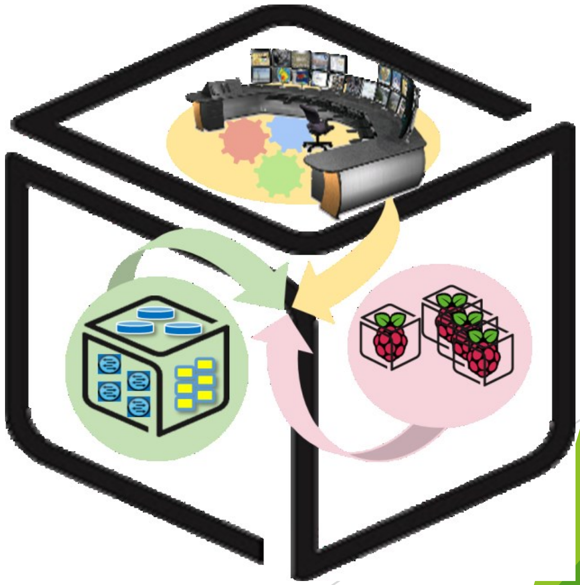
# SmartX Labs for Computer Systems

InterConnect & Tower Lab

(2017, Spring)

NetCS Lab



# History and Contributor of InterConnect & Tower Lab (2017. 05. 01)

| Version | Updated Date | Updated Contents | Contributor |
|---|---|---|---|
| v0.1 | 2017/05 | Merged with InterConnect & Tower Lab | Seungryong Kim |
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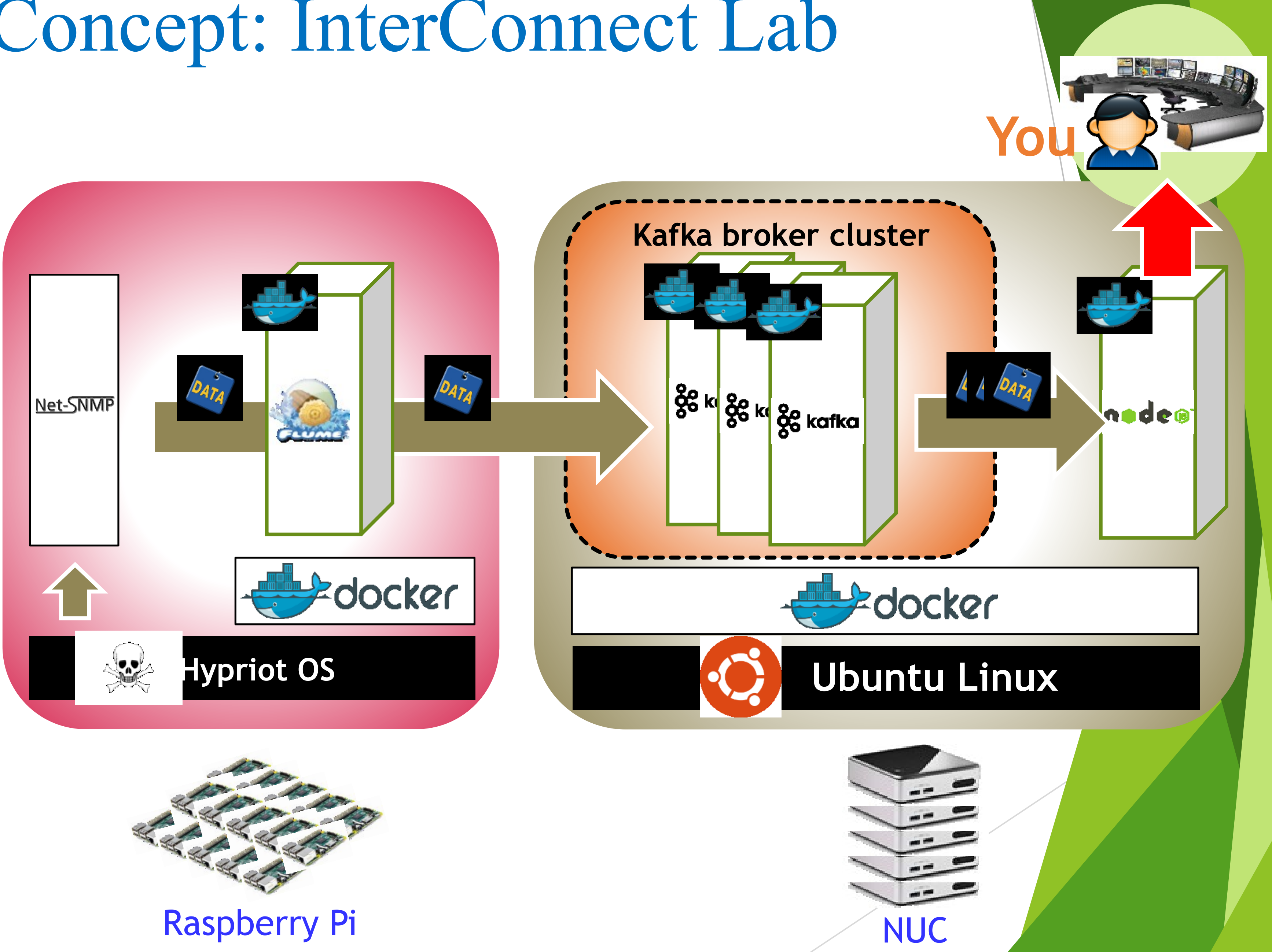
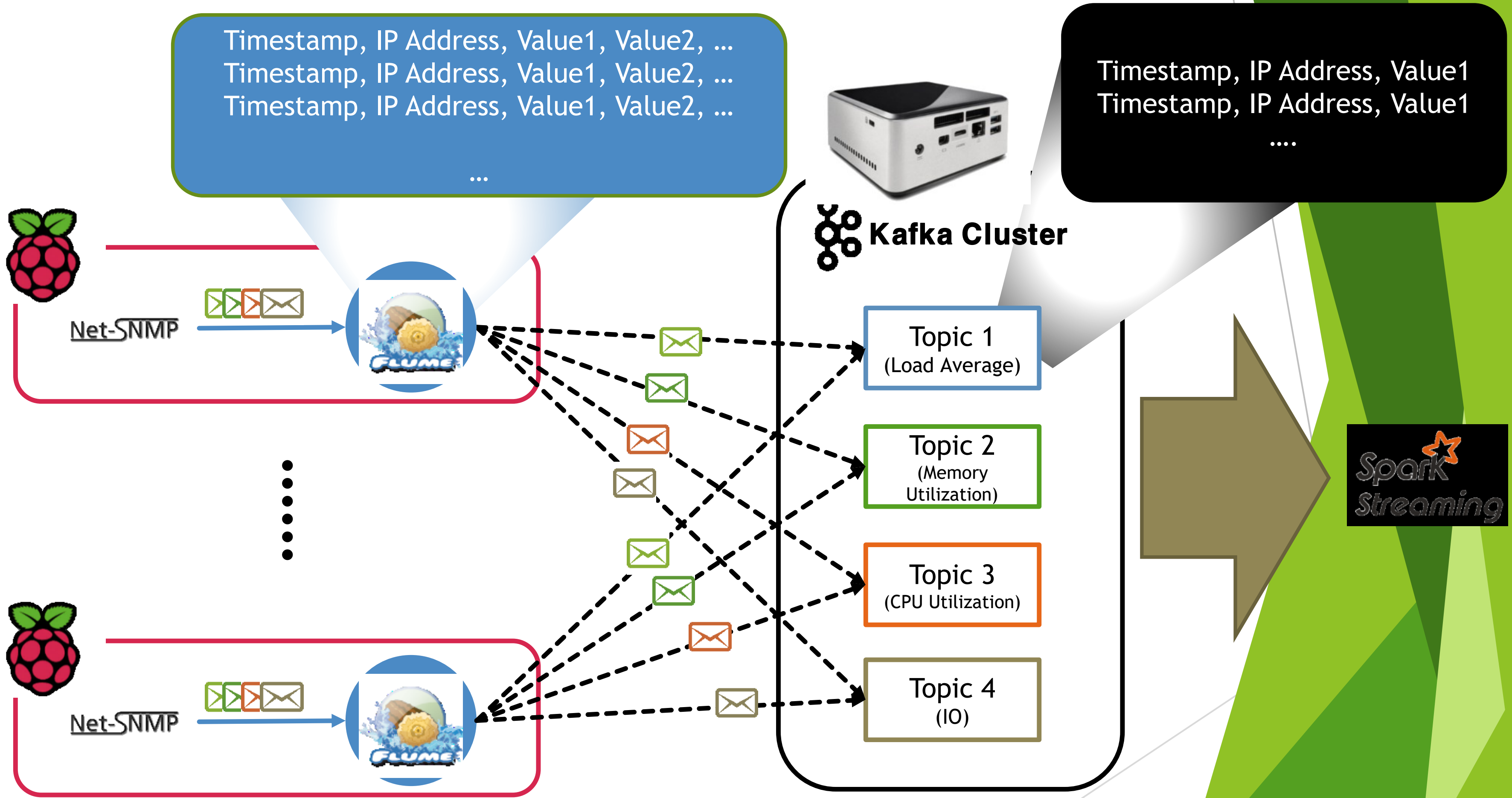
## Goals

- Understanding Concepts
  - Net-SNMP, Flume, Kafka, Hypriot OS
- Connecting with each functions
  - With Raspberry Pi and NUC
- Visibility Center: Resource Monitoring Service
  - Visualize Status of Resource in Inter-Connected Boxes

