Project 4

Unicast DHCP Application

Deadline: 2021/11/17 (WED) 23:59

Outline

- Introduction to DHCP
  - What is DHCP?
  - DHCP Workflow
- Project 4
  - Overview
  - Workflow
  - Project Requirement
  - Supplements
- Upload Configuration for ONOS APPs
- How to Test Your Unicast DHCP APP
- Submission

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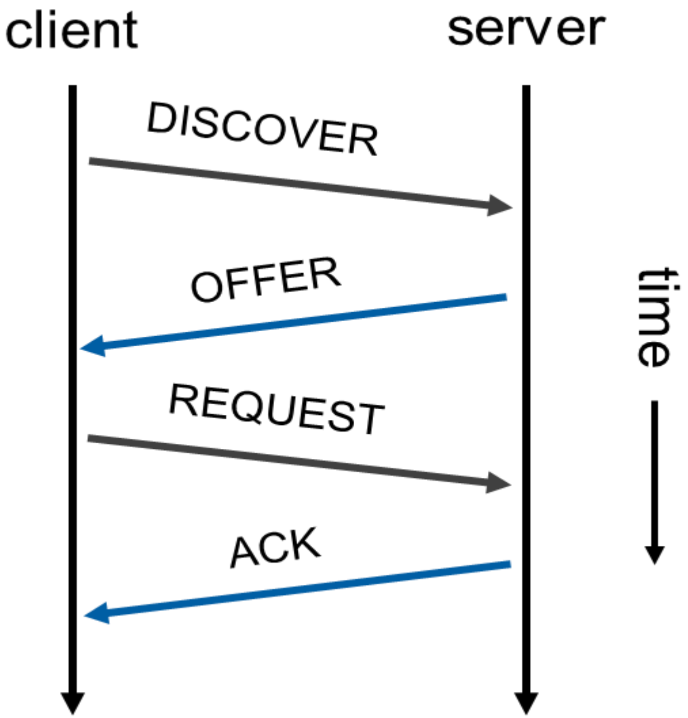
What is DHCP? (Dynamic Host Configuration Protocol)

- Provide necessary information for a host to access network
  - IP address, gateway, DNS (Domain Name Server), etc.
- Client and server use UDP port 68 and 67, respectively
- A DHCP transaction is completed by 4 messages:



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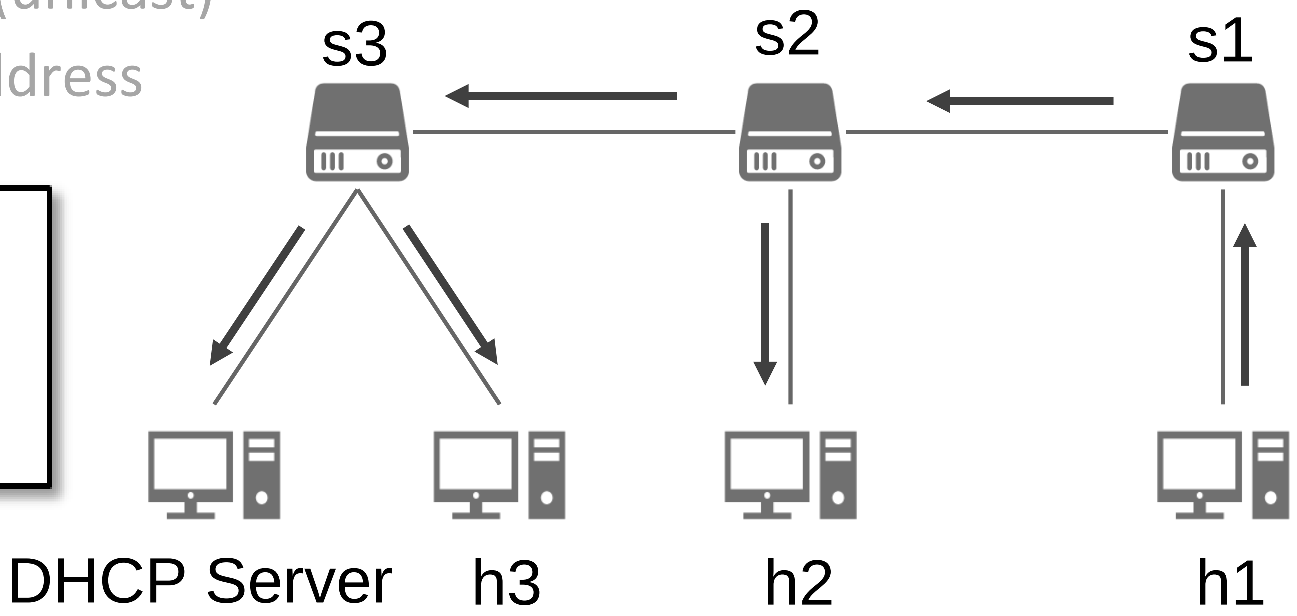
DHCP Discover

- h1 attaches to network
  - Issue DHCPDISCOVER to locate available DHCP server (broadcast)
- A DHCP server receives DHCPDISCOVER
  - Reply DHCPOFFER (unicast or broadcast)
- h1 chooses a server to reply DHCPREQUEST (broadcast)
- The server replies with DHCPACK (unicast)
  - h1 now owns the assigned IP address

```
Src IP:  0.0.0.0
Dst IP:  255.255.255.255
Src MAC: <MAC of h1>
Dst MAC: ff:ff:ff:ff:ff:ff
```

DHCP DISCOVER

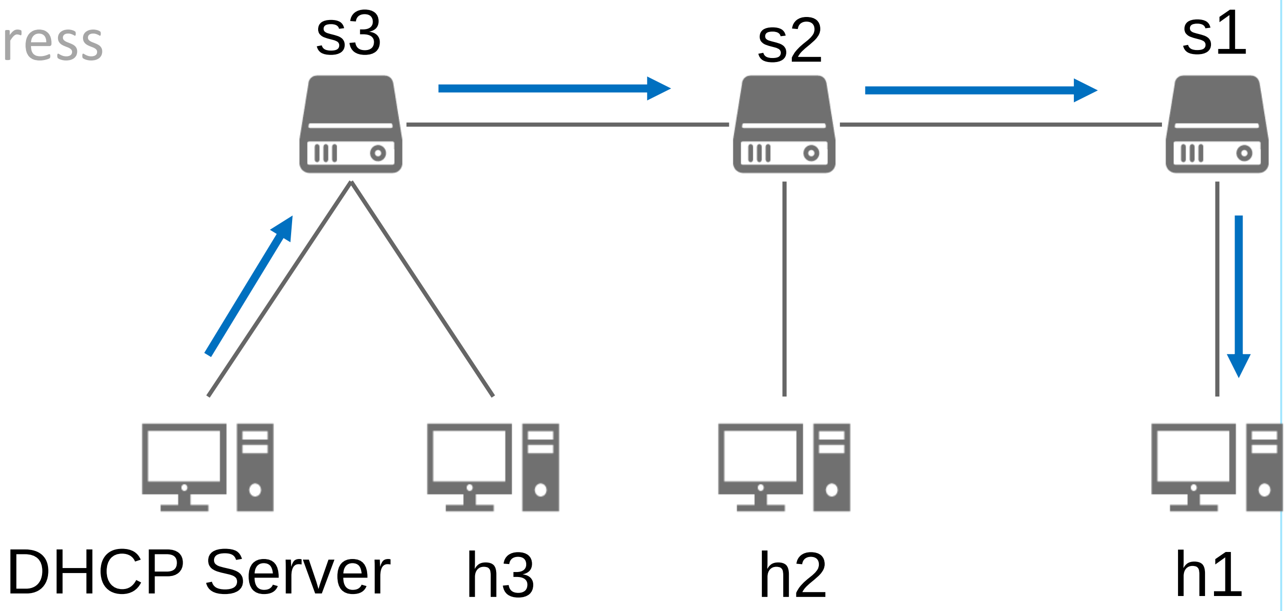


DHCP Offer

- h1 attaches to network
  - Issue DHCPDISCOVER to locate available DHCP server (broadcast)
- A DHCP server receives DHCPDISCOVER
  - Reply DHCPOFFER (unicast or broadcast)
- h1 chooses a server to reply DHCPREQUEST (broadcast)
- The server replies with DHCPACK (unicast)
  - h1 now owns the assigned IP address

```
Src IP:   <IP of server>
Dst IP:   <IP of h1>
Src MAC: <MAC of server>
Dst MAC: <MAC of h1>
Your IP address: 10.0.0.2
Subnet Mask: 255.255.255.0
IP Address Lease Time: 3600
```

