TECHNISCHE UNIVERSITÄT
CHEMNITZ

Seminar Web Engineering

112- SoLiD for WoT Devices

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VSR

Outline

Web of Things

- ✓ **Web**
- ✓ **Things**
- ✓ **IoT vs WoT**
- ✓ **Architecture**

SoLiD

- ✓ **Decentralization**
- ✓ **Linked Data**
- ✓ **SoLiD vs. Typical Web**
- ✓ **The SoLiD Specification**

SoLiD in WoT

Relevant Works

Proposed System

Implementation

The Demo

Conclusion

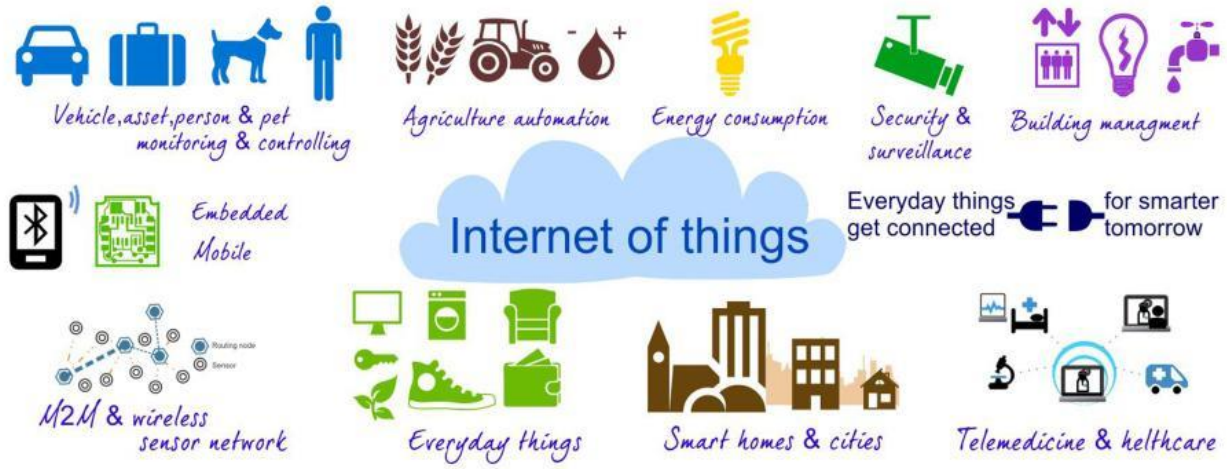
WoT

Web of Things

Web?

- Common name for World Wide Web (WWW)
- Resources are identified by Uniform Resource Locators
- Resources are linked through HTML anchors
- Internet Vs Web
  - The Internet is a global network of networks
    - The infrastructure
    - Physical Network
    - Uses TCP/IP
  - Web is the service on top of Internet
    - Network of documents
    - Logical Network
    - Uses HTTP on top of TCP/IP

Thing?



- Refers to **Anything**
  - Typically a computing device
  - Connected to internet
  - Able to send and receive data over some predefined protocol
- Typical criterias to be fulfilled
  - Identification and info storage (RFID tags, MAC address)
  - Information collection (Sensor networks, store sensor values)
  - Information processing (Understanding commands, filtering data)
  - Communications (Transmit and receive messages),
  - Actuation (Switch control, motor control)

Web Of Things

- ❑ **Web of Things**
- ❑ SoLiD
- ❑ SoLiD in WoT
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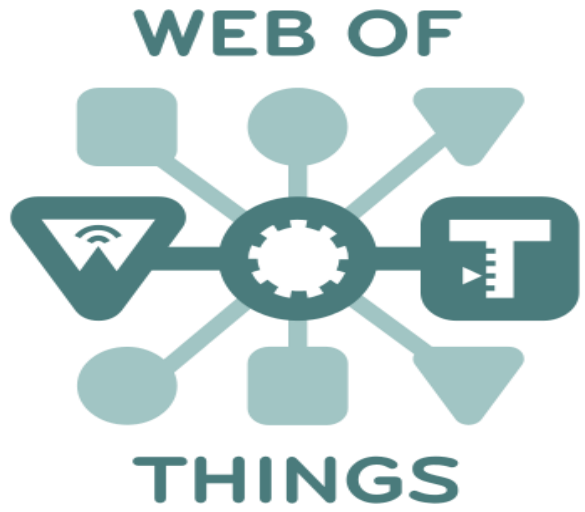
- A computing concept that describes a future where everyday objects are fully **integrated with the Web**.
- You could think of the Web of Things as everyday objects being able to access Web services.
- The **key point** is that this **doesn't involve the reinvention** of the means of communication beause **existing standards are used**.



