Microwave Industry Outlook—Microwaves for Telecommunication Systems

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Invited Paper

***Abstract*—This paper addresses future directions of microwave technology in telecommunication systems. Terrestrial mobile and fixed wireless access and transmission systems and satellite systems are discussed.**

***Index Terms*—Fixed wireless access, mobile cellular systems, satellite telecommunications, telecommunications industry, third-generation cellular.**

I. Introduction

THIS paper addresses future directions of microwave technology in telecommunication systems. The primary applications for microwave equipment in these future systems are in wireless access for fixed and mobile terrestrial networks, satellite system up/down links, and wireless local area networks (LANs). Fiber-optic transmission systems are dominant today and will continue in the future as the primary long-haul media in public telecommunication networks. Point-to-point line-of-sight microwave transmission will continue to be utilized in some private and industrial systems and will play a minor role in back-haul applications in cellular systems and in areas where fiber systems may be difficult and costly to install.

The summer of 2001 is a particularly difficult time to be addressing the future of the telecommunications area since the industry, after a half decade of unprecedented growth, is in the midst of a very serious economic crisis in which many newly formed companies have entered bankruptcy and many of the old-line standard bearers of the industry have encountered huge losses and have had to cut back very significantly to stay afloat. As a result, there has been a significant retrenchment and major layoffs in the industry. Many of the economic pundits anticipate a recovery in the year 2002; however, the emerging economy will be much closer to classical growth levels and the business will hopefully be based on more substantive grounds than those of the "irrational exuberance" times of the late 1990s where overvalued acquisitions and mergers and the reckless financing by manufacturers of equipment purchases for new competitive local exchange carriers and Internet companies, which were unable to meet obligations on the loans, led to an industry debt level of $650 billion, the major contributor to the current crisis.

In spite of the uncertainty in the market place today, it is clear that telecommunications will continue to be a major factor in the worldwide economy and the way society and businesses function in the future.

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II. Future Directions in Terrestrial Wireless Telecommunications

Wireless access in current mobile cellular systems has provided the opportunity for individuals to have voice and limited data communications at any time and from nearly any place. In the future, the convergence of the Internet and wireless will lead to many new and exciting broad-band services that will significantly impact our personal and business activities. Fixed wireless access systems also have a very promising future and have the potential of providing broad-band services with low infrastructure costs and rapid deployment.

Near-term efforts on mobile cellular systems will involve the introduction of the third-generation (3G) digital cellular system with data rates of 144 kb/s to vehicular subscribers and 384 kb/s to pedestrian subscribers, accurate location of mobile subscribers, improved quality of service, and higher voice quality than today's systems. At least two different wide-band CDMA approaches will be used for access. Services and applications will include mobile computing, high-speed Internet access, in-vehicle real-time traffic data and optimum route selection, fleet and individual location information, email, videoconferencing, video games, music downloading, remote monitoring, and initiation of control actions on home appliances and equipment connected to LANs or Bluetooth networks, low-tier service for wireless access to the home, common cordless and mobile handsets, and yet to be invented new services. The 3G fixed-access operation will permit data rates of 2 Mb/s. Smart antennas and adaptive coding and equalization will permit improved non line-of-sight operation. Japan and Europe will introduce 3G systems in the very near future and the U.S. will be at least two years later. Europe has had auctions of spectrum in the 2-GHz band for 3G systems, but the U.S. is still in the midst of deciding which bands will be made available for 3G service. Competition for the U.S. spectrum in the 700-MHz–2-GHz range is between government users, UHF TV broadcasters, and wireless carriers. Fourth-generation (4G) and higher generation systems will be aimed at even higher data rates and quality of service and availability equivalent to the wired telephone systems of today. When these goals are achieved, the mobile handset will be the primary handset of subscribers and the wired handsets will be phased out. The 4G and higher systems will use packet switching for both voice and data. It is unlikely that a uniform global standard for cellular telecommunications services will be reached in the foreseeable future. The different spectrum assignments, CDMA access approaches, and other feature differences will be solidly imbedded in the developing infrastructures and will be too costly to change. However, cost-effective software-defined handsets may become available that will permit global roaming.

Fixed wireless access systems have the potential for providing broad-band services to subscribers using competitive local exchange carriers, business subscribers, and subscribers in remote locations and developing nations where access with physical connectivity would require substantial investment in infrastructure costs. The major applications to date of fixed wireless access have been for business applications and a residential market has yet to develop. The major carriers providing this service encountered severe financial problems in 2001 and are currently undergoing bankruptcy reorganization. Systems in the U.S. provided 1.5–45-Mb/s service at 24-GHz LMDS band (28–31 GHz), as well as duplex service in the 2.5–2.7-GHz MMDS bands. Both point-to-point and point-to-multipoint distribution has been used.

