行動寬頻尖端技術課程推廣計畫

LAB 3: ONOS Controller with Mininet

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Outline

- 實驗目標與步驟
  - 瞭解 controller 與 switch 之間的關係，並且能夠控制封包的傳遞的方向。
- 實驗背景知識介紹
  - Open Network Operating System (ONOS)
  - REST API
- 實驗步驟
  1. 安裝 ONOS
  2. 連接 ONOS 及 Mininet
  3. 由 ONOS REST API 將 flow rule 設置至 OVS
- 實驗考核: 基於 REST API 設置 flow rule

實驗背景知識介紹 1: ONOS

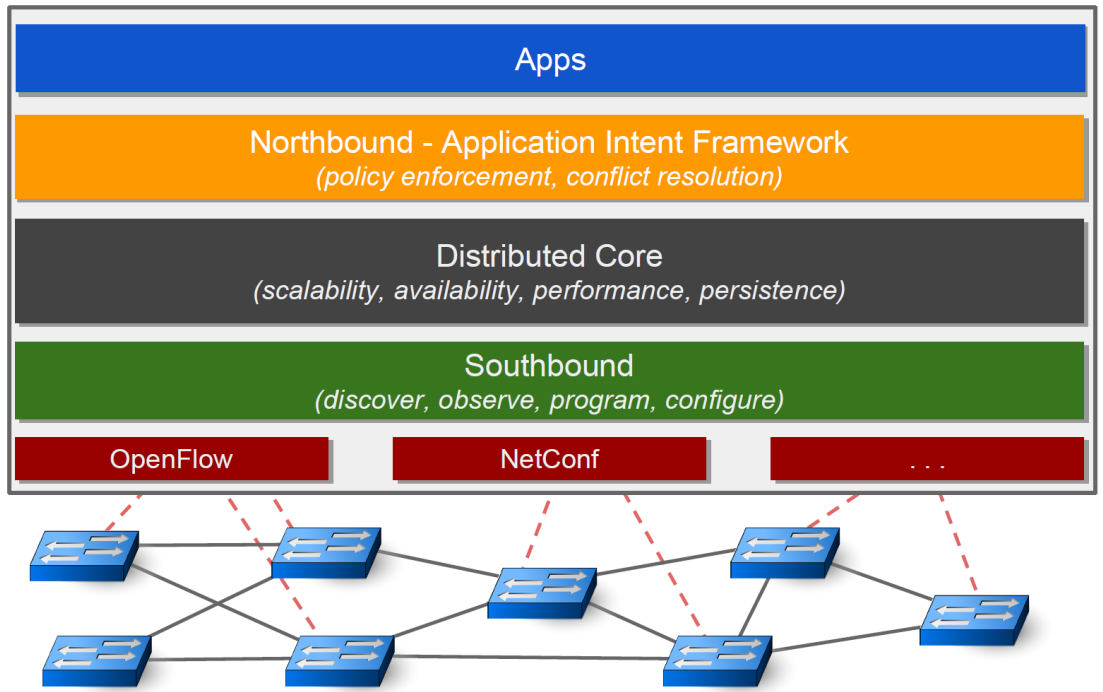
ONOS

- **Open Network Operating System**（ONOS）是由 Linux 基金會託管的一個開源社區。
  - 該項目的目標是為可擴展性、高性能和高可用性設計的通信服務提供商創建一個軟件定義網絡（SDN）操作系統。

Northbound Abstraction:
- network graph
- application intents

Core:
- distributed
- protocol independent

Southbound Abstraction:
- generalized OpenFlow
- pluggable & extensible



實驗背景知識介紹 2: REST API

REST 設計風格

- Representational State Transfer (REST) 是 Roy Thomas Fielding 博士於 2000 年在博士論文中提出的一種全球資訊網軟體架構風格
  - 目的是便於不同軟體 / 程序在網絡（例如：網際網路）中互相傳遞信息。
- 在 REST 中的資源 (Resource) 代表整個網路上的資源。
  - 網路上提供了各式各樣的資源，而網路上的資源由 Uniform Resource Identifier (URI，統一資源標識符) 來提供。
- Client 透過 URI 來獲取資源的具體象徵 (Representational)，並且使應用程式轉變其狀態 (以 Browser 而言，取得 HTML、CSS、JavaScript … 來產生畫面)
  - 隨著不斷取得資源的具體象徵，Client 端不斷地改變其狀態，這樣不斷的反覆 (iterations) 過程就是所謂的 Representational State Transfer。

{ REST }

REST API

- 符合REST設計風格的Web API稱為RESTful API。它對資源(Resource)有以下三個方面的定義：

1. 直觀簡短的資源地址：URI，比如：http://example.com/resources/。
2. 傳輸的資源：Web服務接受與返回的網際網路媒體類型，比如：JSON，XML，YAML等。
3. 對資源的操作：Web服務在該資源上所支持的一系列請求方法（比如：POST，GET，PUT或DELETE等）。

- HTTP請求方法(Request Method)在RESTful API中的典型應用：

資源	GET	PUT	POST	DELETE
一組資源的URI，比如 http://example.com/resources/	列出URI，以及該資源組中每個資源的詳細資訊（後者可選）。	使用給定的一組資源替換當前整組資源。	在本組資源中創建/追加一個新的資源。該操作往往返回新資源的URL。	刪除整組資源。
單個資源的URI，比如 http://example.com/resources/142	獲取指定的資源的詳細資訊，格式可以自選一個合適的網絡媒體類型（比如：XML、JSON等）	替換/創建指定的資源。並將其追加到相應的資源組中。	把指定的資源當做一個資源組，並在其下創建/追加一個新的元素，使其隸屬於當前資源。	刪除指定的元素。

RESTful

實驗步驟 1: 安裝 ONOS

安裝環境設置

在安裝 ONOS 之前，有些套件需要先準備好：

- 首先建立兩個資料夾
  - mkdir Downloads Applications
  - cd Downloads
    - ✓移動到Downloads
- 下載所需要的套件
  - wget http://archive.apache.org/dist/karaf/3.0.5/apache-karaf-3.0.5.tar.gz
  - wget http://archive.apache.org/dist/maven/maven-3/3.3.9/binaries/apache-maven-3.3.9-bin.tar.gz
- 解壓縮到Applications
  - tar -zxvf apache-karaf-3.0.5.tar.gz -C ../Applications/
  - tar -zxvf apache-maven-3.3.9-bin.tar.gz -C ../Applications/

*資料夾名稱務必一樣,解壓縮完回家目錄(cd)繼續下一步驟

安裝環境設置

- 接下來安裝 ONOS 使用的JAVA-8
  - sudo apt-get install software-properties-common -y
  - sudo add-apt-repository ppa:webupd8team/java -y
  - sudo apt-get update
  - sudo apt-get install oracle-java8-installer oracle-java8-set-default -y

  注意安裝時假如碰到組態設置提示請選擇“YES”
- 完成安裝後要確認JAVA有沒有被引入的Linux系統內
  - env | grep JAVA_HOME
- 如果沒有回覆任何指令,請手動加入
  - export JAVA_HOME=/usr/lib/jvm/java-8-oracle

