Performance Analysis of Video Streaming in WiMedia

by

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بسم الله الرحمن الرحيم

Certificate of Approval

It is certified that we have read the project report submitted by **Muhammad Asif [03-FET/MSTE/F-04]** and **Usman Asif [10-FET/MSTE/F-04]**. It is our judgment that this report is of sufficient standard to warrant its acceptance by the International Islamic University, Islamabad for degree of MS Electronic Engineering (MSEE).

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Dedication

We dedicated this research project to our beloved Parents, Family members, respected Teachers and sincere Friends

Project in Brief

Project Title:	**Performance Analysis of Video Streaming in WiMedia**
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Completion Date:	…………...
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Operating System:	Linux Fedora Core
System Used:	Pentium III (797 MHz Genuine Intel) RAM 256 MB HD 40 GB

Declaration

We hereby declare that this research and simulation, neither as a whole nor as a part thereof, has been copied out from any source. It is further declared that we have developed this research, simulation and the accompanied report entirely on the basis of my personal effort made under the guidance of our supervisor and teachers.

If any part of this report to be copied or found to be reported, we shall standby the consequences. No portion of this work presented in this report has been submitted in support of any application for any other degree or qualification of this or any other university or institute of learning.

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Acknowledgement

At very first, we bestow all praises, acclamation and appreciation to Almighty Allah, the most merciful and compassionate. The most Gracious and Beneficent, Whose bounteous blessings enable us to pursue and perceive higher ideals of life, All praises for His Holy Prophet Muhammad (SAW) Who enabled us to recognize our Lord and creator and brought to us a real source of knowledge from Allah, The Quran, Who is roal model for us in every aspect of life. Secondly we must mention that it was mainly due to our family's moral and financial support during our entire academic career that enabled us to complete our work dedicatedly. We would like to thanks to our teacher's and especially consider it a proud privileged to express our gratitude and deep sense of obligation to our reverend supervisors Mr. Raza Hassan Abedi for their dexterous guidance and kind behavior during the project. We also would like to admit to our truly friends that cooperate us in very difficulty. We once again would like to admit that we owe all our achievement to our most loving parents who mean most to is, for their prayers are more precious them any treasure on earth.

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Abstract

Recent advancements in wireless technology have enabled a wide range of conveniences for end users. The need for wireless connectivity has extended well beyond the business world and has entered the consumer market, which in itself has brought new challenging demands to current devices and technology. The increased popularity of wireless personal area networks (WPANs) (i.e. utilization of Bluetooth in consumer homes is a precursor to the demands of the future wireless digital home. Soon there will be a demand for PCs, MP3 players/recorders, HDTVs, digital cameras, set-top boxes, cell phones, PDAs, and other digital equipment to have the ability to connect to each other wirelessly without losing quality of service. "However, today's wireless LAN and WPAN technologies cannot meet the needs of tomorrow's connectivity of such a host of emerging electronic devices that require high bandwidth".

Ultra-wideband (UWB) technology has emerged as a cost effective (in terms of power consumption and manufacturing costs), and reliable alternative to traditional wireless technologies in the area of short to medium range networks. "UWB technology will enable wireless connectivity with consistent high data rates across multiple devices and PCs within the digital home and the office". Traditional wireless systems such as WiFi and Bluetooth are not optimized to handle the bandwidth demands of high definition video and audio streams that have become popular in today's digital home. Even though 802.11g/a networks can reach data rates of 54Mbps (108Mbps for future 802.11n devices), using this technology has a relatively high power consumption which is not conducive to certain consumer electronics. UWB will be able to provide the high bandwidth requirements for multiple emerging high quality video and audio devices and applications, while consuming very little power and maintaining a low manufacturing cost.

WiMedia is the standard radio platform for Ultra Wide Band (UWB) wireless networking. Ultra-Wideband (UWB) is a technology anticipated to dominate the home networking market and eventually provide carriers with an inexpensive LAN alterative. It offers very high data rates, low power consumption, less expensive cost. UWB provides 100 times the data speeds of Bluetooth solution, allowing transmission of large amounts of data i.e. video files between TVs or PCs as well as enabling high quality video applications for portable devices. The objective of this thesis is to study Quality of Service of Video traffic using WiMedia and study of UWB technology. Performance metrics we have chosen are Delay, Throughput and packet loss.

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CHAPTER NO 1

INTRODUCTION AND MOTIVATION

Introduction and Motivation

Introduction

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UWB designed to replace cables with short-range, wireless connections, but it offers much higher bandwidth needed to support huge amounts of data streams at very low power levels. Examples include media players, monitors, cameras, and cell phones. A recent technology demonstration showed a UWB device transmitted at a data rate of 110Mbit/sec. at a range of up to 10 meters. [5]

The primary advantages of UWB are high data rates, low cost, and low power. Because UWB is spectrum hopping, and only for a tiny fraction of a second, UWB causes less interference than narrowband radio designs, nearby neighbors will not interfere with other UWB networks. An additional UWB feature, precise ranging, or distance measurement used for location identification, i.e. tracking persons. UWB uses very little power with long battery life. For the security issue, it is extremely hard to eavesdrop. It is like trying to track someone in a very busy street who continually changes different colors of clothes while running at extreme fast speed. [12]

1.1 Motivation

Recently, ultra wideband (UWB) research has globally reached a big boost up, For example, in Europe there are several ongoing UWB related projects funded by the European Commission. The goal of this thesis is to study Quality of Service of Video traffic over Wimedia and study of UWB technology. The work has been completed both via simulations in network simulator 2.29 and theoretically. The model we used for multimedia application is MPEG4, developed by Ashraf Matrawy, Ioannis Lambadaris and Changcheng Huang. It is targeted for low bit rates. It allows real images to co-exist with computer-generated counterparts, also allows their separation and their receiving different treatment due to interaction with the user. The main feature of importance to the network is MPEG4's capability of real-time adaptive encoding. This enhances network utilization and enables MPEG4 senders to be more responsive to changes in network conditions. It generates video in three different frame types P, B, and I that serve to encode different portions of the video signal in different levels of quality.

CHAPTER NO 2

LITERATURE SURVEY

Literature Survey

In [1] MBOA, "Multiband OFDM Physical Layer Proposal for IEEE Task Group 3a," Sept. 2004 Author work, to study that the Wimedia physical (PHY) layer specifications have already been distributed to MBOA-SIG members who are building products. The organization is also financing the MBOA-SIGs medium access control (MAC) layer specification and development on application profiles for UPnP/IP, the Wimedia convergence architecture (WiMGA) and the Wimedia network protocol adaptation (WiNet) layer are continuing. Also extremely important is the task of interoperability and certification.

In [2] WiMedia MAC Draft Spec. 0.96, "Distributed Medium Access Control (MAC) for Wireless Networks," July 2005, Author mention that entity will often be referred to as WiMedia-MBOA but will officially operate as the Wimedia Alliance, Inc. The merged group is designed to take advantage of the strengths of both groups to drive the standardization and adoption of Wimedia UWB.

In [3] R. Fisher et al., "DS-UWB physical layer submission to 802.15 task group 3a," July 2004, this thesis details the implementation of Wimedia physical layer for performance analysis which follows the standard proposal IEEE 802.15.3a in a straightforward manner. The base band system consists of a data scrambler, a convolution encoder and punctures, a bit interleave, a constellation mapper, and an IFFT. These components completely described. Since Wimedia UWB transmission technology is the future technology, which promises to fulfill the demand of high transmission data rates, understanding the architecture of the system is important. The implementation helps us to achieve it.

In [4] A. Batra et al., "Multi-band OFDM physical layer proposal for IEEE 802.15 task group 3a," March 2004, Author describes that the UWB wireless system makes use of very large bandwidths operating at very low levels and is regarded as an underlay technology that can exist underneath licensed services.

In [5] "IEEE 802.15: Working group for wireless personal area networks (WPANs)." Author work, to study that the traditionally wireless services have resided within narrow frequency allocations that are licensed out by the local regulatory body.

This provides licensed radio services with exclusive use of the frequency allocated to them with known levels of in-band and out of band interference.

In [6] ATIS, "Atis telecom glossary 2000." The industry has endorsed WiMedia & the WiMedia Alliance is undertaking the development of a UWB-based system specification with participation from more than 170 companies. Promoter companies include: Aleron, HP, Intel, Kodak, Nokia, Pliilips, Samsung,Sharp, Staccato Communications, Texas Instruments and Wisiiir In the near term, other companies are expected to be added to this list as well.

In [7] "Mobile Web Service Communication over UDP" Author describe that the Web Service based Middleware for mobile applications is a promising platform to accelerate the application development for mobile systems. Currently, the Web Service protocol stack is using by default the Simple Object Access Protocol (SOAP) on top of HTTP. Since HTTP is using TCP, the round-trip time of a Web Service call in mobile networks is high due to the connection establishment of TCP (three-way handshake) and the congestion and error control mechanisms (slow-start phase). Some applications do not require delivery guarantees of TCP. For these applications an unreliable transport of SOAP messages over the User Datagram Protocol (UDP) is a natural choice. If an application needs a reliable transport of SOAP messages, a lightweight ARQ mechanism on top of UDP is the better choice than using HTTP over a mobile link. The session management of HTTP substituted by introducing Web Services Addressing properties within the SOAP header. This paper will present the architecture and the realization of an unreliable and reliable UDP SOAP binding for a Mobile Web Service based middleware, which consumes Web Services (client) and provides Web Services (server). Both bindings will map two basic MEP to UDP services. The reliable binding encapsulates a Selective-Repeat (explicit request) ARQ protocol on top of UDP, which ensures even the transmission of SOAP messages over several datagram. Some use cases and examples motivate the work and stress the importance according to the mobile middleware. A comparison of method invocation latencies of the reliable UDP binding and the HTTP binding illustrate the performance enhancements.

In [8] "An Overlay Networking Solution for Media Delivery in Future Mobile Networks " The principle of end-to-end network-layer communication is reaching its limits in today's networks in terms of multimedia service provision, especially for multi-user services. This paper describes a concept for media delivery in future mobile networks that uses service-specific overlay networks and media processing nodes in order to optimize media delivery to heterogeneous devices, and to enable discovery and composition of processing nodes. A prototype implementation presented in order to demonstrate the validity of the proposed concept.

In [9] "An Architecture for Wireless Simulation in NS-2 Applied to Impulse-Radio Ultra-Wide Band Networks" Authors present architecture for implementing a wireless physical layer in a packet-based network simulator. They integrate this architecture in the popular ns-2 network simulator and use it to implement an impulse-radio ultra-wide band (IRUWB) physical layer. Contrary to the current wireless physical layer implementation of ns-2, in our case a packet fully received by our physical layer before delivered to the MAC layer. A packet detection and timing acquisition model been implemented. Furthermore, for each packet, a packet error rate (PER) be computed as a function of the received power, interference from concurrent transmissions, and thermal noise. This architecture is quite generic and allows for the simulation of any physical layer where an accurate model of interference is of high importance, e.g., IR-UWB or CDMA. Our implementation for IR-UWB takes into account transmissions with different time-hopping sequences (THS). The underlying modulation is binary phase shift keying (BPSK), followed by a variable rate channel code. Our implementation is the first available that allows for the simulation of IR-UWB networks. It is modular and can thus be easily modified and extended.

In [10] "Low Complexity Low Data Rate UWB Devices Architecture and Performance Comparison" in this work the performance of low data rate Ultra-Wideband (UWB) devices is studied. The most important design constraint is low complexity and low power consumption. Four different architectures of different complexity built in a modular approach from functional blocks. The trade-offs of these architectures between performance and complexity shown.

In [11] "Interoperation Concept for Impulse Low Data Rate and MB OFDM High Data Rate UWB Systems " The Author providing the concept of interoperation on PHY level between impulse based UWB Systems and MB-OFDM UWB Systems is proposed.

Approach investigated and verified by simulations. The changes required for interoperation on hardware architecture for both systems are small. The participation of the HDR (MB-OFDM) devices in LDR (Impulse based) network is transparent and there is no need for LDR devices to change the operation modes. The possibility for communication on distances of up to 10m with speed of 100kb/s proved. The high data rate system (HDR) based on Multiband OFDM system and impulse low data rate (LDR) UWB system may be able to communicate having proposed PHY level alignments. This requires specific parameter set up for LDR devices, which may be feasible because LDR UWB devices are currently in final stage of standardization in IEEE 802.15.4a.

In [12] "MAC Protocols for Ultra-Wide-Band (UWB) Wireless Networks: Impact of Channel Acquisition Time " Author presents that the upcoming Ultra-wide-band (UWB) radio technology holds great promise for revolutionizing wireless communications. UWB radios transmit using precise, very short (e.g. picoseconds) impulses spread over a very large bandwidth (up to a few GHz). The significant advantages of this technology are low-power operation, mitigated multi-path fading effects, high bit-rates and unique precise position/timing location ability. However, one of the drawbacks of this technology, in its current state, is the high channel acquisition time, i.e. the time for a transmitter and receiver to achieve bit synchronization. This tends to be quite high, of the order of a few milli-seconds. Hence, it is important for current medium access control (MAC) protocol design to consider the impact of acquisition time. In this paper, author describe the performance of two standard MAC protocols - the distributed CSMA/CA protocol and the centralized TDM protocol in the context of UWB wireless local area networks. Author mention the effects of varying packet frame sizes and packet arrival rates and present a quantification of the impact of acquisition time on overall performance.

