“Recent trends in Mobile Communications & Computing”.

Conference Paper · April 2012

1 author:

M. Salim Beg
Aligarh Muslim University

Recent Trends in Mobile Communications & Computing

M. Salim Beg

Deptt. of Electronics Engg., Z. H. College of Engg. & Tech., AMU, Aligarh
salim.beg@amu.ac.in

ABSTRACT

There has been an unprecedented growth in the area mobile communications and computing industry during last few years. The success of wireless networks with rapid advances in the technology demands major research and development work not only in new theoretical concepts but also development of new practical sub-systems and components needed for this area. The technical requirements and expectations from mobile personal computing devices have considerably increased and hence major activities concentrating on design issues of such systems and networks have become the order of the day. This invited paper attempts to present a brief overview of some of the recent developments in the field of mobile communications & computing. In particular developments in WLANs such as IEEE 802.11 a/b/g/n, PANs based on Bluetooth/Zigbee have been dealt with. It also outlines some of the current research areas being looked into by the author as well as other researchers such as software radio, error resilient image/video coding for wireless channels.

I. INTRODUCTION

To be able to communicate and compute anywhere and anytime has been one of the goals of this industry since last decade or so which has been vigorously pursued. Due to the huge investments in R&D in the area of Mobile Communications and Wireless networks, both in the academia and the industry, there has been tremendous outcome in terms of new technologies being developed, as well as resulting products and services.

This paper attempts to present a brief overview of only some of the recent developments in this area such as evolution of cellular technologies, developments in wireless data networks (such as IEEE 802.11 a/b/g/n, Bluetooth/Zigbee, WiMAX, etc.), receiver signal processing for high bit rate systems, error resilient image/video coding for wireless channels, and new wireless technologies such as UWB & SDR. It also gives a sprinkling of some of the research carried out by the author as well as other researchers.

II. EVOLUTION OF MOBILE COMMUNICATIONS TECHNOLOGIES

Out of the various second-generation cellular systems, the GSM has emerged to be the most popular and most widely used standard and is first briefly summarized below, with a particular emphasis on its value-added data transmission aspects, and the use of high level modulation to provide enhanced data rates for GSM evolution. For voice-based services, although other technologies like CDMA and its variants have also evolved a lot during last decade or so, however they are not a subject of study in this paper.

Developments related to GSM:

The original version of GSM standard is often referred to as Phase I. Its worldwide popularity and acceptance led to its implementation in two additional frequency bands as well: 1800 MHz and 1900 MHz. Although speech is the main service, the support for data communication over the radio interface is being improved rapidly. Most of the previous GSM products generally provided data services with user bit rates up to 9.6 kbps. The next steps (phase 2 and 2+) in the evolution of GSM are coming up in the form of High Speed Circuit Switched Data (HSCSD) and General Packet Radio Services (GPRS). The imminent introduction of the new higher-bandwidth data standards for GSM, namely HSCSD and GPRS, will make even higher-speed access to Intranets possible. High bit rates are achieved with multi-slot operation, but since both HSCSD and GPRS are based on the original GMSK modulation, the increase of bit rates per time slot is moderate.

Although EDGE reuses GSM carrier bandwidth and time slot structure, it is by no means restricted from being used with other cellular systems [1]. Consequently, as the EDGE concept proved feasible and gained maturity, it was also evaluated and accepted within UWCC for IS-136 evolution. EDGE has been developed as an evolutionary path of existing systems towards higher data rates. One intention is to provide use of EDGE in existing GSM systems within the same frequency bands. Thus EDGE capable transceivers are either added, or replace conventional GSM transceivers, in a cell.

Parallel activities carried out by international standards bodies have led to the development of 3G mobile systems. The third generation systems (UMTS/IMT-2000) will be optimized for higher bit rate services. In brief, the bit rate requirements are 144 kbps for outdoor vehicular, 384 kbps for outdoor pedestrian or fixed, and 2 Mbps for fixed access in local areas (indoor) environments. An evolutionary path towards providing third generation services can be obtained by further development of the existing standards.

Choice of newer modulation methods:

In the current discussions on the modulation strategies for digital mobile radio systems, two approaches are there: (i) linear modulation techniques such as PSK, DPSK, QPSK, OQPSK and QAM and (ii) constant envelope or continuous phase modulation such as MSK and GMSK. Constant envelope modulation avoids the linearity requirements and this reduces the cost of amplifier components.

