Services for the Internet of Things with CoAP

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The Internet of Things as Seen by Gartner

- **Visibility**
  - Internet of Things in July 2014 … Plateau in 5–10 years
  - Peak of Inflated Expectations
  - Plateau of Productivity
  - Slope of Enlightenment
  - Trough of Disillusionment

TIME

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From Internet of Things Building Blocks ...
The Web of Things

Well-known patterns

Web mashups

Cloud services
Tiny Resource-constrained IoT Devices

Class 1 devices
~100KiB Flash
~10KiB RAM

TCP and HTTP are not a good fit
Closing the Gap

Constrained Application Protocol (CoAP)

Web Technology

Constrained IoT Devices
Constrained Application Protocol (CoAP)

- RESTful protocol designed from scratch
- Transparent mapping to HTTP
- Additional features for M2M scenarios

CoAP

- Request-Response Sub-layer
  - RESTful interaction
- Message Sub-layer
  - Reliability

- GET, POST, PUT, DELETE, URIs, and Internet Media Types
- Deduplication
- Optional retransmissions

UDP  DTLS  ...
e.g., Observing Resources

Resource state at origin server

Server

GET Observe

Notification

Notification

Notification

Notification lost

Max-Age

Retransmissions

Replicated state at client
e.g., Group Communication

**Enabled by IP multicast**

GET /status/power

PUT /control/color
    #00FF00

all-lights.floor-d.example.com
e.g., Alternative Transports

Short Message Service (SMS)

Addressable through URIs

\[\text{coap+sms://+123456789/bananas/temp}\]

Could power up subsystems for IP connectivity after SMS signal

* illustration only, +123456789 unfortunately not allowed by URI RFC

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Interoperability at the Application Layer

Web technology

Cloud services

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... to Web of Things Services
Authentication & Authorization
IETF ACE Working Group

- DTLS: all-or-nothing
- ACE: fine-grained policies defined by resource server
  - Per resource
  - Per access method (read/write)

- Rely on unconstrained delegates
  - Authorization servers
  - Can be split into resource owner and client domains
IETF ACE Working Group: Gap Analysis

Push

Authorization Server

Client

Resource Server

e.g., OAuth, Kerberos

Agent

Authorization Server

Client

Resource Server

Pull

Authorization Server

Client

Resource Server

e.g., EAP, ABFAB

Push & Confirm

Authorization Server

Client

Resource Server

e.g., OAuth token introspection

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Scaling Up to 200 Billion Connected Devices

Very high concurrency factors for services

New traffic patterns
Small but numerous messages

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Californium Architecture

http://www.eclipse.org/californium/

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Scalability: CoAP vs HTTP with Keep-Alive

Matthias Kovatsch, Martin Lanter, Zach Shelby

*Californium: Scalable Cloud Services for the Internet of Things with CoAP.*
Scalability: CoAP vs HTTP without Keep-Alive

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Service Descriptions
Classic Approaches

- Devices Profile for Web Services (DPWS)
  - WS-* specifications
  - Efficient XML Interchange (EXI)

- oneM2M
  - M2M super specification: ARIB, ATIS, CCSA, ETSI, TIA, TTA, TTC
OMA Lightweight M2M

- Device management
  - Bootstrapping
  - Registration
  - Function sets (Objects)
  - Access control
  - Reporting

- M2M communication
  - Object IDs (fixed URIs, e.g., /12/1/3)
  - Interfaces (read, write, execute, batches)
  - Payloads (text/plain, binary, JSON)
  - Open registry → ipso Alliance
RESTful M2M Services

- Design of new Internet Media Types
  - *Reuse* as far as possible
    - (http://www.iana.org/assignments/media-types/media-types.xhtml)
  - *Standardize* meaningful, re-usable types (e.g., SenML)
    - (RCF 6838)
- Definition of machine-readable link relations
  - CoRE Link Format attributes
  - *Bottom-up semantics* for self-configuration
And many more challenges

Interaction models

Application runtime

Lifecycle management

Business models
Questions?

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https://github.com/mkovatsc/
http://people.inf.ethz.ch/mkovatsc/
Resource-constrained Devices and Efficiency

https://github.com/contiki-os/contiki

- Embedded CoAP Web server for Contiki OS
- Thin server architecture
- Small size and intuitive resource handler API
- Application-agnostic device infrastructure
IoT Cloud Services and Scalability

http://www.eclipse.org/californium/

- Java CoAP framework at the Eclipse Foundation
- IETF “running code”
- Unconstrained service backend for myriads of IoT devices
- DTLS 1.2 implementation
- Basis for Actinium (Ac)
The Human in the Loop I

http://www.eclipse.org/californium/

- App-server for Californium
- IoT mashups for automation in the background
- Server-side JavaScript
- CoapRequest object API
- RESTful lifecycle management
The Human in the Loop II
https://addons.mozilla.org/firefox/addon/copper-270430/

- CoAP protocol handler for Mozilla Firefox
- Browsing and bookmarking of CoAP URIs
- Interaction with resource like RESTClient or Poster
- Treat tiny devices like normal RESTful Web services