위성링크를 위한 LAN 접속 서비스 설계와 운영

김 정 호† · 최 경 수††

요 약

무궁화 위성 과제 중에서는 지구국 시스템에서 위성 링크를 통한 LAN 상호간의 접속을 제공하기 위한 시범 위성 네트워크 모듈의 구현을 수행하였다. 이 시범 네트워크는 위성을 통하여 다양한 응용들에 대한 수행을 검증하기 위한 시험을 지원할수 있다.

본 논문에서는 위성 전송시의 장단점을 고려하여 충분히 응용할수 있는 위성-LAN 접속 구조를 제안하였다. 본 네트워크 구조는 두개의 노드에서 복수의 논리 접속을 수행하는 연결 중심형인 위성 프로토콜을 사용함으로서 높은 데이타 전송과 위성 접속 에러율에 대한 높은 성능을 제공한다. 또한, 프로토콜 변환 방법에 따라 라우터 접속을 수행할수 있다. 위성과 네트워크 접속의 구조는 4W의 고출력 증폭기가 장착된 1.8m의 안테나, 위성통신용 모뎀, 위성 네트워크 접속 장치가 설계되었다. 이 시스템은 최대 1.544 Mbps의 전송 속도를 지원할수 있으며 네트워크 관리면에서도 우수하게 동작하였다.

Design and Operation of LAN Interconnection Service for Satellite Links

Jeong Ho Kim† · Kyung Soo Choi††

ABSTRACT

In the frame of Koreasat Project, it has been identified the task to implement a pilot satellite network module to provide LAN-to-LAN in ground system for satellite links. The pilot network will support an experiment to verify the performances of the considered applications through a satellite.

This paper proposes a satellite-LAN interconnecting architecture making full use of satellite benifits and counteracting satellite demerits. The architecture provides high quality data transmission and high performance for satellite bit errors by using a connection-oriented satellite protocol which can establish multiple logical links between two nodes. As a protocol conversion method, router-type interconnection was selected to guard against problems. Based on this architecture, a satellite LAN interconnecting system has been designed, which includes a 1.8 meter antenna with a 4 watt transceiver, a satellite modem and the developed satellite network interface. The system can support high speed transmission rates of up to 1.544 Mbps and superior network management as well.

1. Introduction

Local area networks(LANs) have been rapidly installed in laboratories, offices and factories, because LANs not only provide high speed transmission and easy installation,but also enable computer users to share various resourses and informations. As more LANs are installed, the need for interconnecting the LANs increases.

† 종신회원:대전산업대학교 전자계산학과 교수
†† 종신회원:한국전자통신연구소 책임연구원
· 논문접수:1995년 8월 31일, 심사완료:1996년 7월 4일

A satellite LAN interconnection system, which interconnects LANs with a satellite channel, satisfies the need for sharing resources and information distributed over a wide area. Although LAN interconnecting systems using terrestrial leased lines have already been developed and come into wide use, the satellite systems have the ability to build more economical wide area networks for LAN interconnection by making full use of broadcast and multiaccess capabilities of a satellite channel[1]. However, the satellite channel has some demerits as well, that is, long propagation delay and bit errors in a satellite channel.

Satellite LAN interconnecting systems so far developed lack an error recovery function for satellite bit errors. This lack makes end-to-end performances worse because an end-to-end protocol is not suitable for a satellite long propagation delay. In addition, the conventional systems adopt a bridge-type interconnection method, which can not guard against problems such as broadcast[2, 3].

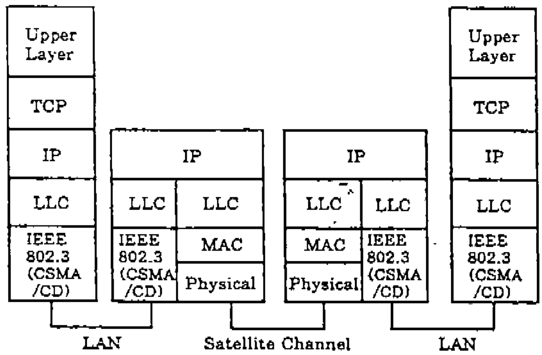
To cope with these problems, this paper proposes satellite LAN interconnecting architecture which makes full use of the satellite benifits. It also presents a satellite LAN interconnecting system based on the proposed architecture.

