Introduction to

IPSO Smart Objects

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September 1st, 2015

The Web

- Narrow Waist
  - Innovation happening on endpoints.
- Stateless Interaction
  - REST APIs
  - HTTP client/server model and a request/response communication model.
  - HTTP stateless methods to indicate the server what to do. (GET, POST, PUT, HEAD, DELETE, TRACE).
- Focus on Resources and Content
  - Support of extensive representation formats (e.g. HTML, JSON, XML etc.)
  - Web content can be anything (HTML files, images, video…) each piece of information is a resource.
- Uniform Addressing
  - Resources are identified URIs, either by location or by name.
  - Hyperlinks pointing to resources.
  - IP addressing and global DNS.

Constrained Application Protocol (CoAP)

- It is a RESTful protocol for constrained devices and networks. Similar to HTTP:
  - Client/server & Request/Response
  - GET, POST, PUT and DELETE Methods (now PATCH too)
  - Same key concepts (Media types, URL, URN…)
- The *well-known* URI

```
coap://[2001:db8::2:1]/.well-known/core
```

- Resource discovery via the Resource Directory (RD)

```
Request   coap://HOST_ADDRESS:PORT_NUMBER/PATH?QUERY
Response coap://ericsson.com:5683/rd/jorvas/room/541/temperature/
```

- IPv6 oriented (using 6LowPAN)
- UDP preferred instead of TCP, SMS also possible
  - Reliability is ensured by using with different message types:
  - *Confirmable* (CON)*, non-confirmable* (NON), *acknowledgement* (ACK) and *reset* (RST).
- Observe/Notify, adding an “observe” flag in the CoAP GET Request
  - Introduces a Publish/Subscribe model for constrained devices.

Web Linking for Constrained Devices

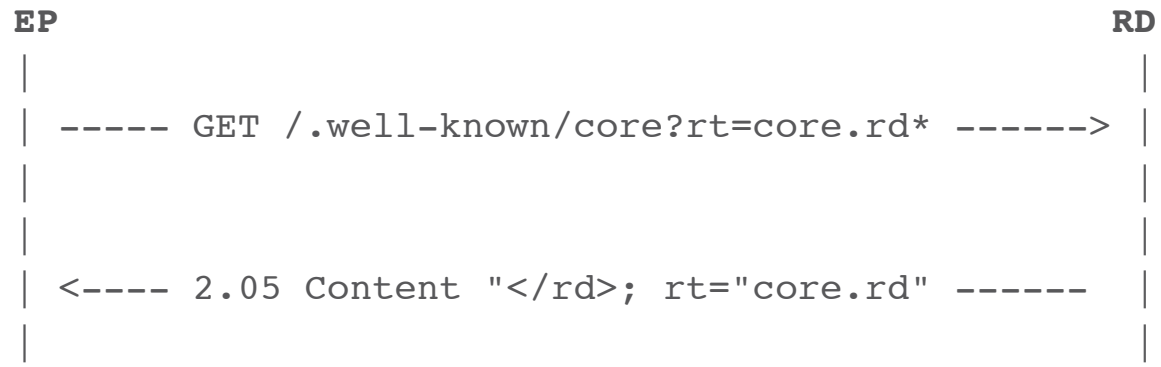
- RFC6690 Constrained RESTful Environments (CoRE) Link Format.
  - Reuses Web Linking RFC5988 for IoT.
  - Defines semantic link serialization and M2M content types.
  - GET ./well-known/core?optional_query_string.
  - Enables query string parameters for discovery by attribute and relation (rt, if, sz). The response looks like:

```
<3303/0/5700>;rt="ipso:temp";ct="0";obs=1
```

  - Links are discovered using GET with content type "application/link-format"
  - JSON representation using GET with content type "application/link-format +json"

Discovery for Constrained Devices

- CoRE Link defines
  - Link format
  - Device to device discovery.
- Resource Directory draft adds
  - Sleepy node support.
  - No multicast needed.
  - Remote lookup, hierarchical and federated distribution.
- Core Link is also used in RD
  - EP POST (register) resource links to RD.
  - EP PUT (refresh) to RD.
  - EP DELETE (remove) their RD entry.

