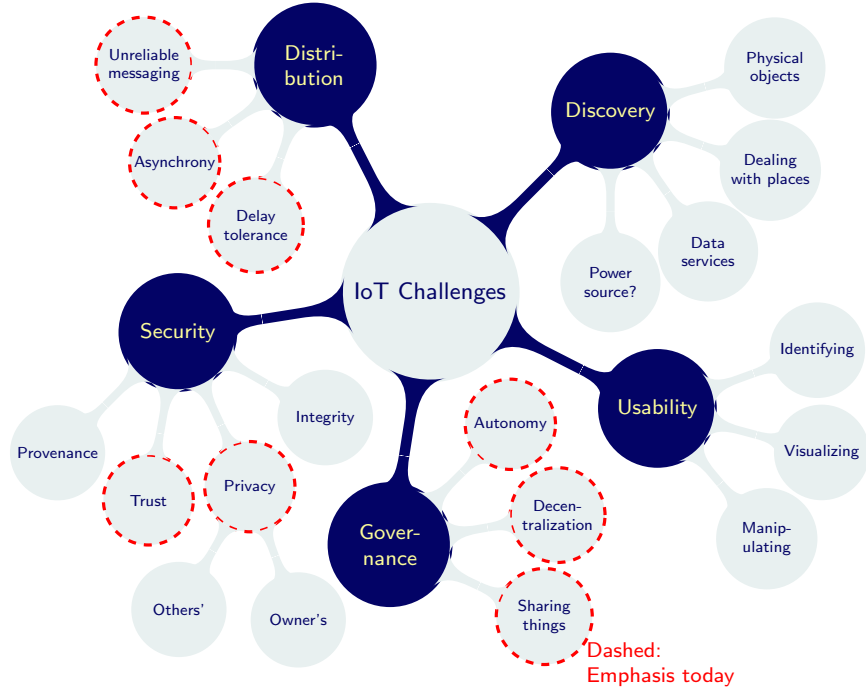


The Internet of Things and Multiagent Systems: Decentralized Intelligence in Distributed Computing

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Internet of Oceans: Global Hybrid Profile Mooring Launch