2. LAN Interconnecting Architecture

Satellite channels have multiaccess and broadcast capabilities, which allow the user to choose a star or full mesh network topology other than a point-to-point topology. We introduce a satellite subnetwork having an original satellite communications protocol, in order to be adaptable to various network topologies [2, 3]. The whole network then consists of LANs, a satellite subnetwork and the SNI(satellite network interface) , as shown in Fig. 1. The SNI is a gateway between the LAN and the satellite subnetwork.

2.1 Communication Architecture

The proposed communication architecture is shown in Fig. 1, where LAN protocols, satellite communication protocols and protocol conversion between them are included.



(Fig. 1) Sat-LAN communication architecture

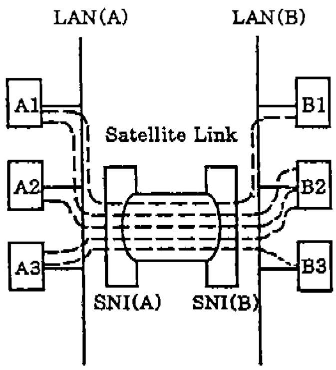
The LAN protocol stack is assumed to consist of IEEE 802.3(CSMA/CD) at the datalink layer, IP (Internet Protocol) at the network layer and TCP (Transaction Control Protocol) at the transport layer. It is the most popular protocol stack for local area networks. The satellite communication protocols consist of LLC(Logical Link Control) and MAC(Media Access Control)sublayer protocols. The LLC protocol is based on the IEEE 802.2 protocol, which can be applied to any network topology such as point to point, star or full mesh[4, 5]. As protocol conversion method between LAN protocols and satellite communication protocols, router-type interconnection, where packet routing is accomplished at the network layer, is adopted[3, 5].

2.2 Satellite Communication Protocols

Of the protocol stacks, an only LLC level protocol is discussed in this paper, for the following reasons. Many multiaccess protocols for satellite channels have already been proposed and developed. Discussion on the MAC level protocol and developed. Discussion on the MAC level protocol requires assumptions of network topology and traffic patterns.

Based on the IEEE 802.2 type 2, the LLC level protocol is devised by introducing the selective repeat ARQ to counteract satellite propagation delay. Owing to error recovery functions in the LLC level protocol, the satellite subnetwork provides high quality data transmission[5, 6].

In addition, to maintain high performances for satellite bit errors, we propose establishing multiple logical links between any two nodes. A conventional data link level protocol establishes only one link between two nodes, even if there are many independent paths, as shown in Fig. 2.

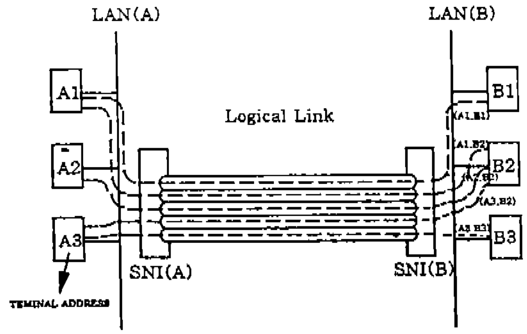


(Fig. 2) Conventional datalink protocol

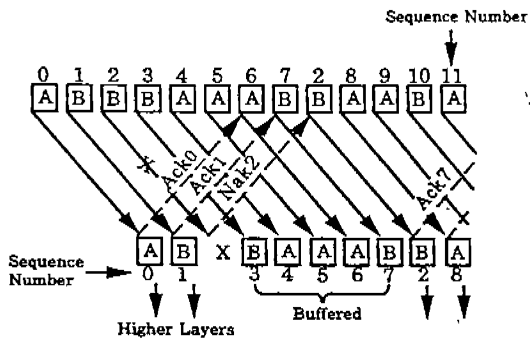
The datalink level protocol accomplishes error recovery on this link without distinguishing these independent paths. This cause throughput and response time degradations because if an error occurs, other paths irrelevant to the error are involved in the error recovery process.

On the other hand, the proposed LLC level protocol establishes independent logical links for different paths, as shown in Fig. 3.