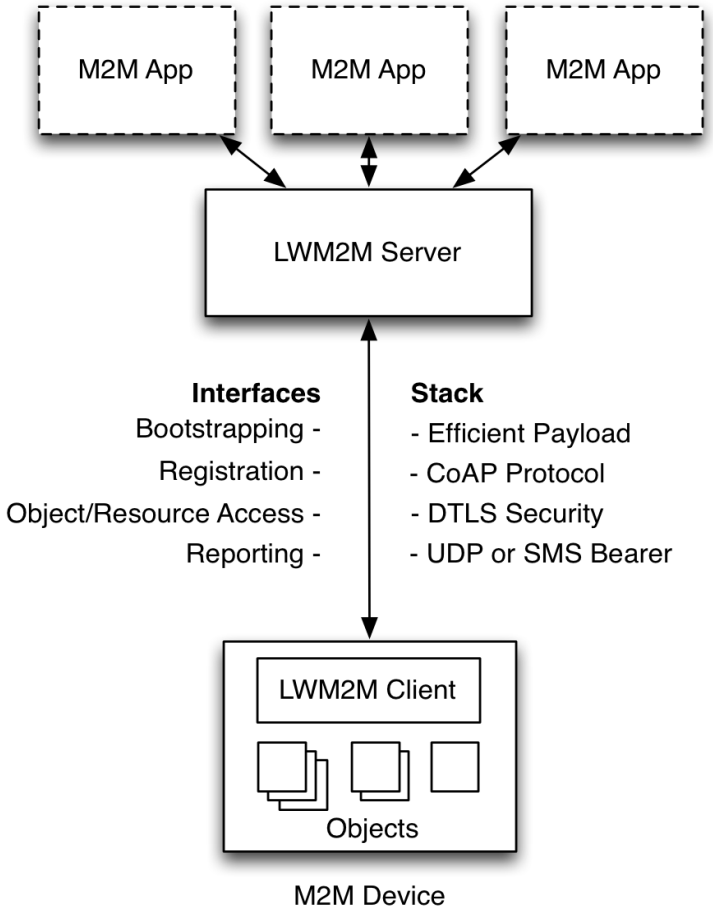



```
 Req: GET coap://[ff02::1]/.well-known/core?
rt=core.rd*

 Res: 2.05 Content
 </rd>;rt="core.rd",
 </rd-lookup>;rt="core.rd-lookup",
 </rd-group>;rt="core.rd-group"
```

OMA Lightweight M2M (LWM2M)

