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TITLE: **CHANNELIZED SYSTEM ACCESS METHOD USING INFRASTRUCTURE CONTROL**

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SUMMARY

This access method is based upon a system plan with code-division-spread-spectrum channelization of 10 or 17 channels which is optimized for large-scale, wide area use. The method depends upon infrastructure access control.

Contention is allowed for Stations requesting access within a limited set of contenders; however, allotment of a data transfer channel is exclusive within one reuse cluster.

The protocol is implemented with sequential message transfers using the referenced message set.

Full provisions have been made for direct peer-to-peer communication and virtual circuits with demand-assigned bandwidth.

It is possible that the access method could be expanded to include the non-infrastructure mode of -96 when there is no infrastructure available.

This is the second of three access methods that have been developed all using the same message set and which can be characterized as follows:

1) With and without infrastructure, sequential use of one channel at all Access-points within one reuse group. (Revision of IEEE 802.11/91-19)
2) **With infrastructure control, sequential use of a common setup channel and parallel use of a number of data transfer channels derived by code-division spread spectrum or otherwise.**
3) Independent of infrastructure and without virtual circuit support, random contention use of a common setup channel and distributed channel selection for following use of one of several data transfer channels.

Table of Contents Page

CHANNELIZED SYSTEM ACCESS METHOD USING INFRASTRUCTURE CONTROL

OVERVIEW

Three access methods have been developed all using the same message set. The first two plans make primary use of infrastructure, though they both support direct peer-to-peer communication when possible. The last plan supports only peer-to-peer until infrastructure is added.

This access method is based upon a system plan with code-division channelization of 10 or 17 channels which is optimized for large-scale, wide area use. The use of this number of channels provides considerable space isolation between Access-points using the same channel code.

One of the derived channels is defined as a "setup" channel commonly but sequentially used at all Access-points. All transfers begin on this channel.

Contention is allowed for use of the system within a restricted set of contenders, however allotment of a data transfer channel is exclusive within one reuse cluster.

The protocol is implemented with sequential message transfers using a message set which is capable of serving this and the other access methods.

Full provisions have been made for virtual circuits with demand-assigned bandwidth.

The identical plan would be equally usable for channelization by frequency or time division. It is a good way to use the availability of code-division channels in a spread spectrum transmission technique.

Transmission are initiated asynchronously meaning that there are no fixed dimension timing frames or slots. Each transmission begins when the necessary pre-conditions are satisfied none of which are fixed time intervals. There is no addressing in the form of time location in the bit stream.

The topology assumed is one system (reuse group) with 9, 16 or 25 Access-points on which Invitation-to-transmit appears sequentially. Dynamic allocation is possible when the number of available and parallel usable data channels is less than the number of Access-points in a reuse block.

The protocol is fully described, but traffic capacity analysis is left for a later contribution.

This access method is well suited to data rates in the physical medium of about 1 to 2 Mb/s with code division spread spectrum modulation, and higher with narrowband modulations.

DESCRIPTION OF THE ACCESS PROTOCOL

This access method uses the message set shown in a separate contribution to IEEE 802.11/91-80. This message set is also used or usable in other types of systems.

The description below is from the viewpoint of the individual user Station unless otherwise noted.

Initial Conditions and Common Setup Channel

Using the channels selected by code division in the direct sequence spread spectrum modulation, one channel or code (e.g. N=0) is selected as the "setup" or default value. It is used by all Access-points and Stations until a packet transfer is set-up. The Station is quiescently always ready to receive on the Setup-channel. Stations and Access-points then know in advance that this channel will be used to initiate communication.

This is the same as a dedicated signaling channel found in telephone type system designs, except for the site-sequential use pattern for the Setup-channel.

If an infrastructure is present, its Access-points are transmitting *POLL*, *INVITATION-TO-REGISTER* and *INVITATION-TO-REQUEST* messages as described below.

No Infrastructure Present

When a Station does not hear any of the above infrastructure messages, there are two possibilities:

1) the Station may assume a default no-infrastructure, contention mode is in operation, or
2) the Station assumes no infrastructure is present, and it activates a simplified default Access Manager which makes the first activated Station operate sufficiently like one Access-point to enable autonomous intercommunication within small groups of Stations.

Operation with no infrastructure is more fully described later below for the default Access manager mode, and in a separate contribution (802.9/91-96) for the distributed contention mode access method.

In this protocol direct peer-to-peer is a supported function with or without infrastructure.

Registration Function

Stations just entering the system listen first for the *POLL* and *POLL-INVITATION-TO-REGISTER* messages on the Setup-channel from which they identify the system providing the infrastructure. The Station cannot know which is the strongest signal received or which site would provide it, though it can recognize a usable signal on the Setup-channel.

