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Course: Information & Network Security MEng

Supervisor: Dr. Sean McGrath

Project Title: Docker Containers Deployed Using Bluemix

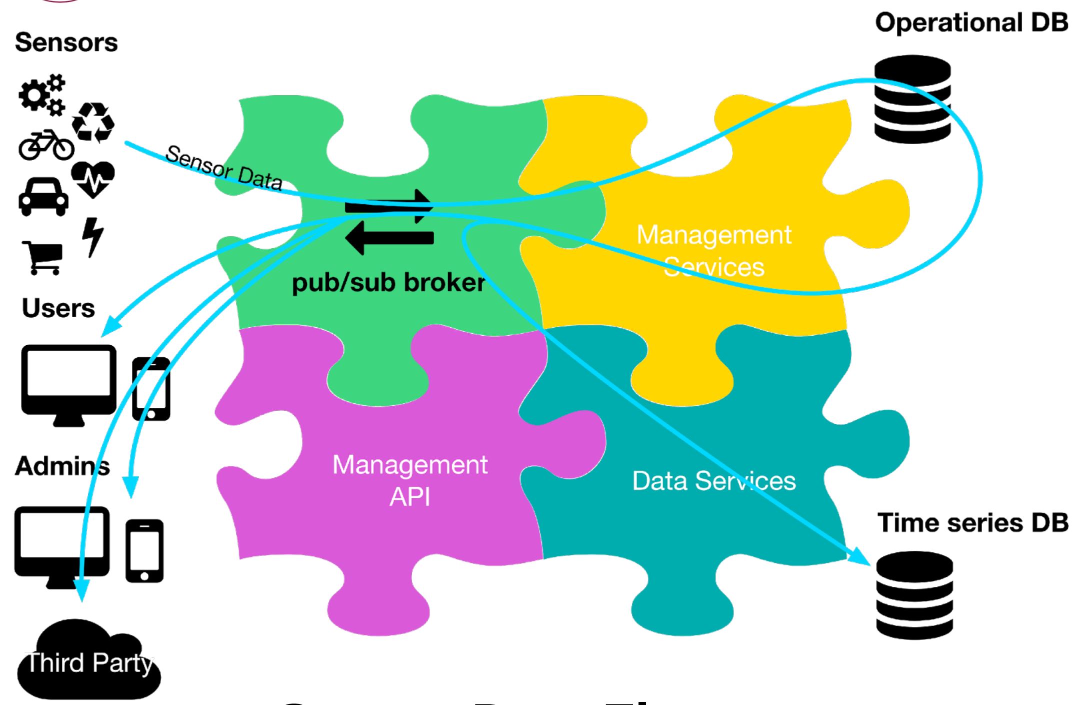
Containerization platform

- Linux OS
- Open source
- Packages application code

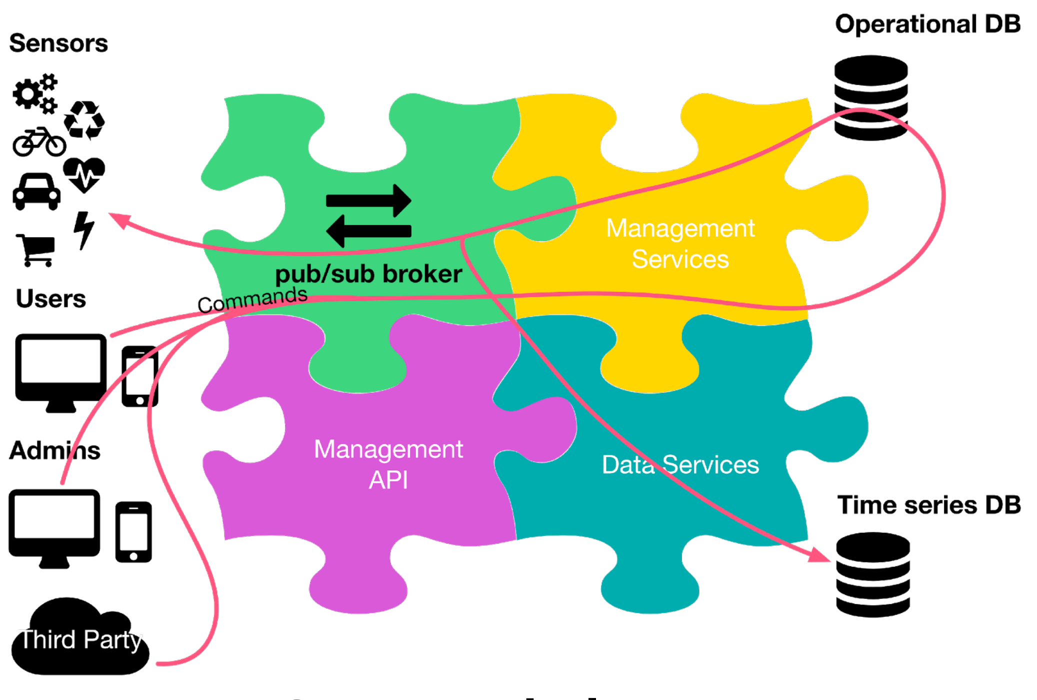
Platform as a service

- Integrates Docker
- Bare metal depoyment
- Container lifecycle management

IoT Architecture



Sensor Data Flow



Command Flow

Sensor API ➢ Called by the sensors to deliver data readings and receive commands

Public API ➢ Called by the sensors to retrieve real-time data, historical data, and to manage the devices

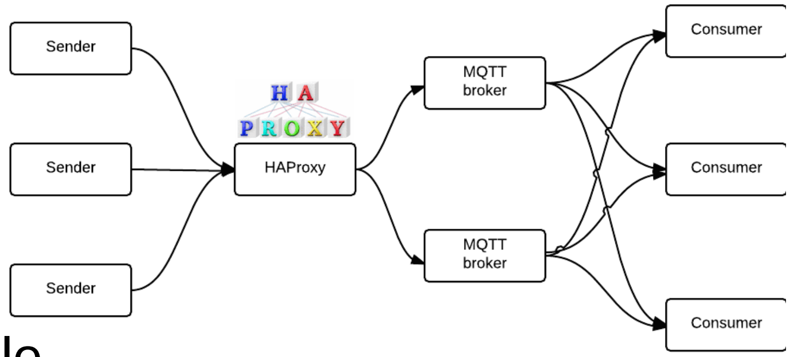
Operational Services ➢ Responsible for authentication and authorization, among other things

Data Services ➢ Responsible for storing and analyzing the data in real time or offline