CHAPTER NO 3

WiMedia (UWB) COMMUNICATIONS TECHNOLOGY

WiMedia (UWB) Communication Technology

Background

Traditional business models of mobile communications, ones that used in the current vertical and closed communications markets, will challenged in the near future. New unregulated band wireless broadband networks will begin to complement existing and next generation cellular networks and fixed networks in forming a technologically heterogeneous networking environment. In this environment IP connectivity will be available everywhere, only the underlying technology and connection speeds vary. Multimode terminals needed in order to establish a network connection, radio interface of which will select according to the location of a moving user and the particular service to use. In addition to multimode terminals and heterogeneous IP networking, the need for local very high data rate wireless products is also emerging. Internet-based streaming video services and high definition wireless video connections within the home are an essential ingredient of the next phase of digital revolution. Ultra Wideband (UWB) impulse radio technology will play a prominent role in enabling these services and products with its very high speed, low cost and low power consumption. [10]

It used as a highly reliable communications method because the signal is spread out over so much radio spectrum that it is almost impossible to completely jam the signal. Developers today are developing UWB solutions for consumer electronics devices to provide wired bandwidths wirelessly, at reasonable size, cost and power. This requires a complex combination of highly technical skills in radio, OFDM modulation and high frequency operation. [3]

3.1- Introduction

Wimedia is the standard radio platform for Ultra Wide Band (UWB) wireless networking. The standard incorporates Medium Access Control (MAC) and physical (PHY) layer specifications based on Multi Band Orthogonal Frequency Division Multiplexing (MBOFDM) technique. It offers solution to enable data rates up to 480 Mbps with lower power consumption. The platform also optimized for Wireless Personal Area Network (WPAN) technology such as Bluetooth 3.0, Wireless Universal Serial Bus (USB). The standard utilizes the unlicensed 3.1 to 10.6 GHz UWB and divides the spectrum into

14 bands each with bandwidth of 528 MHz. At the physical layer, power, modulation and other parameters can be dynamically adapted to changing channel conditions. By this way, the c hannel can utilized more efficiently. WiMedia refers to t he ultra-wideband (UWB) common radio platform that enables high-speed (480Mbps and beyond), low power consumption multimedia data transfers in a wireless personal area network (WPAN). [1]

WiMedia is the de-facto standard radio platform for ultra-wideband (UWB) wireless networking. With efficient power consumption and high data rates, the Bluetooth SIG and the USB Implementers Forum as the foundation radio of their high-speed wireless specifications for use in next generation consumer electronics, mobile and computer applications h ave s elected WiMedia U WB. O ver 2 00 i nternational m ember c orporations and research institutions support the non-profit WiMedia Alliance, developing specifications, certification tests, and educational programs.

Ultra-wideband technology has the inherent capability to optimize wireless connectivity between multimedia devices within a WPAN. The WiMedia UWB common radio platform is unique in that no other existing wireless standard can fulfill the market's stringent requirements such as low cost, low power consumption, small-form factor, high bandwidth and multimedia QoS support. The WiMedia UWB common radio platform presents numerous technical advantages that clearly make it the best UWB solution. For instance, the Alliance's scheduling medium-access technique offers the industry's only viable solution to operating different wireless applications in the same network-thereby providing consumers with a choice.

Non-technical advantages of WiMedia UWB largely related to the Alliance's membership composition. The world's leading CE (Customer Equipment), PC (Personal Computer) and mobile device companies actively support the WiMedia UWB platform, exemplifying its importance and position in the industry. Together with leading semiconductor, software, component and test companies, the member companies and member organizations form the complete ecosystem necessary to build and deliver the UWB market. [1]

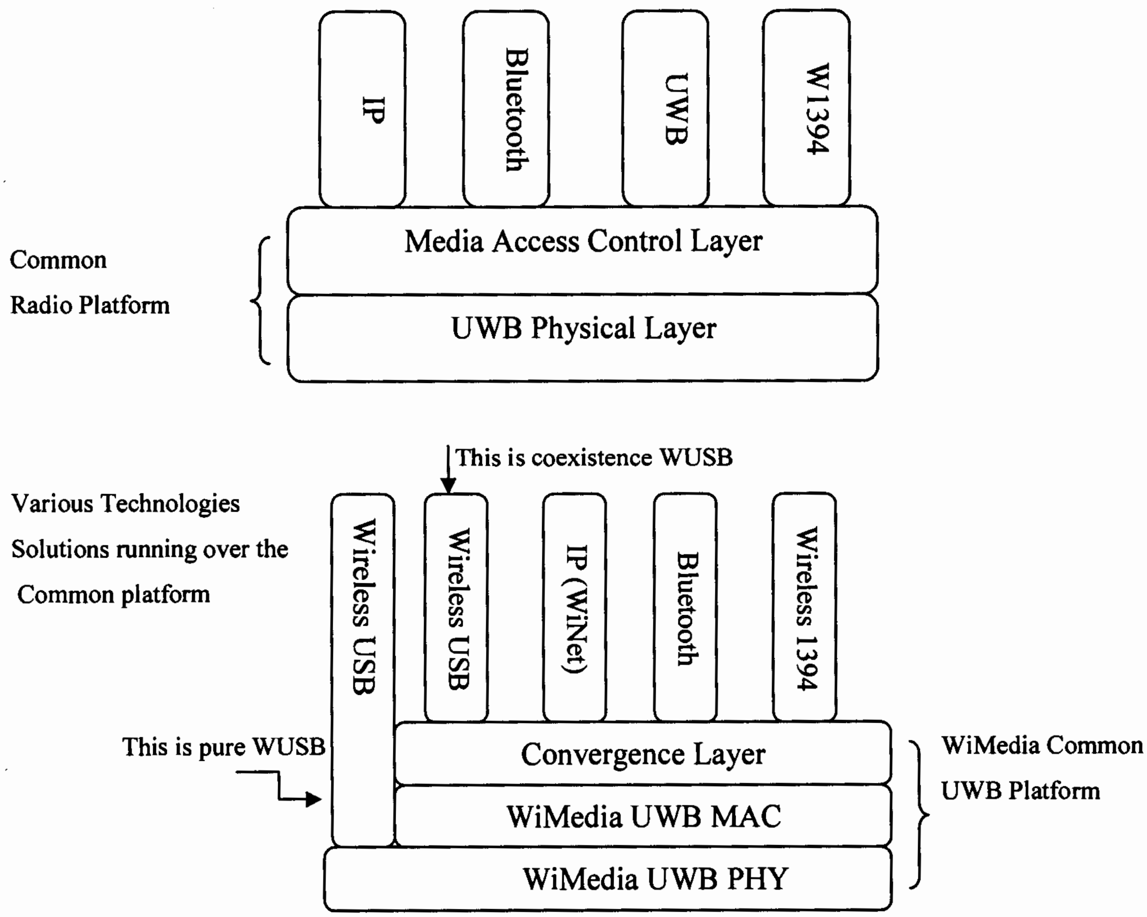


Figure 3.1:- Common Radio Platform

3.2 Characteristics of UWB

UWB technology has the following significant characteristics:

3.2.1- High Data Rates

UWB technology can do things that the existing wireless networking systems cannot. Most importantly, UWB can handle more bandwidth-intensive applications like streaming video, than either 802.11 or Bluetooth because it can send data at much faster rates. UWB technology has a data rate of roughly 100 megabits per second, with speeds up to 500 megabits per second, This compares with maximum speeds of 11 megabits per second for 802.11b (often referred to as Wi-Fi) which is the technology currently used in most wireless LANs; and 54 megabits per second for 802.11a, which is Wi-Fi at 5MHz. Bluetooth has a data rate of about 1 megabit per second. [9]

3.2.2- Low Power Consumption

When transmitting data, UWB devices consume less than several tens of microwatts. That is a huge saving and the reason is that UWB transmits short impulses constantly instead of transmitting modulated waves continuously like most narrowband systems do. UWB chipsets do not require Radio Frequency (RF) to Intermediate Frequency (IF) conversion, local oscillators, mixers, and other filters. The low power consumption makes UWB ideal for use in battery-powered devices like cameras and cell phones.

3.2.3- Interference Immunity

Due to low power and high frequency transmission, UWB's aggregate interference is "undetected" by narrowband receivers. Its power spectral density is at or below narrowband thermal noise floor. The low power level thus causes no irritating interferences to existing home wireless systems. According to its First Report and Order, the FCC requires that indoor UWB devices transmit only when operating with a receiver. A device connected to AC power is not constrained to reduce or conserve power by ceasing transmission, so this restriction will eliminate unnecessary emissions. Additional tests conducted by the FCC have also demonstrated conclusively that UWB devices may be permitted to operate under a proper set of standards without causing harmful interference to other radio operations.

3.2.4- High Security

UWB's white-noise-like transmissions enhance security since receivers without the specific code cannot decode it. Different coding schemes, algorithms, and modulation techniques can assign to different users for data transmissions. Security can realized at the Media Access Control (MAC) level by allowing two devices to communicate with each other. Although currently no security standard is available for UWB, the study group IEEE 802.15.3 has defined AES-128 symmetric security for payload protection and integrity.

3.2.5- Reasonable Range

IEEE 802.15.3a Study Group defined 10 meters as the minimum range at speed 100Mbps However, UWB can go further. The Philips Company has used its Digital Light Processor (DLP) technology in UWB device so it can operate beyond 45 feet at 50 Mbps for four DVD screens.

3.2.6- Low Complexity, Low Cost

The most attractive of UWB's advantages are of low system complexity and cost. Traditional carrier based technologies modulate and demodulate complex analog carrier waveforms. In contrast, UWB systems are made of "all-digital" with minimal RF or microwave electronics. The inherent RF simplicity in UWB designs make the systems highly frequency adaptive and enable them to be positioned anywhere within the RF spectrum. Also home UWB wireless devices do not need transmitting power amplifier. This is a great advantage over narrowband architectures that require amplifiers with significant power back-off to support high-order modulation waveforms for high data rates. The cost of placing UWB technology inside a consumer electronics device - is $20, compared with $40 for 802.11b and $65 for 802.11a. [9]

3.3- How UWB Works

UWB broadcasts short digital pulses, which are timed very precisely (intervals of about 10 picoseconds) on a carrier signal across a very wide spectrum (number of frequency channels) at the same time. The duration of the short pulse is generally less than 1 nanosecond. Transmitter and receiver must be coordinated to send and receive pulses with an accuracy of a trillionth of a second. In a multiple access system, a user has a unique "pseudo-random" (PN) code. A receiver operating with the same PN code can decode the transmission. The UWB receiver consists of a highly accurate clock oscillator and a correlate to convert the received RF signal into a baseband digital or analog output signal. The UWB transmitter and the receiver are tightly coupled by means of an acknowledgement scheme where the transmitter waits for the receiver's response for a specific time period (approx. 10 seconds). [9]

3.4- Advantage of WiMedia

3.4.1- Ultra-popular:

The WiMedia Alliance is an open industry association that defines WiMedia technology. Alliance members consist of PC (Personal Computer), CE (Customer Equipment) and mobile industry leaders based in Asia, Europe and North America. The wide range of geographical and technical participation from companies that craft WiMedia platforms ensures broad and popular adoption by end-users.

3.4.2- Ultra-friendly:

The WiMedia Alliance views ease-of-use as the key to consumer acceptance. The Alliance is working with other organizations to ensure wireless networking is transparent to average users. The Alliance achieves this by helping to establish a uniform industry approach that will simplify installation and operation for consumers. WiMedia addresses the urgent need for clear co-existence guidelines when multiple devices (even multiple devices using different protocols) share the same wireless spectrum. WiMedia specifies fairness and "good neighbor" policies that permit wireless USB, wireless 1394 (FireWire®) and native TCP/IP devices utilizing Multiband OFDM ultra wideband radios to operate side-by-side.

3.4.3- Ultra-trustworthy:

WiMedia is committed to defining and certifying specifications that build trust for consumers. Trust devices to be secure and private. Trust they will deliver glitch-free HD video and trust that future products will remain compatible. Ensuring multi-vendor interoperability, quality of service (QoS), security and "future proof" compatibility are key goals of the WiMedia Alliance and its logo certification program.

3.4.4- Ultra-smart:

Smart new technologies recognize their place in the real world. WiMedia recognizes that it lives in a world where well-established wired protocols want to extend into wireless applications, where batteries have limited lives, and where wired "backbone" topologies will continue to exist for good reason. And since WPANs are designed for limited area reach, WiMedia is complementary with existing and the emerging wired "backbone" approaches.

3.4.5- Ultra-powerful:

Ultra wideband wireless technology offers fantastic potential for bandwidth intensive multimedia applications. WiMedia will continue to develop the MultiBand OFDM physical layer radio (PHY) – now delivering up to 480 Mbps – and a sophisticated medium access control layer (MAC) optimized for mobile multimedia applications. This will ensure that WiMedia-enabled devices offer powerful, high-performance connectivity for both fixed and mobile applications. Additionally, fast device discovery and association ensure that devices can quickly and easily join and leave an ad-hoc network.

3.5- Application Area of UWB

Some of the potential areas considered for UWB application are: [9]

3.5.1- Imaging and Printing

In terms of data transfer in computing applications, UWB has an opportunity to supplant wired USB 2.0 for bandwidth-intensive imaging and printing applications.

3.5.2- Radar in Automotive Industry

A compelling application for UWB is radar in the automotive industry. It is ideally suited for collision avoidance, detecting the movement and location of objects near a vehicle, improving airbag activation and suspension settings. Studies prove conclusively that UWB will not interfere with GPS, especially as the first cars to have collision avoidance will be the same premium models that also host GPS-based Telemetric systems. Barriers to the start-up focusing on this sector are quite tough as:

- UWB devices will have to support a wide range of automotive operating temperature and failure rate
- Design cycle for automotive projects is quite long; measured in number of years, dealing with the tier one vendor, carmaker, design standards (QS9000), car trials (winter/summer tests) and production ramp-up. This all could be resource intensive and exhaustive
- First cars to use it will be low-volume premium models, limiting early revenue opportunities
- Car makers are also very conservative, and would be wary of working with startups, but as a secondary market, it would be possible to work in the automotive industry via a

module partner who already has a supply relationship with the tier-1 vendor or carmaker. [9]

3.5.3- Security applications

Applications such as ground penetrating radar (GPR), through-wall surveillance, appear attractive given today's focus on detection, but are best handled by established systems companies.

3.5.4- Tracking applications

Applications involving the tracking of children, personnel, equipment and inventory, to an accuracy of less than one inch, are attractive, especially as UWB can work indoors (factories, shopping malls), unlike GPS. However, a number of things must be borne in mind in tracking applications:

- The UWB device may require greater transmitting power owing to the amount of noise in an industrial setting
- Wide temperature range operation may be required for some environments
- Many tracking applications will be adequately satisfied by using cheaper RFID tags.
- Wireless Home Networks

Typically, a wireless home network should provide connection among various electronic consumer devices such as PC, MP3 player, digital camera, printer, scanner, High-Definition TV (HDTV) and video game console. However, the current popular usage of home networking is sharing data from PC to PC and from PCs to peripherals. With increased customer demand for home control, multiplayer gaming, and video distributions, significant efforts are being invested in building solutions around UWB enabled home networks.

Additionally, the set-top box could route Internet access traffic from multiple users within the home to the single broadband connection. To provide seamless no-wire communications between home electronic devices, it is vital that technology offers:

- ➢ High data throughput
- ➢ Low power consumption
- ➢ Interference immunity

- Security
- Reasonable range
- Low cost.

