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
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](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

```javascript
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

```html
<!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

- Test Manager
- Test Agent UI
- Web Browser Tab
- Test App
- SUT* specific
- Web Hub (SUT*)
- Control Channel
- HTTP Server
- Test Agent UI
- Protocol Adapter Layer
- SUT* Specific
- HTTP
- WS
- ... (Web of Things messaging protocols)
- * SUT = System Under Test
Demos & Questions

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