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Software-Defined Networking – Part II
Recent Advances of SDN in IoT

Dr. Sudip Misra
Associate Professor
Department of Computer Science and Engineering
IIT KHARAGPUR
Email: smisra@sit.iitkgp.ernet.in
Website: http://cse.iitkgp.ac.in/~smisra/

SDN for IoT - Recap

- ✓ Software-Defined WSN

- ✓ Different approaches – Sensor OpenFlow, Soft-WSN, SDN-WISE

- ✓ Software-Defined WSN can improve overall performance over traditional WSN

Traditional (Wireless) Mobile Network

- ✓ Problems in Traditional Mobile Network
  - Difficult to Scale – static over-provisioned network are inflexible to manage the mobile traffic with high demand
  - Difficult to manage – many times lead to misconfigurations
  - Inflexible – Requires too much time to introduce a new service as the hardware architecture is inflexible
  - Cost-expensive – Both capital expenditure and operational expenditure are high

*Based on information from Open Networking Foundation (ONF)

SDN for Mobile Networking I

- ✓ Flow-Table Paradigm of SDN
  - Well suited for end-to-end communication over multiple technologies such as WiFi, 3G, 4G, etc.
- ✓ Logically Centralized Control
  - Particularly useful for efficient base-station coordination for addressing inter-cell interference

*Based on information from Open Networking Foundation (ONF)
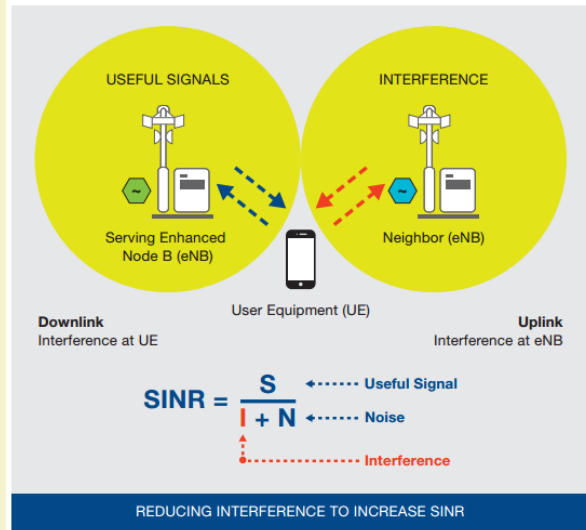
SDN for Mobile Networking II

- ✓ Path Management
  - Data can be routed based on service requirements without depending on core routing policies
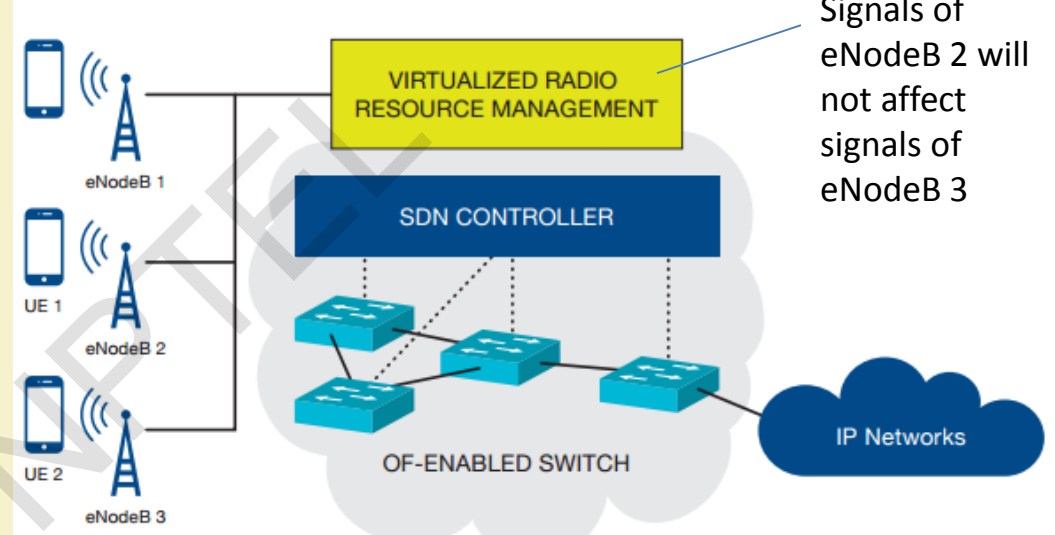- ✓ Network Virtualization
  - Abstracts the physical resources from the network services
  - Helps in providing seamless connectivity and service differentiation among users

