

MPAP: Virtualization Architecture for Heterogenous Wireless APs

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ABSTRACT

This demonstration shows a novel virtualization architecture, called *Multi-Purpose Access Point* (MPAP), which can virtualize multiple heterogenous wireless standards based on software radio. The basic idea is to deploy a wide-band radio front-end to receive wireless signals from all wireless standards sharing the same spectrum band, and use separate software base-bands to demodulate information stream for each wireless standard. Based on software radio, MPAP consolidates multiple wireless devices into single hardware platform, and allows them to share the same general-purpose computing resource. Different software base-bands can easily communicate and coordinate with one another. Thus, it also provides better coexistence among heterogenous wireless standards. As an example, we demonstrate to use non-contiguous OFDM in 802.11g PHY to avoid the mutual interference with narrow-band ZigBee communication.

Categories and Subject Descriptors

C.2.1 [COMPUTER-COMMUNICATION NETWORKS]: Network Architecture and Design—*Wireless communication*

General Terms

Algorithms, Design, Experimentation

Keywords

Software radio, Sora, Virtualization, Wireless

1. INTRODUCTION

The last decade has witnessed the proliferation of standards for short-range wireless communication, including 802.11 family (b/g/n), ZigBee/802.15.4, Cordless Phone, Home Monitoring Devices, and *etc.* Nowadays, it is a common case that multiple heterogenous wireless standards are actively in use simultaneously. For example, in a home, one might want to use both cordless phone and WiFi; while in a hospital, more heterogenous wireless standards, *e.g.* ZigBee and WiFi, might be involved for sensing and monitoring.

Although all these standards use the same license-free industrial scientific and medical (ISM) band, they cannot communicate with one another because of the significant difference in their physical (PHY) and medium access (MAC) layer design. Thus, to simultaneously use heterogenous wireless standards, multiple Access Points (AP) or Network controllers (NC) are needed, adding

considerable management overhead and cost. Moreover, there is also a complex coexistence issue among these heterogenous wireless standards to avoid mutual interference from one another.

In this demonstration, we propose a new virtualization architecture, called *Multi-Purpose Access Point* (MPAP), which can virtualize multiple heterogenous wireless standards based on software radio. The basic idea is to deploy a wide-band radio front-end to receive wireless signals from all wireless standards sharing the same spectrum band, and use software base-bands to separate and demodulate information stream for each coexisting wireless standard. MPAP consolidates multiple wireless devices into a single platform and thus reduces the maintenance cost. Based on software radio, MPAP enables multiple wireless standards sharing the same general-purpose computing resource (*e.g.* multi-core CPU). MPAP is also flexible and extensible to support future wireless standards. Finally, implemented purely in software, heterogeneous software base-band programs can communicate and coordinate together to provide better coexistence and avoid the mutual interference among heterogenous wireless.

Our demonstration is based on the Sora platform [1, 4]. To show the flexibility, we configure MPAP to run with two heterogeneous modes simultaneously: 802.11g AP and ZigBee NC. We can create more virtual ZigBee NICs by running additional software base-band instances. Further, we also demonstrate the better coexistence among these two heterogeneous wireless with MPAP. Specifically, we propose to use non-contiguous OFDM [2, 3] in 802.11g PHY to avoid the mutual interference with narrow-band ZigBee communication. This non-contiguous OFDM technique is useful when the channel is crowded (run out of orthogonal spectrum-bands) or there are some legacy devices that are configured on fixed bands that cannot be easily changed.

2. MPAP ARCHITECTURE

The MPAP architecture is shown in Figure 1. It relies on the state-of-the-art software radio technique and wide-band RF front-end hardware. MPAP uses a wide-band RF front-end that can receive heterogenous wireless signals with different standards in the same spectrum band (*i.e.* 2.4GHz ISM band). The received signals are transferred into a PC's main memory using Sora Radio Control Board (RCB). Then, the Sora SDR Service may distribute these raw digital samples to various virtual network card interface (VNIC) for further processing.

VNIC is a software program that implements both PHY and MAC of a wireless standard. Since in MPAP, a much wider band signal is sampled, it is essential for each software baseband to perform filtering on the incoming samples to match their own wireless channel definition, as shown in Figure 2. Then, the matched digital

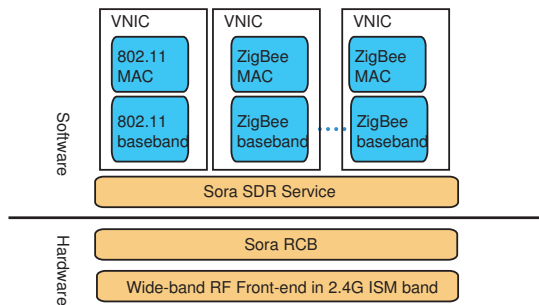


Figure 1: MPAP architecture.

