IEEE 802.11
802 LAN Access Method for Wireless Physical Medium

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TITLE: **EQUIPMENT TYPE DEFINITION AND MARKET ANALYSIS METHODS BY TYPE**

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SUMMARY

It is not possible for one solution to meet all needs for wireless LAN. 802.11 must find some way to satisfy a wide spectrum of applications with a short list of possibilities. While laptop computers are numerous enough to be a market, and while GM Automatic Guided Vehicles are important enough to be a legitimate need, they are too specific to be a target of the 802.11 Committee.

There is a large market for pocket telephones, but the claimed market used in regulatory proceedings overlaps the business use of wireless IVD LAN in office and other type premises.

It is necessary to define the wireless possibilities into a short list of parameter sets so that market can be analyzed, and claims for the use of frequency spectrum can be substantiated against other claimants.

Equipment Types

The following are the classes of wireless LAN equipment types which are thought sufficient to meet nearly all of the larger needs.

Personal and Consumer
Industrial
Office and Retail
Laboratory and Workstation

Market Analysis Methods

A market analysis considering those who would like to avoid wiring is nearly everybody that communicates which has no meaning. Until cost and function are included as criteria, it is not possible to sort out the market for any particular product.

This will be illustrated in a discussion of market analysis methods.

EQUIPMENT TYPE DEFINITION AND MARKET ANALYSIS METHODS BY TYPE

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SUMMARY

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Equipment Types

The following are the classes of wireless LAN equipment types which are thought sufficient to meet nearly all of the larger needs.

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The motivations for using wireless are shown in Table I. Further definition of the necessary equipment classes is shown in Tables II and the applications for each in Table III.

Market Analysis Methods

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PART I
EQUIPMENT TYPES AND FUNCTIONS

POSITIONING OF WIRELESS SYSTEMS

For those interested in reducing wiring cost, the prime target is "ad hoc" wiring for computers. The more structured wiring for PBX supported telephony consumes far less money and effort in large Companies.

The "best of all worlds" for wiring and for 802.11 is where the system will serve both needs without difference in the installed physical plant.

This integration is commonly assumed to be non-existent or technically costly if it were. The position of this presentation is that the costs for the fixed portion of a wireless system are little different whether for data or for circuits or for both. This proposition is defended in other contributions, more particularly in "Access Protocol" -- March, 1991.

An integrated data/telephony system is assumed, and this assumption is critical to the scope and definitions of a market evaluation.

The office system is now assumed to encompass the PCS function as a subset application.

A more critical distinction is that PCS, as now defined, is a public access system used in predominantly public space. Its use in business areas will be secondary.

SERVICES NECESSARY FOR PREMISES AREA WIRELESS SYSTEMS

A number of services must be provided by a wireless communication system for substantial entry into the computer-intensive commercial and industrial environment.

Voice-data Integration

The IEEE LAN Standards Committee 802.9 is developing a workstation interface that supports 4.096 and 20.48 Mb/s on ordinary telephone pairs which will become the new functional level of

UTP. Replacement of wiring with voice-only capability is of declining importance. UTP now provides simultaneously high-bandwidth circuits and packet-LAN at multi-megabit speeds.

DECT (Digital European Cordless Telecommunications) is often put forward as having a data capability. This is true, but it is a voice-modem-like at a small fractions of the minimal LAN rate of 1 Mbits/s.

Studies of an asynchronous packet protocol for 802.11 lead this Contributor to believe that one protocol can equally well serve LAN packets or virtual circuits or both.

Connection-oriented Services

The modern digital public network services must be provided in office, laboratory and many industrial environments. These particularly include 64 kb/s B-channels, 384 kb/s data-channels (for video and high resolution images) and the PRI payload at 1.536 Mb/s. Call set-up and control is by means of a D-channel packet.

Without advanced digital network interface capability, a wireless system is addressing a temporary niche market.

Connectionless Packet Services

Since the introduction of 802.3 10BaseT, the market will have difficulty in accepting LAN equipment with a medium signaling rate on UTP of less than 10 Mb/s. Differing needs on trading off reach and rate are the reason for the two signaling rates in 802.9.

There are less visible requirements on LAN capability relating to delay on gaining access and delay in relay between users. The acceptable delay levels are measured in milliseconds within a department, and there is desire for the same speed through the public network.

It is commonly assumed that capacity is a function of signaling speed, but it may also be limited by execution time for complex protocols or other software and architecture factors.

