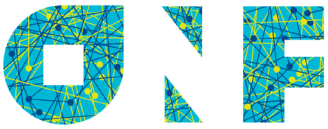

OPEN NETWORKING
FOUNDATION

Wireless & Mobile

Working Group

Table of Contents

1 Executive Summary

The Wireless & Mobile Working Group (WMWG) is chartered to collect use cases and determine architectural and protocol requirements for extending ONF based technologies to wireless and mobile domains. Areas of interest and pertinence include optimization and management of various network types including wireless backhaul, cellular Evolved Packet Core (EPC) - which entails traffic management, traffic steering, and network security - IEEE technologies such as OmniRAN, and unified access and management across enterprise wireless and fixed networks (e.g., campus Wi-Fi). This WG will work closely with other technical WGs within ONF to determine architecture and OpenFlow protocol issues and suggest extensions to ONF specifications to support wireless and mobile use cases. It also intends to collaborate with other standardization bodies to further enhance and promote the use of OpenFlow and OpenFlow-based SDN solutions. While the discussion group has as members a number of service providers and vendors the formation of a WG seeks to accelerate the participation of enterprise members of ONF. Sections 2-6 below constitute the main charter application; Section 7 provides a brief overview of relevant use cases as these were submitted by the group's members and in support of this application.

2 Mission & Motivation

The growth in mobile data, the inherent need to simultaneously operate over multiple wireless technologies, and the rapidly evolving mobile services market impose significant challenges for wireless and mobile networks. OpenFlow-based SDN technologies have the potential to provide scalable solutions for these networks. Although technologies such as OpenFlow can be certainly applicable to wireless and mobile networks, there has not been an examination of the specific needs and requirements of these networks. By studying the unique requirements of SDN in wireless and mobile networks, OpenFlow can be incrementally enhanced to bring the benefits of SDN into this space. In addition, a number of use cases, as we describe in this document, have emerged as potential fields of application that can leverage and thus greatly benefit from OpenFlow. It is easier and lifecycles are shorter, when it comes to replacing access points or upgrading base stations (as mobile technologies evolve), given also the strong market demand for mobile devices and content. We strongly believe that OpenFlow could ultimately find its niche in this space. All in all, an OpenFlow-based SDN is a great fit for mobile due to the existing separation of the control and data planes in mobile networks.

A WG is needed to bring together experts with experience building wireless and mobile networks that have interest in incorporating OpenFlow as a related protocol technology. The clear separation and decoupling of the control and data planes enabled by OpenFlow is a perfect match for wireless and mobile networks and their architectures. For instance, OpenFlow permits the central control plane to optimally direct traffic in the data plane based on individual service needs, not bound by the IP routing configuration. Especially in a mobile environment where the customer is changing locations, this adds flexibility while reducing network management burdens.

3 Scope

The work of this WG will include identifying and developing use cases, proposing simplified reference architectures that leverage OpenFlow-based SDN. It is foreseen to also include the identification and

creation of any necessary OpenFlow protocol extensions or enhancements, and adaptation to or integration with, existing efforts within the ONF scope. The scope is described below in more detail as sought goals and non-goals for the proposed WG.

A unified SDN control & management that spans across a wireless and fixed infrastructure, for instance, over a few SDN domains and thus even encompassing an end-to-end (E2E) SDN architecture would be enabled and enhanced by a wireless SDN giving rise to a universal SDN (and which would be completely transparent to the end user). Applications can vary from an enterprise environment (SDN for WLAN/WiFi, that could be, for instance, a great tool for enforcing BYOD policies) to a service. provider/operator environment (e.g. using a single controller or federated controllers when crossing multi-operator domains).

4 Goals & Non-Goals

The WG will focus on a number of areas and perform specific tasks as described by the following goals and non-goals.

