An Overview of ATM Infrared Wireless LANs: A Proposed Architecture

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Abstract

This short term paper is a summary for a Proposed Architecture of ATM Infrared Wireless LANs. Due to many advantages it provides, Infrared WLANs are becoming more popular. In this point, providing wireless access to fixed ATM networks starts to be a necessity. This paper is about architecture of such a LAN. The network is established to provide seamless operation between the wired and wireless network, and system performance is revealed under some parameters.

Introduction

Wireless indoor communications which support multimedia services such as voice and video are becoming more interesting in these days. Most of the proposed systems suggest using radio waves for carrier; however infrared wireless technology needs to be considered, especially for indoor networks. Bandwidths of systems using radio waves are not high enough for multimedia services. On the contrary, infrared systems are capable of delivering the high bandwidths for those services. Another thing is that IR cannot pass through walls or other opaque objects, which has both advantages and disadvantages. The advantageous part is that it enables privacy within the area and same bandwidth spectrum can be used in adjacent areas. Its drawback is the increasing cost and increasing system complexity. Another disadvantage about IR transmission is the high noise rate. Solar radiation in outdoor environments and fluorescent lights in the indoor are the main causes of the noise.

Diffuse IR technology is included as a part of the IEEE 802.11 standard, but there are very few manufacturers of the devices for this technology. The main reason for this is the lack of research into the layers except physical layer. Systems such as ATM which enable the transmission of multimedia services needs to be extended into IR diffused channel. This extension must include the possible solution to the Quality of Service (QoS) issue because of the high error rate of the IR. A medium access control (MAC) different than that for the wired network must exist to control the wireless bandwidth for different terminal units (TU). Also, mobility must be supported in the architecture since a TU can move in the network from one cell to another.

A Proposed Scenario for ATM IR Wireless LANs

There are a number of key points in the possible scenario. There is a base station (BS), which connects IR network to the ATM network. First of them is enabling multi-cell system which can be used for covering large areas. Adjacent cells must transmit at different times to prevent collusions. Therefore, BS must control the transmission times of these cells. This control can be done with the MAC protocol at the BS. Another point for the BS is that it should provide seamless connections between ATM and IR. In this multi-cell system, one TU can move from one cell to another, so BS must provide mobility functions such that at any time a TU can only be connected to only one cell. In this scenario, required functions and procedures are gathered in the BS, which makes the overall wireless system less dependent on the ATM network.

The Protocol Reference Model

The protocol reference model explains how to establish a connection between IR and ATM networks. The model includes two different planes, user plane and control plane. In the user plane, the highest layer is the user applications. Below that, there is a layer called ATM adaptation layer (AAL) in the TU which acts as an interface between user applications and ATM layer. The ATM layer is responsible for the routing of the cells. Below ATM layer, DLC and MAC layers exist. DLC layer is responsible for improving the performance loss of the IR link because of the high error rate of the IR link. The MAC layer shares the capacity of the LAN according to the bandwidth requirements of each TU. The lowest layer in the TU is the physical layer. The BS has all of the TU layers except AAL, which enables the transportation between TU and ATM node as transparently as possible. In the control layer, TU, BS and ATM node has SIG layers, which is responsible for the establishing and releasing connection. Signaling ATM adaptation layer exists below the SIG layer and it is responsible for the transport of the signaling and mobility function protocol.

The working mechanism is briefly as follows: First, the BS finishes the control signaling from TU and carries out admission control (CAC) and sends the SETUP message to the ATM node. After that, the connection between ATM and TU is established after checking both networks can support the required level of QoS.

The Medium Access Control (MAC) Protocol

In the protocol, Time Division Multiple Access (TDMA) protocols are used. To prevent collusions when TUs try to reserve a slot, optical codes are utilized. The frames of the MAC protocol are divided into J channel frames, J is the channel reuse factor, and each channel frame is divided into slots. Uplink channel frame is composed of a reservation slot (R) and N information slots (I). Reservation slot is used to request a reservation from BS. When there are not enough slots, BS allocates the slots with a priority order. A downlink channel frame is composed of an acknowledgement slot and N I slots. Acknowledgement frame is used for reservation messages after determining slot reservations for TUs. If there are no free slots for a TU, a delay occurs for the packets that are waiting for transmission. This waiting time is critical in real-time multimedia applications. In these applications, terminals will just drop the packets that exceed a maximum delay (D_{max}). The probability of a packet drop (P_{drop}) must not exceed 1 percent for speech transmissions. Because of this reason, dynamic allocation of the slots becomes more important.

ATM Traffic Models

This article only considers real-time traffic. For this kind of traffic, MAC layer can have two different multiplexing schemas to allocate bandwidth for each TU. The first one is deterministic multiplexing, which allocates peak bandwidth requirement for each TU, which results in small utilization. The second multiplexing schema is statistical multiplexing which allocates a bandwidth smaller than the peak, but greater than the average bit rate of TU. Of course, in such a situation, the value of the statistical bandwidth must be estimated.

Performance Investigation

The performance of the system with a fixed number of variable bit rate (VBR) voice and video sources exist in the system. By the reasons given in [1], the MAC protocol can be modeled as an $M/M/N/^{0}/M$ queuing model, exponential distribution of arrivals and services, N parallel servers, infinite storage and N TUs.

The first result is about the P_{drop} of the system versus the number of voice TUs (M) per cell for various numbers of video sources in the same cell. When there is no video source in the system, M=15 results with an acceptable P_{drop} value, 1%. When one video source is in the same cell, M drops less than 15. Above these M values, QoS is not satisfied, because of the fact that an increase in the M results an increase in the P_{drop}. The second result is about the average access delay (D) versus M per cell. As in the first result, increasing M results with increasing D because of the same reasons. When there is no video source in the same cell, after M=12, D increases rapidly. The third result is about the throughput of the system versus M. Throughput increases as M increases at some point; however at some point it stops increasing, which points the good stability of the system.

Conclusions

In this paper, an indoor WLAN which supports ATM protocol is briefly explained. A scenario for WLAN is given, and a model is given to provide seamless connections. The performance of the system is evaluated for a fixed number of VBR voice and video TUs in the same cell. It is concluded that the MAC protocol structure mainly determines the system performance. Numerical results that show the system performance is also given.

References

[1] ATM infrared wireless LANs: a proposed architecture, Theodorou, P.; Elmirghani, J.M.H.; Cryan, R.A.; Communications Magazine, IEEE, Volume 36, Issue 12, Dec. 1998 Page(s):118 - 123