The 10BaseT market has also demonstrated the value of placing the contention resolution function in the hub equipment and using one or only a few stations per hub port. The use of a hub equipment in the wiring closet is now a commonplace usage.

MOTIVATION FOR USE OF WIRELESS ACCESS

Some absolutely need radio for moving vehicles and robots or to link sites with costly to overcome obstacles in the path. Many would like wireless simply for the convenience and flexibility. Many workers perform their job function on the move and with little time spent at a particular desk with telephone and computer.

If the replacement of all or a portion of existing building wiring is the objective, then all of the functions of those wires must be replaced. Much more of this wiring is related to computers than to telephones. The substitution cannot be made without supporting IEEE 802 LAN capabilities at high megabit rates.

These different motivations must be recognized in defining widely-needed equipment types. This complex of inducements is shown in Table I following.

EQUIPMENT TYPES

A wireless service would be useful for laptop computers if the addition was cheap, small and low power drain. It would be useful as a small autonomous peer-to-peer system where all are sitting in a meeting room, but it would be much more useful if it gave University students ubiquitous access anywhere on the Campus. The good news is that the volume is large and that the transmission rate needed is low.

Most industrial needs for mobile equipment could also be satisfied with a 1 Mbits/s rate, but the hardware would be much different with much more importance attached to ruggedness, reliability and 802 interworking.

The ordinary office or retail establishment would not put in the 802.11 for telephones, but many of the new functions require circuit type access to host computers via the public network. The duty cycle for these connections is far lower

than for ordinary voice. Easy reconfiguration is a big inducement for wireless.

The high-end users in laboratories and some offices need everything and more. For these, simultaneous wide-band circuits, non-blocking telephones and over 10 Mbits/s of LAN simultaneously is usually enough if there is not too much sharing of this capacity.

All of these situations are considered in the Equipment Types in Table II, and their applications in Table III following.

TABLE I – MOTIVATION FOR USE OF WIRELESS ACCESS

Mobility required over:
- Wide Area
  - with Public Network backbone
    - Cellular with adaptation
    - PCN with archipelago service area
  - with private system access facility
    - Multi-premise private PCN
    - *LAN services indoor/outdoor with inter-premise bridging*
- Campus Area
  - with private system access facility
    - Multi-premise private PCN
    - *LAN services indoor/outdoor with inter-premise bridging*
- Premises Area
  - with Public Network backbone
    - Public transportation terminals
    - Shopping malls
    - Convention centers
  - with private system access facility
    - *Industrial robot and moving equipment*
    - *Transportation, cargo handling*
    - *Warehousing*
    - *Retailing*
    - *Hospital and Medical Facilities*

Wiring avoidance in premises area private network:
- Cost avoidance
  - *Alternative to installation of ad hoc add-on wiring for data services*
  - *Multi-vendor standards based equipment*
  - Overcoming architectural limitations of older buildings
  - Tenant-owner separation of improvement cost and retained investment
  - Different depreciation practices
- Functional advantage
  - *Increased variety of service*
  - *Faster response time and larger data capacity*
  - *Quick reconfiguration of movable but not moving stations*
  - *Service to moving equipment or persons*
  - *Service at unwirable locations*
  - Off-loading of higher cost external access facilities
  - Redundant path system reliability enhancement

ITALICS = Within scope of 802.11 standard

TABLE II -- CATALOG OF SYSTEM TYPES

P1 MINIMUM SIZE, COST, BATTERY DRAIN FOR **PERSONAL USE**

PHYSICAL MEDIUM:	ISM BANDS AT 0.9 & 2.5 GHZ
TRANSMITTER POWER:	100 MW
SIGNALING RATE:	0.5 OR 1 MBS
CAPABILITIES:	LAN AND INTERCOM CODED VOICE
	PRIMARY PEER-TO-PEER WITH MINIMAL COMMON EQUIPMENT
REACH AT 1 MBS:	1 KM UNOBSTRUCTED
	100-200 METERS CLUTTERED PATH

I2 SMALL SIZE, MODERATE POWER DRAIN FOR **INDUSTRIAL MOBILE USE:**

PHYSICAL MEDIUM:	ISM BAND AT 5.9 GHZ
	FUTURE 1.9 GHZ ALLOCATION
TRANSMITTER POWER AT 5.9 GHZ:	100 MW
SIGNALING RATE:	1 OR 2 MBS
CAPABILITIES:	LAN AND INTERCOM CODED VOICE
	ENHANCED ARQ ERROR CORRECTION
	STRONG EQUIPMENT AND PATH REDUNDANCY
	ADDRESS MANAGEMENT FOR EXTERNAL BRIDGEABILITY
REACH AT 1 MBS:	400 METERS UNOBSTRUCTED
	40-80 METERS CLUTTERED PATH

