sMAP – a Simple Measurement and Actuation Profile for Physical Information

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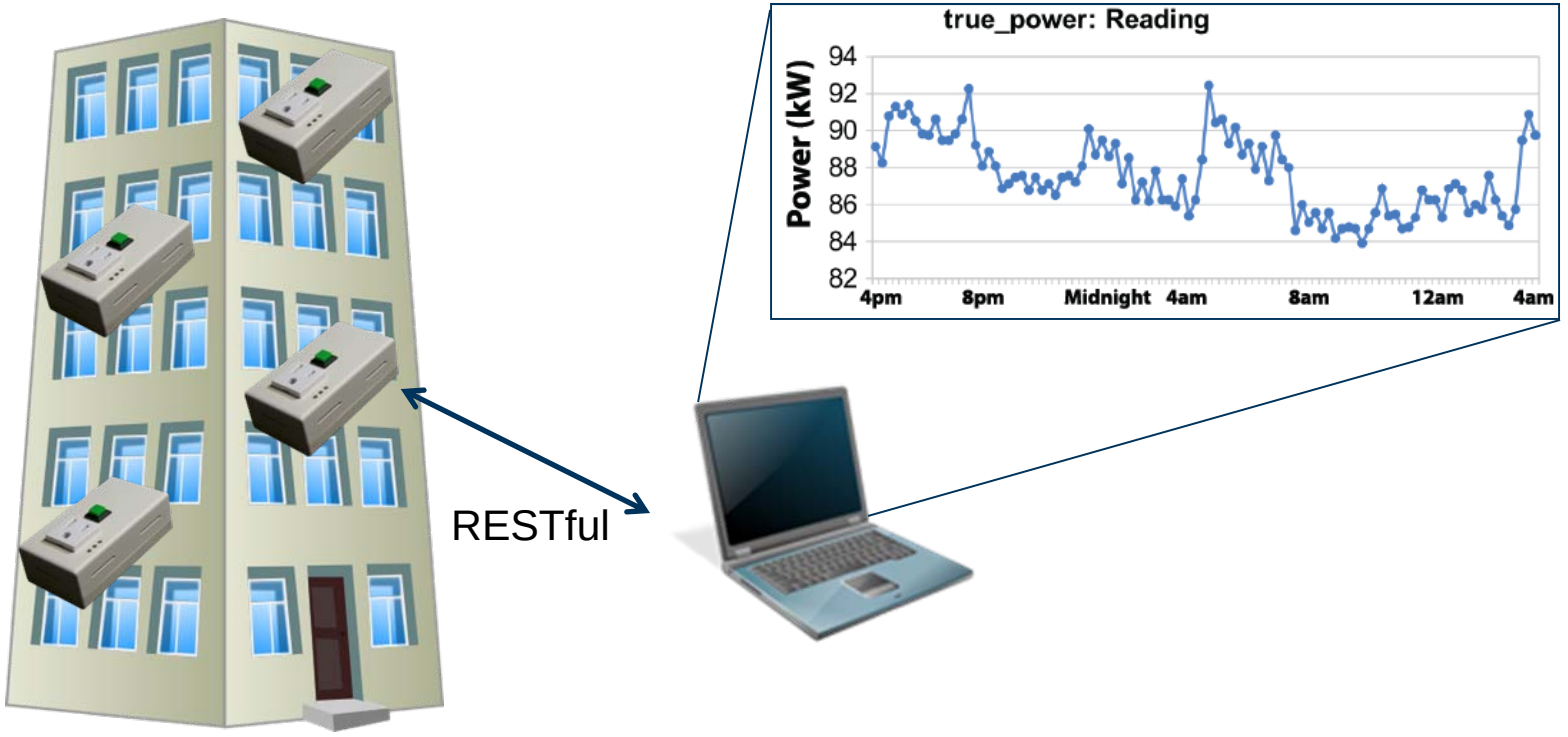
Presentation by Ilias Rinis

sMAP Scenario




```
http://smap-root/data/35/sensor/power/profile
```

Building from [http://www.clker.com/clipart-25562.html]

ACme Sensors from [http://acme.cs.berkeley.edu]