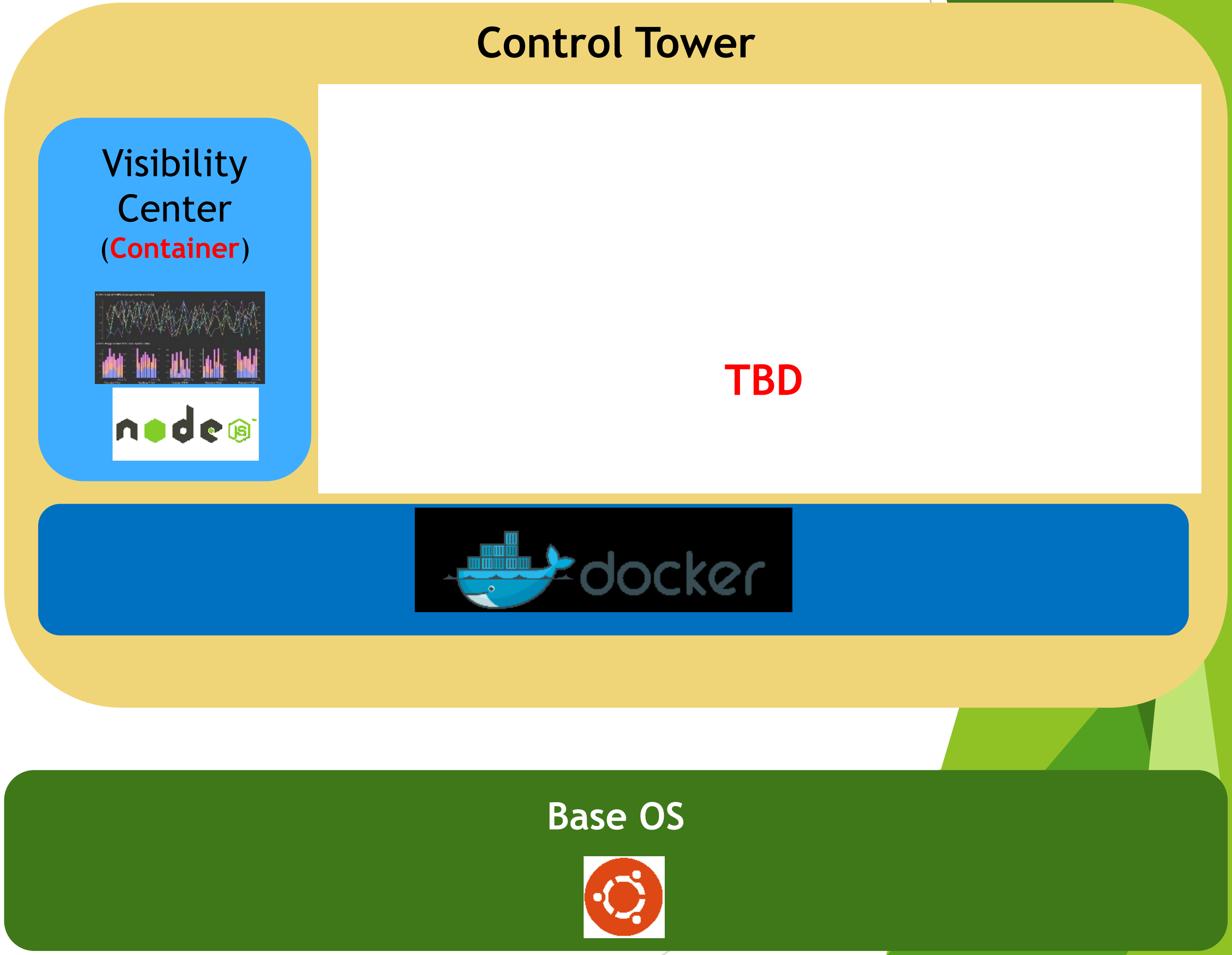
# Concept: InterConnect Lab



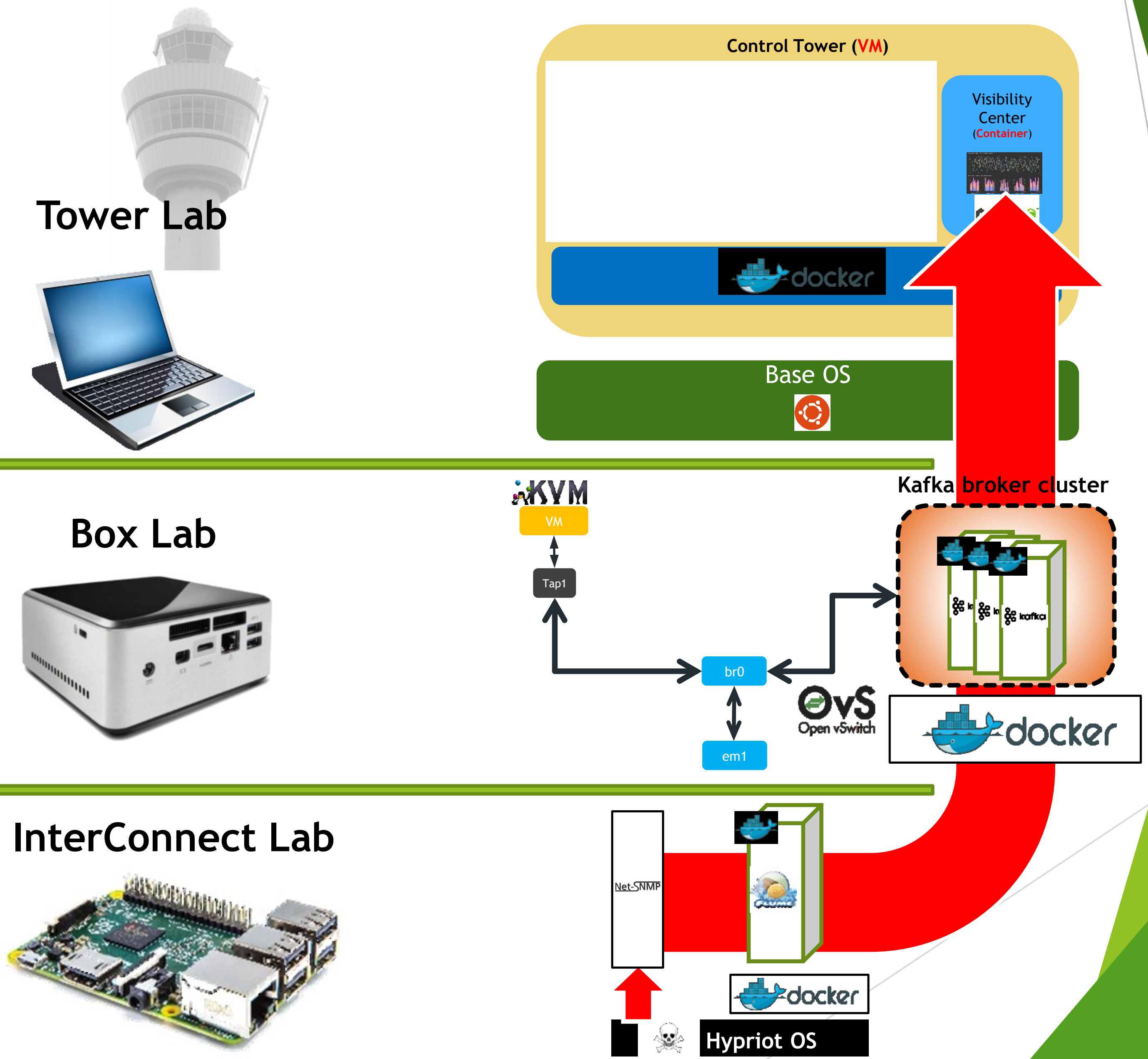
# Cont’d


Timestamp, IP Address, Value1, Value2, …
Timestamp, IP Address, Value1, Value2, …
Timestamp, IP Address, Value1, Value2, …
…
Timestamp, IP Address, Value1
Timestamp, IP Address, Value1
….
Kafka Cluster
Net-SNMP
Net-SNMP
Topic 1 (Load Average)
Topic 2 (Memory Utilization)
Topic 3 (CPU Utilization)
Topic 4 (IO)
Spark Streaming

# Concept: Tower Lab



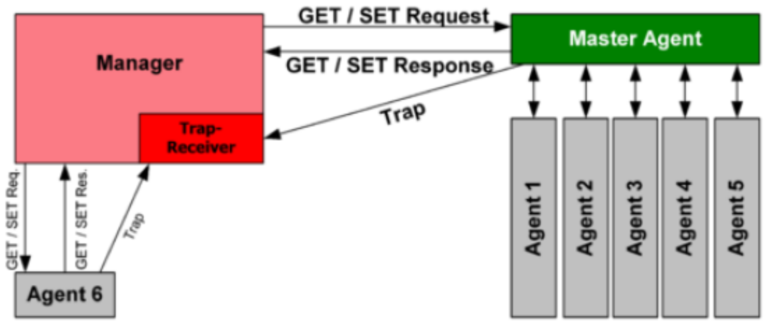
# Relation of SmartX Lab



# Backgrounds

## SNMP

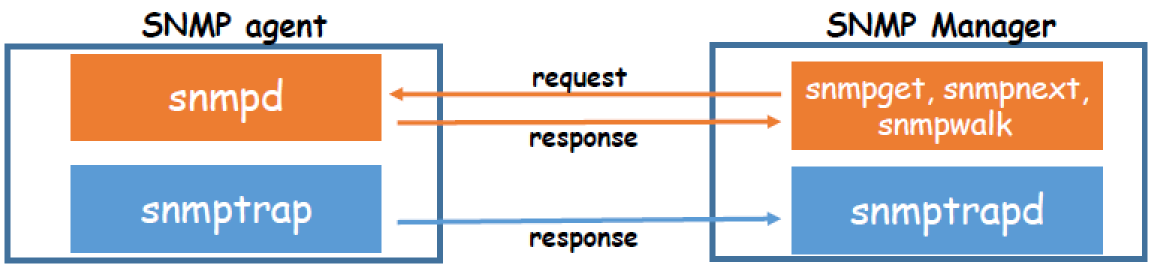
- SNMP: **Simple Network Management Protocol**
- Used in network management systems
  to monitor network-attached devices
- Include routers, switches, servers, workstations, printers, modem racks and more.



# Backgrounds

## Net-SNMP Net-SNMP

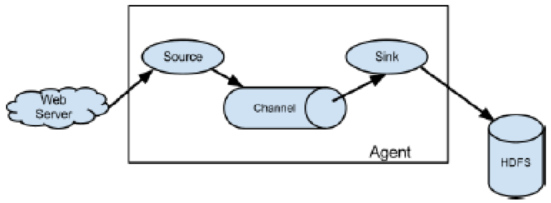
- A Suite of **software** for using and deploying the SNMP protocol



# Backgrounds

## Flume

- **Log aggregator**
  - Many customizable data sources
  - Flume can be used to handle them.
  - Run asynchronously



- Flume Agent
  - **Source**
    - Consuming events having a specific format.
    - Delivering it to the channel
  - **Channel**
    - Holding the event until that consumed
  - **Sink**
    - Removing an event from the channel.
    - Putting it into an external repository or another source.