DHCP OFFER

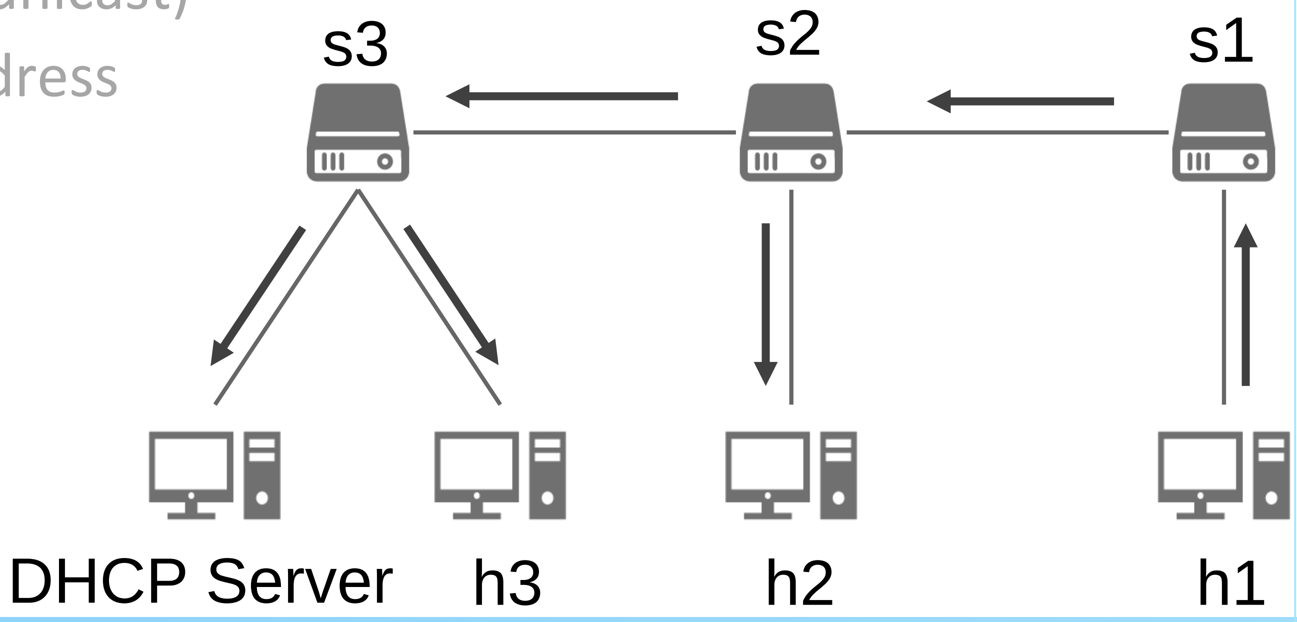


DHCP Request

- h1 attaches to network
  - Issue DHCPDISCOVER to locate available DHCP server (broadcast)
- A DHCP server receives DHCPDISCOVER
  - Reply DHCPOFFER (unicast or broadcast)
- h1 chooses a server to reply DHCPREQUEST (broadcast)
- The server replies with DHCPACK (unicast)
  - h1 now owns the assigned IP address

```
Src IP:  0.0.0.0
Dst IP:  255.255.255.255
Src MAC: <MAC of h1>
Dst MAC: ff:ff:ff:ff:ff:ff
Requested IP address: 10.0.0.2
DHCP Server Identifier: <server IP>
```

DHCP REQUEST

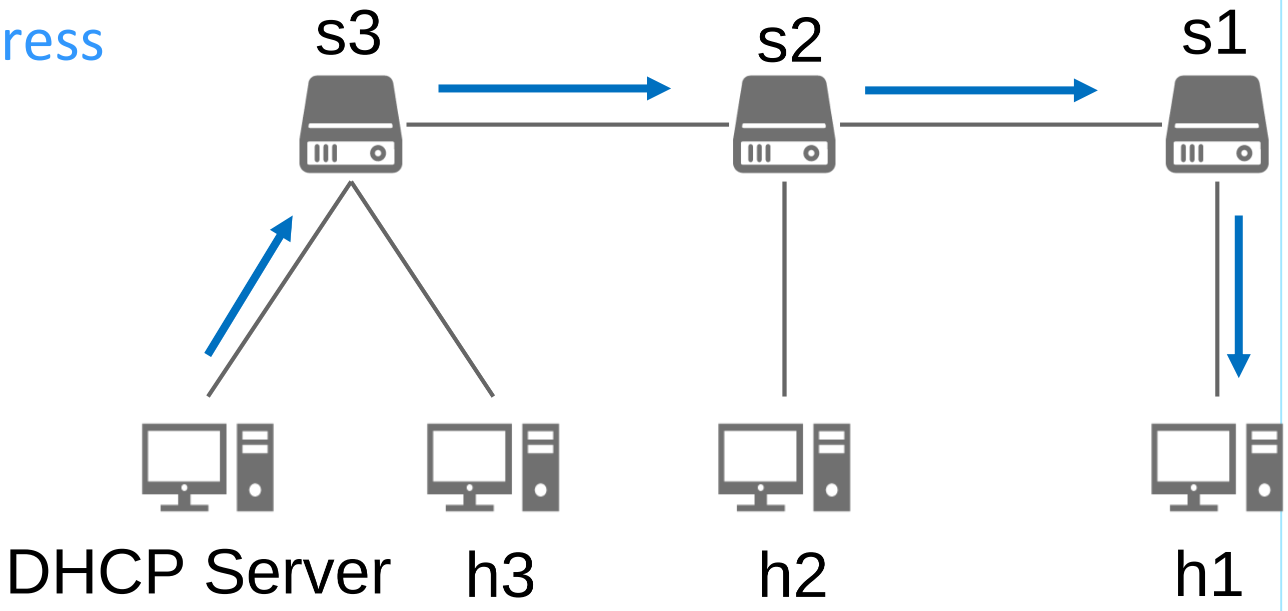


DHCP Ack

- h1 attaches to network
  - Issue DHCPDISCOVER to locate available DHCP server (broadcast)
- A DHCP server receives DHCPDISCOVER
  - Reply DHCPOFFER (unicast or broadcast)
- h1 chooses a server to reply DHCPREQUEST (broadcast)
- The server replies with DHCPACK (unicast)
  - h1 now owns the assigned IP address

```
Src IP:   <IP of server>
Dst IP:   <IP of h1>
Src MAC: <MAC of server>
Dst MAC: <MAC of h1>
Your IP address: 10.0.0.2
Subnet Mask: 255.255.255.0
IP Address Lease Time: 3600
```

DHCP OFFER



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Overview

- Originally, there are many broadcast packets in the network
- In this project, you need to implement an unicast DHCP application

1. Configure a DHCP server location
2. Install flow rules to Packet-in DHCP packets
3. Compute path between a DHCP client and the DHCP application
4. Install flow rules to forward DHCP packets via unicast

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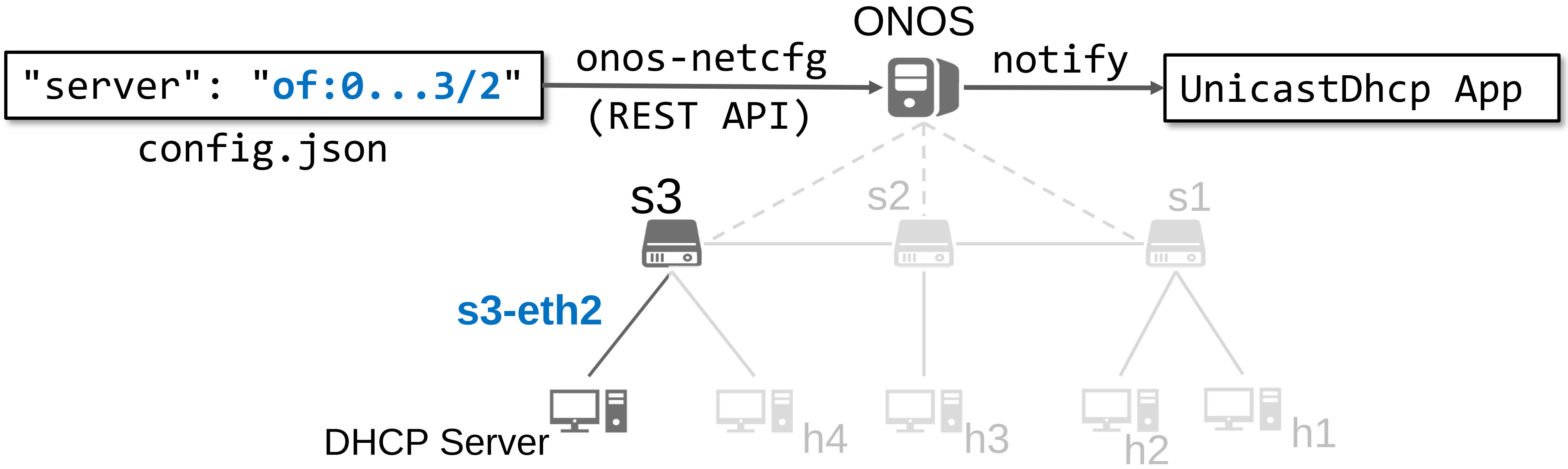
Step 1 – Configure DHCP Server Location

