MIT – Middleware for Internet of Things Summary

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# (1) Communication and Coordination patterns in Middleware for IoT

" Middleware can be categorized according to the coordination model they implement "

- Interaction Paradigms :
  - Communication : Ex. Shared Data, Message Passing
  - Coordination : Ex. Remote Procedure Call, Event

Valérie Issarny, Amel Bennaceur, Yérom-David Bromberg. Middleware-layer Connector Synthesis: Beyond State of the Art in Middleware Interoperability. Marco Bernardo and Valerie Issarny. *11th International School on Formal Methods for the Design of Computer, Communication and Software Systems: Connectors for Eternal Networked Software Systems*, 6659, Springer, pp.217-255, 2011, Lecture notes in computer science, 978-3-642-21454-7.
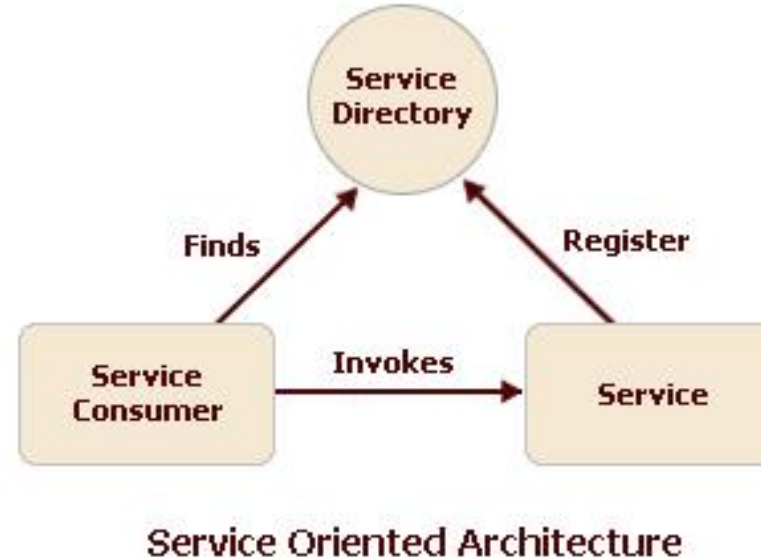
(2) Event based Middleware for IoT : MQTT

▶ machine-to-machine (M2M)/"Internet of Things" connectivity protocol

▶ Over IP

▶ MQTT v3.1.1 has now become an OASIS Standard

▶ Shared Data : **Broker** and DataBase

▶ Evented coordination : **Publish**-**Subscribe** pattern

▶ Towards ... CEP : Complex event processing
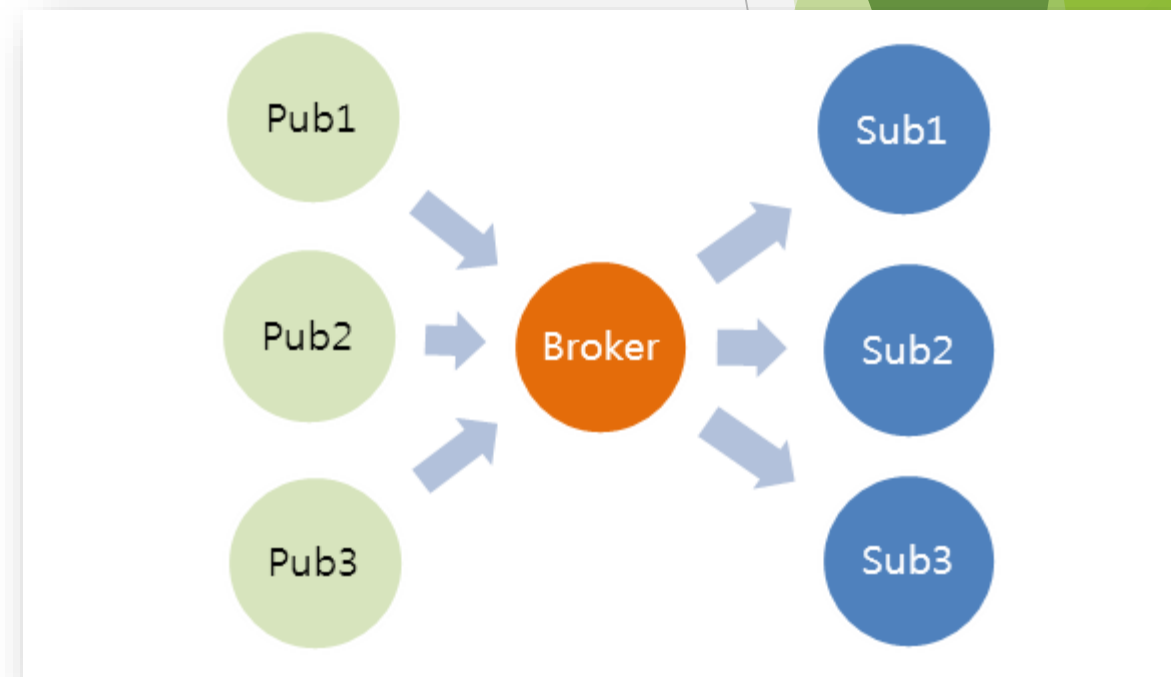
(2) Service oriented Middleware for IoT