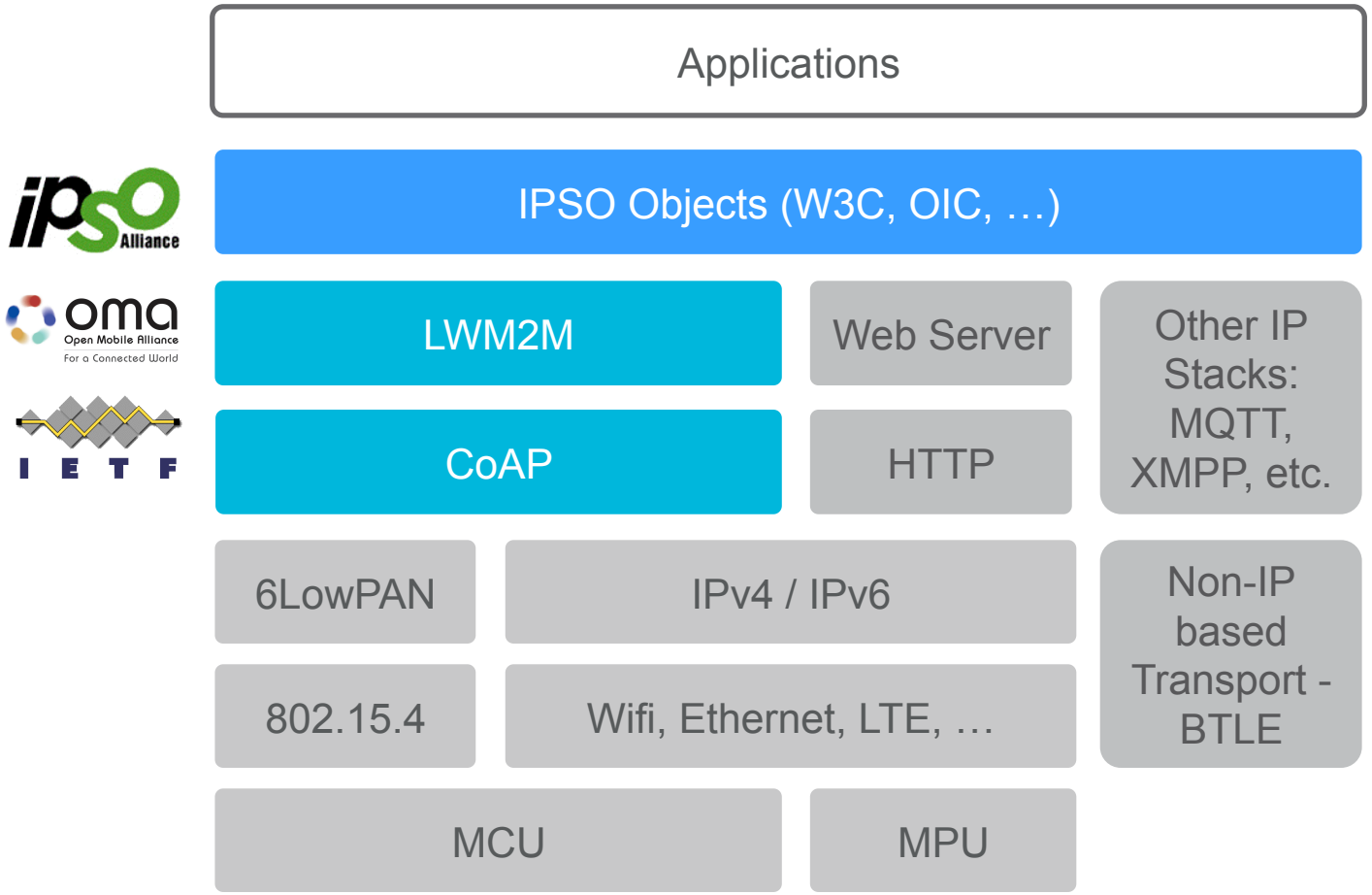
- Based on CoAP (runs on top) and used for management and control of constrained devices
- Provides a set of interfaces for managing of constrained devices.
  - Bootstrap
  - Registration
  - Information Reporting
  - Device Management
  - Service Enablement
- Also allows for operations on objects (RWX, Access Control, Observation, Notification)
- Offers a simple object based model.



Next issue?

Semantic Interoperability for IoT

The Web in constrained devices



IPSO Smart Objects

- Developed by IP for Smart Objects (IPSO) Alliance in the Smart Objects Working Group.
- Work exclusively on semantic Interoperability across IoT devices and applications.
- Based on LWM2M Object Model.
- Reusable Object IDs and Resource IDs.
- Protocol Independent (CoAP, LWM2M, MQTT, HTTP…) if support addressing, content formats and data types.
- Encoding Independent (JSON, TLV, SenML…)
- Basic Objects represent simple sensors and actuators.
- Basic Starter Pack published (2014)
- Expansion Pack Published (31st August 2015)
- Tested over CoAP and LWM2M during IPSO Interoperability test on May 2015 (ARM, Ericsson, Intel, SICS, Yanzi, TUT …) .

