IEEE 802.11
802 LAN Access Method for Wireless Physical Medium

DATE: March 1, 1993 Rev: March 1, 1993

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TITLE: **ATM CELL BASED ACCESS METHOD FOR WIRED AND WIRELESS LOCAL DISTRIBUTION**

SUMMARY

Since radio the radio wireless medium absolutely requires a burst mode of operation, and since 802.11 has accepted the task of providing both packet and connection type services; it is appropriate to look closely at Asynchronous Transfer Mode (ATM) cell relay for definitions which are relevant to the 802.11 MAC and PHY. The motivation for the development of cell relay technology was to provide a common transmission and switching technology for packet and connection type service. Further, demand-assigned bandwidth and capacity allocation is provided by this technology, and this capability is essential to new and developing computer communication applications.

The conclusion supported is that the ATM cell format and the segmentation of packets into cells described in IEEE 802.6 is suitable for 802.11. The use of Virtual Circuit Identification is conventient and efficient as a means of short addressing of segments following setup or transfer of packet headers. Adopting this view, many problems in circuit-packet integration disappear or are more easily solved.

It is a further conclusion that the design of large scale systems is best implemented using an 802-defined phy and access method for local distribution from high capacity ports on fast packet switches using ATM cell relay definitions and technology.

This subject is relevant to IEEE 802.6, 802.9 and 802.11, however this contribution limits its scope to the subset dealing with the wireless medium, though use of telephone twisted pair is an essential sub-technology for wireless.

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PART I -- INTRODUCTION

BACKGROUND

Asynchronous Transfer Mode (ATM) cells of 48 octet payload and 5 octet header are the molecule of Broadband ISDN, IEEE 802.6 Metropolitan Area Networks (MAN) and many other implementations which have reached a significant product and market presence. The ATM cell backbone environment is now developing rapidly. It is timely to consider the role of wireless LAN access as an available local distribution service in this context. Medium independent local distribution based on cell relay is now proposed and described.

Motivations

Incentives for using integrated ATM technology are as follows:

- switching and format for cells is independent of whether their content is packet or connection type service.
- the physical medium and access method are decoupled from most of the detail of providing connection type services and public network compatibility.

Without this technology the integration of telephone and computer services is complicated, expensive and little different than running two parallel independent systems. With it, a common communication environment will serve departmental and wide area computing (personal and workstation levels) and ordinary wired and wireless telephony.

IEEE 802.6-1990 and 802.9 Integrated Voice Data Committees

IEEE 802.6 has created an adopted Standard based on a multiplexed isochronous medium into which are loaded ATM cells. Slots are defined to match the cell length, and the access method defines the indication that slots are available or busy and the actions following. The medium is dual bus created from two-ended cables between drops. IEEE 802.6 is a backbone interface adopted by Bellcore for SMDS.

The 802.9 Committee has produced a draft Standard that has passed the Committte on the way toward acceptance. The draft standard defines telephone twisted pair transmission between a workstation and a theoretical hub entity. The station lines are dedicated to the served station and operate at either 4.096 or 20.480 Mbits/sec. The multiplexed isochronous frames in the medium are partly defined as common header with frame configuration control fields and a dedicated Basic Rate Interface. The amount of capacity reservation in the frame for connection services is demand adaptive. While this medium could carry cells, there is no specific utilization of the cell header within the MAC.

802.9 has heard a proposal for a further generation of physical medium multiples with a 16 Mb/sec medium time divided into 125 μsec frames with 10 Mb/s reserved for CSMA/CD type LAN and 6 Mb/s for isochronous services. It is an example of oft-proposed "wire savers" where there is no other commonality between the two services.

Neither 802.9, the prosal to 802.9 or 802.6 access methods could be used with concentrated, uncontained and unreliable mediums for a user station interface.

CONCLUSION SUMMARY

Present ATM practice transports the cells on a reliable, two-ended synchronous bearer such as DS-3 or SONET. The bearer establishes the bit timing relationships between the ends, and the cells are payloads loaded into appropriately dimensioned slots.

In a related wireless local distribution network, there are new considerations:

- The timing for each cell must be re-established for each cell independently of the previous transfers.
- The medium is unreliable, and must make use of physical layer repetition and of redundant copies of one message.

The packet frame and ATM cell header fields and the payload can be passed transparently through the local distribution bearer to and from backbone ATM networks.