The infrastructure provides an *INVITATION-TO-REGISTER* message (007) at the same frequency as a complete Poll described below. The message format differs only in having an open destination address field. This message is sent sequentially from a group of overlapping coverage Access-points all operating on the common Setup-channel.

The unregistered Station upon hearing an *INVITATION-TO-REGISTER* sends a *REGISTER* message (102) with a long address (6 octets for LAN and 60 bits for telephony within an 8 octet field) and hears a Packet-data-frame (003) with long address in response. The payload of that frame contains the assignment of a temporary short address (2 octets) to that Station. If there is no response, the Station tries again at the next opportunity on a different Access-point if available or the same one. The registration *ACK* includes the identification of the Access-point from which it came, and the Station notes this as the current serving Access-point.

Once a Station is registered, it is periodically polled and the infrastructure knows how to reach it. The *POLL* message is the means used to be sure that each Station is present, active, assigned a short address and associated with the correct Access-point in the directory maintained by the System in the Hub Controller.

Polling Function

Using the Setup-channel, the infrastructure sends a *POLL* message (007) to every known user of the system periodically. The time used is one *POLL* after each round of *INVITATION-TO-REQUEST* messages on all Access-points after a *POLL* round is initiated and where there is no traffic waiting. This time makes only a slight increase in the minimum scan time.

The *POLL* transmission originates on the Access-point last used by that Station, otherwise a group of surrounding Access-points is used for a second try. The *POLL* messages are interspersed with other Access-point transmissions.

The addressed Station responds with a Setup-channel *ACK* message (110), and it notes the identification of the Access-point from which the *POLL* was received as current.

The air-time required for one poll is ((8+7)octs+10μsec) 130 μseconds at 1 Mb/s. With 20 Stations per Access-point and 16 Access-points per group (320 Stations), the polling function uses 41.6 milliseconds per round. The frequency with which a *POLL* round is initiated is a configurable parameter.

Only the Access-points have the capacity to measure and use received signal level. If the response of a Station is at a higher level on a different Access-point than on the currently identified Access-point, the status entry for that Station will be changed accordingly in a system status directory.

Summary of Access Method for Station Originated Packets

The concept of the system is that Stations may *REQUEST* permission to transmit on a common Setup-channel only when enabled following receipt of an *INVITATION-TO-REQUEST* message originated at the Hub Controller. The *GRANT* is made on the data channel after which the data is transferred on the assigned data transfer channel.

Station-to-Station case: For the addressed Station to receive the message directly without repetition by the infrastructure, it must hear the data channel designated in the *INVITATION-TO-REQUEST* and the *REQUEST* message directly; and it must immediately switch to the designated data channel. When the *PACKET DATA FRAME* has been received correctly, the addressed Station must send *ACK* before the same action by the Hub Controller.

Access-point Originated *INVITATION-TO-REQUEST* Messages

The Hub Controller will send *INVITATION-TO-REQUEST* messages only if the conditions necessary for immediate and successful transmission are present. The Hub Controller is responsible for knowing the interference possibilities that go with the use of each Access-point, and to assign an appropriate channel for the data transfer.

The *INVITATION-TO-REQUEST* message (005) is originated consecutively on the same channel at each Access-point in a block to avoid interference from radio coverage overlap if used simultaneously. The *INVITATION-TO-REQUEST* message contains a CHL field identifying the channel that will be used for *GRANT* (015) and the following data message. This serialization of the use of each Access-point is employed for the access function, but not for the data transfer function which is parallel and distributed over many channels.

Normally, and when there is no inter-system synchronization of the Setup-channel, it is possible for the Hub Controller to step quickly to the next Access-point because the packet transfer on the current Access-point is on a different channel and non-interfering. Further, several packet transfers can be simultaneously in progress on different Access-points using different channels.

Numerical Example at 1 Mb/s with 10 μsec Propagation Time

Scan time is used below to describe the time period required for all Access-points in one group to have given its served Stations an access opportunity when not saturated by Access-point originate messages.

INVITATION-TO-REQUEST requires 64 μseconds to transmit. If there is no *REQUEST* observed within 36 μsec, it would be possible to transmit these at 100 μsec intervals. If there is a *REQUEST* and the *GRANT* is sent on a pre-designated data channel, the total channel time used is (88+10+64+10 =) 172 μsec. With a 9 Station sequence and one access per round, there would be an access opportunity once every (172+8x100=) 972 μsec. The transfer of a 48 or 288 octet payload would use (*GRANT*+10+PDU) 558 or 2,478 μsec on a data channel. The 48 octet payload corresponds to a 64 Kb/s isochronous channel sent with 6 milliseconds of samples in each packet.

