IEEE 802.16/WiMAX Technology for Telemedicine Applications

ABSTRACT

Telemedicine services have typically been provided via use of wired networks and broadband access systems dependent on cable modems or DSLs for transfer of biomedical information among hospitals and points of care. These fixed systems, however, have inadequacies in service delivery to remote and mobile patients. But thanks to the popularity of emergent m-health applications in medical specialties, prompt and effectual patient care has become a reality. Plus, with evolving wireless technologies, patient access to health care is possible not only from hospitals; the access is also possible from rural homes and clinics. In this report, IEEE 802.16-based broadband wireless access is seen as a promising technology as regards provision of high data transfer-requiring wireless access and stringent QoS obligations (e.g. for usages in telemedicine) in indoor and outdoor settings. Furthermore, the advantage of combined Wi-Fi (802.11) and WiMAX networks in broadband wireless access makes integrated networks the obvious and viable alternative for applications in telemedicine. This, as seen in the report, is because an 802.11/802.16 hybrid network can generate a synergetic enhancement to telemedicine provisions on rates of data transfer, QoS provisioning and coverage to mobile end-users. Basically, this report explains the suitability of IEEE 802.16 criterion-based networks in telemedicine from certain perspectives.

Index terms— Broadband wireless access (BWA), IEEE 802.11, IEEE 802.16, quality of service (QoS), Wi-Fi, worldwide interoperability for microwave access (WiMAX).

1. INTRODUCTION

Telemedicine refers to the combination of wired and wireless medical data transfer wherein biological images, videos and signals are conveyed to remote locales for diagnostic purposes. It lessens the demands on healthcare staffs and offsets the physical distance between caregivers and (their) patients. Usage of mobile exchange in sending medical data has given rise to the term m-health, or “mobile computing, medical sensor, and communication technologies for healthcare” [1, p. 2]; m-health lowers infrastructure costs and is beneficial in provision of healthcare in short-staffed areas like rural hospitals, in trains, at home, in aeroplanes, and in ships. The operation of m-health is underpinned by four As, i.e. “Anytime, Anywhere Access with Always best connected features” [1, p. 2] that combine emergent wireless communications and network technologies, in turn facilitating healthcare delivery over the various infrastructures. Typically, systems for wireless telemedicine comprise medical gadgets that can be either worn or implanted, as well as wireless data exchange networks. Wireless networks are advantageous; they surmount “most geographical, temporal, and organizational barriers to the transfer of medical data and records” [2, p. 30]. In particular, telemedicine usages involve transmissions of huge

quantities of radiological images and medical data from (remote) patients to their doctors, and hence, real-time data transfer may be necessary, especially in cases of trauma. Here, broadband data transmission technologies are the *best* solution. Broadband wireless access, thanks to worldwide interoperability for microwave access (WiMAX) and Wi-Fi networks, makes these two technologies the obvious and viable option for telemedicine usages.

Wireless telemedicine has been an emergent specialty. Earlier wireless technologies' prohibitive costs and/or low bandwidth hindered enhanced telemedicine services. In recent years, the setting up of broadband wireless criterions such as WiMAX (IEEE 802.16) has facilitated the execution of telemedicine applications that, in the past, were only viable via cable links. The 802.16 criterion combines a number of superior radio (data) exchange technologies like FEC (adaptive forward error correction), OFDM, and AMC (adaptive modulation and coding), and is meant to deliver broadband wireless capability by use of a distinct QoS framework. Hence, it is a promising technology as regards provision of wireless services that require high-speed (Mbps) data transfer and rigorous conditions for QoS (e.g. telemedicine usages) in all environments (indoor & outdoor).

1. **SYSTEM DESCRIPTION**

WiMAX, which is 802.16 criterion-based, is a telecom technology intended to provide broadband wireless connectivity of data across long distances. It is designed to facilitate broadband (wireless) access to end-users (fixed and mobile) in a WMAN (wireless metropolitan area network) setting. For provision of flexibility for separate usages, 802.16 supports 2 key implementation situations: *Last-mile broadband wireless access* wherein "broadband wireless connectivity is provided to home and business users in a WMAN environment" [5, p. 73] – the basis being "on a point-to-multipoint single-hop transmission between a single base station (BS) and multiple subscriber stations (SSs)" [5, p. 73] and *backhaul networks* whereby "a WiMAX network works as a backhaul for cellular networks to transport data/voice traffic from the cellular edge to the core network (Internet) …" [5, p. 73] via interconnecting ("meshing") along 802.16 subscriber stations.

