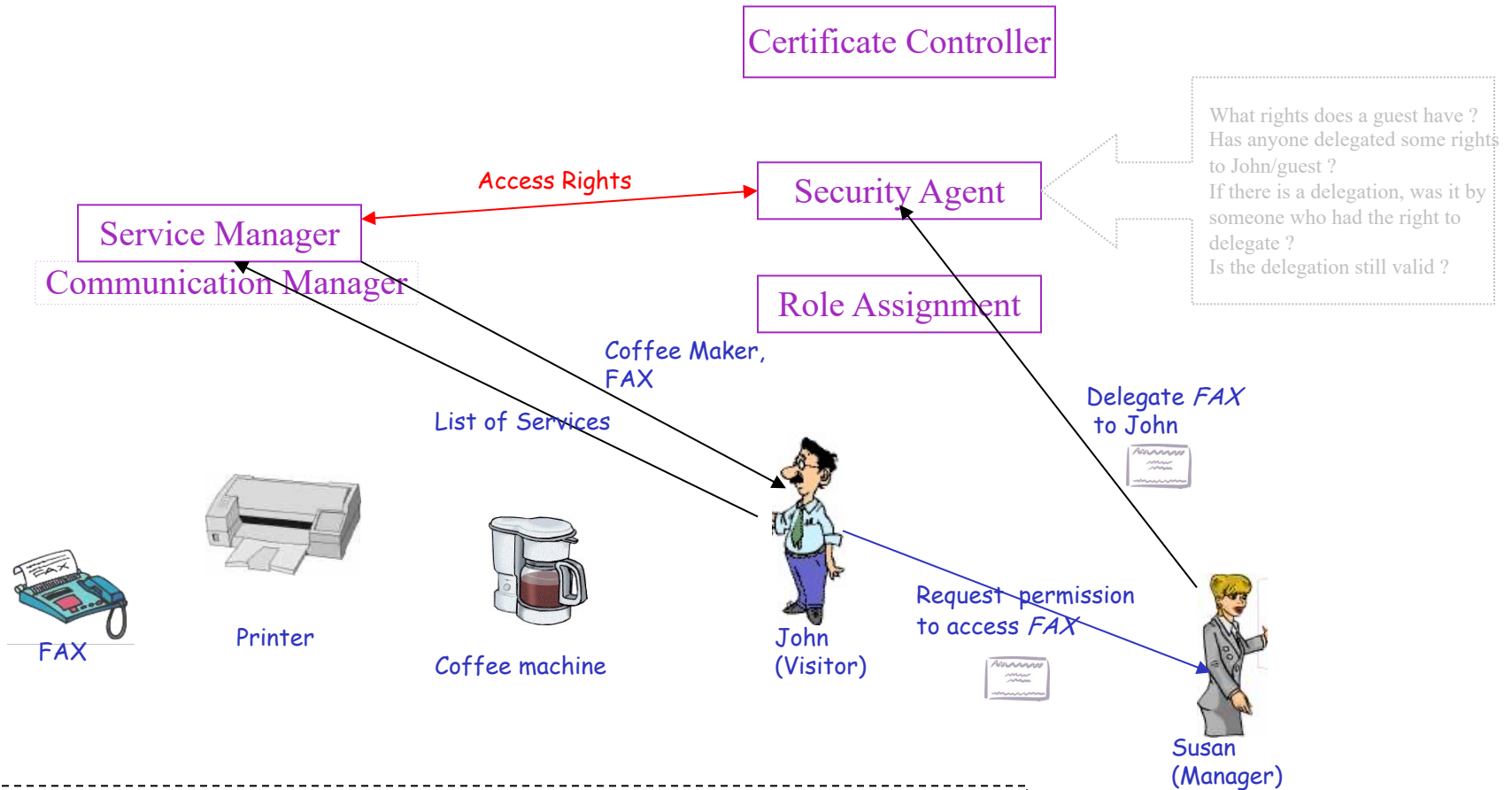
Printer's Security Policy

Only attendees of the meeting can use the printer  
Accept the organizer's beliefs about attendees

# Meeting Room Example



# Delegation Example



```
has(Person, right(delegate(right(use-fax, [])), [role(Person, abc, manager)]))
```

Simplified Rule for delegation :