IoT vs WoT

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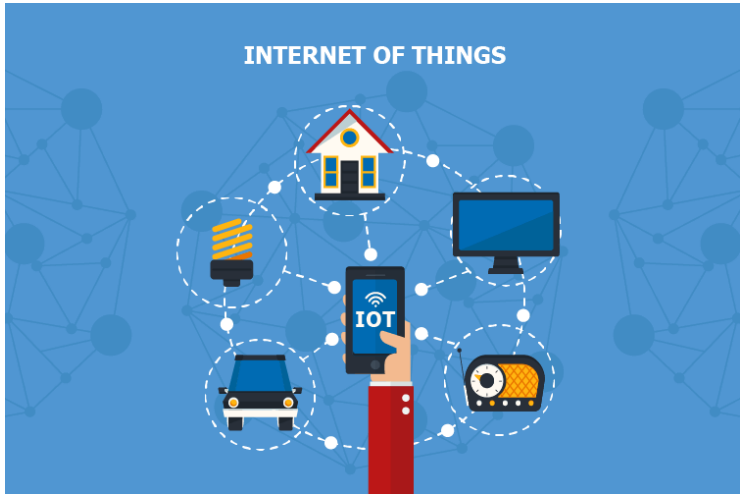
- The **I**nternet **o**f **T**hings is simply "A network of Internet connected objects able to collect and exchange data.„
- Interoperability is a major challenge on the Internet of Things
- Web of things is the **subset** of Internet Of Things.
- WoT is **Application Layer** over IoT.
- Interoperability challenge is taken care of by using existing web technologies



WoT vs IoT: Way of doing things

IoT

- Fosters a **event-driven nature** of applications
- Use protocols like MQTT or CoAP etc

WoT

- Integrates **Things** with the Web
- Limitations: The request-response nature of HTTP
- The event-driven nature is suggested to be implemented by the use of HTML5 WebSockets
  - Natively or through the use of translation brokers
    - e.g., translating from MQTT or CoAP to WebSockets)

WoT Architecture

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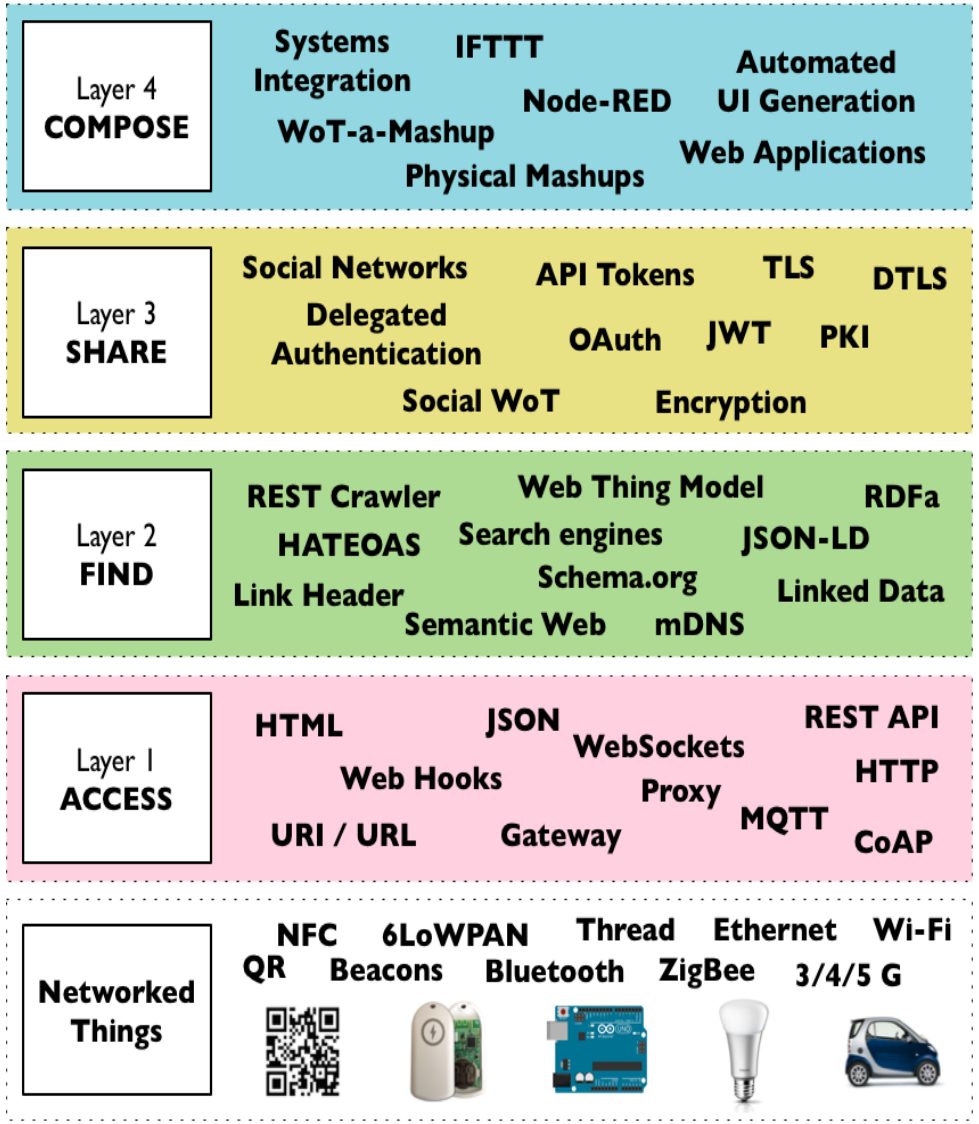
- 4 Main layers
- Describes the framework to classify the different patterns and protocols involved.