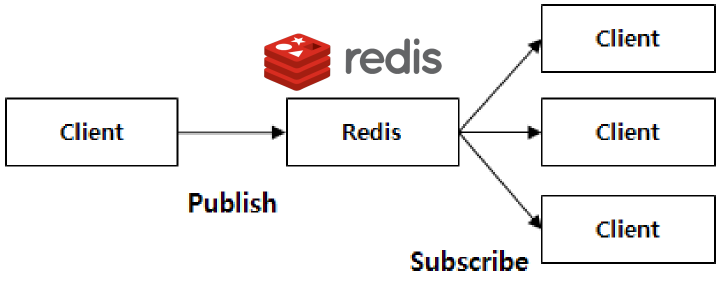
Technologies

- Open source MQTT broker written in Javascript
- MQTT 3.1 and 3.1.1 compliant
- QoS 0 and QoS 1
- Various storage options for QoS 1 offline packets, and subscriptions
- Usable inside any other Node.js app

- Open source software load balancer
- Written in C
- Session consists of two TCP connections
- One from the client to the load balancer
- One from the load balancer to the server
- Loadbalancing policy specified in config file



- Open source, BSD licensed
- In-memory data store
- Can be used as a high-performance database, a cache, and a message broker
- Various clients written in several languages
- Log aggregation
- Various data structures



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Technologies

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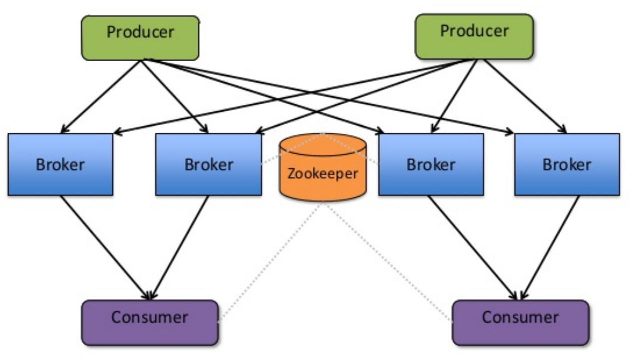
kafka

- Distributed publish-subscribe messaging system
- High-throughput
- Can support thousands of messages per second
- Persistent messaging with disk structures that provide constant time performance even with many TB of stored messages
- More than one consumer from a consumer group can retrieve data simultaneously, in the same order that messages are stored

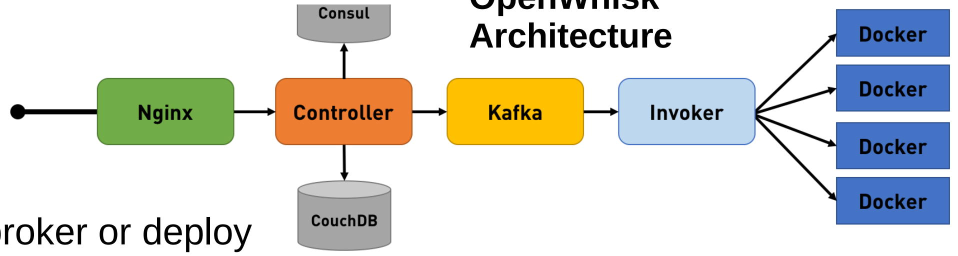
Kafka Architecture



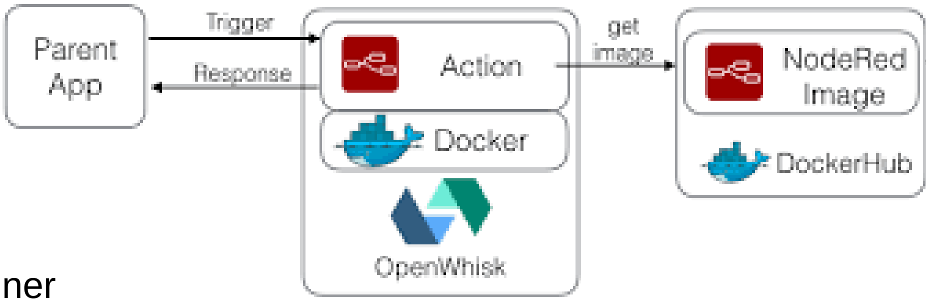
OpenWhisk

- Serverless architecture
- Abstracts away infrastructure
- Makes it simple to deploy microservices
- Eliminates the need to manage your own message broker or deploy your own worker servers
- **Triggers:** A class of events emitted by event sources
- **Actions:** Encapsulates the actual code to be executed
- **Rules:** An association between a trigger and an action
- **Packages:** Describe external services in a uniform manner

OpenWhisk Architecture



Trigger, Action, Rules



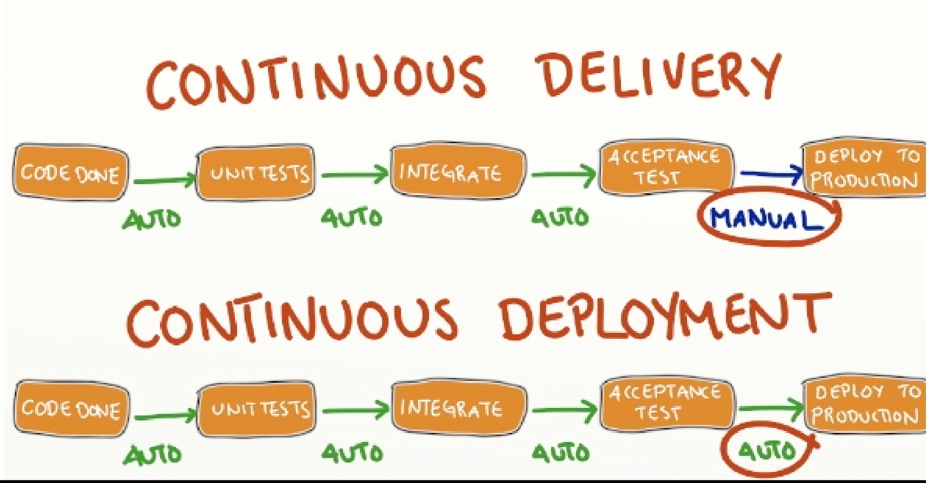
IBM Cloudant®

CouchDB relax

- Managed NoSQL JSON database service
- Cloudant Geo
- **Index –** efficiently via algorithms optimized for spatial data
- **Query –** using complex polygons and geometric relations
- **Visualize –** with interactive maps, powered by Mapbox, directly in the Cloudant dashboard