The technology's extended reach and high bandwidth render it appropriate for provision of a wireless "substitute" for "cable and DSL for last mile broadband access" [3, p. 2]. The worldwide interoperability for microwave access technology is capable of providing BWA (broadband wireless access) to as far as "30 miles … for fixed stations, and 3-10 miles (5-15km) for mobile stations" [3, p. 2]. Conversely, the Wi-Fi/802.11 WLAN criterion is, in most cases, restricted to between 30 and 100 metres. Also, WiMAX has a multiplicity of attributes that make its usage attractive when it comes to applications in telemedicine. The 802.16 criterion, unlike IEEE 802.11, can cover wider areas with rates of data transmission as high as "72 MBpsec in optimal conditions" [4, p. 250]. Moreover, the differentiated and potent QoS-strengthened platform that WiMAX adopts allows (for) management of several kinds of data "in conformance with specific telemedicine applications service demands, what is relatively limited for wireless E-health networks with WiFi-enabled access technology …" [4, p. 250]. As such, WiMAX appeals to rigorous e-health applied and PC system modelling customized for specific telemedicine situations.

III. STATE-OF-THE-ART

Zhang, Ansari and Tsunoda [2] describe an integrated network for provision of ubiquitous accessibility of audio-visual aid services and usages in telemedicine, considering the trends in mobile and wireless technologies; they have been advancing towards combination of diverse access networks in provision of

universal multimedia service availability (which telemedicine demands). As such, the authors argue that a cross network that is WLAN- and WiMAX-based is a powerful contender because the design of both technologies was intended for provision of ubiquitous affordable, high-speed rates of data transfer, service quality provisioning, and broadband wireless internet availability. To them, the combined network can lead to a synergetic enhancement to telemedicine applications in the areas of QoS provisioning, information transmission rates and coverage to mobile end-users. Specifically, they detail several futuristic scenarios that would maximize integrated wireless LAN and WiMAX networks for telemedicine applications. The advanced system suggested [2, p. 35] is further categorized into 5 sub-networks namely "body area networks (BANs), home care network/tele-homecare, intranet of a healthcare provider …, a network between the patient home and the healthcare provider, and a mobile telemedicine network for mobile patients and health service providers" [2, pp. 34-35]. In the sub-networks (scenarios), the authors justify the applicability of a telemedicine system based on the integrated network.

In [3], the authors propose an application of an IEEE 802.16-based combined e-medicine system in Macedonia. Enhanced telemedicine services – due to previous wireless technologies' prohibitive costs and low bandwidth – could not be effectively initiated. Considering that practical implementation of telemedicine is highly dependent on developments in computing and networking systems, the establishment of the 802.16 criterion came at an opportune time for telemedicine. Generally, [3] contends that "Wireless telemedicine is especially suitable for areas lacking proper cable connections or places where installing cable links is expensive … or simply impossible" [3, p. 1]. The choice of WiMAX for telemedicine in Macedonia owed to how "privileged" Macedonia is. A number of "state-wide backbone networks operated by various data communication providers …" [3, p. 2]. The suggested MIS (Medical Information System) incorporated all the typical considerations of a telemedicine service: knowledge, experience and expertise sharing, decision support, and multimedia services.

In [4], the authors describe an effectual method of video distribution that applies to surveillance and e-health and is enabled by 802.16 technologies. The authors sought to resolve the "ever-struggling challenge of optimal bandwidth allocation between competitive data-consuming applications in wireless communications" [4, p. 245]. In one example, the authors devised and tried out the global design for virtual 24-hour care "and consultancy of remote patients with heart-related abnormal functionality detected through ECG signal measurement" [4, p. 250]. The suggested solution would enable remote patients to consistently send electrocardiogram signals monitored on moveable wrist-worn gadgets via "the ZigBee/IEEE RF module to the responsible physicians through a WiMAX transceiver" [4, p. 251]. In the event that the patient has atypical symptoms, the physician is remotely able to observe the patient(s) using an application-run personal digital assistant or a wireless laptop via "activating the nearby IP surveillance camera via WiMAX connections" [4, p. 251]. The proposed solution's structure has four core sub-segments, especially: (i) an electrocardiogram transceiver fitted with a ZigBee module for transmitting electrocardiogram signals; (ii) an IP camera for patient video panning; (iii) a WiMAX AP (access point) to facilitate ECG signal and patient video delivery to the physician; and (iv) the physician's personal kit for viewing the panning video(s) and conducting data evaluation, "which supports medical consult-based services" [4, p. 251]. The 802.16-enabled telemedicine system, as the authors put it, proved satisfactory as regards "monitoring and consultancy services through wireless communication channels …" [4, p. 251]. 802.16-based technology (WiMAX) proved effective in prompt and easy transfer of data, video surveillance, and effectual collaboration between the patient and their physician.