Source: Building the Web of Things: book.webofthings.io
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WoT :: Layer-1: Accessibility Layer

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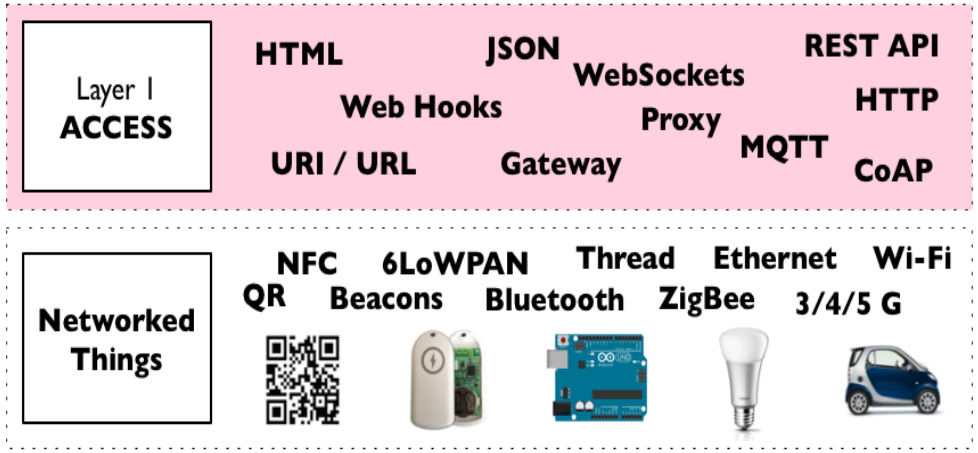
- This is the **core layer** of the WoT
- Deals with the **access of things** to the Internet
- Ensure they expose their services via **Web APIs**.



WoT :: Layer-2: Findability Layer

- Focus: To provide a way to find and locate things on the Web
- **Strongly influenced by the semantic Web**
- Reuse Web semantic standards to describe things and their services.
  - HTML5 Microdata integration, RDF / RDFa, JSON-LD etc.
  - Enables machine to machine interaction following some standards.

WoT :: Layer-3: Sharing Layer

- Deals with the idea of things **pushing data to the Web**
- Intelligence and Big-data patterns can be applied
  - Manage our health (Wearables),
  - Optimize energy consumption (Smart Grid)
- Ensures that data generated by things can be shared in an **efficient and secure** manner.

WoT :: Layer-4: Composition Layer

- Integrates the services and data offered by things into higher level Web tools
  - Analytics software
  - Mashup applications such as IFTTT
- Makes simpler to create applications involving things and virtual Web services.

SoLiD

The Web Decentralization Project by Prof. Tim Berners-Lee

Decentralization

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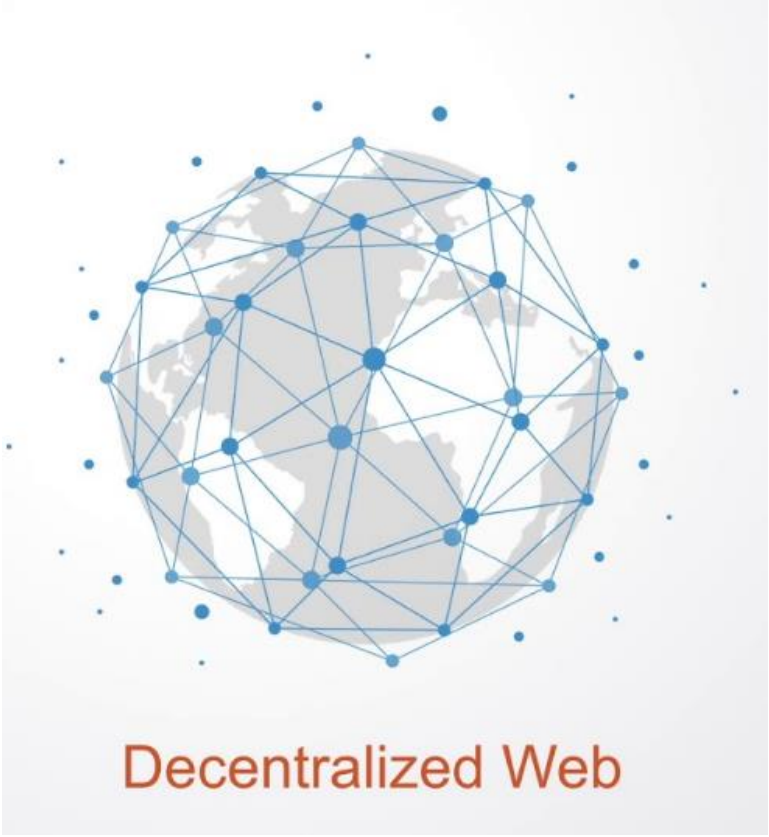
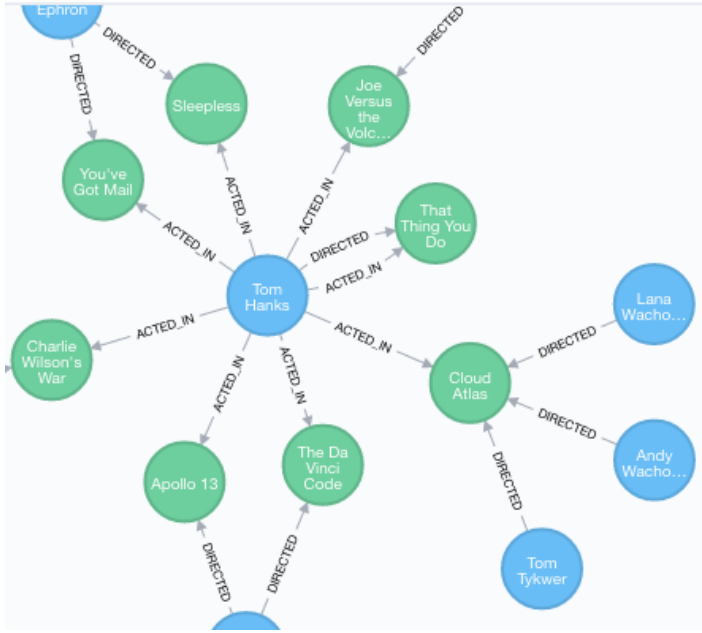
- Web runs across a number of machines that are **owned by regular users** rather than owned in a central place like a server.
- It is supposed to be like the web you know but **without** relying on **centralised operators**.
- Individual **user** have the **full control** of there data instead of any big tech firms.