Resource sharing, here for scientific collaboration



© Tom Kleindinst, WHOI

Internet of Oceans: Glider Being Launched

Intelligence at the end points



© Craig Hayslip, Oregon State University

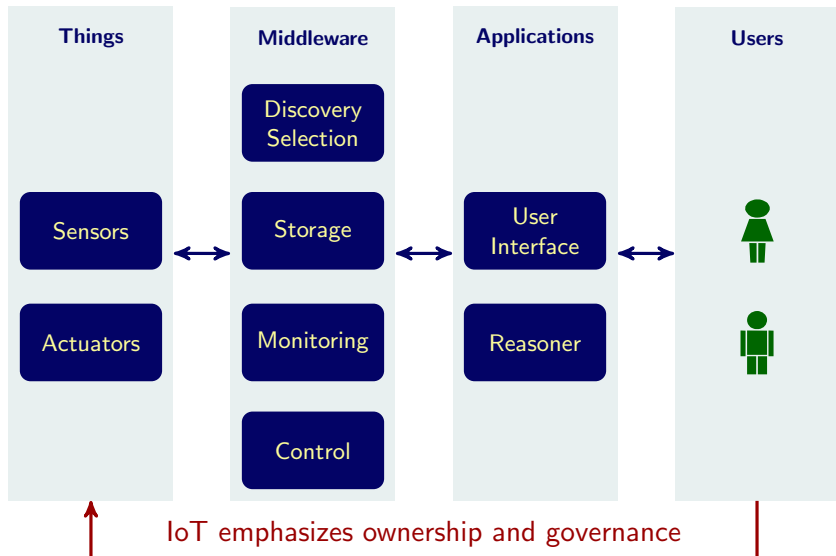
Vehicle Actuators

Remote configuration: Over the air modification of Tesla chassis elevation



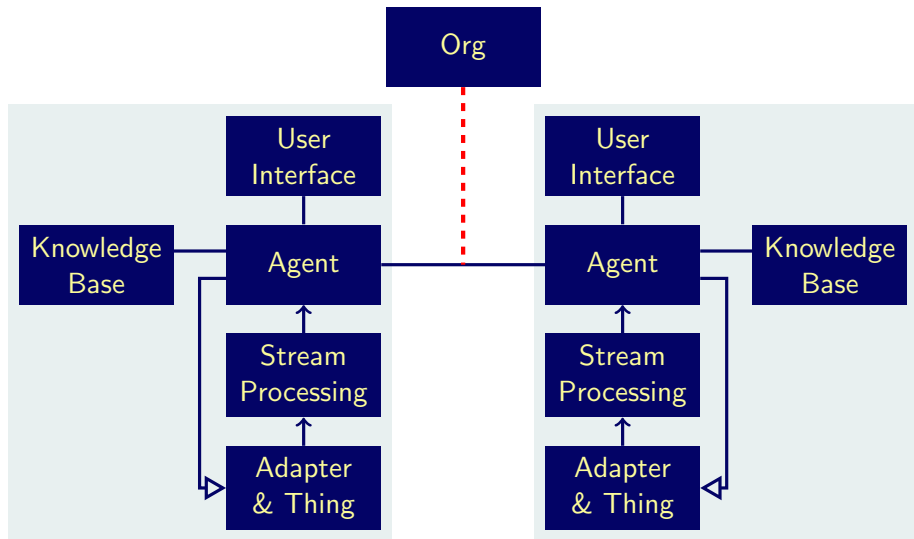
US Government Work
<https://www.flickr.com/photos/departmentofenergy/9522268517>

Main Architectural Elements



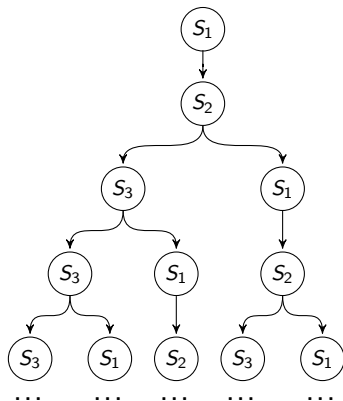
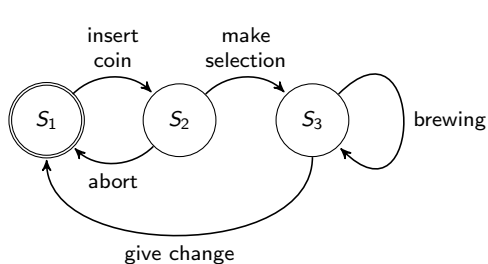
Decentralization Calls for a Multiagent Architecture

Each agent represents an autonomous party; each Org represents an interaction context



Vending Machine in Vienna

Conventional software engineering focuses on technical artifacts



AF[Brew]: On every path, coffee is eventually brewed

A[¬Brew U Coin]: On every path, no coffee is brewed prior to payment

©Fachhochschule Technikum Wien

<http://embsys.technikum-wien.at/projects/decs/verification/formalmethods.php>

Vending Machine in Valencia

Users plus machine form
a sociotechnical system

- ▶ Tall structure
- ▶ Hard to reach for short people
- ▶ Is that a bug or a feature?



Vending Machine Close Up: Cigarettes!



Regulation: Violations are Possible

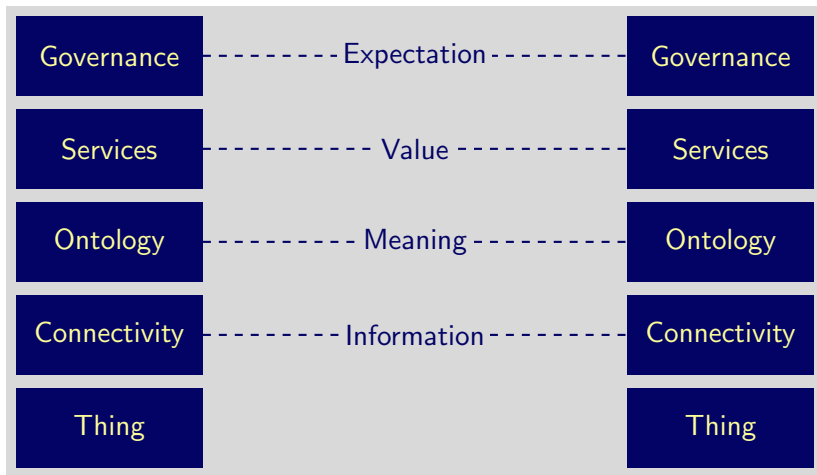
Appropriate assumption when dealing with autonomous parties