Station Originated Message

All Stations monitor the Setup-channel continuously and are able to hear *INVITATION-TO-REQUEST* messages usually from more than one

Access-point. A Station may send a Setup-channel *REQUEST* message (106 or 108) immediately following receiving an *INVITATION-TO-REQUEST* message (005) from the same Access-point at which it was last polled. If the *INVITATION* messages from that Access-point are not heard within a specified interval (e.g. 100 milliseconds) and if other Access-points are heard, a Station would re-register. However, a Station with a message waiting could use any Access-point with matching system identification (SYS field) after the no-receipt time-out is expired.

The Station will receive a Setup-channel response, *GRANT* or *NACK*, from the last assigned Access-point immediately or not at all. It is possible, and may be desirable, to have a wait interval during which the Station may receive a *GRANT* (015); and in this case, the infrastructure would reply with immediate *ACK* (011) which would enable the wait function. The wait state would be appropriate for delays not greater than a maximum transmission length (e.g. 2,500 µsec).

Alternatively, there could be either *NACK* (013) which would cause *REQUEST* to be repeated or no reply to the Station *REQUEST* which would return the procedure to the beginning. It is possible for a *REQUEST* to be rejected because the infrastructure does not have the resources to process the message at the time of the *REQUEST*.

The *GRANT* message repeats the N value of the channel to be used for the following transmission, it sends a power level setting, and both destination and source short addresses. After the *GRANT* is received the Station sends the *PACKET DATA FRAME* (114) using the assigned Channel-N.

It is also possible for the *GRANT* message to indicate a second change of channel for transmission of the data frame, however no use for this capability is now apparent.

After the *PACKET DATA FRAME* is sent, the originating Station waits for *ACK* (110 or 011) which may come immediately and directly from the addressed Station or from the Access-point after a delay equal to the length of the *ACK* message. Either *ACK* ends the cycle. This is the mechanism which allows successful Station-to-Station transmission to supersede the repeat function of the infrastructure.

If the Hub Controller knows that there is no possibility of the addressee having heard the *REQUEST* directly, the *ACK* is immediate.

If no *ACK* is received, the Station may repeat the cycle unless the message is part of a connection-type service. For virtual circuits, there is no *ACK* function since a delayed packet is a lost or useless packet.

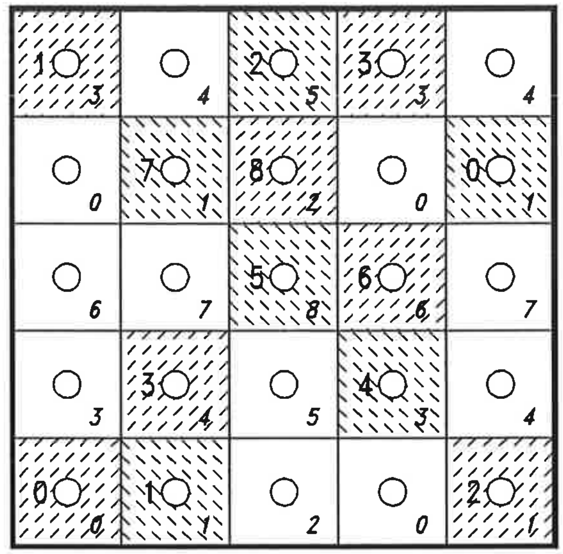

Figure 1 25 Access-Points of which 13 are Active using 9 data transfer channels

Italic numbers lower right =
fixed assigned channel numbers for reuse=9
Roman numbers center left =
dynamically assigned channel number

Fixed-Assigned Channel Selection for Data Transfer

The basic Channel-N selection is determined by a fixed relationship between Access-point location and data transfer channel used. A reuse factor 9 group needs 9 data transfer channels which can all be used simultaneously.

The use of the Setup-channel may be asynchronous for one group of 9 Access-points. If several such groups are used contiguously, the use of Setup channel must be time-slotted synchronously between the reuse groups. The width of the slot must be the time required for *INVITATION-TO-REQUEST* and *REQUEST*. At 1 Mb/s, this is less than 200 µsec per slot and a total scan time of 1800 µsec.

The longest possible message (2.5 milliseconds) may not be completed before the access opportunity comes around again. The corresponding Access-point will not transmit *INVITATION-TO-TRANSMIT* unless at that instant the data channel is available.

Dynamic Assignment

Channels can be dynamically-assigned by the Hub Controller by a variety of methods. As shown in Figure 1, channels can be assigned as needed so that the number of available channels can cover a larger number of Access-points. A number of strategies are possible which all depend upon additional logic in the infrastructure but which do not affect the air-interface of the Station logic.