  並再次確認是否安裝成功。

註：ONOS API 使用 JAVA 開發為主

安裝 ONOS

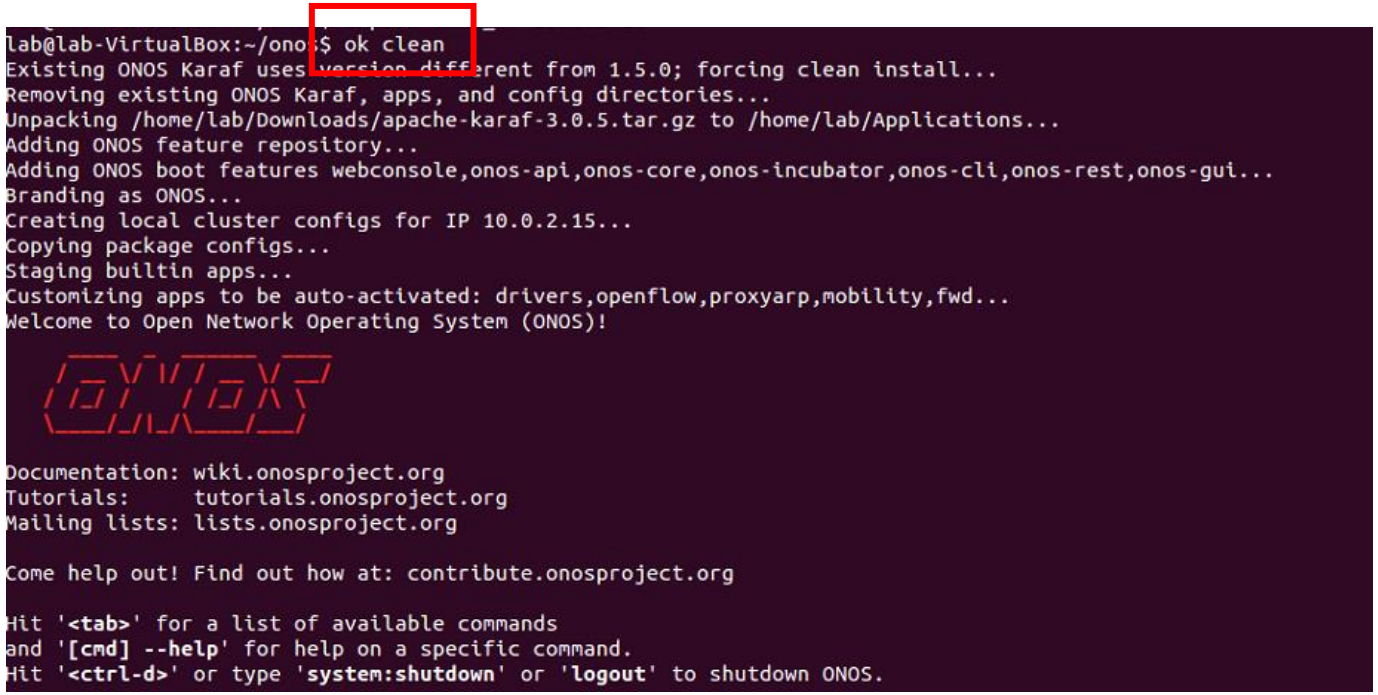
- 請先安裝 git
  - sudo apt-get install git
- 下載套件包
  - git clone https://gerrit.onosproject.org/onos
- 下載完畢後移動至資料夾內執行以下指令
  - cd onos
  - git checkout 1.5.0
    - ✓ 我們使用的版本為 1.5.0
- ONOS 的環境變數設置
  - export ONOS_ROOT=~/onos
  - source $ONOS_ROOT/tools/dev/bash_profile
- 進行安裝
  - mvn clean install
    - ✓ 安裝過程需十五分鐘左右

安裝成功畫面

```
[INFO] onos-app-cordvtn ..................................... SUCCESS [  3.038 s]
[INFO] onos-app-mfwd ........................................ SUCCESS [  1.049 s]
[INFO] onos-app-igmp ........................................ SUCCESS [  0.943 s]
[INFO] onos-app-pim ......................................... SUCCESS [  1.136 s]
[INFO] onos-app-mlb ......................................... SUCCESS [  0.884 s]
[INFO] onos-app-pp .......................................... SUCCESS [  1.080 s]
[INFO] onos-app-drivermatrix ................................ SUCCESS [  0.859 s]
[INFO] onos-app-cpman ....................................... SUCCESS [  9.343 s]
[INFO] onos-events .......................................... SUCCESS [  0.946 s]
[INFO] onos-app-vrouter ..................................... SUCCESS [  0.921 s]
[INFO] onos-app-cord-mcast .................................. SUCCESS [  3.030 s]
[INFO] onos-app-vpls ........................................ SUCCESS [  3.761 s]
[INFO] onos-app-openstacknode ............................... SUCCESS [  1.316 s]
[INFO] onos-app-openstacknetworking ......................... SUCCESS [  0.411 s]
[INFO] onos-app-openstacknetworking-api ..................... SUCCESS [  0.679 s]
[INFO] onos-app-openstackswitching .......................... SUCCESS [  1.228 s]
[INFO] onos-app-openstackrouting ............................ SUCCESS [  1.107 s]
[INFO] onos-app-openstackinterface-app ...................... SUCCESS [  1.149 s]
[INFO] onos-app-openstacknetworking-web ..................... SUCCESS [  1.086 s]
[INFO] onos-app-openstacknetworking-app ..................... SUCCESS [  0.475 s]
[INFO] onos-incubator-core .................................. SUCCESS [  0.714 s]
[INFO] onos-incubator-rpc ................................... SUCCESS [  2.797 s]
[INFO] onos-incubator-rpc-grpc .............................. SUCCESS [ 38.816 s]
[INFO] onos-features ........................................ SUCCESS [  9.535 s]
[INFO] onos-archetypes ...................................... SUCCESS [  0.130 s]
[INFO] onos-api-archetype ................................... SUCCESS [ 15.653 s]
[INFO] onos-bundle-archetype ................................ SUCCESS [  0.108 s]
[INFO] onos-cli-archetype ................................... SUCCESS [  0.087 s]
[INFO] onos-rest-archetype .................................. SUCCESS [  0.036 s]
[INFO] onos-ui-archetype .................................... SUCCESS [  0.104 s]
[INFO] onos-uitab-archetype ................................. SUCCESS [  0.093 s]
[INFO] onos-uitopo-archetype ................................ SUCCESS [  0.098 s]
[INFO] onos-branding ........................................ SUCCESS [  0.988 s]
[INFO] ------------------------------------------------------------------------
[INFO] BUILD SUCCESS
[INFO] ------------------------------------------------------------------------
[INFO] Total time: 17:19 min
[INFO] Finished at: 2017-09-06T19:01:48+08:00
[INFO] Final Memory: 310M/741M
[INFO] ------------------------------------------------------------------------
```