Linked Data



- A Structured data
  - Interlinked with other data
  - Described based on some semantic vocabularies
  - Can be useful through semantic queries.
- Based on the RDF model
  - Views data as a collection and in relation to other data.
- Provides a single standardized access mechanism for all involved
- Shareable, Extensible and Reusable, even on different results and different interfaces.

Typical HTML Data vs Linked Data

- HTTP Protocol
  - ✓ HTTP Documents
  - ✓ Interfaces: GET/POST/PUT/DELETE etc
- RDF Protocol
  - ✓ RDF Documents
  - ✓ Interface: SPARQL (On top of HTTP)

Linked Data Platform

- The term **Linked Data** was coined on around 2006
- Data model: **RDF** (Developed in the 1990s)
- Format: **RDF/RDFa, Turtle, JSON-LD etc.**
- Communication protocol: **HTTP**
- Architectural style: **REST**

SoLiD

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- **S**ocial **L**inked **D**ata is a web decentralization project led by Tim Berners-Lee.
- Proposed set of conventions and tools for building decentralized social applications
- Based on **Linked Data Principles**
- Today's web applications is centralized for a variety of reasons. **User data** became the **source of power and income** for Internet companies. Solid is a solution to this.
- POD: Allow **users** to **have full control** of their own data, including access control and storage location

SoLiD Specification

- Identity (WebId)
- Profiles
  - WebID Profile Documents
- Authentication
  - Primary Authentication: WebID-TLS
  - Alternative Authentication Mechanisms
  - Secondary Authentication: Account Recovery
- Authorization and Access Control
  - Web Access Control
- Content Representation
  - RDF in the form of JSON-LD, Turtle, HTML+RDFa, etc
- Reading and Writing Resources
  - HTTPS REST API
  - WebSockets API
- Social Web App Protocols (Under Development)

Linked Data applied to SoLiD

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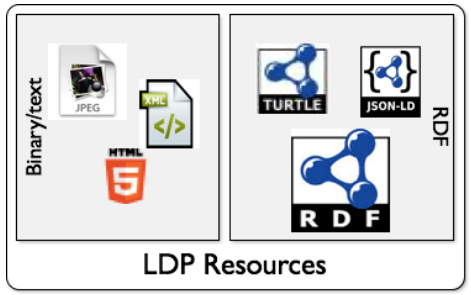
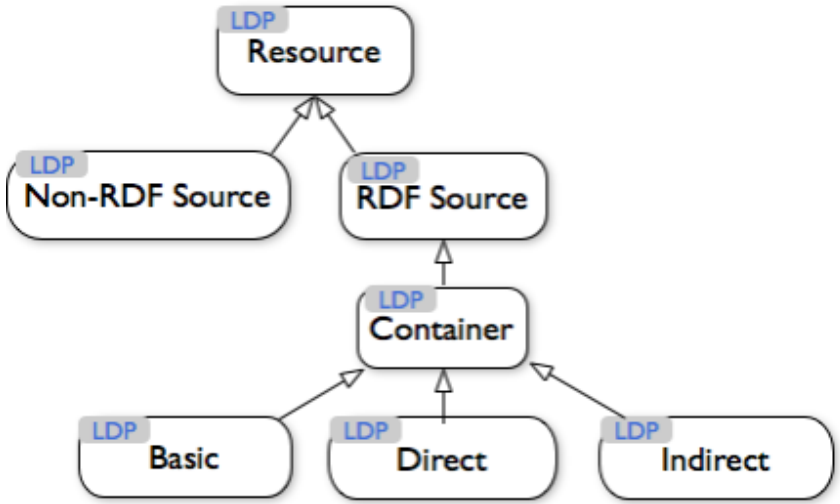
- Profile
  - ✓ A RDF Resource
- Content Representation
  - ✓ RDF Containers or Resource
- Authorization
  - ✓ RDF Resource (ACL files)
- Social Web App Protocols
  - ✓ Yet to discover





SoLiD: Content Representation

- Two kinds of Resources
  - Linked Data resources
    - RDF in the form of JSON-LD, Turtle, HTML+RDFa, etc
  - Everything else
    - Binary data and non-linked-data structured text

- Linked Data provides considerable benefits
  - In terms of **interoperability** with the rest of the Solid app ecosystem.