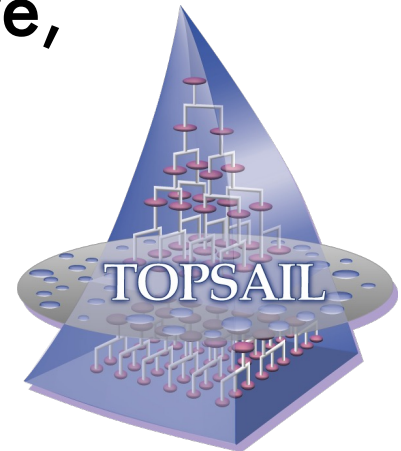
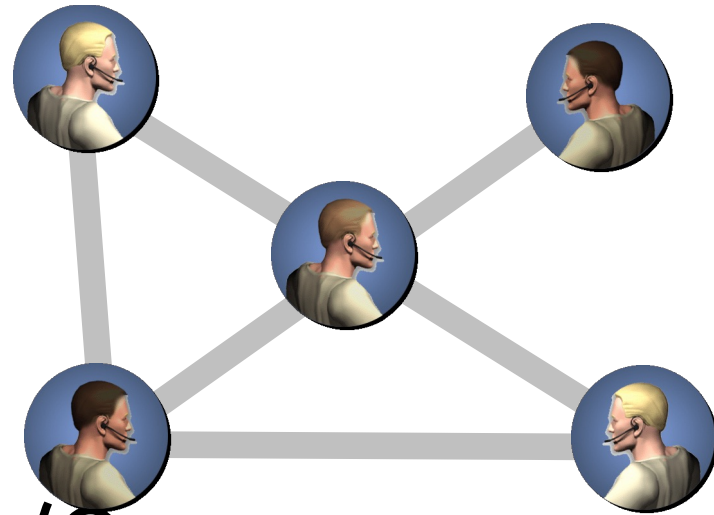
```
has(Person, Right) :- delegate(From, Person, Right), has(From, right(delegate(Right))).
```



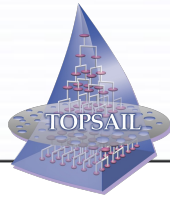
# human collaboration

# Enhancing collaboration in human teams

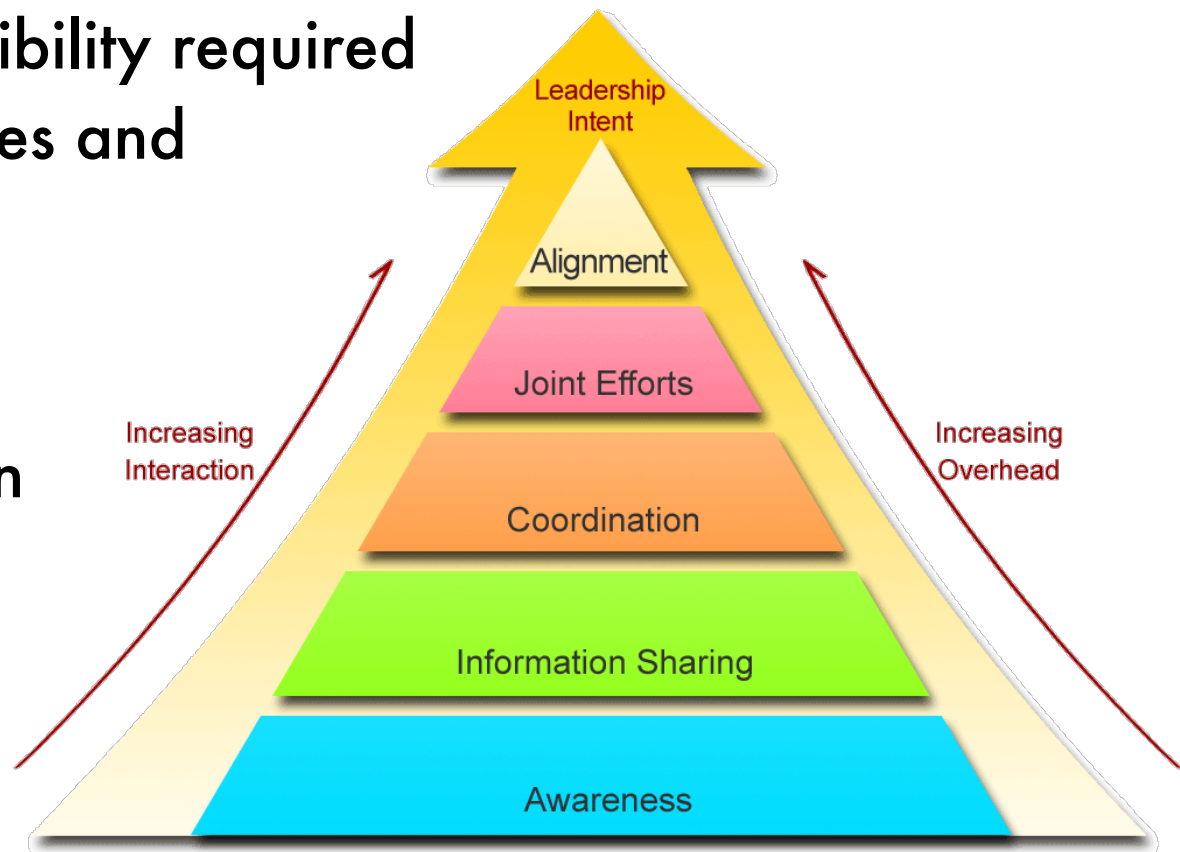
- **Objective:** facilitate collaboration in inter-agency teams
- **Scenario:** collaboration on an inter-agency team formed in face of a crisis
- **Approach:** augment conventional collaboration tools (Groove, email, workflow) with agents to assist in team formation, team maintenance, information flow, workflow, ...
- **Lead:** Global Infotek Inc. for DoD