Goals

- Propose a common ground architectural framework that will encompass different elements of OpenFlow-based or OpenFlow-oriented wireless and mobile network domains.
- Define and prioritize use cases of 3GPP Evolved Packet Core (EPC) based networks that could benefit from the use of OpenFlow protocols. This involves using OpenFlow protocols in the core network entities of EPC connected by wired physical links but supporting wireless users.
- Define and prioritize use cases for wireless transport networks leveraging OpenFlow in order to improve the network controllability and management flexibility. This involves using OpenFlow protocols in transport and backhaul network entities connected by wireless physical links (e.g., microwave) supporting wired or wireless users. Using OpenFlow, the group will aim to simplify the interaction between wireless physical networks and packet networks. Similar to the Optical Transport WG (OTWG), this group will explore direct control of wireless transport network elements and control using an abstract view of the wireless transport network.
- Define and prioritize use cases related to the IEEE family of wireless networks that could benefit from the use of OpenFlow protocols. Currently identified areas of study include but are not limited to:
    - IEEE Media-Independent Handover and how it provides a path towards enabling an SDN controller to facilitate handovers between wireless Points of Attachment.
    - IEEE 802.16r's proposal for applying Small Cell Backhaul (SCB) techniques via SDN and SDN controllers to manipulate wireless switch modules.
    - Unified access and management of enterprise wireless and fixed networks such as (large) campus Wi-Fi deployments.
- Identify and prioritize requirements of OpenFlow protocol family enhancements to support such use cases.
- Identify security related issues with OpenFlow protocol family enhancements to support such use cases.
- The WG will seek close collaboration and cross-pollination with other WGs within ONF.
    - Work with OTWG to validate use cases and requirements related to wireless transport

network. This WG needs to make sure its work is well coordinated and does not overlap or interfere with the work of the OTWG.
    - Work with Architecture and Framework WG on exploring any architectural issues. Such issues may include additional terminology, for example.
    - Work together with Extensibility WG on examining any OpenFlow family protocol issues, extensions and enhancements.
    - Work with the Security DG on examining any OpenFlow family protocol issues related to security when used in wireless and mobile networks.
- External to ONF, work with 3GPP, IEEE and other wireless/mobile related Standards Developing Organizations (SDOs) on understanding wireless and mobile technologies and the incorporation of OpenFlow family functionality into these technologies. Coordinate the work of ONF with these SDOs' development of standards. The idea is to leverage the work done in other SDOs so as to achieve faster results that are aligned with various wireless and mobile technologies.

Non-goals

As this Working Group follows other standards and interacts with other SDOs, it shall be careful to work harmoniously and in a complementary manner with these other SDOs.

- This WG will not write requirements that conflict with the existing specifications of 3GPP, IEEE, SCF, NGMN, MEF, BBF, ITU, ETSI, IETF or other existing industry SDOs.
- This WG will not duplicate the work performed at other SDOs.
- This WG will not seek to modify or otherwise change existing protocols defined by other SDOs

5 Deliverables

This section describes the deliverables planned by the Working Group. The WG will build on the output of the Discussion Group which started collecting use cases and initiated the discussion around some initial architectural and protocol issues. The WG will collect, merge, and refine the initial use cases and vet them for suitability with respect to further steps, as decided by the WMWG and also taking into account feedback from other ONF stakeholders. The analysis will come from extracting requirements revealed by the use cases and then studying any architectural or protocols issues and performing gap analysis relative to the OpenFlow family of protocols. These form to two main deliverables of the WG. They may be contained in two (or more) documents as shown below:

- Wireless & Mobile Use Cases & Requirements– Collection of relevant use cases for wireless and mobile network use of SDN technology. Extraction of requirements to enhance the OpenFlow family to support the collection of use cases.
- Wireless & Mobile Reference Architecture and OpenFlow Study – Contains simplified architectures to support the wireless and mobile use cases. These architectures will not be normative but illustrative to provide a framework to study any gaps in the current OpenFlow family of protocols. This document will include the determination or any architectural or OpenFlow family protocol specific issues and suggestions for OpenFlow family extensions or enhancements. The purpose of this document is to provide architectural and protocol recommendations to other ONF working groups such AFWG and EXT WG. As protocol extensions or enhancements are adopted by ONF, this WG will help support submission of the relevant running code to these other WGs.

