Norms as a Basis for Governing Sociotechnical Systems
IJCAI Journal Track Presentation

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A Sociotechnical System (STS) is a Microsociety

Traditional view: A “system” is an artifact, e.g., a computer
STS Setting: Collaboration in the Internet of Things
Each agent represents an autonomous party, contains a reasoner; interact within Org

Diagram:
- User Interface
- Knowledge Base
- Agent
- Stream Processing
- Adapter & Thing
- Org
- User Interface
- Knowledge Base
- Agent
- Stream Processing
- Adapter & Thing

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STS Setting: Participants and Artifacts in Security

Greatest challenges arise in the upper two; most past effort is on technical architecture.

Stakeholders
- Promulgation
- Participation
- Development Administration

Social Architecture

Adversaries
- Subversion
- Deception
- Intrusion

Users

Technical Architecture

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Internet of Oceans: Global Hybrid Profile Mooring Launch
Internet of Oceans: Glider Being Launched
Schema for IoT Resource Sharing: Four Protocols

What are the normative requirements or meanings behind these protocols?

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Resource Contribution

contributionID

Owner
mcID

User
mcID

Resource Negotiation

UsageID

Resource

rID

Resource Discovery

episodeID

Resource

rID

Member

mID

Community Membership

mID

Community

mID

Moderator

modID
Governance Challenges: Autonomy and Dynamism
Capturing norms is essential to addressing these challenges

- Support *configurational adaptation*, for example
  - Resource sharing: Offer ocean instrument for sharing
  - Affiliation: Add new laboratories
  - Sanction: Allow external sharing of results to fulfill deliverables

- Support *operational adaptation*, for example
  - Resource sharing: Preempt low-priority users in case of oil spill
  - Affiliation: Forbid unilateral publishing of results
  - Sanction: Absolve researcher who reveals results to prevent public endangerment (extenuating circumstances)

- Research challenges
  - Abstractions to capture rules of encounter
  - Methods to design and analyze such abstractions
  - Methods to implement such abstractions
Governance

Current Practice
- Managerial
  - Regimented
  - Control focused
- Manual
  - Not scalable
  - Not maintainable
  - Error-prone
  - Hides rationales
Norm-Based
- Collaborative
- Regulated
- Communication focused
- Supports flexibility
- Scalable
- Adaptive
- Computational
- Main-tainable

Obstructs user needs

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Social Architecture for Governance of Secure Collaboration

Principals and Orgs

Role Façade

- **Liability**: imposes
- **Privilege**: grants
- **Qualification**: requires

Principal

- Internal Policy

Individual

- applies

Org

- plays
- includes

Role
Normative Relationships for Governance

Each norm type is a directed relationship: crucial for accountability

- **Org**
- **Norm**
- **Principal**
- **Antecedent**
- **Consequent**
- **Commit**
- **Authorize**
- **Prohibit**
- **Sanction**
- **Empower**

[Diagram showing the relationships and context]
Norms as façades

<table>
<thead>
<tr>
<th>Norm</th>
<th>Subject’s façade</th>
<th>Object’s façade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commitment</td>
<td>Liability</td>
<td>Privilege</td>
</tr>
<tr>
<td>Authorization</td>
<td>Privilege</td>
<td>Liability</td>
</tr>
<tr>
<td>Power</td>
<td>Privilege</td>
<td>Liability</td>
</tr>
<tr>
<td>Prohibition</td>
<td>Liability</td>
<td>Privilege</td>
</tr>
<tr>
<td>Sanction</td>
<td>Liability</td>
<td>Privilege</td>
</tr>
</tbody>
</table>
Life Cycle for Norms: 1
Using a variant of the UML state diagram notation

Norm

Terminated

- Null
- Satisfied
- Violated

create
terminate
suspend
reactivate

Active

- Conditional
- In Force
- Pending

antecedent
Life Cycle for Norms: 2
Substate of a terminated norm

<table>
<thead>
<tr>
<th>If terminated in</th>
<th>Then</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Com</td>
</tr>
<tr>
<td>false false</td>
<td>null</td>
</tr>
<tr>
<td>false true</td>
<td>sat</td>
</tr>
<tr>
<td>true false</td>
<td>vio</td>
</tr>
<tr>
<td>true true</td>
<td>sat</td>
</tr>
</tbody>
</table>
Governance and Policies: Two Kinds of Interaction

Conversations with autonomous parties; control over resources

Interaction: Conversation

Internal Policy

Principal

Principal Qua Self

Principal Qua Other

Communicative Act

Interaction: Control

determines

applies

considers

context

content

actor of

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Vocabulary for Governance and Policies
Attributes of principals, their relationships, resource states and capabilities