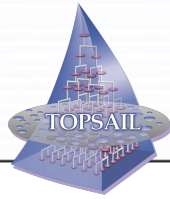
# Motivation and Problems



- **Motivation:** Technology to increase collaboration effectiveness
- Large amount of flexibility required
- Heterogeneous entities and networks
- Each agency has its own policy
- Teams have their own policy and priority
- Possibility of policy conflict is high



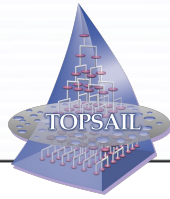
# Research components



- Enhancing conventional collaboration tools with **software agents**
- Exploring the use of declarative **policies** to constrain and guide system components
- Using **social network analysis** to model and understand human team structure and roles
- Acquiring **user and team models** automatically by instrumenting coordination tools (e.g., groove, email) and employing 'smart badges'



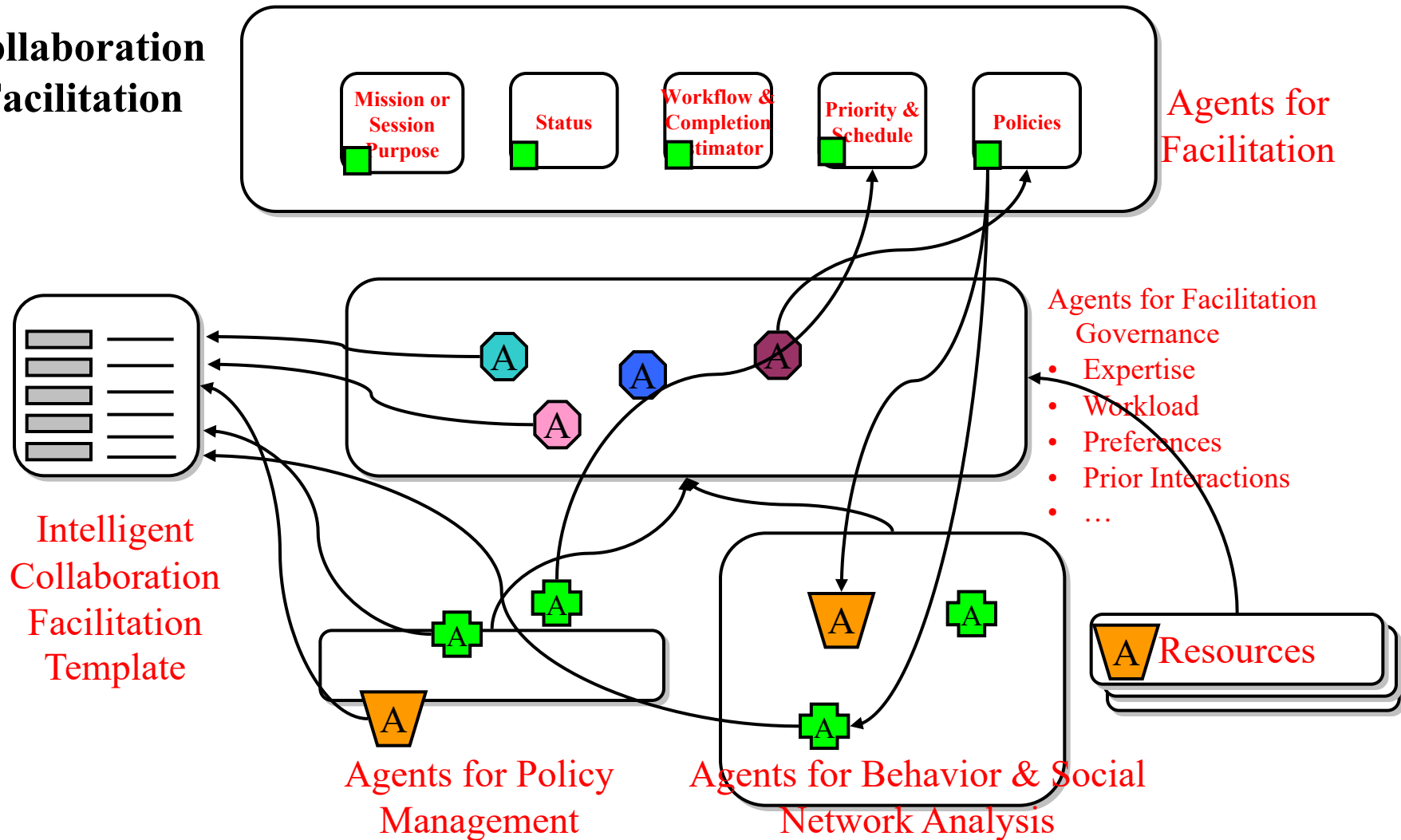
# Example: Team Support



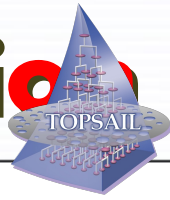
- A team is characterized by
  - Crisis type
    - Defines the skill set required for the team members, the number of team members required, etc.
  - Length of activity
  - Priority
- Actions involved
  - Team Formation
  - Collaboration support
  - Information flow monitoring and control
  - Workflow monitoring and management
  - ...

# Agent-enabled collaboration tools

## Collaboration Facilitation

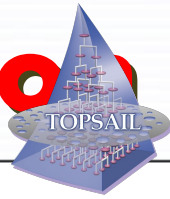


# Role of policies in Team Formation



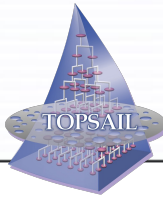
- Includes **finding leader** and **choosing members**
- Policy constrains who can be a team leader in terms of attributes of leader (experience, technical skills, ...) and team (e.g., objective, size, budget, length, ...)
- Modeled as negative and positive *authorization* policies
  - Eg: CIA staff with >5 years of experience and biowarfare knowledge are **permitted** to form a team of length of 6 months to deal with a crisis involving bioweapons
