Internet of Things

Machine to Machine Communications

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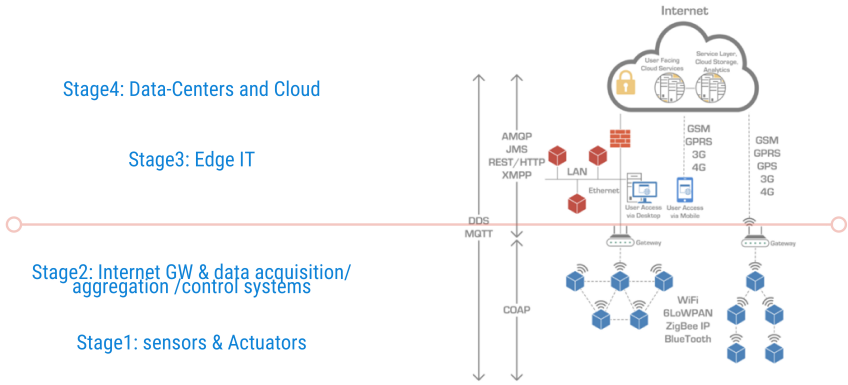
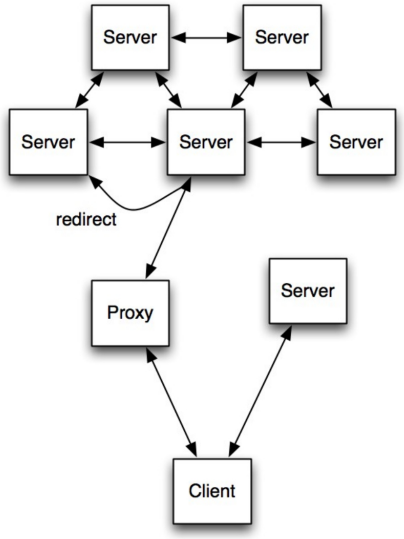
Lecture 6:
Machine to Machine Communications

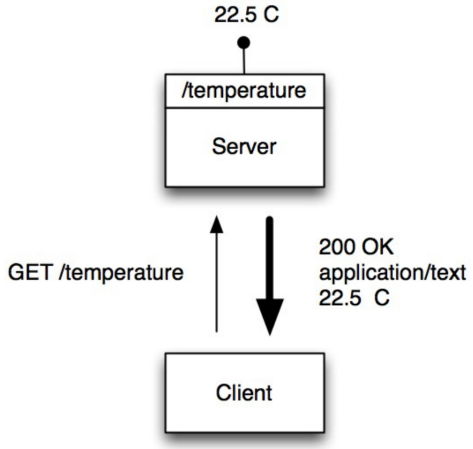
Components, Processing Stages and Protocols