ACCESS METHOD PROPOSAL SUMMARY

The primary transfer mode uses a cell frame in which 52 octets are formatted as an 802.6 QA/PA segment (6.3.1, 6.4.1). The QA segment is defined only for packets in 802.6, and the PA segment for pre-arbitrated slots used for connections.

- A local distribution header is prefixed with two octets of preamble and a few octets for access control and start delimiting replacing the 802.6 ACF field. In addition to the suffix CRC-32 and PAD from the IMPDU, a one octet (physical medium) end delimiter may be added.
- The segmentation formats for packets are as shown for 802.6 Derived MAC Protocol Data Units (DMPDU Figure 6-16 and 6.5.2) in which the result is formation of the QA segments for a long packet.
- The 20-bit Virtual Circuit Identifier (VCI) replaces the short address function in the proposals of C. Rypinski to 802.11 (91-19, 91-95).
- The connection type service setup and the 802 MAC header information are contained within the REQUEST message for the station-initiated transfers in 802.11/91-95.
- The last cell (EOM) is any lesser length in which the payload is an integer multiple of 4 octets.
- E.164 public telecom addressing is not supported in the access method, but it is supported as part of a setup payload within the REQUEST message cell.

The length of a transmission will **not** have one fixed length, but will be the necessary length to perform its function. Shorter transmissions will be used for: POLL, ACK, NACK, GRANT, INVITATION-TO-REQUEST and INVITATION-TO-REGISTER (sign-on).

For continuing segments (COM) 0.5, 1, 2 and 4 times 48 octets are proposed as allowed payload size. The upper limit may be adaptive.

PART II -- DETAIL DESCRIPTION

ASSUMPTIONS

The necessary technical functions are assumed which enable the mixing of high performance LAN and wideband connection type services as follows:

1) Medium transfer rates above 16 Mbits/sec on wireless and twisted pairs
2) Modems for very short burst transmissions, acquiring bit clock within a few bits of receiving the transmitted signal.
3) A common medium access protocol for isochronous and packet services.

It is further assumed that local distribution by twisted pair will continue to be the primary medium supporting wireless access points and usingr higr transfer rates. While much of the installed pair wiring is or will be very good, there is still a large proportion that is not. There must be a capability for EIA/TIA 568 DIW 24 gauge horizontal wiring even though newer data grades will allow higher rates and greater distances.

ENVIRONMENTAL DIFFERENCES IN ATM LOCAL DISTRIBUTION

ATM cell relay is primarily a backbone technology using intelligent nodal equipment with high capacity per port and accurate two-ended transmission media between them. Because of the high volume of traffic supported on each link, fairly high cost per port is justified.

The following are major points of similarity and difference between backbone ATM networks and wireless local distribution for the very same services:

- DIW wiring used at high rates resembles wireless because of impulse noise and crosstalk caused erro.
- In local distribution, transmitters should only be ON when in use. With a synchronous bearer, transmitters are ON continuously which is unusable in wireless and causes a higher level of crosstalk in multi-pair cables.
- Multiple copies of the same cell, considered a near unimaginable malfunction in an ATM backbone network, will routinely happen in a wireless network. Similarly, totally unrelated foreign cells will commonly appear on wireless access point ports.
- With an unreliable transmission medium, handshakes and acknowledgments are necessary.
- The station MAC must include a subset access method for peer-to-peer communication when infrastructure is absent.

The protocol for a two-ended reliable medium cannot be used in this environment. The necessary functions for unreliable mediums will not be part of any present or future ATM cell relay equipment.

ACCESS METHOD FOR IEEE 802.11

The IEEE 802.11 Wireless LAN Standards Committee has received a number of proposals for an access method and physical medium few of which contain any specific provision for connection-type services. Those that are concerned with isochronous transfer mostly have periodic frames with a length N x 125 μseconds. A portion of this frame is reserved for the connection-type transfers. This approach is a PHY layer multiplexing of otherwise independent protocol stacks for isochronous and packet services.

In IEEE 802.6, the 52 octet slots are reserved at setup (PA or pre-arbitrated) for isochronous services. The same result is produced in the present proposal by transmitting GRANT or other enabling messages to a station when the designated instant is reached.

The proposals of this Author (802.11/91-19, 802.11/91-95) are based on an access method and physical medium using short packets for all services. This is MAC layer multiplexing. There is more hope that a common LLC can be used when the support for isochronous service is cell-based, and when E.164 addressing is not processed at layer 2.