ONOS 參數設置

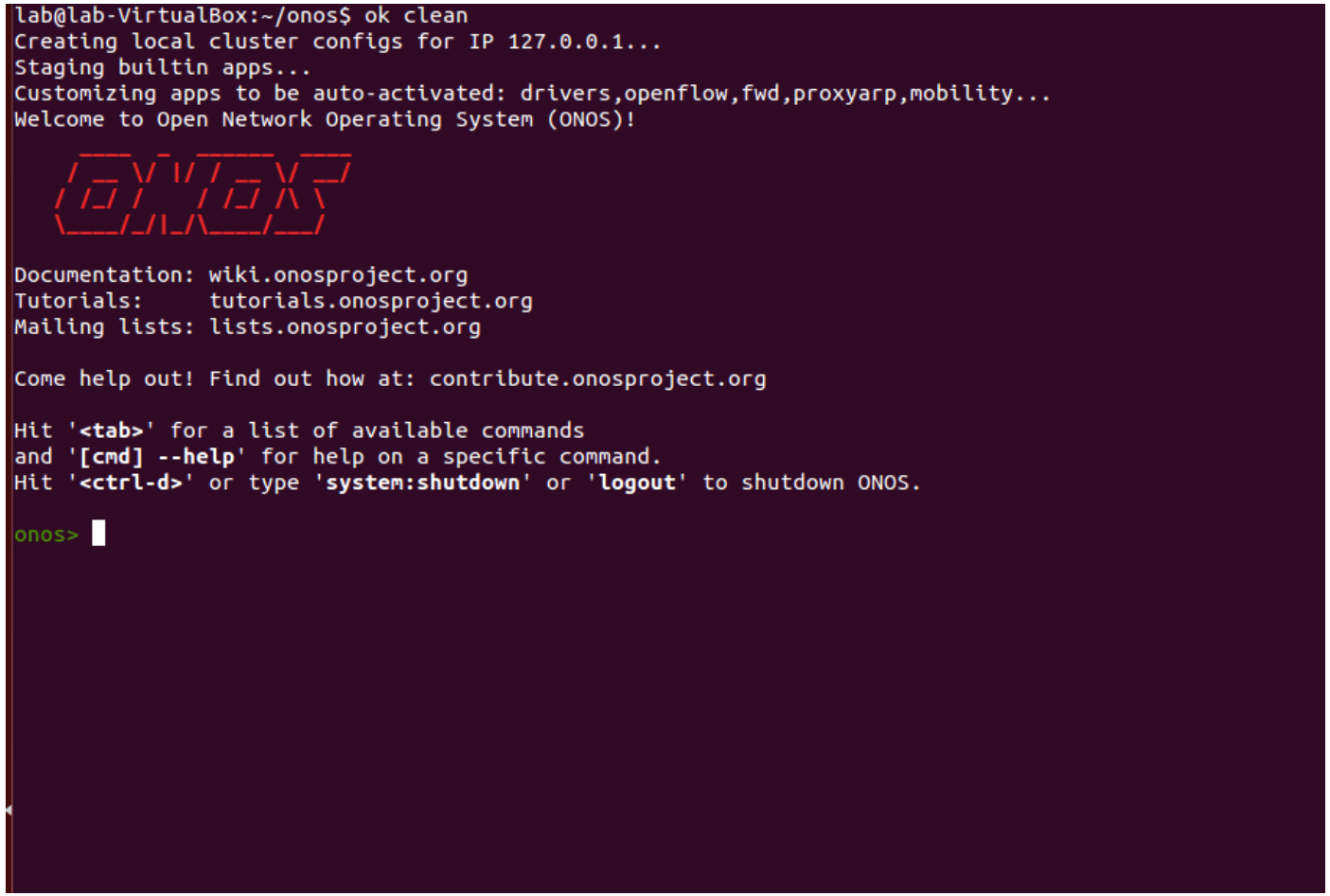
- 首先加入onos的參數
  - export ONOS_IP=自己interface的ip
    - ✓使用 ifconfig 查看
  - export ONOS_APPS=drivers,openflow,proxyarp,mobility,fwd
- 接著輸入指令
  - ok clean