Example 1: IPSO Humidity Sensor

Object	Object ID	Object URN	Multiple Instances?	Description
IPSO Humidity	3304	**urn:oma:lwm2m:ext:3304**	Yes	Relative humidity sensor, example units = %

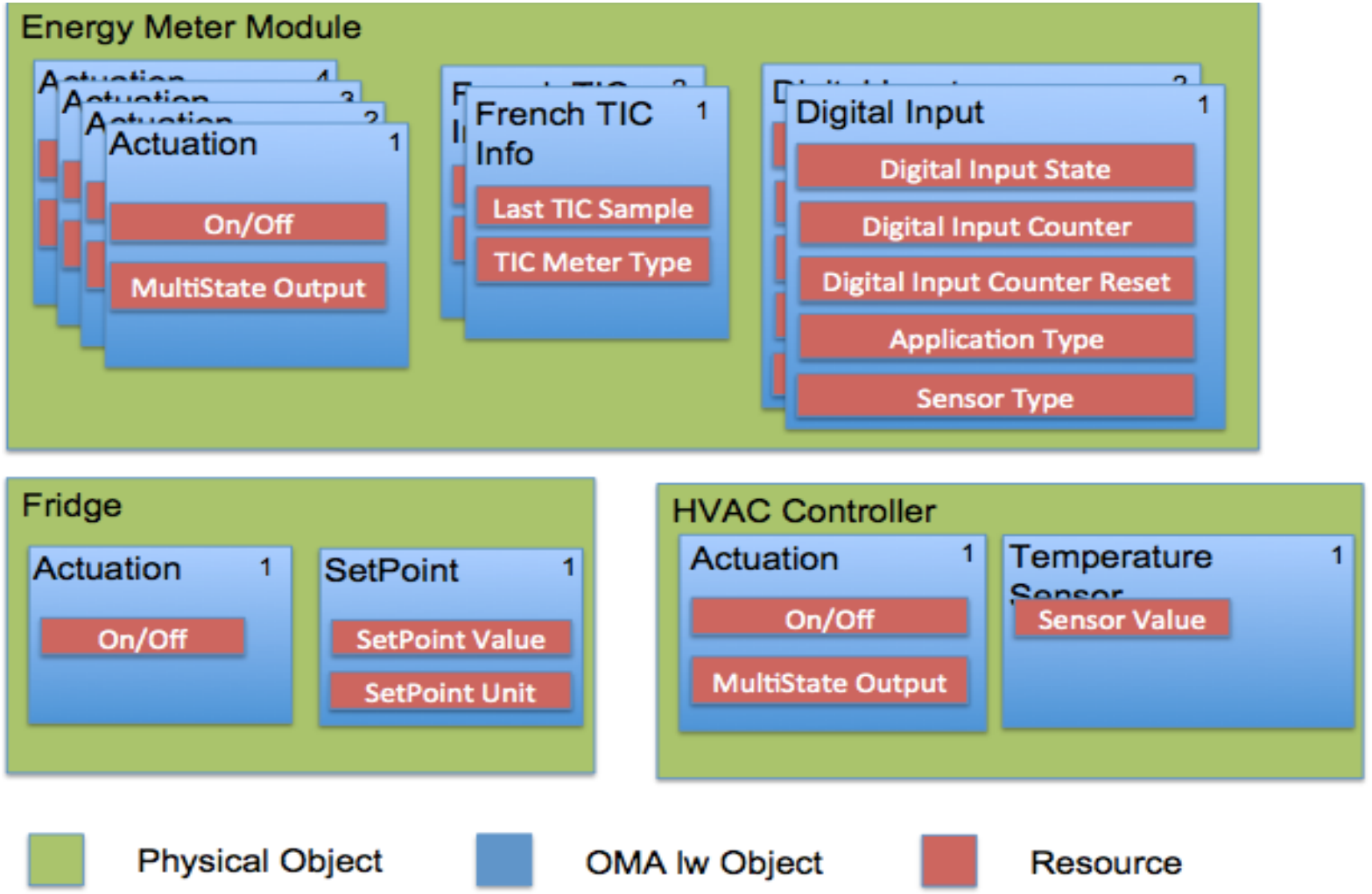
Resource Name	Resource ID	Access Type	Multiple Instances?	Mandatory	Type	Range or Enumeration	Units	Descriptions
Sensor Value	5700	R	No	Mandatory	Float			Last or Current Measured Value from the Sensor
Units	5701	R	No	Optional	String			Measurement Units Definition e.g. “Cel” for Temperature in Celsius.
Min Measured Value	5601	R	No	Optional	Float	Same as Measured Value	Same as Measured Value	The minimum value measured by the sensor since power ON or reset
Max Measured Value	5602	R	No	Optional	Float	Same as Measured Value	Same as Measured Value	The maximum value measured by the sensor since power ON or reset
Min Range Value	5603	R	No	Optional	Float	Same as Measured Value	Same as Measured Value	The minimum value that can be measured by the sensor
Max Range Value	5604	R	No	Optional	Float	Same as Measured Value	Same as Measured Value	The maximum value that can be measured by the sensor
Reset Min and Max Measured Values	5605	E	No	Optional	Opaque			Reset the Min and Max Measured Values to Current Value

