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Convergence in wireless transmission technology promises best of both worlds

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A heterogeneous network environment that harmoniously resolves differences between two key wireless technologies will offer advantages in terms of cost, efficiency, and capability.

Integrated standards for wireless networks promise a broad range of opportunities and exciting applications. Interoperability for microwave access (WiMAX) may eventually be expected to dominate wireless networking worldwide for decades to come. However, existing conditions do not permit communication between WiMAX and WiFi networks due to differences in frequency, protocol, and synchronization. To construct a heterogeneous network using WiFi and WiMAX devices, these differences must be resolved. WiMAX, the trade name for the IEEE 802.16 standard, is designed to meet requirements for the 'last mile' applications of wireless technology for broadband access, providing mobility, high bit rate, security, and long-distance coverage. Still evolving, 802.16 applies to a vast array of the spectrum, ranging from 2 to 66GHz, which at present includes both licensed and unlicensed (i.e., licence-exempt) bands.[1]

WiFi, the widely deployed predecessor technology, is inexpensive and readily available, with multiple vendors. But WiMAX offers better spectrum efficiency, data rate, and long-distance capability. The technology in its current form should complement the 802.11 (WiFi) standard. Its widespread adoption could diminish the number of WiFi users while enlarging the number of WiMAX users and 'hot spots.' The newer standard will help corporations and Internet service providers expand their services to rural and other neglected markets.[2]

A variety of ongoing research and development projects indicate the movement toward convergence. Intel is developing a chip that will receive and transmit both WiMAX and WiFi signals from a single die.[3] A system combining extensions of 802.11 and 802.16 has been shown to meet 4G requirements.[4] In addition, the emerging standard for media-independent handover services, 802.21, supports 'seamless' mobility between 802.11 and 802.16. Such mobility would integrate the two radio access technologies. Recent work suggests a likely system for 4G technology: 802.11 VHT + 802.16 m + 802.21.[5] In effect, convergence should combine the novel features of WiMAX and the low cost of WiFi.

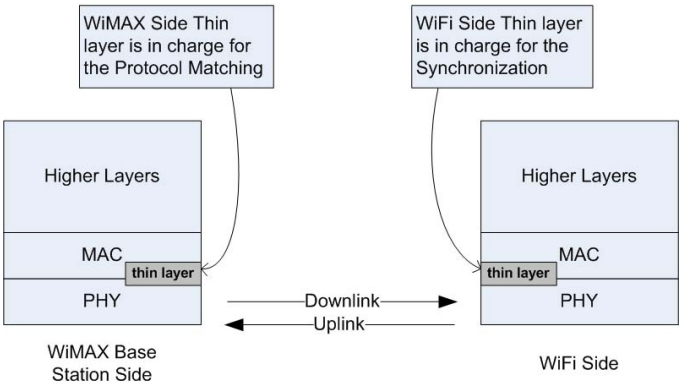

Figure 1. *Schematic illustration of the extra thin layers for synchronization and protocol matching with WiMAX and WiFi.*

With a view to creating a heterogeneous network environment, incongruities that separate the two technologies have already been investigated and resolved. In single-carrier standards, differences in frequencies, protocols, and synchronizations have been verified. Converting the carrier frequency of WiFi to that of WiMAX, the base station carrier frequency will be implemented as a physical (PHY)-layer modification, while protocol matching and synchronization will be implemented as a media access control (MAC)-layer modification.[6] The mechanism for convergence is based on matching the two standards by interposing an extra thin layer between the MAC and PHY

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layer in both standards without changing the standard itself (see Figure 1). The WiFi thin layer is in charge of the synchronization task, while the WiMAX thin layer takes care of the protocol matching (i.e., translator).

Currently we are developing the multicarrier aspects of convergence concerning orthogonal frequency-division multiplexing (OFDM): for WiMAX ($N_{fft} = 256$) and WiFi-OFDM ($N_{fft} = 64$).[7] The mismatch in the number samples (N_{fft}) cannot be resolved at the MAC layer, and we deal with it as a physical layer issue by creating a 'convergence bridge' similar to an extra thin layer to harmonize the mismatch.[7] Generally, any OFDM signal, $s(t)$, could be produced from the following equation[8] whether it is WiMAX or WiFi. This equation underpins the design of the proposed convergence bridge.

$$s(t) = Re\left\{ e^{j2\pi f_c t} \sum_{\substack{k=-N_{fft}/2 \\ k\neq 0}}^{N_{fft}/2} C_k . e^{j2\pi k\Delta f(t-T_g)} \right\} \quad (1)$$

In general, fundamental similarities make WiMAX-WiFi convergence possible while providing the prospect of new applications associated with wireless mesh architecture. Convergence is a cost-effective approach inasmuch as the various function blocks are not duplicated but reused. The ultimate objective is to enable WiFi nodes to join any WiMAX environment to create a heterogeneous wireless mesh network.

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Ali Al-Sherbaz, an electronics and communication engineer and PhD candidate, belongs to the wireless research group at the University of Buckingham. His main research areas are WiFi-WiMAX convergence with nanosecond MAC-level synchronization, field-programmable gate array support for OFDM bridges for mixed network standards, and network routing strategies using ad hoc mechanisms in a predominantly wireless environment.

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