ABSTRACT

Wireless operators today are facing a dilemma. Customers are demanding more and more data applications to be delivered on the go. However, the operator is using scarce expensive licensed spectrum that is overburdened with delivering core voice services. Support for voice, data, location awareness, chat and other applications are required for customers that are very mobile. The operator is facing a choice of acquiring more licensed spectrum (if any is available) or losing customers due to demand for advanced services. xG Technology has a solution to this dilemma of overwhelming demand for advanced applications versus lack of spectrum.

xG Technology is developing an affordable mobile voice and data cellular system that operates in free unlicensed bands using what is known as cognitive radio technology. Using cognitive (i.e., smart) radios and advanced system and signal processing capabilities, the xG system makes unlicensed spectrum communications as reliable as licensed band communications. This is made possible by effectively mitigating the interference in the congested and chaotic unlicensed bands. Another advantage of xG's cognitive radio approach is the reduction of the RF engineering the operator needs to deploy and maintain the system. A third benefit of this system is the ability to reuse all the engineering going into smartphones, tablets and laptops today. The xG system is designed to support these devices through a physical or WiFi connection. Finally, the xG system is all-IP protocol based so that it can utilize COTS (commercial off-the-shelf) infrastructure components for network connectivity, standard applications and established management interfaces.

Introduction

xMax, as a physical layer technology, can be configured for use in wired and wireless products; designed for deployment at any frequency; configured for licensed and unlicensed spectrum, or in a spectrum sharing fashion. Importantly, it can improve range and battery life in such applications and uses the radio spectrum in a very power efficient manner. The original xMax system is a hybrid technology in the sense that it has aspects of both narrowband and wideband communication systems; it uses pulse position modulation (PPM) and ultra wideband communications (UWB), but also employs a narrowband carrier. The use of the carrier at the receiver basically eliminates the difficult synchronization and search problems inherent with PPM and UWB systems.

Low-cost mobile voice and broadband data services, xG Technology, Inc. has developed an innovative wireless communication system (aka "xMax") that is capable of delivering mobile voice over IP (VoIP) and broadband data services in the 902-928 MHz unlicensed band. From a business model perspective xG Technology is targeting this scalable radio access network (RAN) solution towards new-entrant service provider partners, such as cable companies, competitive local exchange carriers (CLECs), satellite companies, foreign incumbent local exchange carriers, etc. that may be seeking to deliver mobile VoIP/data services to the market on a nationwide or selected market basis.

The inclusion of voice capability in addition to broadband data in the xMax RAN solution is a critical differentiation that will be emphasized throughout this white paper. This is because despite the media fascination with the iPhone™ and other smartphones and despite the increasing demand for mobile broadband data services, mobile voice remains and will continue to remain the major revenue earner for mobile operators. Note the following market facts:

The GSM Association estimates that of the 4B mobile users worldwide, roughly 90% are voice only users

Thus we see that despite the hype, mobile broadband data revenues are less than 20% of that of mobile voice. Even using bullish industry assumptions for mobile broadband data growth, it is likely to take 9-10 years before mobile broadband data revenues are on parity with mobile voice revenues.

Overview of xMax

xMax is a mobile voice and data solution from xG Technology that has been designed to address the issues raised above and more. In particular, it was designed with the following requirements in mind:

1. Leverages COTS end user devices including 3G and 4G smart phones, tablets and net books without requiring licensed commercial frequencies.

2. Dynamic Spectrum Access (DSA) and advanced interference mitigation to increase operational and deployment flexibility.

3. Full cognitive networking capabilities including dynamic access and optimization of available spectrum resources, as well as self-Radio Frequency (RF) planning and self-organizing.

4. A single end-to-end IP network architecture supporting mobile voice, wideband data, real time video, chat and other apps.

xMax Working

Take the energy issue first. xMax uses a modulation technique designed to allow more data to be transmitted on a single sine waves than is required with typical modulation technologies. So instead of using more than 100,000 sine waves to transmit one bit of data, xMax uses a ratio closer to 1:1. This technique would therefore be more efficient and keep energy levels very low, which would mean devices that receive the signals wouldn't consume much power. To solve the distance problem, xMax uses frequency channels in the sub-gigahertz range, which can penetrate obstacles such as walls or trees. But channels below 1GHz are very narrow, which means it is difficult to pack large amounts of data into them. xMax fulfills the need for a radio technology that According to the inventor Joseph Bobier "xMax's unique signal profile is a perfect fit for low frequency channels that have previously been unsuitable for wireless broadband." The technology will benefit rural ISPs due to the lower number of base stations required. xMax, because it has 20 times the range of Bluetooth, could challenge that technology. Other possibilities are enterprise WLANs and metropolitan networks. Nowadays it is used for VoIP (Voice over Internet Protocol).