Characteristics such as high data throughput, low power consumption, interference immunity, high security, reasonable range, and low cost, make UWB highly suitable for home networks. [9]

3.6- WiMedia MAC

Defining a bit stream is necessary but not sufficient in enabling wireless digital communication. In networking jargon the definition of the physics of how bits are transmitted is called the physical or PHY layer.

The logical structure of the message is called the MAC or Media Access layer. The MAC defines addressing. In a multipoint network the MAC layer also defines how the medium is accessed or shared between several nodes. The first proposed use for UWB was to stream compressed video short distances. This was initially viewed as a cable replacement technology for set-top box to TV screen. UWB promises to provide unprecedented amounts of short range bandwidth. UWB is also very power efficient for applications that only require 'normal' bandwidth, such as internet browsing. This power efficiency comes from the fact that data can be transmitted in a short period of time, and the radio can spend most of its time in a low power state.

As the standard for UWB was evolving, groups representing USB, Bluetooth, internet protocols, and 1394 all had plans to exploit UWB for wireless versions of their existing standards.

As a result of all these demands, the WiMedia MAC is more complex and attempts to solve more problems than any wireless technology to date. The committee designing the WiMedia MAC recognized they could specify a MAC of unprecedented complexity because it is possible today to base the MAC around a powerful 32-bit microprocessor.
On the other hand most features are not mandatory, and it is possible to build a very simple device such as a mouse that can be implemented with a minimum of circuitry.

Prior to WiMedia the two most prominent local area wireless networks were Bluetooth and Wi-Fi. Both use a master slave arrangement. Wi-Fi is a star configuration where there is an access point and clients. This works well as Wi-Fi is designed to provide network connectivity, but does not support peer-to-peer connectivity for most implementations. (Microsoft's Zune media player uses Wi-Fi in a peer-to-peer mode, but details on how this is done have not been made public, and it is unclear whether Zune can interact with other Wi-Fi devices in this mode. Wi-Fi has a peer-to-peer mode, but it is rarely used.

This restriction was unacceptable to members of the WiMedia Alliance. While internet access is important, so is sharing of media files between battery-powered devices. Even better is the ability to do both simultaneously. The group designing the WiMedia MAC decided to take a decentralized or peer-to-peer approach. Any two devices wishing to communicate with one another must make their own arrangements, while cooperating with other devices. Devices still need to arrange some form of TXOP, but the WiMedia MAC can't rely on some central authority to coordinate all devices.

WiMedia introduced the concept of a superframe. A superframe is 65536 microseconds and the period is divided into 256 MAS or Media Allocation Slots each 256 microseconds long. The superframe allows all devices which can hear one another to share a common clock accurate to one fifth of a microsecond.

By sharing a common clock, devices can announce when they will be transmitting and when they will be listening, and it can easily deduce when the medium will not be in use.

The super frame divided into a beacon period and a data period. The first few MAS after the start of the super frame make up the beacon period. All devices are required to identify themselves in the beacon period. Beacons transmitted at 53.3 Mbps, which is the most reliable form of transmission and carries for the longest distance.

We do not have room to show all 256 MAS that make a complete super frame. Time runs from left to right in that slots on the left arrive first. The first few slots of a super frame are called the beacon period. In these slots, devices announce their presence and what capabilities they support. Here we show USB and Bluetooth (incompatible protocols) sharing the medium. While these two communication schemes can't communicate, they can share the medium through common signaling in the beacon period.

The inherent high-bandwidth of UWB and fine time granularity of the WiMedia MAC allow these trade-offs to be made so that systems based on WiMedia can provide high bandwidth and low latency when seen from a human scale. For example, USB mice get polled every 8 milliseconds. While this is a short time span on the human scale, this represents 32 MAS, which is a long time on the WiMedia time scale. [10]

3.7- Multiband UWB (MB UWB)

A competing UWB technology corresponding to the traditional multi-carrier or orthogonal frequency division multiplexing system has been proposed to be a physical layer technique for short-range, high data rate applications by the study group the IEEE802.15.3. Multiband-OFDM based technology was actually the only survivor in a vote in IEEE802.15.3 meeting at Albuquerque, NM, USA at Nov 9-14, 2003 but did not get the required 75% approval in the final vote to be a UWB standard. This decision lets the markets define the de facto standard to be used in high data rate, short link UWB applications. The forthcoming applications could be based on either a direct sequence or multiband approach.

Multiband-UWB utilizes a set of carriers with a data signal spread over 500 MHz around each carrier. Frequency hopping between the bands is used to decrease the average transmitted power within victim bands. The advantage of multiband UWB compared to single band UWB is that, if required by the radio regulations, the sub-blocks (or sub-carriers) can suppressed individually to avoid intentional interference against other services. Of course, the performance of an MB-OFDM based system can be improved by selecting the sub bands, which are interference free. The spectral efficiency is also improved, the higher the data rate a multiband system can offer. MB-UWB makes it possible to use the same system globally, still adopting the local radiation regulations, by proper selection of the used sub bands.

The weakness of the MB-UWB approach is a more complex transceiver structure if compared to the original impulse radio working at the base band. New functional blocks are needed for the up-converter and down-converter; mixers and amplifiers that are excluded from the simplest impulse radio concept. This also means that the basic idea of cheap, low power consumption UWB devices is lost. On the other hand, the technique can offer higher data rates for medium distances than the single-band approach, and commercial OFDM technology nowadays is quite mature, with components available on the shelf. However, the aim of this thesis is not to make a hardware complexity analysis between different proposals or technologies.

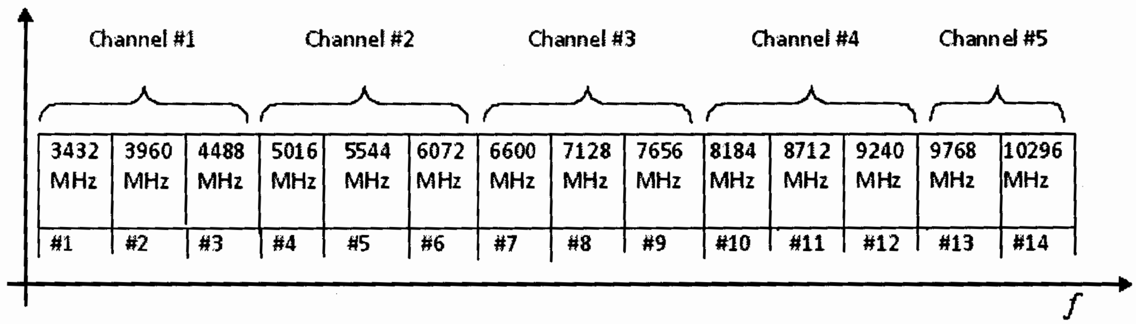


Figure: 3.3 Multiband UWB (MB UWB) Channels

This technology envisages convergence of data, entertainment and mobile communications devices into a single network architecture enabling high data rate applications. This would facilitate three categories of usage scenarios:

i) **Computer data communication:**

This scenario covers two areas: peripheral connections and personal area networking. Similar to Bluetooth technology UWB could be use to connect peripheral devices to computer devices. For example wireless USB could be used to connect a CD Rom to a laptop instead of using a wired USB. UWB technology also facilitates personal a rea networking that enables direct communication between two computing devices.

ii) **Multimedia communication:**

This scenario relates to connecting multimedia devices to achieve ubiquitous access. For example, home entertainment devices could be set up and connected to each other using high-speed UWB technology. This would allow a portable audio player to stream audio to high quality surround□sound speakers or a laptop to connect to a digital projector wirelessly to deliver a multimedia presentation.

iii) Communication with mobile devices:

This scenario refers to connecting a computing device to a LAN or WAN over a mobile phone. This usage is similar to the use of Bluetooth device as a data access point. While MBOFDM Alliance is developing specifications for UWB physical and MAC layer, WiMedia Alliance is developing a common abstraction platform, which enables multiple applications to run on MBOFDM platform.

3.8- DS-OFDM Ultrawideband Modulation Technique

DS-OFDM UWB radios will be able to use all or any part of the 3.1 gigahertz (GHz) to 10.6 GHz spectrum allocated by the FCC. UWB rates and distances will be significantly increased using DS-OFDM architecture. [8]

While several WiMedia companies have received FCC approval for UWB technology, none have done so without waiver -- until now," said Tom Hamilton, executive vice president and general manger of Focus Enhancements' semiconductor group. "Focus Enhancements has the FCC approval necessary to accomplish its goal to deliver longer distances and faster wireless transfer rates for manufacturers of consumer electronics and personal computer peripherals used worldwide.

The ability to use DS-OFDM has several significant advantages in the UWB space," said Michael Ngo, vice president of engineering of Focus Enhancements' semiconductor group. "In the U.S., Talaria™, our wireless UWB technology which uses DS-OFDM, will be able to access all 7 GHz of the available UWB spectrum. In Europe, where it looks like UWB will be restricted to the frequency range between 6 GHz and 10 GHz, we will be able to use all 4 GHz of the allocated frequency; and in Japan, we can use all 3 GHz allocated between 7 GHz and 10 GHz.

UWB is an inherently low-power radio technology where power levels are restricted to the level of noise typically emitted by a laptop computer. Performance of UWB radios will be dependant on the amount of the allocated spectrum utilized. DS-

OFDM is allowed to occupy the entire allocated spectrum as defined by international regulatory bodies.

Focus Enhancements' Talaria UWB wireless technology embraces and integrates both WiMedia Standard MB-OFDM modulation and its own DS-OFDM modulation. Talaria seamlessly integrate both techniques into one smoothly operating radio which can talk to both WiMedia and DS-OFDM devices simultaneously. In addition, Talaria is also designed to be compatible with the Certified Wireless USB Standard.

This multi-functional approach will deliver high-speed, short-range, cable-free connectivity for a wide array of multimedia consumer electronics, personal computer peripherals and mobile devices. With the enhanced performance of DS-OFDM, video, distribution in the home and high-speed media transfers to mass storage devices will be achievable. In initial testing, Focus Enhancements has already surpassed the performance and distance specifications set forth by UWB standards organizations. [8]

3.9- UWB Standards IEEE 802.15.3

IEEE 802.15.3 is the IEEE standard for high data rate (20Mbit/s or greater) Wireless Personal Area Networks (WPAN) to provide Quality of Service (QoS) for real time distribution of multimedia content. IEEE 802.15.3 is accomplished by the IEEE 802.15.3 High Rate (HR) Task Group (TG3). The task group is charged with defining a universal standard of ultra wideband radios capable of high data rate over a distance of 10 meters using the 3.1GHz to 10.6GHz band for TVs, cell phones, PCs, and so forth. Besides a high data rate, the new standard will provide for low power consumption, low cost solutions addressing the needs of portable consumer digital imaging and multimedia applications. In addition, ad hoc peer-to-peer networking, security issues are considered. When combined with the 802.15.3 PAN standard, UWB will provide a very compelling wireless multimedia network for the home. The IEEE 802.15.3 standard enables wireless multimedia applications for portable consumer electronic devices within home coverage. The standard supports wireless connectivity for gaming, printers, cordless phones and other consumer devices. It can be used to develop wireless multimedia applications including wireless surround sound speakers, portable video displays, and digital video cameras. It addresses the need for mobility, quality of service (QoS) and fast connectivity for the broad range of consumer electronic devices.

3.10- FCC regulations

- UWB is available spectrum, not a specific technology
- 7,500MHz of unlicensed spectrum
- First regulation ever that allows spectrum sharing: low emission limit (-41.3dBm/MHz EIRP) doesn't cause harmful interference
- Transmitters need to occupy at least 500MHz all the time
- UWB devices are NOT defined as impulse radios or by any specific modulation
- Enough spectrum to reach much higher data rates than in the ISM band (83.5MHz at 2.4GHz) or the U-NII bands (300MHz at 5GHz)
- Optimized for short-distances applications

3.11 Types of UWB devices

- Imaging systems
    - Below 960 MHz or between 3.1-10.6 GHz
- Vehicular radar systems
    - Between 22 and 29 GHz
- Communication systems
    - Between 3.1-10.6 GHz

CHAPTER NO 4

WIRELESS TECHNOLOGIES & STANDARDS

Wireless technologies and standards

In this chapter, the wireless technologies presented, with focus on their key characteristics and typical usage scenarios. The aim of this section is to highlight the big differences among existing wireless personal area network standards. The aim of this review is not to do yet another comprehensive review on wireless access.

4.1 Cellular systems and Wireless MAN

4.1.1 GSM/GPRS

GSM is the most frequently used cellular telephony standard in the world. Over 670 GSM mobile operators serve more than 200 countries and territories of the world. GSM provides wireless services to over a billion people today, according to GSM Association (GSMA) statistics. GSM offers voice and data bearers in several qualities. Up to GSM Phase 2, only circuit switched data services up to 9600 bps offered. With additional infrastructure (as shown in the diagram 4.1), a new General Packet Radio Service (GPRS) was introduced on top of GSM in the second half of the 1990s. GPRS offers packet switched wireless data services up to approx. 40 kbps. The evolution of cellular standards shown in Figure 4.1. [14]

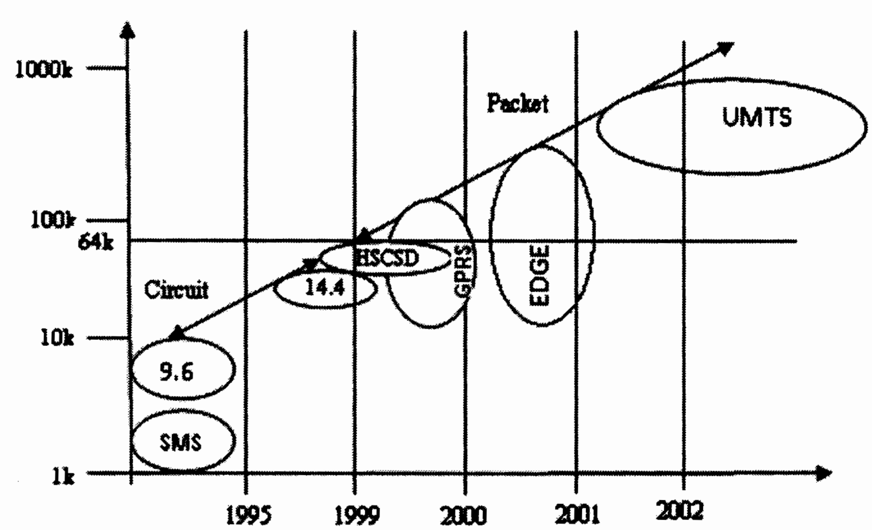


Figure 4.1 Cellular systems and Wireless MAN

Cellular standards evolution

In addition to the traditional voice, data call and the short message service (SMS) appear. At this point, the communications are circuit switched and connection oriented based (data and voice calls) in opposition to the SMS service, which is connectionless.

