

**IEEE P802.11**

**Wireless Access Method and Physical Layer Specifications**

***Wireless LAN Requirements***

***and***

***Market Forecast***

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**Executive Summary**

Local area networks have become the dominant data communications tool to the desktop. By the mid-90s, more than 50% of all desktop devices and more than 70% of all desktop PCs are expected to be LAN connected. And today, that means via one of the existing wired LAN standards. In order to capture significant market share, a wireless LAN standard must be brought promptly to market.

Examination of the LAN and voice markets reveal little evidence that real-time voice and data must cohabitate on same link media. The need for an early standard motivates against delaying for a more complex standard accommodating both services with

doubtful market value. It is imperative that 802.11 develop a standard that provides the necessary data services without burdening the standard with requirements for synchronous services of both doubtful market value as well as doubtful implementation feasibility. These required data services are straight-forward: low transmission delay, low packet error rate, "best effort" datagram transmission.

UTP will own the desktop for some time to come. Wireless LANs offer few advantages and several disadvantages re UTP networks for desktop data devices. However, the move towards small, mobile computers replacing desktop computers is the key opportunity. Mobility is key. Wire replacement not interesting.

## I. A Sense of Urgency

Local area networks have become the dominant data communications tool to the desktop<sup>1</sup>. By the mid-90s, more than 50% of all desktop devices and more than 70% of all desktop PCs are expected to be LAN connected. And today, that means via one of the existing wired LAN industry standards. The rapid market changes pioneered by the overwhelming success of wired local area networks introduce urgency in the development of an 802.11 standard.

These figures illustrate the growing pervasiveness of networking during this time period. As 802.11 considers a standard, substantial numbers of LAN connections (largely wired) will be installed. Further, technological developments will substantially increase the utility and performance of this installed and to-be-installed wire asset. Unshielded twisted pair will increasingly be used for higher and higher speed up to and over 100 Mb/s at costs of only a few hundred dollars per connection.

The strong industry movement towards portable computer systems evidenced by

- the sharply increasing market share of portables even beginning to replace desktop computers - about 10-15% of the total PC shipment volume;
- the anticipated introduction of palmtop and handheld computers for general purpose applications;
- the existing and growing substantial market for special purpose handhelds - about 10% of the PC shipment volume;

lays the groundwork for future strong wireless LAN demand for mobile computer systems.

Price is a strong factor with the overwhelming acceptance of low-cost unshielded twisted pair wiring and price points for LAN adapters well below \$500/connection. The last decade's experience with LAN systems suggests that typically the LAN adapter price point must be below 20% of the price of the computer before the LAN will see wide market acceptance.

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<sup>1</sup>K. Biba, "Local Area Network Market and Forecast", IEEE P802.11/91-17, March 1991.

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## II. Data Communications as a Focus

Examination of the LAN and voice markets reveal little evidence that real-time voice and data must cohabitate on same link media. Indeed, the very lack of success of voice PBXs in serving the data market (substantially less than 1% of all desktop devices use a PBX as their primary data connection) argues that this is not a compelling user requirement. The substantially higher performance and lower cost of separate data and voice transmission networks have made this the dominant architecture.

Further, while there are strong market moves for integrating store-and-forward data, voice and image via next generation electronic mail systems, no strong market moves can be discerned for real-time integration of these services. These store-and-forward services can be quite adequately served by contemporary LAN protocol architectures - 95% of which (by shipment volume) require only simple, "best effort", datagram delivery services from their link layer networks.

No extant network design has succeeded in integrating voice and data services without degrading either unacceptably to the market. There are examples of data networks that can accommodate a modest amount of real-time voice traffic (e.g. IEEE 802.3, 802.5, etc.) and voice systems that can accommodate a small amount of data traffic but not at expected LAN performance points (e.g. DECT, many dynamic TDMA systems., etc.). While this does not mean that an integrated system cannot be developed<sup>2</sup>, it does suggest its difficulty towards a problematic goal (e.g. does the market desire this capability?).

The need for an early standard motivates against delaying for a more complex standard with doubtful market value. It is thus imperative that 802.11 should develop a standard that provides the necessary data services without burdening the standard with requirements for services of both doubtful market value as well as doubtful implementation feasibility. These required data services are straight-forward: low transmission delay, low packet error rate, "best effort" datagram transmission.

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<sup>2</sup>Particularly with the restrictions of modest network capacity. While integrated services can be provided at very high data rates (e.g. SONET, IEEE 802.6, fast packet architectures, etc.), fitting these architectures within the restrictions of channel speeds less than 10 Mb/s is quite difficult.

### III. The Benefit of Wireless LANs

The market demand for wireless LANs has two poles of attraction:

- as an cost/performance alternative to wire for communications to the desktop; and
- as a necessary technology supporting new types of network computing services not tied to the desktop.

Recent improvements in the technology of wired LANs, in particular the market dominance of star-configured unshielded twisted pair (UTP), have dramatically increased the attractiveness of wire.