The possible logics may be slightly different for an indefinitely large system and one that has many Access-points but is still bounded (e.g. 25 Access-points or less).

Receiving Station-to-Station Direct Communication

If a Station hears first a Setup-channel *INVITATION-TO-REQUEST* containing a designated data channel and a *REQUEST* message for which it is the addressee, it is primed for a direct transfer on the designated data channel. The addressed Station now switches to the designated channel where the *GRANT* message is heard as a confirmation, and then the full data frame is transmitted. The addressed Station must *ACK* immediately on the data channel when the data transmission is completed or the same frame will be retransmitted from the Access-point.

This functional capability is what requires that the *REQUEST* message be transmitted on the Setup-channel.

The direct Station-to-Station capability is configurable within the infrastructure to be active or disabled.

Hub Controller Originated Message

For the Hub Controller to send a *PACKET DATA FRAME* to a Station, the addressed *SET* Channel-N message (009) is transmitted using the Setup-channel from the appropriate Access-point. If power setting is used, the power level setting commanded is determined by the result of the last poll of that Station.

The *SET* message is heard by the addressed Station which immediately switches to the channel indicated in the message. Immediately following, the Access-point transmits the *PACKET* or *SEGMENT DATA FRAME* (003 or 001) to the Station using the same Channel-N value.

At the end of the *PACKET DATA FRAME* transmission, the Station sends *ACK* (110) or *NACK* (112) or nothing. There is no *ACK* for packets used for virtual circuits or for broadcast messages.

The message transmitted could be from outside the network or from any Station within the network.

Channel Assignment and Implementation Features

When a the Hub Controller uses an Access-point to send an *INVITATION-TO-REQUEST* message, it contains the Channel-N identifier that will be used for the subsequent message(s). The Channel-N is sequentially selected by the Hub Controller according to any suitable algorithm. The access protocol and the design of the Station logic are constant and unaffected by the particular data channel assignment plan that is used.

With this access protocol, a Station receiver is not required to search for the right channel or code or evaluate comparative signal level. The Station either uses the Setup-channel or the channel instructed by the Access-point in either an *INVITATION-TO-REQUEST*, a *GRANT* or a *SET* message. The Station and the Access-point always know what channel will be used next.

SEGMENTATION AND AUTO-GRANT

There must be a limit to the maximum length of one message or connection bundle. By using a low limit for one data transfer, it is possible to allot a fraction of the capacity to each of several users rather than queue all behind a long message transmission. This is a feature that may or may not be used for packet data, but it is essential to the guarantee that a portion of the transmission capacity is available for connection-type services.

With limited message length, it is necessary to segment the transmission of long packets and connections. The implication is that the setup procedure is done once with full exchange of information, but thereafter segments are transmitted with only sufficient information attached for identification of the associated packet or connection.

In either case an auto-grant procedure is used where the Hub Controller automatically sends a *GRANT* without a *REQUEST* on the setup channel. It is not necessary to send consecutive segments on the same data channel because the CHL field is in the *GRANT* format.

The procedure for handling LAN packets longer than the protocol payload limit (e.g. 288 octets) is to divide the message into transmission segments of maximum length except for the last. A similar procedure is used for virtual connections where each bundle of samples is processed as a segment of a message of undefined (or long) length except for marking of the last segment.

REQUEST-GRANT Procedure for First Segment and Setup

There is no difference in the setup procedure for a complete message or the first segment of a long message. The format is identical for the *PACKET DATA FRAME* (003) and *REQUEST* (003/108) that is a complete message or the first segment of a long message. The difference is in the content of the LEN, SID and CNN fields. These fields are not available in the Short address format so it cannot be used for segmented messages.

In the long address, there are 4-bits set aside for distinction between LAN and ISDN addressing, and for marking first, intermediate and last segments. The definitions used are determined by future public network practice for B-ISDN, SMDS and IEEE 802.6. Similar functions are independently defined for this access protocol by the SID field in the first transmission only.

The LEN field at 13-bits can define lengths up to 8,191 octets which is larger than the length limits in most Standard LAN protocols.

Auto-Grant

A rule of the access protocol is that a Station may not transmit except after receiving a permission message from the Hub Controller. The Hub will know that a Station has requested a service which is a multi-segment LAN packet. From the SID and LEN fields, the number of segments required can be deduced.

The first *GRANT* (015) is for the first segment only, however, with the auto-grant feature implemented no new *REQUEST* need be made for the following segments. The Hub Controller, using a time interval preceding that of an *INVITATION-TO-REQUEST,* can issue a *GRANT* automatically for each following segment until the transfer is complete.

