IEEE 802.11

DATE: May 6, 1991

TITLE: **REQUIREMENTS FOR WIRELESS IN-BUILDING NETWORKS**

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SUMMARY
The discussion of market requirements for wireless LANs have mainly been based upon secondary statistics. The author has performed extensive primary market research to determine the communications needs for the 1990's; specifically, to define the requirements for the next major communications frontier: wireless in-building networks. This paper highlights the results from over 1000 corporate and government entities surveyed through different marketing research techniques. Discussions include: the personal computer trend and local area network growth; the problems with cabling, particularly associated with business moves, adds, or changes; cost effectiveness of wireless LANs; requirements of a wireless local area network for acceptance by the users; the environment best suited for wireless LANs and specific product requirements.

THE WIRELESS IN-BUILDING VISION

To date, the evolution of wireless communications has been exemplified by the dramatic growth in cellular communications. Cellular has enabled customers to transcend the constraints of fixed telephony in communicating outside of buildings with portable and now personal communications devices.

There has been significant interest and publicity regarding wireless in-building communications lately, both for data and voice. Throughout the 1980s, we have seen the development of a significant range of in-building business communications problems that have been caused by changes in the technological, business, and regulatory environments. Because of these developments, buyers of telecommunications and data communications systems increasingly are having to face significant time, cost, and logistical problems associated with the installation, movement, and management of computing and communications equipment in dynamic office environments.