實驗步驟二：連接 ONOS 及 Mininet

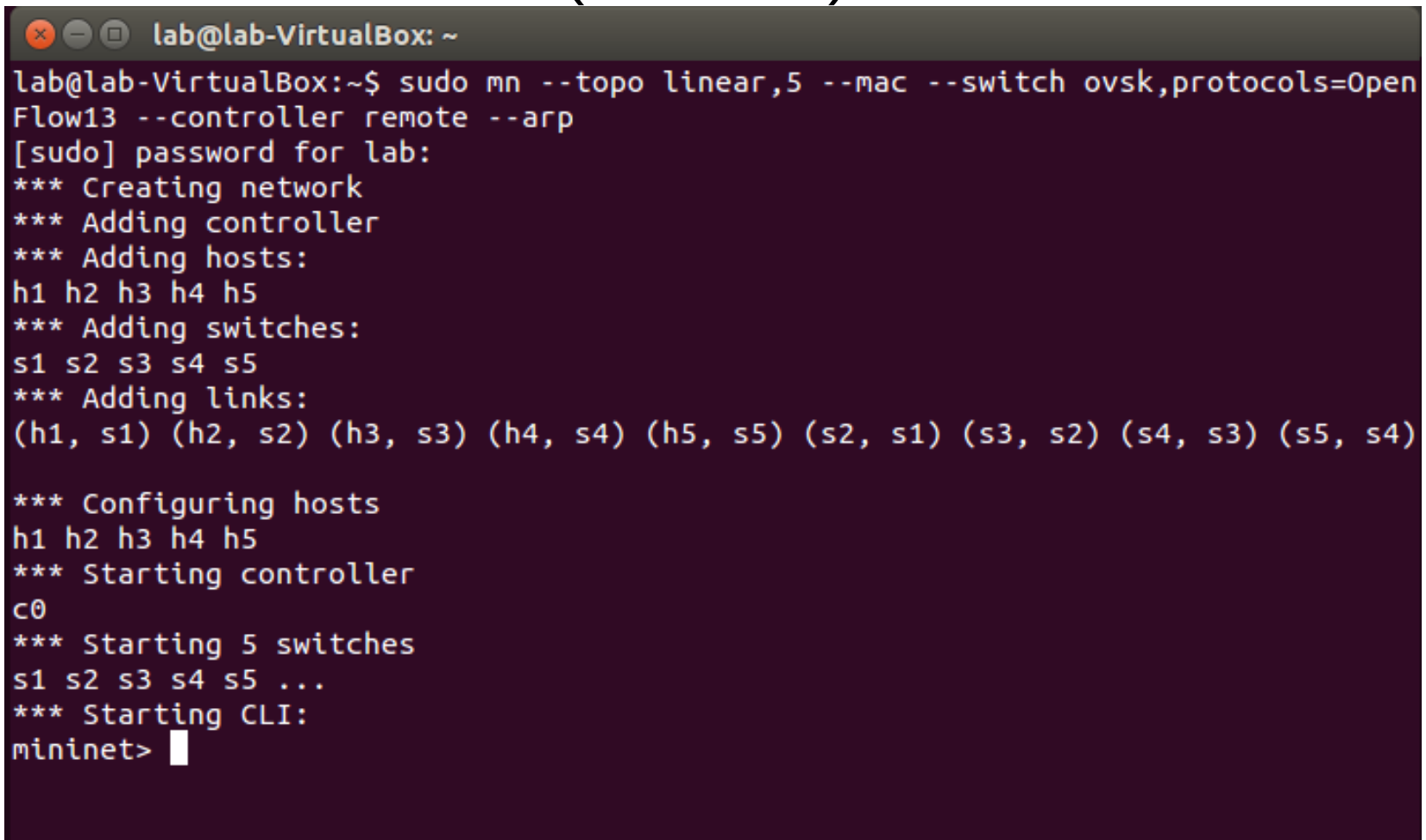
Step1. 開啟 ONOS controller

首先先開一個終端機，並開啟ONOS controller



Step2. 開啟 Mininet

- 再開另一個新的終端機 (Terminal) 並執行 Mininet



Step2. 開啟 Mininet

- sudo mn --topo linear,5 --mac --switch ovsk, protocols=OpenFlow13 --controller remote --arp
  - ✓“--topo linear,5”：製作一個範例拓樸，使用線型的方式，製作五個節點
  - ✓“--mac”：mac 使用內建的方式編排
  - ✓“--switch ovsk”：使用 OpenVSwitch
  - ✓“protocols=OpenFlow13”：限定 Openflow 為 1.3 版本，預設為1.0
  - ✓“--controller remote”：使用外部的 controller 來控制 Mininet

註：相對於 LAB 1，此處增加了 OpenVSwitch 的設置，包含 OpenFlow 版本設置與 controller 控制方式

- sudo mn --controller=remote,ip=127.0.0.1 --topo=linear,3 --switch ovsk,protocols=OpenFlow13

註：可指定 controller ip=127.0.0.1

Step3. 測試 Mininet

- 使用 pingall 的指令來檢查自己設定的拓樸

```
mininet> pingall
*** Ping: testing ping reachability
h1 -> h2 h3 h4 h5
h2 -> h1 h3 h4 h5
h3 -> h1 h2 h4 h5
h4 -> h1 h2 h3 h5
h5 -> h1 h2 h3 h4
*** Results: 0% dropped (20/20 received)
mininet>
```

  - 共有5個節點,彼此都可以互相通訊

Step4. 在 ONOS 上確認有無擷取設備

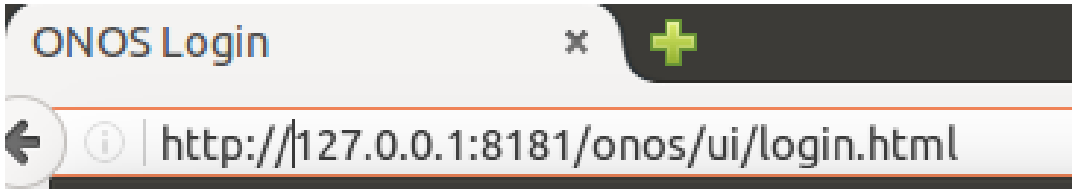
- 切換至 ONOS 的終端機上操作，輸入 hosts

```
onos> hosts
id=00:00:00:00:00:01/-1, mac=00:00:00:00:00:01, location=of:0000000000000001/1, vlan=-1, ip(s)=[]
id=00:00:00:00:00:02/-1, mac=00:00:00:00:00:02, location=of:0000000000000002/1, vlan=-1, ip(s)=[]
id=00:00:00:00:00:03/-1, mac=00:00:00:00:00:03, location=of:0000000000000003/1, vlan=-1, ip(s)=[]
id=00:00:00:00:00:04/-1, mac=00:00:00:00:00:04, location=of:0000000000000004/1, vlan=-1, ip(s)=[]
id=00:00:00:00:00:05/-1, mac=00:00:00:00:00:05, location=of:0000000000000005/1, vlan=-1, ip(s)=[]
onos>
```