SoLiD & WoT

How they make sense together

SoLiD & WoT at a glance

WoT Requires

- ❑ Access
- ❑ Discover Things
- ❑ Share Data
- ❑ Actuate

SoLiD Provides

- ✓ REST interface
- ✓ RDF+SPARQL
- ✓ POD
- ✓ Web Socket + SPARQL

Related Works

- ❑ **Web of Things**
- ❑ **SoLiD**
- ❑ **SoLiD in WoT**
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[1] Käfer, T., & Harth, A. (2018, October). **Specifying, monitoring, and executing workflows in linked data environments**. In International Semantic Web Conference (pp. 424-440). Springer, Cham.

WiLD

Karlsruhe Institute of Technology

WEB OF THINGS

- Interfaces to IoT sensors/actuators
- Built on Linked Data

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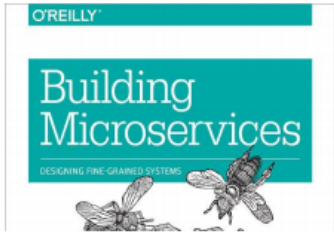
- Interfaces to personal data storages
- Built on Linked Data



- Interfaces to core company functions
- Built on REST (lift to Linked Data)

Further Motivation

- Data Controls us
- We think the things as entities of the Social Web
- One thing will be able communicate with each other and **share data** as we share thoughts
- Things will **take decision** based on the data generated by other things as we human being do
- Proper semantic is needed to assure to facilitate the above points

WoT Scenario: A Top Level View

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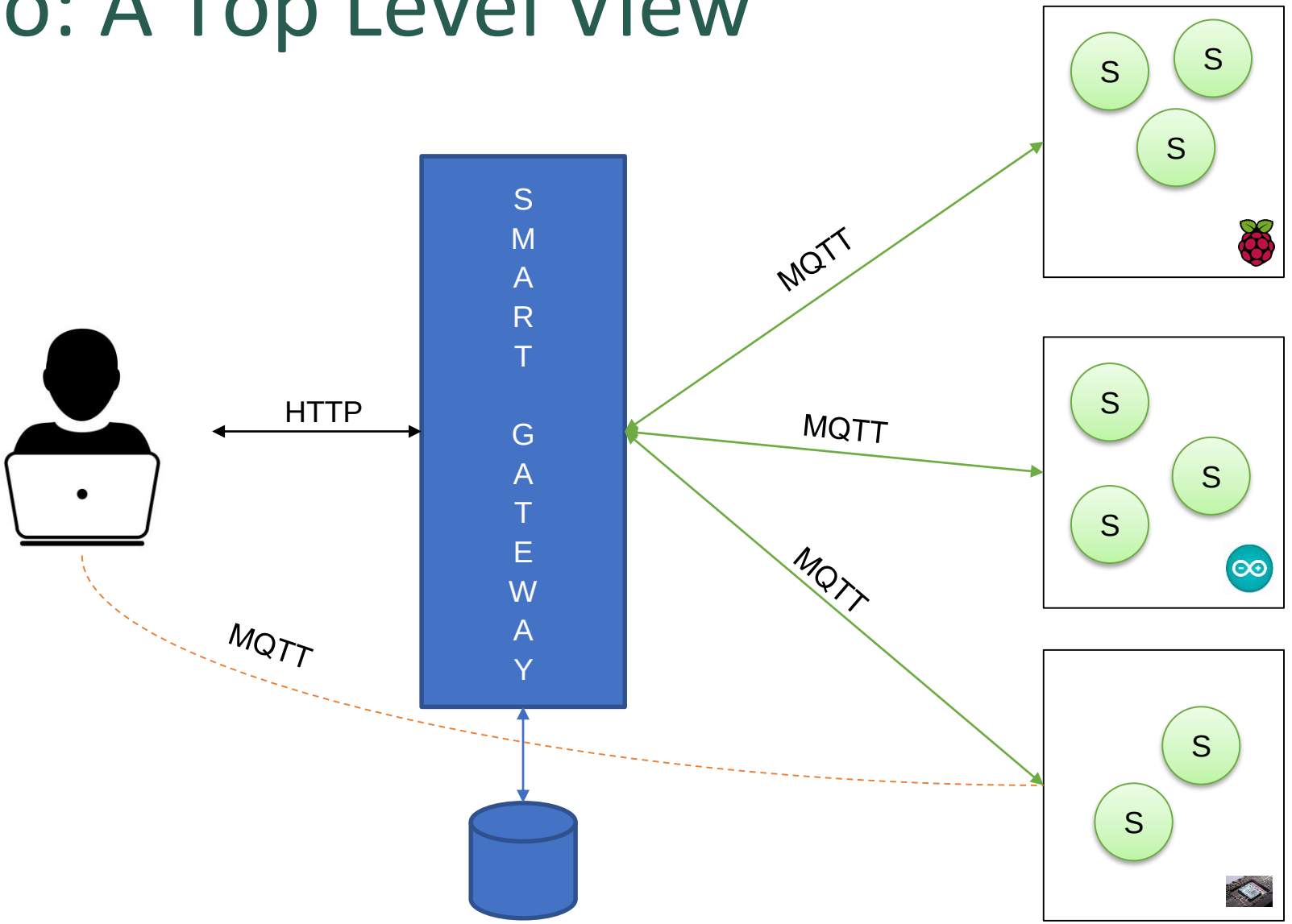
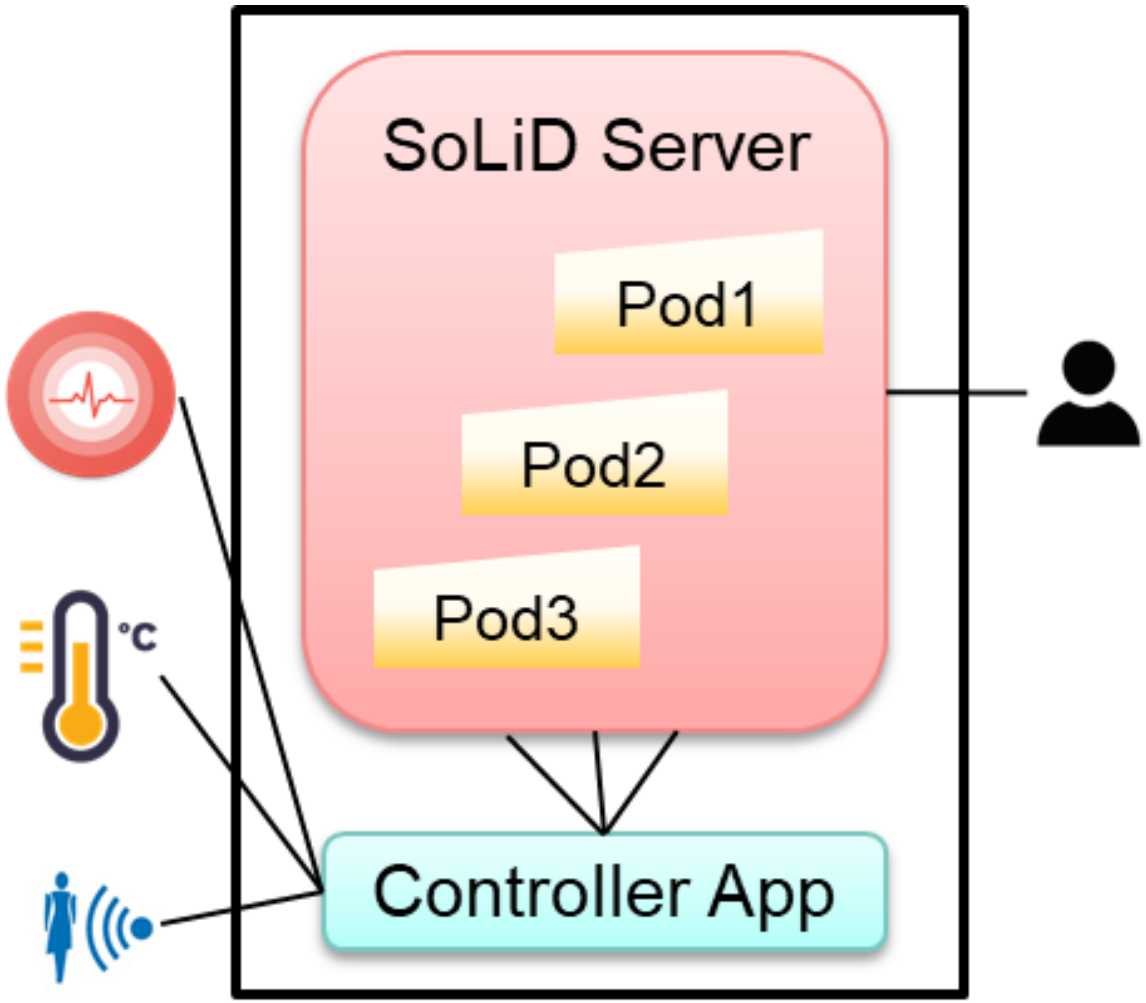