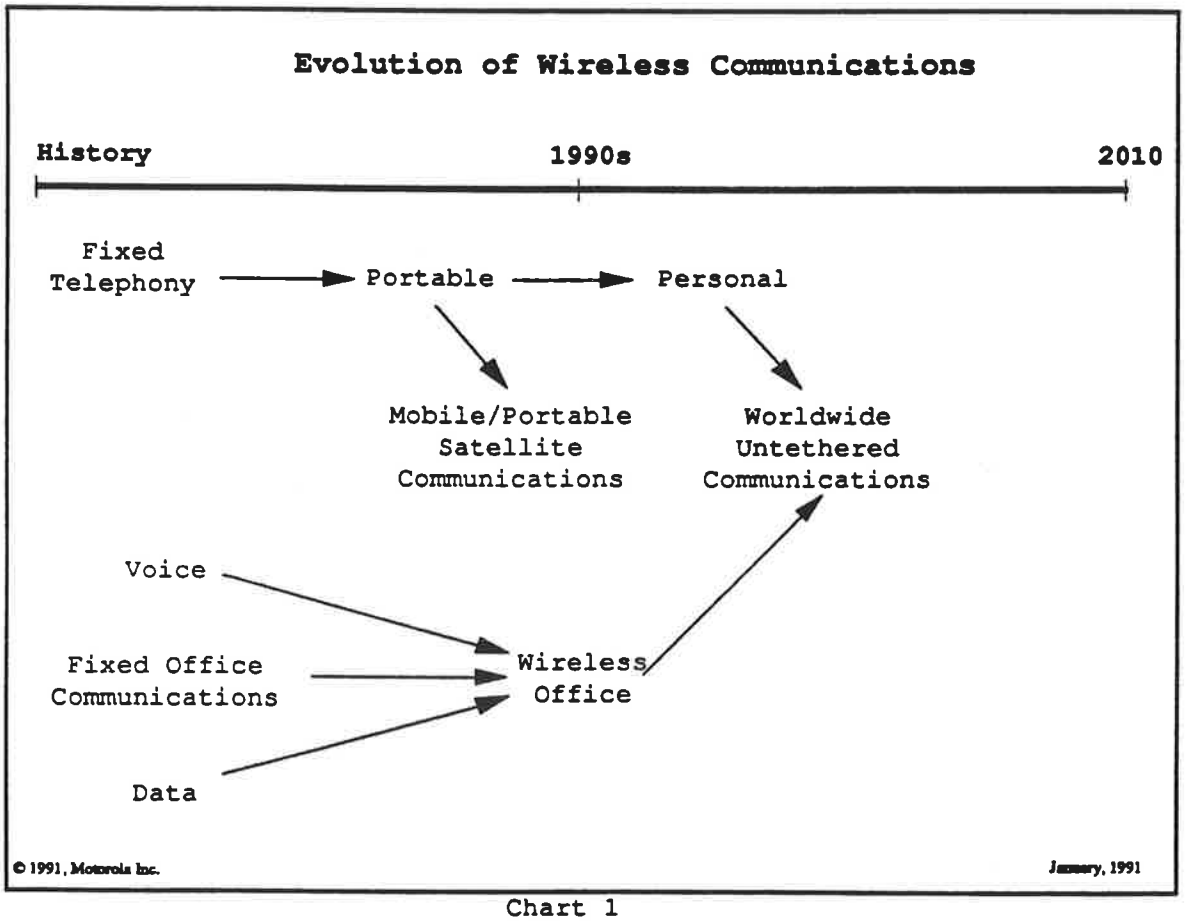

Chart 1

Over the next 20 years, society will witness a significant "wireless evolution" in both personal and professional communications, and change the way we conduct our lives at home, on the road, and at work (See Chart 1). New forms of wireless communications will free us from the "bonds" of wire that today restrict our movements or interaction.

MARKET RESEARCH

Beginning in the mid-late 1980s, a systematic evaluation of the technological and environmental attributes necessary to anticipate and define wireless in-building communications was undertaken. This included a comprehensive marketing needs assessment and research program.

The overriding objective was to anticipate and identify customer needs and trends; that is, "What are the specific needs of various customer groups, and what type of product attributes will satisfy their needs?"

To determine answers to these and a whole host of other questions, a multi-phased marketing research program was conducted. The overall aim of the program was to anticipate and ascertain the customer need, where this need existed currently, what were the market and customer environmental characteristics, and what product characteristics would be needed to provide an optimal wireless solution.

The multi-phased market research program was divided into three fundamental mechanisms. Each mechanism was selected to achieve precise and select objectives of that phase. The three mechanisms selected were Focus Groups, Surveys/Conjoint Analysis and Face-to-Face interviews.

Focus Groups

The first of three basic phases, focus groups, was completed in 1988. The focus group mechanism is a commonly used marketing research tool employed at formative stages of a product market development program. The objectives were to:

- Ascertain general reactions of wireless technology and its introduction to the office.
- Determine optimal configuration(s)/applications of wireless features that will make the greatest impact on customer response, and direct the design process toward the product attributes that would most likely satisfy customer requirements.
- Evaluate prospective buyer perceptions and preferences for various wireless features and end-user benefits.
- Measure the congruence of these perceptions with existing competing offerings and potential new product offerings.

The results were encouraging and provided sufficient reason to continue both market and product definition activities. One of the primary outputs of a focus group, and certainly in this case, is the ability to provide the foundation to pursue more definitive lines of investigation. As such, the next step was to initiate survey techniques to a broad based group of Fortune 1000 MIS, telecommunications, and facilities executives.

Surveys/Conjoint Analysis

Next, two sizable market based surveys were conducted. Each of these surveys was geared toward more targeted markets and groups to achieve very specific information objectives.

The first objective specifically was to identify the product attributes necessary to provide identifiable market segments with the most desired product, and understand environmental attributes across a number of different market dimensions.

The second survey was orientated toward determining the highest demand markets and desired product attributes. Specifically, the research objectives were to:

- Identify potential market segments and profile the characteristics of these segments.
- Identify the optimal desktop module features, performance and packaging configurations.
- Determine the price sensitivity of select target markets.
- Profile the prospective customer's area for first product install.
- Develop an understanding of installation logistics.

The second survey phase included a state-of-the-art conjoint, disk by mail, or "Smart Survey." An independent market research firm recruited and mailed survey packets to nearly 1000 MIS, data, and telecommunications executives from a random sample of company locations within several broad target industries.

Information on the installed base of data and voice communications equipment was obtained separately for these firms. The information on company equipment demographics enabled the researcher to focus the smart survey on product and implementation issues without taxing the respondents with redundant questions.