  - 發現在 ONOS 上也有找到剛剛 Mininet 上的節點。

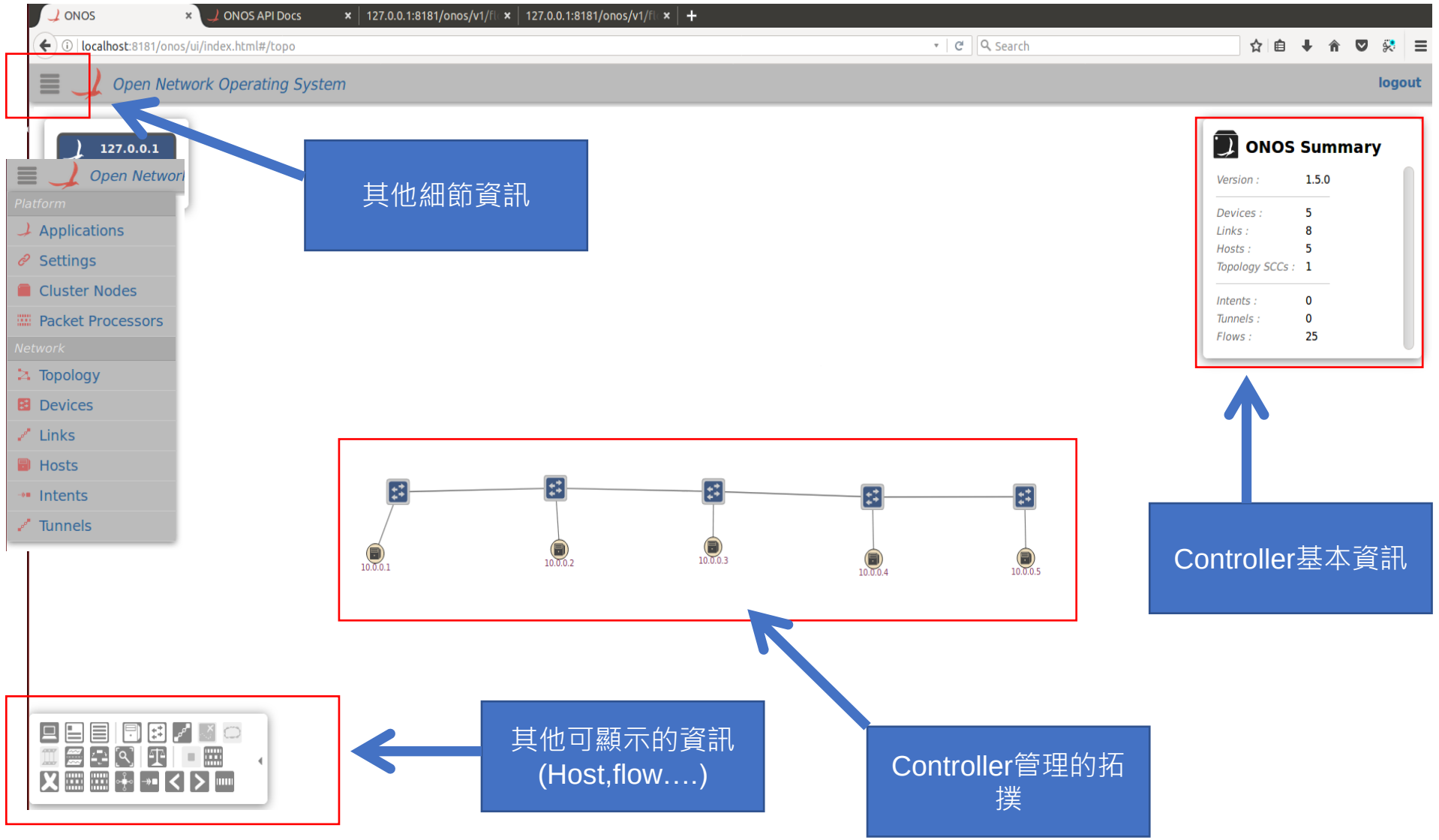
Step5. 利用瀏覽器操作ONOS

- 開啟瀏覽器在網址列輸入



- 可以看見登入畫面
  - 帳號和密碼都是:karaf

ONOS GUI 介面


ONOS
ONOS API Docs
localhost:8181/onos/ui/index.html#/topo
Search
Open Network Operating System
logout
127.0.0.1
Platform
Applications
Settings
Cluster Nodes
Packet Processors
Network
Topology
Devices
Links
Hosts
Intents
Tunnels
其他細節資訊
ONOS Summary
Version : 1.5.0
Devices : 5
Links : 8
Hosts : 5
Topology SCCs : 1
Intents : 0
Tunnels : 0
Flows : 25
Controller基本資訊
10.0.0.1
10.0.0.2
10.0.0.3
10.0.0.4
10.0.0.5
其他可顯示的資訊
(Host,flow….)
Controller管理的拓撲

實驗步驟三：由 ONOS REST API 將 flow rule 設置至 OVS

開啟 ONOS

- 基礎功能結束後，要開始來替 LAB1 的拓樸建置 Flow rule了!

開啟 Mininet

- 用mininet開啟自製拓樸

topo-3sw-3host.py

```
lab@lab-VirtualBox:~/mininet/custom$ sudo mn --custom topo-2sw-2host.py --topo mytopo --mac --controller=remote
```

  - 自製拓墣請參考 LAB 1
- pingall

```
mininet> pingall
*** Ping: testing ping reachability
h1 -> h2 h3
h2 -> h1 h3
h3 -> h1 h2
*** Results: 0% dropped (6/6 received)
mininet>
```

  - 一開始會能夠互 ping是 因為 ONOS Controller 開啟封包自動轉傳的應用程式 fwd

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ONOS 拓撲查詢

- 利用ONOS查詢有哪些設備 devices

```
onos> devices
id=of:0000000000000001, available=true, role=MASTER, type=SWITCH, mfr=Nicira, Inc., hw=Open vSwitch, sw=2.0.2, serial=None, managementAddress=127.0.0.1, protocol=OF_10, channelId=127.0.0.1:57232