The necessity of both increasing the bit rate and to migrate to a packet switched (PS) scheme appears due to the inherent importance of data transmission, the number of applications and functionalities requiring and using remote data access and the interest of the network operators in the enhancement and promotion of their data networks usage. An environment was required where mobile applications were able to be "always online" at a reasonable cost to the TCP/IP – Internet world.

Currently virtually, every GSM network operator is providing GPRS service. Typically class 10, 11 or 12 this means that no more than 53.6 kbps are available in GPRS and not simultaneously in uplink and downlink. In GPRS there is a considerable variation (jitter) in the real bit rate available and there is no mechanism to transmit this information through the control interface to the applications.

Mobile devices could divide into two types of terminals according to their main use. On one side there are the voice-centered devices, these are the most common ones and addressed to humans. On the other side, there are the PC cards and GSM/GPRS modules, which intended to use by applications. It is also useful to remember that voice centered devices usually have IrDA and/or Bluetooth support –additionally to data cable enabling them for usage just as GSM/GPRS modems.

The network operators are only forcing the proper support of the set of AT commands related to and required for the use of their own applications (e.g. an application making easy the connection to the internet from a laptop using a PC card, or and application providing comfortable way to send SMS messages). The use of the GSM/GPRS network capabilities implies that the applications themselves should be the entities which control and interact with the AT command interface. There is no a general purpose API allowing the connection management in an abstract and non-technology dependent way wrapping the AT commands use. In the embedded applications case the interaction takes place using native and proprietary operating system API's. Currently the device and the network are managing the radio channel themselves. There isn't any kind of reporting to the applications about measurements or actions taking place related to the communication channel (i.e. when a handover is done, what channels are available, which technologies could be used, what the bit rate is, etc). By the use of optional (not mandatory) AT commands an application could at most force the register of the network operator and to ask for automatic reporting when the register status changes. Considering the facts presented it could stated that to interact with and to manage cellular communication modules:

There is a high-level interface allowing the management of these GSM/GPRS modules. The interface intended to offer a good degree of control but unfortunately, the manufacturers are not implementing a big part of the API.

There is some kind of reporting information and events (i.e. changing in the register status, call status, etc.) but it is allowed just a high level network interaction (i.e. it is not possible to order a handover or to know the neighbor cells or to be informed when there is no channel in the middle of a handover process).

Currently the data call option is hardly used and the applications are almost exclusively employing GPRS data communications. This is due to a couple of simple reasons: GPRS supports a higher bit rate and GPRS allows the applications to be "always on line" at a reasonable cost since charging relies on data traffic and not in time of connection. In the negative side it has to be mentioned the high bit rate variability (jitter) and that it is not possible to act or even to know about the parameters, events and measurements that are managed in the device to control the radio link channel.

A homogeneous interface enabling access and control of cellular GSM/GPRS communications will avoid a dedicated and exclusive control using AT commands: it could make easy the adoption, development and deployment of applications and services requiring the use of mobile networks. [14]

4.1.2 IEEE802.16

The 802.16 standard, "Air Interface for Fixed Broadband Wireless Access Systems," also known as the IEEE Wireless MAN air interface. The technology designed from scratch to provide wireless last mile broadband access in the Metropolitan Area Network (MAN). It delivers performance comparable to cable, DSL and TI access. With

802, it will be possible to quickly provision services, even in areas that are hard for wired infrastructure to reach. It will also avoid the steep installation costs and has the ability to overcome the physical limitation of traditional wired infrastructure.

The 802.16 standard published in April 2002, covers frequency bands between 10 and 66 GHz. In January 2003 the 802.16a amendment was approved. This allows non line of sight fixed wireless access in the 2 GHz to 11 GHz range. 802.16REVd introduced support for indoor wireless access through additional radio capabilities such as antenna beam forming and OFDM sub channeling. In September 2004 the project authorization request (PAR) 802.16e was approved. The 802.16e amendment covers Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands. It will operate in the 2 to 6 GHz range.

4.2 Wireless LAN

WLAN technologies enable users to establish wireless connections within a restricted area (e.g. within a corporate or campus building, or in public spaces, such as an airport). WLANs can use in temporary offices or other spaces where the installation of extensive cabling would be prohibitive, or to supplement an existing LAN so that users can work at different locations within a building at different times. These and other benefits have brought up a large spread on the usage of this sort of technologies. The main usage scenario for WLAN has been providing portable computing devices with wireless access to corporate or domestic LANs. New usage scenarios are emerging which are relevant to the embedded domain, as explained later. WLAN technology support and consideration and consideration are an integral and important part of the GOLLUM project design. [14]

4.2.1 IEEE802.11a/b/g

In 1990, the Institute of Electrical and Electronics Engineers (IEEE) established a committee with the main goal of developing a standard for wireless LANs, operating at 1 and 2 Mbps. For several reasons, but most importantly due to the existence in the market of different LAN products made by the corresponding manufacturers, the first of the standards was published seven years later. The IEEE 802.11 system was approved in

1997, defining two different data rates: 1 and 2 Mbps. In the fall of 1999 the standard was extended to break the 10 Mbps barrier. At that time, the IEEE 802.11b was born, increasing the data rates up to 5.5 Mbps and 11 Mbps. In parallel to this activity, a second group was working on an amendment to the specification within the 5 GHz band. This standard, known as IEEE 802.11a, added the following data rates: 6, 12 and 24 Mbps defining 9, 18, 36 and 54 Mbps as optional. Another standard, the IEEE 802.11g brings up the same data rates, but as an extension of 802.11b (thus working within the 2.4 GHz ISM band• Streaming Multimedia content in the home: connecting Consumer Electronics devices and PC using WLAN is a reality today with several audio distribution systems already on the market; video transmission is more technically demanding since the required bandwidth is higher and the channel capacity varies over time due to transmission errors and interference. Support for Quality of Service is essential in this domain.

4.2.2 IEEE802.11e

Task group e specifies MAC enhancements for QoS support while maintaining full backward compatibility. It intended to support VoIP and streaming audio and video. 802.11e introduces the concept of traffic categories (in accordance to DiffServ). There are eight traffic classes (user priorities), mapped to four priority levels. Low priority traffic must wait longer for medium access. Two modes supported contention based channel access (EDCA) and controlled channel access (HCCA). EDCA is a probabilistic priority mechanism to allocate bandwidth and provides no guarantees of service. In HCCA, the controller polls stations during the contention free period. A station granted a specific start time with maximum transmit duration. The characteristics can be very detailed, e.g. delay bound, minimum data rate, minimum service interval etc. Two optional features are the Direct Link Protocol (DLP) and block acknowledgement (which increase throughput). IEEE802.11e not finalized yet.

4.2.3 WiFi Multimedia

In order to promote interoperability among IEEE802.11 devices that wish to stream multimedia content in a home environment, the WiFi Multimedia (WMM) initiative created, focusing on QoS aspects. WMM is a profile of the upcoming IEEE 802.11e QoS extensions for 802.11 networks. WMM based on the IETF DiffServ architecture, which has been proposed for providing QoS on shared media technologies like WiFi, as it enables effective traffic prioritization without imposing an heavy overhead. Individual data packets labeled with either IETF DSCP headers or IEEE 802.1d tags. WMM provides prioritized media access and based on the Enhanced Distributed Channel Access (EDCA) method. It defines four priority classes (voice, video, best effort and background) to manage traffic from different applications. The common DiffServ foundation enables UPnP QoS to manage WMM, and allows network owners to develop and enforce network wide policies that apply to the wired and wireless infrastructure.

4.2.4 IEEE802.11n

The next generation WLAN aims at offering up to 100Mbps throughput at the MAC Service Access Point. Although this is still work in progress, the way of achieving the target is by means of Multiple Input Multiple Output (MIMO) technology and advanced coding techniques at the PHY layer. A more efficient MAC layer is also introduced. IEEE802.11n will operate in the 5 GHz (and optionally in the 2.4GHz) band with a canalizations of 20 MHz and optionally 40 MHz. [14]

4.3 Wireless PAN Technologies

WPANs are short distance wireless networks that allow devices to communicate and interoperate with one another. The devices are in the proximity of one person and they may or may not belong to the same person. Wireless PANs are facilitated by several network technologies including Bluetooth, Zigbee and UWB. This section describes basic characteristics of different Wireless Personal Area Network (WPAN) technologies and their usage models. [13]

4.3.1 Bluetooth

Bluetooth is a short range, frequency hopping radio link protocol that provides a low cost, Low power, high security data communication solution for mobile devices.

IEEE 802.15.1 specification describes Bluetooth essentially as a wire replacement technology. Bluetooth uses 79 one MHz frequency channels across the ISM band starting from 2.402 GHz. Bluetooth employed spread spectrum frequency hopping with hopping frequency of 1600 per second. Bluetooth specifies 64kbps voice channels, asymmetric link with 732 kbps in forward channel and 57.5 kbps in return channel and symmetric link with 432kbps in both forward and return directions.

The figure 4.2 shows the basic protocol stack of Bluetooth. Bluetooth communications achieved via a number of protocols. Some of these are unique to Bluetooth while others adopted from existing protocols used by other technologies. Different applications will use services from a combination of the protocols shown above to achieve communication among appropriate layers. Typically, the services provided by these protocols will access using an API specific to Bluetooth technology. [13]

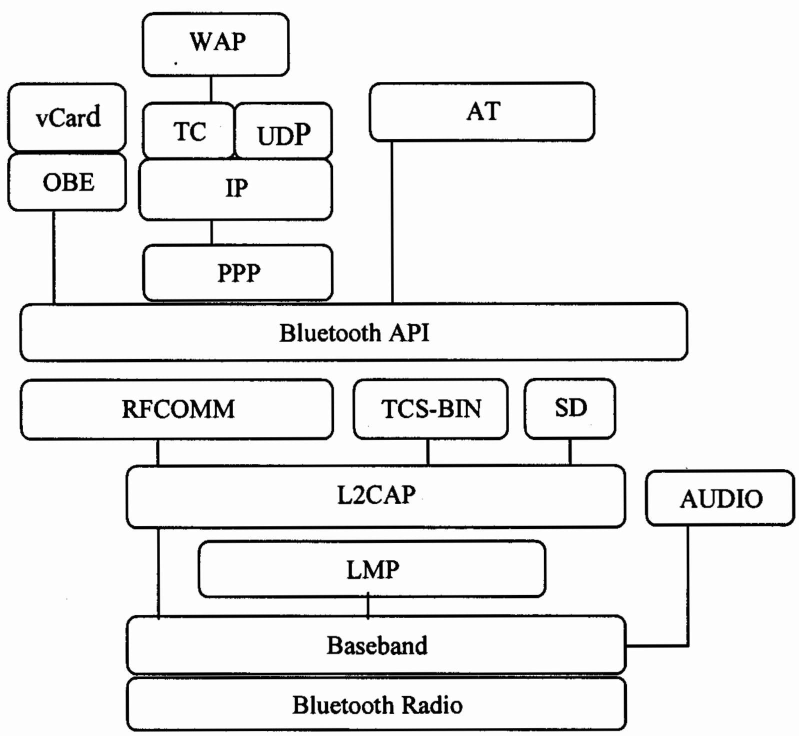


Fig:-4.2 Bluetooth Protocol Stack.

Overview of Operation

The Bluetooth RF (physical layer) operates in the unlicensed ISM band at 2.4GHz. The system employs a frequency hop transceiver to combat interference and fading, and provides many FHSS carriers. RF operation uses a shaped, binary frequency modulation to minimize transceiver complexity. The symbol rate is 1 Mega symbol per second (Msps) supporting the bit rate of 1 Megabit per second (Mbps) or, with Enhanced Data Rate, a gross air bit rate of 2 or 3Mb/s. These modes are known as Basic Rate and Enhanced Data Rate respectively.

The physical channel is sub-divided into time units known as slots. Data is transmitted between Bluetooth enabled devices in packets that are positioned in these slots. When circumstances permit, a number of consecutive slots may be allocated to a single packet. Frequency hopping takes place between the transmission and reception of packets. Bluetooth technology provides the effect of full duplex transmission through the use of a time-division duplex (TDD) scheme.

Above the physical channel there is a layering of links and channels and associated control protocols. The hierarchy of channels and links from the physical channel upwards is physical channel, physical link, logical transport, logical link and L2CAP channel.

The physical link is used as a transport for one or more logical links that support unicast synchronous, asynchronous and isochronous traffic, and broadcast traffic. Traffic on logical links is multiplexed onto the physical link by occupying slots assigned by a scheduling function in the resource manager. [13]

4.3.2- Zigbee

Zigbee is a proprietary set of communication protocols based on IEEE 802.15.4b standard that supports low data rates, low power consumption, with high security. The nominal range is usually 10 meters with data rates of 250kbps (at 2.4 GHz) and 40kbps (at 915MHz) and 20kbps (at 868MHz). The system memory resource is around 4 to 20 KB and battery life is aimed at 100 to 1000 days. Zigbee allows star and mesh networks which could connect over 64000 nodes to a network coordinator. It provides reliable communication through a full handshake and also optional location awareness for monitoring and control applications. This technology forms a general purpose self organizing network that can be shared by industrial sensors, monitors and controls, medical devices, computer peripherals, and domestic electronics.

1) Periodic Data scenario:

The operation is controlled by a beaconing system enabling very low duty cycles and multi year battery life. The device usually wakes up periodically and listens for a beacon from the PAN coordinator, if received, joins the network and passes the data and goes back to sleep. For example, an automatic meter reader could produce periodic type data traffic type.

2) Intermittent data scenario:

The device stays disconnected and only connects to the network when application or external stimulus triggers it. A wireless switch that connects to the network only when needed to communicate refers to this scenario.

3) Repetitive low latency data:

In this scenario a guaranteed time slot is allocated to a device providing QoS that allows PAN controller to facilitate each device to communicate without contention and latency for a specific duration of time. Low rate data transmissions from critical systems including security and medical monitors are example applications for this scenario.

Zigbee application uses a number of additional services implemented by lower layers.