Example 2: New Reusable Object

Object	Object ID	Object URN	Multiple Instances?	Description
Company Humidity	n	urn:company:ext:1	Yes	Relative humidity sensor, example units = %

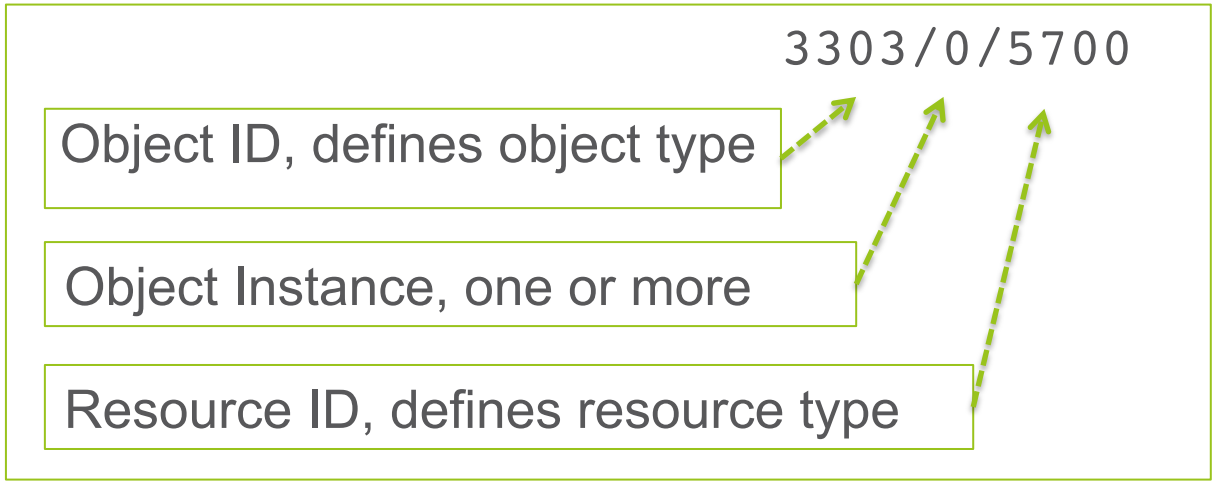
Resource Name	Resource ID	Access Type	Multiple Instances?	Mandatory	Type	Range or Enumeration	Units	Descriptions
Sensor Value	5700	R	No	Mandatory	Float			Last or Current Measured Value from the Sensor
Units	5701	RW	No	Optional	String			Measurement Units Definition e.g. “Cel” for Temperature in Celsius.
Reset Units	12000	E	No	Optional				Reset the Min and Max Measured Values to Current Value
On/Off	5850	R, W		Mandatory	Boolean			This resource represents an on/off actuator, which can be controlled, the setting of which is a Boolean value (1,0) where 1 is on and 0 is off.