- **Action**: Eject, Admit, Contribute, Withdraw
- **Property**: Create, Delegate, Assign
- **Stative**: Inform, Request, Query
- **Organization**
- **Resource**
- **Communication**
- **Participation**
- **Registration**
- **Norm**
- **Operation**
- **Member Registrand Owns**
- **Capable In State**
- **Created Violated Satisfied**

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Norms for Governance
Challenges and Partial Recent Progress

- Fully declarative model of communication [AAMAS 2011, 2012]
- Storing and retrieving events to determine the state of a norm
  - Mapping commitments to relational algebra [AAAI 2015]
- Maintaining alignment of views despite decentralization
  - Communications to guarantee (eventual) alignment [AAMAS 2015]
  - TBD: maximizing partial or “quick” alignment
- Designing protocols and Org contexts for monitorability
  - Failure of compositionality of monitorability [IJCAI 2015]
  - Automatically close a context to ensure monitorability
- Designing protocols and Org for robustness and resilience
  - Typology of sanctions and sanctioning processes [Draft]
  - TBD: Formalization of normative robustness and resilience
  - TBD: Reasoning about sanctions for design of Orgs
- Design processes conducive to autonomy
  - Abstract formal model of a sociotechnical design process [RE 2014]
  - TBD: Methodologies
An Information Model and Commitment Specification

TakeCharge(tcID, nuID, phID, patID, tcThreshold) key tcID
CardiacEvent(ceID, nuID, phID, patID, ceMagnitude) key ceID
CPR(cprID, nuID, phID, patID, cprDuration) key cprID

commitment CardioCare nuID to phID
create TakeCharge
detach CardiacEvent [, TakeCharge + 180]
    where ceMagnitude >= tcThreshold
discharge CPR [, CardiacEvent + 5]

A Cardio Care commitment from a nurse to a physician is

- created upon Take Charge;
- detached if a CardiacEvent for this patient happens above the specified threshold within 180 minutes
  - Else the commitment expires
- discharged if CPR on this patient happens within five minutes of the Cardiac Event (else violated)
Generate Log Schema

CREATE TABLE TakeCharge (  
tcID VARCHAR(10), nuID VARCHAR(10), phID VARCHAR(10),  
patID VARCHAR(10), tcThreshold VARCHAR(10),  
stamp DATETIME,  
PRIMARY KEY(tcID)  
);

CREATE TABLE CardiacEvent (  
ceID VARCHAR(10), nuID VARCHAR(10), phID VARCHAR(10),  
patID VARCHAR(10), ceMagnitude VARCHAR(10),  
stamp DATETIME,  
PRIMARY KEY(ceID)  
);

CREATE TABLE CPR (  
cprID VARCHAR(10), nuID VARCHAR(10), phID VARCHAR(10),  
patID VARCHAR(10), cprDuration VARCHAR(10),  
stamp DATETIME,  
PRIMARY KEY(cprID)  
);
Generate Canonical Queries for Accountability Checking

In relational algebra (Jun Yang's notation)

Query for which Cardio Care commitments are detached
\[
\left( \left( \text{select}_{\{ \text{stamp} \geq \text{stamp38} \}} \left( \text{\text{TakeCharge}} \right) \right) \text{join} \left( \text{rename}_{\{ \text{ceID}, \text{nuID}, \text{phID}, \text{patID}, \text{ceMagnitude}, \text{stamp38} \}} \left( \left( \text{select}_{\{ \text{ceMagnitude} = \text{tcThreshold} \}} \left( \text{CardiacEvent} \right) \right) \right) \right) \right) \cup \left( \left( \text{select}_{\{ \text{stamp} \geq \text{stamp37} \}} \left( \left( \text{select}_{\{ \text{ceMagnitude} = \text{tcThreshold} \}} \left( \text{CardiacEvent} \right) \right) \text{join} \left( \text{rename}_{\{ \text{tcID}, \text{nuID}, \text{phID}, \text{patID}, \text{tcThreshold}, \text{stamp37} \}} \left( \text{\text{TakeCharge}} \right) \right) \right) \right) \right);
\]

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Opportunities for Research

- Taking AI and MAS into the real world
- Major applications areas
  - Internet of Things
  - Cybersecurity
  - Software and analytic organizations
- Numerous research challenges, centered on autonomy
  - Models of interaction, incorporating resilience
  - Strategic aspects, as in game theory
  - Machine learning of strategies
  - Human aspects of emotion and cognition regarding norms
  - Empirical validation of external validity of systems
  - Agent-based simulations of complex systems
Thanks and Plugs

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- Read and publish in
  - ACM Transactions on Internet Technology
  - IEEE Internet Computing

http://www.csc.ncsu.edu/faculty/mpsingh/