1) Security negotiation:

ZigBee provides basic security service through an ACL to protect the device and asymmetric cryptographic to protect transmitted frames. ACL maintains a list of devices from which the device expects to receive frames. Data may be encrypted by a key shared among a group of devices. Higher layers may decide on accepting or rejecting the frames based on the ACL as well as the Key management (generation, transmission and storage).

2) Power consumption:

Zigbee allows an application to control the duty cycle to adapt to power consumption by controlling the required message latency.

3) Reliable data transfers:

Reliable communication is implemented using an Acknowledgement based mechanism. However the acknowledgement mechanism needs to be controlled based on processing and power efficiency (processing and power) considerations. This is achieved through control of parameters; Mac Ack W ait Duration maximum waiting time before retransmission and a Max Frame Retries upper limit on the number of retransmissions of the same frame. Standard also described bit error detection of frames using 16 bit CRC. [13]

4.3.3- IEEE 802.15.4a Specification

IEEE is in the process of developing a standard (802.15.4a) that describes an alternative physical layer that envisages high precision ranging (accuracy for one meter or better), location capability, high aggregate throughput, ultra low power with scalability and longer ranges.

Current proposal considers range of frequency bands including 5 GHz ISM band, 2.4 GHz ISM band, and UWB in 3.1up to 10.6 GHz range. A set of new application requirements have been considered for 802.15.4a specification: Robustness against interference, precision ranging, Mobility, Greater range / link margin, Latency, Less than 17 msec each with 8 users, higher data rate 500 Kbps – 1 Mbps. The technology envisions a range of control and automation applications including: Industrial monitors (sensors, automation and control, medical monitors), Logistics (assets in vehicles drive by drop boxes, road toll payment, on lot fleet tracking), PC and Peripherals (mouse, joysticks, game consoles, and audio devices), Building automation and Meter reading.

4.3.4- Ultra Wideband (UWB)

UWB is a short-range wire replacement technology that could provide very high data rates around 480Mbps. FCC defines UWB to be a minimum of 500 MHz at a 10dB level. IEEE 802.15.3a describes a UWB specification that operates at frequency band between 3.1 GHz up to 10.6 GHz. In multi band UWB system, Multi band Orthogonal Frequency Division Multiplexing (MB OFDM) transmission is preferred to realize an efficient system in a multi path environment. UWB network could connect a maximum of 127 devices using star topology. Multiband OFDM alliance is currently in the process of specifying wireless USB (480Mbps), wireless IEEE 1394 (400Mbps) along with supporting convergence protocols as a potential replacement technology for wired USB, as well as Bluetooth applications. [13]

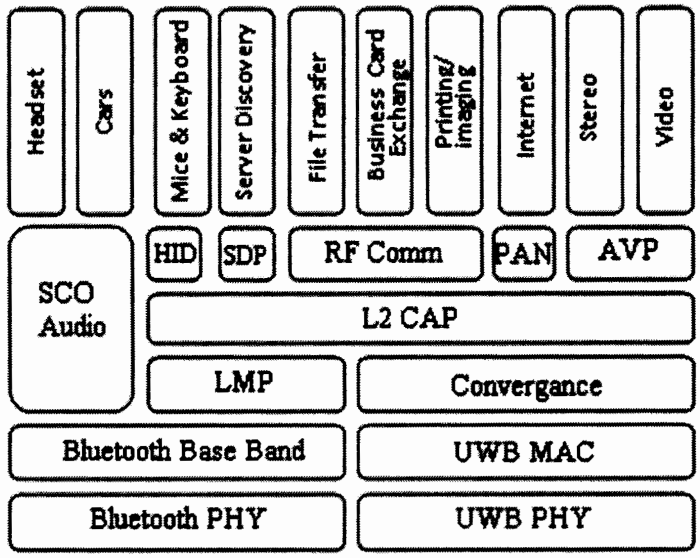


Figure 4.3: Combined Bluetooth Technology/UWB stack

Technology	**Bluetooth 802.15.1**	**Bluetooth Enhanced Data Rate (EDR)**	**UWB 802.15.3**
Application	Wire replaceme	Wire replacement	Wire replacement
Transmission Range	1-10 m	1-10 m	1-10 m
Bandwidth	720 kbps	2.1 Mbps	480 Mbps
System resource (foot print)	250KB+ Typically 16/32bit RISC	250KB+ Typically 16/32bit RISC	
Power consumption	~130nJ per bit at 720 kbps	< basic rate	~ 2nJ per bit at 100 Mbps
Network Size	7	7	127
Success Metric	Cost, convenience	Cost &performance	Performance & Capacity

Table 4.1- Comparison of WPAN technology

CHAPTER NO 5

Introduction to NS-2 Simulator

NS_2 Simulator

Introduction to NS-2

We have carried out our simulation, to analyze the different performance parameters of video streaming in WiMedia using NS-2 (version 2.29) simulator. NS-2 offers some potential benefits, listed below:

5.0.1 Benefits

⇒ *Economy and ease of installation* are important factors while using ns-2 simulations. Because physical simulation demands lot of capital and hard work.

⇒ *Speed* is also an important factor, forces us to ns-2. Because physical simulation is very time consuming. Also modifications in ns-2 are easier and faster than actual scenario.

⇒ *Less space* is required as compared to physical networks. Because in physical networks, one have to put a lot of machines, power cables and other network components while in simulation one have to only installed simulator on a machine.

⇒ *Open source and free* software: There are also other simulators like OPNET, which is very expensive. The research version of OPNET costs more than Rs. 320000. While NS-2 is freely available on Internet.

5.0.2 Limitations

NS-2 offers above mentioned exciting features but it is very difficult to work in NS-2 for new user.

5.1 NS-2 Simulators

NS is an object oriented simulator, written in C++, with an OTcl interpreter as a front end. The simulator supports a class hierarchy in C++ (also called the compiled hierarchy in this document), and a similar class hierarchy within the OTcl interpreter (also called the interpreted hierarchy in this document). The two hierarchies are closely related to each other; from the user's perspective, there is a one-to-one correspondence between a class in the interpreted hierarchy and one in the compiled hierarchy. The root of this hierarchy is the class Tcl Object. Users create new simulator objects through the interpreter; these objects are instantiated within the interpreter, and are closely mirrored by a corresponding object in the compiled hierarchy.

NS uses two languages because simulator has two different kinds of things it needs to do. On one hand, detailed simulations of protocols require a systems programming language which can efficiently manipulate bytes, packet headers, and implement algorithms that run over large data sets. For these tasks run-time speed is important and turn-around time (run simulation, find bug, fix bug, recompile, re-run) is less important. On the other hand, a large part of network research involves slightly varying parameters or configurations, or quickly exploring a number of scenarios. In these cases, iteration time (change the model and re-run) is more important. Since configuration runs once (at the beginning of the simulation), run-time of this part of the task is less important. Ns provide an environment where we can simulate real network and analysis the behavior of different network parameters.

5.2 Network Animator (NAM)

NAM, network animator, is used for visualization of network scenario. It provides visualization of

- Packet flows, different packets can be colored.
- Nodes' native packets queue.
- Packets which are dropped.

For wireless network simulation, NAM plays an important role because it can help that whether a node is within range of another node. NAM is very important to analysis the mobile nodes' movements during simulation.

Following OTcl procedures are used to set node attributes, they are methods of the class Node:

```
$node color [color]              ; # sets color of node
$node shape [shape]              ; # sets shape of node (circular by default)
$node label [label]              ; # sets label on node
$node label-color [lcolor]       ; # sets color of label
$node label-at [ldirection]      ; # sets position of label
```

$node add-mark [name] [color] [shape] ; # adds a mark to node

$node delete-mark [name] ; # deletes mark from node

Nam is a Tcl/TK based animation tool for viewing network simulation traces and real world packet trace data. The design theory behind NAM was to create an animator that is able to read large animation data sets and be extensible enough so that it could be used indifferent network visualization situations. Under this constraint NAM was designed to read simple animation event commands from a large trace file. In order to handle large animation data sets a minimum amount of information is kept in memory. Event commands are kept in the file and reread from the file whenever necessary.

The first step to use NAM is to produce the trace file. The trace file contains topology information, e.g., nodes, links, as well as packet traces. Usually, the trace file is generated by ns. During an ns simulation, user can produce topology configurations, layout information, and packet traces using tracing events in ns. However any application can generate a NAM trace file. When the trace file is generated, it is ready to be animated by NAM. Upon startup, NAM will read the trace file, create topology, pop up a window, do layout if necessary, and then pause at time 0. Through its user interface, NAM provides control over many aspects of animation.

5.3 Nam Command Line Options

nam [-g <geometry>] [-t <graphInput>] [-i <interval>] [-j <startup time>]
[-k <intial socket port number>] [-N <application name>] [-c <cache size>]
[-f <configuration file>] [-r initial animation rate]
[-a] [-p] [-S]
[<tracefile(s)>]

Command Line Options

-g Specify geometry of the window upon startup.

-t Instruct nam to use tk graph, and specify input file nam for tk graph.

-i [Information for this option may not be accurate] Specify rate (real) milliseconds as the screen update rate. The default rate is

-N Specify the application name o f this nam instance. This application name may later be used in peer synchronization.

-c The maximum size of the cache used to store 'active' objects when doing animating in reverse.

-f Name of the initialization files to be loaded during startup. In this file, user can define functions which will be called in the trace

-a Create a separate instance of nam.

-p Print out nam trace file format.

-S Enable synchronous X behavior so it is easier for graphics debugging. For UNIX system running X only.

5.4 User Interface

Starting up nam will first create the nam console window. You can have multiple animations running under the same nam instance. At the top of all nam windows is a menu bar. For the nam console there are 'File' and 'Help' menus. Under the 'File' there is a 'New' command for creating a ns topology using the nam editor (under construction) , an 'Open' command which allows you to open existing trace files, a 'WinList' command that popup a window will the names of all currently opened trace files, and a 'Quit' command which exits nam. The 'Help' menu contains a very limited popup help screen and a command to show version and copyright information.

Once a tracefile has been loaded into nam (either by using the 'Open' menu command or by specifying the tracefile on the command line) an animation window will appear. It has a 'Save layout' command which will save the current network layout to a file and a 'Print' command which will print the current network layout.

The 'Views' menu has 4 buttons:

- New view button: Creates a new view of the same animation. User can scroll and zoom on the new view. All views will be animated synchronously.
- Show monitors checkbox: If checked, will show a pane at the lower half of window, where monitors will be displayed.

- Show auto layout checkbox: If checked, will show a pane at the lower half of window, which contains input boxes and a button for automatic layout adjustments. This box will not be enabled when using link orientation layouts.
- Show annotation checkbox: If checked, will show a list box at the lower half of window, which will be used to list annotations in the ascending order of time.
- Below the menu bar, there is a control bar containing 6 buttons, a label, and a small scrollbar (scale). They can be clicked in any order. We will explain them from left to right.
- Button 1 («) - Rewind. When clicked, animation time will go back at the rate of 25 times the current screen update rate.
- Button 2 (<) - Backward play. When clicked, animation will be played backward with time decreasing.
- Button 3 (square) - Stop. When clicked, animation will pause.
- Button 4 (>) - Forward play. When clicked, animation will be played forward with time increasing.
- Button 5 (») - Fast Forward. When clicked, animation time will go forward at the rate of 25 times the current screen update rate.
- Button 6 (Chevron logo) - Close current animation window.

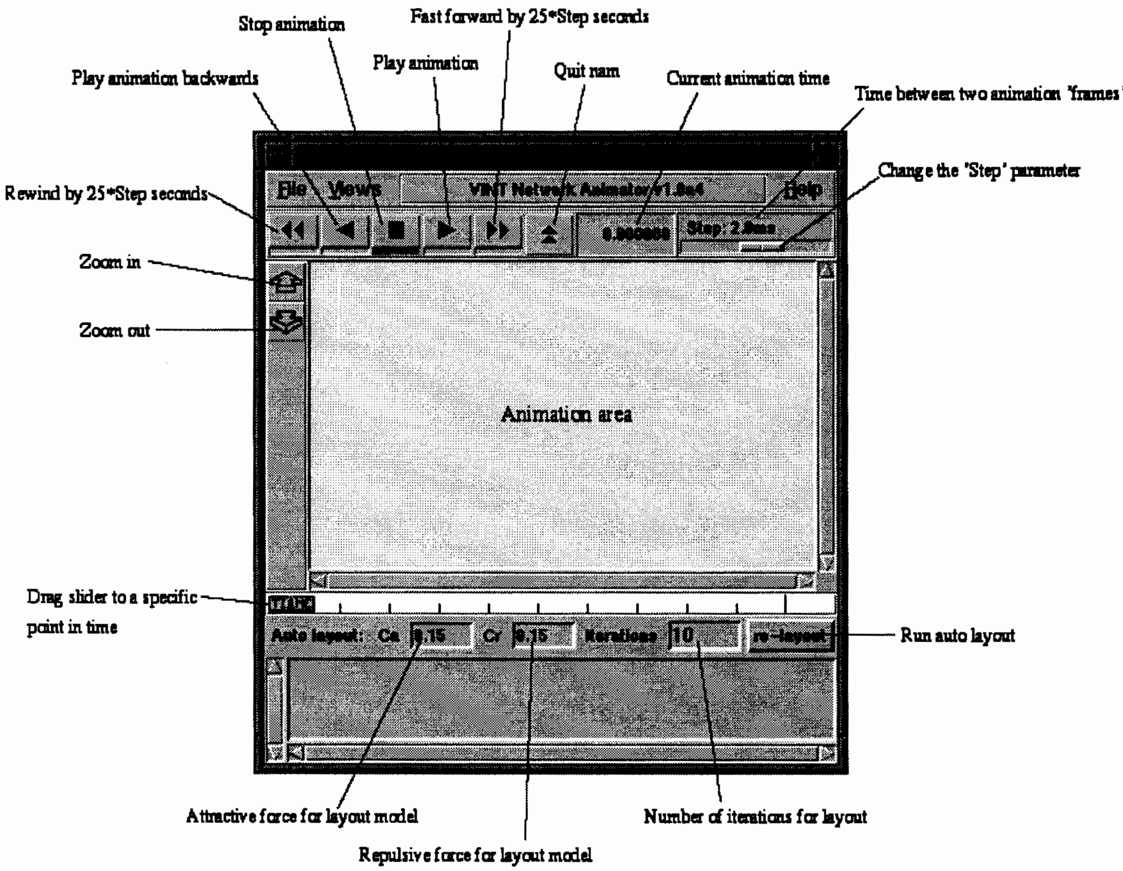


Figure 5.1: NS-2 User interface

Time label - Show the current animation time (i.e., simulation time as in the trace file). Rate Slider - Controls the screen update rate (animation granularity). The current rate is displayed in the label above the slider.