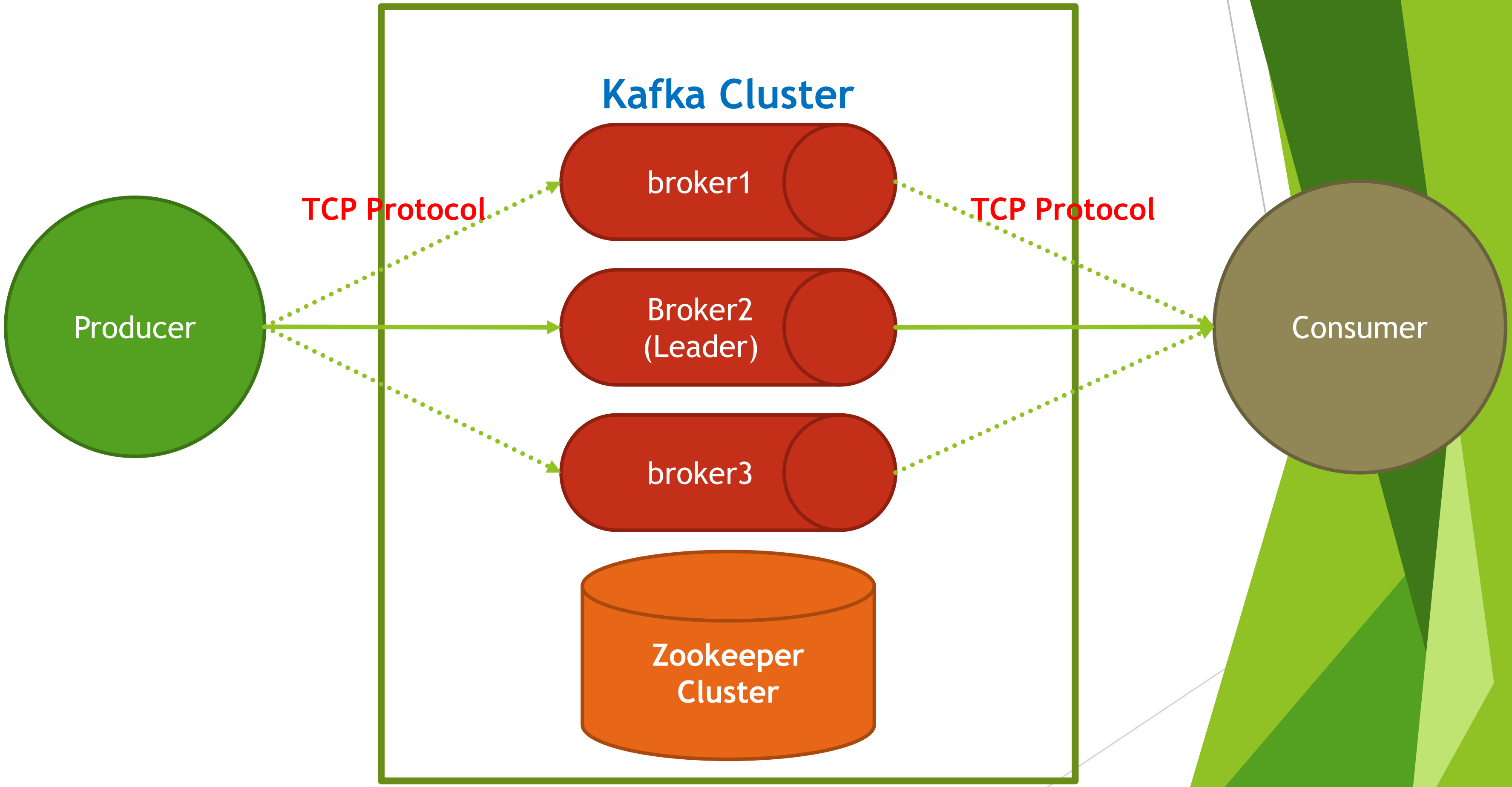
# Backgrounds

## Kafka

- Kafka
  - is a **distributed, partitioned, replicated** commit log service.
  - It provides **the functionality of a messaging system**, but with a unique design
- Basic messaging terminology
  - ***Topics:***
    - maintains feeds of **messages in categories**
  - ***Producers:***
    - processes that **publish messages** to a Kafka topic
  - ***Consumers:***
    - processes that subscribe to topics and process **the feed of published messages**
  - ***Broker:***
    - run as a cluster comprised of one or more servers

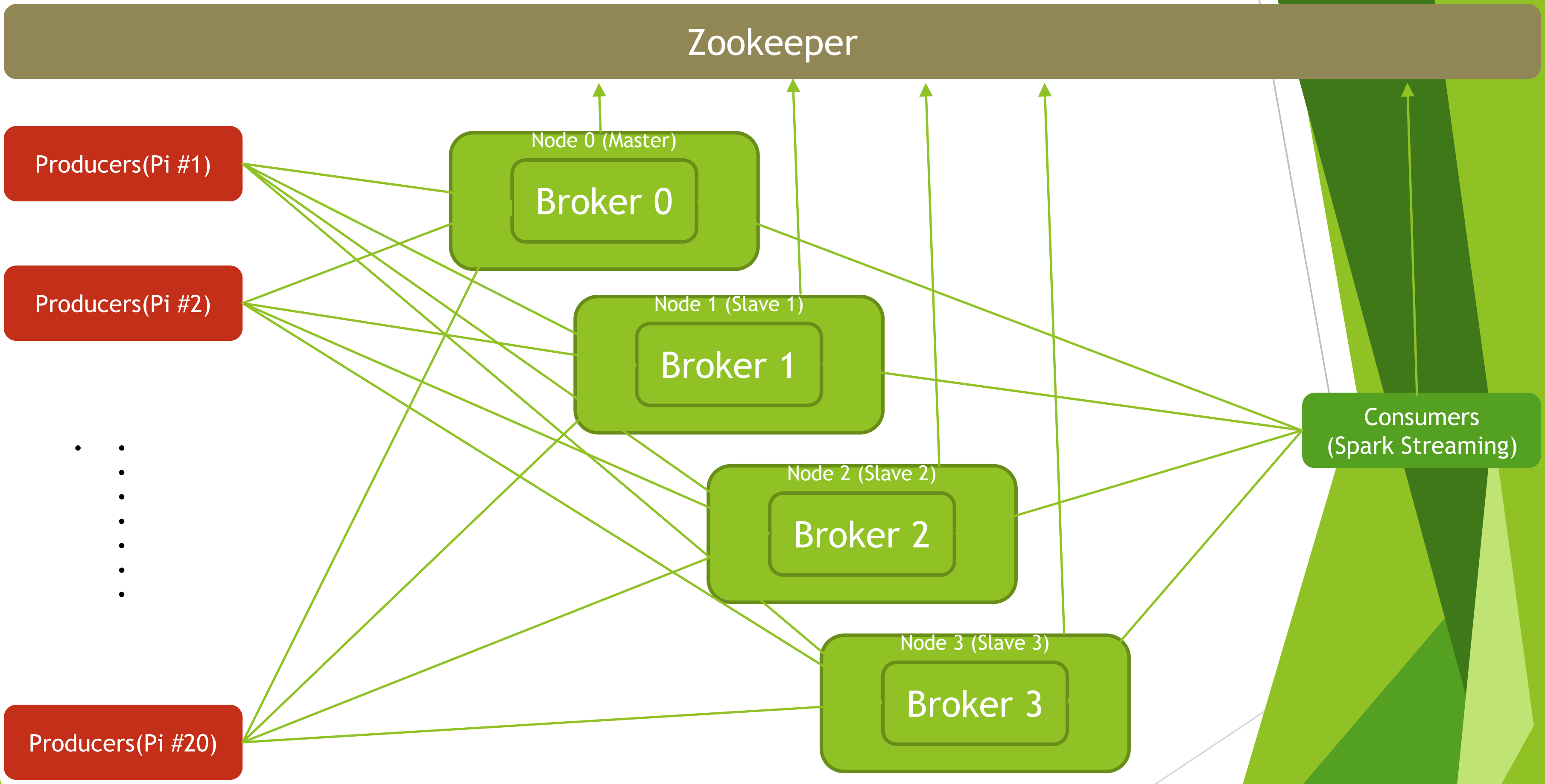
# Backgrounds

## Kafka: Architecture



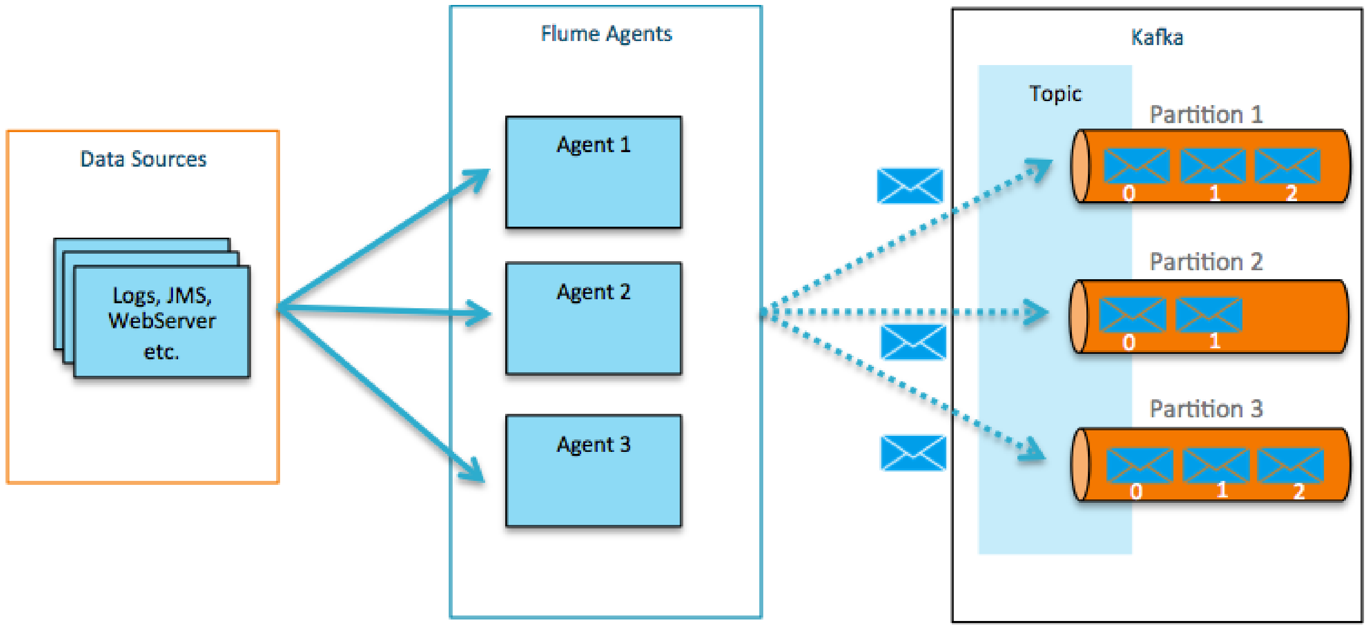
# Backgrounds

## Cont'd



# Backgrounds
## Kafka: with Flume

- **Flafka**
  : Apache Flume Meets Apache Kafka for Event Processing

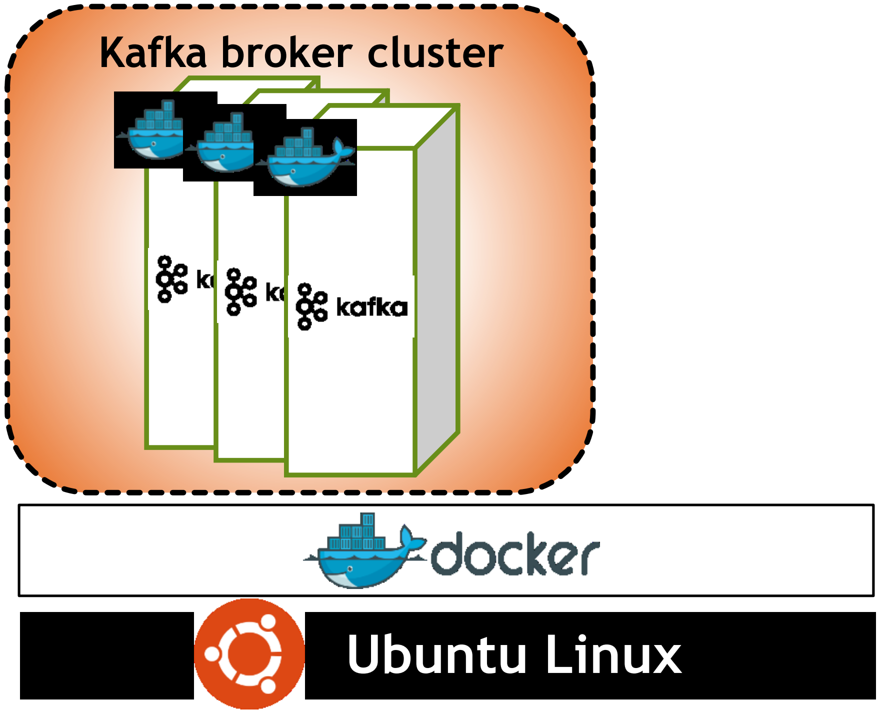


## Backgrounds

- Docker is an open platform for building, shipping and running distributed applications. It gives programmers, development teams and operations engineers the common toolbox they need to take advantage of the distributed and networked nature of modern applications.