Previous Proposal

POD per sensors



The Proposed Secnerio-1

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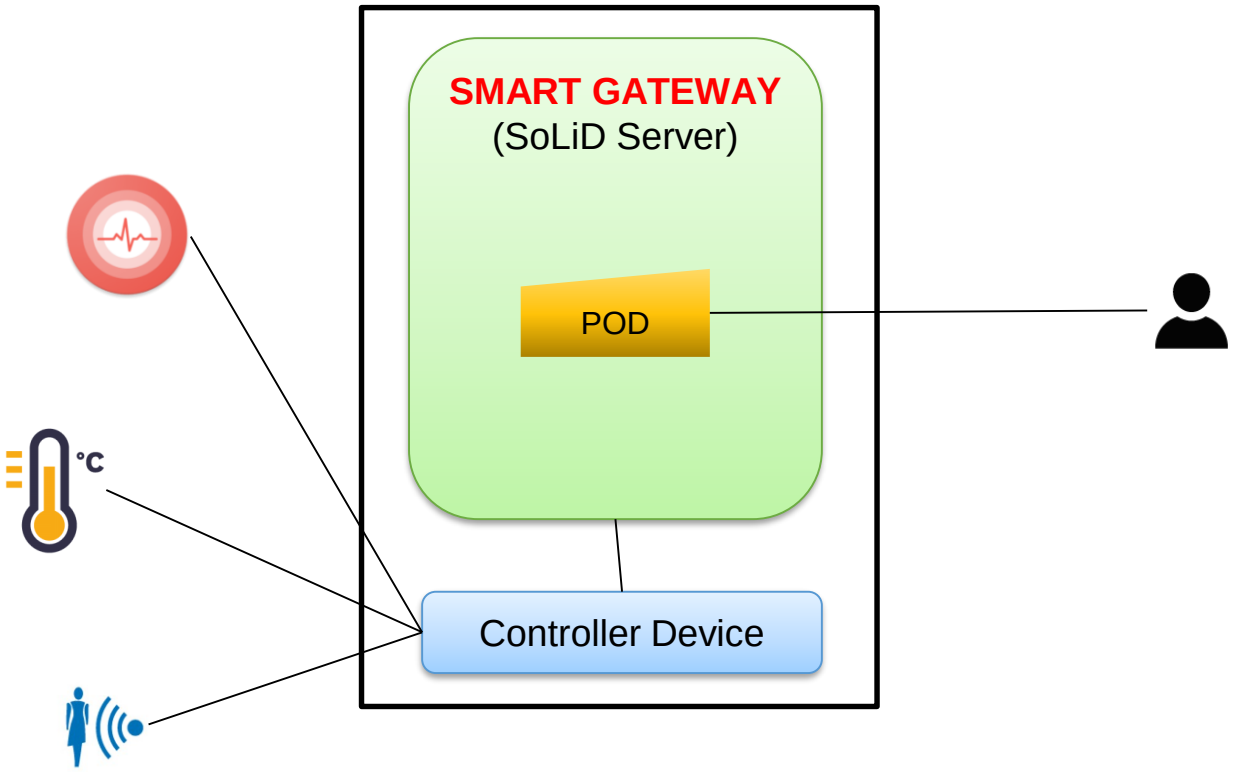
- POD can be configured using WebID