The addressing of following segments is short address as already established for Stations upon registration. The same identification is used for Station-originated segments where the short address is a pointer to the long address passed in the first *REQUEST* message. This procedure resembles the "Virtual Circuit Identifier" in 802.6 defined ATM cells.

Auto-grant is not required for Access-point originated messages. For transmission of segments to Stations, the Hub Controller knows when the appropriate Access-point and Station are available. The *SET* Channel-N and Segment data frame are then transmitted on the setup and data transfer channels consecutively as with ordinary packets.

SEGMENT DATA FRAMES

The *SEGMENT DATA FRAME* uses a short address only (001/100), and it is always transmitted on the assigned data transfer channel following receipt of an initiating message on the Setup-channel. For Access-point originated segments, the initiation starts with the *SET* (009) message, and for Station-originated messages, it starts with the *GRANT* (015) message. Both of these messages necessarily contain CHL and PWR fields.

The SGN (segment number) counter field of 5-bits is a continuing up-counter on the number of segments transmitted which is set to 0 the first time transmitted (For Access-point originate, the second data frame and the first segment. For Station originate, the first data frame.). This counter provides a means for resequencing or detecting missing segments. The value of SGN will not repeat for packets shorter than 9,790/9,216 octets.

3-bits of the SGN field are used for a status indication of initial, intermediate or final segment in a long transfer.

The CNN field is in the segment header because of the possibility of concurrent multiple connections during a packet transfer. A Station may transfer only one packet at a time.

COMPATIBILITY AND CAPACITY ALLOCATION FOR PACKET AND CONNECTION-TYPE TRAFFIC

With infrastructure present, absolute allocation of capacity for carried traffic is possible, because the Hub Controller determines who may transmit and the carriability of offered traffic. The logic of the Station does not participate in this choice in anyway, except for assigning the priority of its own originated traffic.

Every system or plan has a limit to the amount of traffic that can be carried. Many efficient systems carry less rather than more traffic when the level of demand reaches a critical point. When both voice and data are carried, there must be a means and method for dividing capacity in a pre-planned way so that one does not destroy the service for the other. This access protocol provides for the implementation of an adaptive or managed strategy for capacity division and handling of peak usage demands within the infrastructure and without requiring any concurrent changes in the user Station.

Excess Demand from Stations

The first characteristic is that saturation of data channels is more likely (but not certain) than saturation of the setup channel. The Hub Controller will know the state of all of the Access-point data transfer channels including the ability to predict, using message length information, when busy ports will become available.

The first method of suspending new demands for service is by withholding the *INVITATION-TO-REQUEST* message, but this cannot be used because saturation of datagram and connection-type service capacity will rarely occur simultaneously.

INVITATION-TO-REQUEST will be issued, but after a *REQUEST*, *GRANT* may be withheld or *ACK* sent which orders the Station to wait. The response message does not use the setup channel so it does not add to setup congestion. When there is excess demand, the queued messages stack up in the originating Stations and not in buffer memory in the Hub Controller. The determination of the state of the available buffer memory is one of the criteria for sending the *GRANT* message.

Timely Transmission of Virtual Connection Packets

If a digital circuit is 64 kbits/second, it may be reproduced by a payload bundle of 48 octets every 6 milliseconds. The amount of time used for a duplex connection on a 1 Mb/s transmission path, is the sum of the Station-originate time used by *GRANT*+PDU (72+10+384+80+10 = 556 µsec) and Access-point-originate used by *SET* and PDU (72+10+384+80+10 = 556 µsec) is required totaling 1,096 µseconds. The remaining channel time is what is left after deducting the consumed time (6,000-1,112 = 4,888 µsec) which is the acceptable variability of initiation of sending for timely arrival.

It is necessary that the *INVITATION-TO-TRANSMIT* be transmitted from all Access-points in somewhat less than this time interval. If it is assumed that half of the *INVITATIONS-TO-REQUEST* are unanswered, then an average of 150 µsec per message per point can be assumed. Considering extra time used by Hub Controller originated traffic, there is a scan limit of about 24 Access-points before unacceptable delayed transmission of circuit packets can occur with these particular numerical proportions.

The timing becomes increasingly favorable as the speed of the transmission path is increased above the example rate of 1 Mb/s or as the sampling interval for the virtual circuit is made longer.

The detail of the choice of content and placement of message functions (*GRANT* on data transfer channel) performed on the setup and data transfer channels is much influenced by the requirement to limit maximum scan time to accommodate virtual circuit service.

Use of Priority Function

It is a consideration, that an Access-point cannot be used simultaneously for setup and for data transfer. A very important feature of this access protocol is that the circulation of opportunities for Station access is not dependent on message transmission time which takes place on data transfer channels. The next setup function can be initiated on the next Access-point without waiting for completion of the current data transfer.