*Based on information from Open Networking Foundation (ONF)
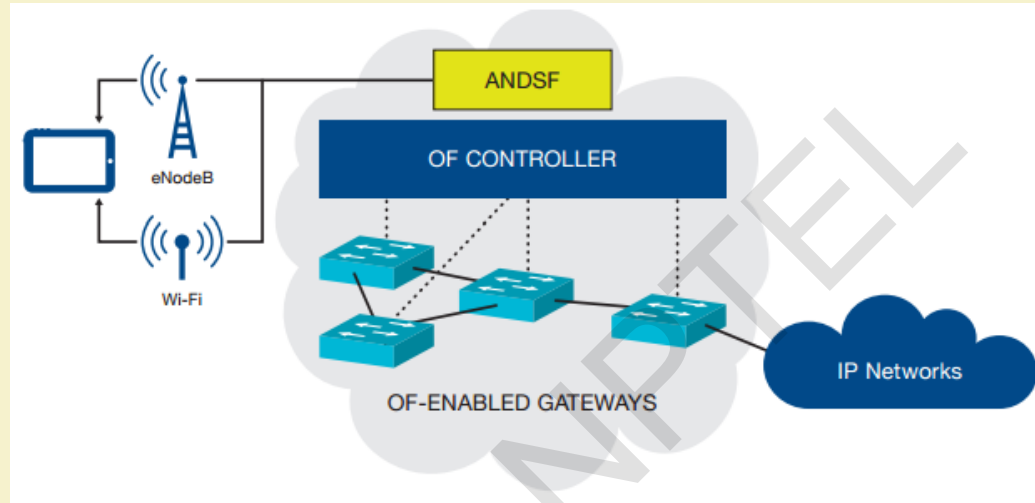
SDWMN-Use Case: Interference Management

Traditional Mobile Network

Software-Defined Mobile Network

*Based on information from Open Networking Foundation (ONF)

SDWMN-Use Case: Mobile Traffic Management

ANDSF – access network discovery and service function

Mobile traffic offloading based on OpenFlow

*Based on information from Open Networking Foundation (ONF)

Key Benefits

- ✓ Centralized control of devices manufactured by multiple vendors
- ✓ Higher rate of integration of new services
- ✓ Abstracted network control and management
    - ▪ Network abstracted from the user

Rule Placement at Access Devices

✓ Challenges

- General OpenFlow does not support wireless network
  - Modified version of OpenFlow is required
- Typically, users are mobile in nature – network is highly dynamic
- Frequent changes in rule placement is also required
- Presence of heterogeneous devices in the network
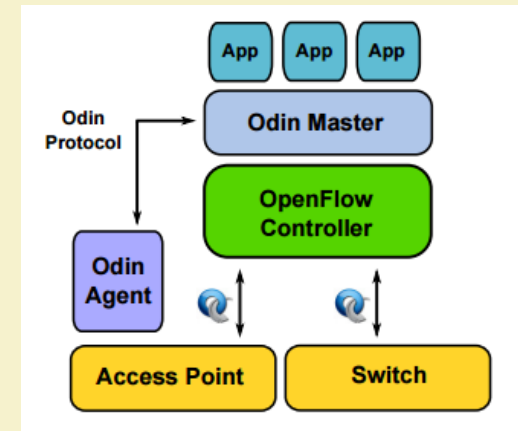 - How to support such heterogeneous devices in a single platform
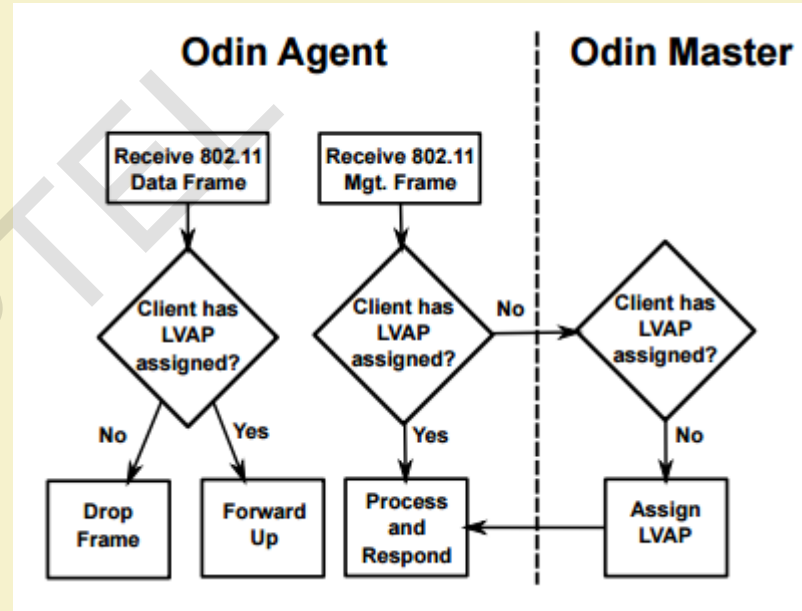
Approaches