Network Structure

In order to meet the objective of providing low-cost mobile voice and broadband data services the xMax carrier class cognitive radio solution has been developed around commonly used and open Internet protocols including IP, RTP, UDP and IP. In addition, it was designed to operate in both unlicensed spectrum, such as the 902-928 MHz ISM band, and licensed spectrum.

As a result of these design considerations, xMax includes responsive opportunistic-use technology based on "Identify And Utilize (IAU) techniques capable of combating in-band interference encountered in the unlicensed spectrum, and extends the SIP and RTP protocols to the wireless domain.

Among VoIP signaling protocols, SIP is regarded as very bandwidth-inefficient from a signaling overhead standpoint. In fact, SIP signaling can consume up to 400% of the VoIP payload bandwidth, an unacceptable figure for mobile networks.
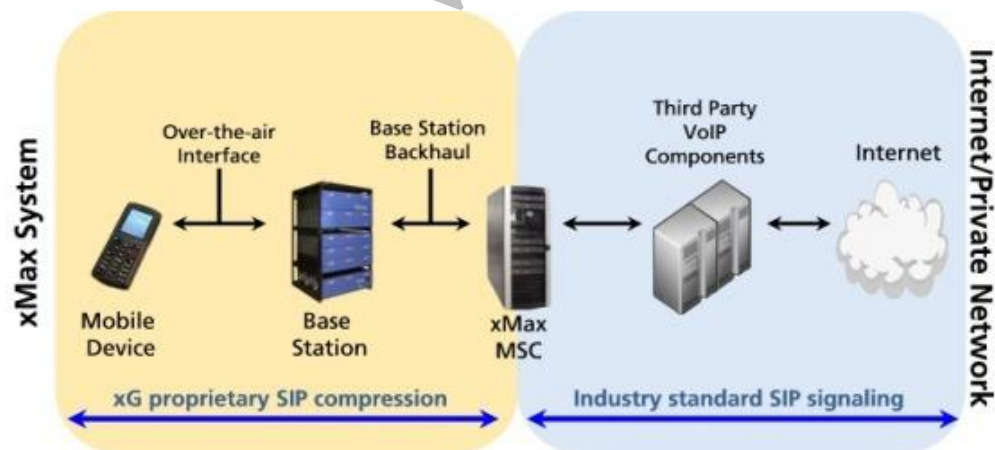
To increase the efficiency of SIP signaling, yet maintain 100% standards compatibility with external VoIP systems and soft switches, xG has created patent pending SIP compression technology for the xMax system that reduces SIP overhead bandwidth from 400% to 66% on the over the air links and backhaul links from the Base Stations to the xMax MSCs. The MSCs do the SIP compression and decompression to maintain 100% interoperability

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with third-party VoIP systems. This also has the benefit of making more bandwidth available for mobile data applications being carried alongside voice traffic.

Network Architecture

The primary consideration in the network architecture design of the xMax system is to achieve the goal of providing robust, scalable, and full-featured voice and data services to mobile subscribers at a fraction of the cost of traditional approaches. A reference model form of the resulting Internet Protocol (IP) centric network architecture is shown in Figure 2.
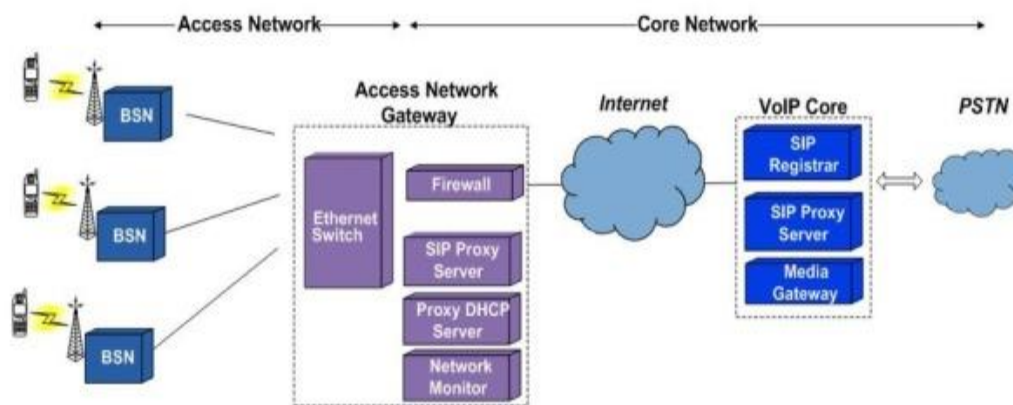