DevOps Tools

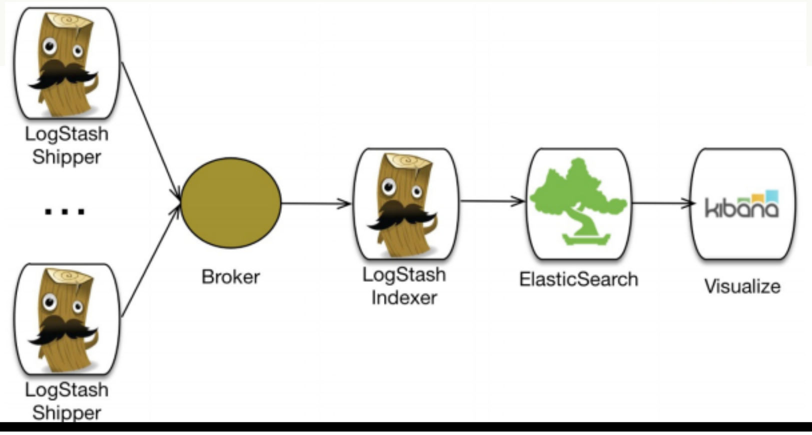
- Container Lifecycle Management
- Scaling
- Integration Testing
- Container monitoring
- CI/CD pipeline
- Git sync



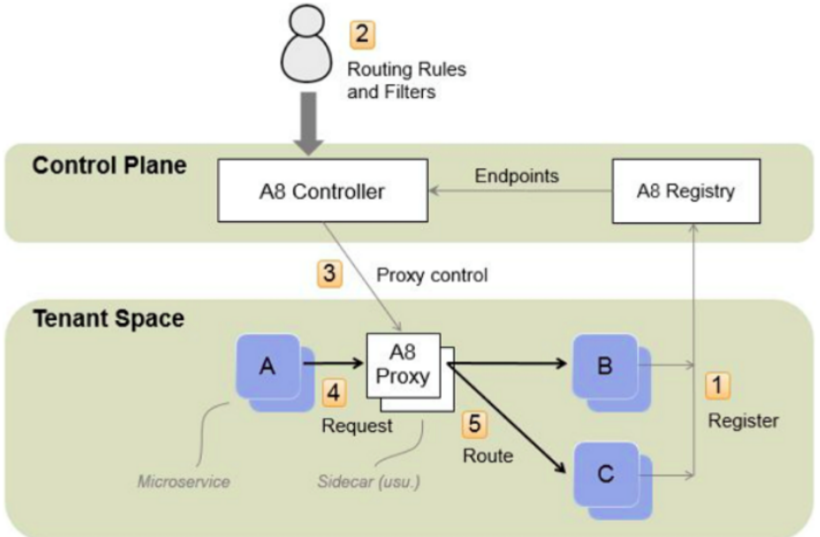
elasticsearch
- Distributed, RESTful search and analytics engine

logstash
- Open source, server-side data processing pipeline that ingests data

kibana
- Kibana helps visualize Elasticsearch data and navigate the Elastic Stack



Amalgam8
- Microservice management framework that provides systematic resiliency testing and red/black deployment
- ***Registry* –** A high-performance service registry that provides a centralized view of all the microservices in an application, regardless of where they are actually running
- ***Controller* –** A tool that monitors the Registry and provides a REST API for registering routing and other microservice control-rules, which it uses to generate and send control information to proxy servers running within the application



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High level design

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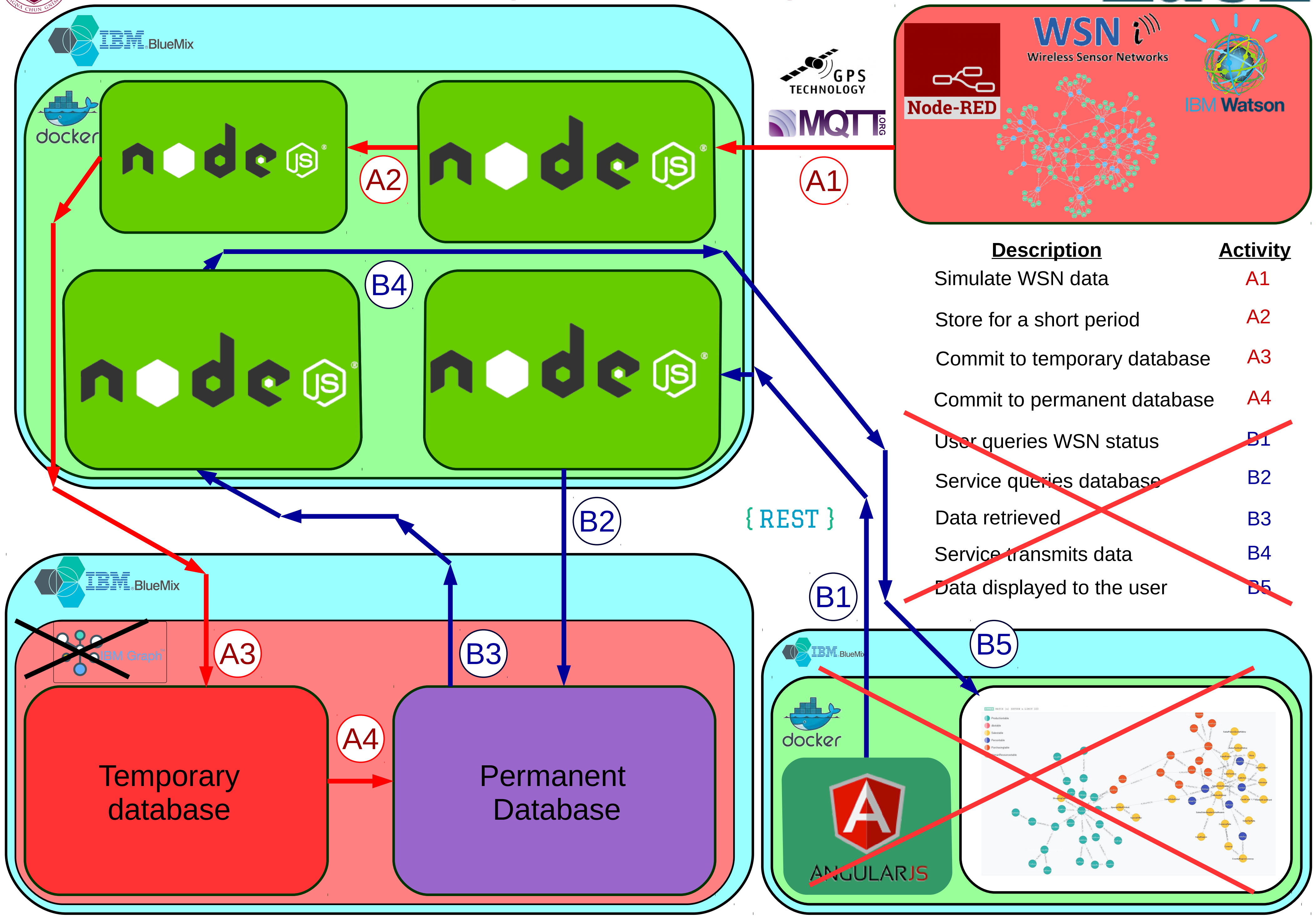