C4 SMALL SIZE AND LOW POWER DRAIN FOR **DESKTOP/PORTABLE USE:**

PHYSICAL MEDIUM:	ISM BAND AT 5.9 GHZ
	FUTURE 1.9 GHZ ALLOCATION
	SINGLE UTP
TRANSMITTER POWER AT 5.9 GHZ:	20 MW
SIGNALING RATE:	4 MBS
CAPABILITIES:	LAN, POTS AND ISDN B-CHANNEL
	ARQ ERROR CORRECTION
	LAN 48-BIT ADDRESSING
REACH AT 4 MBS AT 5.9 GHZ:	100 METERS UNOBSTRUCTED
	10-20 METERS CLUTTERED PATH

W16 MODERATE SIZE AND POWER DRAIN FOR **DESKTOP/WORKSTATION USE:**

PHYSICAL MEDIUM:	ISM BAND AT 5.9 GHZ
	FUTURE 1.9 GHZ ALLOCATION
	UNCOLLIMATED IR OPTICAL
	SINGLE UTP
TRANSMITTER POWER AT 5.9 GHZ:	20 MW
SIGNALING RATE:	16 MBS
CAPABILITIES:	LAN, POTS AND ISDN BRI, H0, PRI
	ARQ ERROR CORRECTION
	E.164 AND LAN 48-BIT ADDRESSING
REACH AT 16 MBS, 5.9 GHZ:	28 METERS UNOBSTRUCTED
REACH AT 16 MBS, INFRA-RED:	14 METERS UNOBSTRUCTED

W24 SAME AS W16 EXCEPT: PHYSICAL MEDIUM--IR ONLY, SIGNALING RATE--24 MBITS/S

TABLE III -- APPLICATIONS FOR SYSTEM TYPES

P1 BATTERY-POWERED PERSONAL/PORTABLEEQUIPMENTS
EQUIPMENT TYPES:
LAPTOP COMPUTERS
PERSONAL TELEPHONES
HAND-HELD DATA ACQUISITION TERMINALS
SYSTEM ENVIRONMENTS:
AUTONOMOUS SMALL SYSTEMS WITH RADIO COVERAGE TO EACH OTHER
AUTONOMOUS SMALL SYSTEMS WITH LINE LEVEL PSTN INTERCONNECT
SHOPPING MALL SMALL TO MEDIUM SIZE SYSTEMS
CAMPUS INDOOR/OUTDOOR NETWORKS

I1 INDUSTRIAL APPLICATIONS INCLUDING MOBILE STATIONS
FUNCTIONS:
ORDER WIRE
MAINTENANCE NETWORK
SUPERVISORY CONTROL
STATUS REPORTING AND DATA ACQUISITION
BACKUP NETWORKING
SYSTEM ENVIRONMENTS:
FACTORY
TRANSPORTATION HUBS
CHEMICAL PROCESS PLANTS
BUILDING SECURITY AND HVAC

C4 SUPPLEMENTAL OFFICE ACCESS SYSTEM WITH MOBILE, HEAVY PORTABLE AND POWERED STATIONS
FUNCTIONS:
LAN WITH 4 MBITS/S CAPACITY AND PERFORMANCE
SECONDARY TELEPHONE CAPACITY
SYSTEM ENVIRONMENTS:
SUPPLEMENT TO FIXED WIRING FOR TEMPORARY AND MOVING STATIONS
HIGH CAPABILITY RETAIL STORES
NORMAL CAPABILITY HOSPITALS
INDOOR CAMPUS NETWORKS

W16 PRIMARY OFFICE ACCESS SYSTEM WITH MOBILE, HEAVY PORTABLE AND POWERED STATIONS
FUNCTIONS:
LAN WITH 12 MBITS/S CAPACITY AND PERFORMANCE
TELEPHONE CAPACITY FOR CONCENTRATED ISDN SERVICES UP TO AND INCLUDING PRI
SYSTEM ENVIRONMENT:
HIGH USAGE OFFICES
ENGINEERING DEPARTMENTS
LABORATORIES
HIGHLY AUTOMATED PROCESS PLANTS