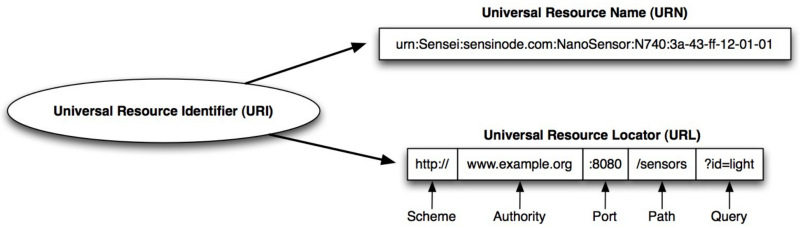
The Web and REST



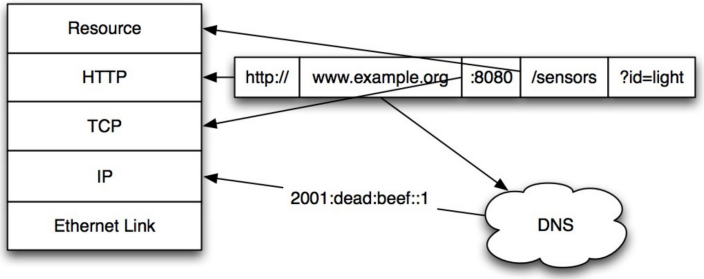
A REST Request



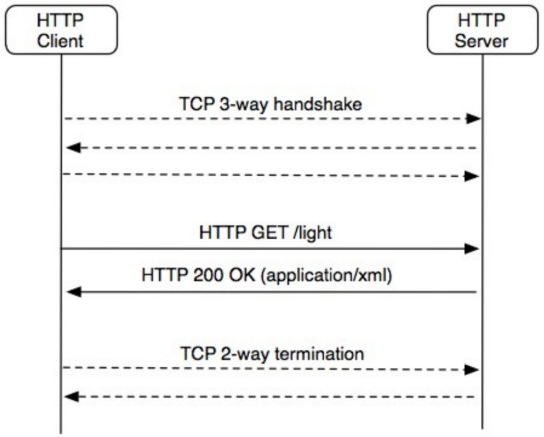
Web Naming



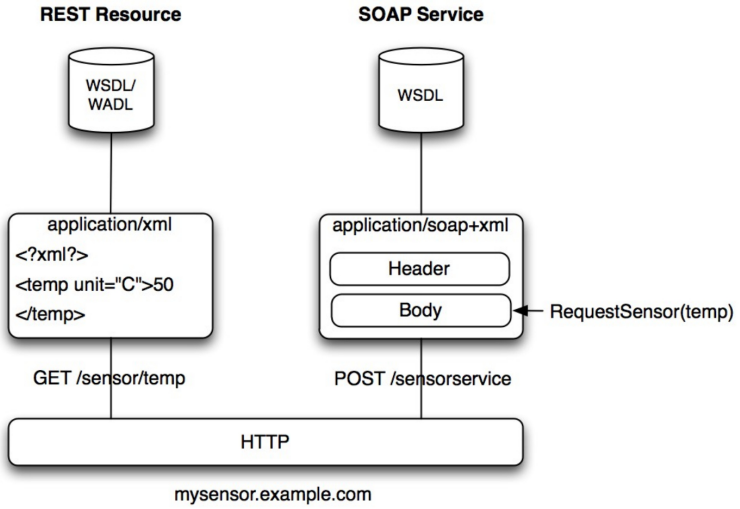
URL Resolution



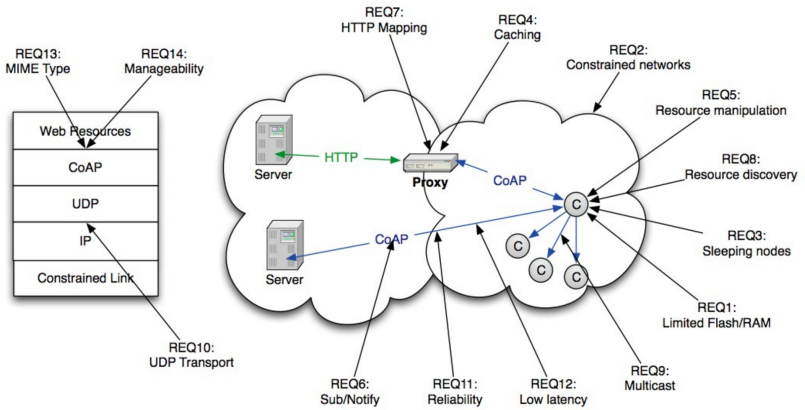
An HTTP Request



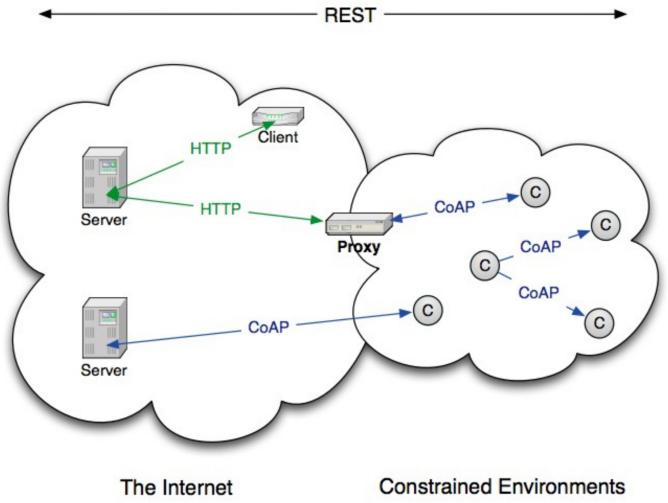
Web Paradigms



CoAP Design Requirements



The CoAP Architecture



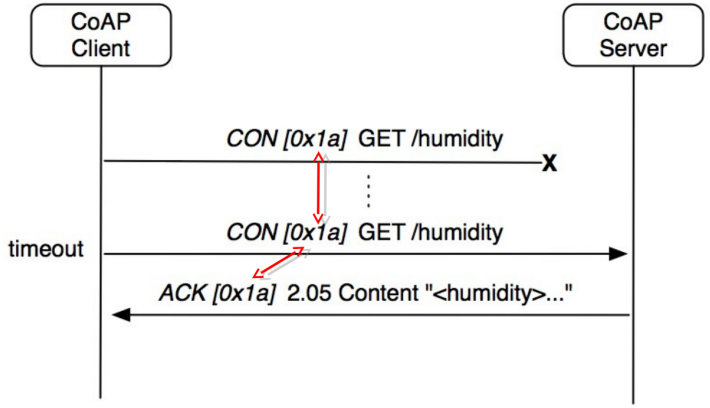
The CoAP Protocol

- A very efficient RESTful protocol
- Ideal for constrained devices and networks
- Specialized for M2M applications
- Easy to proxy to/from HTTP
- Does not replace HTTP
- Is not a cut-down HTTP version
- Not just for resource-constrained networks