Below the first control bar, there is Main Display, which contains a tool bar and a main view pane with two panning scroll bars. All new views created by menu command 'Views/New view' will have these three components. The tool bar contains two zoom buttons. The button with an up arrow zooms in, the button with a down arrows zooms out. The two scroll bars are used to pan the main animation view. Clicking the left button on any of the objects in the main view pane will pop up a information window. For packet and agent objects, there is a 'monitor' button in the popup window. Clicking that button will bring out the monitor pane (if it is not already there), and add a monitor to the object. For link objects, there will be a 'Graph' button. Clicking on that button will bring up another popup window, where users can select between drawing a bandwidth utilization graph or drawing a link loss graph of one simplex edge of the duplex link. Below the user interface objects we have discussed so far, there may or May not be a Monitor pane, depending on whether the checkbox 'Views/Show monitors' is set. (The default is unset). All monitors will be shown in this pane. A monitor looks like a big button in the pane. Currently only packets and agents may have monitors.

A packet monitor shows the size, id, and sent time. When the packet reaches its destination, the monitor will still be there, but will say that the packet is invisible. An agent monitor shows the name of the agent, and if there are any variable traces associated with this agent, they will be shown there as well.

Below the monitor pane (or in its place if the monitor pane isn't there), there is a Time Slider. It looks like a scaled ruler, with a tag 'TIME' which can be dragged along the ruler. It is used to set the current animation time. As you drag the 'TIME' tag, current animation time will be displayed in the time label in the control bar above. The left edge of the slider represents the earliest event time in the trace file and the right edge represents the last event time. Clicking left button on the ruler (not on the tag) has the same effect as Rewind or Fast Forward, depending on the clicking position. The Automatic Layout Pane may be visible or hidden. If visible, it is below the time slider. It has three input boxes and one relay out button. The labeled input boxes let user adjust two automatic layout constants, and the number of iterations during next layout. When user press ENTER in any of the input boxes, or click the 'relay out' button, that number of iterations will be performed. Refer to the AUTOMATIC LAYOUT section for details of usage. The bottom component of the nam window is an Annotation List box, where annotations are displayed. An annotation is a (time, string) pair, which describes an event occurring at that time. Refer to ns (1) for functions to generate annotations. Double-clicking on an annotation in the list box will bring nam to the time when that annotation is recorded. When the pointer is within the list box, clicking the right button will stop the animation and bring up a popup menu with 3 options: Add, Delete, Info. 'Add' will bring up a dialog box with a text input to add a new annotation entry which has the current animation time.

5.5 Operating Systems for NS-2

NS can be used on the following platforms:

- UNIX (Free BSD, SunOS, Solaris).
- Linux (RedHat 9, Enterprise Edition, FEDORA 4)
- Microsoft Windows

However for windows, Cygwing emulator is required for NS. The favorable operating system for NS is Linux/Unix operating system.

Chapter No 6
Performance Metrics and Simulation Methodology

Performance Metrics

This is the most important chapter in this thesis, since it deals with the performance evaluation of performance metrics. Application specifies the type of QOS that is actually needed for example FTP is not a delay sensitive but demands reliability. MPEG4 video type of traffic is delay sensitive so adding more reliability can delay the frames/packets. We have selected performance metrics are Delay, Throughput and Packet Loss over WiMedia network.

6.0.1 What is Throughput?

The amount of data transferred from one place to another or processed in a specified amount of time. Data transfer rates for disk drives and networks are measured in terms of Throughput. Typically, Throughputs are measured in Kbps, Mbps and Gbps.

$$\text{Percentage Throughput} = \frac{\text{No of Recieved Packets}}{\text{No of Send Packets}} \text{x} 100$$

6.0.2 What is Packet Loss?

Packet Loss is equal to number of packets sent form source minus number of packets received on destination.

$$\text{Packet Loss} = \text{No. of Send Packets} - \text{No. of Recieved Packets}$$

6.0.3 What is Delay?

The average time taken by the data packets to reach the intended destinations, here we considered Average End-to-End delay. This includes delay occurred due to different reasons like queuing delay, propagation delay, processing delay etc. It is an important parameter for delay sensitive application like multimedia application. It is also very important for application where data is processed online.

$$\text{Mean Delay} = \frac{\sum_{i=1}^{n} \text{Delay of Packet}}{n}$$

6.0.4 What is Buffer?

A buffer is an internal memory area used for temporary storage of data during input or output operations. This storage area is usually in RAM. A buffer can be used in different ways. Most programs (e.g., word processors, graphics programs) keep track of changes in the buffer and then copy the buffer to a disk. This is a small amount of data that is stored for a short amount of time, typically in the computer's memory (RAM). The purpose of a buffer is to hold data right before it is used.

6.1 What is MPEG?

MPEG (pronounced EHM-pehg), the Moving Picture Experts Group, develops standards for digital video and digital audio compression. It operates under the auspices of the International Organization for Standardization (ISO). The MPEG standards are an evolving series, each designed for a different purpose.

To use MPEG video files, you need a personal computer with sufficient processor speed, internal memory, and hard disk space to handle and play the typically large MPEG file (which has a file name suffix of .mpg). You also need an MPEG viewer or client software that plays MPEG files. (Note that .mp3 file suffixes indicate MP3 (MPEG-1 audio layer-3) files, not MPEG-3 standard files.) You can download shareware or commercial MPEG players from a number of sites on the Web.

6.2 What is Streaming video?

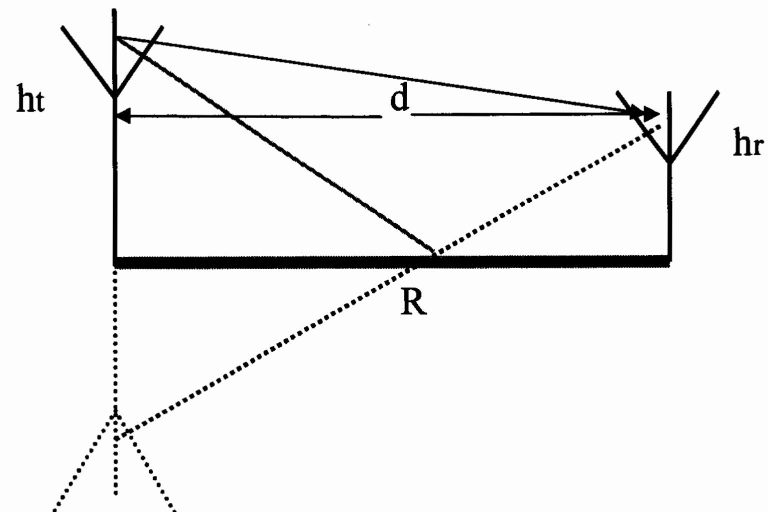
Streaming video is a sequence of "moving images" that are sent in compressed form over the Internet and displayed by the viewer as they arrive. Streaming media is streaming video with sound. With streaming video or streaming media, a Web User does not have to wait to download a large file before seeing the video or hearing the sound. Instead, the media is sent in a continuous stream and is played as it arrives. The user needs a player, which is a special program that uncompressed and sends video data to the display and audio data to speakers. A player can be either an integral part of a browser or downloaded from the software maker's Web site.

Major streaming video and streaming media technologies include Real System G2 from Real Network, Microsoft Windows Media Technologies (including its NetShow Services and Theater Server), and VDO. Microsoft's approach uses the standard MPEG compression algorithm for video. The other approaches use proprietary algorithms. (The program that does the compression and decompression is sometimes called the codec.) Microsoft's technology offers streaming audio at up to 96 Kbps and streaming video at up to 8 Mbps (for the NetShow Theater Server). [5]

Streaming video is usually sent from pre-recorded video files, but can be distributed as part of a live broadcast "feed." In a live broadcast, the video signal is converted into a compressed digital signal and transmitted from a special Web server that is able to do multicast, sending the same file to multiple users at the same time.

6.3 Two-ray ground reflection model

The two-ray model of propagation is a model where the receiving antenna sees a direct path signal as well as a signal reflected off the ground. Secular reflection much like light off of a mirror is assumed and to a very close approximation, the secular reflection arrives with strength equal to that of the direct path signal. The reflected signal shows up with a delay relative to the direct path signal and as a consequence, may add constructively (in phase) or destructively (out of phase).



Tow-ray ground reflection model

A single line-of-sight path between two mobile nodes is seldom the only means of propagation. The two-ray ground reflection model considers both the direct path and a ground reflection path. It is shown equation 6.1 that this model gives more accurate prediction at a long distance than the free space model. The received power at distance *d* is predicted by

$$P_r(d) = \frac{P_t G_t G_r h_t^2 h_r^2}{d^4 L} \tag{6.1}$$

Where h_r and h_t are the heights of the transmit and receive antennas respectively. Note that the original equation in 6.1 assumes L = 1. To be consistent with the free space model L is added here.

The above equation shows a faster power loss than Equation (6.1) as distance increases. However, the two-ray model does not give a good result for a short distance due to the oscillation caused by the constructive and destructive combination of the two rays. Instead, the free space model is still used when d is small. Therefore, a cross-over distance d_c is calculated in this model.

When d < dc Eqn. (6.1) is used and when d > dc, Eqn. (6.1) is used. At the cross-over distance, Eqns. (6.1) give the same result. So dc can be calculated as

$$d_c = \frac{4\pi h_t h_r}{\lambda}$$

6.4 Implementation Details and Simulation Methodology.

In previous chapters, we covered background and general concept required to understand our projects. Also in pervious chapters, we explored basics of NS-2, the simulation tool, we are going to use for implementation of our scenario.

This chapter discusses the implementation specifications which are related to the simulation model and the various components of the environment. It also provides description of the various simulation parameters and analysis used in this study.

6.4.1 Basic Scenario (Topology)

In Figure 6.1 there are two nodes Node 0 acts as a source that send MPEG4 video traffic in Mbits per second while the Node 1 act as a Destination. The parameters are calculated by varying the send rate of video traffic from 1Mbps to 10 Mbps.

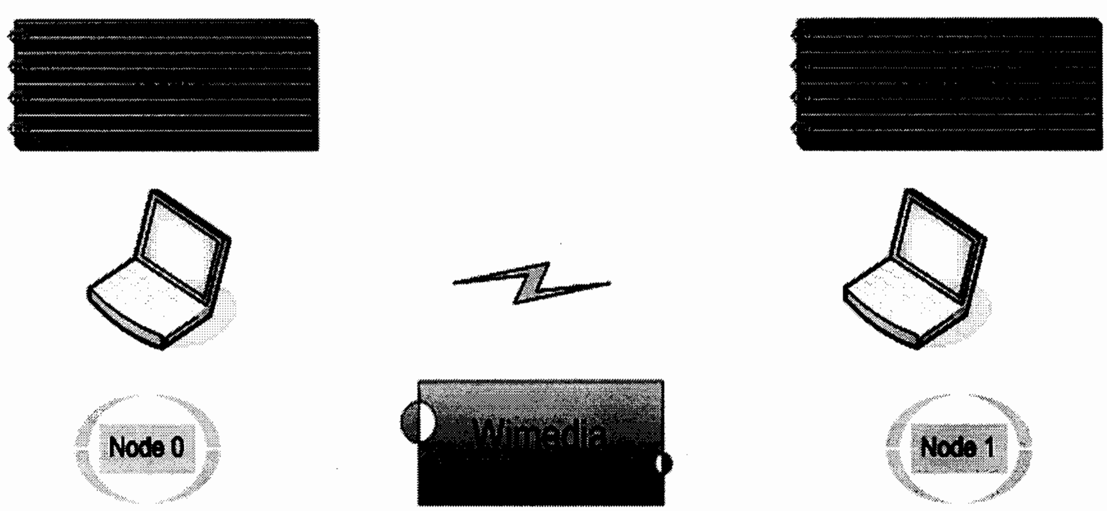


Figure 6.1- Basic Scenario (Topology)

6.5 TCL Script

The following parts of TCL script sets the channel type used, the modulation model, the propagation model, the network interface type, the queuing mechanism used between sender and receiver. There are two mobile nodes and the antenna type for communication is Omni. The buffer size is set to be 50 packets.

set val(chan)

Define the wireless channel characteristics for simulation.

set val(modulation)

Define the modulation technique we use the PPM in simulation

set val(prop)

Define the propagation model for simulation. We choose the two ray channel propagation model in this simulation

set val(netif)

Define the physical layer. In this simulation we choose the wimedia physical layer

set val(mac)

Define the MAC layer .in this simulation we choose IF control.ns2 use it for wimedia.

set val(ifq)

Define the queue for the transmission and receiving nodes.

set val(ll)

Define the link layer and its properties like MAC type and point to point correction and detection

set val(ant)

Define the antenna type for simulation .we uses the omni type antenna.

set val(ifqlen)

Define the maximum no of packets in queue that equals to the buffer size 50 packets.

set val(rp)

Define the routing protocol we uses the NOAH protocol.

set val(nn)

Define the number of nodes in the simulation which is 2.

```
$ns_ node-config -adhocRouting $val(rp) \
                 -llType $val(ll) \
                 -macType $val(mac) \
                 -ifqType $val(ifq) \
                 -ifqLen $val(ifqlen) \
                 -antType $val(ant) \
                 -propType $val(prop) \
                 -modulationType $val(modulation) \
                 -phyType $val(netif) \
                 -channel $chan_ \
```

