Preface

Wireless multimedia networks

Quite soon, wireless multimedia communications will no longer be a novelty, but will be an integral part of our lives. New designs and strategies must be generated to get the most out of the wireless environment. The wireless industry and the academic community must work together to produce timely and compatible equipment that can be operated while carried between regions and networks. Standards organizations must also ensure that systems intended for global access are interoperable. Finally, governments across the globe must ensure security for the individual user and the region alike, while fostering healthy global expansion.

Wireless network

Wireless networks are a class of networks that use infrared or radio channels as the transmission medium. Wireless networks offer great promise as an enabling technology for applications like personal and indoor communications, automation and mobile computing.

We can classify the growth of the wireless networks into three ages. *First generation* analog voice wireless networks have sprung up worldwide; *second generation* digital voice/data networks are under development; and some networks have been deployed or are undergoing trials. *Third generation* networks are designed to carry multimedia traffic ultimately. With the advent of GSM (Groupe Special Mobile) there is a popular belief that mobile computer communications will become easier, cheaper and better.

It is clear, from the present-day developments, that these wireless networks of the future will be required to interface with much higher bandwidth fiber-based wired networks, possibly carrying B-ISDN ATM-type traffic. The interfacing of the lower bandwidth, often hostile, wireless radio medium with much cleaner fiber networks itself poses interesting problems that need to be resolved.

Multimedia applications over wireless networks

There are limitless possibilities for multimedia applications over wireless networks. While potential applications exist in commerce, education, medicine, government, public safety, and numerous other areas, market and social forces will determine which are accepted or rejected. Systems and protocols are designed and implemented to support specific applications, and this principle should be actively employed in the wireless mobile networking arena.

Multimedia service requirements

A multimedia environment, presently, consists of applications accessing pagers, facsimile, answering machines, telephone lines, speech synthesis, and digital recording and playback. Its key contributions are the integration of multiple media into a cohesive nomadic information infrastructure and a graceful transition from desktop to nomadic locals. This integration is at the service and user interface levels.

A typical distributed multimedia environment, in which multiple, remotely located users participate in a joint work or design project demand for:

- *resource sharing* to integrate information on a more global basis, preserve investments, and ensure the use of a system's available information;

- *multimedia data integration* such as images, graphics, sound, text, and structured data, to present information in a more immediate and understandable form;

- *local intelligence and autonomy* to perform tasks independent of centralized systems;

- *graphical interfaces* to reduce training costs and assist occasional and inexperienced users; and

- *vendor independence* to achieve freedom from any specific hardware vendor.

Problems in multimedia wireless networks

The salient features of multimedia wireless networks environment may be described as the '3M' environment: real-time multimedia, Multihop and Mobile (We use mobile and wireless as synonyms throughout). In the past, there have been studies and implementations of systems that combined any two of these 'M's, but not all the three.

A well-known wireless communication problem is the reception of the same transmission at multiple bases. The problem is apparent with the infrared network, where a zone may have a number of bases. Now, add to this the fact that the mobile users would typically be moving in a lower bandwidth, error-prone environment where fading problems are quite common.

The other problems in the area of wireless communication have tended to focus either on physical layer issues such as CDMA versus TDMA and multiaccess protocols for the wireless environment, or on higher layer control issues such as call handoff, hierarchical cell design, and dynamic allocation of channels among cells for multimedia communications environment. A major problem arises in the control when the wireless networks have to carry multimedia traffic, or interface with much higher-speed wired networks designed to carry such traffic.

Besides these, sophisticated management techniques are required for handling:

- *Location management:* It should be possible for users to retain their assigned addresses, so that a connection continues to work even after temporary disconnection and reconnection, and access to network-based resources and services should appear similar regardless of where the user accesses the resource from. Multiparty connections between any combination of mobile or fixed users should also be possible. Location management works at several layers and is, therefore, a complex process.

- *Resource management*

  Support for quality of service (QoS): It is universally agreed that a richer set of QoS levels is needed to allow emerging applications to use these networks. In particular, multimedia applications, which exchange data, voice, images, and video, make exacting demands on the QoS delivered by a network.

  Multicast: This is expected to assume an important role in wireless mobile networks, especially in support of multimedia transmission. In particular, multicast is essential for many collaborative systems, in which information is usually disseminated from a source to several destinations, allowing for node mobility and by using low-bandwidth, unreliable wireless links.

- *Energy management:* The core issue which surfaces in energy-constrained systems is that more efficient power usage translates directly to better performance. Multidimensional tradeoffs between energy usage and various performance criteria exist. One may choose to burn power to decrease latency, increase throughput, achieve a higher level of QoS support or some combination thereof.

Solutions

Next generation wireless networks are expected to provide solutions to most of the wireless problems. These require a completely different network design, centered around a packet-switched architecture and a new set of power and bandwidth allocation algorithms.

The most prominent characteristic of these future wireless mobile networks which differentiates them from fixed wireline networks is the requirement to share a limited spectral bandwidth while coping with the contention and mutual cochannel interference resulting from a large and variable number of randomly located and perhaps mobile users with diverse service and traffic requirements all trying to communicate with a relatively small number of access points to a fixed wireline backbone network. Furthermore, the wireless communication links themselves can generally be described as time-varying frequency-selective fading multipath channels. The topology, link performance and QoS delivered to user applications in this communications environment is characterized as highly time-varying. The following are some works reported in designing reliable wireless multimedia communication systems and networks that provide efficient bandwidth and power performance in such environments.