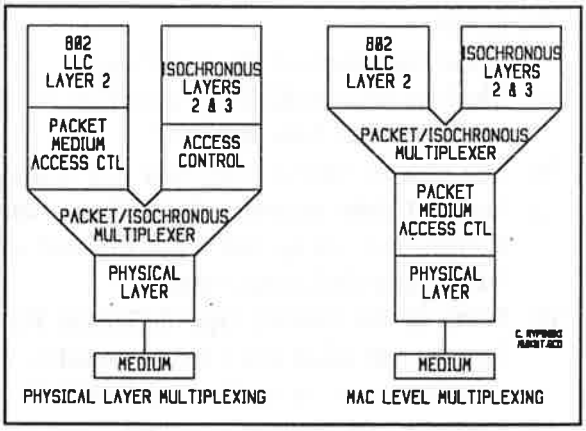

Figure 1 Protocol Stacks for PHY and MAC Level Multiplexing of Isochronous and Packet Services.

These 802.11 proposals describe a limited-length packet medium with asynchronous sequencing. In addition, a five-step handshake is used for station originated messages. The messages using 16-bit short addressing are those that are within the local area and those that follow after source and destination have been identified with long addressing. ATM compatibility is provided by enabling the cell payload of 48 octets to be the payload within the normal packet.

The format convergence between ATM and wireless LAN is provided at an intelligent hub common to a number of access-points and many more stations. This hub is specific to wireless and twisted pair local distribution.

This proposal now describes modification of the access method to use the ATM cell formats and segmentation definitions taken from IEEE 802.6 MAN, however the access methods and unrelated physical medium are not used.

MESSAGE FUNCTIONS WITH INTEGRATED ATM FORMATS

The type and function of the various messages is somewhat changed by the introduction of the ATM header fields. Short address functions are replaced by VCI identifying both source and destination, but not directionality of the transfer.

Some consequences are as follows:

a) The long address REQUEST remains but the short address form is deleted.
b) The address field is shortened to 6 octets.
c) Segment data transfers that did use short address now use the 802.6 QA segment with VCI plus added prefix octets.
d) Some of the service type definition fields become redundant and are superseded by the same functions in the QA and DMPDU.
e) Multiple simultaneous connections and sessions are differentiated by VCI rather than the connection no. field.
f) Only a controller within the infrastructure can assign an active VCI to a station. The station can only assign itself the default VCI for an overhead function.

Quiescent Mode

In the quiescent mode, each access point transmits the following types of messages:

1) INVITATION-TO-REQUEST (services)
2) INVITATION-TO-REGISTER (sign-on)
3) Addressed Station POLL
4) ACK (registration or poll)

The first two messages are unaffected since these messages use null addresses (VCI format). The POLL and the overhead ACK messages could use the default VCI now defined as the 20 last bits (LSB) of the global 48-bit LAN address. Response to the POLL from the station also could use the default VCI.

Traffic to the Station

The infrastructure becomes aware of the identity of the access point to be used for the next transmission toward a station from the POLL information. The message initiation does not require a search to determine the access-point with which a station is associated. The infrastructure controller determines when a message can be sent to a station.

Even though a packet is a transmission between local stations permitting short addressing, the address **should not be the default VCI of the addressed station.** It is necessary to use long addressing on the first transmission of a transfer (BOM) to forward the source address, the destination address and the VCI to be used for a setup function in the first transmission. These field formats become those of the 802.6 IMPDU header (6.5.1.1)

Since a station may have more than one mode or one session of communication operating simultaneously, it is possible for one station to be using several VCIs at the same time.

The ACK from the station to the access-point uses the assigned VCI.

Traffic from a Station

The long form of REQUEST message must be used for the same reasons as above. The long form of addressing is used in the GRANT response message carrying the new assigned VCI from the access-point.

The assigned VCI is used in the Station-originated DATA TRANSFER messages and in the segment ACKs from the access point.

Station Initiated Five Step Handshake Data Transfers

For communication in an unreliable medium, the data transfer should not be attempted unless there is assurance that the channel can be used exclusively and that the necessary path exists. For this purpose, a station originated data message transfer consists of the following sequence of messages:

	Manager Originate	Station Originate
1)	Transmit enable	
2)		Request to transfer
3)	Grant to transfer	
4)		Data transfer
5)	Acknowledgement	

Autonomous Mode Transfers

The autonomous mode is simple "Aloha" inhibited except where there is no infrastructure. At will, an originating station sends a REQUEST and listens for a GRANT from the addressed station. Long addressing in REQUEST and DATA TRANSFER messages must be used. The GRANT and ACK messages could use the default VCI.