id=of:0000000000000002, available=true, role=MASTER, type=SWITCH, mfr=Nicira, Inc., hw=Open vSwitch, sw=2.0.2, serial=None, managementAddress=127.0.0.1, protocol=OF_10, channelId=127.0.0.1:57230
id=of:0000000000000003, available=true, role=MASTER, type=SWITCH, mfr=Nicira, Inc., hw=Open vSwitch, sw=2.0.2, serial=None, managementAddress=127.0.0.1, protocol=OF_10, channelId=127.0.0.1:57228
```

- 利用ONOS查詢有哪些線路連接 links

```
onos> links
src=of:0000000000000001/3, dst=of:0000000000000002/2, type=DIRECT, state=ACTIVE, expected=false
src=of:0000000000000003/2, dst=of:0000000000000001/1, type=DIRECT, state=ACTIVE, expected=false
src=of:0000000000000002/1, dst=of:0000000000000003/3, type=DIRECT, state=ACTIVE, expected=false
src=of:0000000000000002/2, dst=of:0000000000000001/3, type=DIRECT, state=ACTIVE, expected=false
src=of:0000000000000003/3, dst=of:0000000000000002/1, type=DIRECT, state=ACTIVE, expected=false
src=of:0000000000000001/1, dst=of:0000000000000003/2, type=DIRECT, state=ACTIVE, expected=false
```

連結的設備
ID/Port

ONOS 關掉自動轉傳服務

- 此處我們要把 ONOS 上的自動轉傳服務先關掉，之後再利用 REST API 將 flow rule 安裝至OVS上。
  - 關掉自動轉傳服務

```
onos> app deactivate org.onosproject.fwd
```

  - pingall 結果

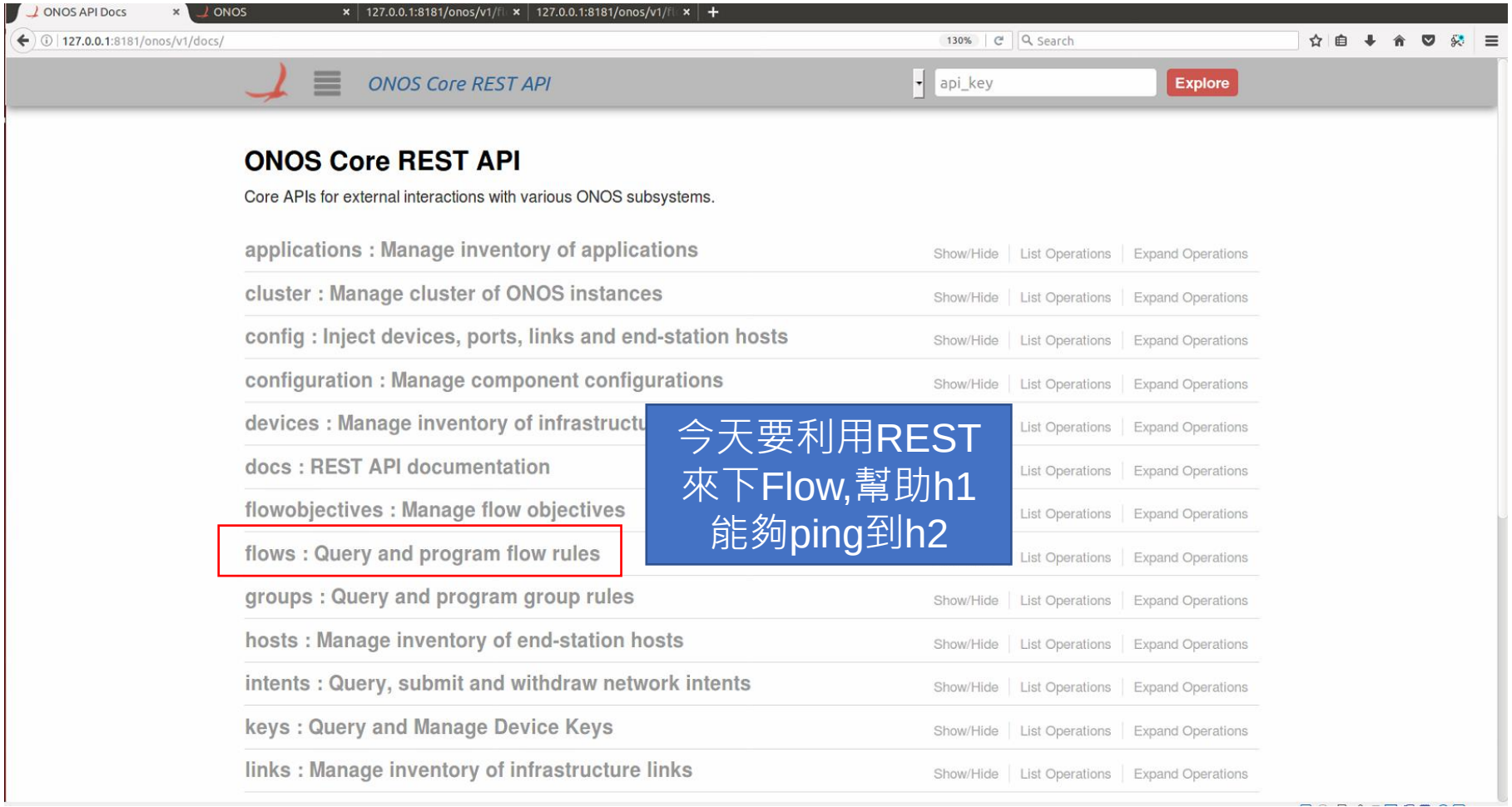
```
mininet> pingall
*** Ping: testing ping reachability
h1 -> X X
h2 -> X X
h3 -> X X
*** Results: 100% dropped (0/6 received)
mininet>
```

