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Embedded Wireless LAN Base-Band Processor for Ubiquitous Computing Systems

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Abstract – **We propose the ubiquitous computing processor, which contains IEEE802.11b wireless LAN for a communication channel. IEEE802.11b wireless LAN would play an important role in first generation of ubiquitous computing systems. In this paper, the hardwired IEEE802.11b wireless LAN base-band processor, which supports AMBA interface, was implemented and verified with verification environment. As the result of this verification, we demonstrated that implemented wireless base-band processor supports the IEEE802.11b standard. Also it shows that IEEE802.11b wireless LAN could play a role of the basic download channel in the proposed ubiquitous processor.**

I. Introduction

According to Mark Weiser's definition, ubiquitous computing is the paradigm of enhancing computer use by making many computers available throughout the physical environment, but making them effectively invisible to the user [1]. In other words, ubiquitous computing is that people can access and process data to process anytime, anywhere. In order to support anytime and anywhere access, the capability of stable communication is needed. It is very important requirements for ubiquitous computing systems, which is focused on a variety of network systems currently. Ubiquitous computing envisages everyday objects as being augmented with computation and communication capabilities. While such artifacts retain their original use and appearance, their augmentation can seamlessly enhance and extend their usage, opening up novel interaction patterns and applications [2].

The wireless LAN, IEEE802.11b supports the paradigm of spontaneous networking, wherein nodes can engage in communications without advance knowledge of each other. When it occurs the need of information exchange, wireless LAN tries to discover access points (APs) that are within communication range and prepare connection. In addition, IEEE802.11b wireless LAN is widespread in our workspaces, such as home, offices, campus of universities, airports and etc.. So, it is self-evident that wireless LAN would play an important role in the first generation ubiquitous computing systems.

II. Ubiquitous Computing Processor

In the past decade, the goal of ubiquitous computing has been pursued in a large number of prototypes. We believe that it is time to move from special-purpose on-of-a-kind systems to more widely deployable systems that scale to the global networks [3]. The proposed ubiquitous computing processor is based on the software defined radio (SDR) system. The SDR is evolving as flexible all-purpose radios that can support multiple modulation waveforms and multiple air interface standards or protocols through reconfiguring or reprogramming [4][5].

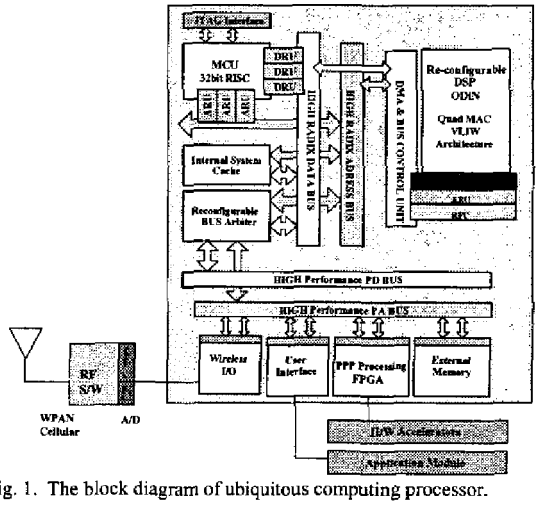

Fig. 1. The block diagram of ubiquitous computing processor.

The figure 1 shows the block diagram of the proposed ubiquitous computing processor. It contains 32-bit RISC ARM9 core for managing overall processor. The RISC core controls all peripherals such as the wireless LAN, the embedded hardware accelerators, and the communication channel with outside environments including the platform debugging channel. It also embeds the 32-bit high performance very long instruction word (VLIW) digital signal processor (DSP), named ODiN [6], which executes maximum six instructions in a single cycle simultaneously with highly orthogonal instruction set. In addition, the embedded Viterbi decoder and FFT processors make it possible to implement variety of communication standards needed in the ubiquitous network efficiently via software reprogramming. IEEE-802.11b wireless LAN base-band processor is embedded in order to establish the basic software download channel and to interface with other ubiquitous devices. This paper focuses on the embedded wireless LAN base-band processor with AMBA interface.

III. Wireless LAN

The WLAN base-band processor is separated into two main blocks, such as base-band transceiver and hardwired media access control (MAC), as shown in fig. 2. The complete structure of a transceiver consists of a data scrambler, header generator, modulator, pulse shape filter, interpolator, matched filter, equalizer, rake receiver, demodulator and descrambler.