## Connecting Configuration on NUC

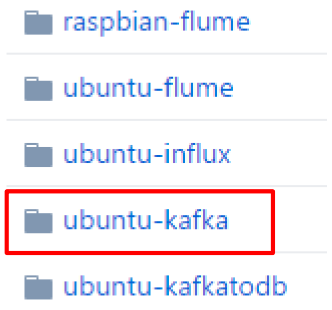
# In this section



## 1. Download Source from Github

- Download all files from Github
  (http://github.com/SmartXBox/SmartX-mini)
  - $ git clone https://github.com/SmartXBox/SmartX-mini.git

- Folder List



raspbian-flume
ubuntu-flume
ubuntu-influx
ubuntu-kafka
ubuntu-kafkatodb

In this section, we use this

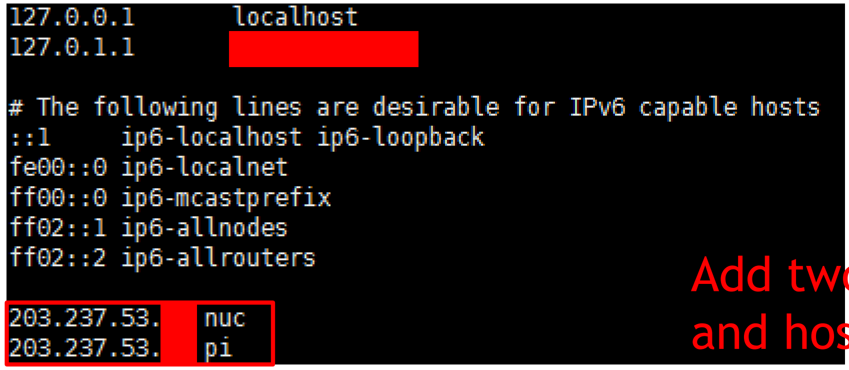
# 2. Edit /etc/hosts

- Every machine which communicate with themselves must know their own address.

1. Edit /etc/hosts

   $ sudo vi /etc/hosts

(For Example)



```
127.0.0.1       localhost
127.0.1.1       [redacted]

# The following lines are desirable for IPv6 capable hosts
::1     ip6-localhost ip6-loopback
fe00::0 ip6-localnet
ff00::0 ip6-mcastprefix
ff02::1 ip6-allnodes
ff02::2 ip6-allrouters

203.237.53.[redacted]   nuc
203.237.53.[redacted]   pi
```

Add two lines which describe the IP address and hostname of devices

# 3. Allocate Broker IDs and Ports

1. We'll use a one zookeeper, 3 brokers and one consumer containers which share host's public IP address
2. Zookeeper container doesn't have broker id.
3. Each Broker has a unique id and port to interact each other.
4. Consumer container just used to manage topic and check the data from brokers.

| Container Name | IP address | Broker id | Listening port |
|---|---|---|---|
| zookeeper | Host's public IP address | - | 2181 |
| broker0 | | 0 | 9090 |
| broker1 | | 1 | 9091 |
| broker2 | | 2 | 9092 |
| consumer | | - | - |

# 4. Build Docker Image

- Build Docker Image

1. $cd ~/SmartX-mini/ubuntu-kafka
2. Build Dockerfile ※ It takes long time.

```
$ docker build --tag ubuntu-kafka .
```

- If you want to check Docker instruction words

```
$ docker --help
```

ex) docker ps : List containers

docker start : Start one or more stopped containers

docker rm : Remove one or more containers

# 5. Run Docker Container

**(recommend making new terminal window)**

- Run Docker Container

  ```
  $ docker run -it --net=host --name [container name] ubuntu-kafka
  ```

  - We need to run 5 containers (zookeeper 1, broker 3, consumer 1)
  - Let's assume the name of each containers,

    zookeeper, broker0, broker1, broker2, consumer
  - Repeatedly type the above command with changing container name
  - If you want to look for more details about Docker command, see https://docs.docker.com/reference/commandline/

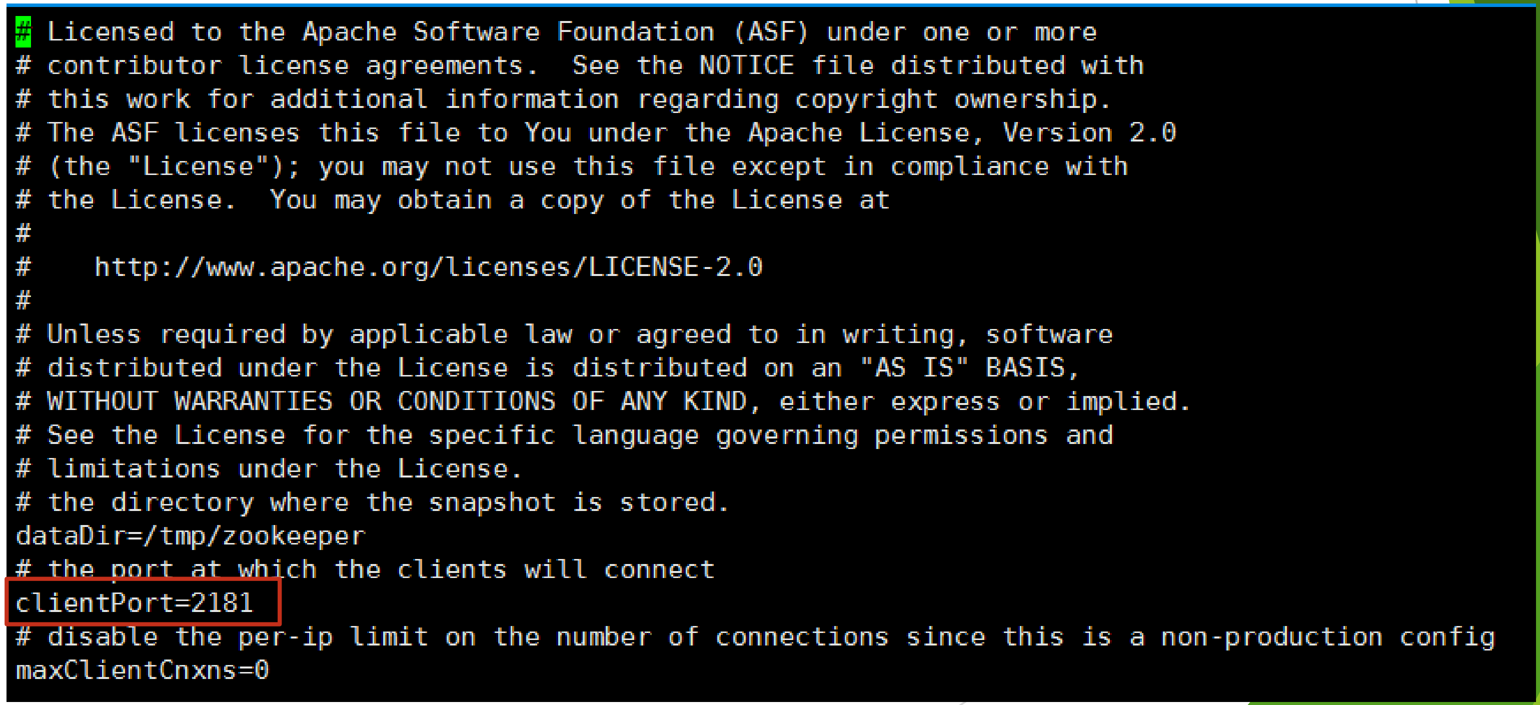
# 6-1. Configure Zookeeper propertie

- Actually we use default configurations

1. Open zookeeper properties file

   $vi config/zookeeper.properties

2. Check the client port

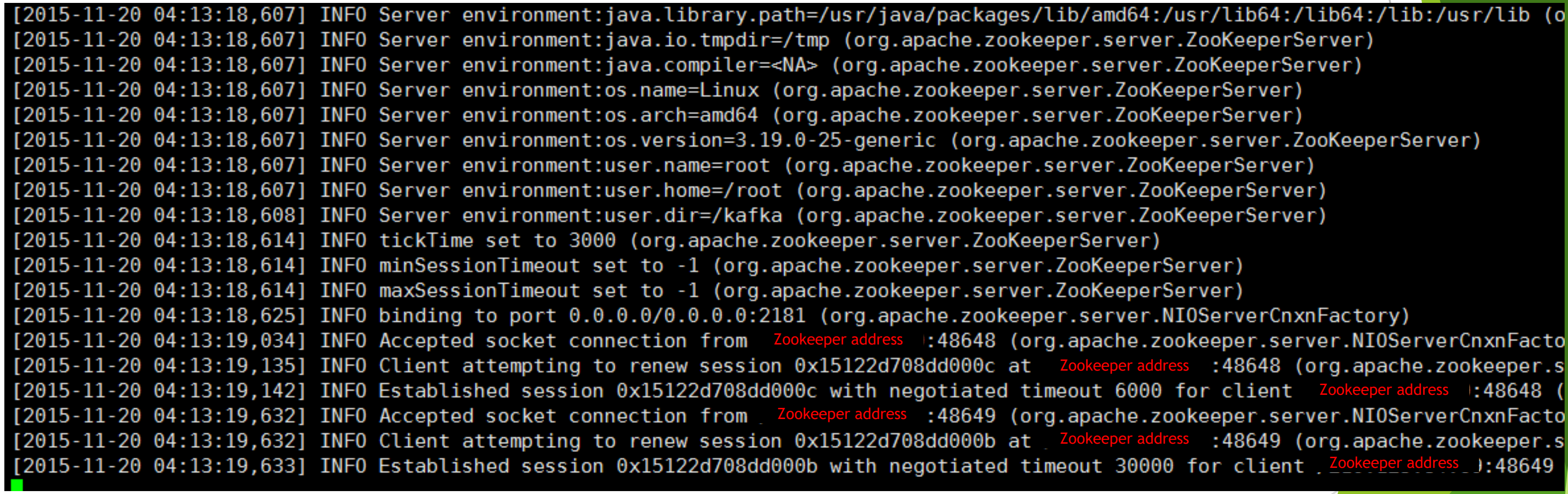


```
# Licensed to the Apache Software Foundation (ASF) under one or more
# contributor license agreements.  See the NOTICE file distributed with
# this work for additional information regarding copyright ownership.
# The ASF licenses this file to You under the Apache License, Version 2.0
# (the "License"); you may not use this file except in compliance with
# the License.  You may obtain a copy of the License at
#
#    http://www.apache.org/licenses/LICENSE-2.0
#
# Unless required by applicable law or agreed to in writing, software
# distributed under the License is distributed on an "AS IS" BASIS,
# WITHOUT WARRANTIES OR CONDITIONS OF ANY KIND, either express or implied.
# See the License for the specific language governing permissions and
# limitations under the License.
# the directory where the snapshot is stored.
dataDir=/tmp/zookeeper
# the port at which the clients will connect
clientPort=2181
# disable the per-ip limit on the number of connections since this is a non-production config
maxClientCnxns=0
```