At each step in the setup function, the Hub Controller must first handle inward or outward connection-type messages ahead of datagrams because of the timely delivery requirement. The *REQUEST* messages contain an SID field which identifies the type of service required and the relative priority. Since connection-type services may have more than one bandwidth and gathering interval, this information is essential to capacity allocation.

The SID field is used to indicate connection-type service function, and the LEN field is used to indicate the interval between accumulated samples and the length of the accumulated sample payload.

Segmentation for Virtual Connections

The segments of a virtual connection are treated as a segmented packet of indefinite length. Setup announces that it is a connection-type service both in the long destination address and in the SID field, redundantly. The sampling dimensions are transmitted in the LEN field.

Each segment contains a marker that the segment is either initial, intermediate or final in 3-bits of the SGN field.

The auto-grant and *SET* field initiation of the transmission of the next segment is the same as for LAN.

Segmentation Compatibility with B-ISDN

The developing broadband ISDN standards for the public network are described in Bellcore Special Report SR-NWT-001763, Issue 1, December 1990. There, and other places, the Asynchronous Transfer Mode (ATM) plan to transmit either voice or data in cells with 48 octets of data and a 5 octet label is described. These cells may be passed at irregular intervals but at a constant average rate on a high speed medium.

This LAN protocol with its adaptive length packets and segments can conform to the ATM payload size so that a second quantitizing delay can be avoided at the boundary between an ATM based network and this wireless LAN. This flexibility would not be available with rigidly dimensioned time slotting in the wireless LAN.

CENTRAL MANAGEMENT FUNCTIONS

In a large scale wireless access system the possible use of one Access-point is in some way dependent on the status of the other Access-points around it. The Setup-channel must be used consecutively among nearby Access-points, and the same data transfer channel may not be used simultaneously on two access points with less than two interposed coverage areas between them (e.g. uniform, square 9-cell coverage patterns).

It is a system requirement that the access protocol contain source records for all of the data noted below, and that the transfer of information from the point of generation to the point of use be provided.

Central management is implemented mainly in the Hub Controller, but the tasks involved require support from the access protocol.

Management of Channel Selection

An important management function is the selection of an Access-point, the channel to which it is switched and the type of sequence for which it may be used. Management of available channels is more complex whenever the number of available channels is squeezed in relation to the size of the system. In large systems, there can be a need to coordinate timing or channel choice across system boundaries.

For efficient systems, the selection of timing for the use of the setup channel and the selection of channel number for data transfer requires concurrent knowledge of the status of nearby Access-points, the channels that they are using and the limitations on channel reuse with respect to these nearby locations.

The channel selection takes place in the Hub Controller, and the result of its decision could reach the Access-point from the content of the protocol messages or in other ways not now described depending upon logic cost at the Access-point.

Management of User Addressing, Status and Usage

A further management function is the transitory status and directory records for all active Stations with the following data:

1) Global LAN address (48 bits)
2) Local LAN address (16 bits)
3) Global E.164 address (60 bits)
4) Current Access-point identifier
5) Secondary and Tertiary Access-point identifiers

6) Current power setting
7) Last poll response time
8) Registration active/not active
9) Permitted address access
10) Changes log

The log record may be stored for some period (e.g. up to 4 weeks) following the last activity before clearing.

In addition, permanent records of usage for each active Station are needed to cover charging and cost distribution, and as evidence of system abnormality with the following data:

1) Global LAN address (48 bits)
2) Local LAN address (16 bits)
3) Global E.164 address (60 bits)
4) For each Access-point identifier used and by day and by hour--
    a) Number of messages by direction
    b) Number of octets of payload transferred
    c) Number of failed transfers requiring repeat
    d) Number and time of registrations and de-registrations including API used

Management of System Operations and Configuration

At the system central controller, a number of operational records should be kept and updated in real time. For each Access-point, the following records should be maintained:

1) Long and short Access-point identifier
2) Location and antenna pattern description
3) Hub Controller location
4) API's where channel reuse is blocked
5) API's and SYS no. of foreign systems received
6) Date of last service
7) Message handling data--
    a) Number of packet messages--transmit, receive
    b) Number of packet octets of payload transferred
    c) Number of failed transfers requiring repeat
    d) Number of direct transfer messages
    e) Number of calls, messages and channel-seconds used for connection-type service

For the system as a whole, data should be collected on the volume and character of out-of-network traffic.

There are also a number of configurable parameters which may require downloading from a "human" system manager. Some of these are:

1) partitioning rules for data and voice capacity
2) authorized user identifications
3) access restrictions selectively by user
4) security screening data
5) changes in configurable parameters

AUTONOMOUS GROUPS NOT USING INFRASTRUCTURE

This plan uses one time-shared radio channel for both up and down link at infrastructure Access-points, and also a single channel is used (for setup) at all Access-points and communicating Stations.