W24 PRIMARY OFFICE ACCESS SYSTEM WITH HEAVY PORTABLE AND POWERED STATIONS
FUNCTIONS:
LAN WITH 18 MBITS/S CAPACITY AND PERFORMANCE
TELEPHONE CAPACITY FOR CONCENTRATED ISDN SERVICES UP TO AND INCLUDING PRI AND A NON-BLOCKING B-CHANNEL FOR EVERY STATION
SYSTEM ENVIRONMENT:
HIGH USAGE OFFICES
ENGINEERING DEPARTMENTS
LABORATORIES
HIGH CAPABILITY HOSPITALS

PART II
MARKET ANALYSIS METHODS

METHOD OF ESTIMATING MARKET AND ECONOMIC SIGNIFICANCE

It is possible to estimate the size and significance of market and economy, by doing the following:

A) estimate the size of the population which are users of telephone or data communication of any kind--wired or wireless. New uses of data communication, not now evidenced by existing applications must be added to the estimate.

B) make a tentative definition of the functions of the wireless service which is likely to subdivide into a short list of types, and then to

C) estimate the proportion of the population A) that would benefit from each prospectively available type B). Better accuracy may be obtain if the populations are categorized, listed and the penetration of each type in that category estimated and summed.

However this is done, the number of workers in the USA so affected is greater than 10 million job positions meaning that it is a large market. Some assumptions would lead to 50 million stations by the end of year 2000. The initial conclusion is: this task is well worth a substantial effort.

The process of associating the need for wireless with job type will be quantitatively subjective. To reduce this judgmental factor, it is necessary to understand the motivation to use wireless and to be sure the assumed equipment types match this motivation. A tabulation and categorization of motivational elements was shown in Table I. The two main categories are the 1) the mobility function, and 2) wiring avoidance or either cost or physical feasibility reasons.

GROSS MARKET SIZE ESTIMATE

Possible data inputs for market size analysis are: 1) data on the installed telephone base by function and enterprise classification, 2) data on the number of installed PCs and LAN ports, 3) government collected statistics on the composition of the labor force, and 4) statistics on the size, age and shape of buildings.

The first pass estimate would use a cumulative total penetration proportion for each equipment/service type. This would have to be refined into year-by-year purchasing separately performed for each equipment category.

Telephone Statistics Basis

It is commonly assumed that the demand for WCS is related to the number of business telephones in use. After using the results of a user survey to develop a weighting factor, Alexander Resources[1] concludes that:

> "19,197,000 workers out of the total U.S. civilian workforce of 114,970,000 represent potential users of WCS. These potential users also represent 30.5% of all current KTS, PBX and CTX users. We estimate sales of the total WCS market could reach $2,151,125,000 by 1997."

This estimate is reasonable for the wiring-cost motivated market sector within premises area networks, and with an accuracy of one plus significant figures at best.

That this method gives reasonable results is somewhat fortuitous simply because there are almost always telephones around the most skilled workers. The connection between telephones and data-based workers may be substantial in a portion of the cases, but it is not a comprehensive view. For example, terminals used by travel agents, order desks, catalog sales and cash registers may be connected to a dial-up or leased telephone line via a modem, and maybe via a concentrator/multiplexer are not clearly in or out. It is very difficult to say what need is or isn't captured by this approach.

Computer Statistics Basis

There are now about 30 million personal computers in use, and there are probably recent numbers for portable (laptop) computers. Because of the context in which some of these surveys were made, they are likely to represent a segment of the entire computer market.

Hand-held data acquisition terminals would not be included in protable PC sales and must be captured separately.

A further difficulty is in estimating the percentage for which wireless would be considered. Even with wiring cost advantage, there is a security and capacity consideration that will absolutely prevent a minor fraction of these from ever using wireless data transfer. The same considerations apply to the use of LAN and Bridge market data.

On the other hand, there is a minimum market that would surely accept wireless if cost, size, power drain and transfer capacity are adequate. There will be a lot functional elasticity in this market.

Labor Classification Statistics

The US Bureau of Labor Statistics provides breakdowns on the makeup of the workforce by industry and job type covering more than 115 million workers. These breakdowns can be made into work sheets with penetration percentage estimates for each category. [Caution: some of these statistics are extrapolation of 1986 numbers for which updating is now taking place.]

For classification methods that depend entirely on work force information, there are still major segments of the population which would not be included, but that would still use wireless communication--e.g. college students, military base staff. It is possible that these groups could be 2-8% of the wireless usage.