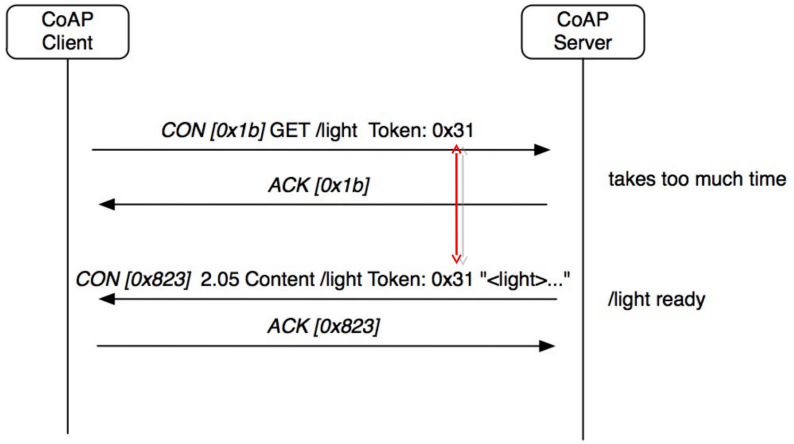
CoAP Features

- Embedded web transfer protocol (coap://)
- Asynchronous transaction model
- UDP binding with reliability and multicast support
- GET, POST, PUT, DELETE methods
- URI support
- Small, simple 4 byte header
- DTLS based PSK, RPK and Certificate security
- Subset of MIME types and HTTP response codes
- Built-in discovery
- Optional observation and block transfer

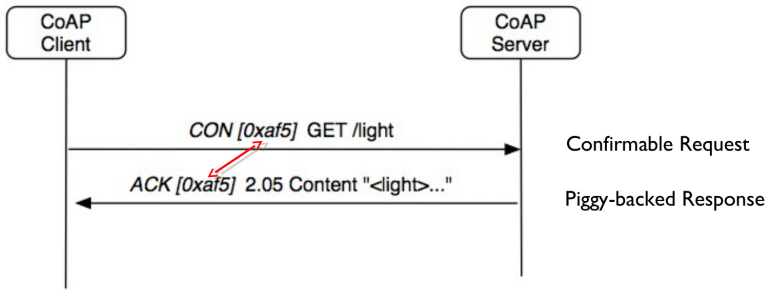
Request Example



Separating Response and Acknowledgement



Dealing with Packet Loss



A Hands-on Example using libCoap

- libCoap: C-Implementation of CoAP
  `https://libcoap.net/`
- Simple command-line server included for testing:
  `coap-server -A 127.0.0.1 -p 13001`
- Simple command-line client included for testing:

```
coap-client coap://127.0.0.1:13001/.well-known/core
</>;title="General Info";ct=0,</time>;if="clock";
rt="ticks";title="Internal Clock";ct=0;obs,</async>;
ct=0
```

Various implementations available on GitHub

- CoAPthon: a python library to the CoAP protocol aligned with the RFC – `https://github.com/Tanganelli/CoAPthon`
- Simple client in python:

```
from coapthon.client.helperclient import HelperClient

host = "127.0.0.1"
port = 13001
path ="/"

client = HelperClient(server=(host, port))
response = client.get(path)
print(response.pretty_print())
client.stop()
```

Various implementations available on GitHub

- Interroperable with libCoap

```
Source: ('127.0.0.1', 13001)
Type: ACK
MID: 11490
Code: CONTENT
Token: rK
Content-Type: 0
Max-Age: 196607
Payload:
This is a test server made with libcoap (see https://libcoap.net)
```

CoAP server resource in Python + CoAPthon

```
from coapthon.server.coap import CoAP
from coapthon.resources.resource import Resource
class BasicResource(Resource):
    def __init__(self, name="BasicResource", coap_server=None):
        super(BasicResource, self).__init__(name, coap_server, visible=True,
                                            observable=True, allow_children=True)
        self.payload = "Basic Resource"

    def render_GET(self, request):
        return self

    def render_PUT(self, request):
        self.payload = request.payload
        return self

    def render_POST(self, request):
        res = BasicResource()
        res.location_query = request.uri_query
        res.payload = request.payload
        return res

    def render_DELETE(self, request):
        return True
```

CoAP server in Python + CoAPthon

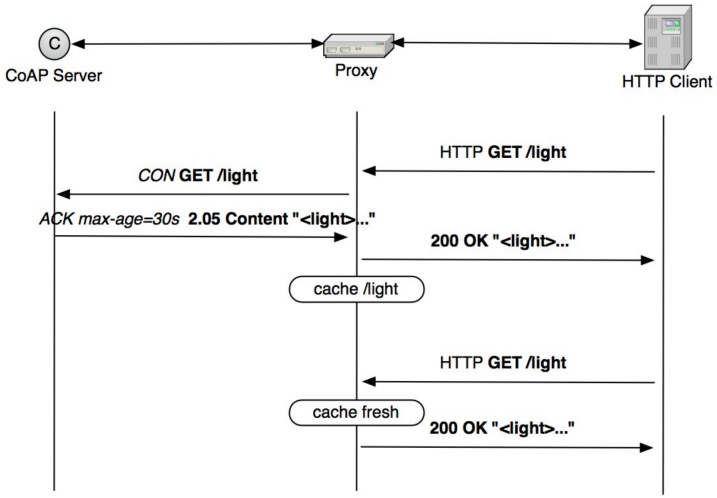
```
from coapthon.server.coap import CoAP
from coapthon.resources.resource import Resource

class CoAPServer(CoAP):
    def __init__(self, host, port):
        CoAP.__init__(self, (host, port))
        self.add_resource('basic/', BasicResource())

def main():
    server = CoAPServer("0.0.0.0", 5683)
    try:
        server.listen(10)
    except KeyboardInterrupt:
        print("Server Shutdown")
        server.close()
        print("Exiting...");

if __name__ == '__main__':
    main()
```