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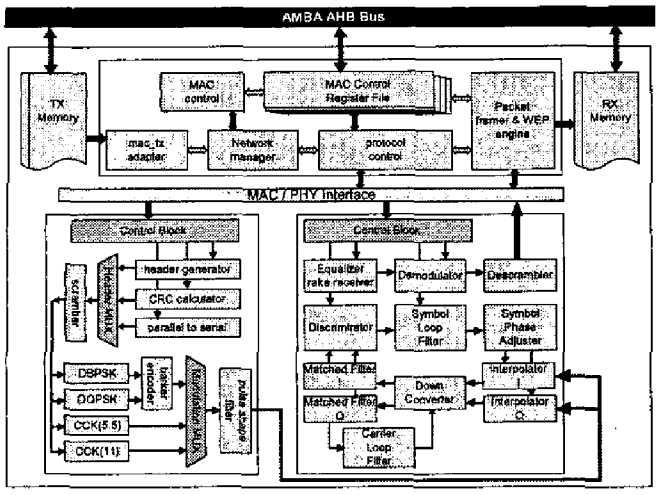

Fig. 2. The block diagram of wireless LAN IEEE802.11b base-band processor.

The hardwired MAC is fully implemented in digital logic. It fully supports IEEE802.11 standard without extra processing load of DSP or RISC processor. It consists of MAC controller, network manager, protocol controller, packet framer and WEP engine. It operates as a carrier sense multiple access with collision avoidance (CSMA/CA) on a various physical layers. So the hardwired MAC is easily applicable to wireless LAN applications, such as 802.11a, 802.11b and 802.11g. In addition, the adoption of AMBA interface makes it possible to reuse the wireless LAN base-band processor in a variety of system on a chip (SoC) application efficiently [7].

IV. Implementation and Verification

The wireless LAN base-band processor is verified on Altera's Excalibur. The verification system is the subset of proposed ubiquitous computing platform as shown in fig. 3. The base-band processor verification environment is consists of Excalibur, analog front-end, and RF module. The full wireless LAN base-band processor is ported in PLD inside of the Excalibur. In order to interface ARM9 core with the wireless LAN base-band processor, AMBA interface circuit was designed and applied to the wireless LAN base-band processor. The analog front-end board was implemented with D/A and A/D converters, which operate with 44MHz. The RF module is a monolithic, highly integrated CMOS radio transceiver, especially complying with IEEE802.11b wireless standard and designed to operate in the 2.4GHz ISM band [8].

Finally, the wireless LAN base-band processor is verified with verification environment through establishing the communication channel between the wireless LAN base-band processor and a commercially provided wireless LAN access point successfully.

Furthermore the wireless LAN base-band processor was synthesized with the 0.25μm standard cell static CMOS process library. The gate count of base-band transceiver is 134,915 gates and the gate count of hardwired MAC is 292,117 gates. The estimated die size of full wireless LAN base-band processor is about 1.63 mm^2 with embedded memory.

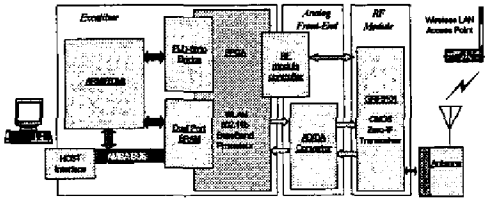

Fig. 3. The verification environment of the wireless LAN base-band processor.

V. Conclusion

In this paper, we proposed the ubiquitous computing processor, which contains IEEE802.11b wireless LAN for a communication channel. An embedded 32-bit RISC (ARM9) core controls all peripherals such as wireless LAN, embedded hardware accelerators, and communication with outside environments including the platform debugging channel. In addition, embedded six-way digital signal processor, ODiN, empowers the performance of proposed processor.

Especially, we described proposed processor focused on the hardwired IEEE802.11b wireless LAN base-band processor, which supports AMBA interface. The wireless LAN base-band processor was verified with verification environment through establishing the communication channel between implemented base-band processor and commercial wireless LAN access point. As the result of this verification, we demonstrated that implemented wireless base-band processor supports the IEEE802.11b standard. Also it shows that IEEE802.11b wireless LAN could play a role of the basic download channel in the proposed ubiquitous processor.

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