

IEEE 802.11
Wireless Access Method and Physical Layer Specifications

TITLE: WIRELESS SIGNAL DISTRIBUTION
ARCHITECTURAL CONSIDERATIONS

DATE December 14, 1990

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1 INTRODUCTION

A Wireless Distribution Architecture for use in an Extended Service Area (ESA) is proposed. The basic concept is of a Time Slotted Up and Downward channel using a Central or Distributed "Dynamic Bridge" which routes the MAC frame within one "hop" to the required Service Area. The technical assumptions and tradeoffs that must be made are mentioned including the area in which further investigation and contributions are needed. In as far as possible, the nomenclature used follows IEEE 802.11/90-18 "Wireless System Architecture - Major Choices and Considerations" by Chandos Rypinski.

2 FUNCTIONAL SPECIFICATIONS

The functional specifications follow the intent of the 802.11 PAR.

- a) LAN Throughput equal or exceeds existing 802 wired based standards.
- b) A Basic Service Area has a "reasonable coverage" of a typical "soft partitioned" office floor.
- c) Larger Areas or Buildings with "hard partitions" will use multiple BSAs interconnected via a Dynamic Addressing Bridge Protocol.
- d) User Equipment is movable in a continuous fashion between Basic Service Areas (BSA).

- e) Simultaneous Transmission between User equipment within different BSAs is coordinated in a user transparent manner by a "Dynamic Addressing Bridge" (DAB).
- f) Overlapping ESAs and non-Bridged BSAs, due to different LAN owners, will be supported.
- g) The ISM Frequency Band using the Spread Spectrum Regulations FCC 15.247 is the assumed band of operation since this is the only band available. It is noted that 1.7 - 2.3 GHz might be available with a limited power density regulation. This would be the "preferred band" of operation.
- h) Digital Voice (digital connection oriented services) will be supported but is not the main objective of the protocol.
- i) User equipment power and size will be minimized for true "portable" operation. If applicable low power (small BSA range) could be an option.
- j) A premium cost per User equipment is tolerated for application in Industrial environments.
- k) All configuration activity which allow multiple simultaneous wireless coverage areas, Interference avoidance from neighboring LANs will be automatic and transparent to the end user.
- l) No complicated directing of antennas will be needed.

3 Nomenclature

-Access Point

A fixed transceiver whose electromagnetic reach defines a limited coverage area.

-Basic Service Area (BSA)

The area in which a particular Access Point can service most effectively.

-Extended Service Area (ESA)

The area in which all connected BSAs can service User equipment.

-Dynamic Addressing Bridge

The system which forwards messages via an Access Point, using only one hop, from User equipment from one or the same BSA to another within the ESA. Since User equipment is mobile and the channel is time variant, all address tables are changing accordingly

-Dynamic Addressing Bridge Relay

The system which forwards messages via Access Points, using one or more hops as a function of the "least cost path", from User equipment in one or the same BSA to another within the ESA.

4 TOPOLOGY

As a basis of discussion topological assumptions are made. It is important to realize that this is only to facilitate "first order" approximations of the system and to isolate and analyze a particular "locally defined" problem. This is due to the fact that the indoor radio channel is quite different in topology than typical "cellular" systems in the amount of flexibility one has in demarcation of the BSAs. One is forced to follow the contours of the building, a three dimensional twisted configuration, which makes the four color problem of the cellular hexagon model more of a "rainbow". Also the floors and walls of a building structure change the interference level, it is no longer a simple relationship of wanted to unwanted path ratios. This, combined with proper antenna design, can be used effectively in increasing the spacial reuse of such a structure. A typical example of an indoor environment is shown in Figure 1. The floors of this multistory building follow an L shaped pattern. Each floor has a mixture of ceiling to floor walls and soft partitions of 5 feet in height. It is topologies like these, including User equipment and the buildings communiation network, which will be used to "test" the capacity of the system in simulations.

