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, Virtualization, Wireless

1. INTRODUCTION

The last decade has witnessed the proliferation of standards for short-range wireless communication, including 802.11 family (a/b/g/n), ZigBee/802.15.4, cordless phone, home monitoring devices, and *etc.*. It is a common case that multiple devices with heterogenous wireless standards are simultaneously used in a vicinity. For example, at home, a user may simultaneously talk over a cordless phone while browse pages using WiFi; while in a hospital, more diverse wireless devices, *e.g.* WiFi, ZigBee and Wireless Body-area Networks (WBAN), may involve for sensing and monitoring purposes.

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Though all these standards use the same license-free Industrial Scientific and Medical band (ISM), they cannot communicate with one another because of the significant difference in their physical layer (PHY) and medium access (MAC) layer designs. As a consequence, to simultaneously use heterogenous wireless standards, multiple Access Points (AP) or Network Controllers (NC) have to be deployed and configured for each wireless standard, adding considerable management overhead and hardware cost. Further, it is also a complex coexistence issue for these heterogenous wireless standards to avoid mutual interference from one another.

In this demonstration, we show a new virtualization architecture, called *Multi-Protocol Access Point* (MPAP), that exploits the software radio technology to virtualize multiple heterogenous wireless standards over the same radio hardware. 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 streams for each coexisting wireless standard. MPAP consolidates multiple wireless devices into a single hardware 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 them.

Our demonstration is based on the Sora platform [1,4]. To show the flexibility, we configure MPAP to run two different wireless networks simultaneously: 802.11g and ZigBee. For each wireless, we generate a virtual network card (NIC) that appear to applications as if there were separated radio hardware. One can create more virtual NICs if needed by simply running additional software base-band instances.

Finally, we demonstrate that MPAP can achieve better coexistence between these two wireless networks. Conventionally, when a ZigBee node is sending, an entire 20MHz 802.11g channel cannot be used even though ZigBee occupies only 5MHz band in that channel. In MPAP, we propose to use non-contiguous OFDM [2,3] in 802.11g PHY to make use of the remaining 15MHz channel while at the same time avoiding the mutual interference to narrow-band ZigBee communication. We believe this non-contiguous OFDM technique is a general technique and is particular useful when the channel is crowded (running out of orthogonal spectrum-bands) or there are legacy devices that are configured on fixed frequency bands.

2. MPAP ARCHITECTURE

Figure 1 shows the MPAP architecture. It is built upon the state-of-the-art software radio technique and wide-band RF front-end hardware. MPAP uses a wide-band RF front-end to receive radio signals for different wireless standards sharing the same spectrum band (*i.e.* 2.4GHz ISM band). The received radio signals are digitized and transferred into a PC's main memory using Sora Radio Control Board (RCB). A new service layer, SDR Service Layer, will extract proper signals from these raw samples and distribute them to different virtual network cards (VNICs) that contain different PHY and MAC modules for further processing.

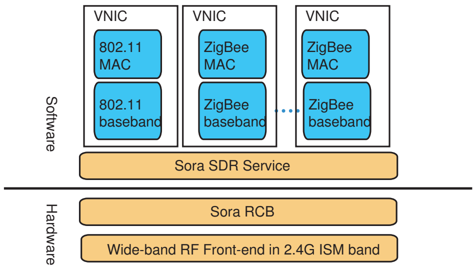

Figure 1: MPAP architecture.

Since in MPAP, a much wider band signal is sample, a core function for SDR Service Layer is to preform filtering on the incoming samples and obtain signals that match the channel definition of each wireless standard. After channel matched filter, the matched digital samples can be fed into demodulator to get correct frame data.

MPAP deploys a coordinating module to ensure the friendly coexistence among multiple heterogeneous VNICs, as shown in Figure 2. One key function of this coordinator is to synchronize the transmitting/receiving behavior of each VNIC. This is because M-PAP uses only a single wide-band RF front-end, which can only transmit or receive at a time. In other words, in MPAP, if a VNIC is transmitting/receiving, all other VNICs should be transmiting/receiving as the same time. A scheduler is implemented to ensure such synchronization while maximizes the concurrent transmissions if they are on orthogonal bands. The MPAP coordinator also collects spectrum usage information from all VNICs and may use this knowledge to reconfigure each wireless network, thus to minimize the mutual interference.

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

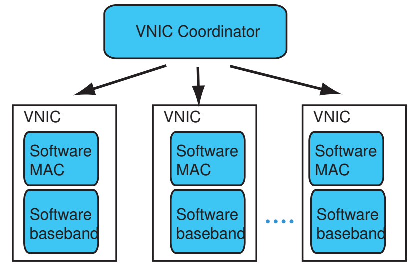

Figure 2: A MPAP coordinator to synchronize multiple VNICs.

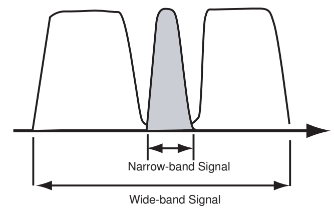

Figure 3: Non-contiguous OFDM to avoid interference with narrow-band signals.

3. DEMONSTRATION

Our demonstration setting is shown in Figure 4. It includes a M-PAP node, a 802.11g client and two ZigBee clients. The MPAP node is based on the Sora platform and configured to run both 802.11 and ZigBee VNICs. Additional ZigBee networks can be created by launching addition software VNICs on MPAP. These VNICs can run on different spectrum bands (*e.g.* two ZigBee VNICs run on channel 12 and 14, respectively), but all can still communicate with the MPAP node seamlessly at the same time.

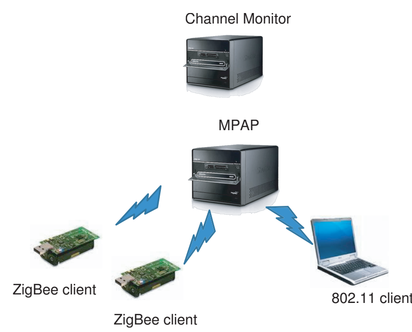

Figure 4: Demonstration setting.

We also run a spectrum monitoring tool to visualize the channel usage on a second Sora system. A graphic UI is displayed to show the spectrum occupation for both ZigBee and 802.11 as well as the non-contiguous OFDM used in a modified 802.11g client in real-time.

4. REFERENCES

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