6 Milestones

Milestone dates are relative to the time the Working Group is approved & chartered.

+0 Months	WMWG charter approved by ONF Board of Directors
+1Q	Initial WMWG use cases finalized, grouped into areas/projects and prioritized
+2Q	Initial draft of WMWG use cases and requirements circulated to other ONF WGs (as needed); collect feedback
+3Q	Incorporate feedback from other ONF WGs into WMWG use cases and requirement. ONF-wide review
+3Q	Initial draft of WMWG Ref Arch and OpenFlow Study circulated to ONF.
+4Q	AFWG and EXT WG feedback incorporated into WMWG Ref Arch and OpenFlow Study, ONF-wide review.

7 Example Use Cases – Summaries

The section below outlines the various new use cases for wireless and mobile that could leverage OpenFlow-based SDN. A separate supporting document contains detailed descriptions of those use cases.

7.1 Flexible and Scalable Packet Core

SDN enabled mobile packet core that separates controller and switch for flexibility, enhanced reliability and scalability.

7.2 Dynamic resource management for wireless backhaul

Mobile data traffic is increasing rapidly and with it the backhaul capacity requirements. As opposed to wired backhaul, the wireless backhaul resources are limited and are more prone to instability effects. The use case addresses wireless backhaul resource management enabling the operator to maximize the available resources and minimize the traffic congestion in a multi-vendor environment.

7.3 Mobile Traffic Management

Managing the traffic in a mobile network, for instance to handle sudden traffic surges, can be challenging for the mobile operator and hence it presents a lot of interest in the overall context of traffic steering. This particular use case suggests mobile traffic offload as a useful field of application for OpenFlow

7.4 Connection-Oriented SDN for Wireless SCB

Fixed broadband wireless access can provide Carrier Ethernet services. One major application is the backhaul of wireless cells, particularly small cells supporting LTE, Wi-Fi, etc. Wireless backhaul allows for flexible placement driven by user capacity requirements rather than wired backhaul availability. The IEEE 802.16 Working Group on Broadband Wireless Access is developing in Project 802.16r on Small Cell Backhaul to address the problem. The project may provide an OpenFlow controller the opportunity to select from among multiple 802.16 connections, even selecting from among a set of various alternative transport technologies.

7.5 Management of secured flows in LTE

Existing security procedures for flow protection in LTE are based on the usage of IPsec tunnels. The IPsec protocol allows for a differentiated processing of the IP packets based on packet selectors, according to packet header information fields (e.g., IP destination, IP origin, remote or local port, transport protocol, etc). There are clear similarities with the way OpenFlow handles the traffic and the flow tables, and this suggests that a flexible handling of IPsec traffic can be obtained by applying SDN principles for enforcing IPsec policies in LTE.

7.6 Media-Independent Handover

The use case enables OpenFlow to effectively perform both break-before-make and make-before-break flow reassignments by using media-independent handover protocol commands as specified by IEEE

Wireless TG 802.21, particularly including 802.21c for single-radio handovers. Media-Independent Handover (MIH) is under development in the IEEE 802.21 Task Group of the 802 Wireless Standards group. It is expected that 802.21 is very well suited for OpenFlow implementation because OpenFlow is specified in a media-independent manner, and 802.21 focuses exclusively on media-independent protocol messages and information elements which are needed for handovers.

7.7 SDN Enhanced Distributed P/S-GW

Although 3GPP standards doesn't specific how many P/S-GW should be deployed in LTE's core network, in practice, the LTE core network usually use centralized and integrated P/S-GW, which serves a large area of eNodeBs, like one province or a state with millions of subscribers. This results in a lot back and forth IP traffic in the P/S-GW. A distributed P/S-GW implemented with a centralized MME (or controller) which use SDN/OpenFlow to dynamically manage those P/S-GW local/mobile IP traffic would be a more feasible and flexible case to reduce the aforementioned back-and-forth traffic as well as LTE core network cost. This use case discusses how SDN could be used to implement such a distributed P/S-GW for LTE core network.