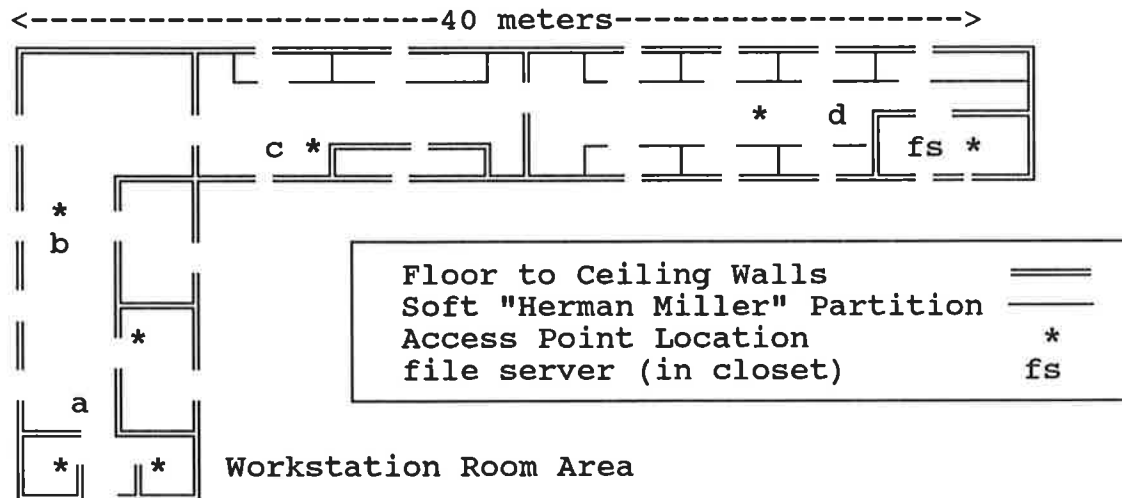


FIGURE 1 L Shaped Office Building

5 SYSTEMS DESCRIPTION

5.1 Specifications

Specifications to be used in future simulation work in assessing system performance parameters.

5.1.1 The Channel

Path Loss inside building:
6 dB/octave first 10 meters
12 dB/octave thereafter

Path Loss outside (between windows):
6 dB/octave

Delay Spread (Gaussian and two ray profiles and Simulation Models, for example SIRCIM [1]):
Up to 200 ns for non LOS link.
< 50 ns @LOS < 10 meters

Fading Distribution: Rayleigh

Floor to Floor Attenuation [2]: $-27.5 - 41.7 \times \log(p)$
Where p is the number of floors.

5.1.2 The Receiver

Signal to Interference Ratio for Access Point Reuse: 12 dB

This makes an assumption on the Modulation Structure used. It has been shown that 4 level modulation in cellular systems [3] is the most spectrally efficient when frequency reuse is taken into account. In the case of indoor building propagation the optimum value could be different.

5.2 Communication Link

5.2.1 Time Slots

A Time Slotted channelization will facilitate the Upward (User equipment to Access Point) and Downward (Access Point to User equipment) communication link. The length of each time slot (TS) will be such to optimize total system efficiency. It is noted that a TS can not be forward to the proper Access Point until the MAC address field is received. A reserved TS for package voice will be part of the slotting allocation. Of course this places heavy demands upon the total system protocol (bounded time of package arrival requirements). The protocol will be reserved for a future contribution.

5.2.2 Frequency Bands

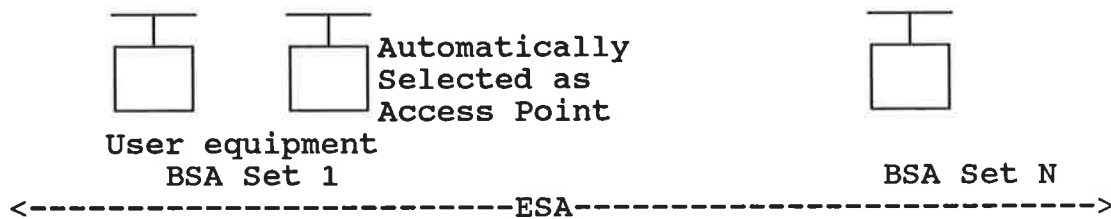
All User equipment and Access Points operate using the same frequency band. The bandwidth being determined by spectral resources, modulation structure and raw data rate. It is noted that within a bandwidth constrained system, maximizing the raw data rate of a single link does not necessarily maximize the total system throughput. This depends upon the amount of Access Point reuse that can be achieved within various indoor system topologies.