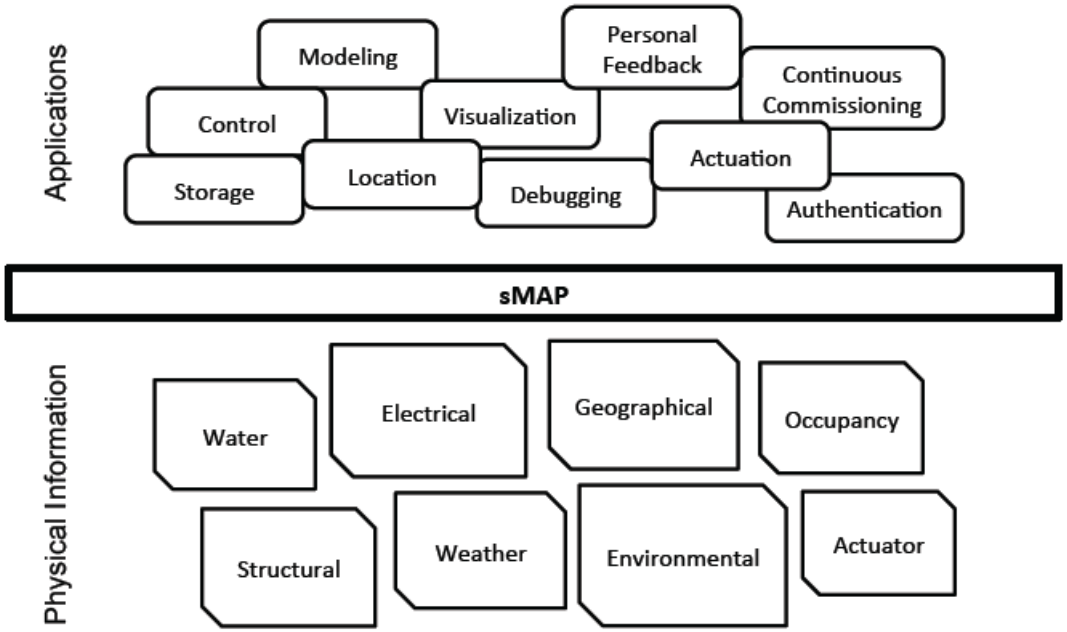
Motivation

- Availability of physical information
- Instrumentation evolves
  - Networked instruments
  - Sensors, actuators
- Challenging management
  - Dependent interpretation of physical information
  - Diversity of sensors
  - Efficiency requirements

Goals

- Integration of diverse sources
- Uniformity, machine independence
- Self-describing physical information

} Web Service



[Dawson-Haggerty 2010]

BACKGROUND

Different communities have addressed several related topics

Related Work

- Compact protocol design
- Decentralized architecture
- Syndication
  - Publish / Subscribe
  - Notifications
- Data representation
  - Simple, self-describing
  - Machine independent

RESTful Web Services

- REpresentational State Transfer
  - Architectural Style
  - URIs, Standardized data formats
  - Definition of architectural constraints
  - Typically implemented using HTTP methods

- Imagine a temperature sensor and a light switch
  - GET `http://example.com/resources/device0/temperature`
  - DELETE `http://example.com/resources/device0`
  - PUT `http://example.com/resources/actuator/light`

RESTful Web Services

- REST vs. SOAP
  - Lightweight
  - Easy to build services
  - Component mplementation is free, typically uses only HTTP
  - Security straightforward with HTTP semantics