Example 3: Composite Object



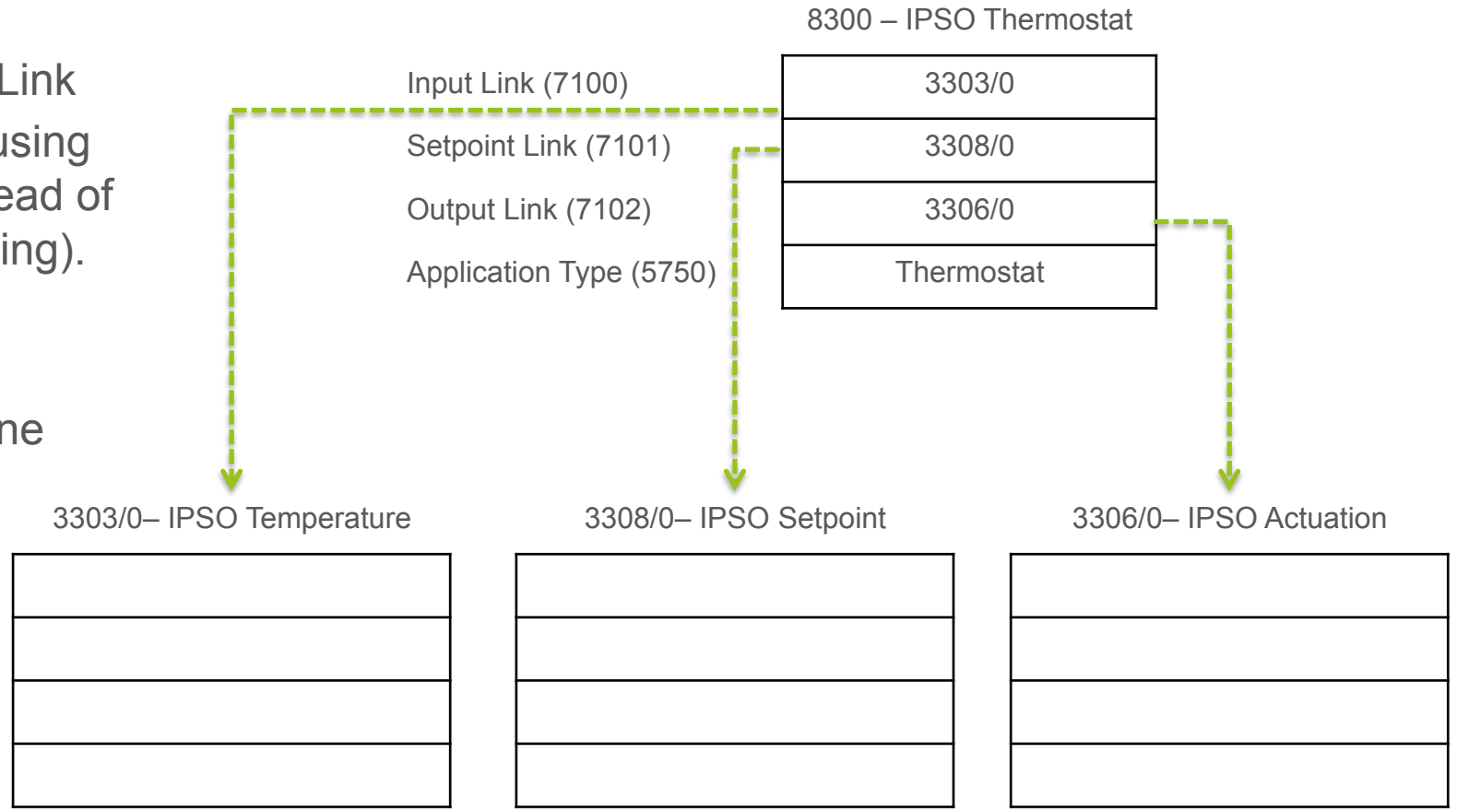
IPSO Smart Object Structure

- Reusable Data Model for Constrained Devices
  - Across domains
- Reusable resource and object IDs
  - Common definitions for concepts
  - Map to semantic terms e.g. temperature, currentValue
  - IDs are registered with the OMNA
- Usable in different transport protocols that support
  - URI Addressing
    - (…/home/weather/3303/0/5700)
  - Data Types
  - Content Formats
  - RWX Operations



IPSO Object Linking

- New LWM2M data type: Object Link
- Composite objects can be built using by referring to other objects instead of explicitly adding resources (nesting).
- Similar to the web-like pattern, following links.
- Linked objects are serialized inline using SenML.



