High Level Interoperability Testing

For the Web of Things

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Testing and the Web of Things

Two talks:

- **Dave Raggett** on high level interoperability testing
  - W3C staff activity lead for Data and a champion for Web of Things
  - Long history of work on web standards (HTML, HTTP, …)
- **Ege Korkan** on testing things exposed by particular devices

This work has been supported by F-Interop

F-Interop, see www.f-interop.eu

- European project supported by the European Commission and the Swiss Government with the following partners
  - Sorbonne Université, Mandat International, ETSI, imec, EANTC, Digital Catapult, Université du Luxembourg, INRIA, UDG and W3C/ERCIM
- Interoperability testing at the protocol level, e.g. HTTP, CoAP
  - Using AMQP for test control messaging
  - And a VPN for intercepting packets
  - Available as Docker images for easy installation
- W3C/ERCIM has added support for high level testing for the Web of Things
  - Moving beyond protocol level testing to ensure application interoperability

Horizon 2020
European Union
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and Innovation

Swiss State
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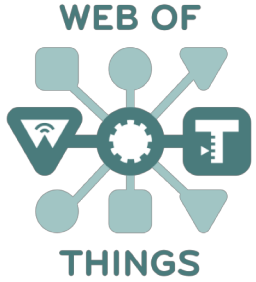
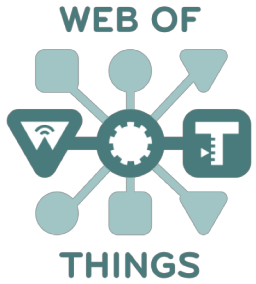
Education, Research
and Innovation

The Web of Things



The Web of Things

- **The IoT is fragmented**
  - Lots of incompatible technologies, protocols and standards
  - This is holding back the potential by increasing costs and risks
- **Web of Things as a simplifying abstraction layer**
  - Software objects with properties, actions and events for sensors, actuators and related information services
  - Descriptions of the kinds of things, their capabilities and the context in which they reside
- **Web of Things for open standards based application platforms that insulate developers from the myriad IoT technologies and standards**
  - Loosely analogous to Web browsers and how HTML & HTTP revolutionised Internet services for consumers
  - This will stimulate rapid growth in services as happened with the Web