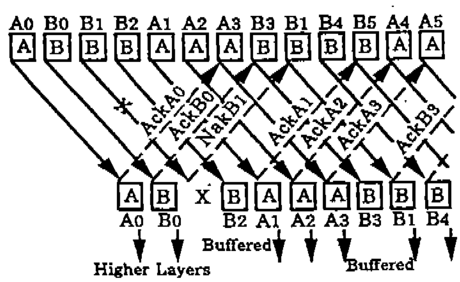
Since the error recovery process on a certain logical link does not affect other logical links, this protocol can maintain high throughput and short response time[7, 8]. Fig. 4 and 5 show error recovery sequence for the conventional protocol and the proposed protocol with two paths A and B.



(Fig. 3) Logical link control



(Fig. 4) Sequence for conventional protocol



(Fig. 5) Sequence for logical link protocol

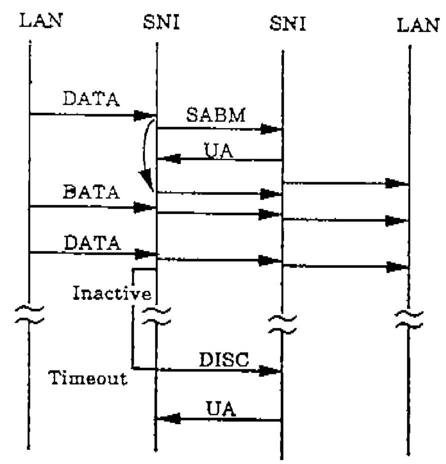
The conventional protocol stores all the correct packets following the error packet until the error is recovered, while the proposed protocol stores only correct packets belonging to the path B. It can be seen that the proposed protocol providc a shorter response time for the path B. At a high bit error rate, it happens that all the correct packets following the error are retransmitted, because REJ type retransmission is activated in an actual selective repeat type ARQ. In this situation, the proposed protocol improves throughput as well as response time.

2.3 Connection Control

Since the paths can be distinguished by using a pair of source and destination IP addresses in IP packets, the logical links can be easily related with the paths. However, there remains one problem regarding when to establish and terminate logical links. This problem comes from connectionless protocols in LANs.

Most LANs use connectionless protocols at lower layers, in order to realize high speed data transmission. This protocol stack does not degrade performances, because LANs have a low bit error and short propagation delay characteristics. Such connectionless protocols do not involve path establishment and path termination processes. The opportunity to establishment or terminate logical links can not be taken, as a result,from LAN protocols[5, 6]. A new connection control for logical links is introduced. When a packet arrives at the SNI from LANs, it is examined whether or not the logical link for sending this packet exists. If the logical link exists, then the packet is sent on that logical link. If it doesn't, a new logical link is created and the packet is then sent on the new link. When an established logical link is not used during a predetermined time interval, that logical link is terminated.

Fig. 6 shows connection control procedures. SABM (Set Asynchronous Balanced Mode) is a command which establishes a new logical link in the asynchronous balanned mode. DISC is a disconnect command which terminates the logical link previously set by a SABM command. UA (Unnumbered Acknowledgment) is a response which acknowledges the acceptance of a SABM or DISC command. The establishment or termination of a logical link is completed, when the UA respones is received aftcr sending a SABM or DISC command. Packets can be sent on the established logical link. Every time packets are sent, a timer is reset. If the time set in the timer has expired, a DISC command is automatically sent to terminate the logical link. The timer period is set on an order of minutes, so as not to frequently terminate the logical link during the time that uper level protocols communicate with each other.



(Fig. 6) Connection control for logical links

2.4 LAN interconnection

Although bridge-type interconnection is simple and can support higher speed packet processing, the proposed architecture adopts a router-type interconnection, where packet routing is carried out at the network layer.

As is well known, a bridge, which connects two network segments, operates at the datalink layer, making the result appear logically as one network. This means that the bridge does not make isolation between the segments, and broadcast packets must thus be passed[3, 8]. By connecting more segments by bridges, broadcast traffic increases. The problem is that increasing broadcast packets causes exhausting more CPU power of all machines on the networks, because all machines must process all broadcast packets.

