# Distributed Security Risks and Opportunities in the W3C Web of Things

Michael McCool (presenting) and Elena Reshetova

NDSS DISS 2018
February 18, 2018
San Diego

# Outline

Goals

W3C Web of Things

Risks and Opportunities

1. Local Links
2. Vulnerability Analysis
3. Endpoint Adaptation
4. Secure Discovery
5. Distributed Security

Summary and Conclusions

# Goals

## Why this paper?

- Necessary to perform security review of standards under development
- Paper lists a number of **problems** with the proposed W3C Web of Things standard under development that need to be addressed
- The paper does not, *generally*, propose **solutions**

## Desired outcome:

Discussion, collaboration, and research to find solutions to these problems.

# Web of Things

Working Group within W3C chartered December 2016

- Based on ongoing work in an Interest Group by the same name

Target date of December 2018 to deliver specifications for

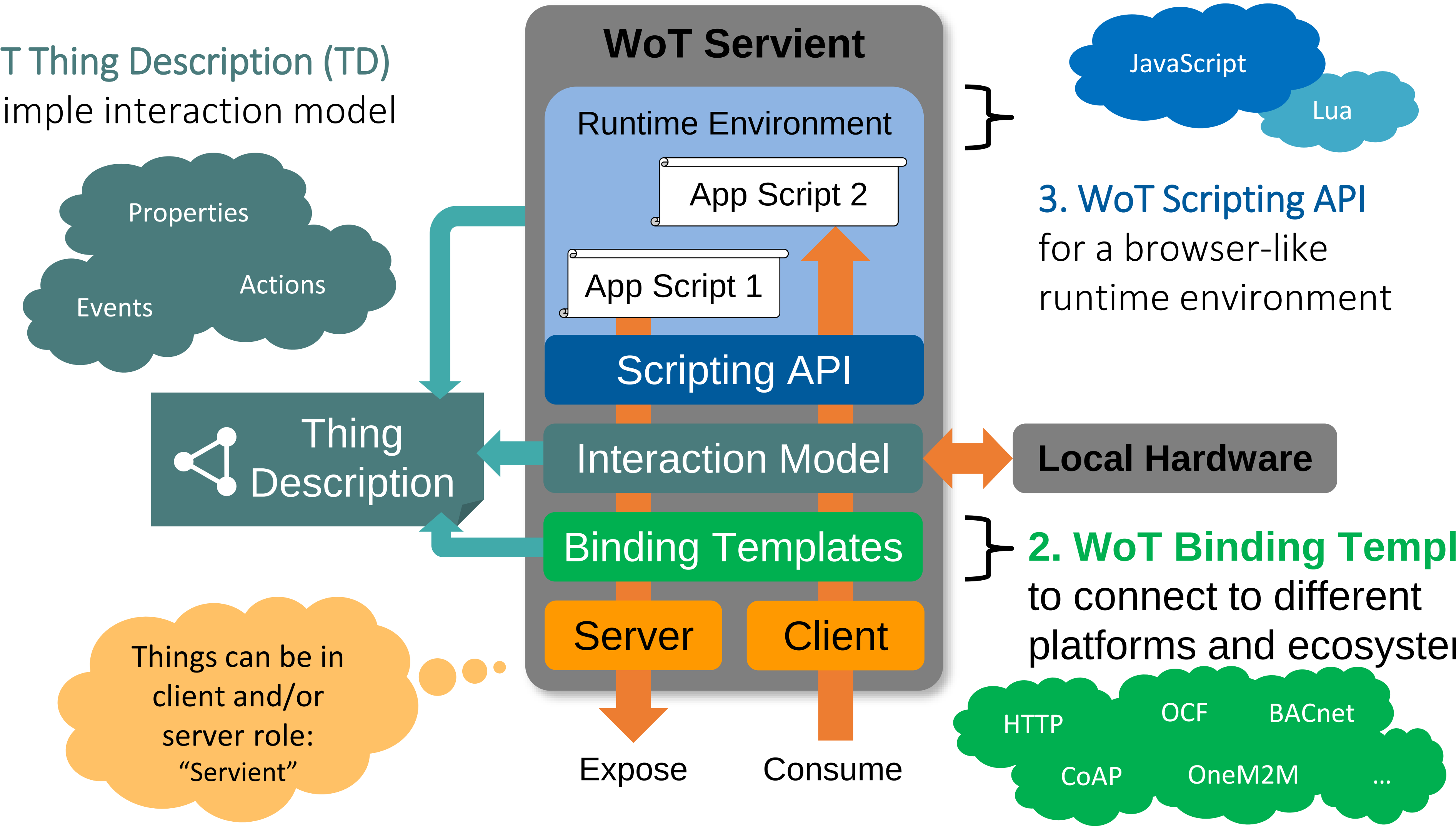
- Thing Description: metadata for WoT Things
- Scripting API: standardized mechanism to consume and expose Thing Descriptions and program the behaviour of Things
- Protocol Bindings: mappings of WoT architecture to various concrete protocols: HTTP, CoAP, MQTT, etc.