- ✓ ODIN
- ✓ Ubi-Flow
- ✓ Mobi-Flow

ODIN I

✓ An agent is placed at access points to communicate with controller

✓ Two components are present

- Odin agent – placed with the physical devices
- Odin master – placed at the controller end

Source: Towards Programmable Enterprise WLANs with Odin, ACM HotSDN 2012
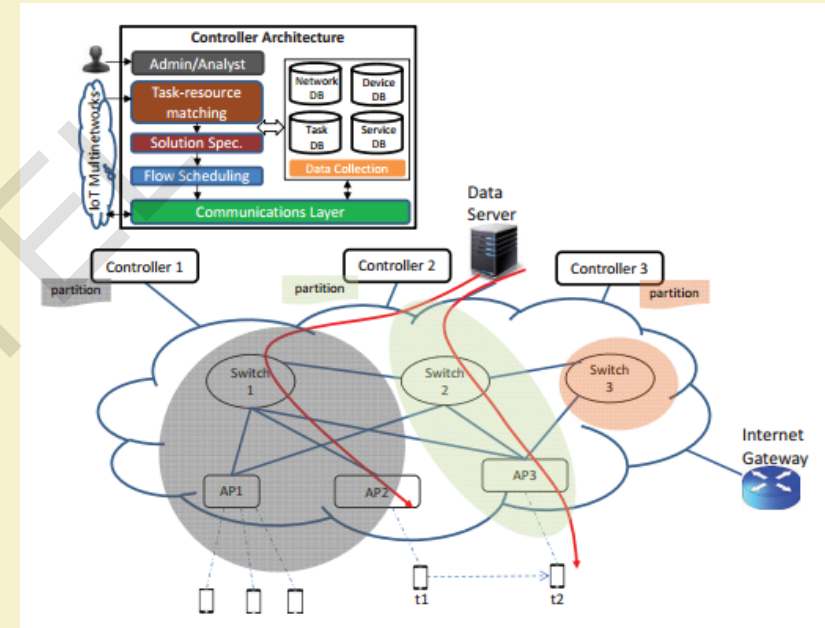
ODIN II

- ✓ Conversion of 802.11
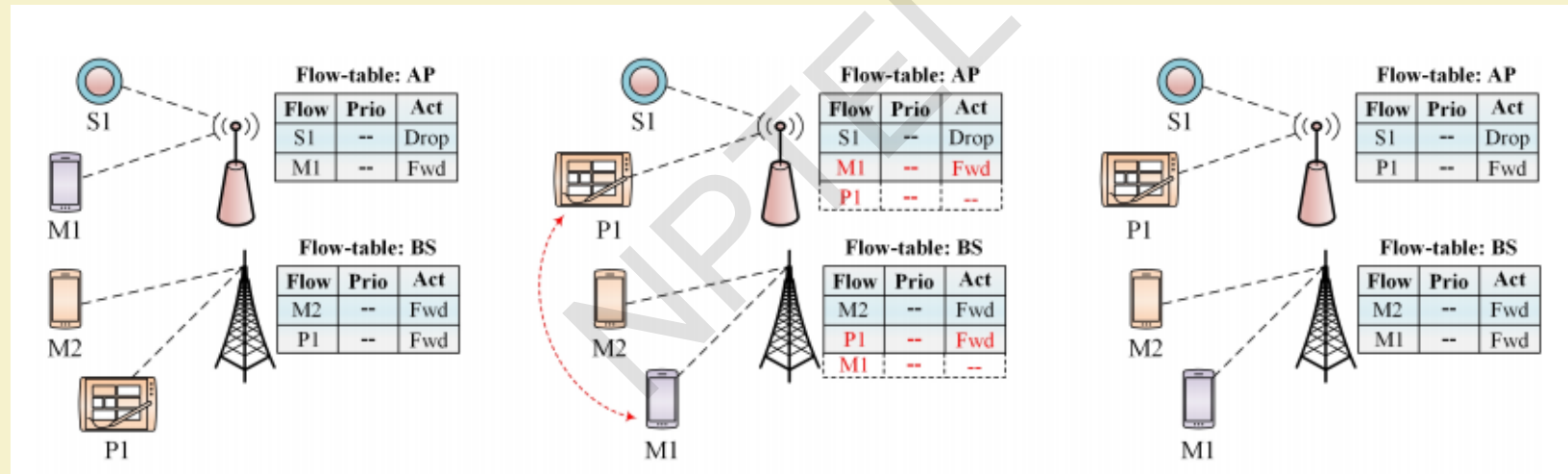- ✓ LVAP – Light virtual AP