- Team members are specified in the same way
  - Policy constrains that sets of individuals that are a valid team via permissions and prohibitions
  - Leader queries policy management system for help in assembling a valid team and subsequent changes (e.g., replacing a member)

# Role of Policies in Collaboration



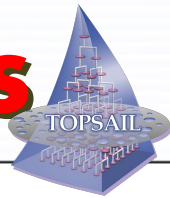
- This involves several tasks that a team member must do including reporting
- These tasks are modeled as *obligations* on the team member
  - All team members of team T **must** send weekly reports to the team leader
- The workflow component of the agent reasons over these obligations while deciding what to do next

# Role of Policies in Information Flow



- Constrain information exchangeable by team members based on importance, team priority, agencies involved, etc.
- These are modeled as permissions and prohibitions, e.g.:
  - Members of CIA and FBI are **prohibited** from exchanging information about X
  - Members of CIA and FBI are **permitted** to exchange information about X if they are on the same high-priority team that deals with X.
  - A **metapolicy** rule that team policy dominates agency policy resolves the conflict when a CIA member wants to send information about X to an FBI member.

# Discovering social networks

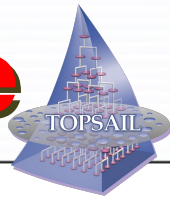


- We're working on discovering a team's social network structure using several techniques
- Custom smart badges record degree of face-to-face interactions between team members.
- Instrumentation of coordination tools (e.g., Outlook) record degree and quality of computer mediated interactions



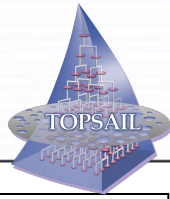
- v1 & v2 use IR to detect f2f neighbors.
- Designed to be low power and inexpensive (~\$10)
- v3, prototyped on PDAs, also detect user's talking
- Correlating badge info yields conversational model