CoAP server in Python + CoAPthon

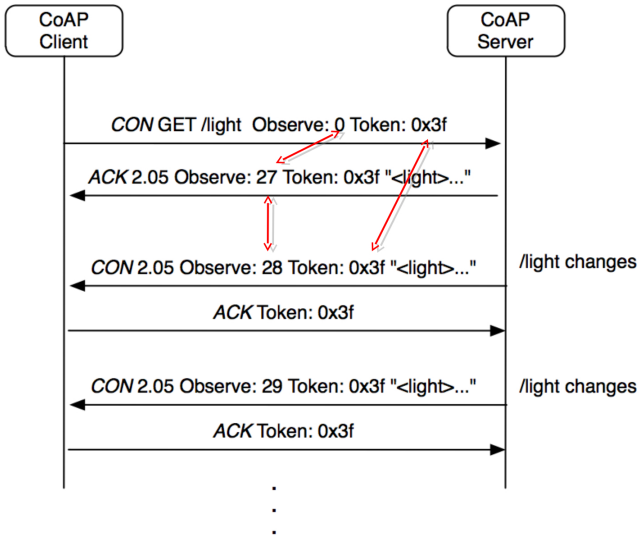
Interroperable with libCoap command-line client:

```
coap-client coap://127.0.0.1:5683/basic
Basic Resource
```