Description	**Activity**
Simulate WSN data	A1
Store for a short period	A2
Commit to temporary database	A3
Commit to permanent database	A4
~~User queries WSN status~~	~~B1~~
~~Service queries database~~	~~B2~~
~~Data retrieved~~	~~B3~~
~~Service transmits data~~	~~B4~~
~~Data displayed to the user~~	~~B5~~

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Load Balancing Architecture

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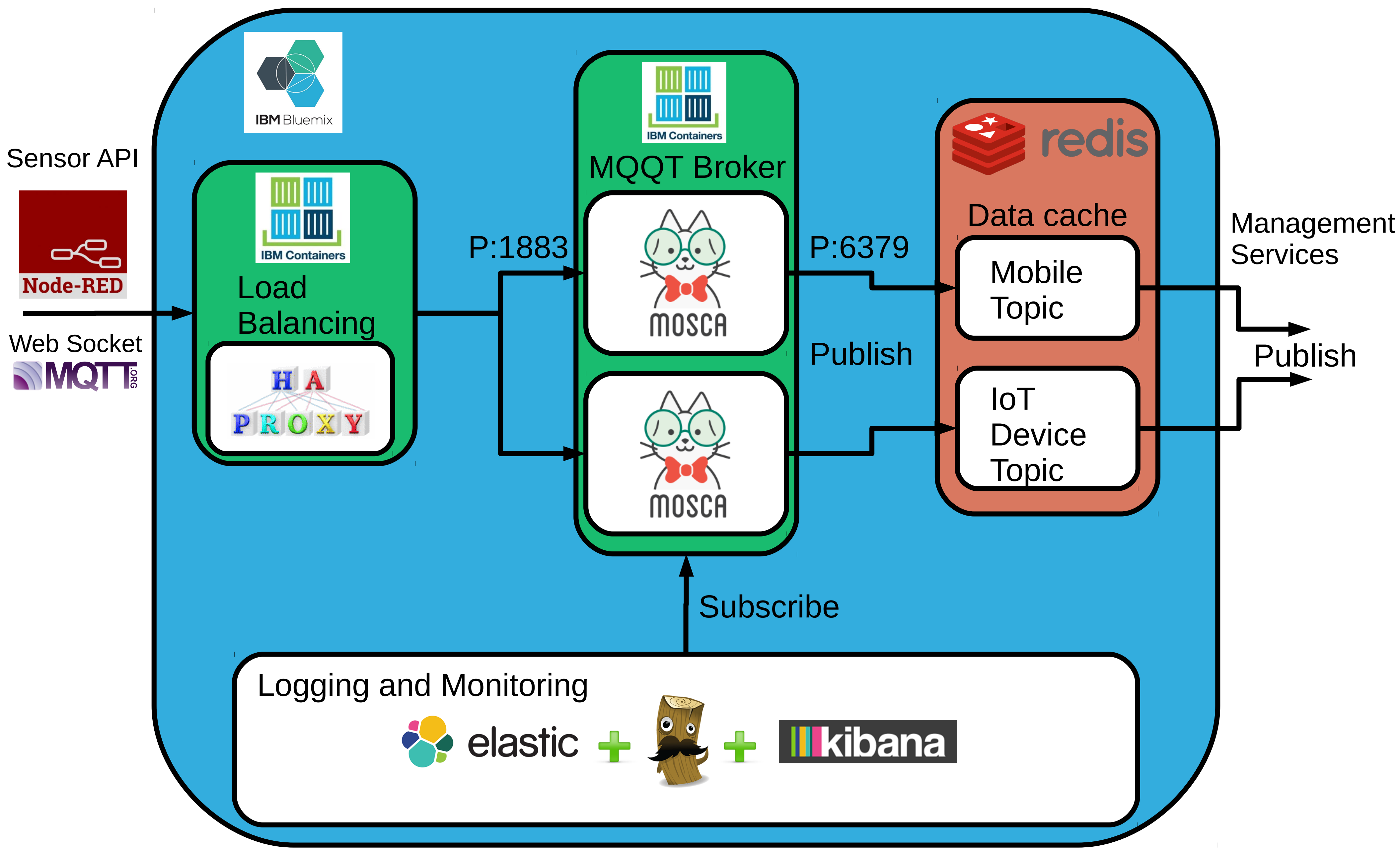

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Mosca Broker Test

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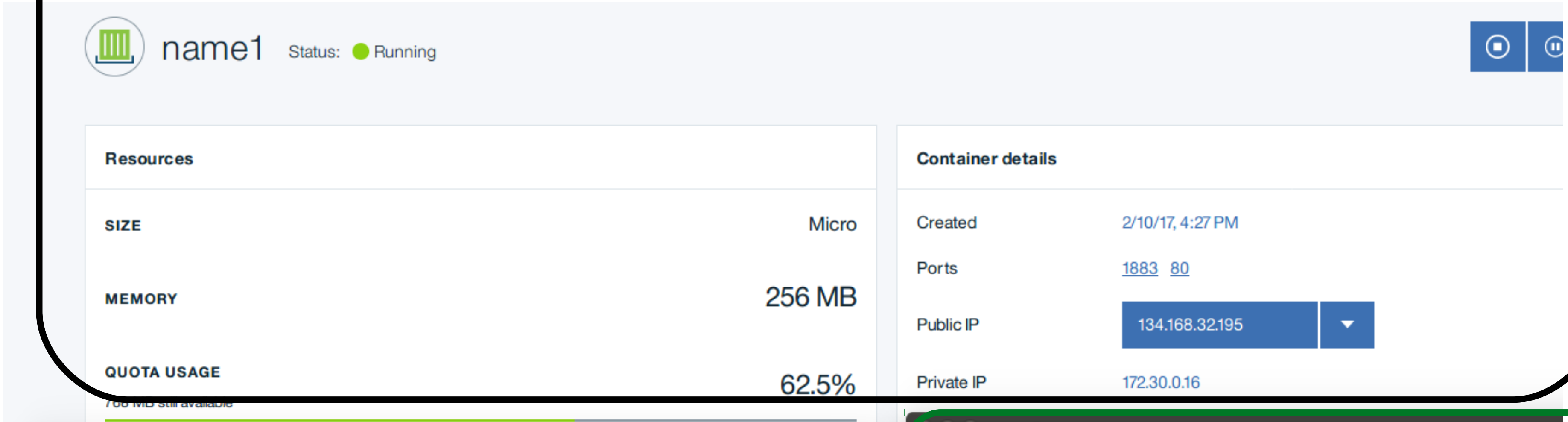
Mosca **Broker** running on Bluemix