JSON: JavaScript Object Notation

- JSON

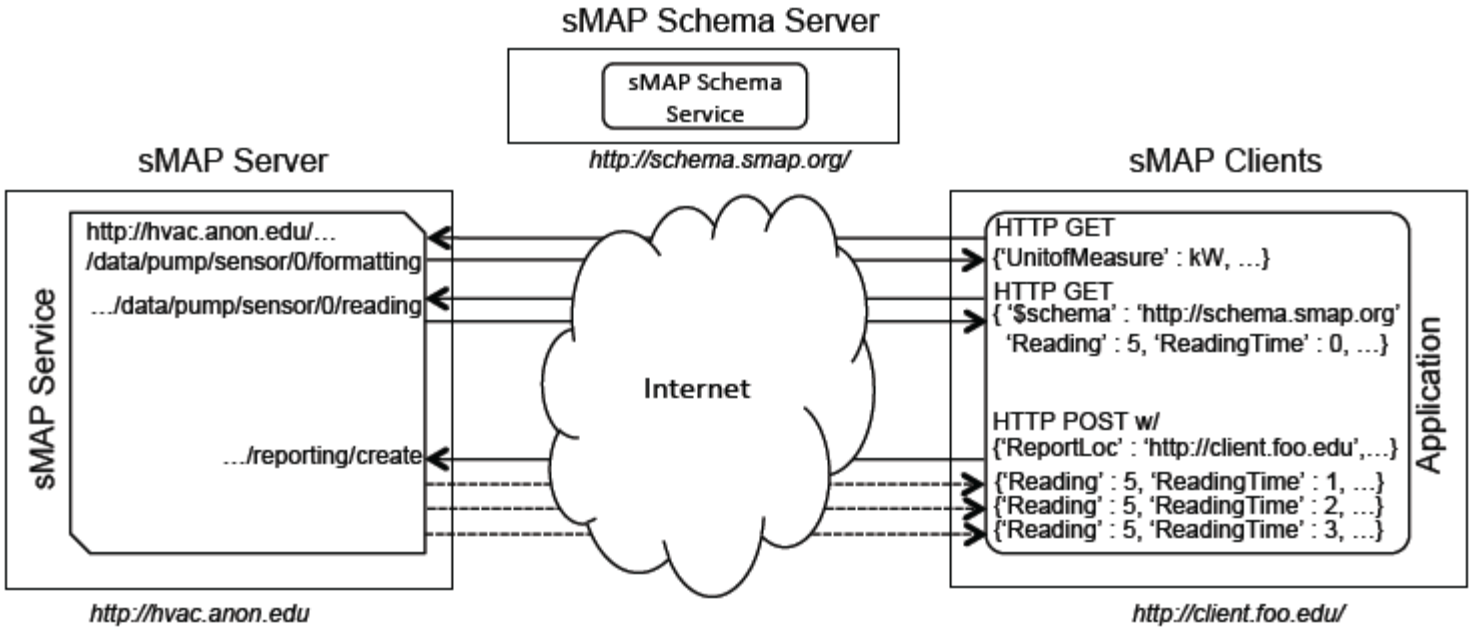
```
{"UnitofMeasure" : "kW",
 "Multiplier" : 1,
 "Divisor" : 1,
 "UnitofTime" : "second",
 "MeterType" : "electric" }
```

- vs XML
  - Simpler, smaller
  - No reference support (`<foobar id="foo">`)
  - API not standardized
  - Verification based on schema
  - Binary formats available for both

DESIGN OF SMAP

Metrology Design and Architecture of the Service

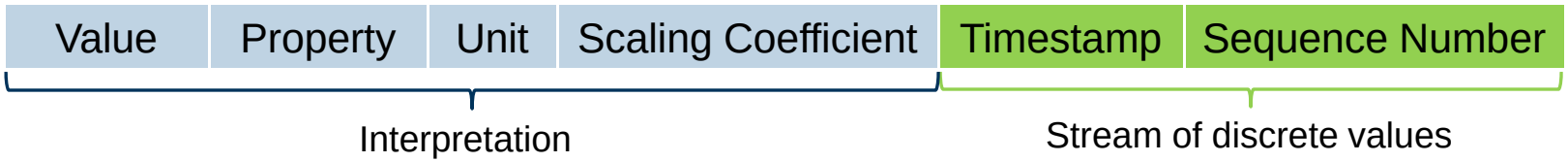
sMAP Usage



[Dawson-Haggerty 2010]

Metrology

- Representation
  - Scalar Measurements



  - Units
    - Enumerated list, simple strings
  - Traceability
    - Unique Identifier

Metrology

- Location
  - Multiple scalar quantities per instrument
  - Data source decomposition
    - Measurement Point (a circuit-level meter)
    - Channel (voltage reading, power reading)

Metrology

- Modalities
  - Sensing
    - Instantaneous measurement
  - Metering
    - Accumulated quantities
  - Actuation
    - `get` and `set` operations
    - Nonce

Binary	Two discrete states
N - State	Finite set of positions
Set Point	Setting in a continuous range
Control Bands	Control loop with min and max range

The Web Service

- RESTful
  - Each device provides a RESTful web service
  - Several resources per device

- HTTP Access
  - Sense points and channels as standardized URLs

```
/<resource>/<point>/<modality>/<channel>/<object>
```

  - Sensing and metering: GET method
  - Actuation: POST method

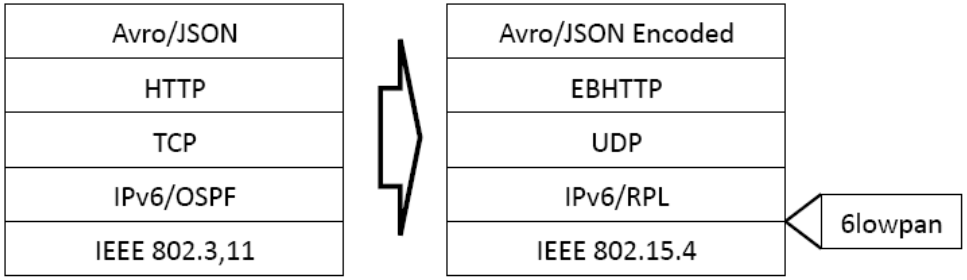
The Web Service

- Four top-level resources
  - `/data` : reading and controlling modalities
  - `/reporting` : periodic reporting propagation
  - `/status` : device status information
  - `/context` : relationship with other devices