IoT Federation Levels and What Flows Across

Current techniques: lower levels

IoT applications need upper levels



Driver nearly crashes when her car suddenly shut down on a busy interstate because auto lender hit remote kill switch when she missed a payment

- **T. Candice Smith had to have her car pushed out of on-coming traffic**
- **Starter Interrupt Devices allow auto lenders to 'shut down borrower's cars at any moment'**
- **The devices emit flashing lights, beeping noises and then shuts down the car and prevents it from starting**
- **These devices have been installed in more than two million vehicles**

By CHARLENE ADAMS FOR MAILONLINE

PUBLISHED: 11:50 EST, 25 September 2014 | UPDATED: 14:21 EST, 25 September 2014

Back to the Future

Current techniques: orchestration and a central mindset
IoT applications need decentralization and social protocols

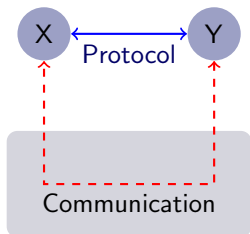


Figure: Before IT:
social but not
computational

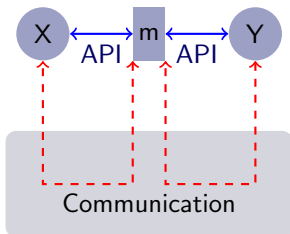


Figure: Current:
centralized but
computational

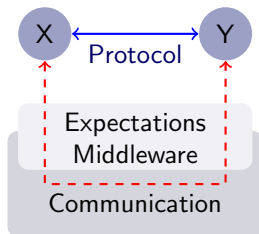
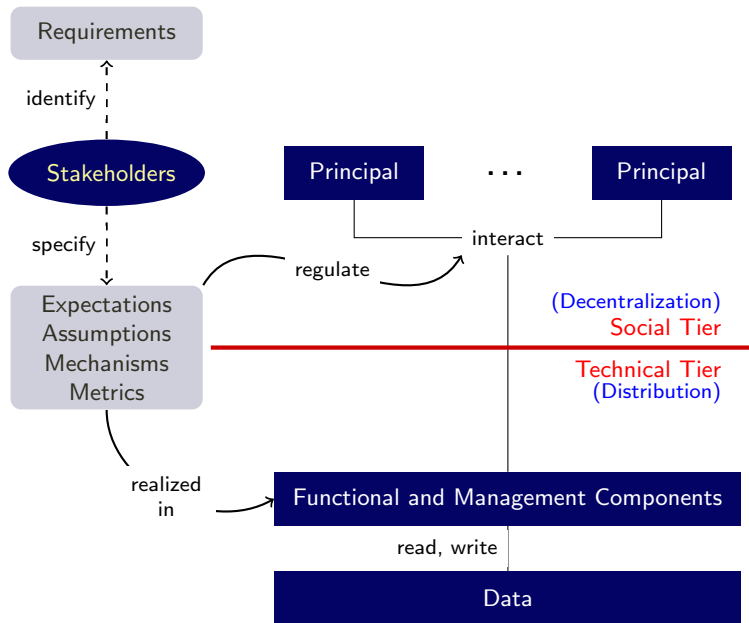