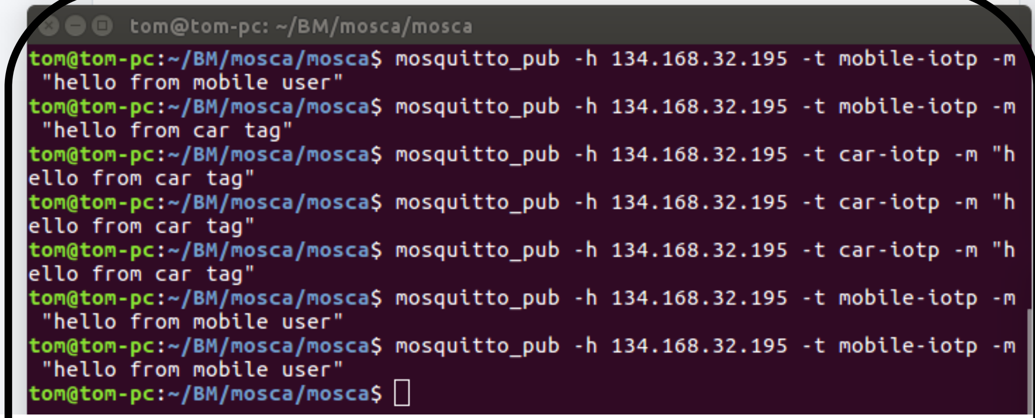

name1 Status: ● Running

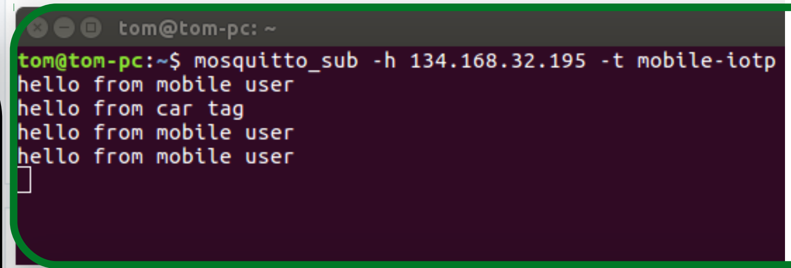
Resources

SIZE	Micro
MEMORY	256 MB
QUOTA USAGE	62.5%

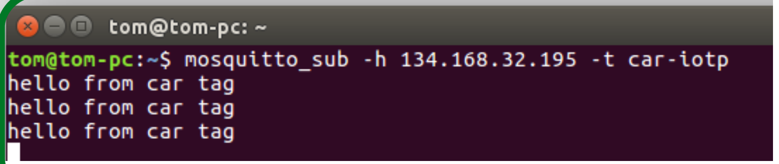
Container details

Created	2/10/17, 4:27 PM
Ports	1883 80
Public IP	134.168.32.195
Private IP	172.30.0.16


```
tom@tom-pc: ~/BM/mosca/mosca
tom@tom-pc:~/BM/mosca/mosca$ mosquitto_pub -h 134.168.32.195 -t mobile-iotp -m
 "hello from mobile user"
tom@tom-pc:~/BM/mosca/mosca$ mosquitto_pub -h 134.168.32.195 -t mobile-iotp -m
 "hello from car tag"
tom@tom-pc:~/BM/mosca/mosca$ mosquitto_pub -h 134.168.32.195 -t car-iotp -m "h
ello from car tag"
tom@tom-pc:~/BM/mosca/mosca$ mosquitto_pub -h 134.168.32.195 -t car-iotp -m "h
ello from car tag"
tom@tom-pc:~/BM/mosca/mosca$ mosquitto_pub -h 134.168.32.195 -t car-iotp -m "h
ello from car tag"
tom@tom-pc:~/BM/mosca/mosca$ mosquitto_pub -h 134.168.32.195 -t mobile-iotp -m
 "hello from mobile user"
tom@tom-pc:~/BM/mosca/mosca$ mosquitto_pub -h 134.168.32.195 -t mobile-iotp -m
 "hello from mobile user"
tom@tom-pc:~/BM/mosca/mosca$ 
```


```
tom@tom-pc: ~
tom@tom-pc:~$ mosquitto_sub -h 134.168.32.195 -t mobile-iotp
hello from mobile user
hello from car tag
hello from mobile user
hello from mobile user
```

Mobile Topic


```
tom@tom-pc: ~
tom@tom-pc:~$ mosquitto_sub -h 134.168.32.195 -t car-iotp
hello from car tag
hello from car tag
hello from car tag
```

Car Topic

Mosquitto Client publishes to “car-iotp” and “mobile-iotp”