Installation	Installation costs in all but the most intractable of existing buildings are quite modest (a few hundred dollars) for UTP wiring plans.
Upkeep	The ubiquitous, controlled wiring closet architecture of UTP as well as contemporary network management tools has decreased the cost of moves/adds/changes.
Performance	Today's UTP wiring plans support up to 10 Mb/s and it is likely that the same wiring plan will support 100 Mb/s.
Capacity	In addition to capacity increases due to transmission rate improvements, the major cost of UTP is the installation labor rather than the wire itself. Thus the space division multiplexing of pulling more wire than immediately required has small additional cost or inconvenience.
Adaptability	Today's UTP wiring plans can equally support all current major LAN standards (e.g. IEEE 802.3 and 802.5) as well as likely expansion to support higher performance FDDI over UTP. A desirable side effect is that pulling a few extra pairs (a minor cost increase) will also support voice over the same wiring plan.

On the other hand, wireless LANs have properties that limit their attractiveness for communications to the desktop.

Performance	Regulatory, technological and environmental limitations make even 10 Mb/s LAN performance difficult as current product offerings evidence. Given the progress of wired LANs it can be anticipated that wireless LANs will lag at least one generation behind wired LANs w.r.t. performance.
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Scale      Low power, microcell wireless LAN architectures require, in many cases, a wired backbone to extend network services beyond a small microcell. If no other motivation is present, solving the "last 20m connectivity" problem with a wireless LAN off a wired LAN backbone, does not seem compelling to the market.

The decreasing costs, increasing maintainability and increased performance of unshielded twisted pair wiring compared to the anticipated limitations of wireless LANs suggest that wireless LANs have an uphill market battle when considered as wired LAN replacement to the desktop.

Therefore, the key benefits of wireless LANs are not to replace wire at lower cost or higher performance but rather for

- convenience      more easily installed small networks without the perceived hassle of installing wiring; the increasing attractiveness of mail order "plug and play" networks;
- extension      extend wired networks either for convenience/cost in the few places where it is difficult to get wire and it is acceptable to accept diminished performance and in cases of necessity - where wire simply cannot be feasibly run (e.g. into nuclear reactor containment buildings) - these are all quite small niche markets; or
- necessity      where there are no wire alternatives, in particular mobile computer systems.

#### IV. Wireless LAN Functional Requirements

Wireless LANs inherit many of the performance and market requirements of wired LANs since many of the same applications will be run on both. In addition, there are requirements unique to their anticipated use for mobile computer systems as well as ones that reflect the state-of-the-art in wireless data transmission.

Applications	Essential to support existing desktop LAN applications plus anticipated wireless LAN applications. Minimal need for real-time synchronous services. Substantial interactive datagram services are required. Major anticipated application area is the support of mobile, handheld applications rather than desktop wired LAN replacement.
Mobility	User components can be expected to move - often. Users expect not only to initiate communications sessions in new locations, but also to maintain existing communications sessions while in motion. Would be useful to better use paging model so as to minimize local mass storage for mobile machines.
Services	Users expect contemporary enterprise and local area network functionality: file access/transfer, remote terminal access, reliable virtual circuits, datagrams and remote procedure calls. Underlying these services must be effective techniques for resource naming, routing, and network management. This must be accomplished without reinventing contemporary LAN operating systems. Essential to provide basic "best effort" datagram delivery services with roaming. Consistent with existing 802.2 Type I and Type II services, optimized for datagram services.
Scale	Minimal initial setup for small networks, easily scaling for capacity and/or area coverage to support large populations and/or large areas. Architecture should not unduly constrain size either geographically or in terms of numbers of stations. Minimum network size should be two (2) stations and/or 2000 m <sup>2</sup> and maximum network size should be about 10 <sup>4</sup> stations over 3x10 <sup>6</sup> m <sup>2</sup> .
Performance	Burst channel rate of no less than 1 Mb/s, preference for channel speeds of between 4 and 10 Mb/s. Low frame transmission delay (< 5 msec) at low to moderate load. Congestion control at high load. Capacity that scales with network size.