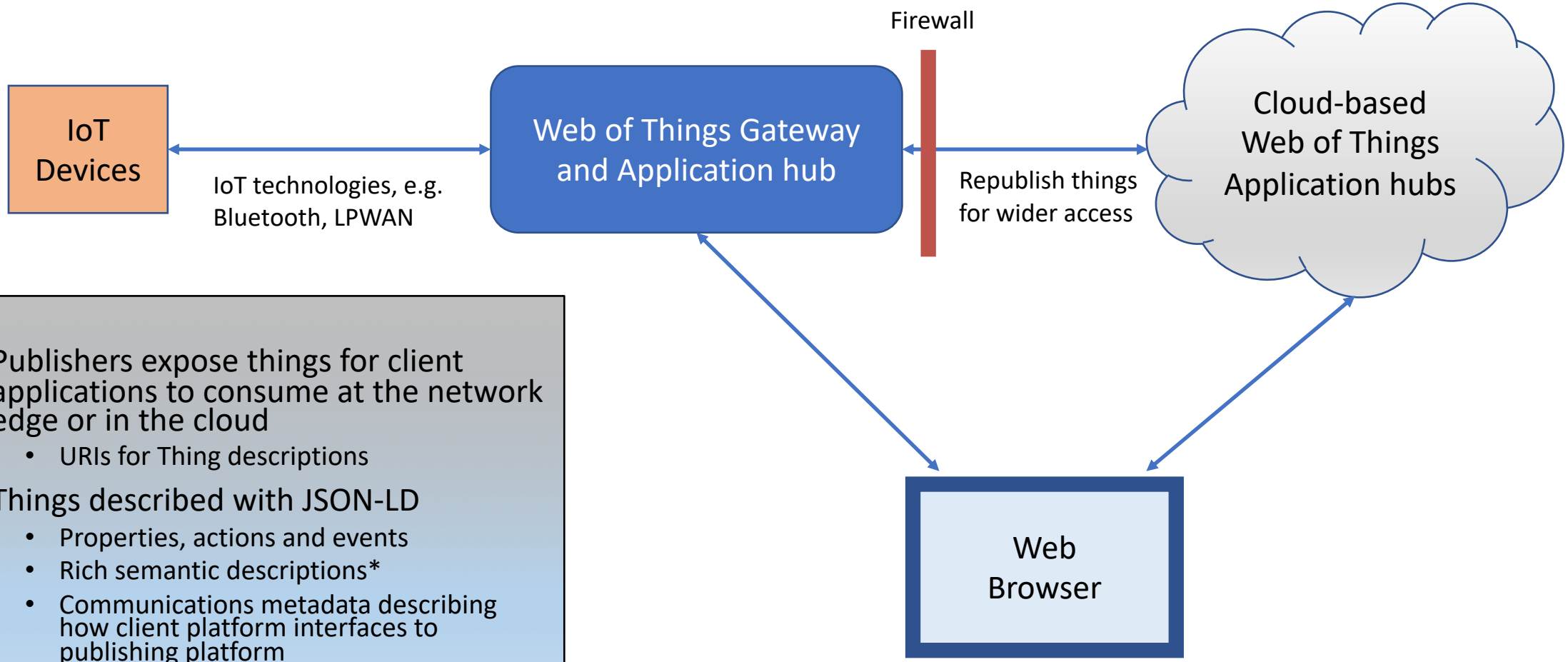


Web Hubs as open Web platforms

- Each thing has a URI
  - Dereference to obtain JSON-LD describing its properties, actions and events
    - With datatypes expressed using JSON schema and physical units such as “celsius”
    - Metadata defining how client libraries remotely access the thing
    - Or request HTML description via HTTPS GET with Accept: text/html
  - This URI allows things to be described with Linked Data, including the kinds of things, their capabilities, interrelationships and the context in which they reside
    - e.g. a smart light with controllable hue and brightness in a room in your home
- Open source implementations
  - Eclipse *ThingWeb*, Mozilla *Things Gateway*, and my *Arena Web Hub**

** Named after my web browser which was the first to support tables and CSS*

Web Hubs host web apps that expose and consume things



- Publishers expose things for client applications to consume at the network edge or in the cloud
  - URIs for Thing descriptions
- Things described with JSON-LD
  - Properties, actions and events
  - Rich semantic descriptions*
  - Communications metadata describing how client platform interfaces to publishing platform

* e.g. as defined by iot.schema.org

Arena Web Hub

- Node module installable with npm
  - *npm install arena-webhub*
  - Installable on Raspberry Pi etc. for home gateway
  - Github project at https://github.com/draggett/arena-webhub (release: November 2018)
- Used by server-side application to expose things for use by clients
  - Server-side application hides IoT protocols, e.g. Bluetooth, ZigBee, …
- Security based on use of TLS and JWT
- Supports HTTPS, Server-Sent Events and WebSockets*
  - Applications responsible for generating and validating JWT bearer tokens
    - As well as management of user accounts and notifications over SMTP and SMS
    - Examples for how to do this securely are provided in the GitHub project
  - JavaScript client library for use in web pages
    - With examples for some virtual things
- Looking for help with providing examples for Bluetooth, ZigBee etc.

* Protocols you can use from web page scripts using the fetch, EventSource and WebSocket APIs

Simple server app example

```
let webhub = require('arena-webhub').({
        port: 8888,
        validateJWT: (token, url) => { // some code to validate the JWT token }
});

webhub.produce({
        name: "test",
        properties: {
                power: {
                        type: "boolean",
                        value: false
                }
        }
}).then(thing => {
        let state = thing.properties.on.value;
        setInterval( function() {
                thing.properties.on.write(state);
                state = !state; }, 5000 );
})
```

Simple client app example

```
<!DOCTYPE html>
<html lang="en">
<head>
        <title>Web Hub demo</title>
        <meta charset="utf-8">
        <script type="text/javascript" src="wot.js"></script>
        <script>
                let thingURI = "https://localhost:8888/things/test";

                wot.consume(thingURI).then (thing => {
                        thing.properties.power.subscribe(state => {
                                console.log("power set to " + state)
                        }
                });
        </script>
…
</html>
```


Note that Arena Web Hub integrates a Web server for Web pages

High Level Interoperability Testing

High Level Interoperability Testing

- Web Hubs may vary in respect to scripting languages and APIs
- Web Hubs may vary in how they use Web protocols
  - Many different ways to use HTTP and WebSockets
    - HTTP for all things, all properties and all events vs individual HTTP requests
    - HTTP long poll for next event vs text/event-stream with Server-Sent Events
    - Things Gateway shares WebSocket for a thing's properties, actions and events
    - ThingWeb requires separate WebSockets for each property, action and event
    - Further work is now needed to drive **convergence** on use of protocols with the involvement of stakeholders from different application sectors
      - Including work on WebSocket subprotocol
- High level interoperability testing is possible based upon the abstract contract implied by the thing descriptions
  - Properties, actions and events, and associated data types
  - Independent of scripting language and protocols

What to Test?