# 6-2. Launching Zookeeper

- ✓ zookeeper must launch first

  $bin/zookeeper-server-start.sh config/zookeeper.properties



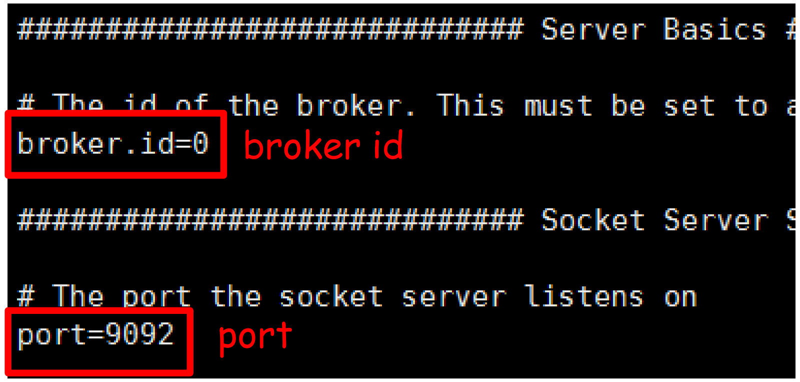
```
[2015-11-20 04:13:18,607] INFO Server environment:java.library.path=/usr/java/packages/lib/amd64:/usr/lib64:/lib64:/lib:/usr/lib (o
[2015-11-20 04:13:18,607] INFO Server environment:java.io.tmpdir=/tmp (org.apache.zookeeper.server.ZooKeeperServer)
[2015-11-20 04:13:18,607] INFO Server environment:java.compiler=<NA> (org.apache.zookeeper.server.ZooKeeperServer)
[2015-11-20 04:13:18,607] INFO Server environment:os.name=Linux (org.apache.zookeeper.server.ZooKeeperServer)
[2015-11-20 04:13:18,607] INFO Server environment:os.arch=amd64 (org.apache.zookeeper.server.ZooKeeperServer)
[2015-11-20 04:13:18,607] INFO Server environment:os.version=3.19.0-25-generic (org.apache.zookeeper.server.ZooKeeperServer)
[2015-11-20 04:13:18,607] INFO Server environment:user.name=root (org.apache.zookeeper.server.ZooKeeperServer)
[2015-11-20 04:13:18,607] INFO Server environment:user.home=/root (org.apache.zookeeper.server.ZooKeeperServer)
[2015-11-20 04:13:18,608] INFO Server environment:user.dir=/kafka (org.apache.zookeeper.server.ZooKeeperServer)
[2015-11-20 04:13:18,614] INFO tickTime set to 3000 (org.apache.zookeeper.server.ZooKeeperServer)
[2015-11-20 04:13:18,614] INFO minSessionTimeout set to -1 (org.apache.zookeeper.server.ZooKeeperServer)
[2015-11-20 04:13:18,614] INFO maxSessionTimeout set to -1 (org.apache.zookeeper.server.ZooKeeperServer)
[2015-11-20 04:13:18,625] INFO binding to port 0.0.0.0/0.0.0.0:2181 (org.apache.zookeeper.server.NIOServerCnxnFactory)
[2015-11-20 04:13:19,034] INFO Accepted socket connection from  Zookeeper address  :48648 (org.apache.zookeeper.server.NIOServerCnxnFacto
[2015-11-20 04:13:19,135] INFO Client attempting to renew session 0x15122d708dd000c at  Zookeeper address  :48648 (org.apache.zookeeper.s
[2015-11-20 04:13:19,142] INFO Established session 0x15122d708dd000c with negotiated timeout 6000 for client  Zookeeper address  :48648 (
[2015-11-20 04:13:19,632] INFO Accepted socket connection from  Zookeeper address  :48649 (org.apache.zookeeper.server.NIOServerCnxnFacto
[2015-11-20 04:13:19,632] INFO Client attempting to renew session 0x15122d708dd000b at  Zookeeper address  :48649 (org.apache.zookeeper.s
[2015-11-20 04:13:19,633] INFO Established session 0x15122d708dd000b with negotiated timeout 30000 for client  Zookeeper address  :48649
```

# 7-1. Configure Kafka properties

1. Open server properties file

   $vi config/server.properties

2. Editing proper broker id and port (it must be unique)



```
############################# Server Basics #

# The id of the broker. This must be set to a
broker.id=0

############################# Socket Server S

# The port the socket server listens on
port=9092
```

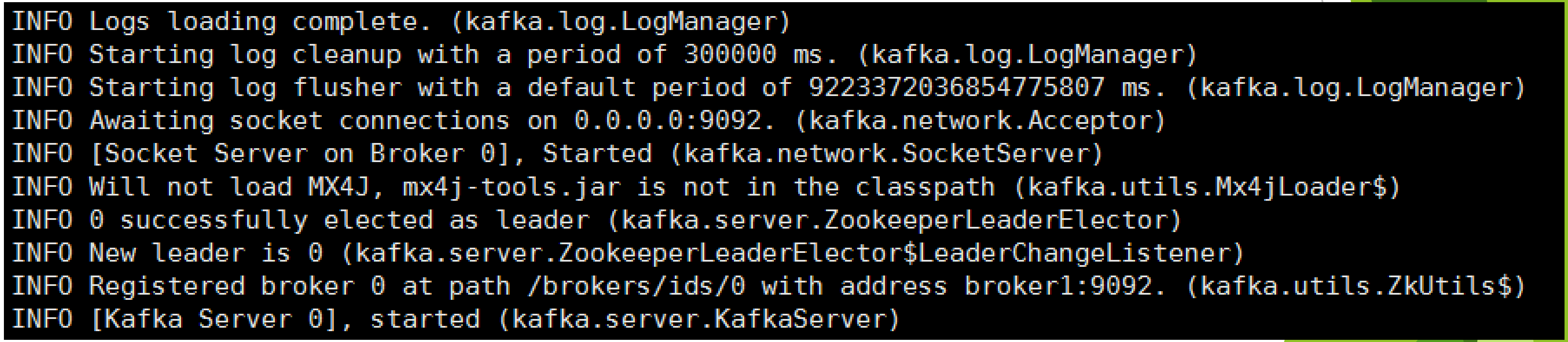
| Container Name | Broker id | Listening port |
|---|---|---|
| broker0 | 0 | 9090 |
| broker1 | 1 | 9091 |
| broker2 | 2 | 9092 |
| consumer | - | - |

Don't need to change anything, actually it doesn't act as a broker

# 7-2. Launching Kafka brokers

- ✓ Attach into each kafka broker container and run scripts to launch

  $bin/kafka-server-start.sh config/server.properties



```
INFO Logs loading complete. (kafka.log.LogManager)
INFO Starting log cleanup with a period of 300000 ms. (kafka.log.LogManager)
INFO Starting log flusher with a default period of 9223372036854775807 ms. (kafka.log.LogManager)
INFO Awaiting socket connections on 0.0.0.0:9092. (kafka.network.Acceptor)
INFO [Socket Server on Broker 0], Started (kafka.network.SocketServer)
INFO Will not load MX4J, mx4j-tools.jar is not in the classpath (kafka.utils.Mx4jLoader$)
INFO 0 successfully elected as leader (kafka.server.ZookeeperLeaderElector)
INFO New leader is 0 (kafka.server.ZookeeperLeaderElector$LeaderChangeListener)
INFO Registered broker 0 at path /brokers/ids/0 with address broker1:9092. (kafka.utils.ZkUtils$)
INFO [Kafka Server 0], started (kafka.server.KafkaServer)
```

# 8. Make a topic

- Create topic
  - $ bin/kafka-topics.sh --create --zookeeper localhost:2181 --replication-factor 1 --partitions 3 --topic resource

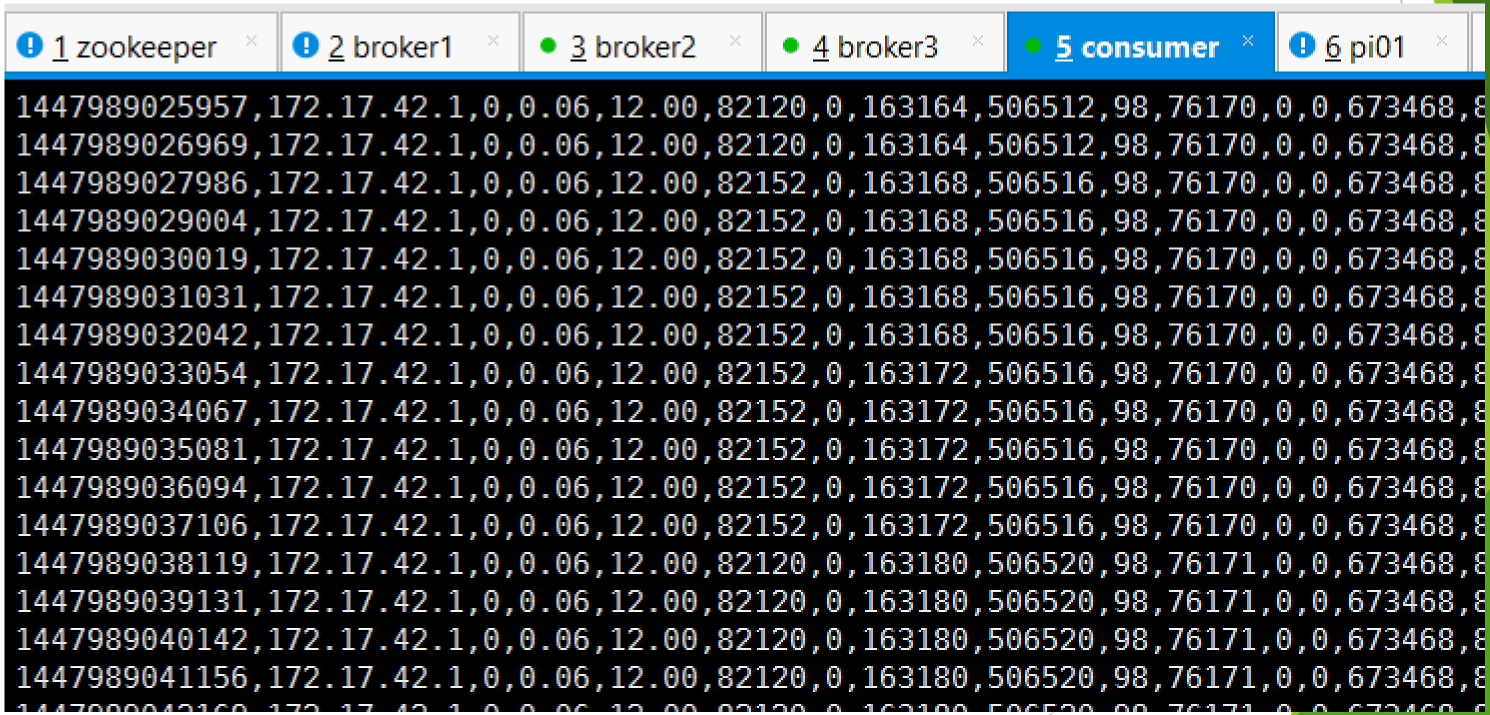
- We can check topics.

  Topic List
  - $ bin/kafka-topics.sh --list --zookeeper <zookeeper host name>:2181

  Topic specification
  - $ bin/kafka-topics.sh --describe --zookeeper <zookeeper host name>:2181 --topic <topic_name>

# 9. Consume message from brokers

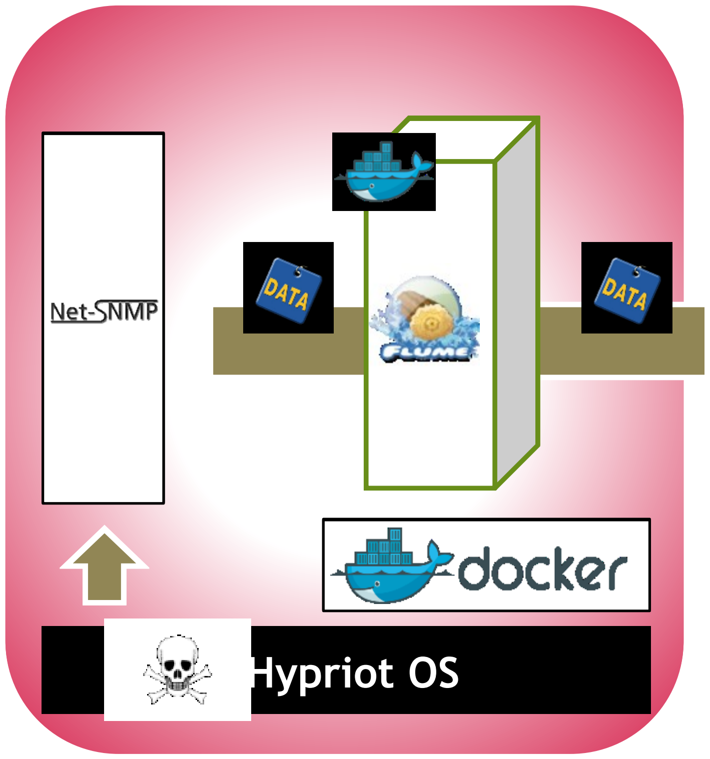
1. Launch consumer script on consumer container
   - $bin/kafka-console-consumer.sh --zookeeper localhost:2181 --topic resource --from-beginning