The "Smart Survey" diskette included both standard survey question sections and two adaptive conjoint analysis sections to derive customers' value systems. The conjoint research technique asked respondents to "consider jointly" such product decision items as price, features, and availability. In real purchase decisions, customers trade-off these attributes. By providing the research framework for simulating the product purchase, the typical research answer, "I want the product for nothing, fully featured, and yesterday", was avoided.

Face-to-Face

The final phase of market research was face-to-face interviews with 50 organizations of various sizes, markets, and geographic locations. The objective, was to present a well-defined product representation to top and mid-level MIS, telecommunications, and facilities executives across the USA and in select countries.

The remainder of this paper describes a higher level overview of the results from the market research phases described. This includes an overview of market needs, the problems/difficulties with current cabling methods, and a description of market requirements.

LAN MARKET FACTORS

Personal Computer Explosion

The move from mainframe and central information processing of the 1960s and 1970s provided an opportunity for mini-computers to enter the market. It was the mini-computer which provided greater computer and applications access by employees.

Throughout the 1980s the move to more intelligent desktop devices like personal computers were just that--personal. Organizations, in an effort to empower the worker, provided all types of applications, software and hardware to the worker. The decremental costs of technology facilitated the distribution of personal computers. More importantly, projections state that business personal computer growth will continue its aggressive pace (See Chart 2).

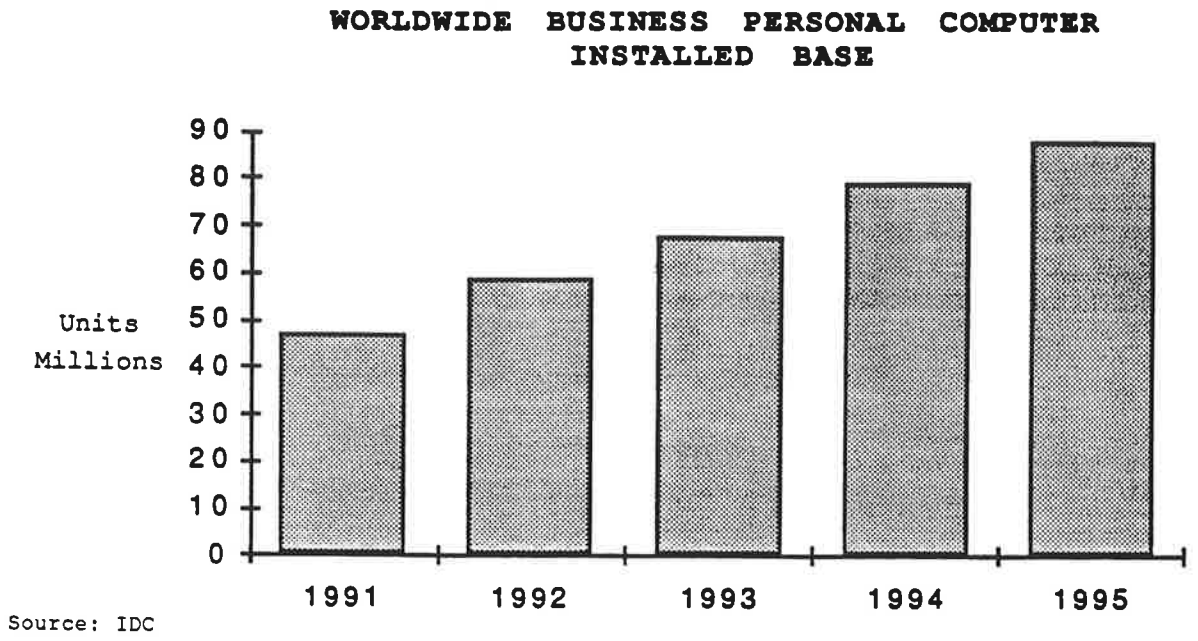

Chart 2

However, the growth of decentralized storage and computing created yet another problem--work groups needed to share information. However, much of this information resided in individual hard disks.