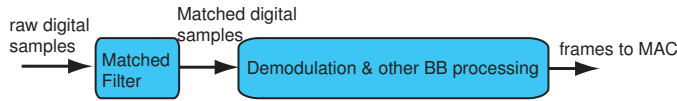


Figure 2: Virtualized software baseband architecture.

samples are fed into demodulator and the corresponding frames are demodulated and sent to upper layer of the network stack.

MPAP also deploys a coordination module to ensure the friendly coexistence among multiple heterogeneous VNICs, as shown in Figure 3. One key function of this coordinator is to synchronize the transmitting/receiving behavior of each VNIC. This is because MPAP uses only a single wide-band RF front-end, which can only transmit or receive at a time. Thus, in MPAP, if a VNIC is transmitting/receiving, all other VNICs should transmit/receive as well. Moreover, MPAP coordinator also facilitates to mitigate mutual interference among heterogeneous wireless standards. It is because MPAP can jointly sense the usage of a wide spectrum band and compute a best configuration based on this knowledge for each VNIC (and its corresponding network) adaptively.

We also use non-contiguous OFDM [3] with 802.11g PHY to avoid mutual interference with other narrow-band wireless (like ZigBee) when there lack of orthogonal spectrum bands. The key idea is shown in Figure 4. When the wide-band wireless is aware of the existence of a narrow-band wireless, it can transmit suppress its own signals on these OFDM subcarriers occupied by the narrow-band wireless. The remaining subcarriers can still be used to transmit information. The narrow-band wireless receiver can filter out out-of-band signals and decode its own frames without interference. At the wide-band wireless receiver, the signals at the null subcarriers are dropped, while the other subcarriers are demodulated and the information is concatenated to recover the transmitted frame.

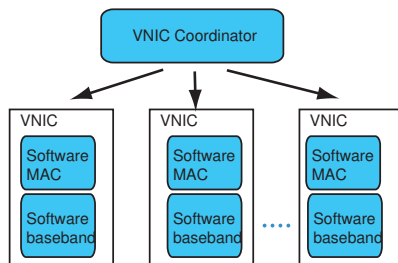


Figure 3: A coordinator is deployed in MPAP to ensure the coexistence of multiple heterogeneous VNICs.

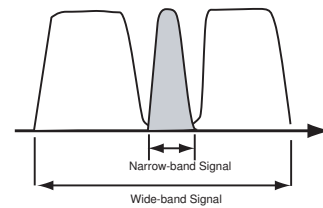


Figure 4: Non-contiguous OFDM to avoid mutual interference among wide-band and narrow-band signals.

3. DEMONSTRATION

Our demonstration setting is shown in Figure 5. It includes a MPAP, a 802.11g client and two ZigBee clients. The MPAP is based on Sora platform and configured to run both 802.11 and ZigBee virtual NICs. We show that both 802.11g and ZigBee clients can communicate with MPAP simultaneously. Additional ZigBee networks can be created by running addition software VNIC on MPAP.

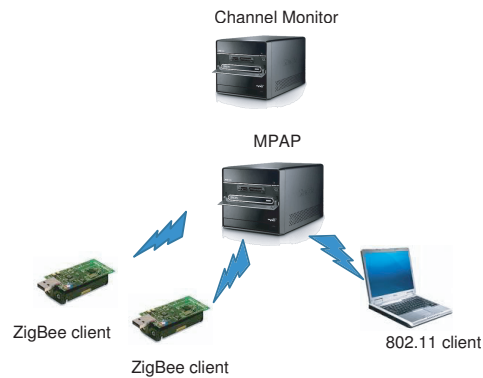


Figure 5: Demonstration setting.

To visualize the channel usage, another Sora platform is used to run a spectrum monitoring tool that can seeking both ZigBee and 802.11 preambles in the wide spectrum band. A graphic UI is displayed to show the spectrum occupation of both ZigBee and 802.11 and the non-contiguous OFDM used in a modified 802.11g client in real-time.

4. REFERENCES

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