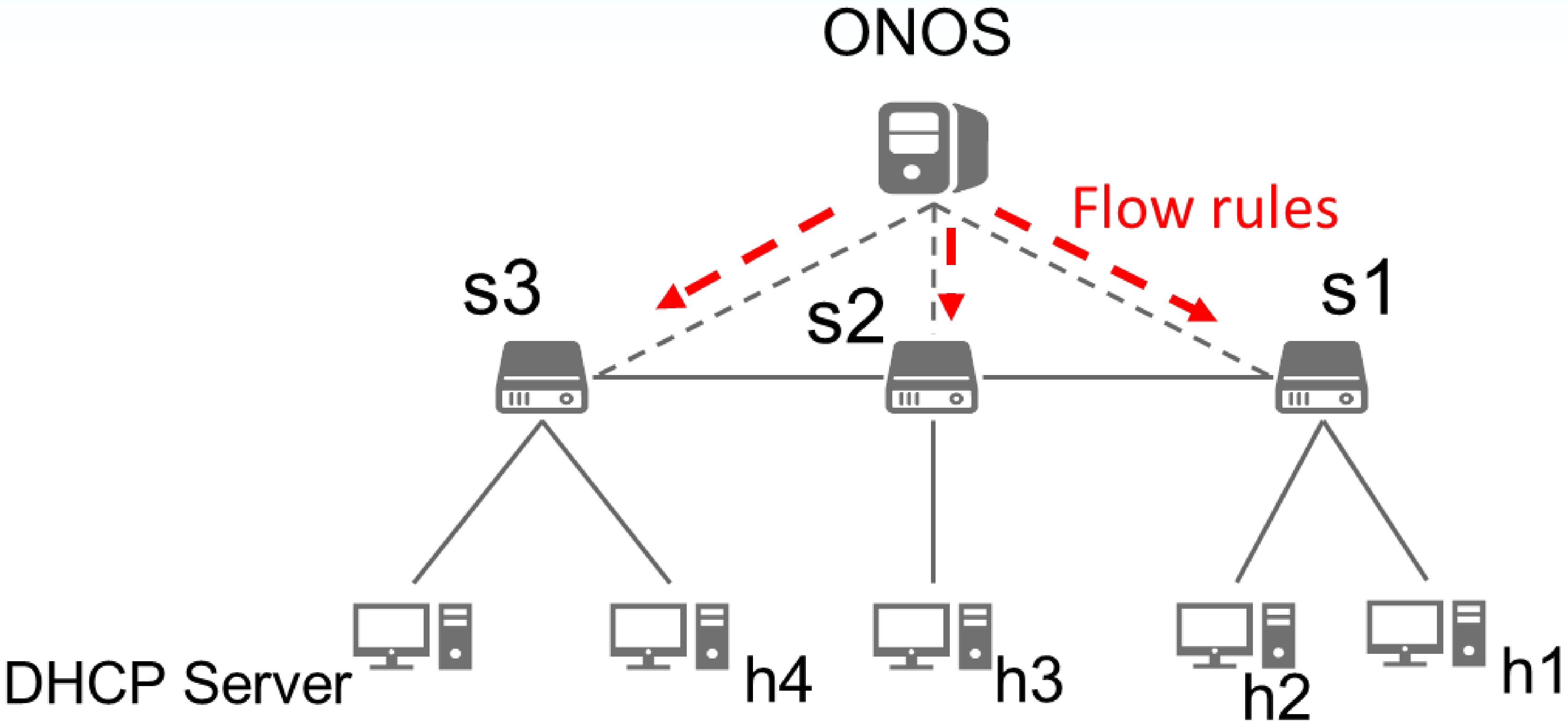
- Describing the ConnectPoint of DHCP server
  - config.json
- Upload the file to ONOS configuration service via REST API
- Should print configured location to ONOS log when notified

```
bash$ onos-netcfg localhost config.json
```