To separate different ESAs and non-bridged BSAs, these all being from different LAN owners, different frequency band assignments may be used. Due to the lack of an omnipotent Dynamic Addressing Bridge between these systems a non-synchronous form of system isolation may be needed.

The frequency assignment of differing LANs will be done in a user transparent fashion. Due to the uncontrolled nature of the topology one must assume that limited cases will arise in which co-channel interference between different LAN systems will occur. The structure of the protocol is such that ~~will~~ the systems throughput will decrease in a "tame" manner.

5.3 Single Basic Service Area

For small coverage area's an Access Point will be established, using an Access Point Selection Algorithm, out of the group of User Equipments. It will be such that new Access Point handoff will be seamless if the initially selected Access Point is turned off or fails. In this way a small wireless LAN can be installed without the need of any infrastructure or "special" functional units.

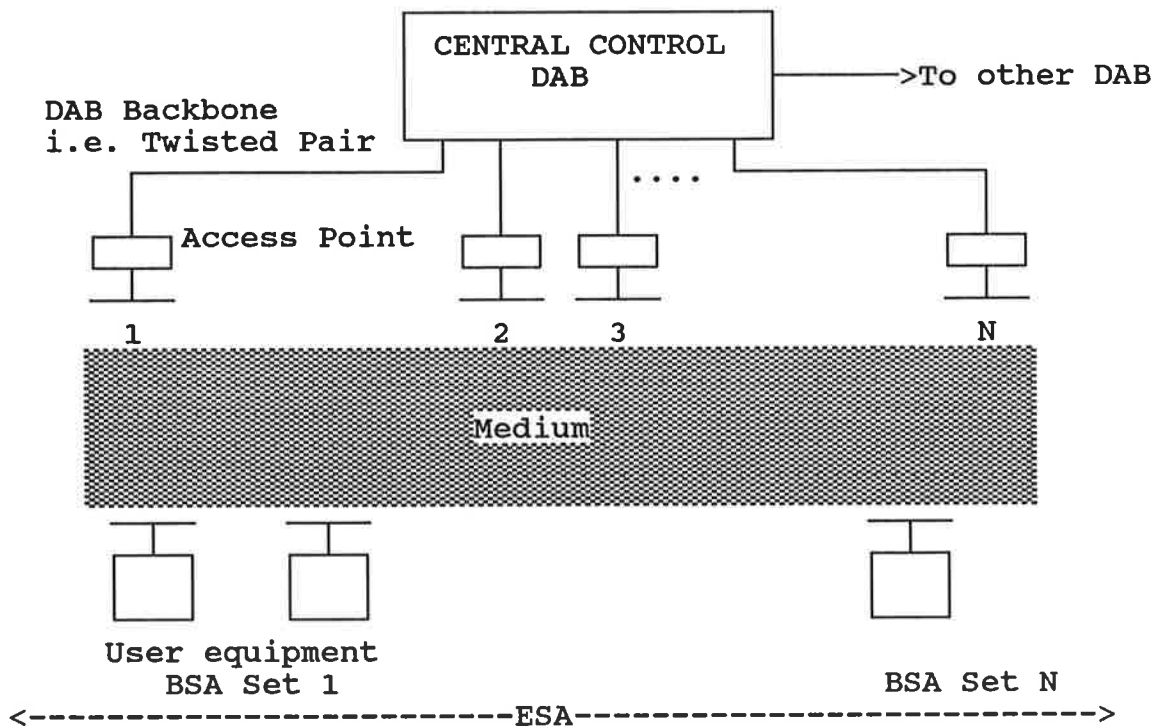


5.4 Dynamic Addressing Bridge (DAB)

For larger installations multiple BSA's will need to be linked together. Each BSA contains a set of User equipment which is in constant flux. It is the task of the DAB to maintain the necessary table which defines this set. The decision variable used in the determination of membership is SIR received from all Access Points within the ESA during User Equipment transmission. It is noted that the exact protocol mechanism of transmission between Access Point and User equipment is still left open.