Subscribers

Publisher

mosquitto

MQTT.ORG

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Node-RED Flow

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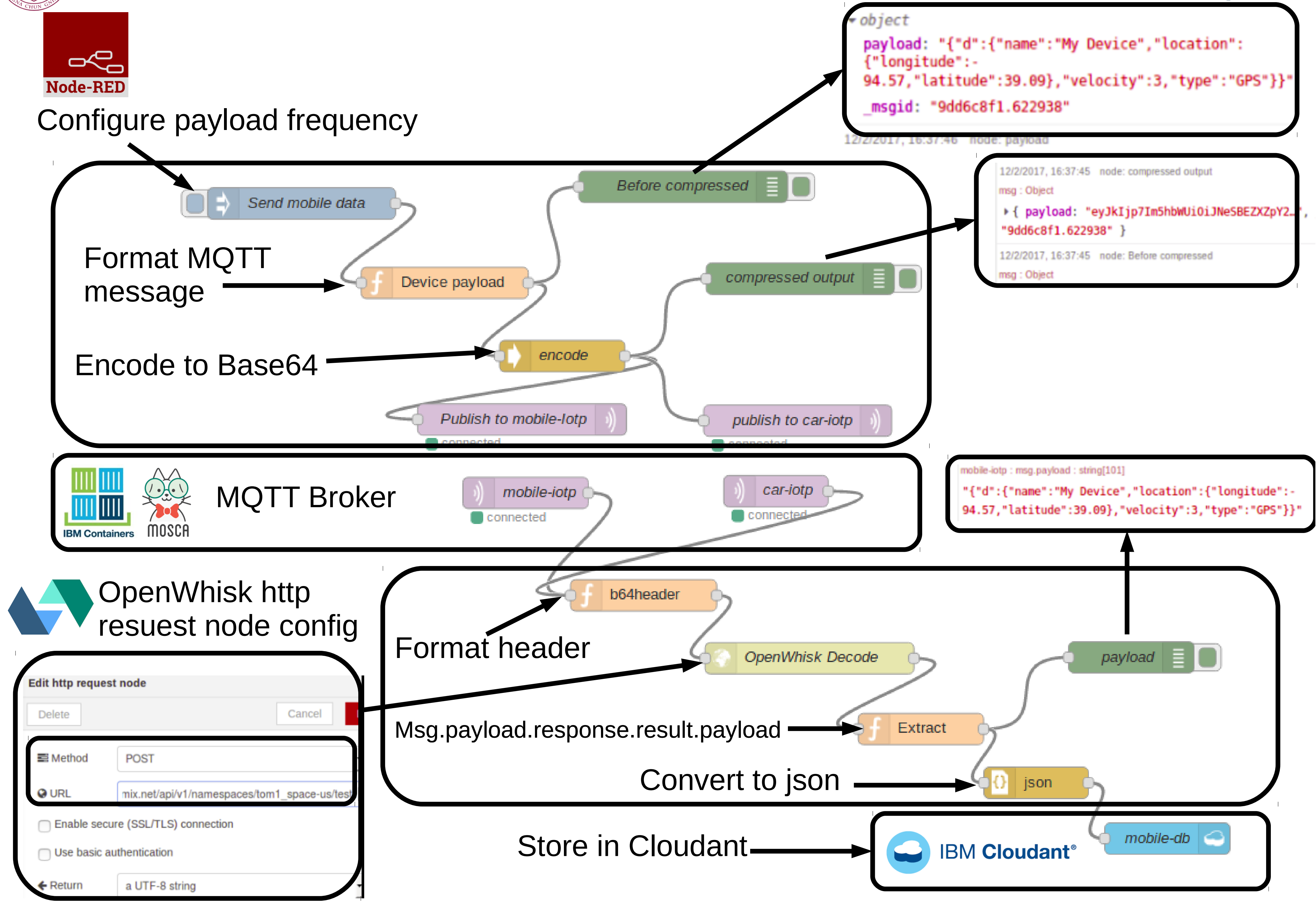

```
▾object
payload: "{"d":{"name":"My Device","location":
{"longitude":-
94.57,"latitude":39.09},"velocity":3,"type":"GPS"}}"
_msgid: "9dd6c8f1.622938"
12/2/2017, 16:37:46   node: payload
```

```
12/2/2017, 16:37:45   node: compressed output
msg : Object
▸{ payload: "eyJkIjp7Im5hbWUiOiJNeSBEZXZpY2…",
"9dd6c8f1.622938" }
12/2/2017, 16:37:45   node: Before compressed
msg : Object
```

```
mobile-iotp : msg.payload : string[101]
"{"d":{"name":"My Device","location":{"longitude":-
94.57,"latitude":39.09},"velocity":3,"type":"GPS"}}"
```

Edit http request node

Delete   Cancel

Method	POST
URL	mix.net/api/v1/namespaces/tom1_space-us/test
☐ Enable secure (SSL/TLS) connection	
☐ Use basic authentication	
Return	a UTF-8 string

OpenWhisk & Cloudant

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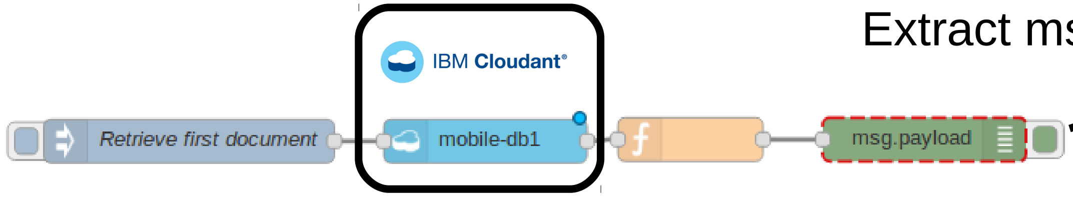
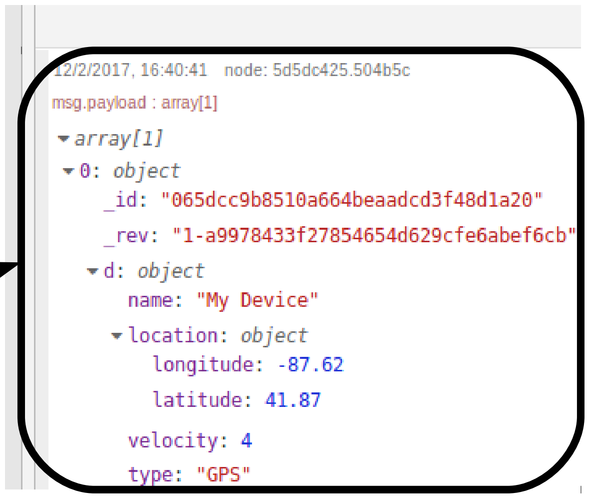
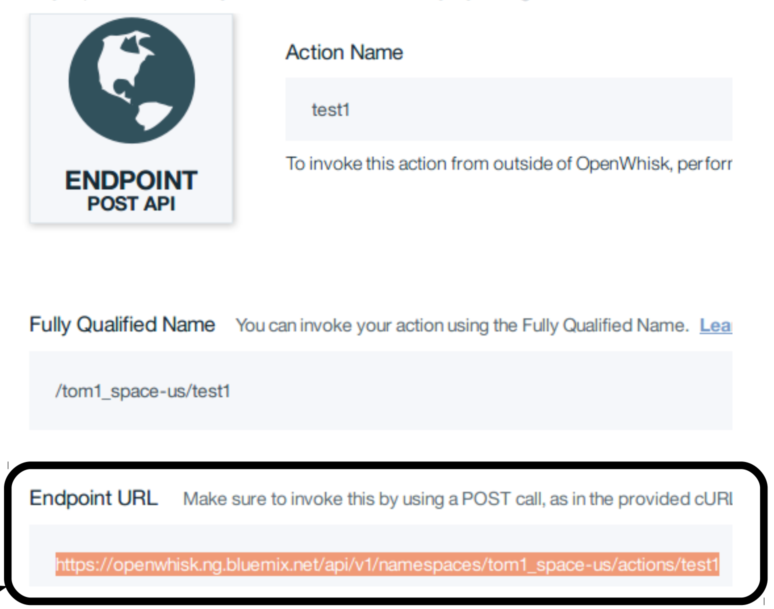