# Social Network Perspective



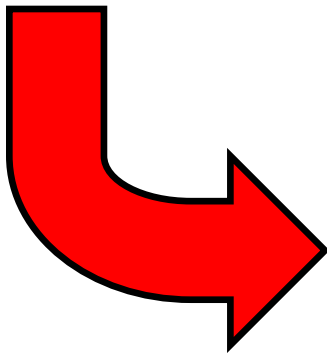
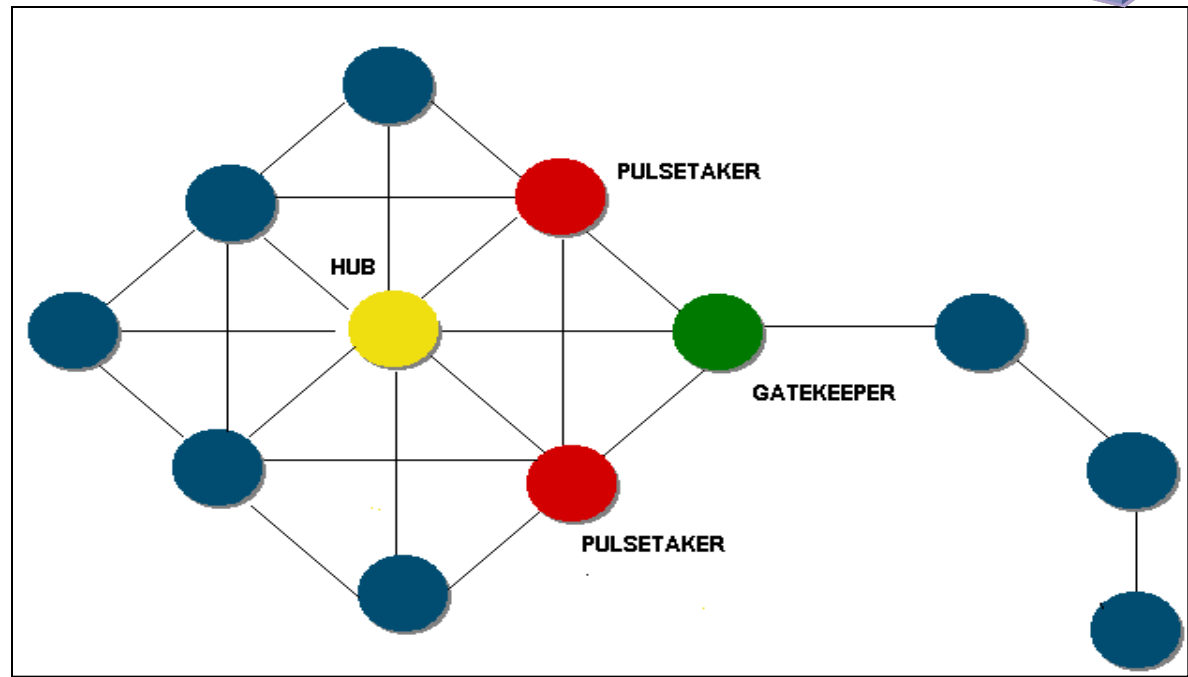
- The **reach** of an individual or team in an organization is constrained by personal influence, local networks and stovepipes.
- It constrains and limits the impact of collaborative problem solving.
- Untended or ignored networks may cut a swath through organizational silos to subsume, submerge and even *redirect* attempts to achieve innovation or change.
- Actively monitoring and nurturing network growth is critical.

# DNA of Social Networks



## Analyzing the network

- Social network analysis can identify individual's roles as
  - Hubs
  - Gatekeepers
  - Pulsetakers
- and recommend the need to introduce new ones.



## Tending the social network

- Add appropriate people to team based on their models (e.g., foaf, MBTI)
- or software agents can fill the gap





# selecting web services

# Security and Trust for Semantic Web Services

- Semantic web services are web services described using OWL-S
- Policy-based security infrastructure
- Why policies ?
  - Expressive – can be over descriptions of Requester, Service, and Context
  - Authorization
    - Rules for access control
  - Privacy
    - Rules for protecting information
  - Confidentiality
    - Cryptographic characteristics of information exchanged

Policies + Semantic  
Web Services



# Example policies

- **Authorization**
  - Policy 1: Stock service not accessible after market closes
  - Policy 2: Only LAIT lab members who are Ph.D. students can use the LAIT lab laser printer
- **Privacy/Confidentiality**
  - Policy 3: Do not disclose my my SSN
  - Policy 4: Do not disclose my home address or facts from which it could be easily discovered
  - Policy 5: Do not use a service that doesn't encrypt all input/output
  - Policy 6: Use only those services that required an SSN if it is encrypted