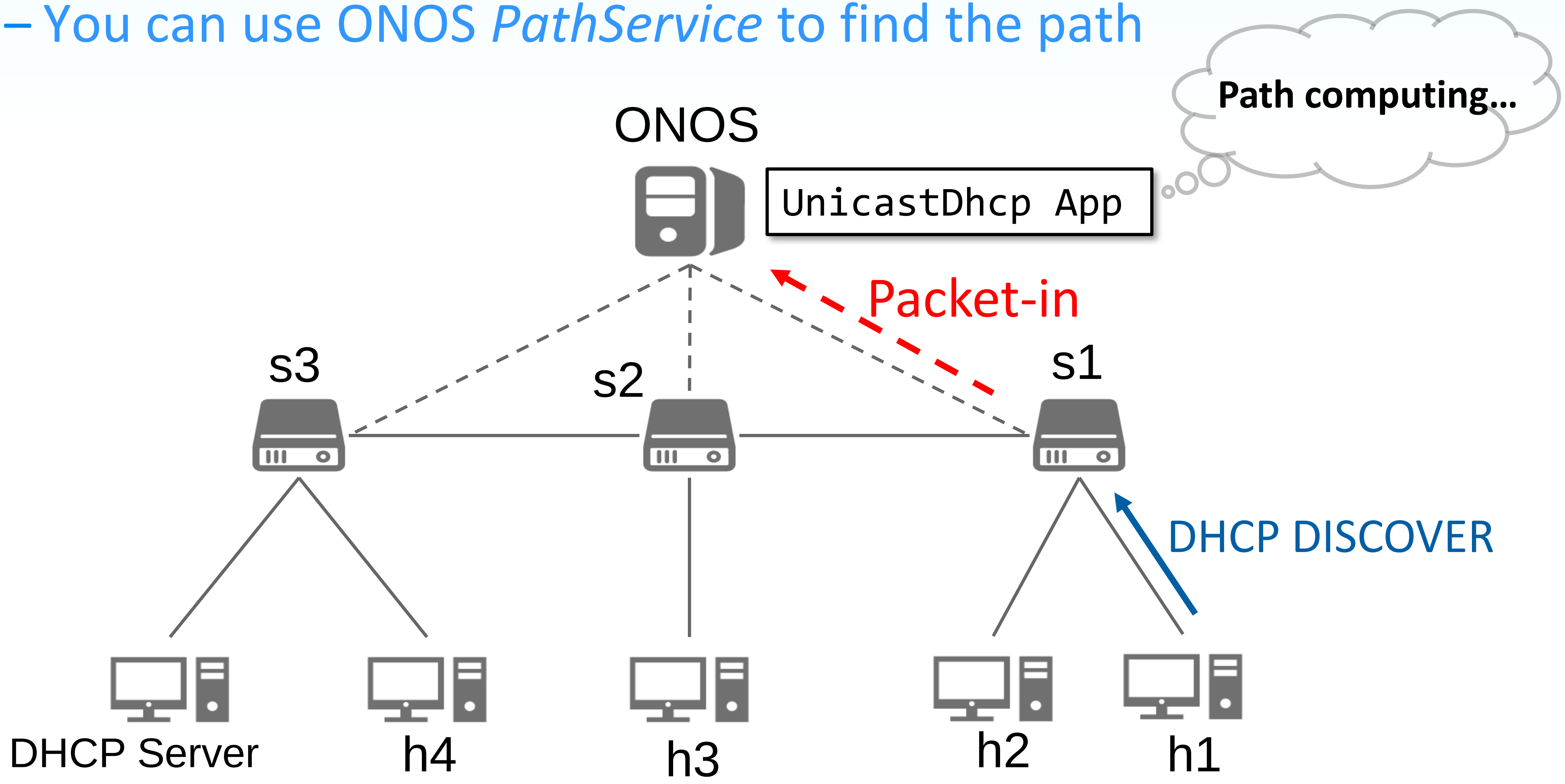
Step 2 – Packet-In DHCP Packets

- Request switches to Packet-in DHCP packets



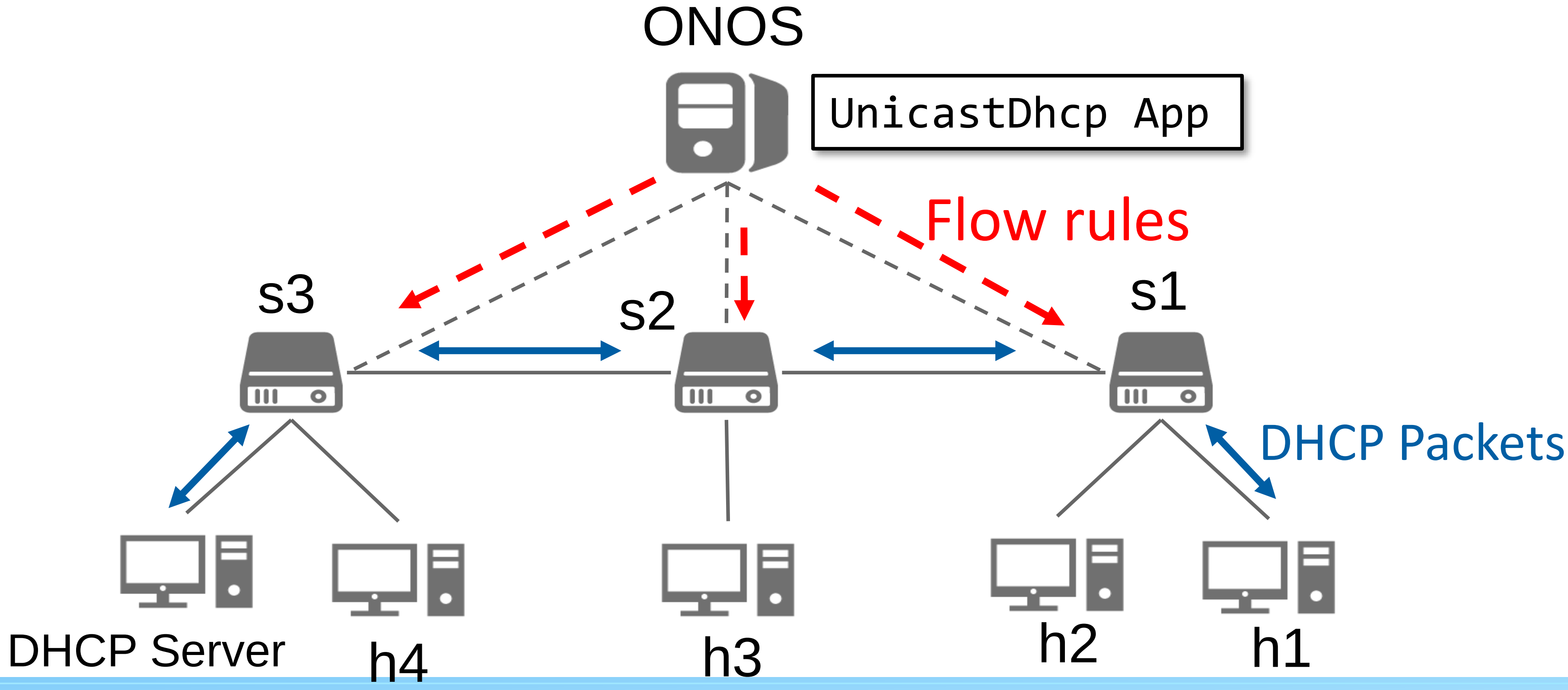
Step 3 – Compute Path

- Compute the path between requester and DHCP server
  - You can use ONOS *PathService* to find the path



Step 4 – Forward DHCP Packets via Unicast

- Install flow rules to forward DHCP packets
- Subsequent DHCP packets should all become unicast
  - DISCOVER, OFFER, REQUEST, ACK
- Interfaces not on the path should not receive any DHCP packet



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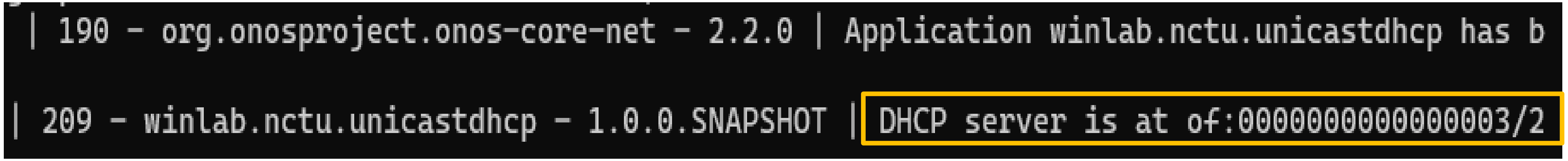
Project 4 Requirements and Scoring Criteria

- **(10%)** Project naming convention
  - <groupId>: nctu.winlab
  - <artifactId>: unicastdhcp
  - <version>: <use default> (1.0-SNAPSHOT)
  - <package>: nctu.winlab.unicastdhcp
- **(20%)** Print DHCP location in ONOS log after uploading config file



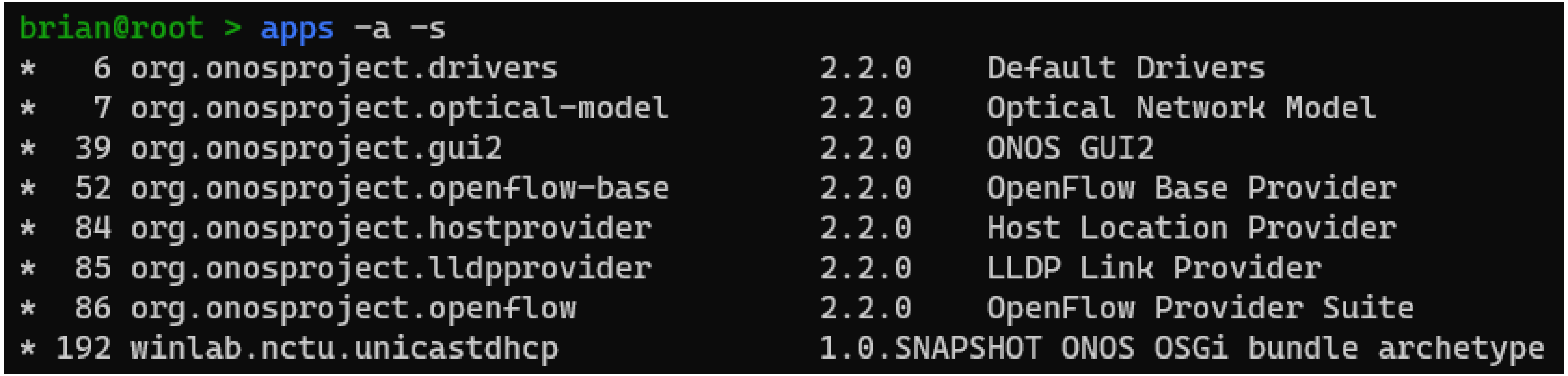
```
 | 190 - org.onosproject.onos-core-net - 2.2.0 | Application winlab.nctu.unicastdhcp has b

| 209 - winlab.nctu.unicastdhcp - 1.0.0.SNAPSHOT | DHCP server is at of:0000000000000003/2
```

- **(40%)** Host(s) can get IP address after using dhclient
- **(30%)** DHCP transaction packets should be forwarded by unicast

Suggestion

- In this project, it is not required to use ping to check connectivity.
  - For simplicity, you should deactivate fwd application
  - We will deactivate fwd when testing your App



```
brian@root > apps -a -s
*   6 org.onosproject.drivers              2.2.0    Default Drivers
*   7 org.onosproject.optical-model        2.2.0    Optical Network Model
*  39 org.onosproject.gui2                 2.2.0    ONOS GUI2
*  52 org.onosproject.openflow-base        2.2.0    OpenFlow Base Provider
*  84 org.onosproject.hostprovider         2.2.0    Host Location Provider
*  85 org.onosproject.lldpprovider         2.2.0    LLDP Link Provider
*  86 org.onosproject.openflow             2.2.0    OpenFlow Provider Suite
* 192 winlab.nctu.unicastdhcp              1.0.SNAPSHOT ONOS OSGi bundle archetype
```

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Supplements

- "project4-supplement.zip" includes following files:
  1. **Program and configuration files of a sample application echoconfig**
     1) AppComponent.java:
        - Main program of echoconfig app
     2) NameConfig.java:
        - validates and retrieves configuration data from config.json
     3) config.json:
        - configuration file for echoconfig app
  2. **Network Topology files for Unicast DHCP App**
     - topo.py: mininet topology
     - dhcpd.conf: DHCP configuration used by topo.py
  3. **Configuration file for Unicast DHCP App**
     - unicastdhcp.json: configuration file for unicast DHCP app

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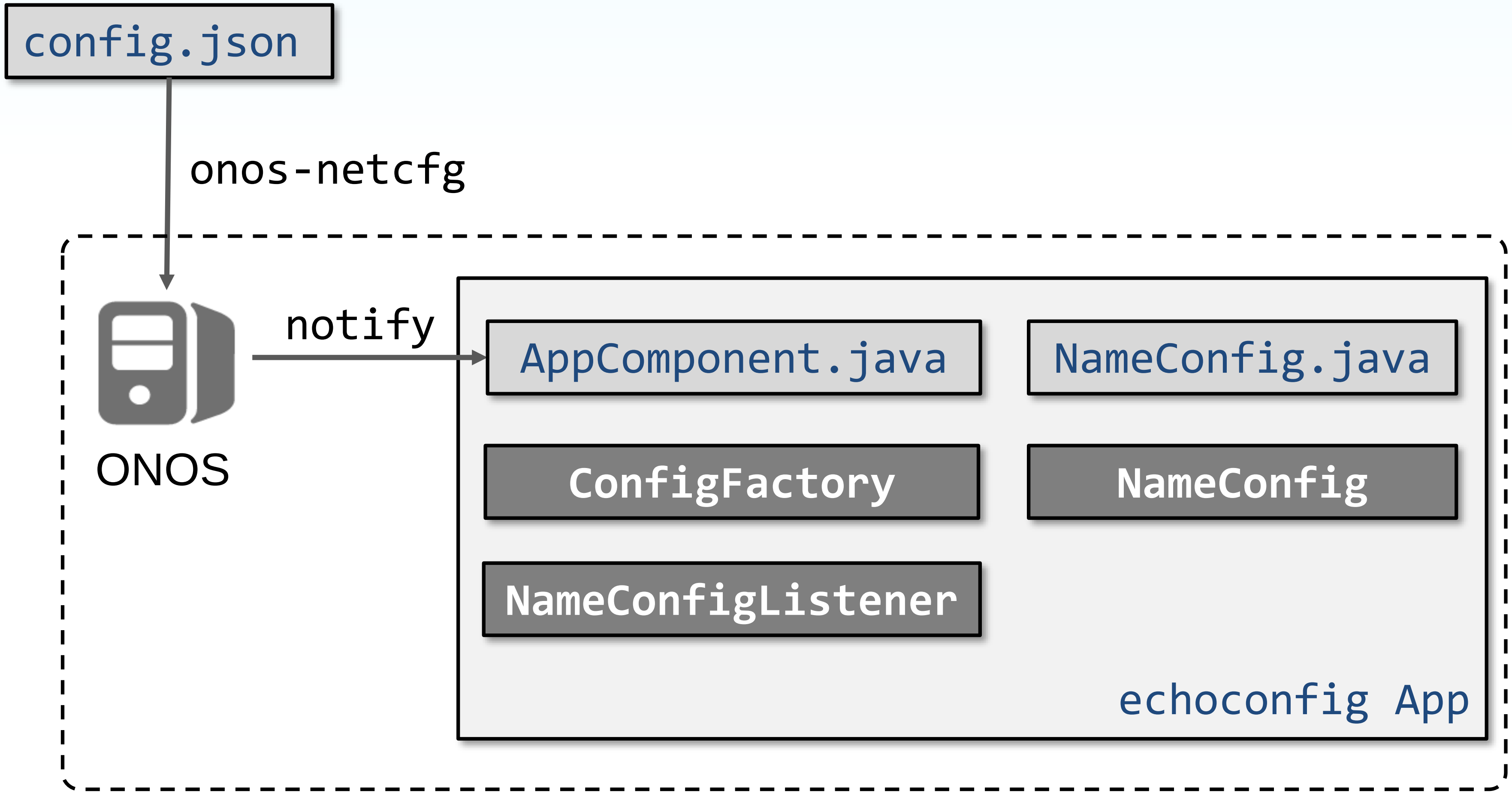
An Example Application – echoconfig