- To access a measurement
  - `/data/reading`
  - `/data/formatting`

Adaptations

- Resource constrained networks and devices
- blip: 6lowpan + HYDRO
- Embedded Binary HTTP
- Binary JSON
- Transcoding by edge routers and HTTP Proxies



[Dawson-Haggerty 2010]

Adaptations

- EBHTTP
  - Minimal transport and space overhead
  - Unacknowledged delivery
  - Elimination of unused headers
- Binary JSON
  - Documents refer to a schema
  - Index from the schema instead of string

IMPLEMENTATION AND EVALUATION

Evaluating and demonstrating the design and usage of sMAP

Complete and General

- Building monitoring project
  - Circuit meters
  - Vibration, humidity, temperature
  - Light switches
  - External weather data
- ACme‘s
  - Senses power, meters energy, actuates a relay

Name	Sensor Type	Physical Layer	Sense Points	Channels
Cory Hall Submetering	Dent 3-Phase	Modbus/Ethernet	40	1600
Cory Hall Building Power	ION and PQube	HTTP/Ethernet	3	150
Cory Lab Temperature	TelosB [28]	802.15.4 + Ethernet	4	8
Cory Lab Machines	ACme [15]	802.15.4 + Ethernet	8	16
Cory Chilled Water	HeatX Meter	Modbus/Ethernet	1	11
Cory Roof Environmental	Hydrowatch Node [34]	802.15.4 + Ethernet	4	36
Soda Sun Blackbox	Fan Speed; Environmental	HTTP/Ethernet	10	84
Soda Lab Machines	ACme	802.15.4 + Ethernet	40	80
Soda Lab Panel	Veris E30 Meter	Modbus/Ethernet	1	42
LBNL Building 90	ACme	802.15.4 + Ethernet	70	140
Berkeley Weather	`wunderground` and Viasala WXT520	HTTP + Serial	2	20

[Dawson-Haggerty 2010]

Complete and General

- SenSys IPSN Proceedings study
  - Novel ideas but simple physical information
- Limitations
  - High frequency data
  - JSON parsing, validation

Scalable

- Up – Millions of clients
  - Scales as the Internet
- Down – Embedded devices
  - No TCP handshaking
  - ASCII to binary conversion
  - Unneeded HTTP headers

	HTTP (octets)	EBHTTP (octets)
Request		
TCP/UDP	190	8
HTTP/EBHTTP	152	4
URL	35	35
Response		
TCP/UDP	192	8
HTTP/EBHTTP	123	4
JSON/Packed JSON	167	25
Total	859	84

[Dawson-Haggerty 2010]

Applications

- Vizualization
  - sMAP Console (http://smap.cs.berkeley.edu/)
  - Google PowerMeter
- Storage
  - Historical and real time query engine
- Personal Energy Footprint
  - Mobile phone
  - Room appliances, actuation

RELEVANT WORK IN ETH

Institute for Pervasive Computing

The Web of Things

D. Guinard, V.Trifa, F.Mattern, E.Wilde

"We hope that the Web of Things can do for real-world resources what the Web did for information resources" *[Guinard 2010]*

- "Smart things" fully integrated with the Web
- REST Architecture similar to sMAP
  - GET http://.../sunspots/spot1/sensors/light
  - PUT http://.../sunspots/spot1/actuators/leds/1
  - HTTP + JSON

References

- [Dawson-Haggerty 2010]: S.Dawson Haggerty, X.Jiang, G.Tolle, J.Ortiz, D.Culler: *sMAP – a Simple Measurement Actuation Profile for Physical Information*, Sensys 2010, Zurich, Switzerland November 2010.
- [Fielding 2000]: R.T. Fielding: *REST: Architectural Styles and the Design of Network-based Software Architectures,* Doctoral dissertation, University of California, Irvine, 2000.
- [Guinard 2010]: D. Guinard, V.Trifa, F.Mattern, E.Wilde: *From the Internet of Things to the Web of Things: Resource Oriented Architecture and Best Practices,* Institute for Pervasive Computing, ETH Zurich