Ubi-Flow I

- ✓ Mobility management in SDIoT
  - ■ Scalable control of the APs
  - ■ Fault tolerance
- ✓ Flow-Scheduling
  - ■ Network partition
  - ■ Network matching
  - ■ Load balancing

Source: UbiFlow: Mobility Management in Urban-scale Software Defined IoT, IEEE INFOCOM 2015

Mobi-Flow I

✓ Mobility-aware flow-rule placement in SDIoT

Source: Mobility-Aware Flow-Table Implementation in Software-Defined IoT, IEEE GLOBECOM 2016
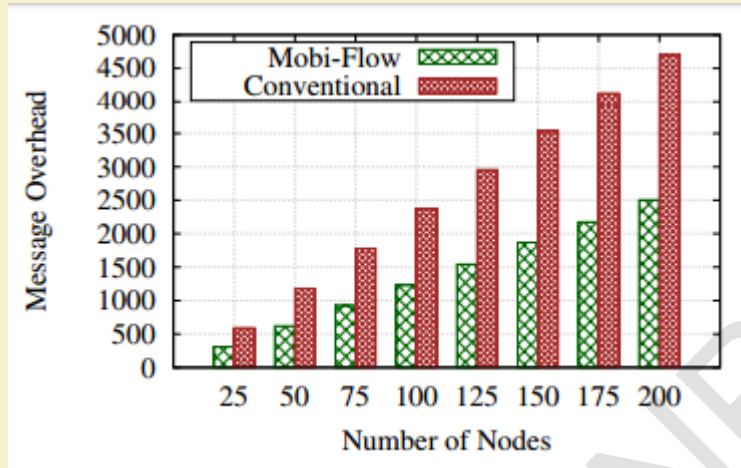
Mobi-Flow II

✓ Proactive rule placement depending on users' movement in the network

✓ Approach

  ▪ Predict location of end-users at ($t+1$) time, while the users are at (t) time

  ▪ Place flow-rules at the APs which can be associated to the users based on their predicted locations
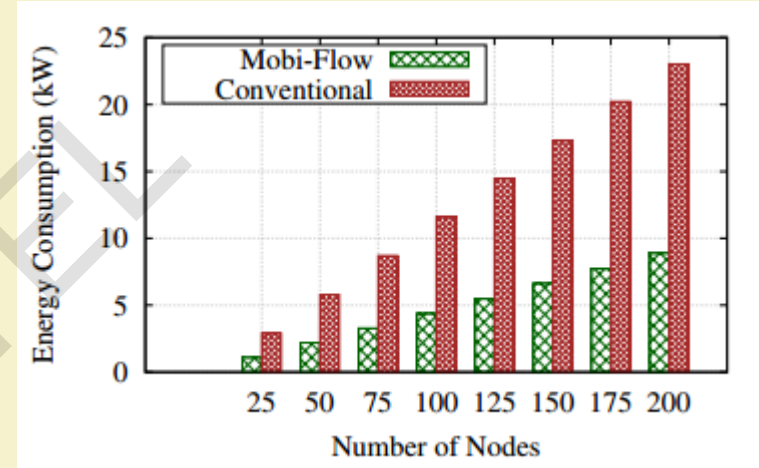
Mobi-Flow III

- ✓ Location prediction
  - Order-K Markov predictor – takes last k-th location instances to predict next location

- ✓ Flow-rule placement
  - Linear programming can be used to select optimal AP

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Mobi-Flow IV

Message Overhead in the Network

Energy consumption in the Network

Control message overhead and energy consumption can be minimized significantly using Mobi-Flow compared to the conventional flow-rule placement schemes.

Rule Placement at Backbone Network

- ✓ Existing rule placement schemes for wired network can be used

- ✓ Load balancing is an important issue due to the dynamic nature of the IoT network

- ✓ Dynamic resource allocation can also be integrated

Data Center Networking

✓ Mice-Flow – Wildcard rules can be placed to deal with mice-flows

✓ Elephant Flow – Exact match rules are useful

✓ We need to classify the flows before inserting flow-rules at the switches to adequately forward them in the network

Anomaly Detection in IoT Network

- ✓ Monitor the network through OpenFlow to detect any anomaly in the network
    - This can be done by monitoring each flow in the network
    - We can also collect the port statistics of the switches
    - If there is any anomaly, it may generate large number of packets in the network – it can be detected by monitoring the flows

Experimenting with Wireless Network

- ✓ Mininet-WiFi
  - Can be used to deploy a network
  - Supports both wired and wireless network
  - Wired – Ethernet protocol
  - Wireless – WiFi protocol (IEEE 802.11 group)
- ✓ ONOS
  - Can be used to place the controllers

Summary

- ✓ SDN-based solution approaches are useful to deal with different challenges present in an IoT network
- ✓ Issues with interference and mobility can be managed using software-defined approaches

Thank You!!