" Internet of Things will cooperate with the Internet of Services to provide users with services that are aware of their surrounding environment"

Service Oriented Architecture

Thiago Teixeira, Sara Hachem, Valérie Issarny, Nikolaos Georgantas. Service Oriented Middleware for the Internet of Things: A Perspective. *ServiceWave*, 2011, Poznan, Poland. Springer-Verlag, pp.220-229, 2011, Proceedings of the 4th European conference on Towards a service-based internet.

(3) IoT Web Services : Web of Things

- Web of Things :
  - ROA : Ressource oriented Approache
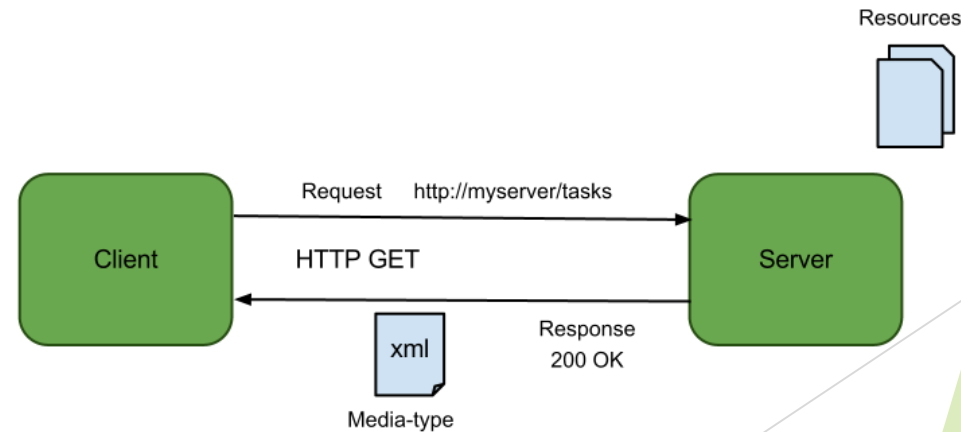 - Ressources are physical data (sensors values, actuators values)