- *echoconfig* App :

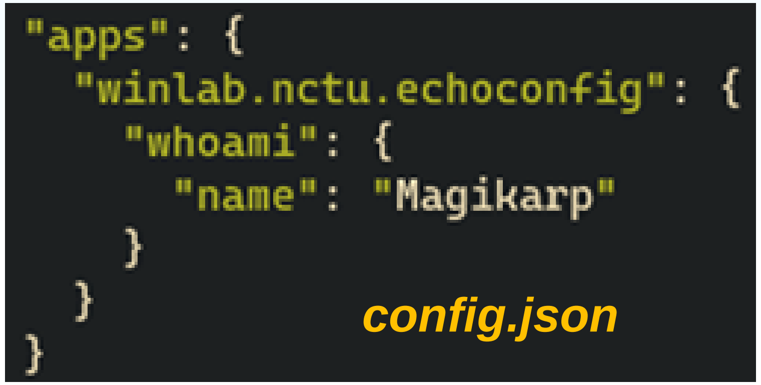
  echoes (prints out) a name specified in the configuration file
- Components of *echoconfig*
  1. *AppComponent.java*: main program of *echoconfig* that
     - Listen to configuration file uploaded event
     - Instantiate a *NameConfig* object
     - Prints value of name specified in configuration file
  2. *NameConfig.java*
     - Provide functions to validate and retrieve data from *config.json*
- Configuration file of *echoconfig*
  3. *config.json*
     - Provide some information

echoconfig APP and Configuration Uploading



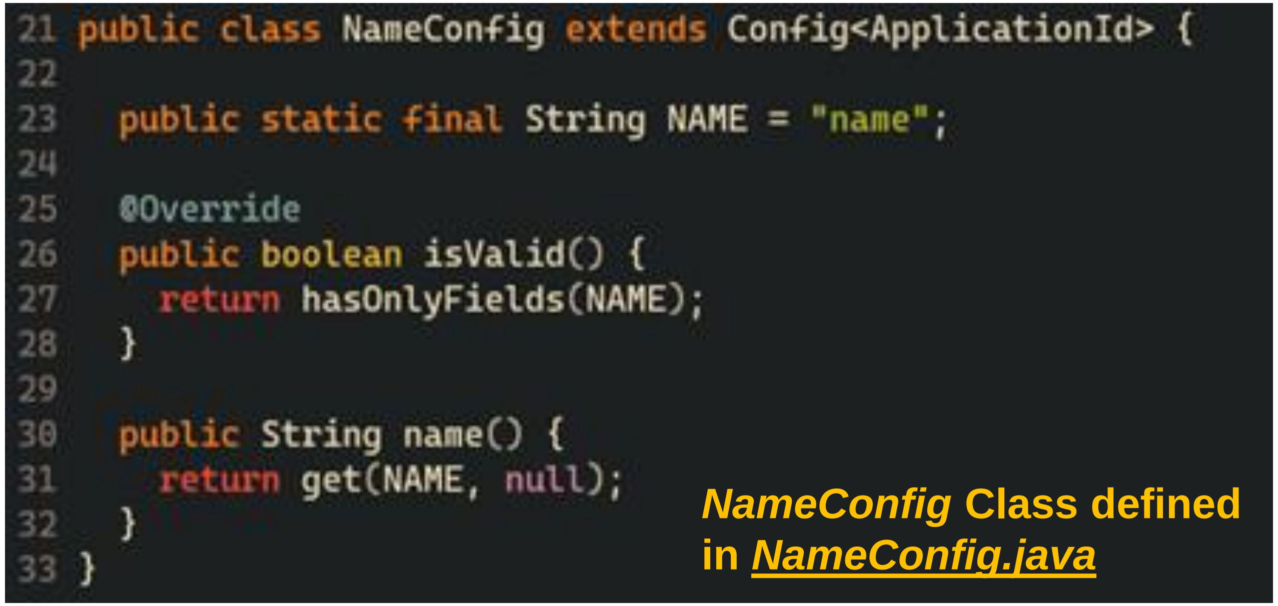
NameConfig.java – NameConfig Class

- Provide functions to:
  - Validate contents of config.json
    - e.g. Check presence of required fields
  - Retrieve “name” value from config.json



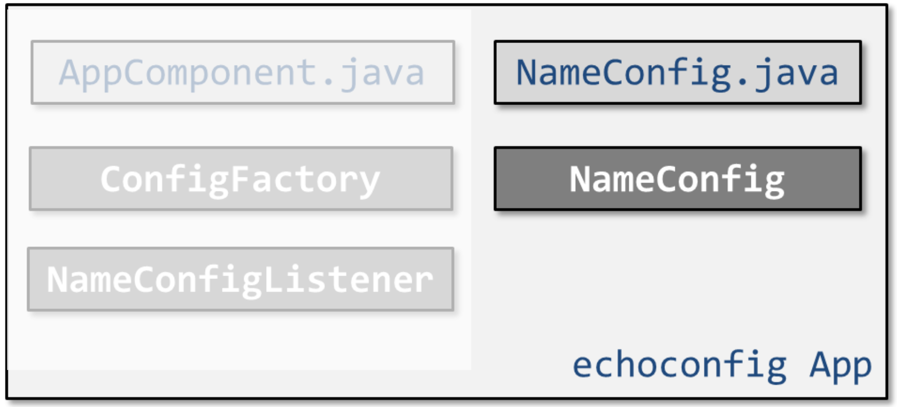
```json
"apps": {
  "winlab.nctu.echoconfig": {
    "whoami": {
      "name": "Magikarp"
    }
  }
}
```

config.json



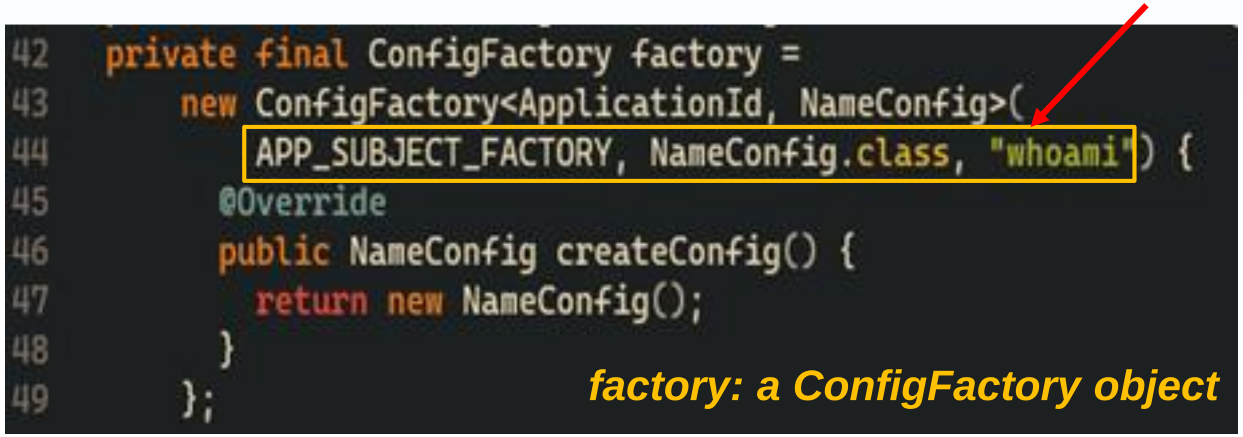
```java
public class NameConfig extends Config<ApplicationId> {

  public static final String NAME = "name";

  @Override
  public boolean isValid() {
    return hasOnlyFields(NAME);
  }

  public String name() {
    return get(NAME, null);
  }
}
```