The Proposed Scenerio-2

- ❑ Web of Things
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- ❑ SoLiD in WoT
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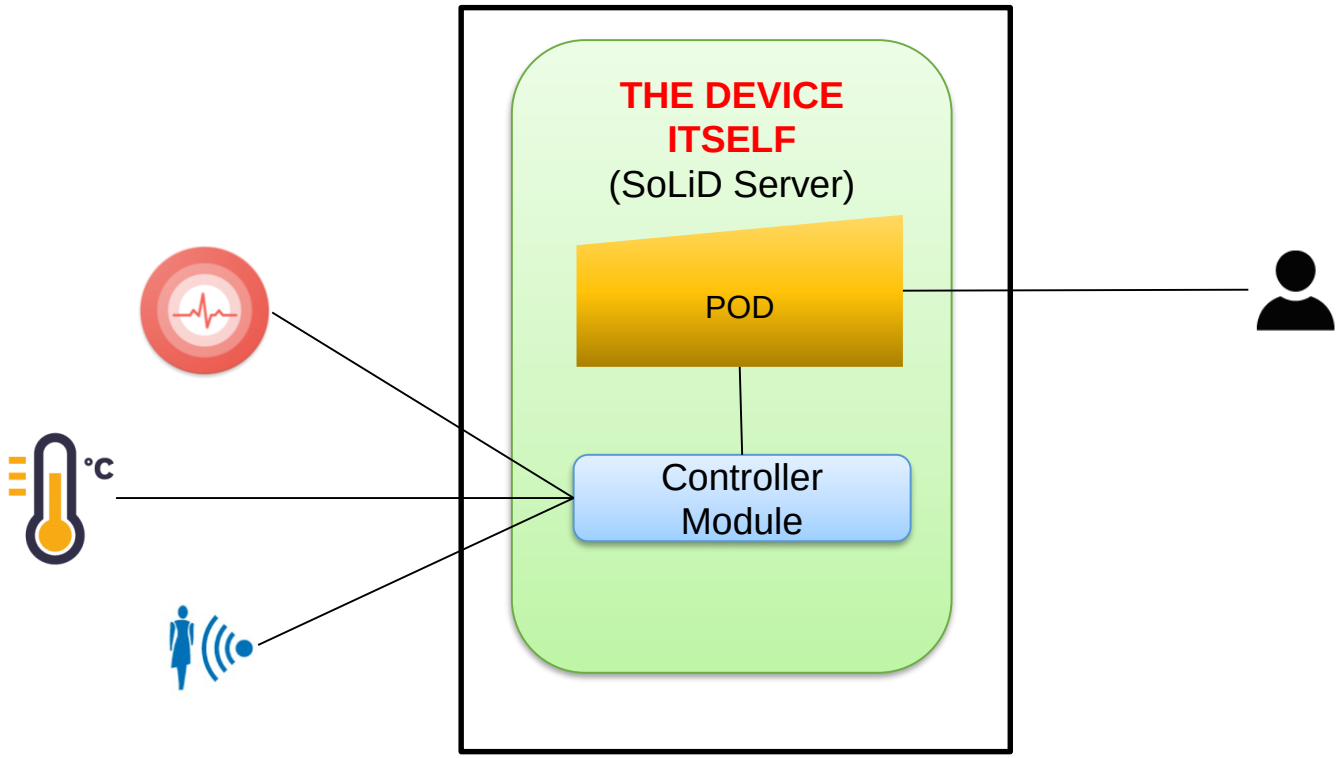
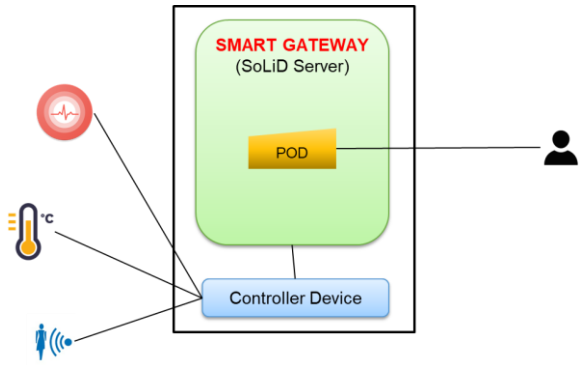
- PODs can be configured using **WebID**