Extract msg.payload


```
12/2/2017, 16:40:41   node: 5d5dc425.504b5c
msg.payload : array[1]
▾array[1]
 ▾0: object
    _id: "065dcc9b8510a664beaadcd3f48d1a20"
    _rev: "1-a9978433f27854654d629cfe6abef6cb"
  ▾d: object
     name: "My Device"
   ▾location: object
       longitude: -87.62
       latitude: 41.87
     velocity: 4
     type: "GPS"
```

REST Endpoint Properties

Every OpenWhisk entity can be invoked directly by using a REST API call



Action Name

test1

To invoke this action from outside of OpenWhisk, perfor

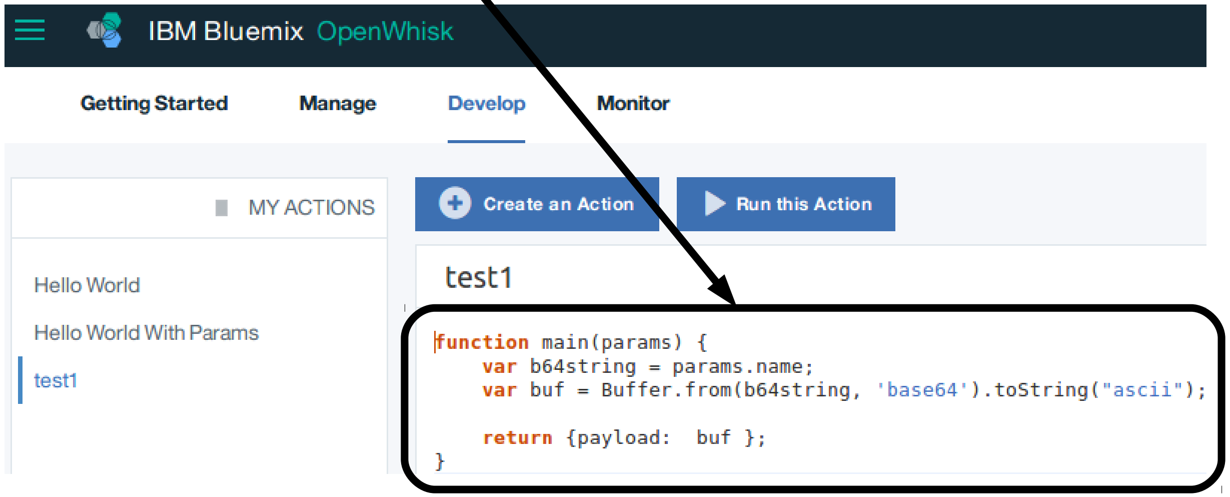
Fully Qualified Name   You can invoke your action using the Fully Qualified Name. Lea

/tom1_space-us/test1

Endpoint URL   Make sure to invoke this by using a POST call, as in the provided cURI

https://openwhisk.ng.bluemix.net/api/v1/namespaces/tom1_space-us/actions/test1

OpenWhisk Base64 Decode Action



test1

```
function main(params) {
    var b64string = params.name;
    var buf = Buffer.from(b64string, 'base64').toString("ascii");

    return {payload:  buf };
}
```

OpenWhisk Action REST Endpoint

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HAProxy

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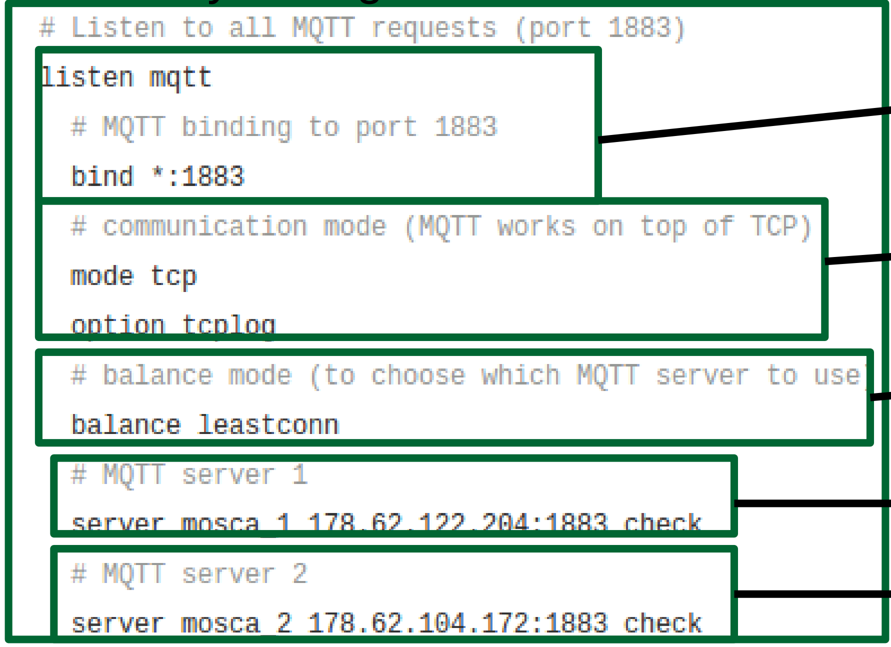
HAProxy Config File



```
# Listen to all MQTT requests (port 1883)
listen mqtt
  # MQTT binding to port 1883
  bind *:1883
  # communication mode (MQTT works on top of TCP)
  mode tcp
  option tcplog
  # balance mode (to choose which MQTT server to use
  balance leastconn
  # MQTT server 1
  server mosca_1 178.62.122.204:1883 check
  # MQTT server 2
  server mosca_2 178.62.104.172:1883 check
```

HAProxy listens for traffic on port 1883

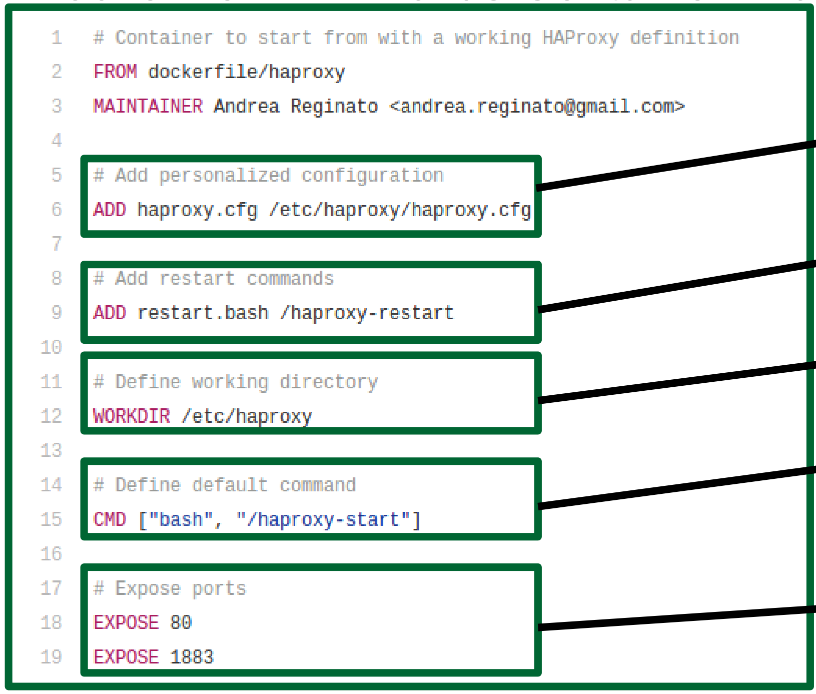
Configured to have MQTT work on top of TCP

