Software Defined and Virtualized Wireless Access in Future Wireless Networks: Scenarios and Standards

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Introduction

● The number of wireless devices and applications grow extremely
  ○ Increasing demand on more bandwidth
  ○ Need for more powerful and faster networks
● The variety of different standard results in the creation of complex wireless heterogeneous networks
● Network function virtualization (NFV) and software defined networking (SDN)
  ○ Programmability, flexibility, elasticity for the managed networks
  ○ Enable scaling and efficiency -> easier network management of achieving interoperability and coexistence of different wireless technologies
Perspectives of Software Defined and Virtualized Wireless Access

- A main benefit SDN/NFV is the decoupling of the network control and management function from data forwarding
  - Functions for the control and management were embedded in the hardware’s ASIC, now can be deployed and developed in software
  - Reduce the dependency of emerging wireless technologies on hardware
  - Enable better exploitation of the available infrastructure
Perspectives of Software Defined and Virtualized Wireless Access (cont’d)

- 3 perspectives of wireless access virtualization can be identified
- Flow Oriented Perspective
  - Data exchange and distribution network
  - Focus on management, scheduling, and service differentiation of different data flows from different slices
- Protocol Oriented Perspective
  - Aim to isolate, customize, and manage the multiple wireless protocol instances on the same radio hardware
  - Sharing of the same radio resources for different instances of the wireless protocol stack
- Spectrum Oriented Perspective
  - Decouples the RF front end from the protocol
  - Allowing multiple front ends to be used by a single node, or for a single RF front end to be used by multiple virtual wireless nodes
Virtualization in Wireless Networks

● Wireless Access Virtualization and Software Defined Networking
  ○ Consolidate the wireless functions in a centralized software controller, where the decoupling of a management and data plane is using CAPWAP (Control And Provisioning of Wireless Access Points).
  ○ The configuration of the wireless access point is controlled using the Simple Network Management Protocol (SNMP)
  ○ Openflow extension: in OpenRoads, the data plane of the wireless access is virtualized through the use of FlowVisor

● Wireless Virtualization using SDRs
  ○ Baseband processing is separated into the processing plane and decision plane
  ○ Ex: OpenRadio: the programmability of both planes increases the flexibility of hardware to be shared among different protocols

● WLAN Virtualization
  ○ Decoupling of IEEE 802.11 MAC frames using the OpenFlow protocol
  ○ Ex: CloudMAC
Enabling SDN and Virtualization over Wireless Networks

● Self organizing networks (SON)
  ○ Main goal of SON is to make planning, configuration, and optimization of heterogeneous and mobile radio access networks simpler and faster in an automated manner

● SDN
  ○ Allow network control and management in a high level abstraction
  ○ Issues that are not necessary in wired networks:
    ■ Link isolation
    ■ Channel estimation
  ○ Provides better cooperation between access points/base stations to reduce interference or to enhance security

● Network virtualization
  ○ Combining hardware and software network resources and network functionality into a single, software-based entity called a virtual network
  ○ Improves the resource utilization scheme by sharing the same hardware in a controlled and an isolated manner
Scenario of deploying SDN over wireless sensor networks (WSNs)

- Weaknesses of WSNs
  - Resource limitations such as processing power, memory, energy, and communication capabilities
- Smart management of network resources through SDN
- Better collaboration between the base station
  - Energy saving, sensor node mobility, network management, localization accuracy, and topology discovery
Scenario of deploying SDN over wireless sensor networks (WSNs) (cont’d)

- [12] considers a WSN that includes a base station and a number of sensor nodes
- Sensor nodes do not make routing decisions, they forward or drop packets according to a set of pre-installed rules
- Easier and more efficient way to deploy different policy

End-to-End SDN in a Wired-Wireless

- SDN-based wired-wireless integration
- Benefits:
  - Unified Management of the Wired and Wireless Network
    - SDN orchestration in Wi-Fi and wired LANs is expected to simplify operations and management functionalities
  - Unified Policy Enforcement
    - Group-based policy model
  - Network Programmability and Network Function Virtualization
    - Achieving the concept of offering the network as a service (NaaS)
Benefits of SDN-based wired-wireless integration (cont’d)

- Performance Improvement
  - Migration and handoff strategies - increase throughput
  - Multiple parallel streams - increase download rates
  - Traffic migrations and sleep configurations - power saving solutions during off-peak traffic conditions

- Vendor Interoperability
  - Open standard and open source implementations of southbound SDN interfaces
  - Due to the different solutions that vendors are offering, interoperability is still an open issue

- Customized Applications
  - Standard northbound and open APIs
Related Standardization Efforts included wireless networks

- **ITU-T** - International Telecommunications Union — Telecommunications Standardization Sector
  - Relevant standards are aimed at SDN in future networks (2014)
  - Wireless networks are included in the overall SDN deployment picture, but not explicitly addressed in the document

- **ETSI** - European Telecommunications Standards Institute
  - Current version of document: ETSI GS NFV-INF 001
  - They address wireless as a possible domain for virtualization, and specifies standard interfaces and use cases, without addressing how virtualization should be performed

- **IETF** - Internet Engineering Task Force
  - SDN standardization in mobile networks are related to the concept of Service Function Chaining (SFC), especially to the SFC Architecture and SFC Use Cases in Mobile Networks

- **ONF** - Open Network Foundation
  - Only use cases

- **IEEE**
  - SDN/NFV — Structured Abstractions
Future Research Trend

● SDN performance in dense mobile networks
  ○ Future needs of increased bandwidth and better QoS
  ○ SDN enabled cross-layer MIMO solution could be necessary to meet the future bandwidth needs

● Internet of Things (IoT) and SDN
  ○ Eliminate bottlenecks and efficiently process the data generated by IoT
  ○ Capabilities of service changing, bandwidth calendaring, and dynamic load management

● SDN based mobile data offloading
  ○ Rapid growth of mobile data services - energy consumption
  ○ Offload applications to nearby servers
  ○ Enabling programmable offloading policies

● SDN orchestrator
Conclusions

- Extend the benefits of virtualization and softwarization to the wireless domain
- Make SDN over wireless a relevant technology to manage scenarios including multi-vendor and multi-owner setups
- Discussed standardization efforts on how to extend SDN to the wireless