REST API for flow rule installation

- 開啟一個瀏覽器在網址列打上
  - http://(ControllerIP:port)/onos/v1/docs
    - ✓Controller IP: 根據一開始 export 的 IP
    - ✓ONOS Controller port: 8181
  - 輸入後會需要輸入帳號密碼
    - ✓均為 karaf

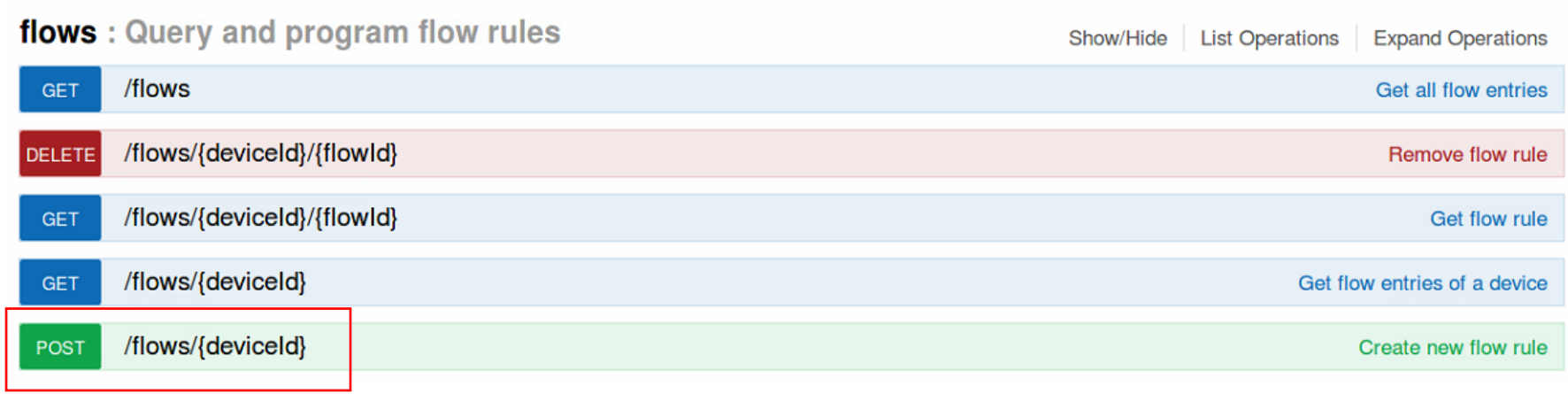
REST API 使用

- 基本上ONOS的功能都能使用REST來控制

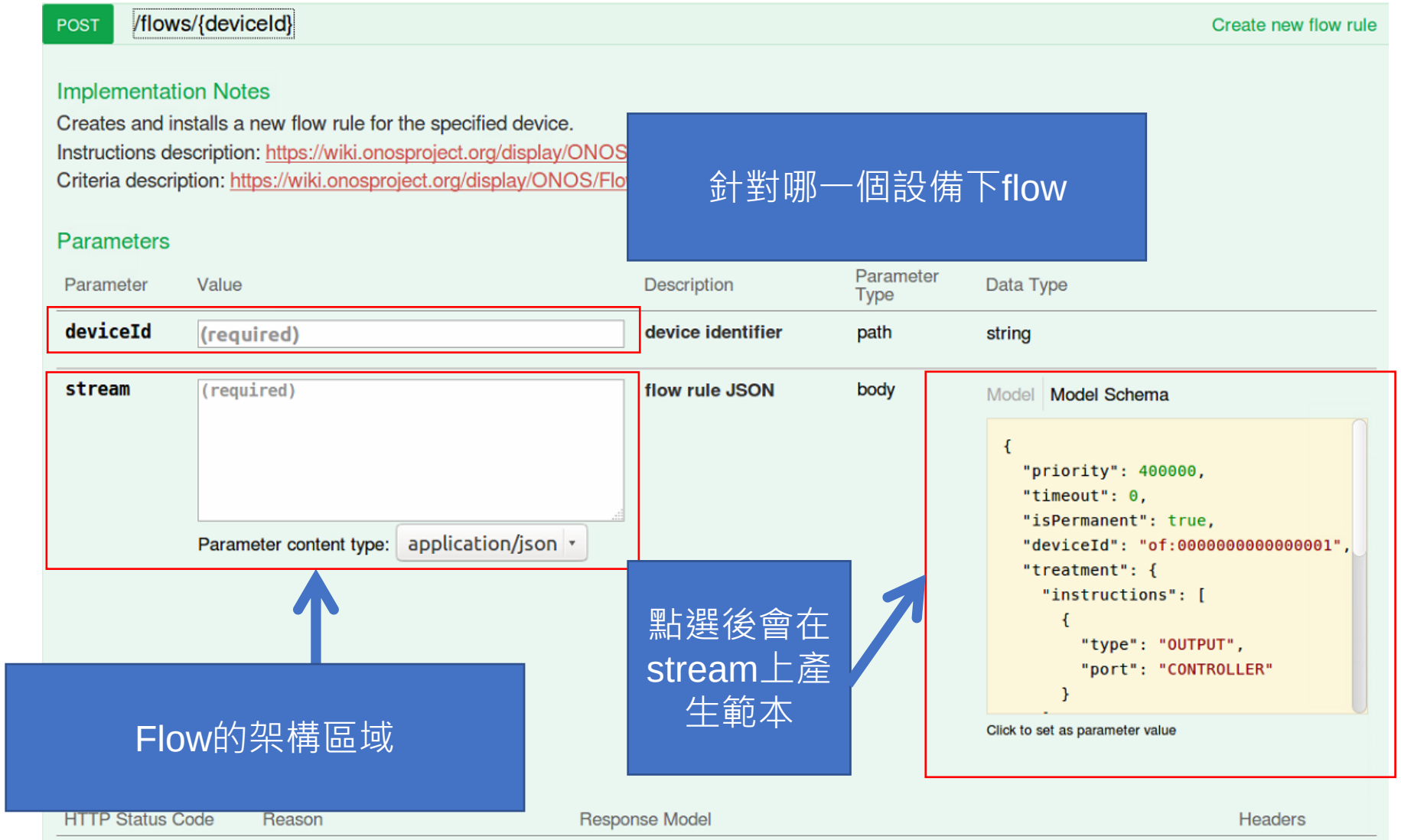


REST API: flows

- 選擇POST flows



REST API: flows



REST API: flows

- Stream的範本
  - 範本為把Input (port:2) 對應到output (port:1)
  - 內容是把 port:2 的資料能夠導向 port:1，並且加入兩個條件ETH_DST (mac 目的地) 及ETH_SRC (mac來源端)，只要符合這樣的封包就轉傳至 port1

```
{
  "priority": 1234,
  "timeout": 0,
  "isPermanent": true,
  "deviceId": "of:0000000000000001",
  "treatment": {
    "instructions": [
      {
        "type": "OUTPUT",
        "port": "3"
      }
    ]
  },
  "selector": {
    "criteria": [
      {
        "type": "IN_PORT",
        "port": "2"
      },
      {
        "type": "ETH_DST",
        "mac": "00:00:00:00:00:02"
      },
      {
        "type": "ETH_SRC",
        "mac": "00:00:00:00:00:01"
      }

    ]
  }
}
```

Priorty: Flow的優先權
Timeout: 逾時時間
isPermanent: 是否永久
deviceId: 設備編號
Selector: 選擇目標
Treatment: 對應目標

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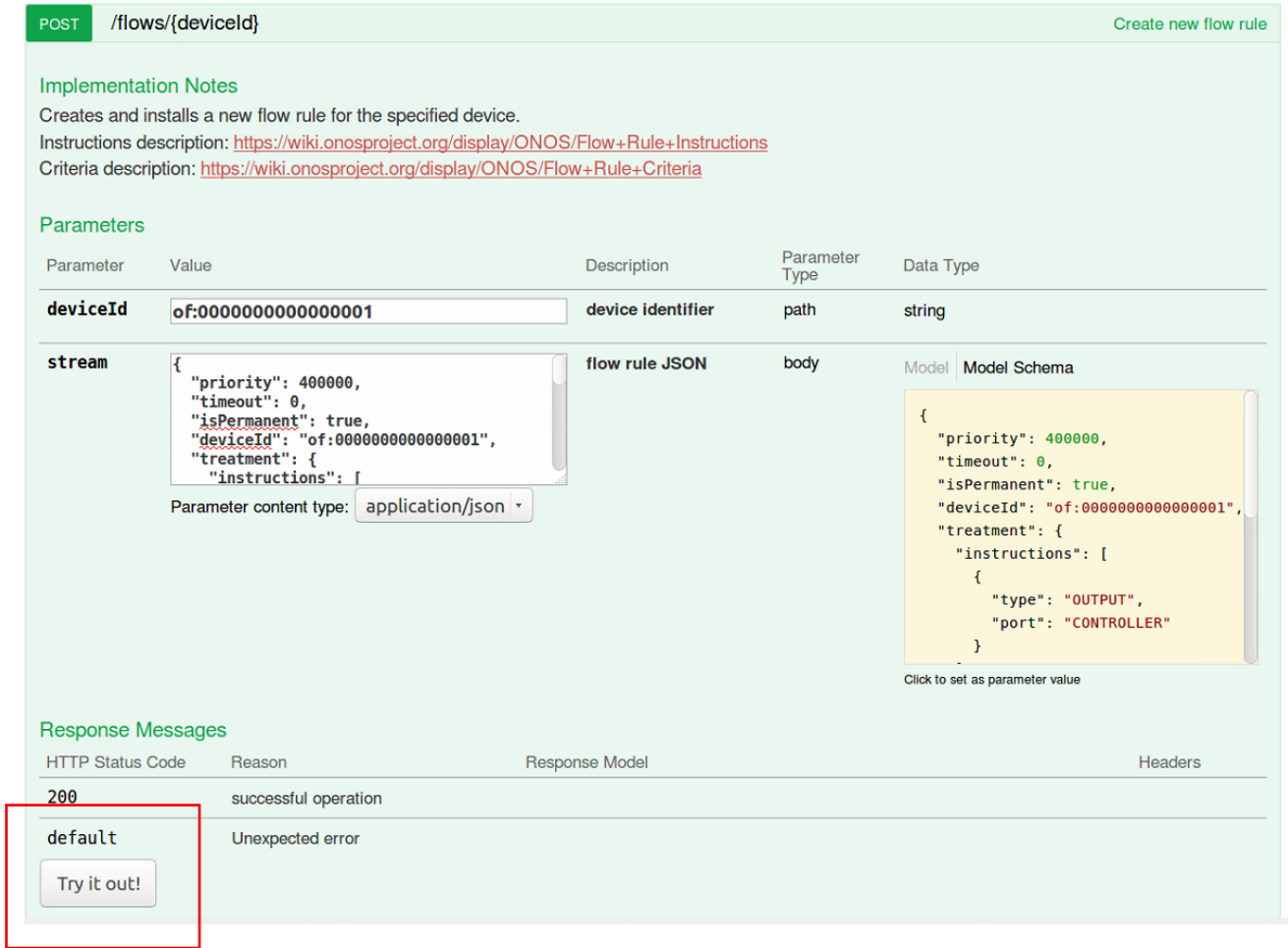
REST API: flows