# Example

- Mary is looking for a reservation service
  - foaf description
  - Confidentiality policy
- BravoAir is a reservation service
  - OWL-S description
  - Authorization policy
    - Only users belonging to the same project as John can access the service

# Mary

```
<!-- Mary's FOAF description -->
<foaf:Person rdf:ID="mary">
  <foaf:name>Mary Smith</foaf:name>
  <foaf:title>Ms</foaf:title>
  <foaf:firstName>Mary</foaf:firstName>
  <foaf:surname>Smith</foaf:surname>
  <foaf:homepage
rdf:resource="http://www.somewebsite.com/marysmith.html"/>
  <foaf:currentProject rdf:resource=" http://www.somewebsite.com/SWS-
Project.rdf "/>

  <sws:policyEnforced rdf:resource="&mary;ConfidentialityPolicy"/>
</foaf:Person>

</rdf:RDF>
```

# Bravo Policy

```
<entity:Variable rdf:about="&bravo-policy;var1"/>
<entity:Variable rdf:about="&bravo-policy;var2"/>

<constraint:SimpleConstraint
  rdf:about="&bravo-policy;GetJohnProject"
  constraint:subject="&john;John"
  constraint:predicate="&foaf;currentProject"
  constraint:object="&bravo-policy;var2"/>

<constraint:SimpleConstraint
  rdf:about="&bravo-policy;SameProjectAsJohn"
  constraint:subject="&bravo-policy;var1"
  constraint:predicate="&foaf;currentProject"
  constraint:object="&bravo-policy;var2"/>

<!-- constraints combined -->
<constraint:And rdf:about="&bravo-policy;AndCondition1"
  constraint:first="&bravo-policy;GetJohnProject"
  constraint:second="&bravo-policy;SameProjectAsJohn"/>
```

```
<deontic:Right rdf:about="&bravo-policy;AccessRight">
  <deontic:actor rdf:resource="&bravo-policy;var1"/>
  <deontic:action rdf:resource="&bravo-
service;BravoAir_ReservationAgent"/>
  <deontic:constraint rdf:resource="&bravo-
policy;AndCondition1"/>
</deontic:Right>
```

.....

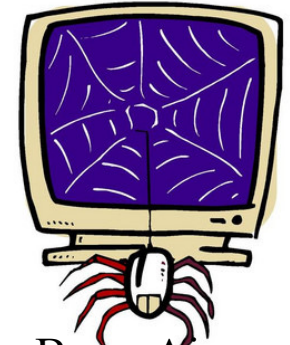
```
<rdf:Description rdf:about="&bravo-
service;BravoAir_ReservationAgent">
  <sws:policyEnforced rdf:resource="&bravo-
policy;AuthPolicy"/>
</rdf:Description>
```

# How it works



Mary

URL to foaf desc  
+ query request



BravoAir  
Web service



Matchmaker

+

Reasoner

`<sws:policyEnforced rdf:resource =  
"&bravo-policy;AuthPolicy"/>`

Bravo Service  
OWL-S Desc

# How it works

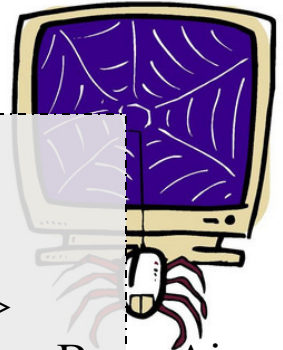


Mary

Mary's query = Bravo Service ? YES  
Extract Bravo's policy

```

<deontic:Right rdf:about="&bravo-policy;AccessRight">
  <deontic:constraint:SimpleConstraint
    rdf:about = "&bravo-policy;GetJohnProject"
    constraint:subject="&john;John"
    constraint:predicate="&foaf;currentProject"
    constraint:object="&bravo-policy;var2"/>
  </deontic:Right />
</deontic:Right />
<policy:Grant var2 = http://www.somewebsite.com/SWS-Project.rdf
  <policy:to rdf:resource="&bravo-policy;var1"/>
  <policy:constraint:foaf:currentProject rdf:resource =
  "http://www.somewebsite.com/SWS-Project.rdf"/>
</policy:Grant />
<sws:Authenticated
  <policy:constraint:SimpleConstraint
    rdf:about="&bravo-policy;SameProjectAsJohn"
    constraint:subject="&bravo-policy;var1"
    constraint:predicate="&foaf;currentProject"
    constraint:object="&bravo-policy;var2"/>
  </sws:Authenticated />
<rdf:Description
  <sws:Authenticated
  </sws:Authenticated />
</rdf:Description />
  Is the constraint true when
  var2 = http://www.somewebsite.com/SWS-Project.rdf
  var1 =
  http://www.cs.umbc.edu/~lkagal1/rei/examples/sws-
  sec/MaryProfile.rdf
  