The disadvantage of these modulation techniques is that they may have a low spectral efficiency which does not always meet the requirements of emerging standards for digital mobile systems. Recently, therefore, attention has been focusing again on the use of linear modulation techniques.

Unfortunately, linear modulation schemes like QPSK, Offset-QPSK (OQPSK) and QAM require coherent demodulation. Also, because of their large phase variations ($\pm\pi/2$, $\pm\pi$), QPSK signals, when band-limited, have large envelope variations (up to 100%). As a result, when a band-limited QPSK signal passes through a non-linear amplifier operating at saturation, there is almost a total regeneration of the filtered side-lobes to their unfiltered levels (nearly 100% spectral spreading).

An alternative modulation scheme with smaller phase variation is OQPSK which has $\pm\pi/2$ phase variations. As a result, band-limited OQPSK signals have less envelope variation and hence, when they are transmitted through a nonlinear HPA, there is less spectral spreading than in the case of a band-limited QPSK signal.

OFDM is a special form of multi-carrier modulation and is particularly suitable for transmission over dispersive channels such as those found in wireless environments. With the help of Guard Interval (GI) between the OFDM symbols, OFDM WLAN system can combat impairments due to large multipath delay-spreads very effectively. OFDM symbols are cyclically extended and this cyclic prefix (CP) provides GI between adjacent OFDM symbols.

III. NEW STANDARDS FOR WIRELESS DATA NETWORKS

In contrast to the traditional cellular systems and networks which are primarily for voice based services and hence of lower bandwidth, the industry has also developed during last ten years or so wireless data networks which are meant for internet access, data and computer communication. This section presents a brief overview of Wireless LANs and Wireless Personal Area Networks (PANs).

Wireless LANs (WLANs):

IEEE 802.11 is the leading standard for wireless LAN WLAN. Based on the transmission technologies and operating spectrum, the later revisions of 802.11 can be classified into three main categories which are currently in use: 802.11a (OFDM, 5 GHz, 54 Mbps), 802.11b (HR/DSSS, 2.4 GHz, 11 Mbps), and 802.11g (OFDM, 2.4 GHz, 54 Mbps).

Another new standard in the form of 802.11n is coming up which will operate at roughly four times higher bit rates. Two basic concepts are employed in 802.11n to increase PHY data rates: MIMO and 40 MHz bandwidth channels. Increasing from a single spatial stream and one transmit antenna to four spatial streams and four antennas increase the data rate by a factor of four [2].

Wireless Personal Area Networks (WPANs):

PAN technologies operate at shorter distances. Bluetooth is a low cost, low power, short-range radio technology. It was originally developed as a cable replacement technology to connect devices such as mobile phone handsets, headsets and laptops. However new usage scenarios incorporating Bluetooth technology has extended this. The main advantages of Bluetooth can be related to its robustness, low complexity and capability to handle both data and voice transmission at the same time.

A lot of research groups, including that of the author [3-5], are active in developing new applications using Bluetooth. Since Bluetooth is constantly evolving, new profiles will be developed in the future. The development is driven by a group of major telecommunication and computer companies organized in the Special Interest Group (SIG) of Bluetooth.

Another WPAN standard is Zigbee (IEEE802.15.4). Although Bluetooth is a more dominant PAN standard compared to Zigbee, Zigbee intended to be cheaper than Bluetooth. Zigbee's lower power allows longer life with smaller batteries. Zigbee's lower cost allows it to be more useful in control, monitoring and sensor applications. Zigbee's mesh networking standard allows for higher reliability and larger range (compared to Bluetooth) and therefore the ZigBee technology is targeting the control applications industry, which does not require high data rates, but must have low power, low cost and ease of use (remote controls, home automation, etc.). Although it operates at lower bit rates compared to Bluetooth, Zigbee is now being used increasingly in Wireless Sensor networks (WSN) for implementing a wide range of applications [6].