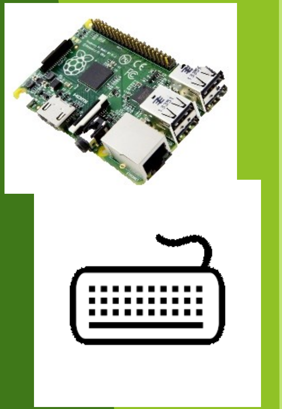
```
1447989025957,172.17.42.1,0,0.06,12.00,82120,0,163164,506512,98,76170,0,0,673468,
1447989026969,172.17.42.1,0,0.06,12.00,82120,0,163164,506512,98,76170,0,0,673468,
1447989027986,172.17.42.1,0,0.06,12.00,82152,0,163168,506516,98,76170,0,0,673468,
1447989029004,172.17.42.1,0,0.06,12.00,82152,0,163168,506516,98,76170,0,0,673468,
1447989030019,172.17.42.1,0,0.06,12.00,82152,0,163168,506516,98,76170,0,0,673468,
1447989031031,172.17.42.1,0,0.06,12.00,82152,0,163168,506516,98,76170,0,0,673468,
1447989032042,172.17.42.1,0,0.06,12.00,82152,0,163168,506516,98,76170,0,0,673468,
1447989033054,172.17.42.1,0,0.06,12.00,82152,0,163172,506516,98,76170,0,0,673468,
1447989034067,172.17.42.1,0,0.06,12.00,82152,0,163172,506516,98,76170,0,0,673468,
1447989035081,172.17.42.1,0,0.06,12.00,82152,0,163172,506516,98,76170,0,0,673468,
1447989036094,172.17.42.1,0,0.06,12.00,82152,0,163172,506516,98,76170,0,0,673468,
1447989037106,172.17.42.1,0,0.06,12.00,82152,0,163172,506516,98,76170,0,0,673468,
1447989038119,172.17.42.1,0,0.06,12.00,82120,0,163180,506520,98,76171,0,0,673468,
1447989039131,172.17.42.1,0,0.06,12.00,82120,0,163180,506520,98,76171,0,0,673468,
1447989040142,172.17.42.1,0,0.06,12.00,82120,0,163180,506520,98,76171,0,0,673468,
1447989041156,172.17.42.1,0,0.06,12.00,82120,0,163180,506520,98,76171,0,0,673468,
```

## Connecting Configuration on Raspberry Pi

# In this section



# 1. Download Source from Github



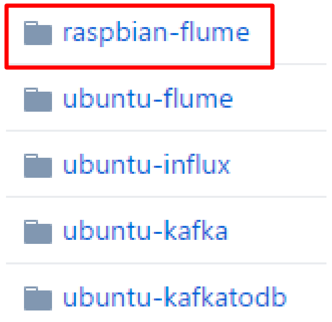
- Git package is already installed in Hypriot OS

- Download all files from Github

  (http://github.com/SmartXBox/SmartX-mini)

  - $ git clone https://github.com/SmartXBox/SmartX-mini.git

- Folder List



raspbian-flume
ubuntu-flume
ubuntu-influx
ubuntu-kafka
ubuntu-kafkatodb

In this section, we use this

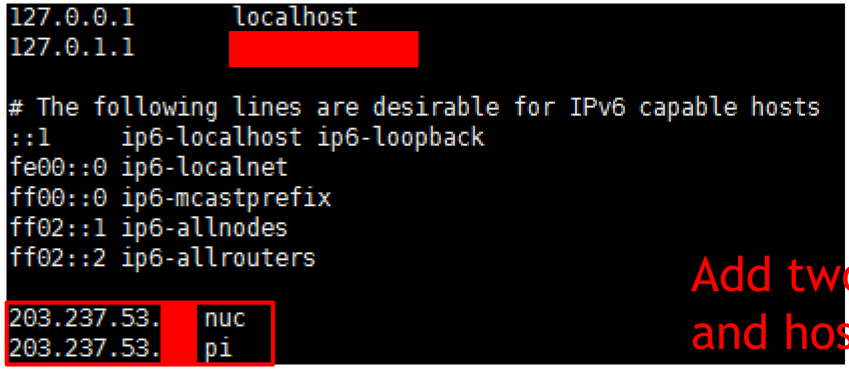
# 2. Edit /etc/hosts

- Every machine which communicate with themselves must know their own address.

1. Edit /etc/hosts

   $ sudo vi /etc/hosts

(For Example)



```
127.0.0.1       localhost
127.0.1.1       [redacted]

# The following lines are desirable for IPv6 capable hosts
::1     ip6-localhost ip6-loopback
fe00::0 ip6-localnet
ff00::0 ip6-mcastprefix
ff02::1 ip6-allnodes
ff02::2 ip6-allrouters

203.237.53.[redacted]   nuc
203.237.53.[redacted]   pi
```

Add two lines which describe the IP address and hostname of devices

## 3. Install Net-SNMP

- Update packages

```
$ sudo apt-get update
```

- Download Net-SNMP

```
$ apt-get install –y snmp snmpd snmp-mibs-downloader
```

- Download MIBs

```
$ download-mibs
```

- Modify configuration file

```
$ vi /etc/snmp/snmpd.conf
    #rocommunity public localhost -> Delete #
$ /etc/init.d/snmpd restart
```

# 4. Install Flume on RPi

1) Build Dockerfile ※ It takes long time.

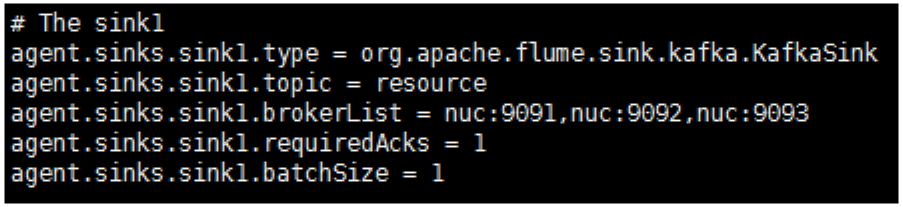
```
$ cd SmartX-mini/raspbian-flume
$ docker build --tag raspbian-flume .
$ docker run -it --net=host --name flume raspbian-flume
```

2) Check the configuration file

```
$ vi conf/flume-conf.properties
```

3) Modifying broker list

- Default value sets "nuc"
- Edit them into your own nuc's hostname

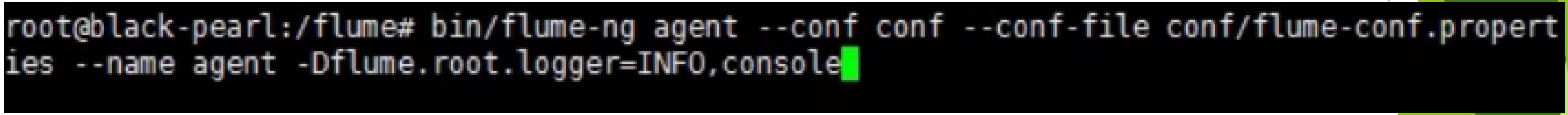


```
# The sink1
agent.sinks.sink1.type = org.apache.flume.sink.kafka.KafkaSink
agent.sinks.sink1.topic = resource
agent.sinks.sink1.brokerList = nuc:9091,nuc:9092,nuc:9093
agent.sinks.sink1.requiredAcks = 1
agent.sinks.sink1.batchSize = 1
```

# 5. Run Flume Agent

- Run Flume on RPi

  $ bin/flume-ng agent --conf conf --conf-file conf/flume-conf.properties --name agent -Dflume.root.logger=INFO,console



```
root@black-pearl:/flume# bin/flume-ng agent --conf conf --conf-file conf/flume-conf.propert
ies --name agent -Dflume.root.logger=INFO,console
```

## 6. Install Net-SNMP

- Update packages

  ```
  $ sudo apt-get update
  ```
- Download Net-SNMP

  ```
  $ apt-get install –y snmp snmpd snmp-mibs-downloader
  ```
- Download MIBs

  ```
  $ download-mibs
  ```
- Modify configuration file

  ```
  $ vi /etc/snmp/snmpd.conf
  ```

  #rocommunity public localhost -> Delete #

  ```
  $ /etc/init.d/snmpd restart
  ```

## 7. Install Flume on NUC

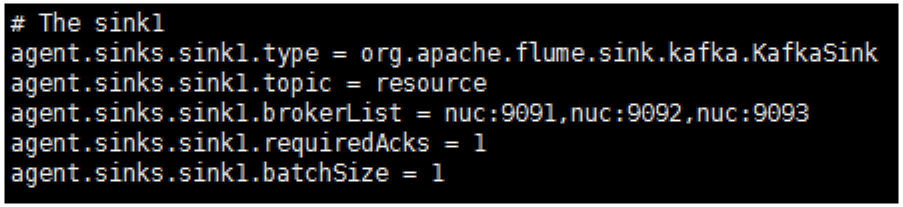
1) Build Dockerfile ※ It takes long time.

```
$ cd SmartX-mini/ubuntu-flume
$ docker build --tag ubuntu-flume .
$ docker run -it --net=host --name flume ubuntu-flume
```

2) Check the configuration file

```
$ vi conf/flume-conf.properties
```

3) Modifying broker list
- Default value sets "nuc"
- Edit them into your own nuc's hostname

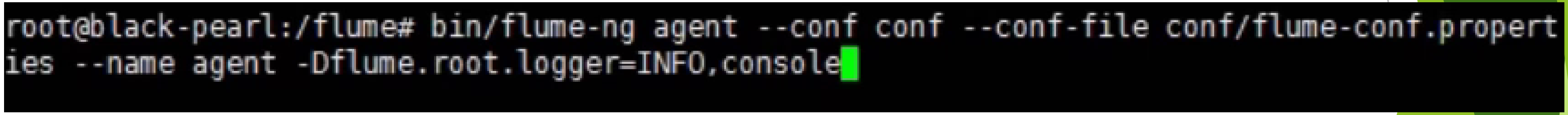


```
# The sink1
agent.sinks.sink1.type = org.apache.flume.sink.kafka.KafkaSink
agent.sinks.sink1.topic = resource
agent.sinks.sink1.brokerList = nuc:9091,nuc:9092,nuc:9093
agent.sinks.sink1.requiredAcks = 1
agent.sinks.sink1.batchSize = 1
```

# 8. Run Flume Agent

- Run Flume on RPi

  $ bin/flume-ng agent --conf conf --conf-file conf/flume-conf.properties --name agent -Dflume.root.logger=INFO,console



```
root@black-pearl:/flume# bin/flume-ng agent --conf conf --conf-file conf/flume-conf.propert
ies --name agent -Dflume.root.logger=INFO,console
```