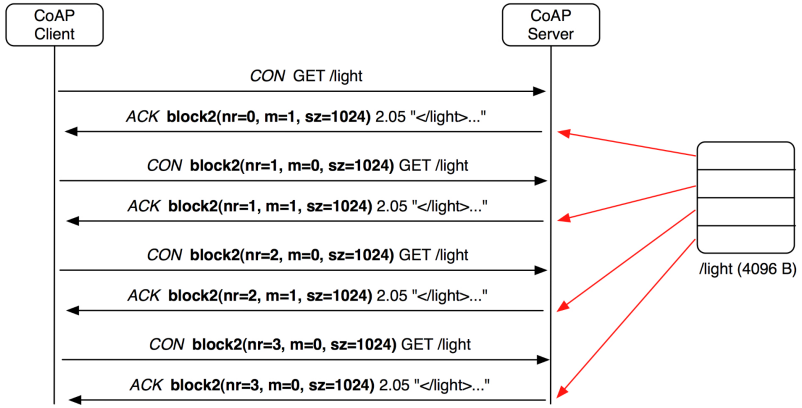
Proxying and caching



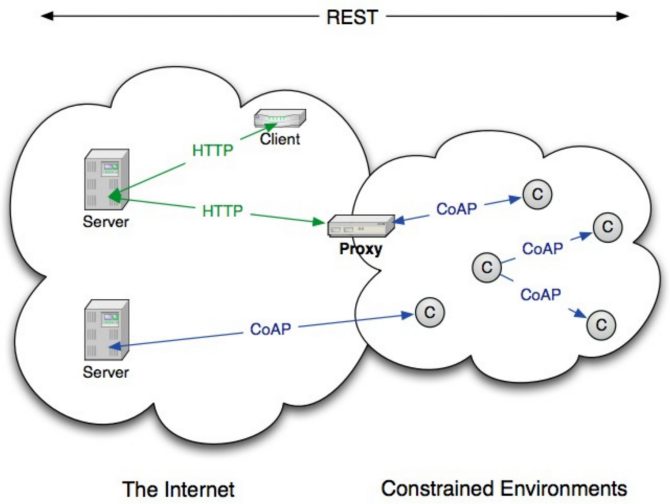
Observation



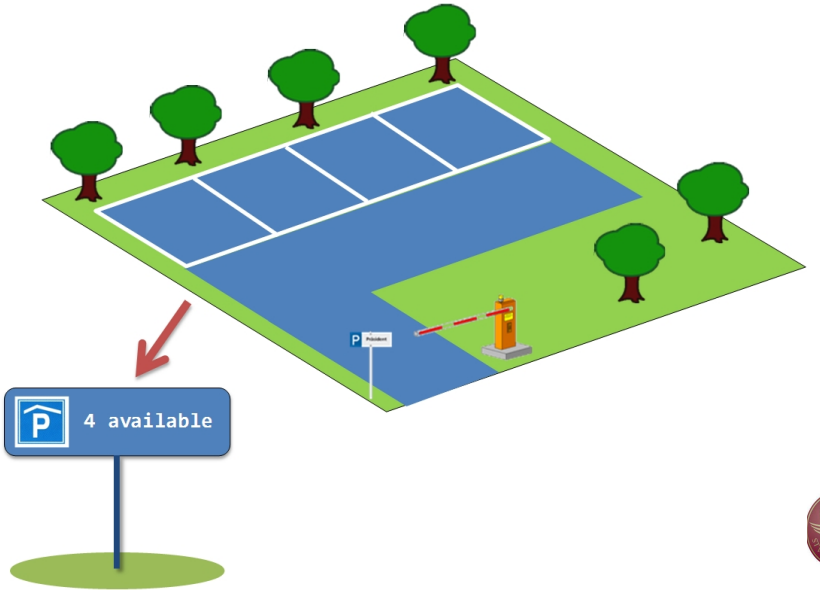
Block transfer



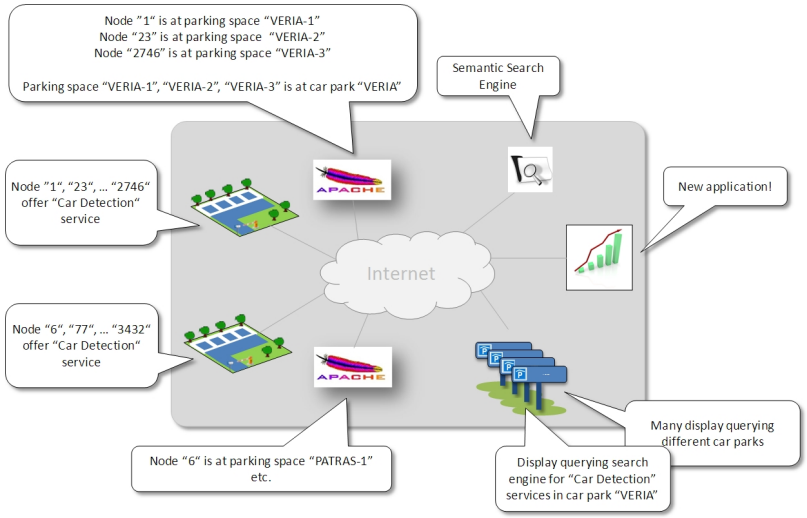
The Web of Things



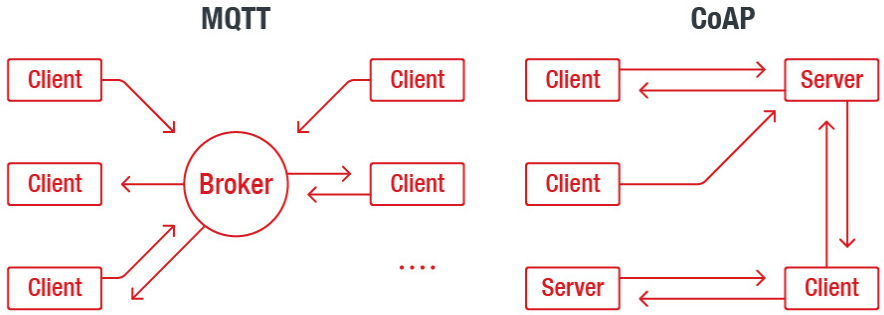
Example: Smart Parking using Web of Things



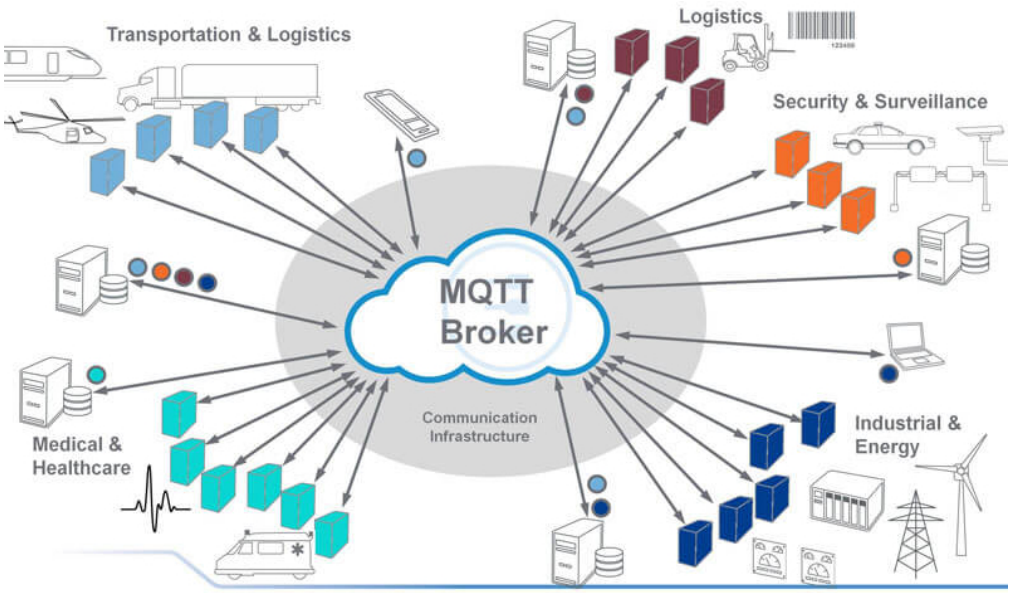
Example: Smart Parking using Web of Things