Figure 2: xMax Network Architecture Reference Model

As the diagram indicates, the network architecture includes the following elements:

- Air-interface designed for operation in unlicensed as well as licensed bands.
- Base station (BSN), which provides radio to network access to handsets. The xMax base station is a three sector, 18 channel mobile VOIP transceiver device. The BSN channelizes the 902-928 MHz band into 18 discrete channels, which are only used when there is traffic to mobile devices that are registered with a particular channel.

- Access Network Gateway (ANG), called the xMSC in an xMax network that provides call process, IP packet delivery services and several other IP, mobility and network signaling related functions.
- Technology agnostic back-haul links from BSN sites and the ANG (Fiber, Metro Ethernet, PTP Wireless, etc.).

While the BSN is conventional in both architecture and functionality, the ANG (xMSC) is a novel piece of wireless infrastructure equipment that consists of 100% off-the-shelf hardware with proprietary software developed by xG:

- Ethernet Switch which aggregates BSN links.
- Firewall which provides private to public network address translation (NAT) services.
- SIP Proxy Server which supports SIP call control, xG's SIP message compression technology, and E911 services.
- Proxy DHCP Server which is used for IP address services.
- Network Monitor (xMonitor) software which is responsible for end-to-end network management and monitoring services.

Among the unique characteristics of the xMax network architecture is the way mobility is implemented. The system provides soft handoffs with make-before-break capability (timeslots are acquired before breaking a connection), which result in reliable roaming and a seamless user experience. This is demonstrated further in rhe ability of the system to perform inter-technology handoff (xMax to WiFi). With all handoff decisions made at the handset level via proactive channel scanning, there is no need for inter-base station communication, which helps drive seamless operation.

The architecture further supports low-cost service deployment objectives by leveraging commercial off the shelf (COTS) voice over IP (VoIP) equipment, software and services, shown as VoIP core in Figure 3. The VoIP core contains the following elements:

- SIP Proxy Server which provides traditional SIP call control services.
- Media Gateway – which provides media transcoding between IP and PSTN networks and is responsible for subscriber accounting/billing, PSTN call termination, "Direct Inward Dialing" (DID) phone number maintenance, voicemail services, and inter-network call signal routing, among others.
- The VoIP core can be owned and operated by the xMax operator, or can be provided as a third party service.

The xMax mobile cellular solution leverages a standard cellular
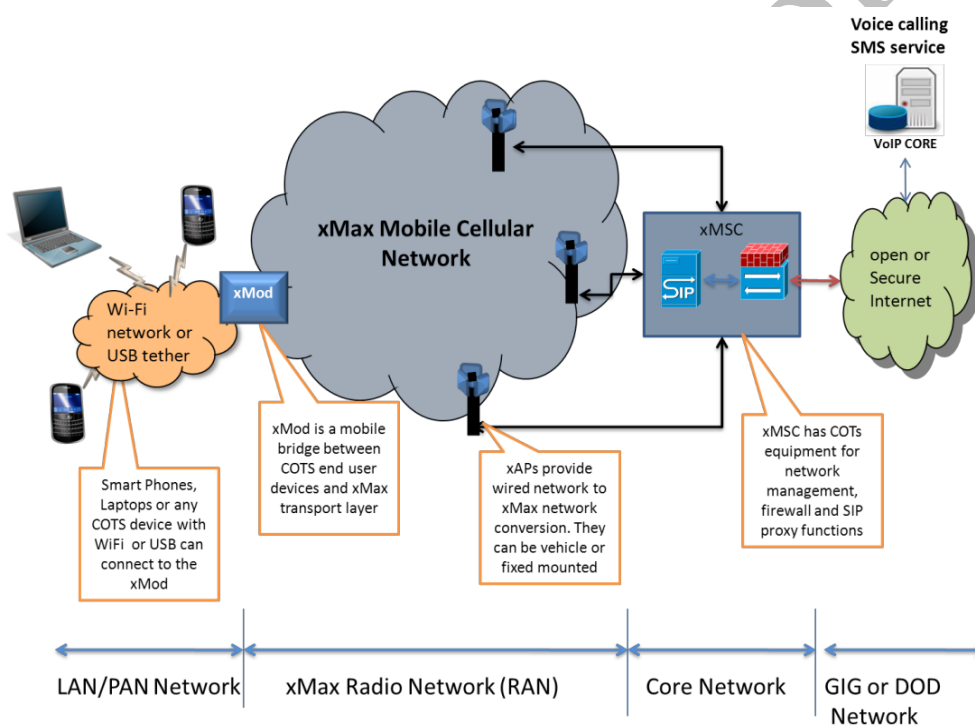