## Visibility Center: Resource Monitoring Service

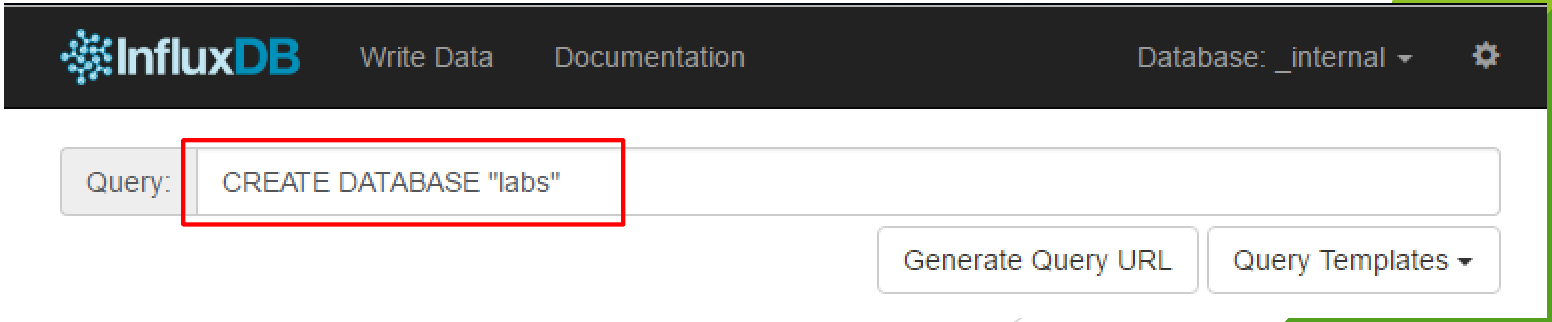
# InfluxDB

- $ cd SmartX-mini/ubuntu-influx

- $ docker run --net=host -d -v /var/lib/influxdb:/var/lib/influxdb -v $PWD/influxdb.conf:/etc/influxdb/influxdb.conf:ro -e INFLUXDB_ADMIN_ENABLED=true --name influx influxdb

- Connect Web UI

  http://localhost:8083/

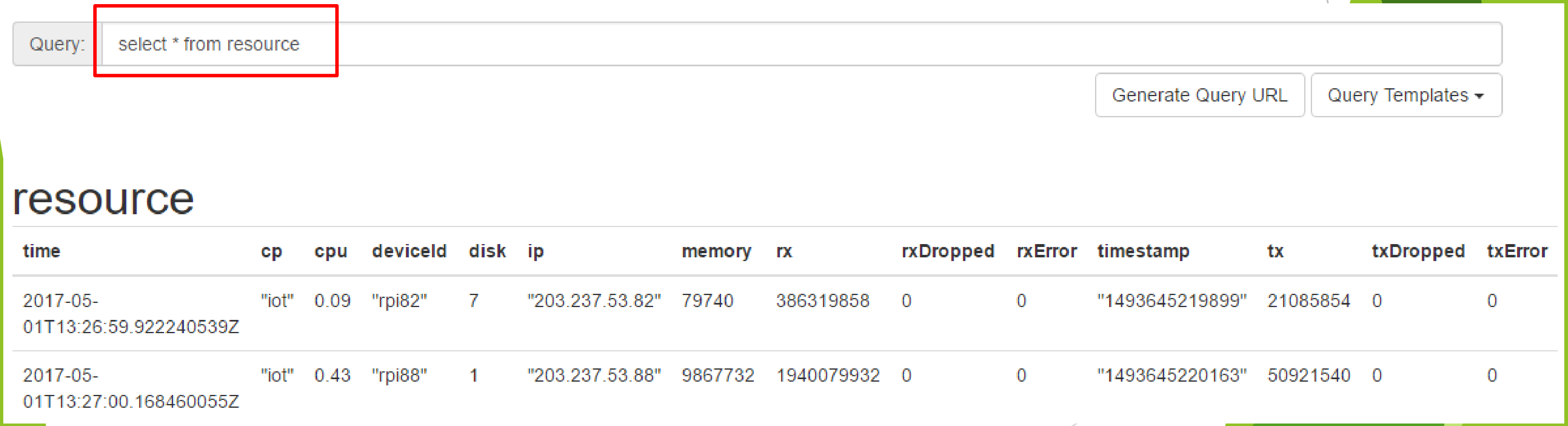


Query: CREATE DATABASE "labs"

# Insert Data from Kafka to InfluxDB

```
$ cd SmartX-mini/ubuntu-kafkatodb
$ sudo docker build --tag kafkatodb .
$ sudo docker run -d --net=host --name kafkatodb kafkatodb
```

- Then, we can check the data in DB



Query: select * from resource

Generate Query URL | Query Templates

## resource

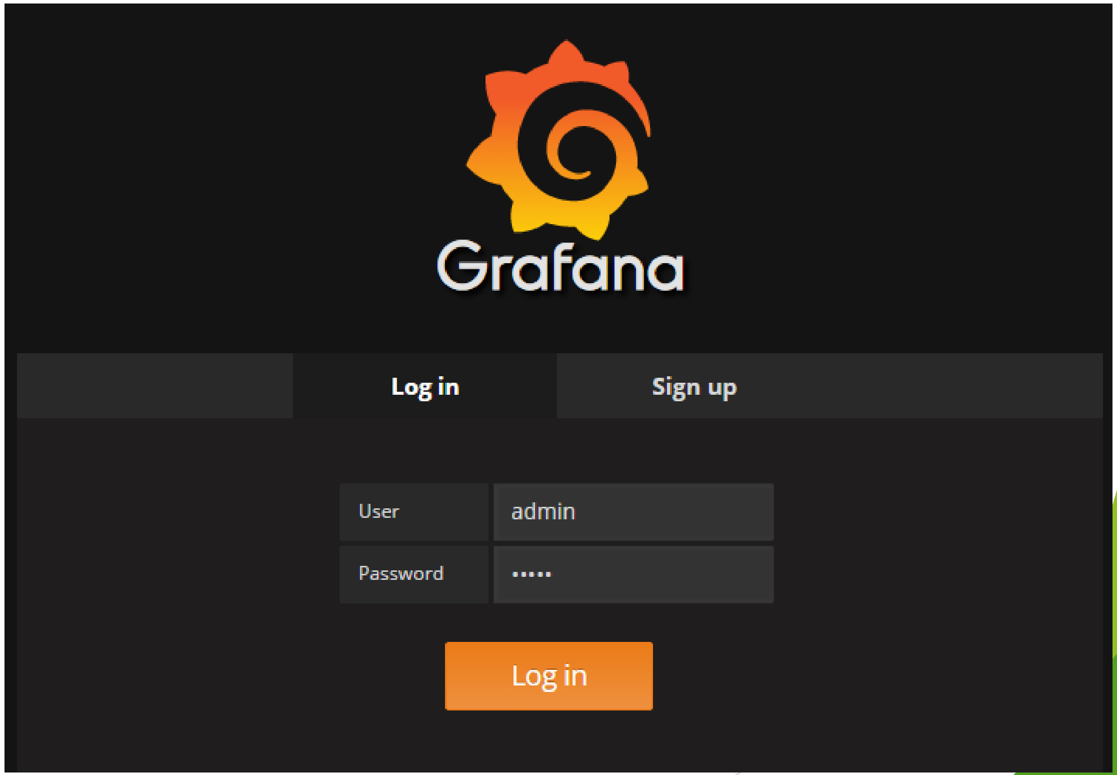
| time | cp | cpu | deviceId | disk | ip | memory | rx | rxDropped | rxError | timestamp | tx | txDropped | txError |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2017-05-01T13:26:59.922240539Z | "iot" | 0.09 | "rpi82" | 7 | "203.237.53.82" | 79740 | 386319858 | 0 | 0 | "1493645219899" | 21085854 | 0 | 0 |
| 2017-05-01T13:27:00.168460055Z | "iot" | 0.43 | "rpi88" | 1 | "203.237.53.88" | 9867732 | 1940079932 | 0 | 0 | "1493645220163" | 50921540 | 0 | 0 |

## Run Grafana

```
$ docker run -d --net=host --name grafana grafana/grafana
```

- Connect Web UI (admin/admin)

  http://localhost:3000/



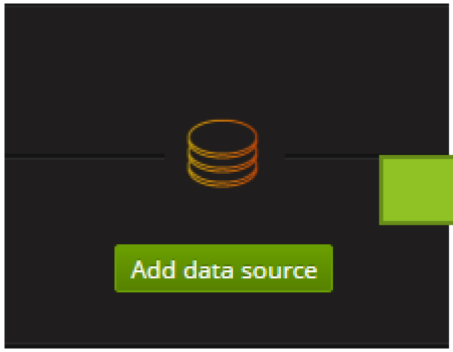
Grafana

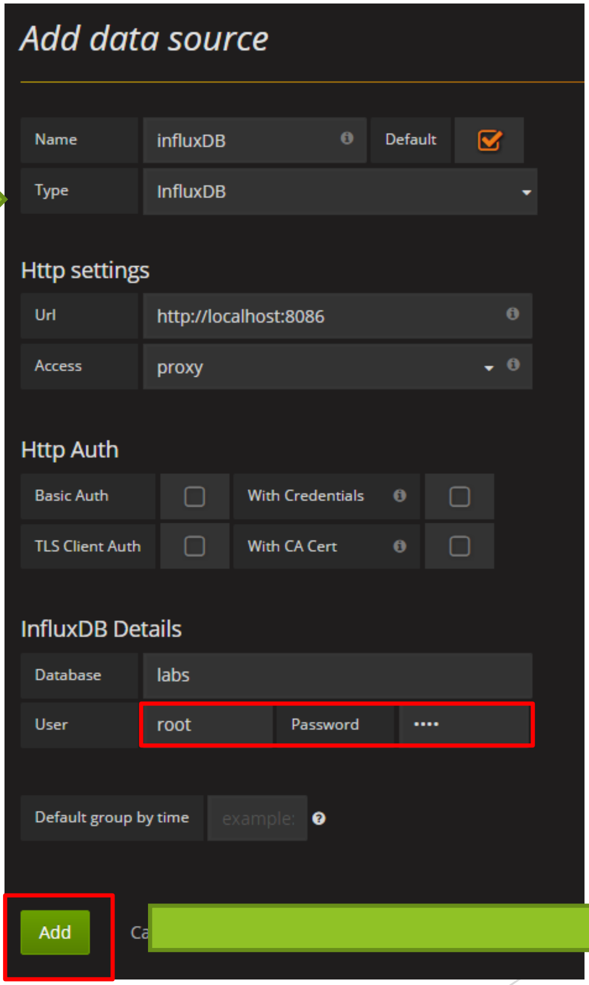
Log in | Sign up

| | |
|---|---|
| User | admin |
| Password | ••••• |

# Configure Grafana Dashboard

- Follow below sequences with written option values




Add data source

| | | | |
|---|---|---|---|
| Name | influxDB | Default | ✓ |
| Type | InfluxDB | | |

Http settings

| | |
|---|---|
| Url | http://localhost:8086 |
| Access | proxy |

Http Auth

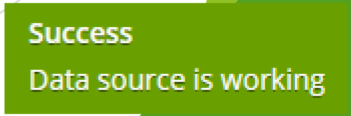
| | | | |
|---|---|---|---|
| Basic Auth | ☐ | With Credentials | ☐ |
| TLS Client Auth | ☐ | With CA Cert | ☐ |

InfluxDB Details

| | | | |
|---|---|---|---|
| Database | labs | | |
| User | root | Password | •••• |