7.8 Network-Aware UE Multiple Radio Interface Management

Users choose different radio interfaces according to a number of different factors, e.g., cost, simultaneous user experience, empirical practices, etc. without awareness of network conditions. Operators want to minimize the transmission cost per byte without deteriorating SLA/user experience (e.g., via WiFi offloading etc). This use case describe how operators can use the information regarding radio interfaces to dictate UEs on how to use the multiple radio interfaces to achieve the above goals.

7.9 S-GW virtualization

This use case addresses S-GW virtualization which emulates a logically single S-GW with distributed OpenFlow switches. It can provide variable benefits such as efficient resource usage in mobile network and GW overload avoidance seamlessly. The use case consists of 3 scenarios, route optimization between eNB and P-GW, seamless load balancing and dynamic GW capacity modification for virtualized EPC.

7.10 Service Chaining in Mobile Service Domain

Service chaining in mobile networks and the relation to OpenFlow.

7.11 Energy Efficiency in Mobile Backhaul Network

The energy efficiency use case addresses the power consumption optimization in mobile backhaul network. The optimization of power consumption on the whole network can be achieved by using the SDN concept. The OF controller can set up a traffic distribution model by monitoring the real time traffic, and set the transmission power level dynamically, or turn off the radio within a radio link aggregation group.

7.12 Security and Backhaul Optimization

The use case describes a backhaul optimization technique based on redundancy elimination. The implementation is based on a chaining concept where specific traffic flows instead of being encrypted, are

steered to compressor/decompressor nodes. This use case enables the operator to provide security to crucial flows while optimizing the flows that consumes most of the backhaul resources.

7.13 Unified Equipment Management and Control

The unified equipment management use case addresses the management and control issue in the wireless backhaul network. It's proposed to use the OpenFlow controller to achieve unified equipment management and control on full outdoor equipment and IDU, on equipment from multiple vendors, and on the microwave equipment and other types of equipment.

7.14 Network Based Mobility Management

This use case addresses the application of OpenFlow to network-based mobility management protocols (e.g., PMIPv6, DMM). Through the usage of these protocols a given Mobile Node (MN) does not require implementing any mobility-specific IP operations, and it is able to change its access link while keeping its IP address. The mobility of the MNs generates dynamic traffic flows in a given mobility domain. Since the handover process is not coordinated between the involved gateways, a centralized SDN control could greatly benefit the process in which the network adapts to the MN's movement, signaling the new flow tables accordingly to the new situation.

7.15 SDN-Based Mobility Management in LTE

IP address is used to identify UE and locate UE in the network topology. GTP tunnel is used to find right location in case of handover without the need of changing UE's IP address. However, under this paradigm, the network is suffering from the GTP tunnel overhead and singling traffic during handover. We can use eNB's MAC address as locator and UE's IP address as identifier. A SDN controller maintains the a <key, value> pair table, i.e, <UE IP, eNB MAC> table to look up the location of UE according to its IP address. In this way, the singling traffic during handover and GTP tunnel overhead due to GTP are eliminated.

7.16 IEEE OmniRAN

Sharing access and backhaul network resources allows operators exploiting infrastructures to expand coverage to more users and to lower the CAPEX and OPEX of the network. By abstracting multiple heterogeneous access technologies into a single access infrastructure, new business models can also be developed, independent of the actual access technologies used by the customers to connect to the service network. All this can be enabled by defining open interfaces to manage and configure heterogeneous access networks, through coordinated efforts between ONF and the IEEE 802 OmniRAN groups.

7.17 Unified Access Network for Enterprise and Large Campus

This use case proposes a unified access network by using the same controller to manage both wired switches and wireless access points with users in standardized way. It lists the requirements of the frame work to run both OpenFlow and CAPWAP (Control and Provisioning of Wireless Access Points) (1) in parallel, by analyzing the gaps with current OpenFlow and CAPWAP protocols.