# Web of Things: Resources and Links

- W3C: World Wide Web Consortium: https://www.w3.org
- Web of Things Interest Group: https://www.w3.org/WoT/IG/
  - Charter: Leverage web standards and technology to enable IoT interoperation
  - Web architecture: https://www.w3.org/standards/webarch/
- Web of Things Working Group in the W3C to develop standard recommendations:
  - https://www.w3.org/2016/09/wot-wg-charter.html
  - Co-chairs: Matthias Kovatsch (Siemens), Kazuo Kajimoto (Panasonic), Michael McCool (Intel)
  - White paper on WoT architecture: http://w3c.github.io/wot/charters/wot-white-paper-2016.html
- WoT current practices: http://w3c.github.io/wot/current-practices/wot-practices.html

# WoT: Deliverables/Architecture

1. WoT Thing Description (TD) with simple interaction model



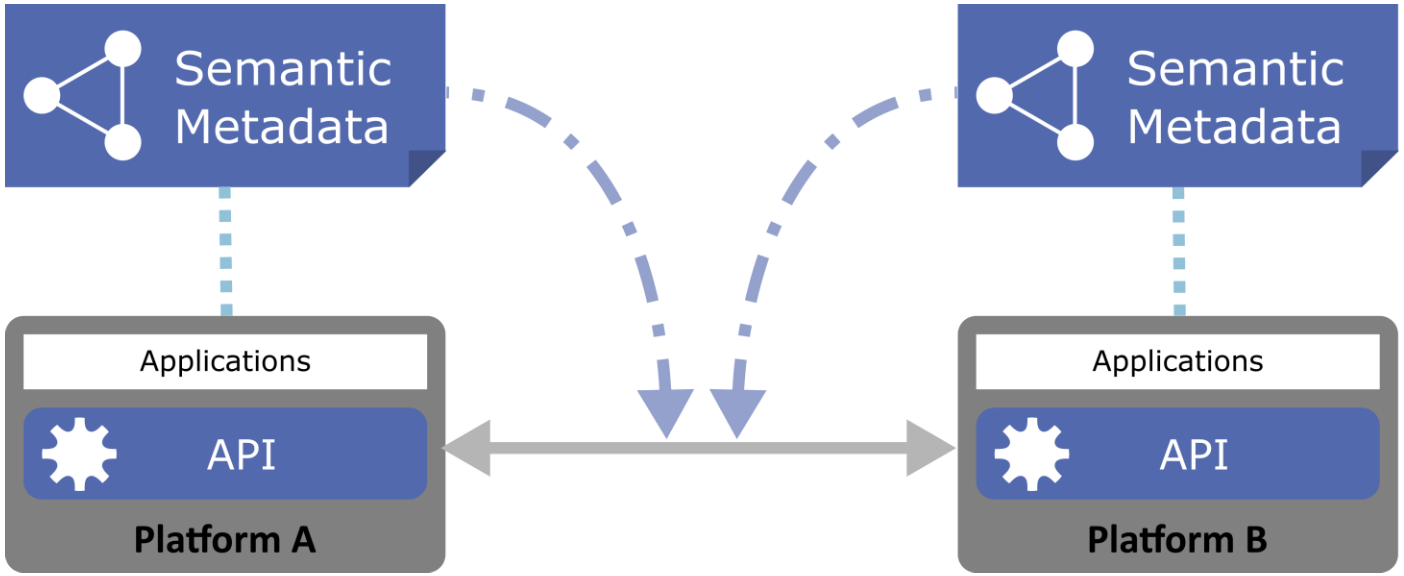
3. WoT Scripting API for a browser-like runtime environment