Because of the need for the autonomous mode, it has been necessary to use time-division duplexing of the medium. This mode is efficient with directionally asymmetric traffic.

VCI Originate-Terminate Ambiguity

Because of a repeater function, an originating station may hear its own message rebroadcast. This case does not arise in a wired plant. Using only the VCI, the station has no way to distinguish its own transmission from the reply of the addressed station.

While separate VCIs could be used for in and out bound transmission. It is better to have fields in other parts of the header to distinguish originating (A) and terminating (B) party messages.

Broadcast Messages

The same long addressing and subfields that is used in 802 LAN for this purpose. It may be possible to associate multiple destinations with one VCI, but this may not be assumed without further study. It may be possible to have some reserved VCI values for broadcast after study of consequences should these fields be passed to or fortuitously received from an external network.

DUTIES FOR THE INFRASTRUCTURE

It is the function of an intelligent hub controller to maintain a data base in which cross-referenced addresses and active communication modes are available for use in relay processing.

Telecom Address Processing

The infrastructure controller must recognize and process E.164 addressing in the setup parts of REQUEST and 802.6 BOM messages. The controller must translate to/from the 802 LAN addresses of its registered users from/to telecom E.164 addresses as needed.

The infrastructure must repeat data transfer segments with VCI addressing unchanged between access-points in the local area or to/from ports to external networks.

Use of Redundant Paths

The intelligent hub for the wireless network will have the means to use redundant radio coverage to increase the probability of successful receipt of a station transmission. This type of space diversity is the most powerful offset to signal loss from passing pedestrians and vehicles.

Automatic Repetition

Normal ARQ function is simply retry on the then existing channel when unsuccessful transfer is detected. For a wireless medium, there may be a choice of ways in which to make a retry. An alternative access-point or transmission rate might be used. As long as the repeat function is medium dependent, it must occur in layer 1. If it does not occur at this point, higher layer functions may have to be altered to accommodate wireless.

The closer to the physical medium at which this function is invoked, the greater the speed with which the decision can be made that repeat is necessary.

SEGMENTATION OF LONG MESSAGES

Higher layer software and protocols all form single packets longer than 192 octets; and therefor segmentation in MAC/PHY is necessary. Lengths of 24, 48, 96 and 192 are proposed. **Cells exchanged with external networks would be limited to only 48 octets at the Gateway.** Once set at the origin, there would be no accumulation and resegmentation in the local network or in ATM based external networks.

It is possible that the longest cell might be used over the wireless medium for wider band connections, even though a connected ATM trunk was processing normal length cells.

The primary motivation for adaptive cell length is better use of radio channel time and faster access and transfer.

Multiple Payload Length Cells

Like the short packets previously described, ATM cells do not use time of occurrence as an addressing mode. Unlike the short packets, they have a fixed rather than an adaptive length.

Should it prove desirable or necessary to obtain a greater efficiency in use of air time for longer messages, it might be feasible to use one of several defined cell sizes. These lengths might be integer ratios of the standard ATM payload as follows:

0.5, 1, 2, and 4 times 48 octets.

The lengths could be assigned adaptively with local long transfers favoring the maximum length, and shorter transfers taking the length necessary. The longer size would be used for large file transfer, system load permitting; and the shortest size for compressed voice where minimum transfer delay is required. The modification of the short packet plan to use a few different fixed payload lengths might usefully reduce the difference between processing in the backbone and local distribution networks without material disadvantage to either.

CONCLUSIONS

Previously, it had been assumed that ATM cells would be transferred through the local distribution by encapsulation within the frame structure used for wireless. The circuits handling the segment formatting for ATM would then be redundant with those processing the local distribution access functions. This would be satisfactory for those networks in which a small fraction of the total traffic is ATM and where that capability might be an option.

The possibility now described is that of using the fields of the ATM header as essential sub-elements of the wireless access method to reduce circuit and function redundancy in the station. It is shown that the VCI can be used as a short address within the local distribution network on all transfers and messages after REQUEST and the first transmission of Station-terminate transfers. The saving in channel time from short addressing will be very important for connections with many segments per setup and for segmented long packet transfers. The improvement in channel time usage is significant.