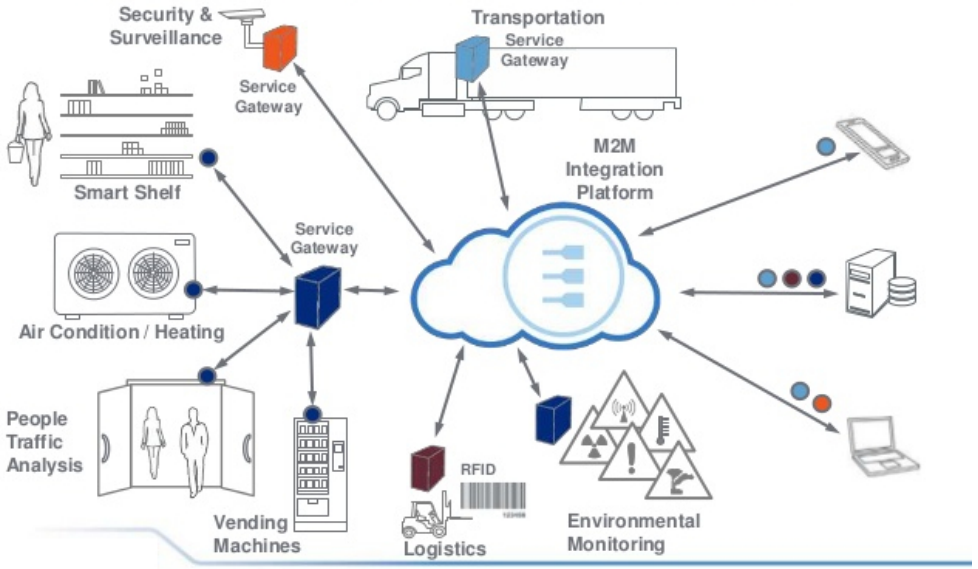
One-to-One vs Many-to-Many



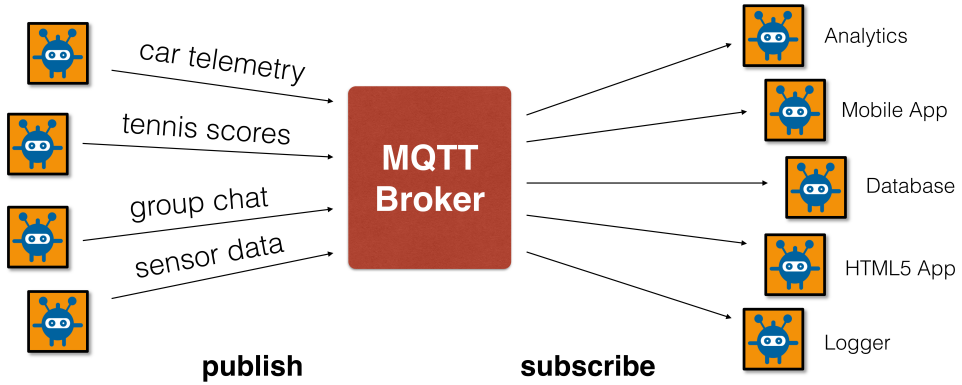
Decoupling Produces and Consumers



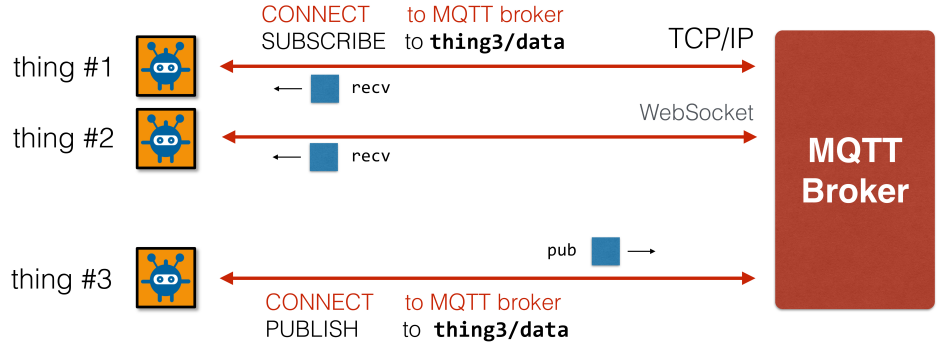
Application Examples



Publish - Subscribe Paradigm



Bi-directional, asynchronous "push" communication

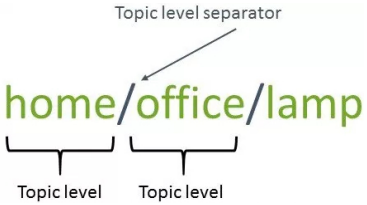


Supported Protocols

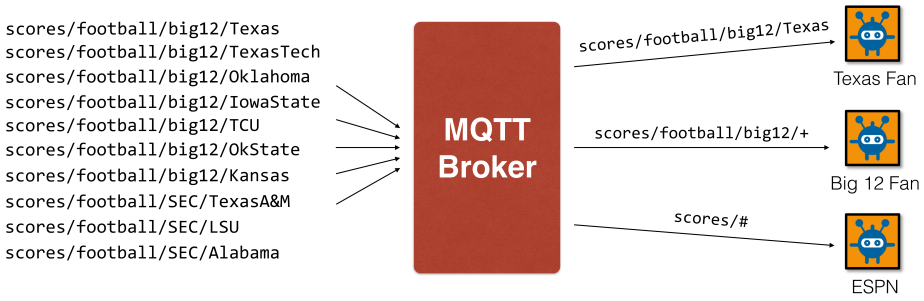
- MQTT through IP version 4 and IP version 6.
- MQTT over the WebSocket protocol.
- HTTPS protocol only to publish through IP version 4 and IP version 6.