The system access protocol is further designed to allow direct communication between Stations when no infrastructure is present. It is possible to assign a working channel from a Station by either of two methods:

1) Access-point simulation by the first Station up
2) Distributed contention-based access method

Default Access Manager

The above described Access Protocol can include a default access manager function in each Station. When turned ON, the Station listens for *INVITATION-TO-REQUEST* messages, and hearing none acts as a reduced function Access-point by sending *INVITATION-TO-REQUEST* and *INVITATION-TO-REGISTER* messages periodically. A second Station nearby can then *REGISTER* and communicate with the first Station, and similarly for further added Stations.

The default access manager can include a prompt for <u>manual entry of a group number</u> with a small number of possibilities. This would be translated into the System Number field of those messages containing that field.

Distributed Contention-based Access Method

This method is described in a separate contribution IEEE 802.9/91-96.

INTERFERENCE CONTROL BETWEEN CONTIGUOUS LANS

The presently described access protocol addresses service from a limited number of radio Access-points where there is not material overlapping radio coverage from other nearby systems. If the other nearby systems are area and capacity extensions of the first system, they are said to be commonly managed. If the other nearby systems are providing like-type service to neighboring enterprises, they are said to be independently managed; and it is for this situation that the SYS field is necessary.

Where necessary for commonly managed systems and with artful system design, the possibility of interference from intersystem overlap can be limited to the setup channel, and avoided on the data transfer channel.

Access-point Separation

Using directive antennas position for inward illumination from a boundary, it is often possible to limit overlap between Access-point transmit and receive coverage in contiguous systems to a very small portion of the served area. Also there is often geographic isolation from parking lots and other separating spaces. Nonetheless, there will be cases of inter-penetration of systems occurring in shopping malls, multi-tenant office buildings, adjacent office building, convention centers, public transportation terminals and many other places which must be considered.

The effectiveness of directional antennas at Access-points can be increased with cooperation between system managers.

Station Separation by Probability

Stations cannot use directive antennas to define their coverage. A mild consequence is that a Station in system A will hear transmissions from system B that can and must be ignored using the SYS field. A more serious consequence is that the Station in system A will not hear transmissions addressed to it because of interference from a few nearby Stations in system B.

Because each Station has an air time duty cycle which probably less than 0.25% (9.0 seconds/hour or 9.0 megabits of transmitted data per hour at 1 Mb/s), there is only one chance in 400 that the interfering Station will be transmitting. Similarly, while Station A listens all the time, there is only 0.25% of the time when he is listening to addressed traffic (approximation). Only a few interfering Stations need be anticipated because there is a higher attenuation rate between Stations than between Stations and Access-points, and because only a few are close enough to cause interference to a particular Station.

Without considering that there is any radio frequency isolation or that the desired signal from the Access-point might be stronger than the interference, the chances of the interfering transmitter being on while there is relevant traffic being received at the interfered Station is about 1-in-200^2 considering overlap. If fewer than 1-in-100 messages must be repeated because of interference, the system is hardly impaired.

The event of a transmitting Station originating interference to another receiving Station in a different system is statistically improbable and well within the capacity of automatic repetition to correct. The provision of automatic repetition of unacknowledged messages is a necessary part of minimizing loss from overlapping radio coverage between Stations of contiguous systems.

POWER CONTROL CONSIDERATIONS

The combination of the access protocol and the properties of the spread spectrum modulation enable this system to operate with all transmitters at full power all of the time, but average interference levels into other systems will be reduced if power is dynamically adjusted to the level necessary.

To assist in this function, it is necessary for the Access-point receiver to measure and report the signal level of each received transmission. One use of the report is on registration and subsequent transmissions from the Station to determine the preferred Access-point for passing messages to that Station and changes that may occur. Reduced power in the Station only occurs on command originating at the Hub Controller.

The power control requirement is quite different from that occurring in spread spectrum systems proposed for cellular and pocket telephone service because in this system only one Station at a time is served by each site. These other systems have many Stations simultaneously communicating with a common base Station each using a different spreading code, and it is required that all arrive with close to the same signal level.

The more precise use of output power control is an area for further study.

CONFIGURABLE OPTIONS

There are a number of parameters which might be configurable. Table I, on the following page, is an initial effort to identify these parameters and list the possibilities. A subset of these are default values and available values required in conforming equipment.

Level A conformance is assumed to be minimum cost, and Level B is higher performance and function version.