    Create Read Update Delete
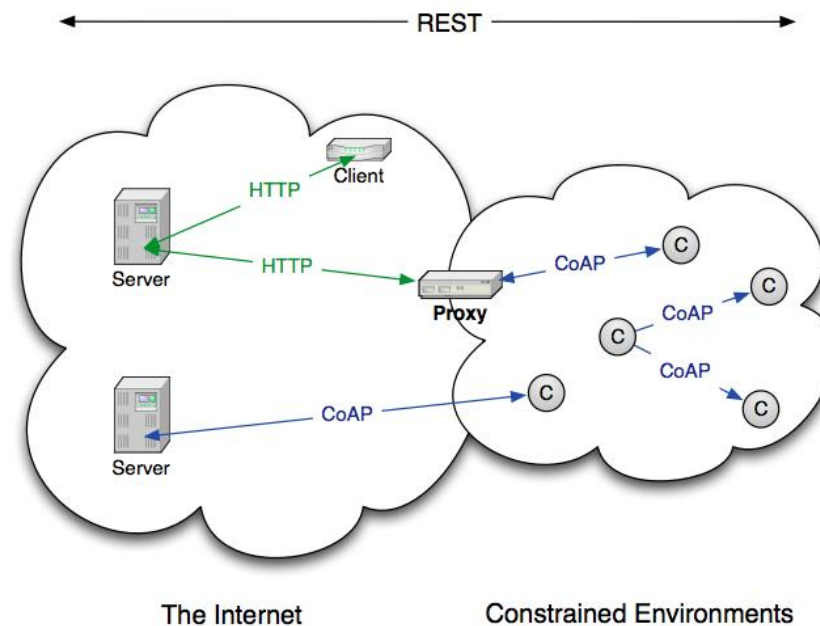
- CRUD Model :
  - Create Read Update Delete

- Web Service REST
 - HTTP : Put/Post, Get, Put, Delete

(4) CoAP : Constrained Application Protocol REST for IoT

- ▶ CoAP is
  - ▶ A RESTful protocol
  - ▶ Both synchronous and asynchronous
  - ▶ For constrained devices and networks
  - ▶ Specialized for M2M applications
  - ▶ Easy to proxy to/from HTTP

(5) IoT Web Services : Web services for Device

- Web Service for Device
- Coordination Model :
  - Remote Procedure Call
  - Events

- Ex. UPnP
- Ex DPWS (Device Profile for Web Service)
  - WS-adressing
  - WS-Eventing
  - WS-Soap
  - …
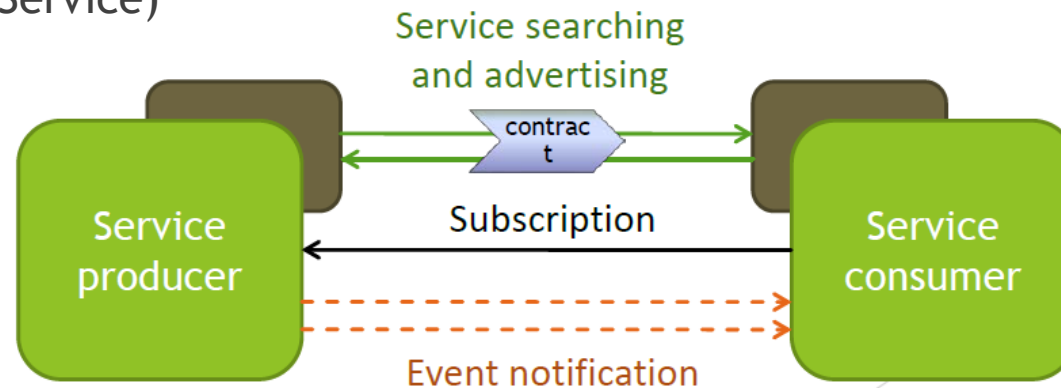
(6) Middleware for IoT Web Service Composition

- Batch and /or Workflow model for Composition

- Language oriented approach like BPEL for Services Orchestration

- Web Services Business Process Execution Language

- Interactive Model for Composition

- Component based approach and Event based coordination

(7) LightWeight Component Approach for Web Service for Device Composition

- LCA : LightWeight Component Architecture

- Bean Components and Event connectors

- Bean proxy for Web service for Device (Ex. UPnP)

- WComp Middleware

(8) Behavioral Model and Formal validation

▶ Behavioral Model using Synchronous Language

▶ Finite automaton equivalence

▶ Formal validation using Model Checking

▶ Application : Validation of a Monitor to control multiple access to a shared service for device in a composition