Figure 3 – xMax Mobile Cellular Network

architecture – with some notable enhancements. The following (next pages) are the major components of the system:

1. xMod

The xMod is a small battery or vehicle-powered radio that bridges the COTS end user device to the wideband transport layer of the xMax system. Devices may be physically tethered or connected via secure WiFi links to the xMod. The xMod can deliver up to 3.5Mbps to the connected end user device(s) under real world conditions
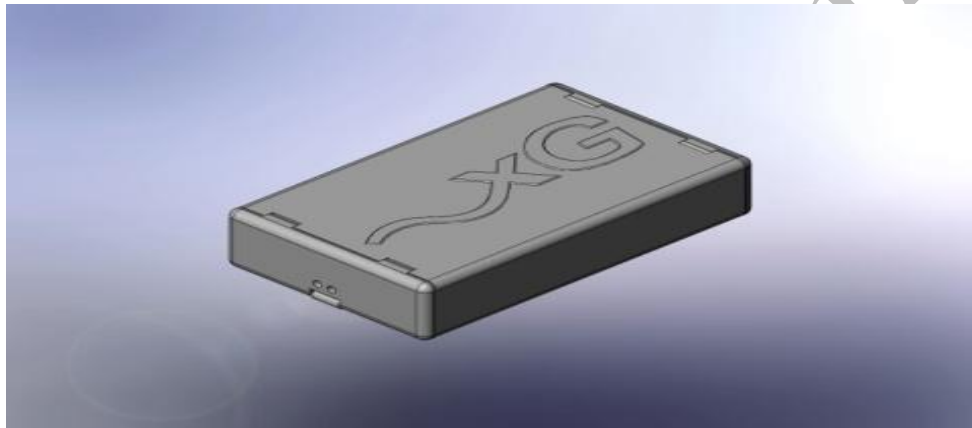

fig.4 : Xmod

Summary

The xMax cognitive radio cellular system from xG Technology represents a complete, scalable mobile wideband solution that is capable of supporting a wide range of smartphones, tablets, netbooks and other end-user devices. The coverage and capacity of the network can be tailored to the market and business model at hand and can be rapidly reconfigured to support new or expanded applications or territories.

The system has been deployed and demonstrated in disparate settings including a military environment at Fort Bliss and at rural cellular operator sites in Florida and Arkansas. This flexibility to serve disparate markets stems from the xG Technology affordable and rapidly deployable all-IP architecture.

While xMax incorporates several state-of-the-art and proprietary technologies such as dynamic spectrum access and multi-spatial interference mitigation, it also leverages COTS end user devices including 3G and 4G

Smartphones, tablets, netbooks, etc. These advanced features increase operational and deployment flexibility while also improving the utilization of scarce spectrum resources. xMax's cognitive networking technology is frequency agnostic and can be adapted to a wide array of TV white spaces, unlicensed and licensed frequency bands.

The xMax system's cognitive networking capability allows it to dynamically access and optimize available spectrum resources, while also enabling it to optimize its own RF plan. Future software releases will enable an automatically self-organizing network (SON) in direct support of xMax's operation as a mobile ad hoc network (MANET and MESH).

Finally, its end-to-end IP network architecture supports mobile voice, wideband data, real time video, chat and other apps over a single integrated network, unlike typical 3G and 4G networks that require separate voice and data network equipment and transport layers.

For all these reasons, operators seeking to enter the mobile business either domestically or internationally will find that xMax represents a practical and attractive technical solution.

Conclusion

This "xMax" Seminar Helps us to understand the basic concept of xMax Network Structure and it'applications, About the cognitive radio. The seminar also introduces the new Technology i.e. xMax Patented technology, it's Specification and Applications.

References

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