Roadmap I

- ☐ UPnP harmonization – from SOAP to REST (ongoing).
- ☐ Schema.org for registration of instances and schemas.
- ☐ BLE/ZigBee harmonization (ongoing).
- ✔ Draft Smart Object Data Model Design Guide @done (15-03-30)
- ✔ Draft Smart Object Expansion Pack for Basic Objects @done (15-04-30)
- ✔ Set up test servers for IPSO objects (LWM2M + TLV payload) @done (15-06-15)
- ✔ Draft Domain Specific Objects reference designs @due (mid 2015)
- ✔ Publish Smart Object Data Model Design Guided @due(15-07-31)
- ✔ **Publish Smart Object Expansion Pack for Basic objects @done(31-08-31)**
- ✔ **Publish Smart Object Expansion Pack for Composite Objects @done(31-08-31)**
- ☐ ~~Publish Smart Object Expansion Pack for Reference Devices @done(15-07-31)~~
- ☐ **IETF 94 – Bits and Bites @due(15-11-1)**
- ☐ **IPSO Challenge – Bits and Bites @due(15-11-1)**
- ☐ **IAB Sponsored Workshop – @due(2016)**

Roadmap II

- Current work
  - **IPSO Expansion Pack** with new basic Objects: https://github.com/IPSO-Alliance/SmartObjectGuidelines/tree/master/BasicObjects/SmartObjectExpansionPack
  - IPSO Challenge! http://challenge.ipso-alliance.org (Demos in December):
  - IETF 93 Bits and Bites participation, November IETF in Yokohama.

Type	Object	Object ID
Common Template Sensors	Voltage	3316
	Current	3317
	Frequency	3318
	Depth	3319
	Percentage	3320
	Altitude	3321
	Load	3322
	Pressure	3323
	Loudness	3324
	Concentration	3325
	Acidity	3326
	Conductivity	3327
	Power	3328
	Power Factor	3329
	Rate	3346
	Distance	3330
Special Template Sensors	Energy	3331
	Direction	3332
	Time	3333
	Gyrometer	3334
	Color	3335
	GPS Location	3336
Actuators	Positioner	3337
	Buzzer	3338
	Audio Clip	3339
	Timer	3340
	Addressable Text Display	3341
Controls	On/Off Switch	3342
	Push Button	3347
	Dimmer	3343
	Up/Down Control	3344
	Multistate Selector	3348
	Multiple Axis Joystick	3345

Roadmap III

- Future Work
  - Alignment across organizations on Semantic Interoperability to be expected for 2016.
  - **Internet Architecture Board (IAB) Sponsored Workshop: "Data Model Alignment for Internet of Things".** Discussing the harmonization of information and data models for use with Internet of Things deployments. https://docs.google.com/document/d/1vs8f3AdT0hFAP4C1WUa9WMio8FuY8_X4-kdcbVMOemk/edit?usp=sharing.
  - Program Committee: Jari Arkko (IAB/Ericsson), Dave Thaler (IAB/Microsoft), Michael Koster (ARM), Hannes Tschofenig (ARM), Jaime Jimenez (Ericsson), Ralph Droms (IAB/Cisco)…
  - IPSO, W3C, OIC, Allseen Alliance, CableLabs, XMPP Foundation, OneM2M, Home Gateway Initiative, UPnP, Bluetooth SIG, HyperCat, OMA, ZigBee, IEEEP, IETF.

References

- IPSO Smart Object Guidelines
  - http://www.ipso-alliance.org/smart-object-guidelines
  - https://github.com/IPSO-Alliance (requires access)
- OMA LWM2M Specification
  - http://technical.openmobilealliance.org/Technical/technical-information/release-program/current-releases/oma-lightweightm2m-v1-0
- IETF CoAP References
  - CoAP (RFC 7252)

    https://tools.ietf.org/html/rfc7252
  - CoRE Link-Format (RFC 6690)

    https://tools.ietf.org/html/rfc6690
  - CoRE Resource Directory

    https://tools.ietf.org/html/draft-ietf-core-resource-directory-02
  - CoRE CoAP PubSub Broker

    https://tools.ietf.org/html/draft-koster-core-coap-pubsub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