-topoInstance $topo \

-agentTrace ON \

-routerTrace ON \

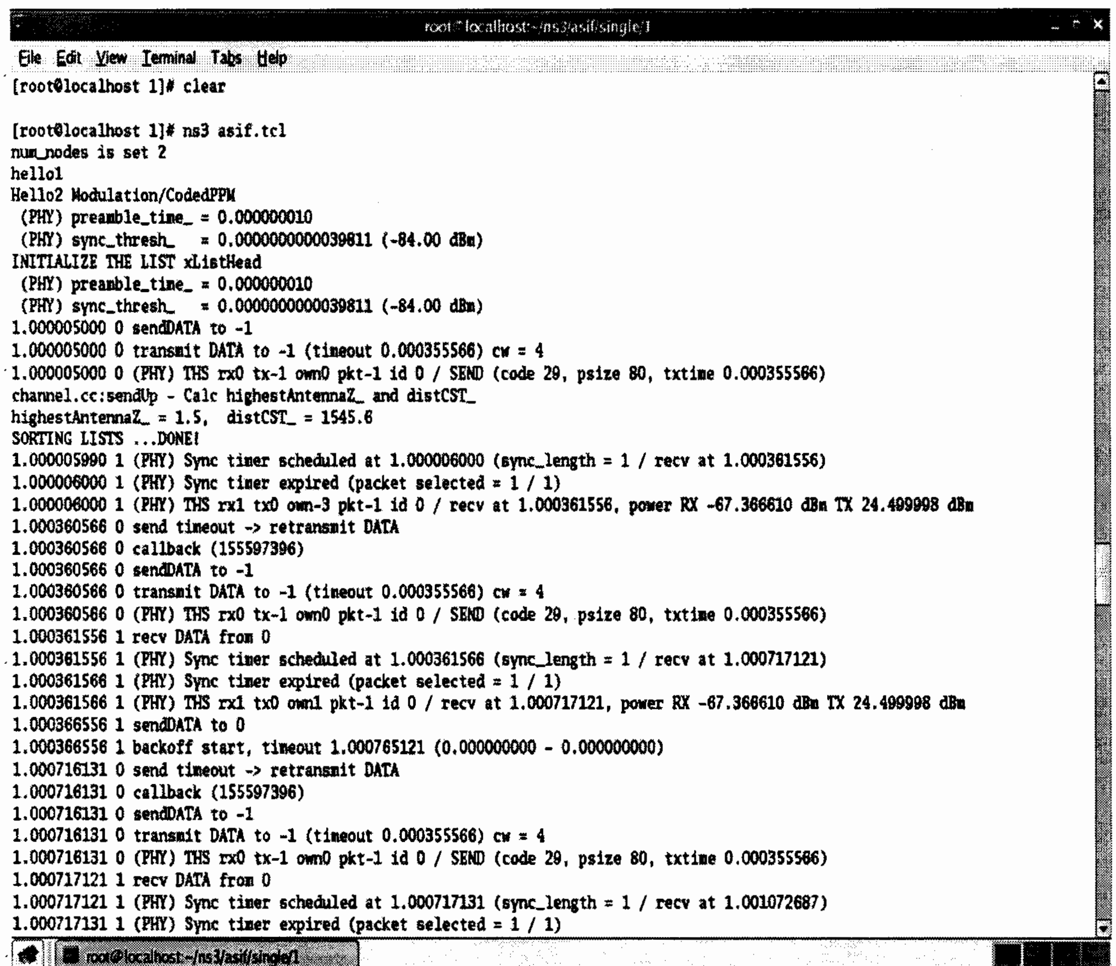
-macTrace ON \

-movementTrace OFF

Now we are configure the enjoinment in the simulation and apply the setting that we chose above and making the environment ready to run the simulation.

6.6 Running TCL Script

The following screen shot show how to run the tcl script. In our case the name of the script is "asif.tcl" and command used to run the script is ns <name of script>.



```
[root@localhost 1]# clear

[root@localhost 1]# ns3 asif.tcl
num_nodes is set 2
hello1
Hello2 Modulation/CodedPPM
 (PHY) preamble_time_ = 0.000000010
 (PHY) sync_thresh_   = 0.0000000000039811 (-84.00 dBm)
INITIALIZE THE LIST xListHead
 (PHY) preamble_time_ = 0.000000010
 (PHY) sync_thresh_   = 0.0000000000039811 (-84.00 dBm)
1.000005000 0 sendDATA to -1
1.000005000 0 transmit DATA to -1 (timeout 0.000355566) cw = 4
1.000005000 0 (PHY) THS rx0 tx-1 own0 pkt-1 id 0 / SEND (code 29, psize 80, txtime 0.000355566)
channel.cc:sendUp - Calc highestAntennaZ_ and distCST_
highestAntennaZ_ = 1.5,  distCST_ = 1545.6
SORTING LISTS ...DONE!
1.000005990 1 (PHY) Sync timer scheduled at 1.000006000 (sync_length = 1 / recv at 1.000361556)
1.000006000 1 (PHY) Sync timer expired (packet selected = 1 / 1)
1.000006000 1 (PHY) THS rx1 tx0 own-3 pkt-1 id 0 / recv at 1.000361556, power RX -67.366610 dBm TX 24.499998 dBm
1.000360566 0 send timeout -> retransmit DATA
1.000360566 0 callback (155597396)
1.000360566 0 sendDATA to -1
1.000360566 0 transmit DATA to -1 (timeout 0.000355566) cw = 4
1.000360566 0 (PHY) THS rx0 tx-1 own0 pkt-1 id 0 / SEND (code 29, psize 80, txtime 0.000355566)
1.000361556 1 recv DATA from 0
1.000361556 1 (PHY) Sync timer scheduled at 1.000361566 (sync_length = 1 / recv at 1.000717121)
1.000361566 1 (PHY) Sync timer expired (packet selected = 1 / 1)
1.000361566 1 (PHY) THS rx1 tx0 own1 pkt-1 id 0 / recv at 1.000717121, power RX -67.366610 dBm TX 24.499998 dBm
1.000366556 1 sendDATA to 0
1.000366556 1 backoff start, timeout 1.000765121 (0.000000000 - 0.000000000)
1.000716131 0 send timeout -> retransmit DATA
1.000716131 0 callback (155597396)
1.000716131 0 sendDATA to -1
1.000716131 0 transmit DATA to -1 (timeout 0.000355566) cw = 4
1.000716131 0 (PHY) THS rx0 tx-1 own0 pkt-1 id 0 / SEND (code 29, psize 80, txtime 0.000355566)
1.000717121 1 recv DATA from 0
1.000717121 1 (PHY) Sync timer scheduled at 1.000717131 (sync_length = 1 / recv at 1.001072687)
1.000717131 1 (PHY) Sync timer expired (packet selected = 1 / 1)
```

Figure 6.2- Running TCL Script

6.7 Trace file

Network simulator generates the following trace file, which includes the events in the network. s indicate send event, R for receive, D for Drop, + indicate the en-queue operation while – refer to de-queue operation. The sub set of the trace file is given below. Second column shows the time at which, event is being performed. Type of traffic is TCP with packet size of 1000 Bytes.

```
s 1.700000000 _0_ AGT  --- 230 tcp 844 [0 0 0 0] ------- [0:1 2:0 32 0] [0 0] 0 0
D 1.700000000 _0_ IFQ  ARP 229 tcp 1020 [0 0 8 0] ------- [0:1 2:0 32 2] [0 0] 0 0
D 1.700366556 _1_ IFQ  --- 0 ARP 28 [0 1000000 608 0] ------- [REPLY 1/1 0/0]
D 1.700722175 _2_ IFQ  --- 0 ARP 28 [0 2000000 608 0] ------- [REPLY 2/2 0/0]
D 1.701077740 _2_ IFQ  --- 0 ARP 28 [0 2000000 608 0] ------- [REPLY 2/2 0/0]
D 1.701433306 _2_ IFQ  --- 0 ARP 28 [0 2000000 608 0] ------- [REPLY 2/2 0/0]
D 1.701788871 _2_ IFQ  --- 0 ARP 28 [0 2000000 608 0] ------- [REPLY 2/2 0/0]
s 1.733333333 _0_ AGT  --- 231 tcp 1000 [0 0 0 0] ------- [0:0 1:0 32 0] [0 0] 0 0
s 1.733333333 _0_ AGT  --- 232 tcp 1000 [0 0 0 0] ------- [0:0 1:0 32 0] [0 0] 0 0
D 1.733333333 _0_ IFQ  ARP 231 tcp 1020 [0 0 8 0] ------- [0:0 1:0 32 1] [0 0] 0 0
s 1.733333333 _0_ AGT  --- 233 tcp 994 [0 0 0 0] ------- [0:0 1:0 32 0] [0 0] 0 0
D 1.733333333 _0_ IFQ  ARP 232 tcp 1020 [0 0 8 0] ------- [0:0 1:0 32 1] [0 0] 0 0
s 1.733333333 _0_ AGT  --- 234 tcp 1000 [0 0 0 0] ------- [0:1 2:0 32 0] [0 0] 0 0
D 1.733333333 _0_ RTR  CBK 230 tcp 864 [0 0 8 0] ------- [0:1 2:0 32 2] [0 0] 0 0
D 1.733333333 _0_ RTR  CBK 234 tcp 1020 [0 0 8 0] ------- [0:1 2:0 32 2] [0 0] 0 0
s 1.733333333 _0_ AGT  --- 235 tcp 1000 [0 0 0 0] ------- [0:1 2:0 32 0] [0 0] 0 0
s 1.733333333 _0_ AGT  --- 236 tcp 1000 [0 0 0 0] ------- [0:1 2:0 32 0] [0 0] 0 0
D 1.733333333 _0_ IFQ  ARP 235 tcp 1020 [0 0 8 0] ------- [0:1 2:0 32 2] [0 0] 0 0
s 1.733333333 _0_ AGT  --- 237 tcp 1000 [0 0 0 0] ------- [0:1 2:0 32 0] [0 0] 0 0
D 1.733333333 _0_ IFQ  ARP 236 tcp 1020 [0 0 8 0] ------- [0:1 2:0 32 2] [0 0] 0 0
s 1.733333333 _0_ AGT  --- 238 tcp 1000 [0 0 0 0] ------- [0:1 2:0 32 0] [0 0] 0 0
D 1.733333333 _0_ RTR  CBK 237 tcp 1020 [0 0 8 0] ------- [0:1 2:0 32 2] [0 0] 0 0
D 1.733333333 _0_ RTR  CBK 238 tcp 1020 [0 0 8 0] ------- [0:1 2:0 32 2] [0 0] 0 0
s 1.733333333 _0_ AGT  --- 239 tcp 1000 [0 0 0 0] ------- [0:1 2:0 32 0] [0 0] 0 0
s 1.733333333 _0_ AGT  --- 240 tcp 38 [0 0 0 0] ------- [0:1 2:0 32 0] [0 0] 0 0
D 1.733333333 _0_ IFQ  ARP 239 tcp 1020 [0 0 8 0] ------- [0:1 2:0 32 2] [0 0] 0 0
D 1.733699889 _1_ IFQ  --- 0 ARP 28 [0 1000000 608 0] ------- [REPLY 1/1 0/0]
D 1.734055454 _1_ IFQ  --- 0 ARP 28 [0 1000000 608 0] ------- [REPLY 1/1 0/0]
```

D 1.734411020 _1_ IFQ --- 0 ARP 28 [0 1000000 608 0] ------- [REPLY 1/1 0/0]

D 1.734766639 _2_ IFQ --- 0 ARP 28 [0 2000000 608 0] ------- [REPLY 2/2 0/0]

6.8 AWK Script

To extract the required information from the traces, generated by NS we required some scripting language. There are different scripting languages such as PERL, GREP and AWK. We used AWK scripting language to extract our required data from the traces.

The AWK scripting used in our script is given below.

```
exec awk {
      {
      if($1=="D" && $7=="video" && $8>100)
        {
         count+=1
         print $2 , count
        }
      }
     } out.tr > drop.tr
exec awk {
      {
       if($1=="s" && $3=="_0_" && $4=="AGT" && $7=="video" && $8>100)
         {
          print $1, $2 , $6
         }
       if($1=="r" && $3=="_1_" && $4=="AGT" && $7=="video" && $8>100)
         {
          print $1 , $2 , $6
         }
      }
       } out.tr > sr_etoe.tr
exec awk {
      {
            if($1=="s" && $3=="_0_" && $4=="AGT" && $7=="video" && $8>100)
          {
          count1+=$8
           print $2 , count1
```

```
            }
          }
        } out.tr > send_bitrate.tr
exec awk {
        {
         if($1=="r" && $3=="_1_" && $4=="AGT" && $7=="video" && $8>100)
           {
            count+=$8
             print $2 , count
           }
        }
       } out.tr > recv_bitrate.tr
```

6.9 NAM Visualization

The following screen shot shows the node sending packets to receiver.

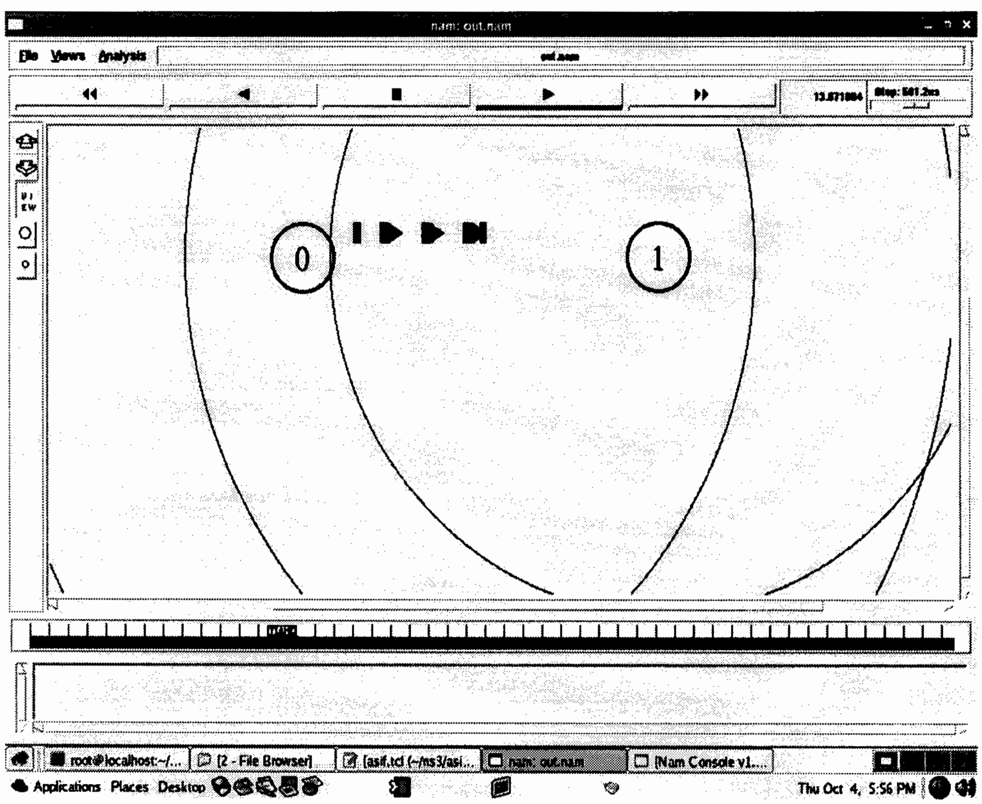


Figure 6.3: Packet Sending Visualization Topology

6.10 Analysis

Data Rate(Mbps)	Calculated Traffic(Bytes) 1024*1024*1	Simulation Traffic per sec Packet size*frames per sec*rate factor(Bytes)	Throughput	Average Delay(ms)	Packet drop %
1	1024*1024= 1048576 B	5000*30*7 1050000 B	100	0.32	0%
2	1024*1024*2= 2097152B	5000*30*14= 2100000B	100	0.5	0%
3	1024*1024*3= 3145728B	5000*30*21= 3150000B	100	1.14	0%
4	1024*1024*4= 4194304B	5000*30*28= 4200000B	100	1.63	0%
5	1024*1024*5= 5242880B	5000*30*35= 5250000B	100	2.02	0%
6	1024*1024*6= 6291456B	5000*30*42= 6300000B	100	2.46	0%
7	1024*1024*7= 6291456B	5000*30*49= 6300000B	100	2.82	0%
8	1024*1024*8= 8388608B	5000*30*56= 8400000B	100	3.32	0%
9	1024*1024*9= 9437184B	5000*30*63= 9450000B	99.6	3.72	0.34%
10	1024*1024*10= 10485760B	5000*30*70= 10500000B	99.5	4.22	1.18%
50	1024*1024*50= 52428800B	5000*30*350= 52500000B	98.8	4.99	1.11%
100	1024*1024*100= 104857600B	5000*30*696= 104400000B	96.09	6.33	3.90%

6.10.1- Throughput vs. Video Send Rate

Table 6.1 and Figure 6.4 show the throughput achieved by varying the send rate from 1 Mbps to 100 Mbps. From our statistics we came to find that from 1 to 8 Mbps data rate we achieve the throughput 100%. This situation has a slight change up to 9 Mbps data rate as we achieve the 99.6% throughput and on 10 Mbps data rate the achieved throughput is 99.5%. From 50 to 100 Mbps data rate, no major difference has been found in throughput. We observe the decline in throughput as it decreases from 99.6% to 96.09%. The parameters that affect the performance of video streaming in WiMedia are the noise (1e-11db), two ray propagation model and UDP protocol.