The Implementation: Scenerio-1

- **Controller Device** was simulated as a web app
  - Developed using Node.js
- **User Interface** is another web app
  - Developed using Node.js
- **Solid Server**
  - node-solid-server 5.1.1



Challenges We Faced

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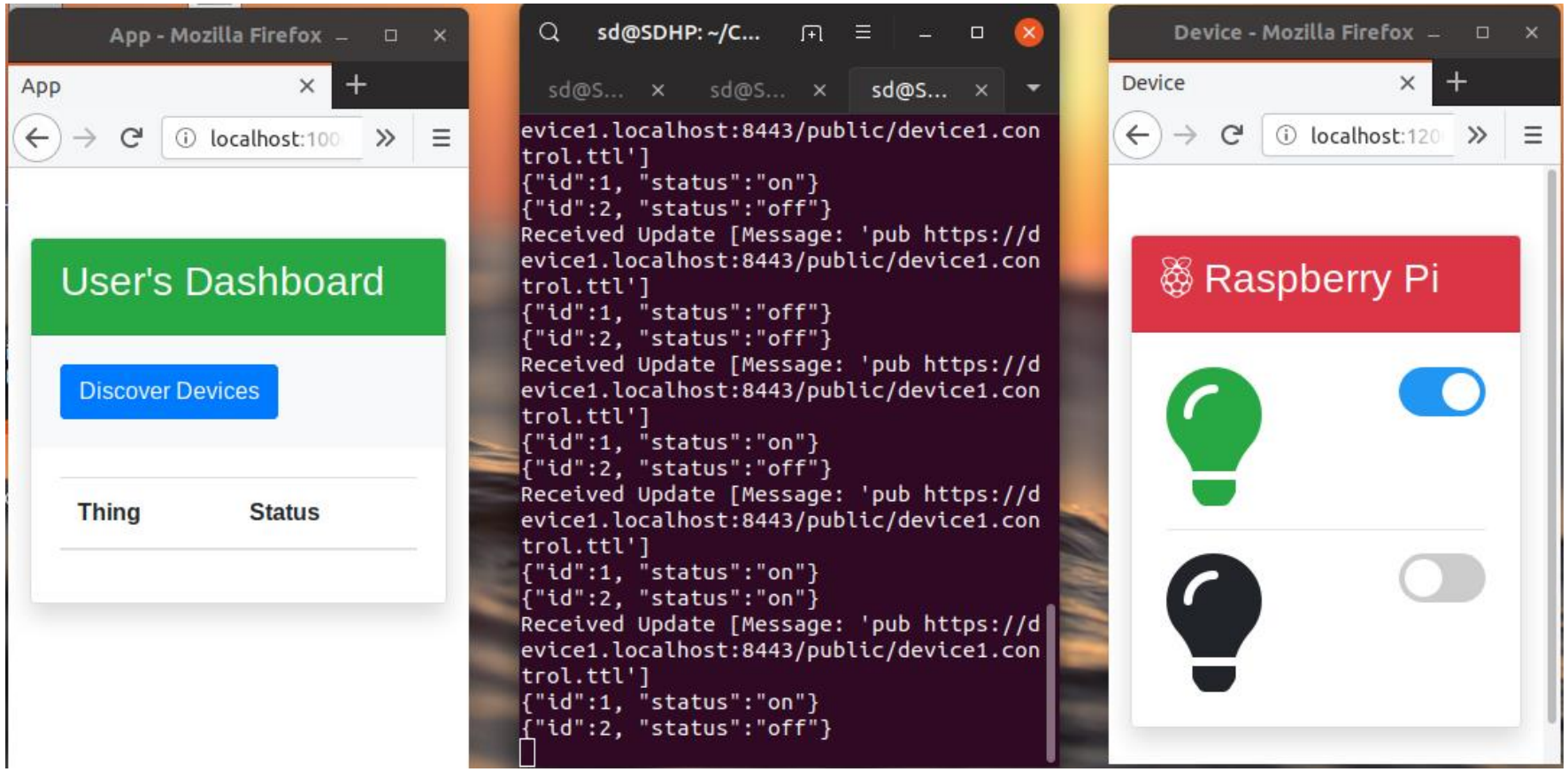
- Understand the RDF Ecosystem
- Deal with the poor SoLiD documentation
- Describing things
- Actuating things

How we solved

- Had some previous knowledge about RDF
- Regarding the documentation, we had to deal with it
- **Describing things**: used RDF
- **Actuating things**: used Web Socket

The Demo


App - Mozilla Firefox
App
localhost:100
User's Dashboard
Discover Devices
Thing
Status
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evice1.localhost:8443/public/device1.con
trol.ttl']
{"id":1, "status":"on"}
{"id":2, "status":"off"}
Device - Mozilla Firefox
Device
localhost:120
Raspberry Pi

Conclusion

- SoLiD can foster WoT
- Enormous Research opportunity
- As of future work we intend to implement the Secenerio 2
  - Providing native support for WoT in SoLiD Ecosystem


Thank you!
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