NameConfig Class defined in *NameConfig.java*



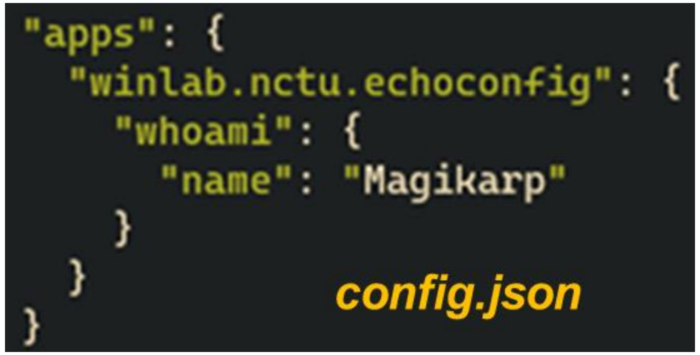
AppComponent.java – ConfigFactory

- Instantiate a ***factory*** for creating a NameConfig object
  - The arguments serve as key for ONOS to select the correct factory



```
private final ConfigFactory factory =
    new ConfigFactory<ApplicationId, NameConfig>(
        APP_SUBJECT_FACTORY, NameConfig.class, "whoami") {
      @Override
      public NameConfig createConfig() {
        return new NameConfig();
      }
    };
```

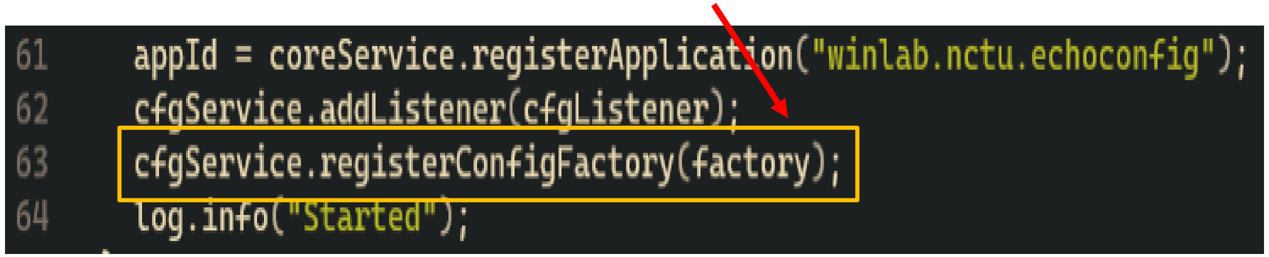
factory: a ConfigFactory object



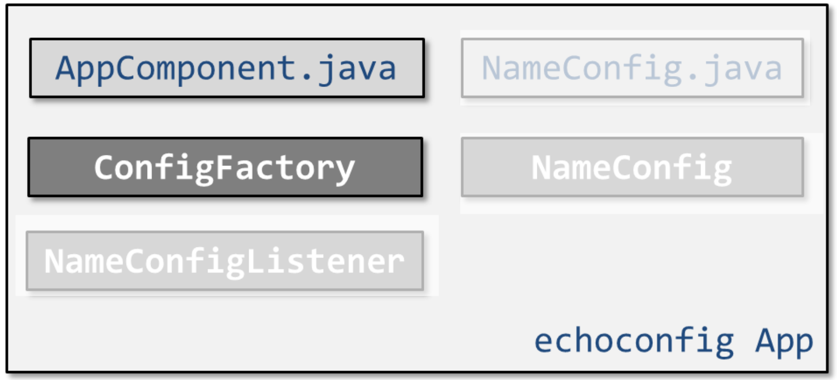
```
"apps": {
  "winlab.nctu.echoconfig": {
    "whoami": {
      "name": "Magikarp"
    }
  }
}
```

config.json

- Register ***factory*** with ONOS



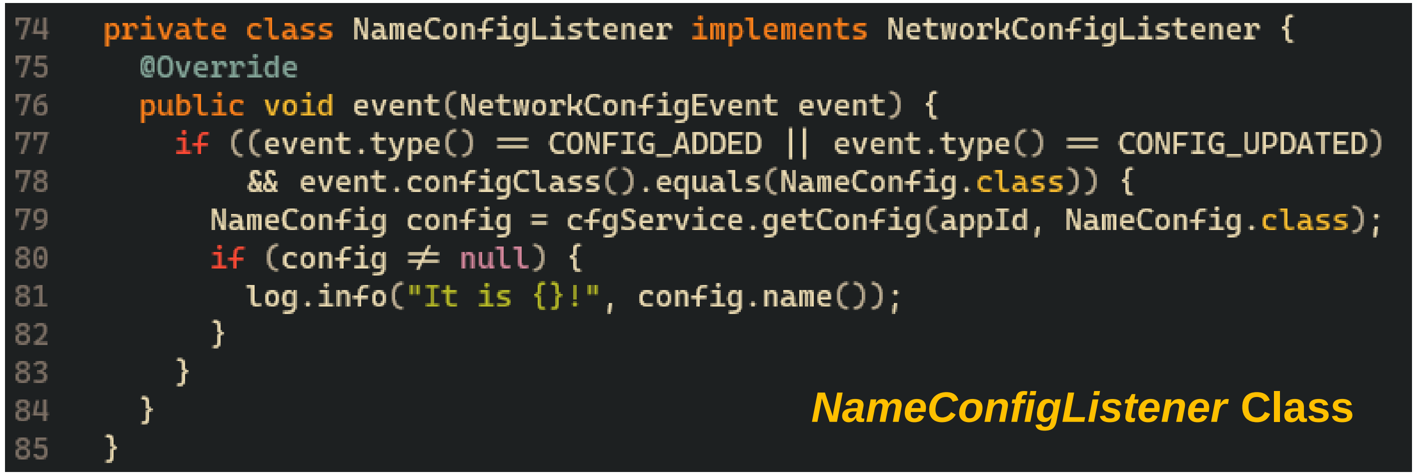
```
appId = coreService.registerApplication("winlab.nctu.echoconfig");
cfgService.addListener(cfgListener);
cfgService.registerConfigFactory(factory);
log.info("Started");
```



- ONOS will use ***factory*** later when receives upload event

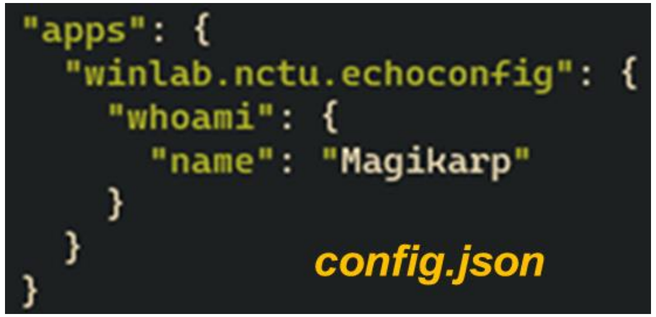
AppComponent.java – NameConfigListener

- Implement NameConfigListener Class and instantiate a listener
  - Listen to network configuration event (e.g. A config file is uploaded)
  - ONOS will call event() when it receives event



```java
private class NameConfigListener implements NetworkConfigListener {
  @Override
  public void event(NetworkConfigEvent event) {
    if ((event.type() == CONFIG_ADDED || event.type() == CONFIG_UPDATED)
        && event.configClass().equals(NameConfig.class)) {
      NameConfig config = cfgService.getConfig(appId, NameConfig.class);
      if (config != null) {
        log.info("It is {}!", config.name());
      }
    }
  }
}
```

NameConfigListener Class



```json
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    "whoami": {
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    }
  }
}
```
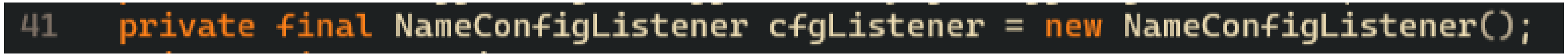
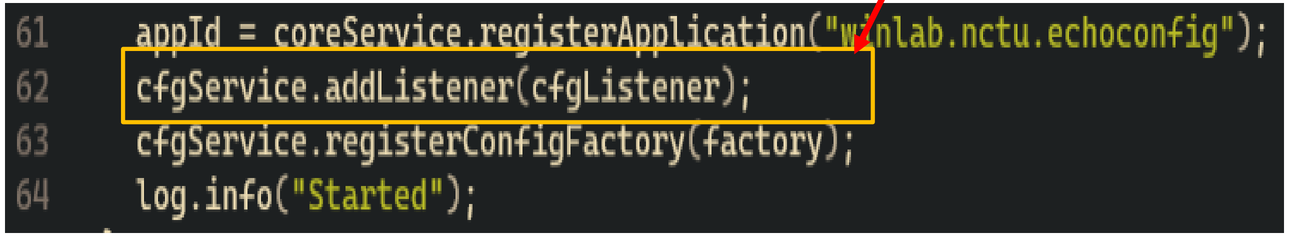

config.json

Instantiate a listener



```java
private final NameConfigListener cfgListener = new NameConfigListener();
```