Wireless Broadband & WiMAX:

For higher data rate wireless services over larger distances, wireless broadband services are being developed at a frantic pace. WiMAX will be to DSL & Cable Modem what Cellular was to land line phones. WiMAX is supported by IEEE 802.16 and its variants and provides fixed as well as mobile access. IEEE 802.20 is being developed to meet the unique requirements for supporting high-speed data services while at the same time supporting full user mobility [7]. It is a standard optimized to provide IP-based broadband wireless (Internet) access in a mobile environment. It has two modes of operation both of which are designed to support a full range of QoS attributes, making this technology suitable to support real-time streaming service as well as near-real-time data service.

IV. SOME RECENT RESEARCH

Although there are a lot of areas wherein important research work is being carried out relating to mobile communications and wireless networks, two of these areas of particular interest to the author are receiver signal processing for wideband mobile systems, and multimedia over wireless.

Receiver Signal Processing for Wideband Mobile Systems:

In order to accommodate new multimedia and internet application services, the transmission bit rate over such channels becomes extremely high. This often gives rise to frequency selective fading and the received signal contains appreciable amount of intersymbol interference (ISI).

Receiver signal processing for such wideband systems becomes extremely challenging because detectors find it difficult to cope with severe ISI and estimators often fail to track rapid changes in signal strength due to high speed mobility [8-11]. Although adaptive equalizers have been found to give modest performance only in certain conditions, they do not perform adequately in severely distorted and rapidly changing mobile channels [8, 11].

When the transmitted data symbols are statistically independent and are equally likely to have any of their possible values, the optimum detector is said to be that which performs a process of maximum-likelihood estimation of the transmitted sequence, also called Maximum Likelihood Detection (MLD). It has been shown that the maximum-likelihood detection of a distorted digital signal can, under certain conditions, be implemented by means of a recursive algorithm called the Viterbi algorithm. Although an implementable design, the Viterbi detector does have a large computational complexity which grows exponentially with the number of components in the sampled impulse response of the channel. Hence there has been a lot of interest in near-maximum-likelihood detectors (NMLD) which are relatively simpler to implement because of their reduced number of stored vectors coupled with smaller length of stored vectors. These have been thoroughly tested for various contemporary channels and exhibit good performance [8-9].

Multimedia over wireless

The above mentioned growth in the area of WLANs and WPANs and more recently WiMAX is putting pressure to provide multimedia delivery into our lives anytime, anywhere and on any device. Out of the various types of media, transmission of visual information (image and video) is more exciting and challenging. Video transmission and reception is however most difficult due to huge amount of data contained in it and limited bandwidth of wireless networks. Channel bandwidth is a valuable and limited resource, and so compression techniques for reducing the data rate are applied. However, a strong data dependency always occurs when the video is compressed. Any transmission error over a noisy wireless channel can disturb the decoding process, thus degrading the video quality [12-13].

Since around 1990, a number of international video coding standards have been developed such as H.261 (1990), M.PEG1 (1993), MPEG-2 (1994-95), H.263(1995-96), H.263+ (1997-98), MPEG-4 v1 (1998-99), MPEG-4 v3 (2001), H.264/AVC (2002) [12]. All the above standard video coders use block-based hybrid coding, wherein each video frame is divided into blocks of a fixed size called Macro-blocks (MB) and each MB is more or less coded independently using a combination of motion-compensated temporal prediction and transform coding.

MPEG-4 represents a different approach to video compression (compared to MPEG-1 and MPEG-2), in which concepts from image analysis, such as segmentation and model based compression, are used to improve coding efficiency. MPEG-4 has the provisions of interactivity between the user and the application, universal accessibility and high degree of compression. MPEG-4 also has option of using wavelet transform for Intra-frame coding. It uses the concept of object based coding.

Standard video codecs like H.263, MPEG-4 and H.264/AVC are based on motion compensation – discrete cosine transform (MC-DCT) coding scheme, which uses the *variable length codes* (VLC). However, the use of VLC in the erroneous compressed data would not allow even the non-corrupted parts to be correctly decoded until after the synchronization point, i.e. start of the following group of blocks (GOB) or slice. Moreover, due to loss of synchronization between the encoder and decoder states, the error may also propagate into the temporal domain. Due to these reasons, the emerging video coding techniques include provisions for error resilience particularly in H.263+, MPEG-4 and H.264/AVC. Although H.264 is based on hybrid video coding and similar in spirit to other standards such as MPEG-4, but it has new coding technologies: multimode and multi-reference MC, fine motion vector precision, B-frame prediction weighting, 4x4 integer transform, in-loop deblocking filter, uniform variable length coding, network abstraction layer (NAL) and so on. Because of these new coding technologies, H.264 has the best performance.

