A Common Performance Monitoring System for Wi-Fi and 3GPP Networks

Icaro da Silva
Ericsson Research
Wireless Access Networks
Stockholm, Sweden
Email: icaro.leonardo.da.silva@ericsson.com

Yu Wang
Ericsson Research
Wireless Access Networks
Stockholm, Sweden
Email: yu.a.wang@ericsson.com

Filip Mestanov
Ericsson Research
Wireless Access Networks
Stockholm, Sweden
Email: filip.mestanov@ericsson.com

***Abstract*—Integration of Carrier Wi-Fi and 3rd. generation partnership project (3GPP) networks is currently one of the hottest topics in the agenda of the mobile industry. Wi-Fi is one key element of heterogeneous networks to handle the traffic explosion in the coming years and as such an integral part of a complete mobile broadband solution. In order to exploit its full potential, Wi-Fi will more and more be seen as an additional radio access technology (RAT) in the mobile network. A path to this is currently being paved in different 3GPP and Wi-Fi related fora and accomplishing this vision requires a number of elements to be considered including strategies for access selection and a common network management framework. This paper addresses a contribution towards this direction. We demonstrate a common performance monitoring (PM) system for Wi-Fi and 3GPP networks. The solution relies on the correlation of performance traces from both technologies and Wi-Fi access point (AP) probes. Interworking key performance indicators (KPIs) are defined assuming the state of the art for Wi-Fi and 3GPP seamless authentication, based on the extensive authentication protocol-subscriber identity module (EAP-SIM) framework. The demo consists of giving an overview of the system architecture, description of different mobility use cases for vertical handovers between Wi-Fi and 3GPP networks and the presentation of the interworking performance recorded from active tests.**

I. Introduction

The number of worldwide mobile subscriptions reached 6 billion at the end of 2011 and is expected to hit the 9 billion mark by the end of 2017. The total traffic generated by mobile devices will also grow to values between 10 and 12 Exabyte/month in 2017 [1]. In order to cope with this data explosion, mobile operators have different alternatives to handle the capacity and coverage enhancements which are needed to meet the growing traffic e.g. by i) enhancing the macro network with additional licensed spectrum, more antennas and better processing capabilities, ii) densifying the macro network and/or iii)adding capacity through small cell-deployment using low-power nodes. This will lead to the formation of a heterogeneous network whose main driver is to deliver high-quality services wherever users need them [2].

Concerning the small cell technologies, Wi-Fi is one key element due to its proved high throughput and the usage of unlicensed spectrum [3]. In addition, the current mobile-data explosion is largely being driven by smartphones and Wi-Fi has become an almost ubiquitous feature on high-end, mass-market devices. Operators have already started deploying Wi-Fi hotspots and signing roaming agreements with wireless internet service providers.

Operators need greater control over the access selection. The best user experience can only be achieved if Wi-Fi selection decisions are based on information available from both the 3GPP and Wi-Fi networks, which includes: user-equipment mobility status and location, total load on both networks, radio conditions in both networks [3]. In order to fully exploit the different business opportunities brought by the integration of Wi-Fi and 3GPP networks mobile operators should be able to observe how each network performs in an integrated way as in the case of 2G, 3G and 4G systems. Assessing the Wi-Fi and the 3GPP performance per common location (Wi-Fi and 3GPP cell pair), user and device type during Wi-Fi selection is important for operators in order to add extra value for this new asset. There are currently ongoing standardization activities in 3GPP to enable some common management functions between the different systems [4]. However, this is currently limited to a standard northbound interface for Wi-Fi domain manager mainly for PM counters. Despite these efforts, it will still not be easy to trace users and device type performances before and after Wi-Fi selection. Individual traces are beneficial for different purposes e.g. troubleshooting, customer care and optimization.

In this paper we demonstrate a research prototype of a common PM system for Wi-Fi and 3GPP networks. Interworking KPIs are proposed assuming the state of the art for Wi-Fi and 3GPP seamless authentication based on the EAP-SIM framework [5]. The impact of these KPIs on the end-user experience is also discussed. We also show the system architecture of our common PM system which runs on a live proof-of-concept (PoC) network consisting of one AP, one evolved NodeB (eNodeB) and 3GPP core network nodes. A JAVA-based graphical user interface (GUI) is used in the presentation layer to demonstrate potential operator use cases.

II. System Architecture

A. PoC Network

The prototype demonstrated in this paper collects data from a PoC network consisting of both Wi-Fi and long term evolution (LTE) technologies. The LTE part consists of a single eNodeB and evolved packet system (EPS) core nodes. The Wi-Fi side consists of one AP. A number of dual-radio devices are used for the active tests. The two systems are integrated in the sense that users from LTE are able to authenticate to the APs