```



BravoAir

Web service



# Status

- Policy compliance checking algorithms are implemented
- Ontologies for describing cryptographic characteristics of data
- Integration with OWL-S Matchmaker is part of our ongoing work



# privacy on the web

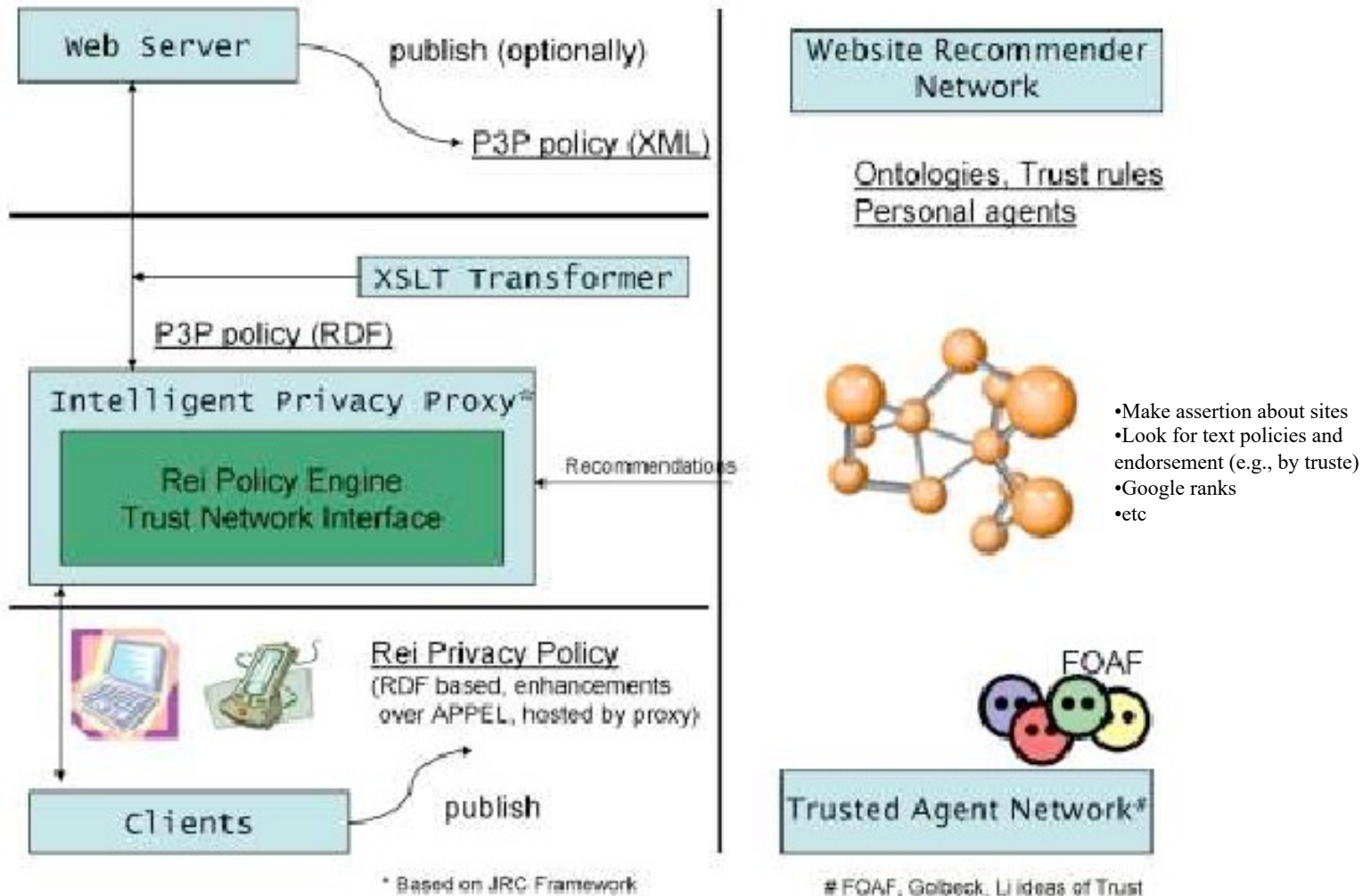
# Privacy and Trust on the Internet

- Current state of the art:
  - Server's privacy practices described and published using P3P, a W3C standard
  - Clients specify a privacy policy using any of several systems, e.g., APPEL, a W3C standard used to describe client's privacy preferences
  - Browser plugin (perhaps using a proxy) alert or prevent users from visiting sites violating their privacy policy.
- Problems
  - Neither P3P nor APPEL is very expressive
  - Not extensible
  - Client side preferences only enforced when website has a P3P policy, which almost none have