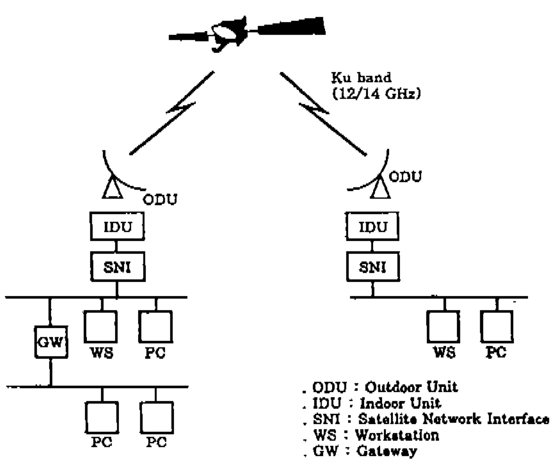
Furthermore, it has been reported that coexistence of different software implementations or different broadcast/subnet configurations generates such strong burst broadcast traffic that few machines can withstadnd their effects[5]. This situation appears in large networks beacuse it is more difficult to mannage and control all software implementations and configurations on the whole network as the networks become larger.

On the other hand, a router provides isolation between network segments and doesn't pass broadcast packets basically. The router can hence connect a number of LANs without the above problems. For these reasons, router-type interconnection is adopted for the satellite LAN interconnection.

3. Satellite LAN Interconnecting System

3.1 System Configuration

This section presents the LAN interconnecting system, in which the proposed architecture with point-to-point topology is implemented between the ETRI(Electronics and Telecommunications Research Institute) in Taejeon and in Seoul. (Ref. Fig. 7)



(Fig. 7) Satellite-LAN system architecture

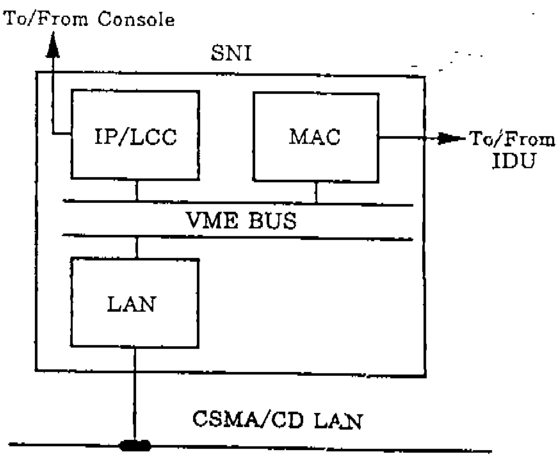
The satellite channel with a 1,544 Mbps transmission rate has been provided by a KT leased tranponder in the satellite, Intelsat VII. The satellite frequency band is 14/12 GHz, called Ku-band. Each site includes a 1.8 meter antenna with Out Door Unit(ODU), which can support up to 1.544 Mbps transmission rates, In Door Unit(IDU), and Satellite Network Interface(SNI). The ODU is a transceiver with 4W power output and is mounted at the focal point of the antenna. The IDU is a QPSK modem with a rate 3/4 convolutional coder and a Viterbi decoder[3, 9, 10]. The SNI developed is a most important unit in the satellite LAN interconnecting system.

3.2 SNI(Satellite Network Interface)

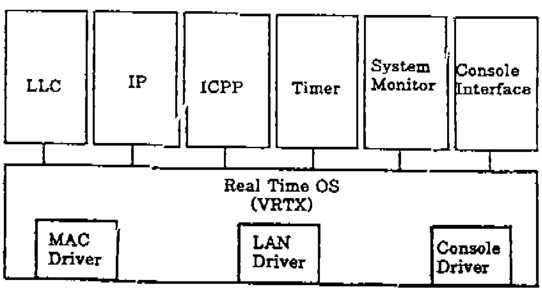
Fig. 8 shows they SNI hardware configuration. The SNI consists of three boards: LAN board, IP/LLC board and MAC board. Three boards are coupled via a common bus. The LAN board contains a LAN communication controller LSI chip, which accomplishes CSMA/CD. The IP/LLC board is a general purpose CPU board, where the programs for protocol conversion are implemented. The MAC board, which accomplishes framing, CRC checking and so on, has been newly developed in order to provide a high speed synchronous interface with any data rates of up to 1,544 Mbps. Because of point-to-point topology, the MAC board has no access control function[4, 11].