Many of the current and future wireless networks are likely to be heterogeneous, and compressed video may be routed through different networks having different characteristics. Some networks, such as Internet, have variable bit rate and cannot guarantee quality of service for real-time video applications. Transmission error causes bit errors or packet losses. These factors will impact the end-to-end performance and thus the design of video coding system.

Scalability in video coding is something which allows specific subsets of video bit-stream with different transport and presentation properties, e.g. different bit rates and different temporal and spatial characteristics. In the emerging video and multimedia applications, the most essential functionality requirements are resolution, temporal and quality scalability. The coding algorithms used in traditional video coding standards like H.263/4 and MPEG-1/2/4 are not inherently scalable in quality or resolution, but scalability is accomplished via layering approach, in which video is coded into a base layer and one or several enhancement layers. The base layer provides low resolution or low but acceptable quality and enhancement layers will incrementally improve the resolution or quality. One of the properties of the layered coding is that it creates bits of different importance, that can be transmitted over insecure mobile and Internet Protocol (IP) channels using unequal error protection. The philosophy is that the higher the number of layers, the lower is the degradation of image/video under channel constraints. However, standard codec provides such a layering that as the number of layers increases, the encoding efficiency decreases. On the other hand due to the hierarchical structure of sub-bands in the wavelet transform, the region of low magnitude coefficients increases with the number of decomposition levels. Thus the wavelet transform provides a better efficiency as the number of layers increases. Hence for video distribution over heterogeneous networks with various bottlenecks, such as IP, the wavelet based video coding is highly desirable. MPEG-4 coded video transmission over practical channels such as Bluetooth [3] and TETRA (Terrestrial Trunked Radio Access) [14-15] has been investigated and is of particular interest to the author.

V. FUTURE WIRELESS TECHNOLOGIES AND R&D TRENDS

This section gives a brief overview of technologies such as UWB, SDR and CR which are likely to advance rapidly in near future.

Ultra Wideband (UWB):

Ultra Wideband (UWB) is the transmission of a signal where the fractional bandwidth is greater than 0.25. UWB signals are not as affected by multi-path as narrowband signals, due to shorter pulse widths. It has high data rates. It has increased security (low probability of detection) due to low spectral power density. Signals transmitted below the noise floor can be recovered due to inherent processing gain. These signals will be invisible to narrow band users allowing for more efficient use of the spectrum. It has multi-path resolution leading to small object resolution. It allows Multiple User Access for a given portion of the spectrum. As far as its applications are concerned, UWB RADAR has been researched for some time as a method of defeating stealth aircraft and as electronic counter measures. Because of the bandwidth occupied by UWB RADAR, it is difficult to develop a system that can jam the RADAR or can effectively appear invisible to the RADAR.

Software Defined Radio (SDR) and Cognitive Radio (CR):

The primary goal of SDR is to replace as many analog components and hardwired digital VLSI devices of the transceiver as possible with programmable devices. The SDR forum stipulates that ideal SDR products must possess two fundamental features - flexibility towards operational standards and independence from carrier frequencies. IEEE 802.22 will be the first cognitive radio (CR) based international standard with tangible frequency bands for its operation. Standardization is at the core of the current and future success of CR. This standard specifies the air interface, including MAC and PHY layers, of fixed point-to-multipoint wireless regional area networks operating in the VHF/UHF TV broadcast bands between 54 MHz and 862 MHz [16].

VI. CONCLUSIONS

In this paper, the author has given a brief overview of some of the important developments in mobile communications and wireless network industry which is fast bringing about a revolution in the field of mobile computing. Evolution of some established mobile technologies like GSM and brief details of GPRS and EDGE have been presented. In contrast to the low-bandwidth voice services provided by GSM, the author has focused attention on wireless data networks which are meant for internet access, data and computer communication. WLAN technologies like IEEE 802.11 and its variants and WPAN like Bluetooth & Zigbee have been critically investigated. Although there are a lot of areas wherein important research work is being carried out relating to mobile communications and wireless networks, two of these areas of particular interest to the author are receiver signal processing for wideband mobile systems with particular emphasis on detection and estimation, and multimedia over wireless with particular emphasis on video delivery. Some recent work by author on compressed video transmission over Bluetooth and TETRA channels have been highlighted. A look at some future wireless technologies such as UWB, SDR and CR is presented. It is thus highly likely that in the near future a lot of new products and services related to this area will emerge.