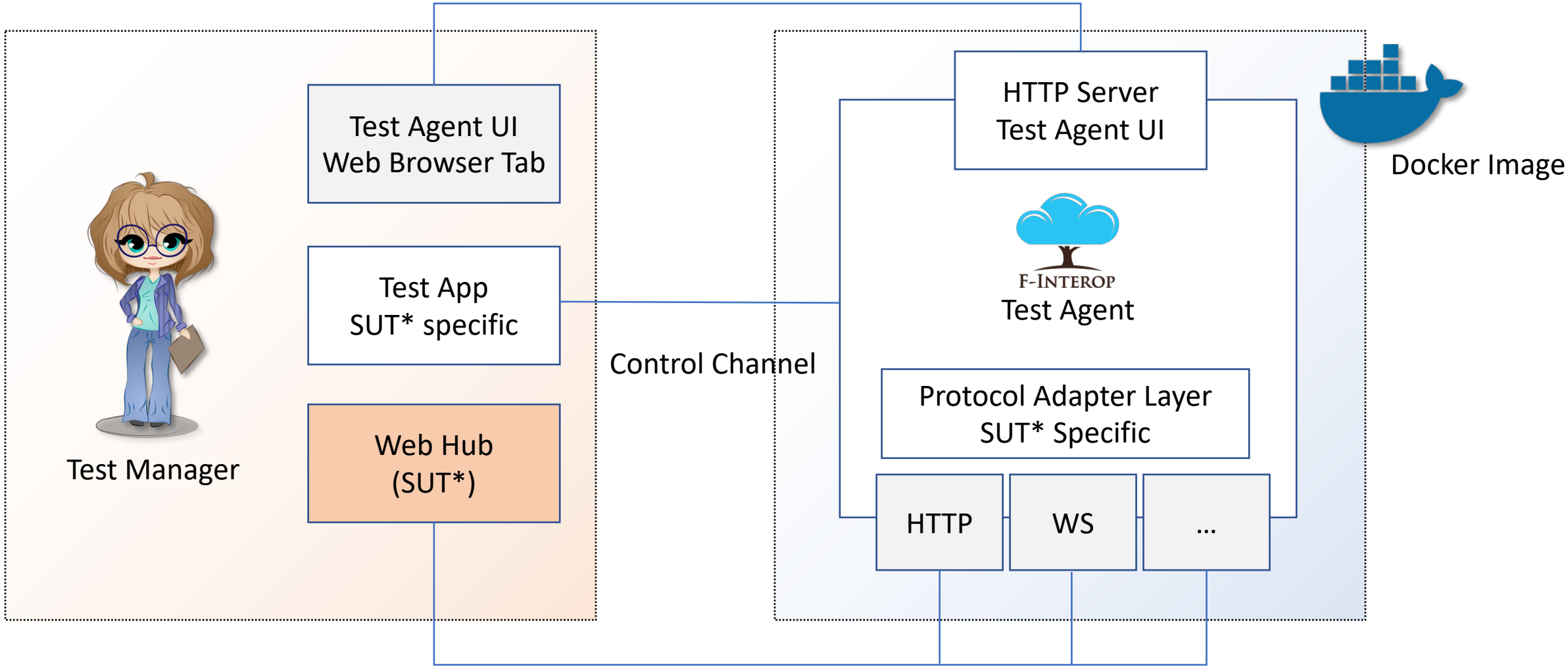
- Test that the property of a consumed thing is the same as for the exposed thing
  - Query property value of exposed thing (request/response)
  - Query property value of consumed thing (request/response)
  - Test that the values are the same (after rendezvous for asynch responses)
- Test that a property update on an exposed thing signals the corresponding event
  - Set property value of exposed thing
  - Listen for corresponding update event from exposed thing
- Test that a property update on a consumed thing signals the corresponding event
  - Set property value of consumed thing
  - Listen for corresponding update event from consumed thing
- Test that setting unknown property triggers exception
  - Set value for unknown property of consumed thing
  - Listen for corresponding exception from consumed thing
- Test trying to set an invalid property value for some example data types
  - Set invalid property value of consumed thing
  - Listen for corresponding exception from consumed thing

And similarly for actions and events …

How to Test

- The aim is to test high level interoperability between a pair of platforms, one exposing things and the other consuming things
  - Suite of tests based upon normative requirements in Thing Descriptions Specification
- Test harnesses for the server and client platforms
  - Applications that expose and consume things, and use them for tests
  - Each test checks a particular assertion, e.g. data type checks for properties
- Functional Tests
  - Client-side between client applications and platform APIs for consumed things
  - Server-side between server applications and platform APIs for exposed things
    - Test application on client sends commands to server via invoking actions on test things
- Non Functional Tests
  - Performance, security, etc.

Interoperability Testing Architecture



Demos & Questions

Many thanks for listening: please contact Dave Raggett dsr@w3.org for further details