- Register the listener object with ONOS



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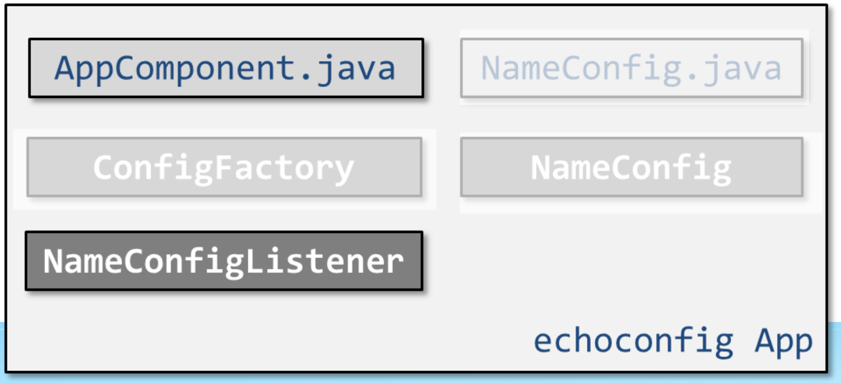
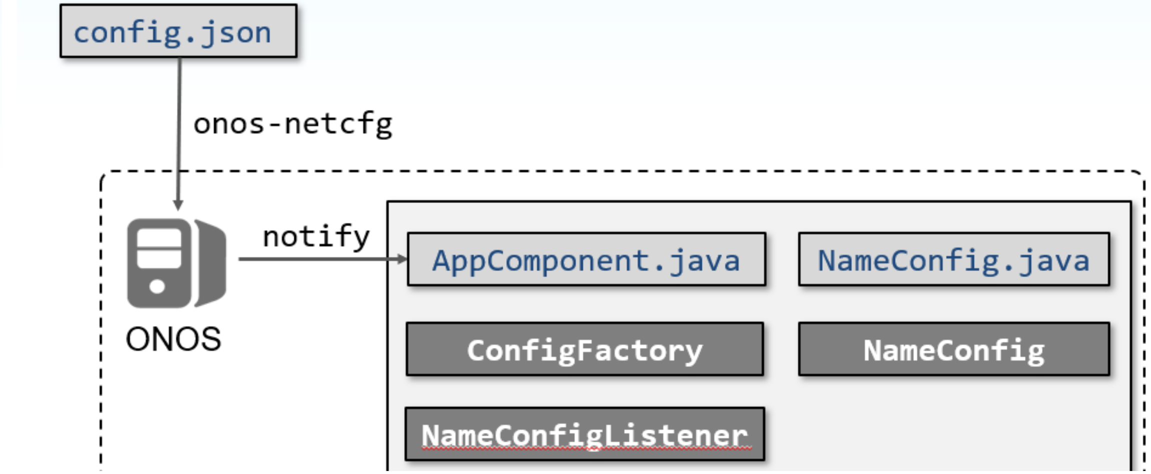
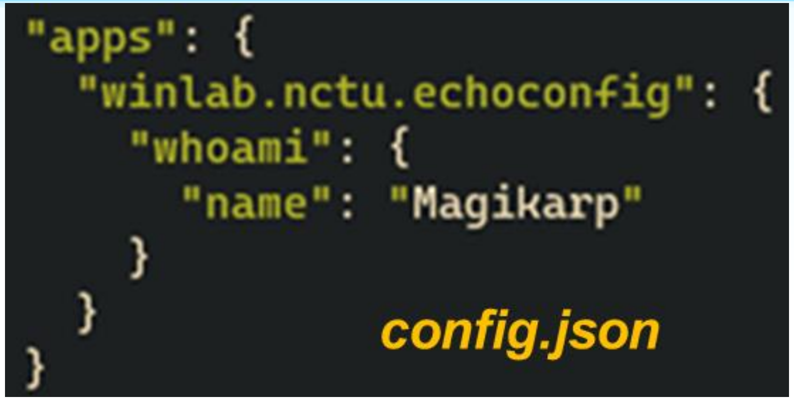


echoconfig Demonstration

- Upload config.json





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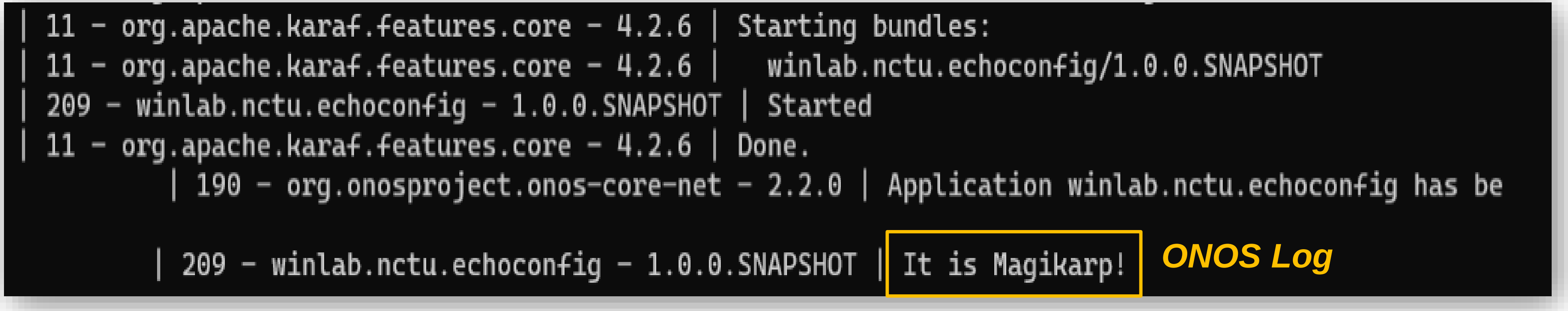
    }
  }
}
```

config.json

- ONOS log will show following message



```
| 11 - org.apache.karaf.features.core - 4.2.6 | Starting bundles:
| 11 - org.apache.karaf.features.core - 4.2.6 |   winlab.nctu.echoconfig/1.0.0.SNAPSHOT
| 209 - winlab.nctu.echoconfig - 1.0.0.SNAPSHOT | Started
| 11 - org.apache.karaf.features.core - 4.2.6 | Done.
          | 190 - org.onosproject.onos-core-net - 2.2.0 | Application winlab.nctu.echoconfig has be

         | 209 - winlab.nctu.echoconfig - 1.0.0.SNAPSHOT | It is Magikarp!
```

ONOS Log

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DHCP Utility Setup

- Install DHCP utility (isc-dhcp-server) before starting this project

```
bash$ sudo apt update && sudo apt install isc-dhcp-server
```

- To use dhcpd inside mininet host properly, you should modify AppArmor settings (**only need to be done for the first time**)
  - For server

```
bash$ sudo ln -s /etc/apparmor.d/usr.sbin.dhcpd \
                 /etc/apparmor.d/disable/
bash$ sudo apparmor_parser -R /etc/apparmor.d/usr.sbin.dhcpd
```

  - For client

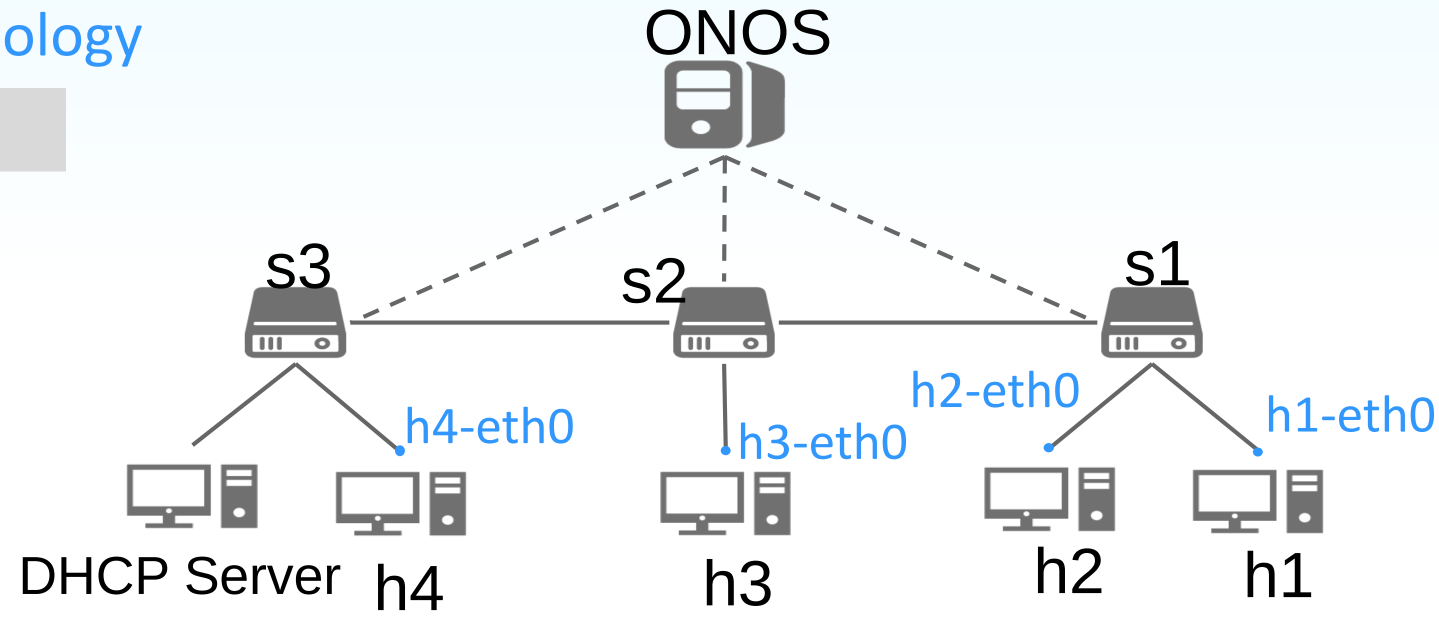
```
bash$ sudo /etc/init.d/apparmor stop
bash$ sudo sed -i '30i /var/lib/dhcp{,3}/dhcpclient* lrw,' \
                       /etc/apparmor.d/sbin.dhclient
bash$ sudo /etc/init.d/apparmor start
```

AppArmor: a Linux kernel security module

How to Test Your App

- Use **topo.py** to build the topology