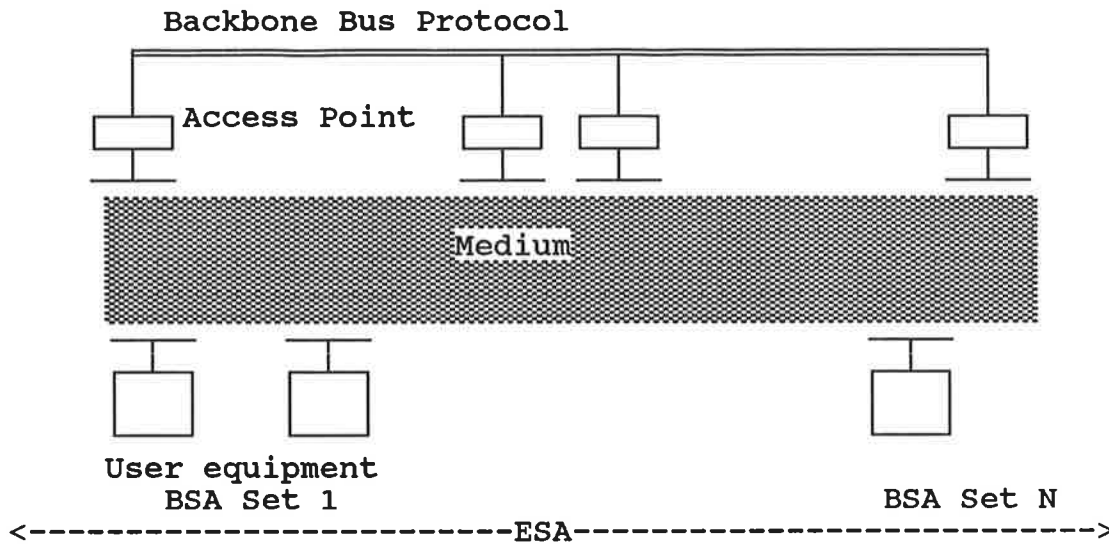
5.4.1 Central Star DAB

Since the Dynamic Addressing Bridge is omnipotent and must have control of all Access Points, a centrally controlled star like structure would lend itself to a simpler implementation.



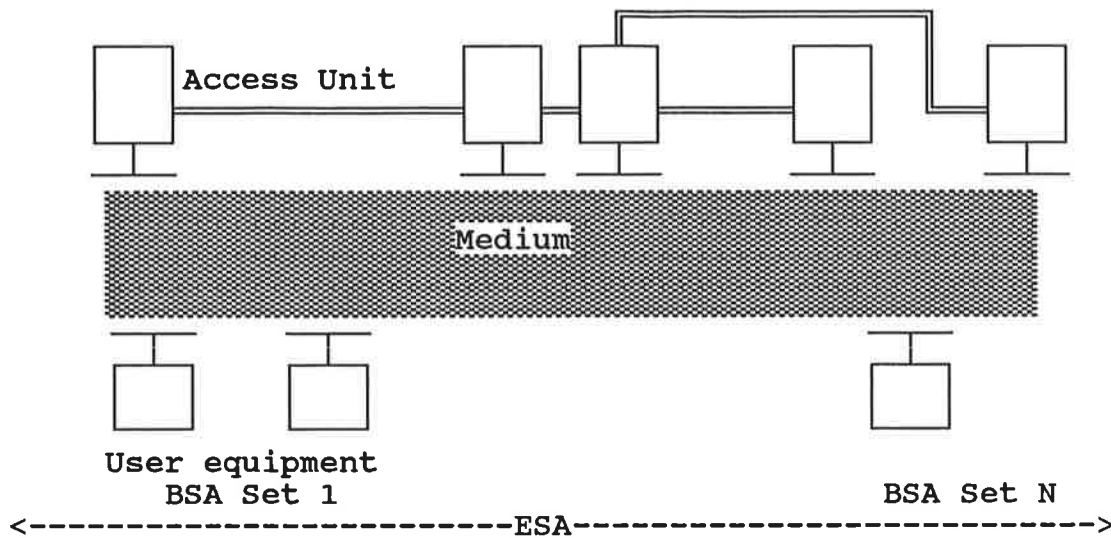
While such a topology would have a relatively simple Backbone Protocol it is vulnerable to a single point of failure and requires a separate wired connection per Access Point. Considering the large coverage potential of the ESA some sort of fault protection is needed. This can be done by DAB redundancy, separation of the to be serviced ESA by multiple interconnected DABs which would minimize the signal failure effect.