# Our Approach

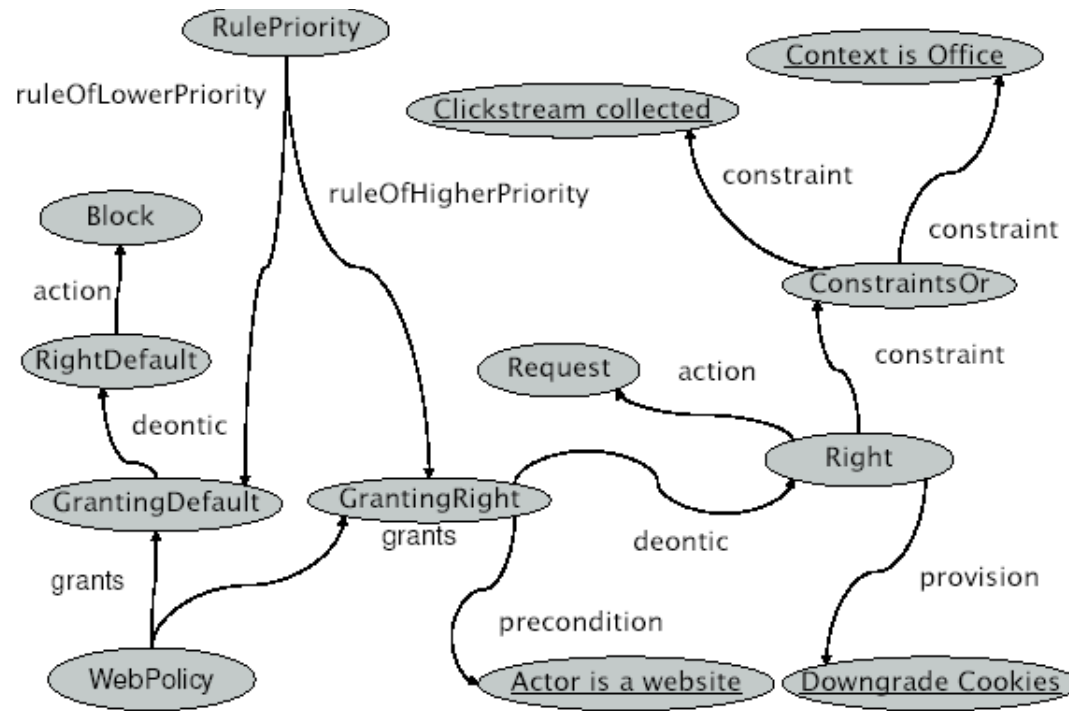
- Convert P3P into RDF (if not already in RDF)
- Model trust for website based on various attributes
- Use Rei to describe client-side privacy preferences over
  - P3P specs
  - Trust and other attributes of websites
  - Context of client

# Our Approach



# Example

- Don't access a site that collects *clickstream data* unless I'm using my office workstation.
- Assume a site collects clickstream data unless there is trusted evidence that it does not.





# summary

# Summary redux

- **Declarative policies** are useful for constraining autonomous behavior in open, distributed systems
- This enables **more autonomy**
- The **Rei** policy language and associate tools have provided a good base
- **Semantic web** languages (e.g., OWL) used, grounding descriptions in sharable, semantically rich, machine understandable ontologies
- We're evaluating and exploring the utility of policies through prototype **applications**
- In one, **Topsail**, policies guide agents to help form, operate and maintain teams of people.





**For more information**

<http://ebiquity.umbc.edu/>



# backup

# Related Research

- **WS-\***
  - Lack of semantic expressiveness and reasoning capabilities
    - Most approaches are based on XML.
    - E.G., XML signature/encryption, WS-security, SAML.
  - Restricted extensibility
    - Possible solution is ontological approach
- **Policy Languages**
  - XACML : OASIS eXtensible Access Control Markup Language
  - EPAL : IBM Enterprise Privacy Authorization Language
  - Ponder
  - KeyNote
  - KAoS : Knowledgeable Agent-oriented System