Modeling Constraints in IoT Systems

Addison Mayberry, Amit Levy, Bharathan Balaji,
Brad Campbell, Longqi Yang, Nirupam Roy, Ranveer Chandra
Vasuki Narasimha Swamy, Victor Bahl, Xiaozhou Li
Moderated by: Ratul Mahajan

IoT Working Group
MSR Student Summit
#GradSummit

Typical IoT Pipeline

- Sensor -> Gateway -> Cloud -> Smartphone -> App -> User

- Sensor -> Middleware -> App -> User

- User -> App -> Middleware -> Actuator

Lot of Data Available

- Sensors: Temperature, Location, Water Flow

- Domains: Agriculture, residences, health

- Problem -> Data not available centrally due to heterogeneity/vertical systems. Assume solved.

Need to Reason about Data

- Need a common data representation

  - Ontology[1], schema.org[2] [Assume Solved]

- Need to represent the physical world

  - Constraints: Laws of Physics, Regulatory policies, User preferences

1. Semantic Sensor Network Ontology: https://www.w3.org/2005/Incubator/ssn/ssnx/ssn
2. http://schema.org/

Examples of Constraints

- Physical Constraints:

  - Can heat up house at 0.2C/min

- Regulatory Constraints:

  - Set house temperature > 55F

- User Constraints:

  - Don't want child to access TV after 8pm

Why Constraints?

- Modern OS services:

  - Memory Protection, Network sharing, Disk access

- What are the equivalent in IoT systems?

  - How do we ensure safety in IoT?

What do we model?

- IoT Attributes

  - Provenance, accuracy

- System level dependencies

  - Dependency between sensors and actuators

  - Feedback loop

  - Dependency on data values. e.g. rate of change

- Access Rights

How do we model constraints?

Graph representations:

- Graph mapping dependencies

    - thermostat —> boiler —> water temperature setting, valve, etc.
      |———-> cooler
      |———-> fan

- Graph mapping state transitions, mapping legal and illegal transitions

    - 69F — legal —> 73F, 69F — illegal —> 45F

- Device constraints & access rights

Enforcement of Constraints

- Can we reduce the problem to graph traversal? or other well understood problems?

- At what level should the safety mechanism be placed?

- How would we implement policies on top of this data model?

Thank You!

Questions and Comments?