REFERENCES

[1] M. Salim Beg, M. Y. Alias and S. Chandran, "Modulation Alternatives in Enhanced Data Rates for Global evolution (EDGE) of GSM", Proc. IEEE Malaysian Int. Conf. On Commun., Melaka, 17-19 November 1999, pp. 292-296.

[2] Eldad Perahia, "IEEE 802.11n Development: History, Process, and Technology", IEEE Communications Magazine, July 2008, pp. 48-55.

[3] H.C. Chong and M. Salim Beg, "Realising MPEG-4 video transmission over wireless Bluetooth link via HCI", IEEE Trans. on Consumer Electronics, vol. 49, November 2003, pp. 1028-1034.

[4] Priyanka Varshney, Nikhil Kumar, M. Rihan, M. Salim Beg, "Implementation of Bluetooth based smart home for assisting the physically disabled", Proceedings of papers & projects for Motorola Scholar Awards 2007-08, Foundation for Advancement of Education & Research, Bangalore, 21-22 July 2008, pp. 134-141.

[5] M. Salim Beg and M. F. Imteyaz, "Development of Wireless sensor networks using Bluetooth", Proc. National Conf. Advancement of Technologies – Global Scenario, Mathura, 25-26 Feb.2007, pp. 14-20.

[6] R. Shamim, M. Salim Beg, R. Muzammil, "Implementation of a Wireless sensor network for real-time Temperature Monitoring and Regulation", Proc. Nat. Conf. Advances in Wireless Cellular Telecommunications: Technologies & Services, New Delhi, 14-15 April 2011, pp. 112-118.

[7] Arnold Greenspan et. .al, "IEEE 802.20: Mobile Broadband Wireless Access for the Twenty-First Century", IEEE Communications Magazine, July 2008, pp. 56-63.

[8] M. Israil and M. Salim Beg, "Mitigation of ISI for next generation wireless channels in outdoor vehicular environments:, International Journal of Electronics, Communication & Computer Engg., France, Vol. 1, No. 3, 2009, pp. 150-155.

[9] M. Israil, M. Salim Beg, "Performance of some detectors for outdoor mobile channels with severe distortion", Mediterranean Journal of Electronics and Communications, United Kingdom, Vol. 5, No. 2, April 2009, pp 58-65.

[10] M. Bhat and M. Salim Beg, 'Computer simulation and modeling of high speed data transmission over mobile radio links', Journal of Institution of Engineers, Vol. 77, Sept. 1996, pp. 20-23.

[11] M. Salim Beg, S.C. Tan, H. Hamidi, "Performance of some Adaptive Equalizers in Mobile radio environments", Proc. International Symp. on Wireless Personal Multimedia Commun., Bangkok, 12-15 Nov. 2000, pp. 761-766.

[12] M. Salim Beg and E. Khan, "Video over Wireless Networks: A brief Review", Proc. 3rd International Conference on Communication System Software and Middleware, pp. 692-694, Bangalore, 5-10 January 2008 (Invited Paper).

[13] M. Etoh, T. Yoshimura, "Advances in wireless video delivery", IEEE Proc., Vol. 93, No. 1, pp. 111-122, Jan. 2005.

[14] Y.C. Chang and M. Salim Beg, "Video over TETRA employing MPEG-4 visual Coding standard", IEICE Transactions on Communications, Japan, vol. E87-B, No. 4, April 2004, pp. 990-998.

[15] Y.C. Chang, M. Salim Beg, and T.F. Tang, "Performance evaluation of MPEG-4 visual error resilient tools over a mobile channel", IEEE Trans. Consumer Electronics, vol. 49, Feb. 2003, pp. 6-13.

[16] Mathew Sherman et. al., "IEEE Standards supporting Cognitive Radio and networks, Dynamic Spectrum Access, and Coexistence", IEEE Communications Magazine, July 2008, pp. 72-79.