Video Send Rate (Mbps)	Throughput
1	100%
2	100%
3	100%
4	100%
5	100%
6	100%
7	100%
8	100%
9	99.6%
10	99.5%
50	98.8%
100	96.09%

Table: 6.1 Video Send Rate vs. Percentage Throughput.

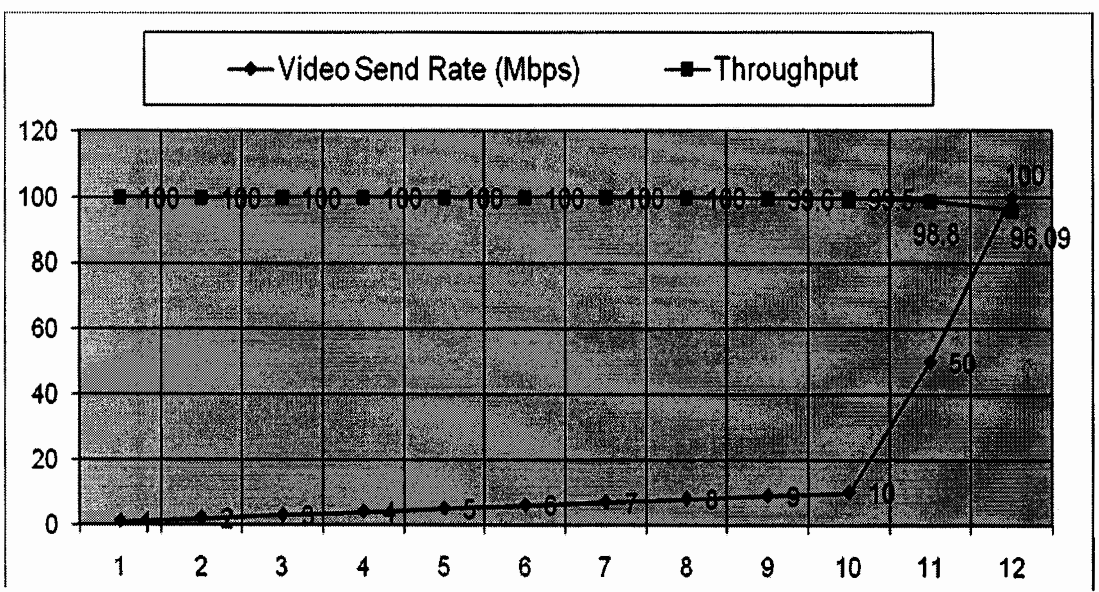


Figure: 6.4 Video Send Rate vs. Percentage Throughput.

6.10.2- Delay vs. Video Send Rate

The impact of video send rate on the Delay performance factor can be analyzed from the Table 6.2 and Figure 6.5 below.

In this case, the variation in delay performance factor is corresponding to the video send rate. Increasing in the video send rate, the delay factor also increased. From our observation we came to find that on 1 Mbps data rate the delay is 0.32ms, on 5 Mbps data rate the delay is 2.02ms, on 50 Mbps data rate the Average delay is 4.04ms and on 100 Mbps data rate the average delay goes to 6.33ms.

As total end-to-end delay is composed of transmission delay, propagation delay, and queuing delay.

Video Send Rate (Mbps)	Average Delay(ms)
1	0.32
2	0.5
3	1.14
4	1.63
5	2.02
6	2.46
7	2.82
8	3.32
9	3.72
10	4.22
50	4.99
100	6.33

Table: 6.2 Delays (ms) vs. Video Send Rate (Mbps)

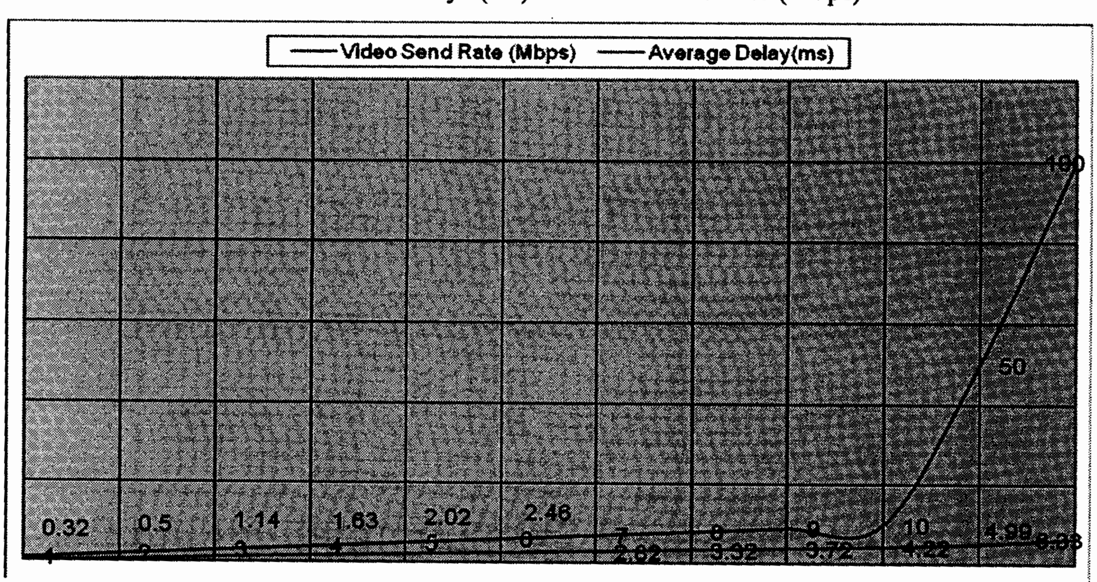


Figure: 6.5 Delays (ms) vs. Video Send Rate (Mbps)

6.10.3- Packet Loss vs. Video Send Rate

Table 6.3 and Figure 6.6 show the number of dropped packets by varying the video traffic send rate. On setting the buffer size 50 packets, and increasing in the video send rate from 1 Mbps to 8 Mbps the number of dropped packets is 0%. When increasing in the date rate from 9 Mbps to so on the packets has dropped. The noise, two ray propagation models are the real factor that affects on the delay performance factor. On transport layer the UDP (User Datagram Protocol) is used, which is unreliable and have no congestion control mechanism.

In this case we observed that the packet loss from 1 Mbps to 8 Mbps is 0%, on 10 Mbps video send rate it goes to 1.18%, and from 50 Mbps to 100 Mbps video send rate it varies from 1.11% to 3.90%.

Video Send Rate (Mbps)	Packet Drops
1	0%
2	0%
3	0%
4	0%
5	0%
6	0%
7	0%
8	0%
9	0.34%
10	1.18%
50	1.11%
100	3.90%

Table: 6.3 Video Send Rate vs. Packet Loss.

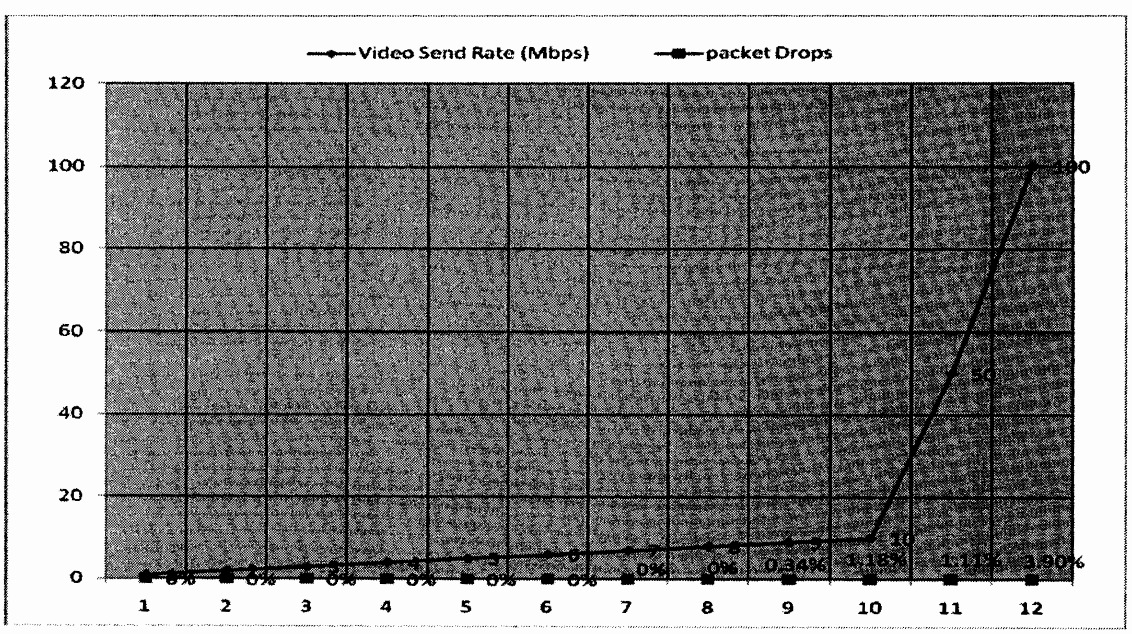


Figure: 6.6 Video Send rate vs. Packet loss

Conclusion

The objective of our research is to analyze the performance of video streaming in WiMedia by taking the performance parameters: delay, packet loss and throughput with respect to data rate. We carried out our experiments in NS-2.29. This simulation consists of two nodes, which are at distance of 10 meters sending MPEG-4 video packets for 50 seconds. In this simulation utilizing the 7.5Gbps bandwidth of WiMedia with a noise $1 \times e^{-11}$ dB and on transport layer UDP (User Datagram Protocol) is used, with a two-ray propagation model.

According to the WiMedia alliance that 110 Mbps data can be send at 10 meter distance, so the achieved results are satisfied, and only miner throughput and packet loss are found. The difference between maximum throughput and achieved throughput is affected by some real factor such as noise, propagation delay and behavior of Two Ray Propagation model. In our topology the distance between two nodes is 10 meter and Two Ray Propagation model is not effective for short distance. The channel capacity (C = W. Log2 (1+S/N)), the noise factor (S/NdB = 10log10.Signal Power/Noise Power) also affects on the performance. According to the channel capacity theorem, the transmission and switching rate at source also affects the performance. The WiMedia Alliance report Reference (Innovative High Performance Baseband Design), is the high speed processor is required for WiMedia. The WiMedia Alliance is preferred to High Speed Turbo Decoder and FFT/IFFT processor & Viterbi Decoder for UWB Applications. Most of the research papers we consulted suggest the basic focus on the hardware specification. They mention that silicon chips and different modulation techniques can help to achieve the better performance of WiMedia technology. So our final result will be that the performance of the WiMedia is hidden in its bandwidth, buffer size, high speed processor (Hardware specification), and coding schemes. The factors noise, propagation delay and two ray propagation models are the real factors that effect on performance.

Glossary

API	Application Program Interface
BPSK	Binary Phase Shift Key
CE	Customer Equipment
CRC	Cyclic Redundancy Check
CSMA/CA	Carrier Sense Multiple Access with Collision Avoidance
DSCP	Differentiated services code point
DSL	Digital Subscriber Line
EDCA	Enhanced Distribution Channel Access
FCC	Federal Communication Commission
FTP	File Transfer Protocol
GPRS	General Packet Radio Switch
GPS	Global Positioning System
GSM	Global System for Mobile Communication
HCCA	HCF Control Channel Access
HTTP	Hyper Text Transform Protocol
IEEE	Institute of Electrical and Electronic Engineering
IF	Intermediate Frequency
IFFT	Inverse Fast Fourier Transform
ISM	Industrial, Medical & Scientific
ISO	International Standard Organization
LAN	Local Area Network
LDR	Liner depolarization Ratio
MAC	Medium Access Control
MAN	Metropolitan Area Network
MBOFDM	Multi-band Orthogonal frequency division multiplexing
MIMO	Multi-input Multi-output
MPEG	Moving Picture Expert Group
NAM	Network Animator
OFDM	Orthogonal Frequency Division Multiplexing

OTcL	Object Tool Command Language
PAN	Personal Area Network
PC	Personal Computer
PHY	Physical
PN	Personal network
QOS	Quality of Service
RF	Radio Frequency
SIG	Special Interest Group
SOAP	Simple Object Access Protocol
TDD	Test Driven Development
TDM	Time Division Multiplexing
UDP	User Datagram protocol
USB	Universal Serial Bus
UWB	Ultra Wide Band
WAN	Wireless Area Network
WMM	Wireless Multimedia
WPAN	Wireless Personal Area network

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