Furthermore, despite the declining costs of personal computers and associated technology, it was and still is considerably expensive to "fully load" the workforce with all of the applications it needs. The ability to share applications became desirable. It was these two trends which highlighted the need for Local Area Networks (LANs).

Information and Resource Sharing

The success of local area network computing was predictable. It started with the basic tenet of sharing resources and/or information. The need to amortize and justify the purchase of expense resources such as printers and storage, was an obvious factor which supported LAN growth.

The need for knowledge workers to exchange data was and is imperative. Furthermore, the ability to share applications supported the growth of network computing.

LAN Growth

The success of LANs throughout the 1980s has been phenomenal. However, the projected growth throughout the 1990s is equally as impressive (See Chart 3). This can be attributed to

not only new installations of LANs, but also to the physical and logical segmentation of LANs as traffic and throughput degradations are observed.

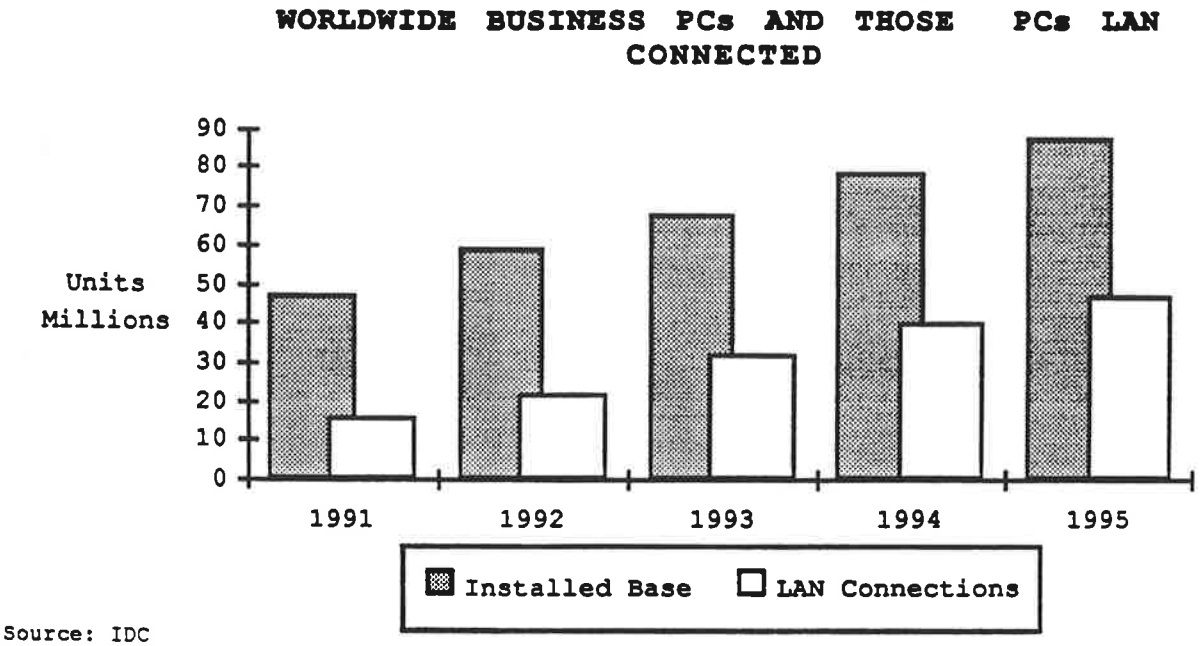

Chart 3

Moves/Adds/Changes And Increasing Mobility

The world economies will continue to develop interdependencies and likewise, global competition. The increasing competitive environment will demand greater worker mobility, changing assignments and reassignments, changing work groups, and mission mobility.

The demand to have information how we want it, when we want it, and where we want it, will be a strategic and competitive weapon. The need to improve efficiency and the growing need for information will accelerate the adoption of wireless communications adoption.

Today's wired network, for all its great strides, is very restrictive. The cost to deploy and redeploy personnel and work groups is time consuming and expensive. Cabling in today's environment inhibits the ability to attain efficiency and competitive advantages. The next section will highlight some of the author's market research findings.