**2. WoT Binding Templates** to connect to different platforms and ecosystems

# WoT Key Deliverable: Thing Description

## Standardized Metadata

- Protocol-independent description of network APIs
- Communication and security requirements
- Data models and constraints
- Semantic annotation



# Thing D toin Example

JSON-LD
(Linked Data)

W3C WoT TD
vocabulary

```
{
  "@context": [
    "http://w3c.github.io/wot/w3c-wot-td-context.jsonld",
    { "domain": "http://example.org/actuator#" }
  ],
  "@type": "Thing",
  "name": "MyLEDThing",
  "base": "coap://myled.example.com:5683/",
  "security": {
    "cat": "token:jwt",
    "alg": "HS256",
    "as": "https://authority-issuing.example.org"
  },
  "interactions": [
    {
      "@type": ["Property", "domain:onOffStatus"],
      "name": "status",
      "outputData": {"valueType": {"type": "boolean"}},
      "writable": true,
      "links": [
        {
          "href": "pwn"
```

domain-specific
vocabulary

JSON Schema

```
"interactions": [
  {
    "@type": ["Property", "domain:onOffStatus"],
    "name": "status",
    "outputData": {"valueType": {"type": "boolean"}},
    "writable": true,
    "links": [
      {
        "href": "pwr",
        "mediaType": "application/exi"
      },
      {
        "href": "http://mytemp.example.com:8080/status",
        "mediaType": "application/json"
      }
    ]
  },
```

Property

```
  {
    "@type": ["Action", "domain:fadeIn"],
    "name": "fadeIn",
    "inputData": {
      "valueType": {"type": "integer"},
      "domain:unit": "domain:ms"
    },
    "links": [
      {
        "href": "in",
        "mediaType": "application/exi"
```

Action

```
      "inputData": {
        "valueType": {"type": "integer"},
        "domain:unit": "domain:ms"
      },
      "links": [
        {
          "href": "out",
          "mediaType": "application/exi"
        },
        {
          "href": "http://mytemp.example.com:8080/out",
          "mediaType": "application/json"
        }
      ]
    },
    {
      "@type": ["Event", "domain:alert"],
      "name": "criticalCondition",
      "outputData": {"valueType": {"type": "string"}},
      "links": [
        {
          "href": "ev",
          "mediaType": "application/exi"
        }
      ]
    }
  ]
}
```

Event
(sources, sinks, …)

# Problem 1: Local Links

**Risks**

- WoT is predicated on Web standards being useful for IoT
- However, the Web is oriented towards browsers and human-readable information, whereas the IoT is includes many machine-to-machine communications
- Web technologies generally also assume an active full internet connection. IoT devices may only have local network connectivity

Major pain point:

- Browser assumptions about certificate revocation checking under HTTPS
- Primarily affects use of HTTPS for “local” user interfaces

# Problem 2: Vulnerability Analysis

**Risks**

- Pervasive metadata allows attacker to analyze a system in detail to find vulnerabilities and plan an attack

**Opportunity**

- Pervasive metadata allows a system owner to analyze a system in detail to find vulnerabilities and prevent attacks

# Problem 3: Endpoint Adaptation

## Risks

- Protocol conversion bridges are vulnerable to attack, and protocol conversion may require “unpacking” data in flight, making it available to interception

## Opportunity

- A system wishing to talk to a WoT Thing can access the metadata for a thing and set up an end-to-end encrypted channel directly to that thing, bypassing multiple translation steps

# Problem 4: Semantic Discovery

**Risks**

- Semantic search is relatively expensive
  - Pathological semantic queries can be created that can consume an unreasonable amount of resources
- If semantic discovery services are “open”, then they will be subject to denial of service attacks

**Opportunity**

- Semantic discovery is a powerful capability we would like to make available to users

# Problem 5: Distributed Security

**Opportunity**

- A Thing Description can provide information that can be useful for enabling distributed security mechanisms

→ How can we make validated and authenticated Thing Descriptions available in a distributed fashion?

→ What distributed security mechanisms should we support and what information do they need?