Fig. 9 shows the software configuration in the IP/LLC board. The application processes includes LLC, IP, ICPP(Internet Control Packet Protocol), Timer, System Monitor and Console Interface. The real time opertating system(VRTX) includes MAC, LAN and Console drivers. The LLC process accomplishes the LLC protocol, that is, logical link establishment and termination, error recovery, flow control and sequence control.

Main task of the IP process is to accept an IP packet from the LAN board, determine whether the logical link for sending the packet exists or not, and



(Fig. 8) SNI hardware configuration



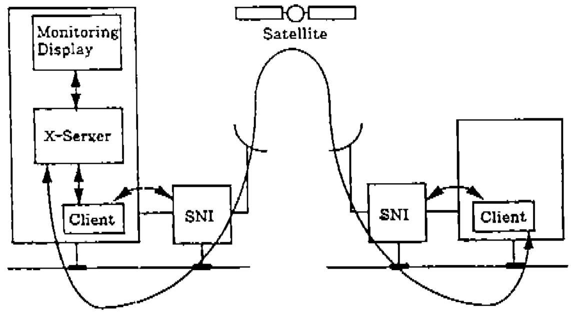
(Fig. 9) Software configuration in the IP/LLC board

then sent it to the LLC process if the logical link exists. If no logical exists, the IP process requests the LLC process to create a new logical link, and then send the packet to the LLC process.

Misclaaified packets are delivered at the ICPP process. If the ICPP process receives such a packet, it generates error messages indicating "parameter problem", "destination unreachable" or the like, and returns them to the IP process. The timer process offers various timing facilities for the application processes. The System Monitor process collects status information such as CPU usage, bus usage, number of retranmissions, etc., and send it to the Console Interface process. The Console Interface process analyzes and executes commands from a console, as well as sending status information from the System Monitor process to a console[7, 11].

3.3 Network Managent

The SNI can operate without a console after initial installation. Even if a system failure should occur, the SNI would be automatically reset by watchdog timer and be recovered immediately. However, in order to support various network management services, we connect a workstation with the SNI mounting programs for network management services onto the workstation[9, 11]. The provided services can be classified into five categories: configuration services, operation services, diagnostics services, performance measurement services and multi-window services. The configuration services enable setting or changing system parameters in the SNI. The operation services provide functions for displaying various bits of current status information, restarting the SNI and escaping to the debugger. The diagnostics services provide self-test and loop-back test functions. The performance measurement services provide functions of logging status information data, processing the data statistically and displaying the results. The multi-window services, based on the X-window system, allow the user to control/monitor both local and remote SNIs simultaneouly[12]. By using the multi-window services, a centralized network management cabn be realized, as shown in Fig. 10.



(Fig. 10) Centralized network management

4. Conclusion

This paper has presented a new satellite LAN interconnecting architecture, where the onnection-oriented LLC layer protocol is used for a satellite subnetwork and router-type interconnection is adopted as a protocol conversion method between a LAN and a satellite subnetwork. Based on the architecture, a satellite LAN interconnecting system including the satellite network interface for protocol conversion has been designed.

The system features are summarized as follows:

- Compact and easily installed
- Up to 1,544 Mbps transmission rate
- Router type interconnection
- High performance error recovery
- Superior network management

The system, which has been installed between the ETRI has been operating since Aug. 1994, and has been used by computer users.

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김 정 호

1980년 경북대학교 전자공학과 (학사)

1983년 경북대학교 전자공학과 (석사)

1990년 S.M.E 위원(네트워크 분야)

1990년 정보처리 기술사(전자계산조직응용)

1991년 전자기술사(공업계측 제어)

1992년 통신기술사(전기통신)

1983년~1996년 한국전자통신연구소 지상시스템 연구부 실장
1996년 3월~현재 대전산업대학 전자계산학과
관심분야: 데이타 통신, 컴퓨터 통신, 위성통신의 지상망 접속

최 경 수

1980년 경북대학교 전자공학과(학사)
1984년 연세대학교 전자공학과(석사)
1980년 한국전자통신연구소 입소
1984년~1986년 Bell Telephone mfg. S1240 파견(벨기에)
1995년~현재 한국전자통신연구소 위성통신기술연구단 책임연구원
관심분야: 데이타통신, 신호망 해석, 위성멀티미디어