Topic-based communication

- Topics register interest for incoming messages.
- Specify where to publish messages.
- Topics are 8-bit Unicode Transformation Format (UTF-8) encoded hierarchical strings
- Each forward slash indicates a topic level.

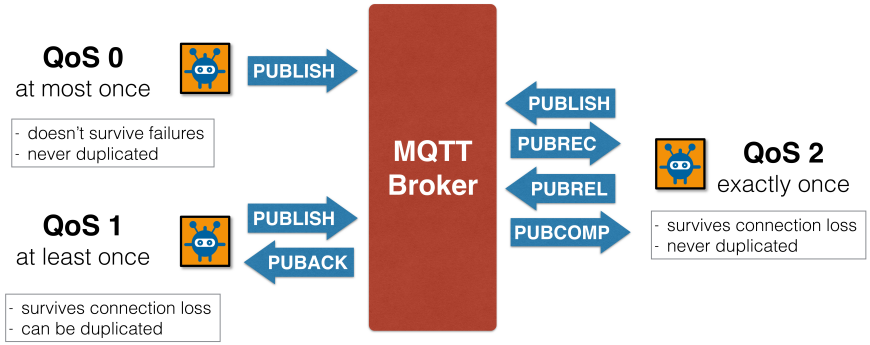


Multi-level Subscriptions

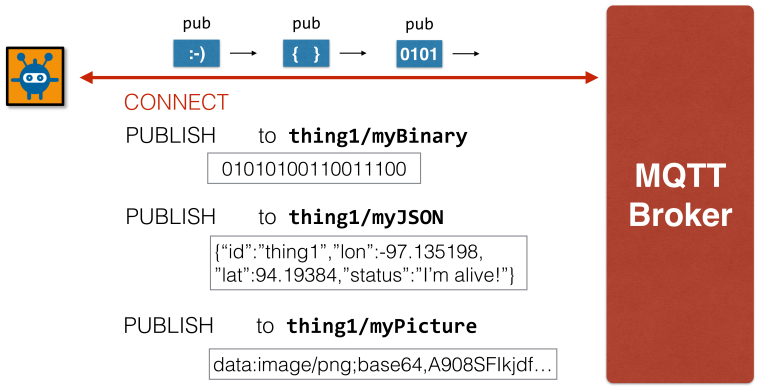


single level wildcard: **+** multi-level wildcard: **#**

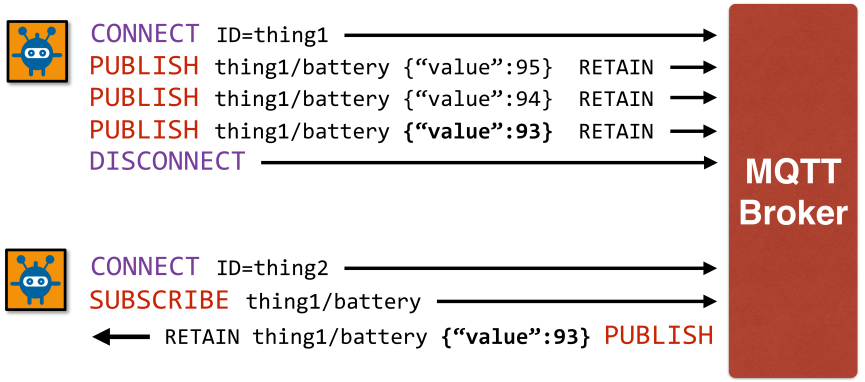
Quality of Service for reliable messaging