5.4.2 Tapped Bus DAB



In this case DAB intelligence is located at all the access points which in turn are physically connected via a Backbone Bus Protocol. While the backbone protocol is more complex in this situation such a topology is fault tolerant and less wire is needed per access point placement, quite significant when the ease of Access Point placement to solve environmental problems in the most flexible way is needed. In summary having an omnipotent all powerful Dynamic Addressing Bridge interconnecting all Access Points does not imply centralized control. The advantages of distributed intelligence, conforming to 802 IEEE standard, seems to outweigh the limited gain, if any, in having a less complex backbone protocol.

5.4.3 Inter Access Unit Distributed DAB



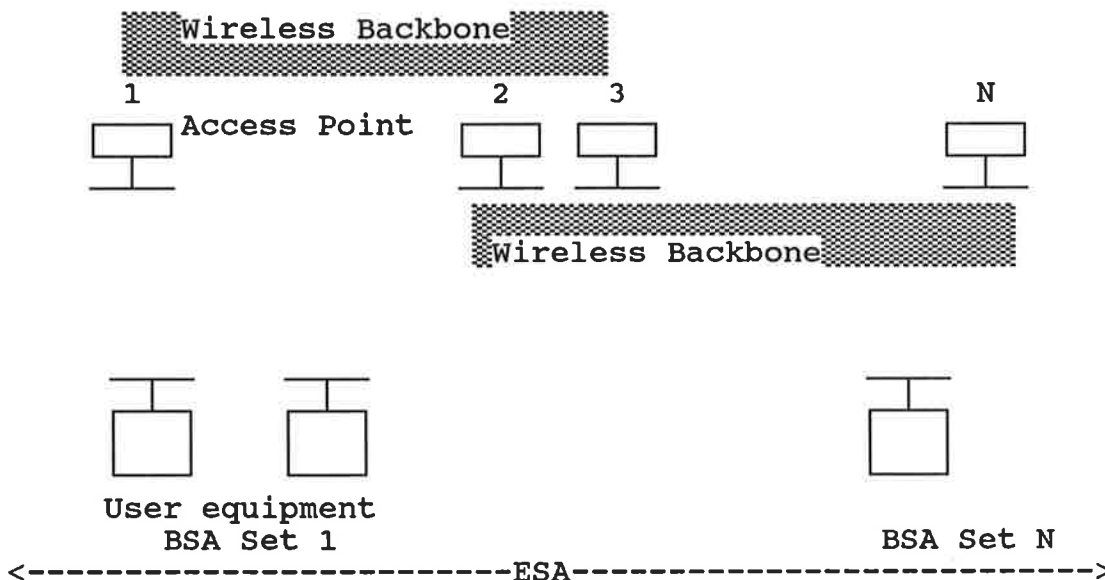
This case gives totally system flexibility. The tapping of a Bus could cause saturation of the Bus with a heavy load (wide distribution of Access Units all tapping the same bus). While Access Unit control information is distributed throughout the total structure, determining the amount of permissible Access Unit reuse, the data flow only moves between the necessary Intermediate Access Units (these do not radiate but put the information on the Bus) arriving at its destination Access Unit.

Take the topology of Figure 1 for example, at the work station area (b) high capacity is need and most of the user traffic is from workstation to workstation (distributed processing) and not to the office file server (fs). Having the backbone activity localized in the area of usage will free up the rest of the office backbone system. While this requires more Access Point to Backbone processing, since each Access Point must contain all routing information, the Backbone capacity advantages are quite significant.