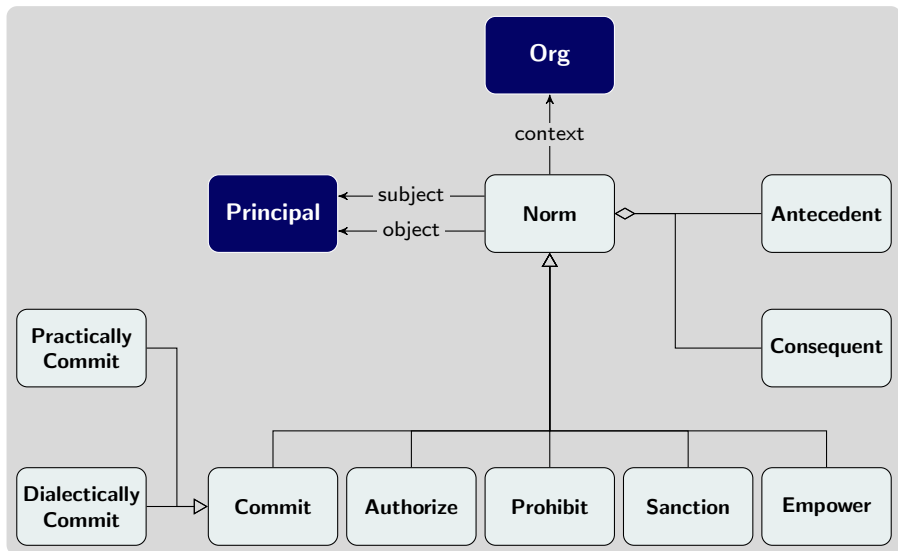
Figure: Envisioned:
decentralized and
computational

Sociotechnical Systems: Decentralized Intelligence



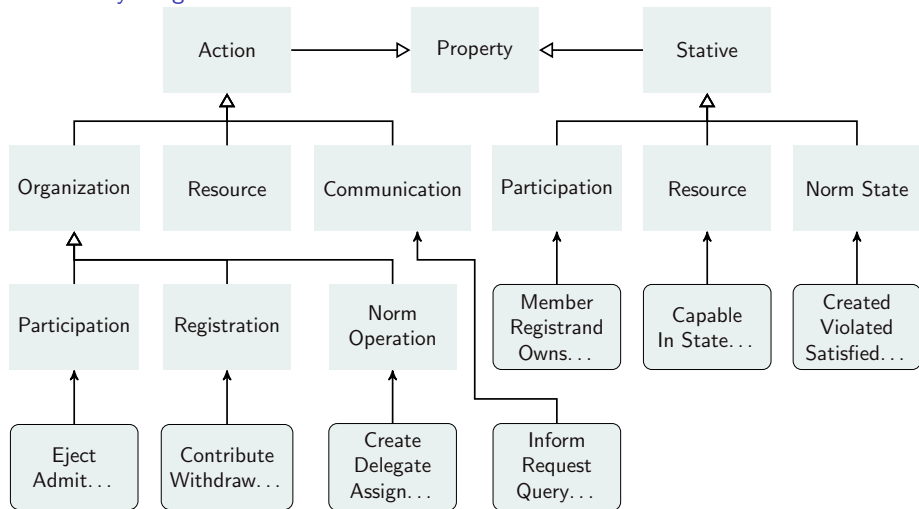
Formalizing Expectations for Distributed Computing

Normative relationships or norms in Orgs: Declarative; composable; manipulable



Simple Domain Model for Sociotechnical Systems

A vocabulary for governance



Summary: Decentralized Intelligence is Key for IoT

IoT applications need computational models of sociotechnical systems

- ▶ Programming models
 - ▶ How can we enacting social protocols?
 - ▶ How may we express expectations via norms?
 - ▶ How can we computationally support reasoning about social protocols?
- ▶ Interaction-oriented software engineering
 - ▶ What modeling constructs cohesively underpin multiple federation levels? Can a declarative treatment of causality yield such constructs?
 - ▶ How can we characterize autonomy and corresponding accountability?
- ▶ Enlightened governance
 - ▶ How can we evaluate the quality of norms?
 - ▶ How can we support social deliberation about norms?
 - ▶ What are high-level architectural abstractions that naturally incorporate governance?
 - ▶ How can we understand ethics in a tangible computational manner?

Thanks and Plugs

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