FM-UWB and WiseMAC-HA for Medical BAN Applications

J. F. M. Gerrits, J. Rousselot, J. R. Farserotu, C. Hennemann, M. Hübner, J.-D. Decotignie

CSEM proposes an innovative dual-mode wireless communication solution addressing the conflicting requirements of medical body area networks. By letting devices switch between interoperable ultra low power and high availability modes, network performance is dynamically optimized for low latency, high throughput, low power consumption, robustness and coexistence.

New wireless technologies help open the door for future preventive healthcare, offering significant improvements in life quality. Medical body area networks (BAN) are expected to become a key element in the tomorrow medical IT infrastructure of tomorrow by enabling the long term collection and analysis of health parameters. The low transmit power of Ultra-wideband (UWB) communications systems offers several advantages in medical BAN applications: low specific absorption rate, low power consumption and facilitated coexistence with existing wireless communication systems.

The IEEE802.15 Task Group 6 (IEEE802.15.6) is currently developing a BAN communication standard[1]. CSEM has proposed a Frequency Modulation Ultra Wideband (FM-UWB) physical layer (PHY) together with a dual mode WiseMAC-HA Medium Access Control (MAC) layer for wearable medical BAN applications[2]. This ultra low power, yet robust PHY-MAC solution is ideal for low data rate (LDR) medical BAN operating at data rates of up to 250 kbps. Figure 1 illustrates how well FM-UWB meets the FCC spectral mask, with a steep roll-off yielding minimum interference in adjacent channels.

Prospective users would quickly abandon medical BAN technology if they have to frequently recharge the devices; ultra low power consumption is imperative. CSEM research effort in ultra low power (ULP) wireless sensor networks led to the development of the WiseMAC protocol. This protocol asynchronously duty-cycles the radio transceivers to save energy and performs opportunistic node synchronization to minimize signaling traffic. However, medical BANs are more likely than sensor networks to require high throughput connections and ultra low latency, at least intermittently.

To meet these additional requirements, CSEM has developed a dual-mode protocol, named WiseMAC-High Availability (HA)[3]. By allowing nodes to switch between the low power WiseMAC mode and a High Availability Carrier Sensing Multiple Access (CSMA) mode depending on the application requirements and the available energy, seemingly irreconcilable requirements are addressed. As these two modes are interoperable, the protocol is inherently robust to global state inconsistency problems. The backoff algorithm used for contention resolution is configured to optimize fairness, leading to graceful coexistence of independent networks. Additionally, dual-mode operation enables exploitation of the full capabilities of more powerful devices in the network, such as smart phones much better. Figure 2 illustrates two BAN networks composed of four sensors and one data collecting device each. In the first network, all communications are performed using the low power WiseMAC mode. In the second network, the data collecting device can be accessed by the sensors in High Availability mode for ultra low latency, while communications towards the sensors use the WiseMAC mode for ultra low power consumption.

The proposed low complexity FM-UWB-WiseMAC-HA solution offers the advantages of low power consumption, low latency, scalability and flexibility of the PHY and MAC, coexistence and robustness in BAN propagation environments.

Figure 1: FM-UWB technology features steep spectral roll-off, minimizing interference with adjacent channels and maximizing spectrum usage within the FCC limits

Figure 2: Possible network configurations for WiseMAC-HA

---