# Summary

Main W3C WoT deliverable and differentiator:

- Universal metadata format (“Thing Description”) for IoT services (“Things”) and associated common Thing abstraction

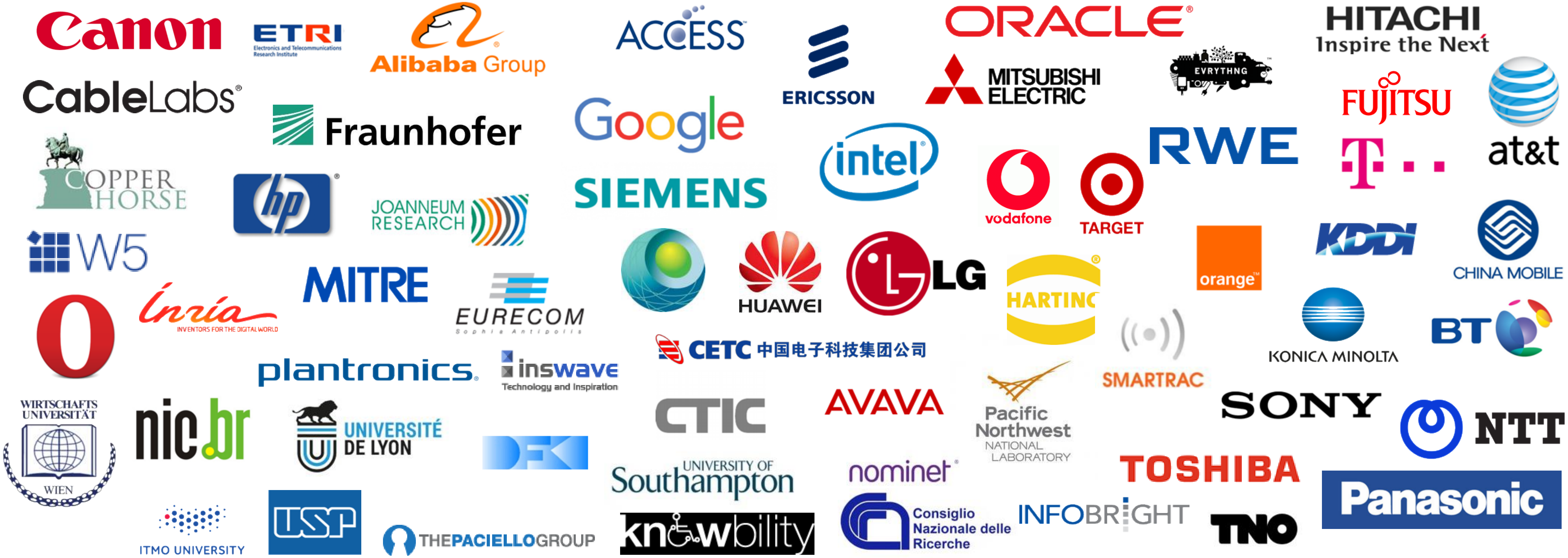
Use of Web Standards for IoT has specific issues:

- Local links, HTTPS, and certificates

Use of semantic metadata has specific risks and opportunities:

- Vulnerability analysis
- Endpoint adaptation vs. link-by-link translation
- Preventing denial-of-service attacks on semantic discovery services

# Web of Things: Interest Group Members


Canon
ETRI
Electronics and Telecommunications Research Institute
Alibaba Group
ACCESS
ERICSSON
ORACLE
HITACHI
Inspire the Next
CableLabs
Fraunhofer
Google
MITSUBISHI ELECTRIC
EVRYTHNG
FUJITSU
at&t
COPPER HORSE
hp
JOANNEUM RESEARCH
SIEMENS
intel
vodafone
TARGET
RWE
T · ·
W5
MITRE
EURECOM
Sophia Antipolis
HUAWEI
LG
HARTING
orange
KDDI
CHINA MOBILE
Inria
INVENTORS FOR THE DIGITAL WORLD
plantronics
inswave
Technology and Inspiration
CETC 中国电子科技集团公司
SMARTRAC
KONICA MINOLTA
BT
WIRTSCHAFTS UNIVERSITÄT WIEN
nic.br
UNIVERSITÉ DE LYON
DFKI
CTIC
AVAYA
Pacific Northwest NATIONAL LABORATORY
SONY
NTT
UNIVERSITY OF Southampton
nominet
TOSHIBA
Panasonic
ITMO UNIVERSITY
USP
THEPACIELLOGROUP
knowbility
Consiglio Nazionale delle Ricerche
INFOBRIGHT
TNO