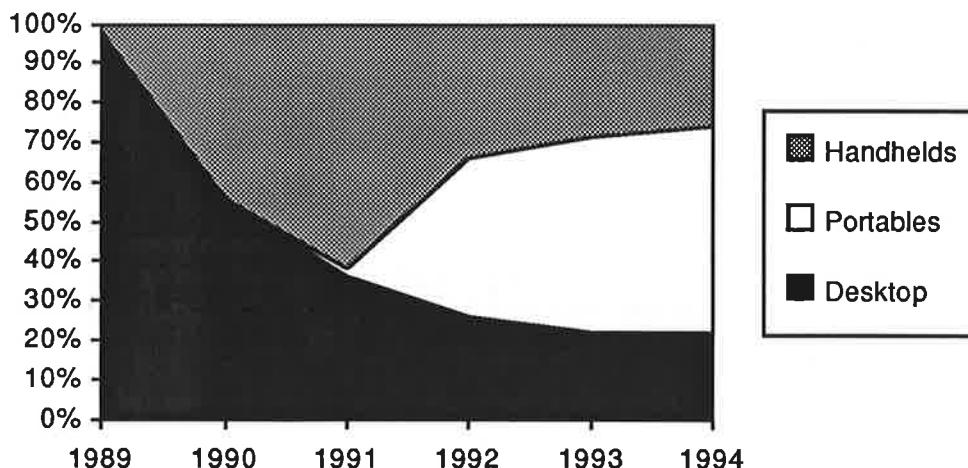
Power	The highest volume WLAN applications are anticipated for mobile computers where (battery) power consumption is extremely important. Low average power usage is therefore of great interest. Simplicity of implementation can, in general, reduce power consumption.
Integrity	Users expect both reliable communications - session error detection and recovery - as well as robustness of the underlying communications internetwork - alternate routing, load sharing, and reconfiguration. System should be robust against interference from 802.11 conforming adjoining WLANs as well as non-conforming interferers anticipated in the environment.
Security	Users expect that their wireless transmissions are perceived to be at least as secure as their wired communications with no substantive cost increase. Casual data theft should be discouraged. High security mechanisms should be (optionally) provided by 802.10 conforming services.
Interoperability	Users demand interoperability with other manufacturer's equipment. Such interoperability provides both a basis for application interconnection as well as long term system growth and support. The use of standard communication protocol suites and interfaces provides the foundation for interoperability.
Cost	Users will, today, pay a premium for the above services for mobile applications. However, the choice of technologies should introduce no inherent cost increases. In any case, wireless LAN services will not be popular until (as a rule of thumb) the incremental cost of the (wireless) LAN interface is less than 20% of the cost of the serviced computer.
Time-to-Market	If wireless LAN products are to provide some measure of wire replacement, some urgency is required since it is clear that wired LANs are becoming cheaper, faster and ubiquitous.

## V. Wireless LAN Market Forecast

Previous studies<sup>3</sup> have suggested that the cost and performance limitations of wireless LANs will lead to only a small market share for wireless LANs amounting to less than 1% of annual LAN shipments. However, the bulk of that analysis focussed on wired LAN replacement to desktop computers.

Our analysis is similarly pessimistic for wire replacement applications suggesting that 2-3% penetration may be possible depending on wireless LAN price point and performance<sup>4</sup>. Wire replacement is considered a modest market since wire is becoming inexpensive to install and manage and has the capability to increase in performance and capacity over time.

However, the anticipated market growth in mobile computers was not fully considered in previous analyses. For these applications, wireless LANs can capture 50-70% market share.



In our wireless LAN analysis, three generic applications are considered:

- Desktop            the wired LAN replacement market;
- Handheld          the existing market of for special purpose handheld computers and terminals; and

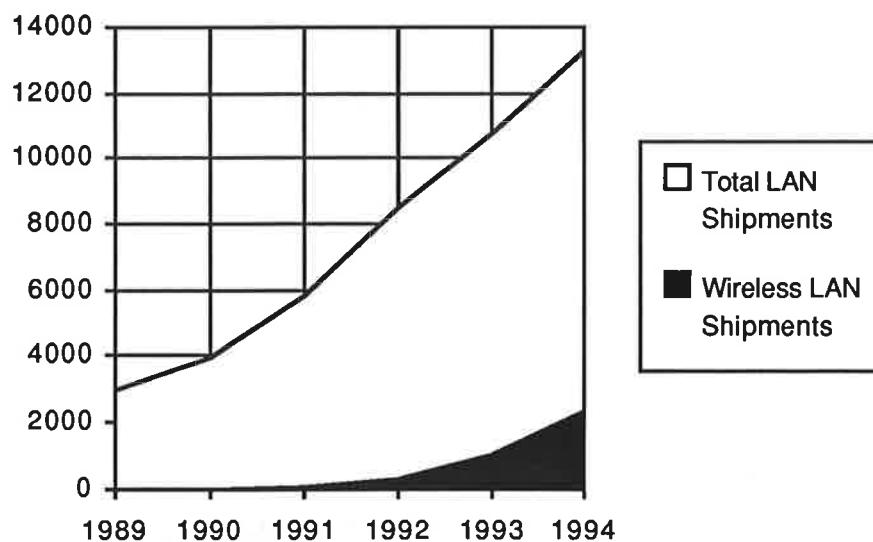
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<sup>3</sup>George F. Colony, "Personal Wireless", Forrester Research Inc., The Network Strategy Report, V4#10, September 1990.

<sup>4</sup>2-3% assumes roughly equivalent performance and price.

Portables      the nascent market for general purpose network connections for portables, laptops, notebooks, pen computers, etc.

Wireless LANs already on the market serve primarily the desktop and handheld markets with only desktop products really being shipped to end users and wireless LANs beginning to appear in handheld products. It is anticipated that the bulk of the long term market will be serving the quick growing portable computer market.



Assuming the continued market success of portables, and the attractiveness of wireless LANs for portables, over the long term wireless LANs can capture up to 25% of forecast LAN shipments. This forecast is heavily weighted on the success both of portable computers as well as the attractiveness of wireless LANs for this class of machine.