CABLING PROBLEMS

As each phase of market investigation was conducted, several problems with today's wired networks were uncovered. Whether twisted pair, coax or fiber optic cable, hard wiring for telecommunications and data communications systems within a building environment is expensive and troublesome to install, maintain, and especially, change. Beneath today's increasingly dense office electronic environment lies a tangled, confusing, virtually unmanageable maze of wiring.

What appeared to be very significant in the focus group research was how quickly the respondents stated the problems they have with wiring. Among the majority of respondents,

the most favorable solution was to free themselves of all wiring. Therefore, their first choice solution would be a wireless system, minimizing the time and effort of implementing a move, add or change.

Moves/Adds/Changes: Cost and Frequency

A major portion of the cost of LANs is the cost of interconnecting them, which experts acknowledge can sometimes exceed the cost of computer hardware and software. Labor and material costs for wiring are almost always significant, and can reach US$1000 per node just for copper wire. Coax and optical fiber, not surprisingly, are considerably higher.

The news, however, gets even worse when it comes to maintenance. A recent study by the Frost and Sullivan[1] group quotes that LAN moves, adds and changes (MACs), is the third largest cost component for LAN installation and hardware maintenance. They state that MACs account annually for almost US$2 Billion of a US$12.2 billion LAN maintenance market. And that US$2 billion does not even include the original cost to install cable.

Estimates of the cost to rewire range from US$200 to US$1000 per change. In fact, a survey by KPMG Peat Marwick[2] recently quoted that the average relocation cost for just rewiring a LAN station averages US$300 per node. But those are just the direct costs; the time to effect the wired change is a significant problem as well. Moves, for example, often take weeks or longer to coordinate in addition to the time to actually make the physical wiring change.

Most of the research respondents were asked what proportion of their company's staff was involved in some kind of a move involving wiring or rewiring. The majority of the respondents, almost 80%, had some type of relocation or addition of personnel over the last year surveyed. Their responses ranged from as few as 20% per year up to as much as 200% annually.

Furthermore, according to the KPMG Peat Marwick study, the average company moves its employees approximately 50% annually. And, Telecommunications consultant, Richard Kuehn, states that data terminals are moved as often as 1.5 to 3 times per year. The combined problems of the actual hard relocation costs, however, are just the beginning. Soft, or hidden costs, further exacerbate the cabling dilemma.

Hidden Costs

Significant problems arise when these moves or changes are implemented. There is always the disruption of the workers involved in the move or change, not to mention the loss in productivity.

The problems, however, become much more involved when dealing with whole departments and more complex user equipment. In fact, surveyed firms responded that when a relocation takes place, over 60% of the time it involves the movement of an entire department.

The toll of wait time and down time on productivity varies greatly and is difficult to quantify, but certainly is significant and costly. And in today's increasingly mobile working environment, it is likely to grow. The situation is exacerbated by relocations and additions which require reconstructions, thereby, continuing to add to the effective cost of a move, add, or change.

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1 PC WEEK MAGAZINE, *Maintenance Costs of LANs keep Soaring*, Source: Frost & Sullivan Inc.

2 KPMG Peat Marwick Study, January 1991

Costs to rewire rise enormously with the age and complexity of the building. The majority of high-rise office space in large metropolitan areas presents major problems and expense for tenants trying to install, add or move network wiring.

Buildings more than 30 or 40 year old, with designs and construction that did not consider today's electronic office, poorly accommodate communications wiring. If asbestos insulation exists in the building, as it does even in many pre-health-safety regulated buildings, rewiring costs can take on huge proportions.

The coordination of personnel and the moving of one group out to prepare for the new group moving-in is a very costly and labor intensive ordeal. In some cases, wiring had to be installed, or different cabling may have been needed to accommodate new or different types of users' equipment.

Cable Is Not Business Friendly

Although office planners, building managers, and network operators are well aware of the problems with wire, the limitations and huge costs of wire haven't generated focused attention outside of this community. The general business world seems to accept wire as inevitable. Perhaps that's because there have been no real alternatives.