Use of ATM format might be considered to enable use of existing and pending designs of cell relay equipment as intelligent hubs (at the wiring closet) for groups of access-points. The functions are described which would not be available in off-the-shelf versions of such equipments. However, there might be a large amount of technical commonality with such cell relay equipments.

The overwhelming advantage of the methods proposed is that a common MAC is much more easily used for both connection-type and packet services. The lower layers for the wireless and twisted pair mediums are much more isolated from the details of the upper layers of these services.

The benefit to the user is that a common infrastructure will serve nearly all wired and wireless communication needs including the new services for real-time compressed video.

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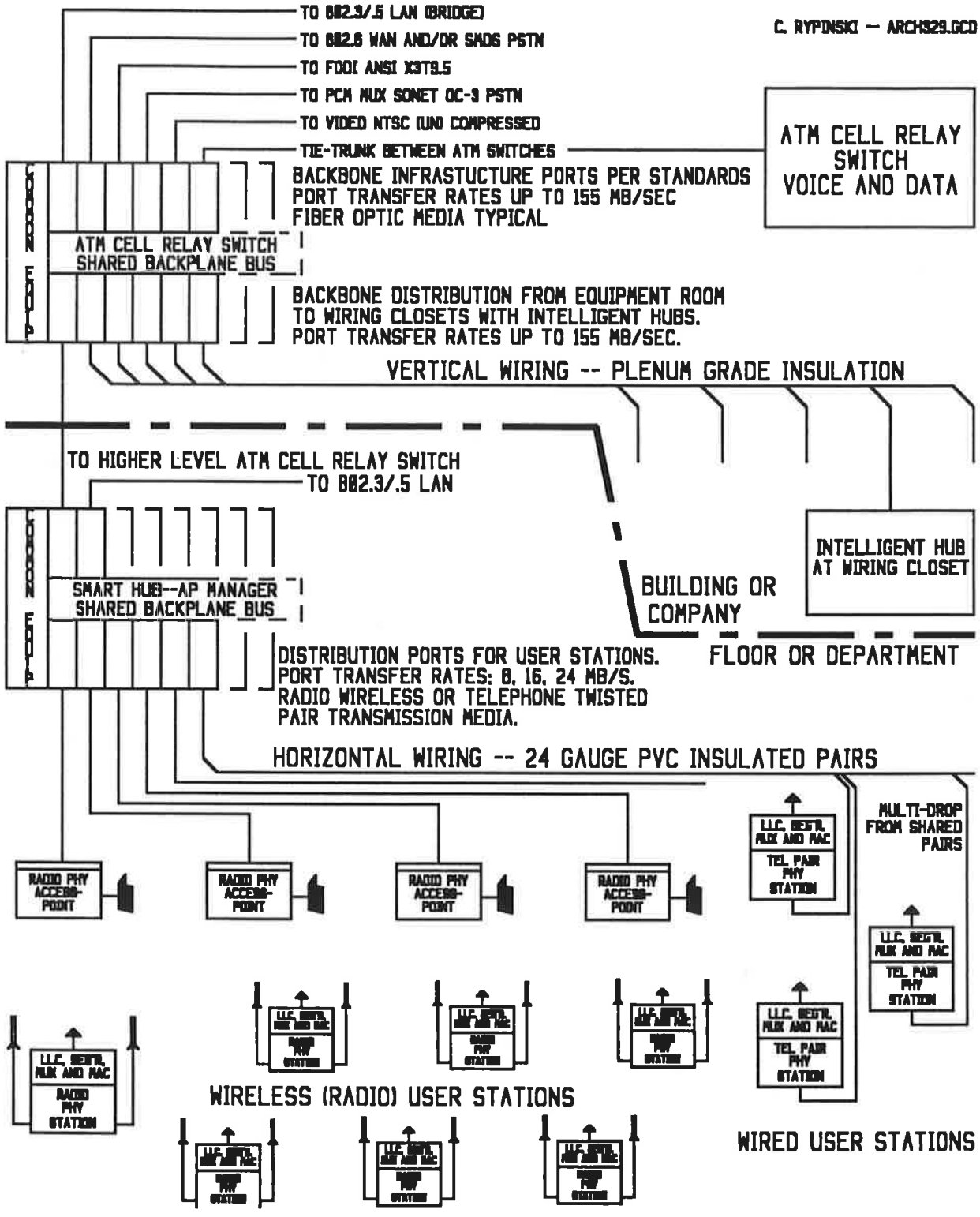

Figure 2 Implementation Topology for Local Distribution with Backbone ATM Cell Relay.