In [5], Niyato, Hossain and Diamond hold that "IEEE 802.16-based broadband and mobile wireless access is expected to be a significant component in the next-generation … wireless systems" [5, p. 72]. Typically, telemedicine services are delivered via hooked-up networks, e.g. telephones, and digital subscriber line "or cable-modem-based broadband access systems" for transmission of biomedical information "between a hospital and the point of care" [5, p. 77]. The weaknesses of such fixed systems as regards service provision to remote patients plus "when the patients are mobile," coupled with the limited usages of conventional wireless telemedicine services because of reliance on 2nd- and 3rd-generation wireless network technologies for local and remote patient surveillance and diagnosis (hence data transfer speed and mobility constraints) led to the authors' suggestion for provision of telemedicine services enabled by 802.16/WiMAX-based broadband wireless access (BWA) technology. Furthermore, the authors deploy 802.16 in specific telemedicine service scenarios. For instance, they suggest use of WiMAX networks for communications between small clinics and healthcare centres. The justification: because clinical networks must facilitate multiple data types, e.g. images and biosignal information, with distinct QoS conditions, the WiMAX architecture's integrated QoS framework can enhance clinical networks' utility. Another scenario is their recommendation of 802.16 "for intra-hospital services" [5, p. 79], e.g. access to patient records. A few 802.16/WiMAX base stations, instead of deployment of numerous WLAN access points, can sufficiently cover the whole hospital, resulting in reduced operation and maintenance costs whilst providing "full mobility support for patients and medical staff" [5, p. 79].

In [6], the authors state the advantages of integrated WiFi/WiMAX networks in telemedicine applications over 2nd- and 3rd-generation wireless network-run telemedicine services – as seen in [5]. The authors explain what typical telemedicine usages entail: telemedicine applications (characteristically) involve transmission of significant quantities of medical data and radiological images from the patient's location to the physician's site, hence requiring real-time transmission of data, especially in instances of trauma. At that, broadband data exchange technologies are necessary. The benefits of hybrid 802.11/802.16 BWA networks render them the "obvious and feasible choice for telemedicine applications" [6, p. 123]. The authors compare IEEE 802.16 to 3 other kinds of wireless systems: satellite transmission systems, cellular networks, and WLANs. Satellite systems cover extensive areas and are the most flexible, but have prohibitive operational costs. Systems based on WLAN suit hospital intranet for telemedicine, but WLANs have coverage and mobility limitations. Cellular networks are appropriate for provision of mobile pre-hospital remedies, and although the networks "offer a reasonable compromise between the mobility requirement and the cost of the system, transmission speed may not be high enough for high-quality diagnostic video and still images" [6, p. 123]. Overall, a BWA network based on 802.16 trumps the aforementioned technologies. IEEE 802.16-based broadband wireless access technology is the most feasible in enabling telemedicine services in fixed and mobile settings owing to properties such as high bandwidth, incorporated services, security and QoS support (*advantages*, in other words) that are essential for wireless telemedicine provisions.

1. CONCLUSION

As seen in the analyses, in telemedicine, IEEE 802.16/WiMAX is the most preferred owing to its suitability in e-health; it satisfies the requirements of e-health, notably high rates of data transfer coupled with extended coverage, internet protocol compatibility with concomitant nearest network paths, management-by-priority with respect to different types of traffic and Quality of Service management, and mobility support. WLANs, as seen in the few e-health examples used by authors

earlier, are inadequate because of their limitations. At that, 802.16-based connections can do away with the obstacles by provision of broadband connectivity over the existing m-health networks for both fixed and mobile end-users in a WMAN setting. In other words, the properties of 802.16-based broadband wireless access, i.e. high bandwidth, incorporated services, security, and QoS support, render it the most feasible in telemedicine applications. Also, when employed in combination with 802.11/WLAN, the resultant hybrid network suits the provision of ubiquitous accessibility of audio-visual aid services and usages in telemedicine – owing to the advances in mobile and wireless technologies toward integrated networks for multimedia – because both technologies are designed to enable ubiquitous affordable, high-speed rates of data transfer, service quality provisioning, and broadband wireless internet availability.

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