Sedentary vs. Mobile Workers

There has been an effort[2] in Canada to determine the proportion of the labor force which is sedentary vs. mobile. Sonneville states:

"This subcommittee focused primarily on voice applications with little said about data. In determining a benchmark measure of "mobility" (actually "portability") among employees, the subcommittee agreed to the following assessment of the market potential:

Table IV
Mobility Among Canadian Employees-1992

Non "mobile":	60%	7.0 M
"Mobile":	40%	
Building itinerant:		1.9 M
Out of building:		2.8 M
Total work force:	100%	11.7 M

Mobile workers are said to spend more than 2 hours/workday away from their respective desk or workplace on work related tasks. Hence 4.7 million mobile workers (40%) might be considered prospects for either in-building or out-of building wireless telecommunication."

The "building itinerant" type of worker (16.2%) above, might well be served by a private system in the premises area rather than a public system. A large proportion of these might well need data access. If the same proportion were to apply in the USA, out of a work force of 115 million there would be 18.7 million candidates for wireless service because mobility is part of their job function. This still leaves 27.5 million (24%) of market potential for public systems.

There is a proportion of non-mobile workers who would use wireless because of savings in wiring cost. If this were 20% of the 60%, another 13.8 million stations could be added for a total of 32.5 million stations using integrated voice-data wireless access.

Industry Classified Employment Categories

More than 80 million are in service industries of which the largest category is government, 20 million in manufacturing and the rest in other categories.

Job Type Classified Employment Categories

There are about 115 million employed persons in the US. Many of them use communication for terminals, computers and telephone service.

The most numerous are the office job types numbering more than 18 million. This group includes categories that might be considered borderline professionals. The defined professionals number more than 6 million.

The art in using this type of information is deciding which non-obvious groups are potential users. For example: truck drivers or the trucks that they drive generate data related to usage, performance and maintenance; to cargo loading and discharge; and to personnel working hours. It is now known that it is convenient and efficient to off-load the collected data and to down-load orders by wireless when that truck is at a terminal.

Maybe a truck driver does not appear to be a computer user, but so long as his time and cargo are valuable, computerized tracking is valuable. Data is generated as the truck is used, and loading and unloading transactions are accomplished. This data could be retrieved at the ends of runs or in real time along the way.

MARKET BY JOB CLASSIFICATION

Assuming the types of equipment listed above, and in addition PCN of the DECT type, an effort can be made to estimate the USA market for wireless access where there are both PCS and Wireless LAN type systems available.

This approach is one where the market could be separated into the categories given in Table II. There is considerable value in knowing the relative commercial importance of these equipment types.

There is an intention to make the results of this type of analysis, possibly giving summary conclusion in a future contribution to 802.11.

MARKET BY OFFICE BUILDING FLOOR SPACE

Shown in Table V on the following page is a summary of the demographics of Office Buildings in the US.

Using the 12 billion square feet of space and one access-point and four stations per 600 square feet, 20 million access points and 80 million stations would cover all US office buildings. One might feel that this transmission method might be used in 5% of the cases (which might be a major understatement in 2000) and which is:

1 million access points and 4 million stations of wireless access in office buildings.

This estimate would leave plenty of room for parallel usage of PCN.

There are many other types of buildings for which wireless access is desirable, but which are not included in this

TABLE V

OFFICE BUILDING DEMOGRAPHICS -- LATE 1990[3]

	Percent of Buildings	Percent of Floor Space
(A) Period When Built:		
Prior to 1960	35	28
1961-1979	32	31
1980-1986	16	23
1986-1990	17	18
Total	100	100
(B) Floor Counts:		
1 Floor	52	21
2 Floors	29	19
3 Floors	12	13
4 or more Floors	7	47
Total	100	100
(C) Employee Counts:		
1-9	48	12
10-19	20	10
20-49	18	14
50-99	7	10
100-249	4	15
250 or more	3	39
Total	100	100

As of late 1990 there were 740,000 office buildings in the U.S. having a combined total of 12 billion square feet of floor space. The table above distributes these by (A) age, (B) floor counts, and (C) employee counts.

References:

1. "REPLY COMMENTS OF ALEXANDER RESOURCES," FCC NOI 90-314, January 15, 1991

2. Final Report On Personal-Wireless Recommendation, Services Definition & Description sub-Committee, Radio Advisory Board, Canada, Nov 23, 1990--Information furnished privately by W. Sonneville

3. Information furnished privately by W. Sonneville