- 填寫好了之後，按下Try it out，就可以上傳flow到controller。



REST API: flows

- 按下try it 後，下方會有URL：

Request URL

```
http://127.0.0.1:8181/onos/v1/flows/of%3A0000000000000001
```

- 開新瀏覽器，貼上這段URL可以看見這個設備的flow。

REST API: flows

- 可以看見剛剛自己下的flow細節

註：請注意每個人的拓撲Port都不一樣，要好設定好自己的Port以免發生轉傳不了的意外


```
2:
    id:             "21673574388798441"
    tableId:        0
    appId:          "org.onosproject.rest"
    groupId:        0
    priority:       1234
    timeout:        0
    isPermanent:    true
    deviceId:       "of:0000000000000001"
    state:          "ADDED"
    life:           5
    packets:        0
    bytes:          0
    lastSeen:       1506734163599
  treatment:
    instructions:
      0:
          type:     "OUTPUT"
          port:     "3"
    deferred:
  selector:
    criteria:
      0:
          type:     "IN_PORT"
          port:     2
      1:
          type:     "ETH_DST"
          mac:      "00:00:00:00:00:02"
      2:
          type:     "ETH_SRC"
          mac:      "00:00:00:00:00:01"
```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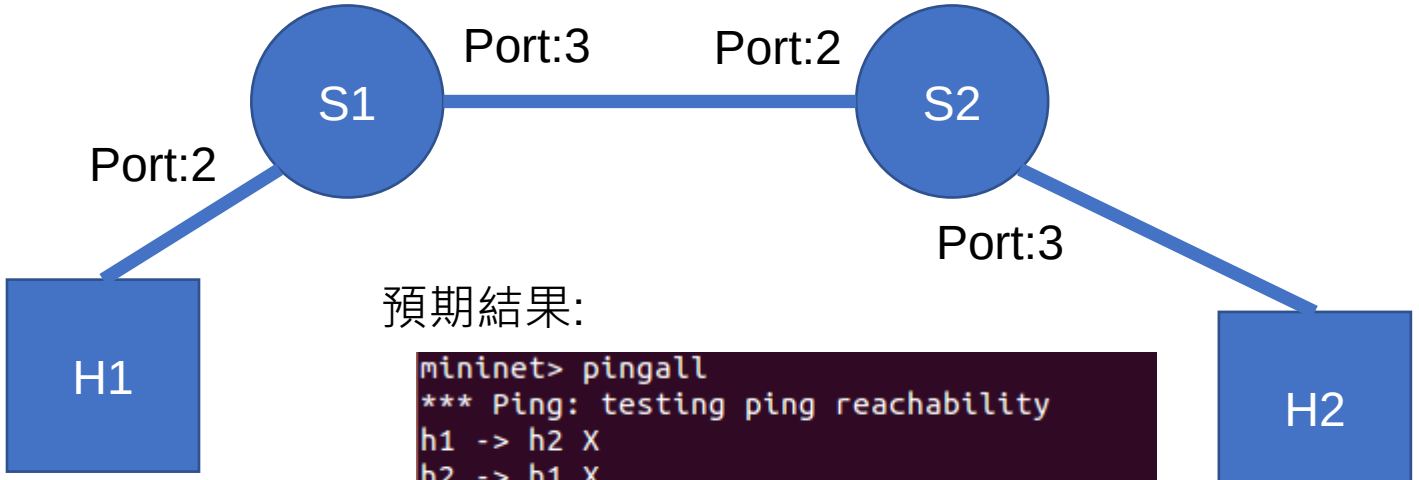
實驗考核

LAB 3 實驗考核

- 請利用剛才的REST API 幫助 H1 Ping H2
- 提示:
  - 1. 剛剛是針對 S1 下 flow，但是封包要抵達 H2 還會經過 S2，所以也需要對 S2 下 flow
  - 2. PING 的封包是需要雙向的溝通，Ping 過去 & 回來的 flow entry都需要有。



預期結果:

```
mininet> pingall
*** Ping: testing ping reachability
h1 -> h2 X
h2 -> h1 X
h3 -> X X
*** Results: 66% dropped (2/6 received)
```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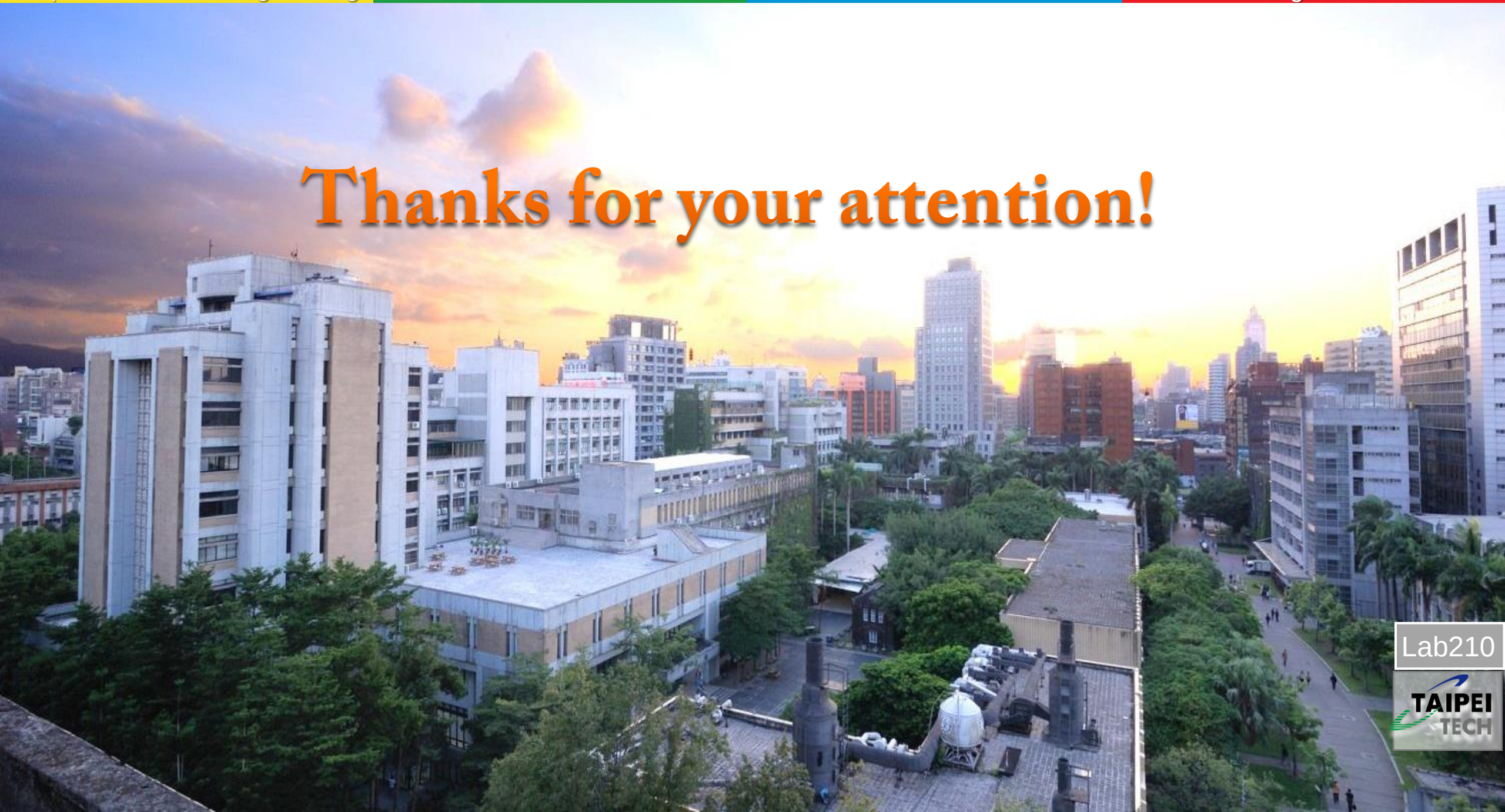
Thanks for your attention!
Lab210
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