The setting of these parameters can affect the Hub Controller, the Access-point and the Station or any combination as shown in the right column.

Line Rate

This parameter affects all major parts of the system. Initially, this rate is a configuration parameter set at a single value throughout one system; however the rate could eventually become adaptive at the Station and configurable at the Hub Controller.

Number Access-points/Channels

Nominally, the number of Access-points in one reuse group, and the number of derivable channels are the same.

If the number of channels is limited (e.g. 12), it is still possible to serve as many as twice that number of Access-points. In this case, there may be more than one algorithm to deal with this matter.

Delay Intervals

The intermessage delay is configurable to provide for longer distances through radio and wire than can be accommodated with the default.

Not all systems will have a peer-to-peer direct requirement. The delay introduced with the length of one *ACK* message should not be compulsory.

The interval between initiation of polls is a configurable parameter.

Lengths and Retries

If the Hub Controller misses a packet, it is a tradeoff on how many retries are appropriate.

The maximum size packet and segment are also configurable tradeoffs. Possibly, the Standard will settle on one or two values for some of these parameters.

TABLE I – CONFIGURABLE PARAMETERS WITH CONFORMANCE-REQUIRED VALUES

PARAMETER NAME & DESCRIPTION	PERMITTED & POSSIBLE VALUES	REQUIRED FOR CONFORMANCE			SCOPE OF EFFECT
		DEFAULT	LEVEL A	LEVEL B	
LINE RATE IN MBITS/SEC:	TBD	TBD	TBD	TBD	STN, A-P, AM
# ACCESS-POINTS/CHNLS	2-25/GROUP	9	TBD	TBD	STN, A-P, AM
CHNL ASSGNMNT ALG	TBD	CH/AP	NA	NA	AM
SERVICE SUPPORT	LAN, CIRCUIT	LAN	LAN	BOTH	STN, AM
INTER-MSG DELAY μSEC:	5-20	10	10	6-16	STN, AM
STN/STN ACK DELAY:	OFF, 4-10 OCT	8	OFF, 8	OFF, 8	STN, AM
MSG RETRIES N TIMES:	0-5	2	1, 2, 3	1, 2, 3	AM
POLL INTERVAL:	.5-10 SEC/POLL	TBD	TBD	TBD	AM
MAX SEG PAYLOAD LEN:	48-384 OCT	TBD	TBD	TBD	STN, AM
MAX PACKET LENGTH:	UP TO 10K OCT	TBD	TBD	TBD	STN, AM
DEFAULT ACCESS MGR	ON, OFF	OFF	OFF, ON	OFF, ON	STN

COMMUNICATION BETWEEN HUB CONTROLLER AND ACCESS-POINT

Further consideration of this matter suggests a need for a fast command transfer between Hub Controller and Access-point which enables transmitter ON and specifies channel and power. If such a message is coded at the 1 Mb/s throughput data rate, it will easily pass through the transmission medium to the Access-point, but it will introduce at least 4 octets of delay on every transmission.

A first possibility is using a higher transmission speed which is a matter for further study.

There is a problem in moving commands from the Hub Controller to the Access-point radio on operating channel and transmit power setting. As described, the channel setting is always Setup-channel, except when the data transfer channel is assigned by that field in the *INVITATION-TO-REQUEST* or *SET* message. The channel command is obtained from the content of the *INVITATION-TO-REQUEST* message, and it takes effect only after a *REQUEST* is received and completed. This implies intelligent interpretation of transmitted and received data messages at the Access-point.

CONCLUSIONS

1. It is possible to use a single protocol for:

    A. Minimum and medium function Stations, and

    B. Short and medium distance, and

    C. Systems with a few to many hundreds of Stations, and

    D. LAN and connection-type services; provided that provision is made for:

    E. some configurable options, and

    F. a medium independent interface to allow more than one type of substitutable PHY.

2. An entirely asynchronous protocol can be evolved on the principle that the next step begins when the current step is completed; and that a high time utilization can be obtained in this way.

3. Adaptively available Station-to-Station communication can be provided.

4. All necessary functions can be obtained from a library of about 16 different message types--half upward, half downward.

5. Protocol for operation with and without infrastructure can be incorporated in a Station with both modes using substantially the same message set and format.

6. Infrastructure might be inactive when its services are not needed.

7. The most important reasons for favoring this Channelized Plan are:

    If spread spectrum modulation is used to obtain higher resistance to multipath thereby increasing the possible radio range, the code division channelization greatly increases the communication capacity in relation to system bandwidth.

    channel selection may be a logical rather than an analog process.

    More than one channel assignment algorithm could be used.

    For low data rates, the required frequency and filtering accuracy required is much easier to implement than for a system of the same data rate using narrowband technology.