5.5 Dynamic Addressing Bridge Relay (DABR)

In the DAB User equipment messages are forwarded to the proper Access Point, N, without the need of any of the other N-1 Access Points (except in updating the address table). This is possible because all Access Points within the ESA have a physical switched wired connection between them. In many applications any form of wired infrastructure would be unacceptable. In such an environment the penalty in system throughput in trade for total wireless operation can be made. In such a case limited voice is not supported due to the bounded response requirements.

In the ESA of a DABR system there is always a pair of Access Points which have electromagnetic communication. The Wireless Backbone Access Point Protocol maintains a network routing table in each Access Point. Access Point routing consists of package hopping from one Access Point to another until the Access Point of the target BSA is reached. The routing algorithm will use a "least cost" calculation to reach a particular BSA, where cost is a weighted function of the number of Access Point Hops and estimated SIR per hop.



6 IMPLEMENTATION CONSIDERATIONS

To implement the Functional Specifications the architectural structure has limitations placed upon it driven by cost and performance.

6.1 Assumptions in System Description

A. An Access Point will transmit only if the addressed User equipment is within the Access Points BSA. This has enormous benefits.

Reason:

a) Simultaneous transmission, in sufficiently electromagnetically separated BSAs, is possible increasing the overall capacity of the system.

b) User equipment does not have to differentiate between the transmission of two Access Point causing frequency "beating" at a rate equal to the reference clock tolerance.

c) Pollution of the Ether will be minimized. Having multiple Access Points transmit simultaneously would form a phased array antenna with significant pollution potential. It is possible that this would not be accepted in the ISM band by the FCC and it is certain that new spectral allocation would never materialize. Also interference with other ESAs or BSAs would be significantly increased.

B. A signal Access Point covering one BSA must be able to cover a reasonable area and support data communications with multipath delay spread of the order of 200 ns.

Reason:

a. There is a significant market for single BSA systems, at least in the initial stages. The multipath performance must not dictate the BSA coverage area. If this was the case, then line of sight (LOS) paths would be needed between Access Point and User equipment. While the average multipath delay spread is correlated with Transmitter Receiver Distance, there is a very large scatter around the average. Also as LOS paths are "blocked" due to people or movement of other obstacles, the variation of delay spread increases. If a LOS restriction was acceptable, which in terms of system flexibility it is not, Infra Red technology might be a better technology choice.

b) While to achieve robust performance in a multipath environment does require a more complex modem design or modulation structure, this does not necessary translate into higher unit cost. With the state-of-art technology of today, microelectronics, Monolithic Integrated Circuits and digital processing techniques, cost and complexity are not strongly linked. Of course the amount of effort to achieve the end-product is higher, but that is not the issue.

C Acknowledgement can be used to improve the performance of the unreliable radio medium.

Reason:

a) The radio channel has noise which cause burst errors. Acknowledgement is a known robust technic in such an environment. Of course simulations and further characterization in needed and will be given in future contributions.

b) Implementation of acknowledge allows the use of Dynamic Macro Diversity for both the Upward, User equipment to Access Point, and the Downward Link. User equipment transmission is simultaneously monitored by all Access Points of the system within electromagnetic reach. The Access Point with the best post processed Signal to Noise Ratio will forward the message to its destination via the Dynamic Addressing Bridge algorithm. A downlink message is forwarded to the Access Point which had the best SIR from the User equipment (where the message is addressed to) during its last transmission. It is possible that the environment changes due to User equipment and object motion, such that the chosen Access Point is no longer optimal since the last update. Proper implementation of acknowledgement from the User equipment will allow a new assessment of the best Access Point to be used for transmission.

D There is no restriction due to the protocol, in the amount of Access Points. Saturated Access Points is possible.

Reason:

a) Problem areas, shadowing, high levels of external noise, as they arise can quickly be solved by placement of an Access Point.

b) Redundancy for fault tolerant systems.

c) Can increase network capacity by deployment density of the network Access Points.

E A time slotted TDM approach will be used for Upward and Downward Channels, instead of dual frequency techniques.

a) In a contiguous frequency band Duplex filters are bulky and relatively expensive.

b) TDM is mainly digital processing circuitry, as compared with dual frequency analog systems which have a more complex receiver architecture.

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