

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

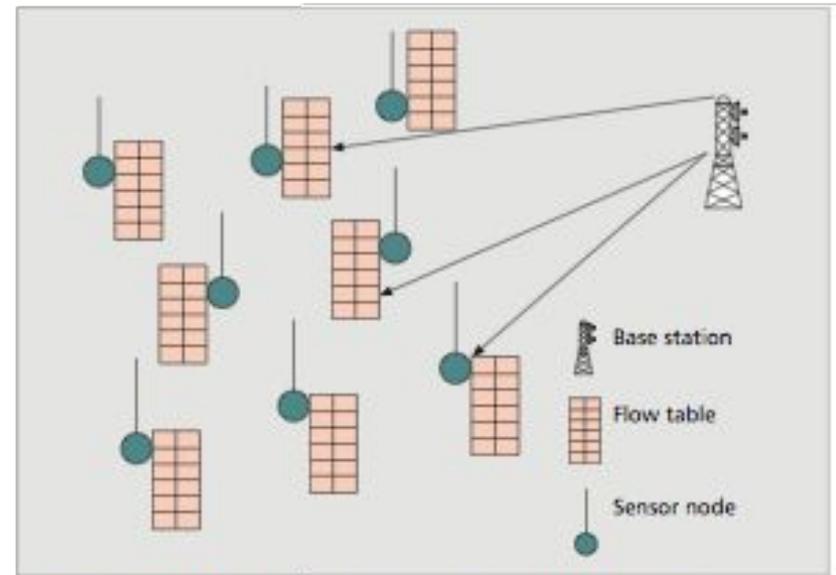


Figure 5. The software defined wireless sensor network framework.

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
 - White paper: “OpenFlow-Enabled Mobile and Wireless Networks.”
 - 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