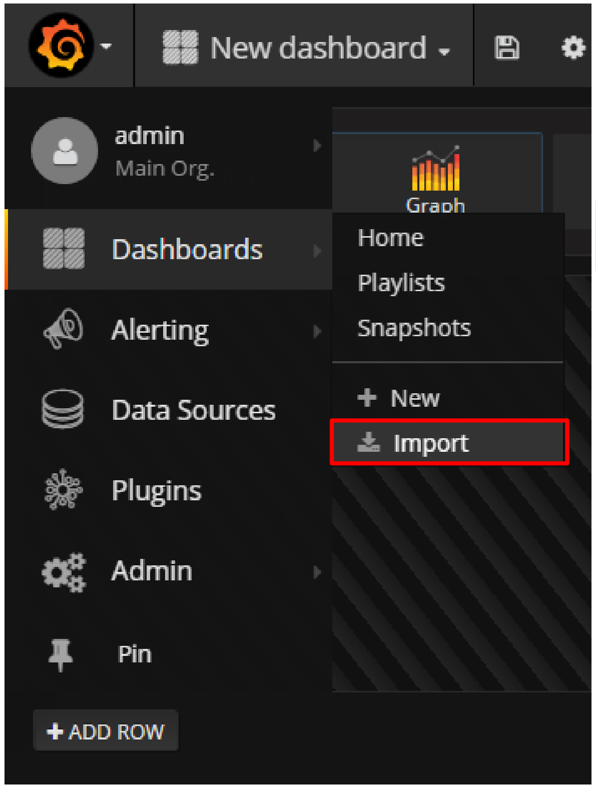
| | |
|---|---|
| Default group by time | example: |

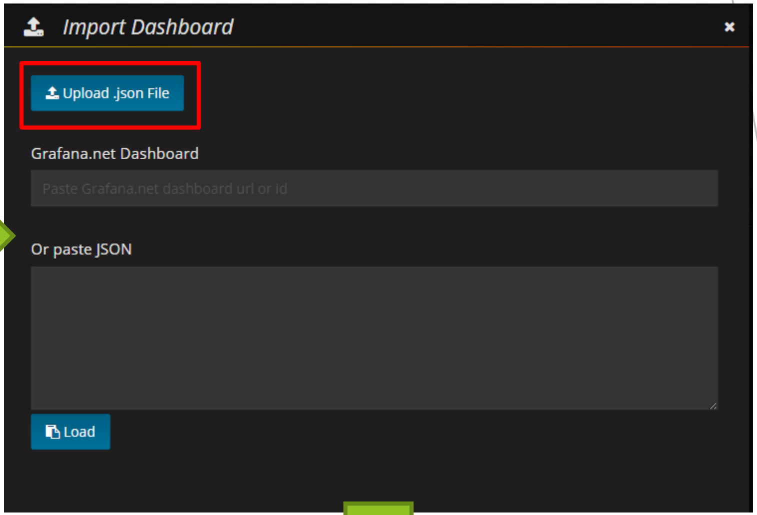
root/root

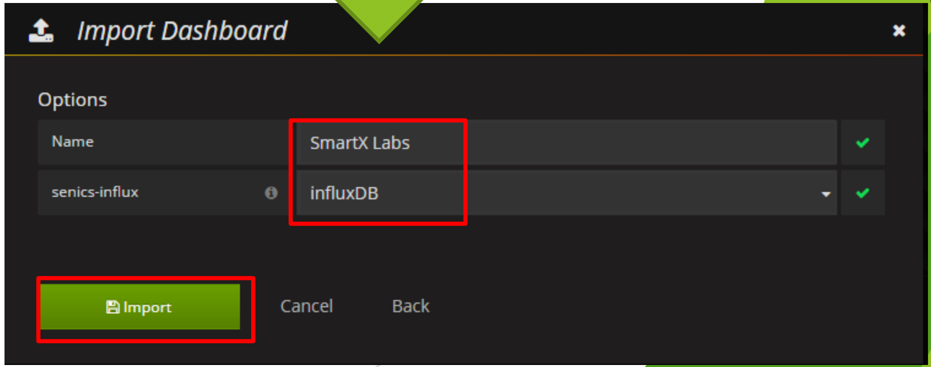

Success

Data source is working

## Cont'd






Import Dashboard

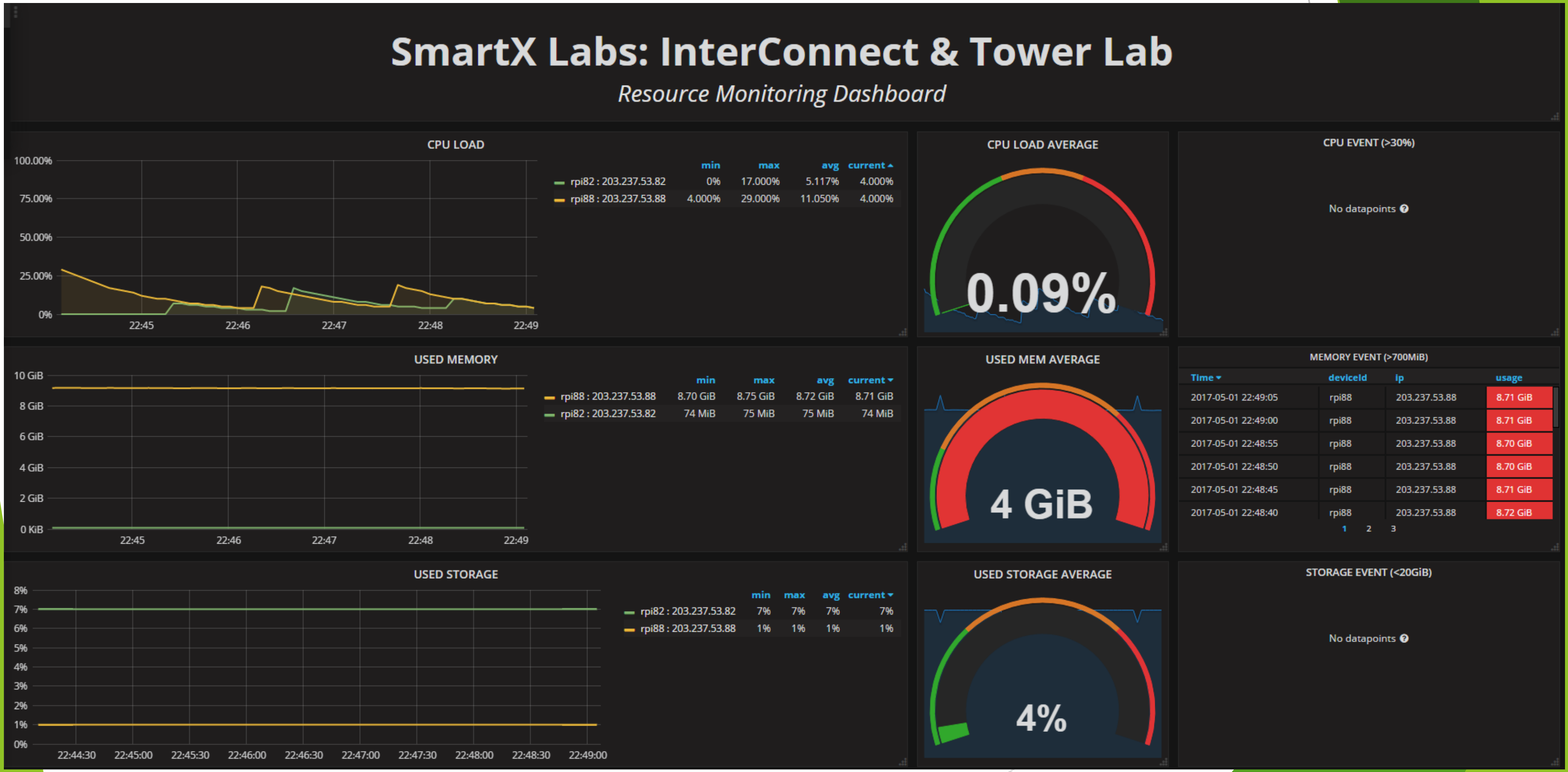
Options

Name: SmartX Labs

senics-influx: influxDB

# Check Dashboard

- We can see the changes of values from database



**SmartX Labs: InterConnect & Tower Lab**

*Resource Monitoring Dashboard*

CPU LOAD

| | min | max | avg | current |
|---|---|---|---|---|
| rpi82 : 203.237.53.82 | 0% | 17.000% | 5.117% | 4.000% |
| rpi88 : 203.237.53.88 | 4.000% | 29.000% | 11.050% | 4.000% |

CPU LOAD AVERAGE

CPU EVENT (>30%)

No datapoints

USED MEMORY

| | min | max | avg | current |
|---|---|---|---|---|
| rpi88 : 203.237.53.88 | 8.70 GiB | 8.75 GiB | 8.72 GiB | 8.71 GiB |
| rpi82 : 203.237.53.82 | 74 MiB | 75 MiB | 75 MiB | 74 MiB |

USED MEM AVERAGE

MEMORY EVENT (>700MiB)

| Time | deviceId | ip | usage |
|---|---|---|---|
| 2017-05-01 22:49:05 | rpi88 | 203.237.53.88 | 8.71 GiB |
| 2017-05-01 22:49:00 | rpi88 | 203.237.53.88 | 8.71 GiB |
| 2017-05-01 22:48:55 | rpi88 | 203.237.53.88 | 8.70 GiB |
| 2017-05-01 22:48:50 | rpi88 | 203.237.53.88 | 8.70 GiB |
| 2017-05-01 22:48:45 | rpi88 | 203.237.53.88 | 8.71 GiB |
| 2017-05-01 22:48:40 | rpi88 | 203.237.53.88 | 8.72 GiB |

1 2 3

USED STORAGE

| | min | max | avg | current |
|---|---|---|---|---|
| rpi82 : 203.237.53.82 | 7% | 7% | 7% | 7% |
| rpi88 : 203.237.53.88 | 1% | 1% | 1% | 1% |

USED STORAGE AVERAGE

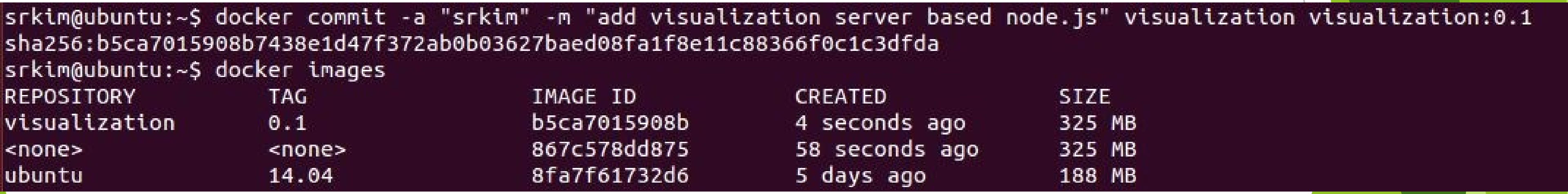
STORAGE EVENT (<20GiB)

No datapoints

Thank You for
Your Attention
Any Questions?

# (참고)
# Container 변경사항 저장 및 재시작

- Commit Container
  - 컨테이너 내의 변경사항을 반영하여 새로운 컨테이너 이미지 작성
  - Ctrl+P+Q
  - docker commit -a “[username]” -m "add visualization server based node.js" visualization visualization:0.1



```
srkim@ubuntu:~$ docker commit -a "srkim" -m "add visualization server based node.js" visualization visualization:0.1
sha256:b5ca7015908b7438e1d47f372ab0b03627baed08fa1f8e11c88366f0c1c3dfda
srkim@ubuntu:~$ docker images
REPOSITORY          TAG                 IMAGE ID            CREATED             SIZE
visualization       0.1                 b5ca7015908b        4 seconds ago       325 MB
<none>              <none>              867c578dd875        58 seconds ago      325 MB
ubuntu              14.04               8fa7f61732d6        5 days ago          188 MB
```

- Restart Container
  - Stop했던 컨테이너를 Restart하면 이전 작업 내용을 유지한 채로 다시 컨테이너를 시작할 수 있다.
  - docker stop visualization
  - docker restart visualization