Chooses the MQTT server with the least amount of connections

Car Broker/Topic

Mobile Broker/Topic

Dockerfile → Builds Container image



```
# Container to start from with a working HAProxy definition
FROM dockerfile/haproxy
MAINTAINER Andrea Reginato <andrea.reginato@gmail.com>

# Add personalized configuration
ADD haproxy.cfg /etc/haproxy/haproxy.cfg

# Add restart commands
ADD restart.bash /haproxy-restart

# Define working directory
WORKDIR /etc/haproxy

# Define default command
CMD ["bash", "/haproxy-start"]

# Expose ports
EXPOSE 80
EXPOSE 1883
```

Add HAProxy config file to image

Add restart command in order to overide default configurations

Define working directory for container

"**haproxy-start**" will be the default command run when container is started

Expose ports to other containers on same local network

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Work to be completed

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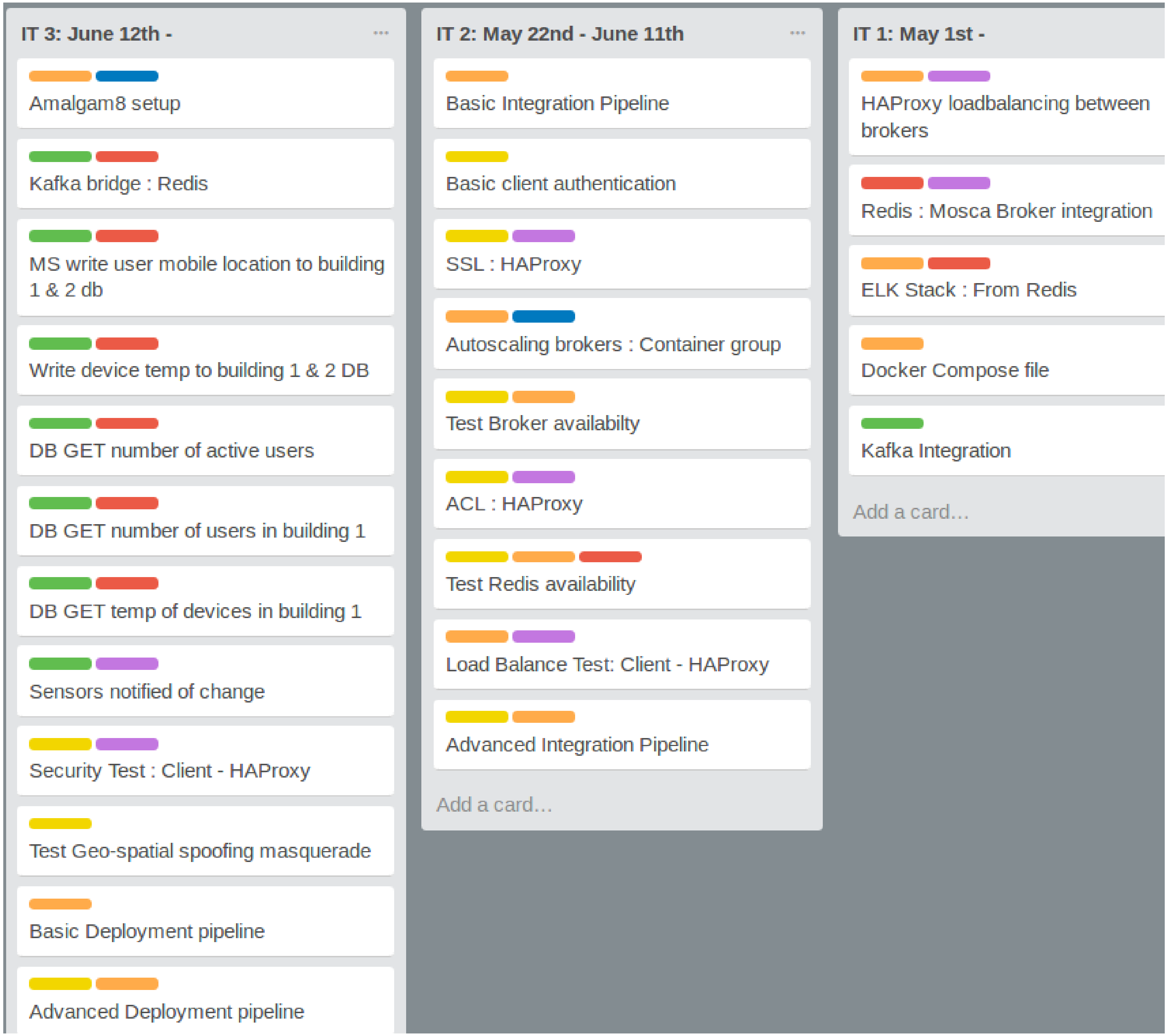
IT 3: June 12th -

- Amalgam8 setup
- Kafka bridge : Redis
- MS write user mobile location to building 1 & 2 db
- Write device temp to building 1 & 2 DB
- DB GET number of active users
- DB GET number of users in building 1
- DB GET temp of devices in building 1
- Sensors notified of change
- Security Test : Client - HAProxy
- Test Geo-spatial spoofing masquerade
- Basic Deployment pipeline
- Advanced Deployment pipeline

IT 2: May 22nd - June 11th

- Basic Integration Pipeline
- Basic client authentication
- SSL : HAProxy
- Autoscaling brokers : Container group
- Test Broker availabilty
- ACL : HAProxy
- Test Redis availability
- Load Balance Test: Client - HAProxy
- Advanced Integration Pipeline

Add a card…

IT 1: May 1st -

- HAProxy loadbalancing between brokers
- Redis : Mosca Broker integration
- ELK Stack : From Redis
- Docker Compose file
- Kafka Integration

Add a card…