Autonomic IoT Systems

Realizing Self-* Properties in IoT Systems

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IoT and CPS

• The internet of things is known as giving any object the ability to be connected to, and uniquely identifiable on the internet.

• Cyber-physical systems form the interface between the physical real world and the cyber world where information is processed, stored and exploited.

• IoT and CPS are sometimes used interchangeably.
IoT Systems

• On May, 2015, the IEEE IoT initiative defined IoT systems by having the following features:

  • Interconnection of things.

  • Connection of things to the internet.

  • Uniquely identifiable things.

  • Ubiquity.
IoT Systems

• Sensing/Actuation capability*.

• Embedded intelligence*.

• Interoperable communication capability*.

• Self-configurability*.

• Programmability.
IoT and CPS

- A cyber-physical system is a system of software components that collaborate to control physical entities to achieve a certain goal.

- CPSs are usually sensor-based, communication-enabled and autonomous.

- Example: smart spaces.
Autonomic IoT Systems

- Smart spaces and IoT system need to adapt to:
  - the existence of heterogeneous components (all kind of things).
  - very large number of components.
  - high churn
  - Self-management is a key.
Autonomic IoT Systems

• “There is still a lack of research on how to adapt and tailor existing research on autonomic computing to the specific characteristics of CPS, such as high dynamicity and distribution, real-time nature, resource constraints, and lossy environments.”[3]

• Most existing research in self-aware IoT is lacking experimentation for validation.
Research in Autonomic IoT systems

- Autonomous objects (thing-level).
  - Example: responsible objects (self-healing)

- Autonomous Cyber-physical systems.
  - Example: Smart cities and smart buildings.
Smart Cities
Smart Cities

• The growing set of technologies for cyber-physical systems and cloud computing encourages the direction toward smart cities.

• cyber-physical systems provide the self-aware properties and act upon the environment by deploying sensors and actuators.

• Cloud computing provides the storage, analysis and processing abilities in scalable, elastic and reliable manner.
Smart Cities

• Essential Self-* Properties:
  • Self-Adaptation.
  • Self-Organization.
  • Self-Optimization.
  • Self-Configuration

• Self-Protection
• Self-Healing
• Self-Description
• Self-Discovery
• Self-Energy-Supplying
Smart City and Feedback Loop

- A general model for execution and lifecycle of smart city systems, applicable for any domain.

- City is represented by a state machine. Sensors monitor the state of the city (as attributes interesting to the system). Actions affect the city state and drive the city toward an ideal or accepted state.
The Execution Model

1. State Observation
2. State Interpretation
3. Action Proposal
4. Action Execution

"As-Is" — "To-Be"

"As-Is" — "To-Be"
The Lifecycle Model
AWS IoT - Deployment Platform

- A new platform that may ease development and experimentation with IoT/CPS/Smart spaces systems.

- Beta version launched on October 08, 2015.
AWS IoT - Components

• Things: Devices of any type (sensors, actuators, software applications). Things can have names, attributes and shadows

• Thing shadow: virtual representation of things allows things state to be available even in temporary connection loss. Moreover, it allows the thing to receive appropriate state/action after reconnecting.
AWS IoT - Components

• Rules Engine: real time transformation and routing of messages according to user-predefined expressions depending on context and message content. Messages can be routed to AWS endpoints for processing, real-time analysis, storage and notifications.
AWS IoT - Components

- Message broker: Allows things to communicate in a topic-based publish/subscribe model. Scalable for billions of responsive and persistent communications.

- Device SDK: library to support secure things communication with message broker by allowing things to identify their self to the broker by X.509 certificates.
AWS IoT - Components

- Things registry: unique identification for each thing with descriptive metadata about thing attributes and capabilities.
AWS IoT

AWS IoT DEVICE SDK
Set of client libraries to connect, authenticate and exchange messages

AUTHENTICATION & AUTHORIZATION
Secure with mutual authentication and encryption

DEVICE GATEWAY
Communicate with devices via MQTT and HTTP 1.1

RULES ENGINE
Transform device messages based on rules and route to AWS Services

MESSAGES
With these endpoints you can deliver messages to every AWS service.

DEVICE SHADOWS
Persistent device state during intermittent connections

APPLICATIONS
Applications can connect to shadows at any time using an API

AWS IoT API
Assign a unique identity to each device

REGISTRY
AWS IoT
amazon web services

AWS IoT (beta)

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Future Work

• Platforms such as AWS IoT makes it easier to experiment with IoT based CPSs by simulating things and connecting them to the IoT platform.

• Assessing existing self-* algorithms by deploying them in AWS endpoint services such as AWS Lambda and Amazon Kinesis.

• Finding solution for goal adaptation for more advanced systems.
Thank You

References:


• Gurgen, Levent; Gunalp, Ozan; Benazzouz, Yazid; Gallissot, Mathieu, "Self-aware cyber-physical systems and applications in smart buildings and cities," in Design, Automation & Test in Europe Conference & Exhibition (DATE), 2013, vol., no., pp.1149-1154, 18-22 March 2013


• https://aws.amazon.com/iot/