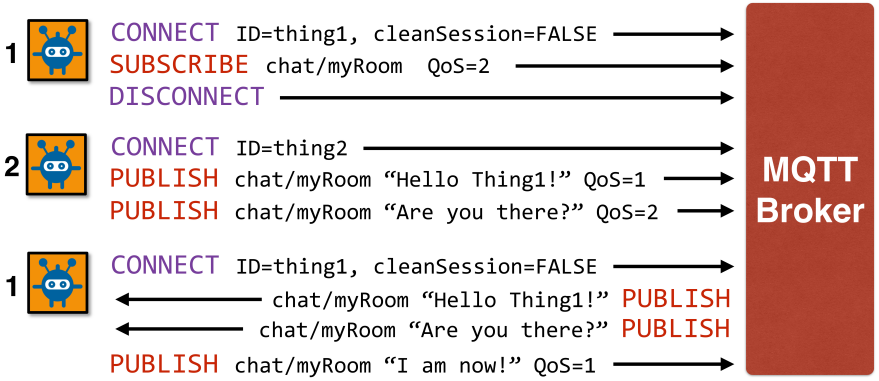
Agnostic payload for flexible delivery



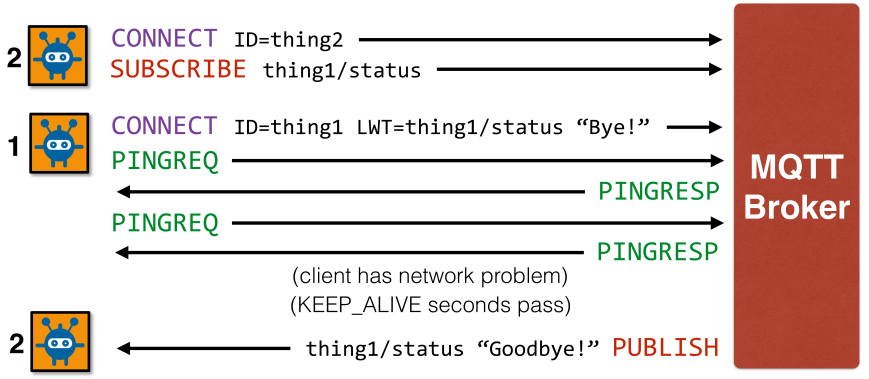
Retained messages for last value caching



Session state control



Last will and testament for presence



Setting up a MQTT Broker

- Several MQTT brokers are available to install locally
  - Eclipse Mosquitto: an open source implementation
    `https://mosquitto.org/`
- Many cloud-based MQTT brokers available
  - CloudMQTT: a hosted broker
    `https://www.cloudmqtt.com/`
  - HiveMQ – both local or clour-based
    `https://www.hivemq.com/`
- Adopted by all major cloud-providers: AWS, Azure, Google ...
- Various implementations available on GitHub
  paho.mqtt: a python library to the MQTT protocol by Eclipse
  `https://pypi.org/project/paho-mqtt/`

Various implementations available on GitHub

```python
import paho.mqtt.client as mqtt

def on_connect(client, userdata, flags, rc):
    print("Connected with result code "+str(rc))

def on_message(client, userdata, msg):
    print(msg.topic+" "+str(msg.payload))

client = mqtt.Client()
client.on_connect = on_connect
client.on_message = on_message

client.connect("localhost", 1883, 60)
client.subscribe("$SYS/#")

client.loop_forever()
```

Various implementations available on GitHub

Interroperable with mosquitto / ...

```
Connected with result code 0
$SYS/broker/version b'mosquitto version 1.6.8'
$SYS/broker/uptime b'3399 seconds'
```

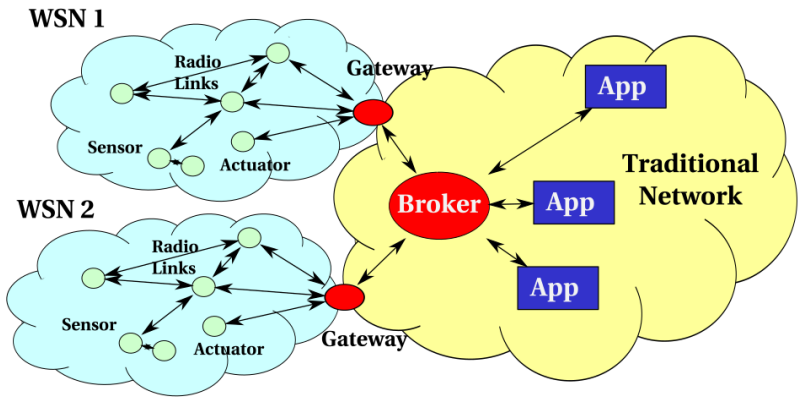
MQTT-S/MQTT-SN: MQTT for Sensor Networks

- Peers are mainly connected via wireless networks.
- Low Power battery operated sensors with very limited processing power and storage.
- Limited payload size.
- Not always on (sleeping).

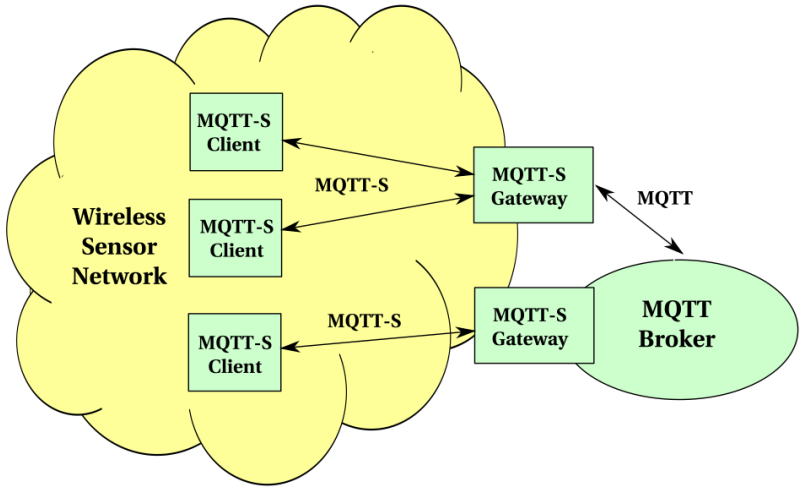
MQTT-S/MQTT-SN vs MQTT

1. Connect message split into three messages two are optional and are used for the will message
2. Topic id's used in place of topic names.
3. Short Topic names
4. Pre-defined topics.
5. Discovery process to let clients discover the Gateway
6. Will Topic and messages can be changed during the session
7. Off line keep alive procedure for sleeping clients.

Integration of Networks



MQTT-S Architecture



MQTT-S Transparent vs Aggregating Gateway