Yet, as computing and telecommunications power continues to proliferate and becomes more widely distributed to the "knowledge worker", the problem will increase. Easy, quick, efficient movement of "people assets" within the working environment is also increasingly being recognized as essential to a business' productivity and competitiveness. Wiring severely inhibits that movement.

The research indicated a need for a flexible, compatible, cost effective, yet high-performance wireless alternative to extend and complement, if not replace, the capabilities of wire, cable and fiber for in-building communications networks. More specifically, it is the convenience and flexibility that users need. In fact, the aggregate need for flexibility and convenience was found to be twice that of the perceived benefit for cost savings.

When research respondents were asked how they could improve upon their experiences when implementing a move, add or change, many solutions were offered. These solutions ranged from having more compatibility among different vendors' equipment, to providing a better way to organize all the different cabling.

Structured Distribution Systems

A number of firms in the research study had deployed Structured Distribution Systems (SDS). An SDS is a topology which advocates cabling saturation of a desired environment to accommodate all potential personnel movements and reconstructions within that office. SDS requires firms to invest large sums of capital initially on the assumption of not knowing how many telecommunications devices may be employed or where the devices are to be located. Consequently Structured Distribution Systems usually plan for worst case conditions, meaning that some or much of wiring systems capability may never be utilized.

However, many firms which have an SDS deployed also expressed those problems which stress their SDS investment. Some of the most frequently mentioned include:

- High equipment addition/relocations exceeding 40% annually

- Expansion and contraction of their workforce
- Changing technology and business support
- Continued investment and vigilance to maintaining the SDS and its intrinsic advantage
- Continued departmental LAN growth requirements

In short, the latter group of SDS respondents provided some notable requirements. A wireless system must:

- Extend the capabilities of their SDS system
- Facilitate the inherent advantages of the SDS
- Offer enhanced flexibility to non-serviced SDS portions of their building or occupancy.

The above points indicate that even in SDS environments, there is an opportunity to employ wireless devices. Wiring--the expense, time, and inflexibility of installing, moving and changing--limits the way companies can productively use networks.

To stay productive, these LANs have to move and change with the workforce they support. Therefore, a wireless offering must be a complementary solution for buildings with an SDS, in bringing wireless flexibility and extensibility to today's networks.

USER REQUIREMENTS ENVIRONMENT

Office Friendly

Several notable conclusions were derived from the marketing research. Secondary research suggests that over 70% of LAN node installations were estimated to reside in an office environment (as opposed to factories and warehouses). Therefore, as an office oriented offering, a wireless system would have to be, by definition, office friendly.

A traditional office is composed of hard offices with opening and closing doors, furniture and personnel movement, cubicles, conference rooms, and walls of varying thickness and substance. Therefore, a wireless system must continually adapt to different and changing conditions, and office layouts.