Architecture and services

- **Infrastructureless or ad hoc networks** are designed for use in areas where there might not be permanent signal coverage. These are networks in which the transmission range of a node is limited and the topology of the network is dynamic, so that multihop communication is necessary for nodes to communicate with each other.

- **Network programmability**, usually limited to end-user nodes, is being pushed into the core of the network. Programmable switches and base stations enhance the flexibility and intelligence of the network by allowing a richer collection of algorithms to reside inside the network.

- **Wireless access architectures** are used principally as a means of access to resources that reside primarily in the wired network. The wireless access network has evolved over time, including analog and digital cellular telephone networks, wireless local area networks (WLANs), mobile data services, personal communications network (PCN), global system of mobile telecommunications (GSM), future public land mobile telecommunications system (FPLMTS), cellular digital packet data (CDPD), metropolitan wireless services, cordless-telephone systems, satellite systems, and millimeter-wave systems.

- **Security**, indeed, even for data confidentiality needs the localization of encryption to a single protocol layer to be reconsidered for wireless and mobile networks. Sophisticated algorithms are being developed for *authentication, encryption, anonymity, untraceability,* and *intrusion and fraud detection.*

Broadband wireless multimedia communication

A few broadband wireless multimedia communication systems have been designed using *TDMA technologies*. These are classified into the adaptive radio resource management technology, including dynamic channel assignment (DCA) and slow adaptive modulation techniques; adaptive receiver technologies, including adaptive equalizer and adaptive array antenna; and adaptive radio transmission technologies, including transmission power control, fast adaptive modulation, and adaptive zone configuration techniques.

Now *CDMA technologies* are emerging as champions for broadband wireless multimedia communications. Spread spectrum(SS) is well known as a key to avoid multipaths and interfering signals and must be a major candidate for submillimeter- and millimeter-wave transmissions. However, SS has been thought to be only for low- or medium-bit-rate transmissions like kilo-bit/s in some cellular systems and megabit/s transmissions in ISM bands, since it requires much wider radio bandwidth than data bandwidth.

Software radios

The software radio architecture centers on the use of wideband A/D and D/A converters as close to the antenna as possible, with as much as radio functionality as possible defined in software. Software-definable channel modulations at wide bandwidths across an entire 25 MHz cellular band have been developed.

Considerable work is to be done before the full benefits of software radio technology are widely available. Open architecture standards for communications are well established, but they are relatively embryonic open architecture standards for high-performance, real-time, digital signal processing used in software.

Multitier networks

Multitier wireless access could be enabled by intelligence that supports the interconnection of a variety of wireless networks. Advances in technology are likely to support multimode terminals.

By using multiple wireless access modes that are optimized for different types of venues, multitier wireless access should be able to achieve high performance with low cost and usage rates that approach those of wireline services.

Wireless ATM

Portable broadband wireless access in the future will support mobility through ATM-based networks for broadband services, such as online multimedia information databases to provide news, entertainment, and educational services. Information and personal communication services through portable wireless access are likely to be desired in a variety of venues, such as offices, residential areas, and vehicles in the near future. While early deployment of emerging wireless access technologies is expected to be based on narrowband networks, the introduction of broadband networks and wireless integration can be expected to become increasingly important.

Integrated wireless/satellite system

In an integrated wireless/satellite system for mobile communication, a satellite subsystem cooperates with a terrestrial wireless network for providing user services. The problems addressed here are:

(i). to determine the feasible degree of reuse in the satellite subsystem, and

(ii). to outline techniques that assure good cooperation between satellite and wireless subsystems.

Ongoing research in wireless multimedia networks

The research community faces formidable technical challenges in designing reliable wireless communication systems and networks that provide efficient bandwidth and power performance in such environments. Nine broad areas of research priorities include the following:

- **Basic research in communication systems:** information theory, bandwidth-efficient modulation and coding, video and audio compression, and joint source/channel coding.

- **Signal processing and physical layer issues:** smart antennas, development of physical and link layers, signal propagation, and channel modeling

- **Protocols:** multiple access, wireless and mobile protocols, multimedia transport protocols, and adaptive protocols

- **Tools:** measurement and experimentation, simulation, and planning tools

- **Upper layers:** mobile middleware and mobile applications

- **Mobility:** location management, mobility management, and incorporating position information

- **Resource management:** support for quality of service, network resource allocation, multicast, and energy efficiency

- **Architectures and services:** infrastructureless networks, network programmability, and wireless access architectures

- **Security:** authentication, encryption, anonymity, and intrusion detection

These topics are not exhaustive, and one expects that other topics will come to the forefront as the field develops given the important distinguishing characteristics of the wireless environment, the mobile nature of tetherless users, and the influence these attributes have on the design and operating characteristics of wireless multimedia communication systems and networks.

Some of the developments in the wireless multimedia networks are highlighted in the special issues of the *Journal of the Indian Institute of Science* in two parts. Most of the areas in the networks are covered in this attempt. We thank all the authors who participated in these special issues by contributing papers.

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