978-3-901882-50-0 ©2013 IFIP

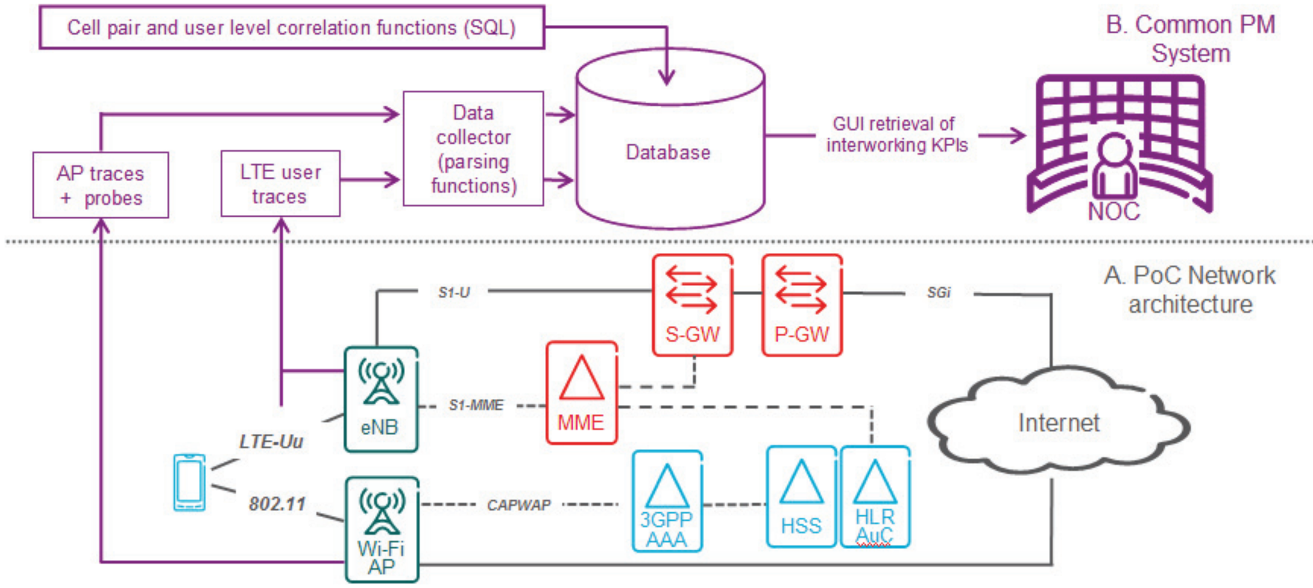

Fig. 1. System Architecture

via EAP-SIM procedure where messages are exchanged with the 3GPP authentication, authorization and accounting (AAA) server. Each time a user enters the Wi-Fi coverage, association and open system authentication is performed, followed by an EAP-SIM authentication attempt. If the user is successfully recognized by the AAA server, access to the AP is granted and an IP address is assigned to the user on the Wi-Fi network. At this point the device may switch the data flows from LTE to Wi-Fi. The PoC network architecture is depicted in the lower part of Fig. 1.

B. Common PM System

The common PM system relies on performance traces (per user) from both systems. For the AP, this tracing functionality is provided by all major Carrier Wi-Fi vendors. In addition to these traces, passive protocol probing is also installed in order to collect additional information (e.g. EAP-SIM messages to detect system transitions from LTE to Wi-Fi). At the LTE side, user traces are also activated. Once these traces and probes are collected they are parsed and stored in a database. After this phase, an engine composed by a set of structured query language (SQL) functions is able to perform user and cell pair level correlation in order to calculate the pre-defined interworking KPIs. The architecture of the common PM system is shown in the upper part of the Fig. 1.

III. Wi-Fi and 3GPP interworking use cases

We demonstrate a set of use cases that represents real mobility scenarios between 3GPP and Wi-Fi networks. Interworking KPIs enabled by the common PM system are defined in order to monitor the performance of both systems in these scenarios. In one of the use cases, a user is always covered by LTE and starts to move towards the AP coverage while a video session is ongoing. Our common PM system shows the throughput gap, which is the difference between user throughput after and before access network changes. Analyzing this KPI enables operators to identify the vertical handovers that improved or degraded the user experience. In the cases of a negative throughput gap (i.e. user throughput drops after the vertical handover) a root cause analysis (RCA) may be triggered, which is critical for performance optimization. To facilitate the RCA, we also define KPIs that reveal radio conditions and congestion status of the two networks around the time when the vertical handover occurs.

In a second use case, a high mobility user covered by LTE moves across the AP coverage area, coming back to the same LTE cell while the same video session is ongoing. Our PM system shows the duration a user spends on Wi-Fi before returning to LTE. Short time is an indication of unnecessary Wi-Fi selection where users connect to Wi-Fi and leave it promptly. The unnecessary Wi-Fi selection may generate unnecessary authentication signaling and cause service interruption.

References

[1] Ericsson, *Traffic and Market Report*, http://www.ericsson.com/res/docs/2012/traffic_report_june_2012.pdf, June 2012.

[2] Ericsson, *Heterogeneous networks (White paper)*, http://www.ericsson.com/res/docs/whitepapers/WP-Heterogeneous-Networks.pdf, February 2012.

[3] Ericsson, *Wi-Fi in Heterogeneous networks, An Integrated Approach to delivering the best user experience (White paper)*, http://www.ericsson.com/news/121127-wifi-heterogeneous-networks_244159017_c, November 2012.

[4] 3GPP, "Telecommunication Management; Study on WLAN Management (Release 12)," TR 32.841, 3rd Generation Partnership Project (3GPP).

[5] H. Haverinen and J. Salowey, "Extensible Authentication Protocol Method for Global System for Mobile Communications (GSM) Subscriber Identity Modules (EAP-SIM)," RFC 4186, Internet Engineering Task Force, Jan. 2006.