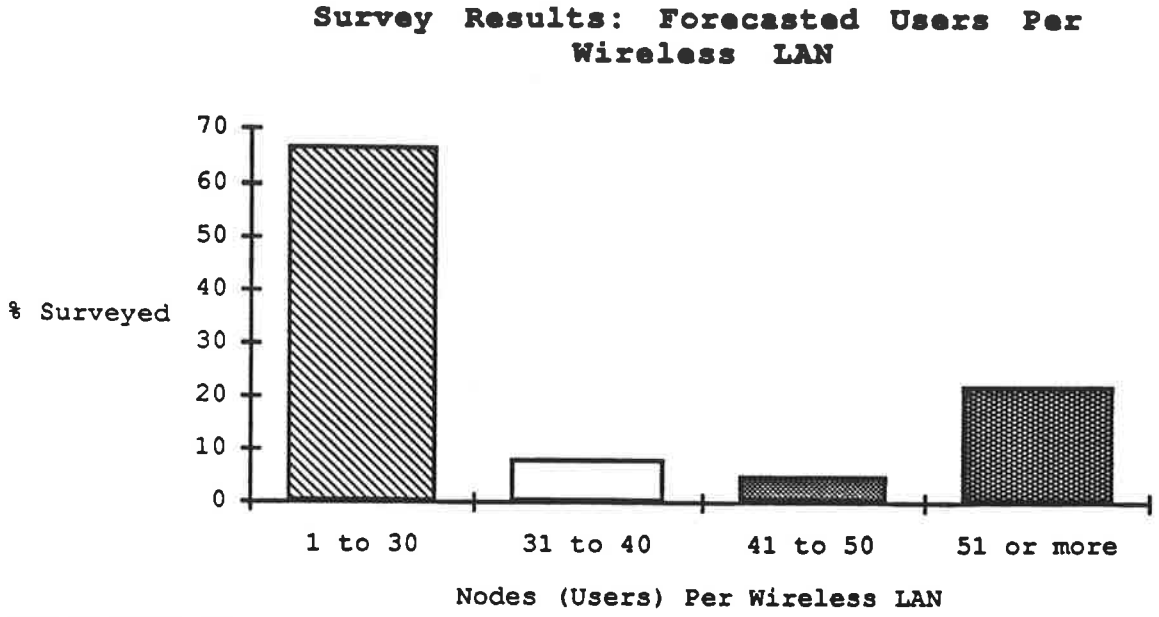
Optimized Service Area

The second wireless in-building need expressed by the office market is the manageability and reuse of any potential system. Unlike the signal propagation characteristics of many lower frequency radio products, LAN administrators desired the ability to control or more aptly, contain, the coverage of a potential wireless system. The reasons were twofold:

- LAN managers wanted the ability to add different services to a new group of users. In fact these new users may very well be physically adjacent to another system, wireless or wired.
- These same managers wanted the flexibility to connect a new or existing user group to either a backbone or to create a stand alone LAN.

LAN Workgroup Sizes

Respondents were asked as to where a wireless offering might be first installed. The market research indicated that approximately 70% of the installations would contain less than 30 users (See Chart 4). Furthermore, the average LAN appeared to be in the 12-15 node range. This is further collaborated by the KPMG Peat Marwick study which found that the average LAN size is about 15 users per LAN.



Source: Motorola Inc.

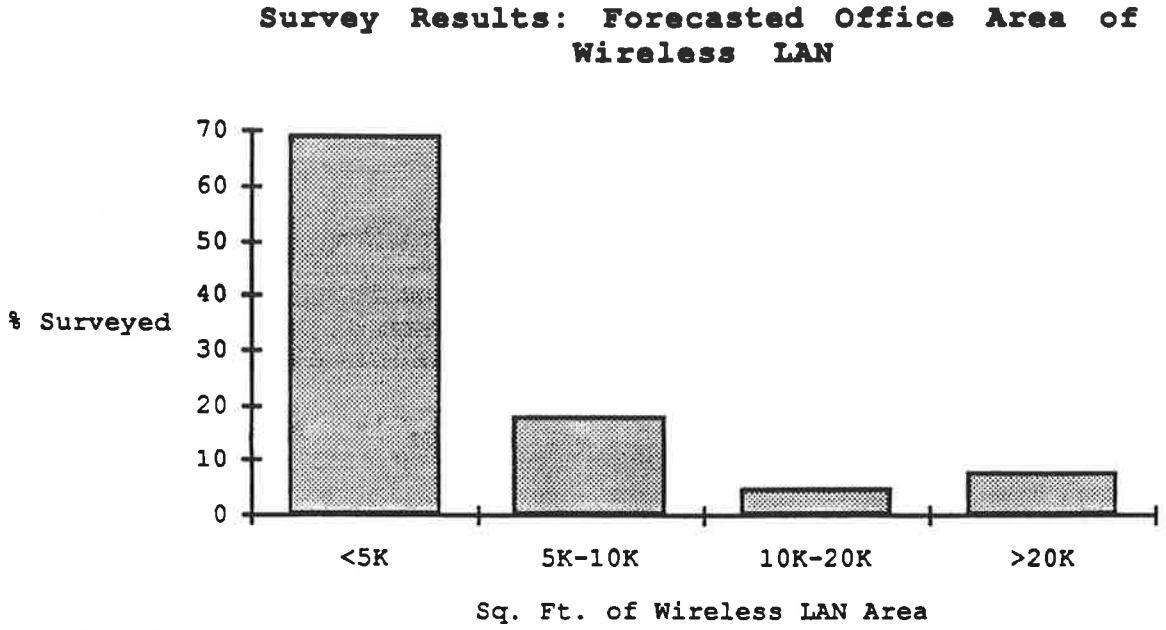
Chart 4

Furthermore, the system must have the flexibility to manage the service area. That ability, to either incrementally add systems whether on the backbone or in a stand alone configuration, must accommodate scalability within an organization.