```
bash$ sudo python topo.py
```



Four hosts without IP addresses in the given topology

- Run DHCP on h1

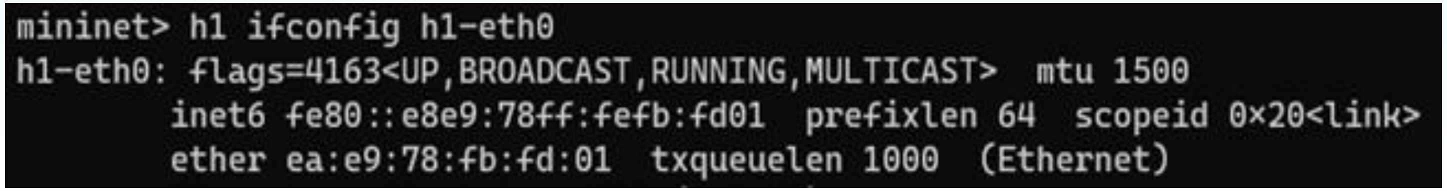
```
mininet> h1 dhclient -v h1-eth0
```

✓ Note: Release current lease before re-issue a DHCP request on an interface (to observe all messages of a DHCP transaction)

```
mininet> h1 dhclient -r h1-eth0
```

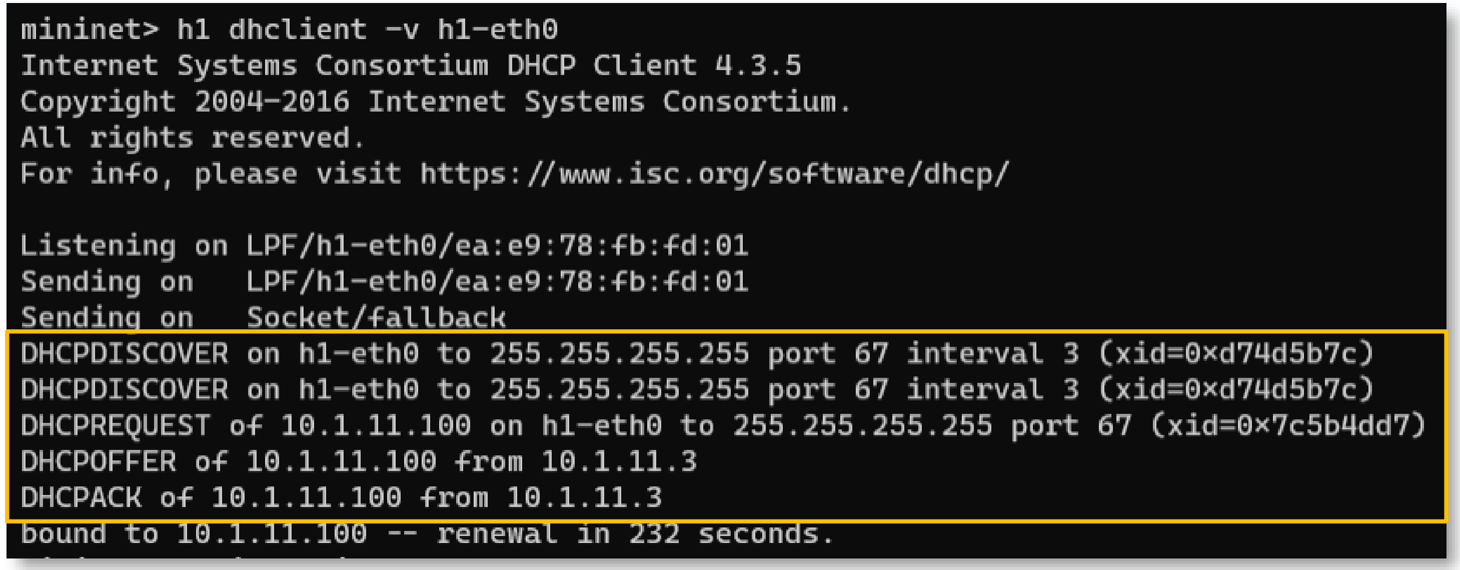
Demonstration

1. h1-eth0 does not have an IPv4 address yet



```
mininet> h1 ifconfig h1-eth0
h1-eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST>  mtu 1500
        inet6 fe80::e8e9:78ff:fefb:fd01  prefixlen 64  scopeid 0x20<link>
        ether ea:e9:78:fb:fd:01  txqueuelen 1000  (Ethernet)
```

2. Observe DHCP procedure on h1-eth0

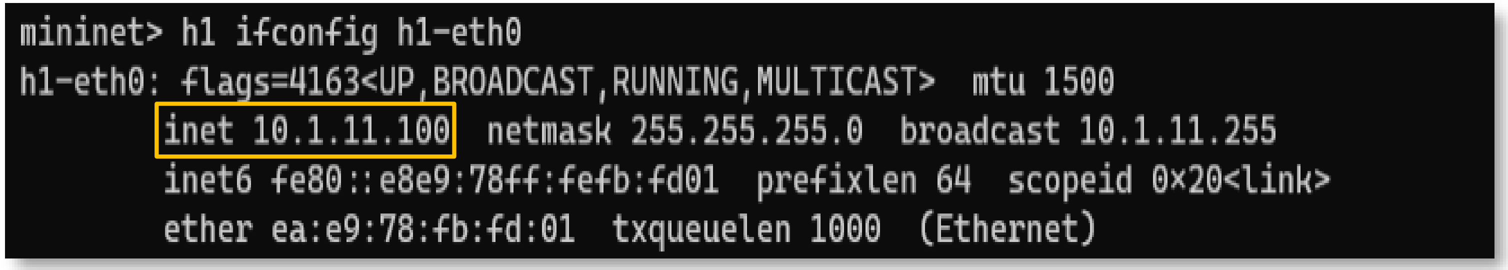


```
mininet> h1 dhclient -v h1-eth0
Internet Systems Consortium DHCP Client 4.3.5
Copyright 2004-2016 Internet Systems Consortium.
All rights reserved.
For info, please visit https://www.isc.org/software/dhcp/

Listening on LPF/h1-eth0/ea:e9:78:fb:fd:01
Sending on   LPF/h1-eth0/ea:e9:78:fb:fd:01
Sending on   Socket/fallback
DHCPDISCOVER on h1-eth0 to 255.255.255.255 port 67 interval 3 (xid=0xd74d5b7c)
DHCPDISCOVER on h1-eth0 to 255.255.255.255 port 67 interval 3 (xid=0xd74d5b7c)
DHCPREQUEST of 10.1.11.100 on h1-eth0 to 255.255.255.255 port 67 (xid=0x7c5b4dd7)
DHCPOFFER of 10.1.11.100 from 10.1.11.3
DHCPACK of 10.1.11.100 from 10.1.11.3
bound to 10.1.11.100 -- renewal in 232 seconds.
```

DHCP Messages

3. h1-eth0 now has an IPv4 address



```
mininet> h1 ifconfig h1-eth0
h1-eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST>  mtu 1500
        inet 10.1.11.100  netmask 255.255.255.0  broadcast 10.1.11.255
        inet6 fe80::e8e9:78ff:fefb:fd01  prefixlen 64  scopeid 0x20<link>
        ether ea:e9:78:fb:fd:01  txqueuelen 1000  (Ethernet)
```

Outline

- Introduction to DHCP
  - What is DHCP?
  - DHCP Workflow
- Project 4
  - Overview
  - Workflow
  - Project Requirement
  - Supplements
- Upload Configuration for ONOS APPs
- How to Test Your Unicast DHCP APP
- Submission

Submission

- Files
  - All files of your application
- Submission
  - Upload ".zip" file to e3
  - Name: project4_<studentID>.zip
  - Wrong file name or format will result in 10 points deduction

References

- ONOS Java API 2.2.0
- The Network Configuration Service