There is excellent potential for broad-band fixed wireless access in the future despite the difficult start although there are a number of challenges to address. The future services will include the unlicensed 5-GHz band, as well as the regulated bands listed above. Additional spectrum at much higher frequencies in the 55- and 95-GHz bands for very short links will also be used. Point-to-multipoint system architectures using cellular configurations, as well as mesh architectures, will find wide applicability. Data rates will be extended to more than 600 Mb/s. Software-defined radios using adaptive architectures defined in the radio setup modes will allow selective modulation systems based on system performance objectives. Schemes to permit high-quality operation in high multipath environments and with nonline-of-sight propagation will be utilized. The lower frequencies will usually be favored, but there will be growing acceptance of higher frequency operation. The initial customers for this service will continue to be the business users, but as the price drops in the future, there will be residential subscribers for this alternate access service. The standards for operation of broad-band fixed wireless access systems are currently being developed by the IEEE 802.16 Standards Committee.

The challenges that must be addressed are spectrum availability, particularly in the lower frequency bands, simple installation of subscriber terminals and antennas that require little or no engineering assistance during installation, cost effective terminals, access to roof tops and building structures for office and apartment complexes and finally operating techniques and user etiquette for the unlicensed frequency bands. Competition will continue with fiber optic systems, as well as free space optical access systems.

III. Future Directions in Satellite Telecommunication Systems

Various satellite systems were proposed and built during the 1990s to provide global mobile and fixed personal communications. To date, none of these systems has proven to be an economic or technical success. The growth of cellular wireless networks globally will obviate the need for satellite systems to provide personal communication services. Satellite systems will, however, continue to be used for navigation and location, for highway, marine, and airborne transportation systems, as well as for communications to ships and planes. The digital direct broadcast satellite for entertainment video and radio has been a significant success and will continue to be used well into the future. In addition, satellites will be used in global private networks and for some transoceanic routes not covered by fiber-optic cables. The broad-band fixed satellite services of the future will address multimedia and Internet service. A challenge that must be addressed in the new generation of satellite networks is the ability to handle both circuit-switched and bursty TCP/IP Internet traffic. High data-rate satellites operating in the 20–30-GHz bands will utilize multiple high-gain spot-beam antennas, on-board processing and switching, adaptive power control, and adaptive coding technologies. Digital broadcasting will be primarily in the 12- and 17-GHz bands.

IV. Requirements for Future Engineers

The profile of telecommunications engineers in the future will not be much different than it is today. The field requires a broad range of engineers to work on communication, microwave, digital, digital signal processing (DSP), antennas and propagation, integrated circuits (ICs), and software technologies.

V. Conclusion

The future opportunities for mobile and fixed wireless cellular systems, digital-broadcast satellite, and multimedia private and special-purpose satellite systems is very bright. However, there are challenges that must be considered and addressed before the full potential can be realized. These challenges include regulatory and political issues, social issues unique to different parts of the world, market acceptance of the new services, and security. Examples of the social issues is the tradeoff between privacy and accuracy of location in mobile systems. In some societies, the “big brother” syndrome of location accuracy may be socially unacceptable. Biological keys may be used to insure that the approved user is operating the handset, but solid encryption is also needed to prevent identification and data theft of the propagating radio signals by various scanners. Indeed, the social and human challenges may be even more difficult than the technical challenges.

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During the 1960s, he was engaged in research on microwave tubes and solid-state devices and led the activities on microwave integrated circuits at RCA Laboratories. He joined Collins Radio, which was acquired by Rockwell International in 1973, and led the development of microwave analog and digital radio, fiber-optics transmission systems, and multiplex and transmission support products. He retired in 1988 as Vice President, Engineering and Advanced Technology, Rockwell Telecommunications. He then joined The University of Texas at Arlington, as Associate Dean for Research and a Professor of electrical engineering. He retired from full-time activities at The University of Texas at Arlington in 1993, but still serves part time and consults with industry.

Dr. Sobol is a Fellow of the Radio Club of America. He was president of the IEEE Microwave Theory and Techniques Society (IEEE MTT-S), served on the Board of Governors of the IEEE Communication Society, and is currently awards chairman of the Communication Society. He also served on the IEEE Fellow Committee for four years. He has been a member of the Technical Program Committee of the IEEE MTT-S Symposium for over 25 years. Sobol has been general chair of the Solid-State Circuits Conference, the Electronic Components Conference, and the Communication Society Globecom. He has been the recipient of numerous awards, including the IEEE Centennial and Millennium Medals, the IEEE MTT-S Microwave Career Award, and the Distinguished Service Award. He was also the 1970 IEEE MTT-S National Lecturer and received the IEEE Dallas Section Outstanding Engineer Award, an Industrial Research IR-100 Award, and the Distinguished Service to Engineering Award presented by The University of Texas at Arlington.