It is interesting to note that these figures are consistent with good LAN administration for purposes of maintaining high throughput and fault isolation. As LANs become larger and traffic more intensive, there is a natural inclination to begin segmenting LANs into more logical and defined user areas/groups.

Coverage Area

To satisfy the majority of requirements, we determined that approximately 70% of LANs would be deployed in areas less than 5000 sq. ft. area (See Chart 5).



Source: Motorola Inc.

Chart 5

This must take into consideration the fairly dense environment, made up of cubicles and apportioned hallway space. The market investigations indicated that a wireless offering must accommodate, at the least, 150 sq. ft. per user. This is equivalent to 32 users/system in a 5,000 sq. ft. area.

PRODUCT REQUIREMENTS: END USER REACTION

Transparency, Compatibility, and Performance

To justify the expense of a wireless system to end-users, a wireless offering would have to provide reliable performance, as well as be practical and cost effective. Our market research indicated that the ideal system should be:

- Easy both to install and move, preferably by the user.
- Able to coexist with both existing wire and cable, as well as with future optical fiber.
- Easy to operate, virtually transparent to the user.
- Almost universally applicable, suitable to replace any LAN cable or wire, in any office environment.
- Powerful, performing comparably to the wire it replaces--providing the minimum 10 Mbps speeds expected of competitive systems

- Secure, absolutely reliable, and cost effective.

A wireless system is a "media replacement" and therefore must be totally transparent. If the customer is to enjoy the attributes of wireless, the respondents indicated that the wireless implementation must not require the user to change the way he operates or interfaces with his personal computer.

Also, a wireless offering must provide true compatibility. The wireless connection must be compatible with standards-based components such as operating systems and applications, LAN cards and other devices, as well as LAN wire that is already in place.

Security and Reliability

In addition, the market mandated that a wireless product offering be absolutely secure and reliable. Security was a requirement across several dimensions. To provide sufficient data security a wireless system should first prevent the effective capture of data by a receiver outside of the wireless system, and second, prevent capture of the data by unauthorized wireless hardware within the system. A wireless product must be secure from eavesdropping, either accidental or intentional.

Reliability was another important attribute. The users required absolute reliability. That is, users wanted a guaranteed packet delivery from the entry/exit wireline points--and they wanted it at least as error free as their current cabled environment.

Cost Effective

Finally, most businesses will place any capital or expense under rigorous financial analysis. As such, the acceptance of a new technology/application must pass the payback test for that business. Therefore, demonstrable payback and justification is needed to facilitate an organization's evaluation of any potential wireless offering.

SUMMARY

The numerous problems with wiring will become even more acute in the office of the 1990's. This environment will be characterized by:

- The proliferation of decentralized computing resources.

- Increased number of telephones and personal computers as an outgrowth of a country's economic shift toward service industries.

As the penetration of Personal Computers (PCs) nears a one-to-one relationship with phones in the office workplace, the limitations of separate voice and data networks will become even more evident. If these problems are not addressed, an organization's flexibility in redeploying "people assets" and ultimately competitiveness, will be seriously hindered.

The time it takes to move/add/change equipment and reconfigure communications wires will be the limiting factor in rapidly reorganizing workgroups and responding to new assignments. Wireless LANs will become an attractive solution in the office of the 1990s, interconnecting personal computers and offering data communications capabilities without the need for elaborate cabling methodologies.

The obvious and inherent flexibility offered by wireless LANs is the obvious primary benefit. However, the ability to retrieve that investment, never retrievable until now, clearly presents a significant economical benefit.