DATE: **July 3, 1997**

TO: **Those interested**

FROM: **Chandos A. Rypinski, Organizer (e-m: rypinski@microweb.com)**

RE: **IEEE 802.9 WIRELESS IS LAN MAC AND PHY**
(IS=Integrated Services=packet data & telecom connections)

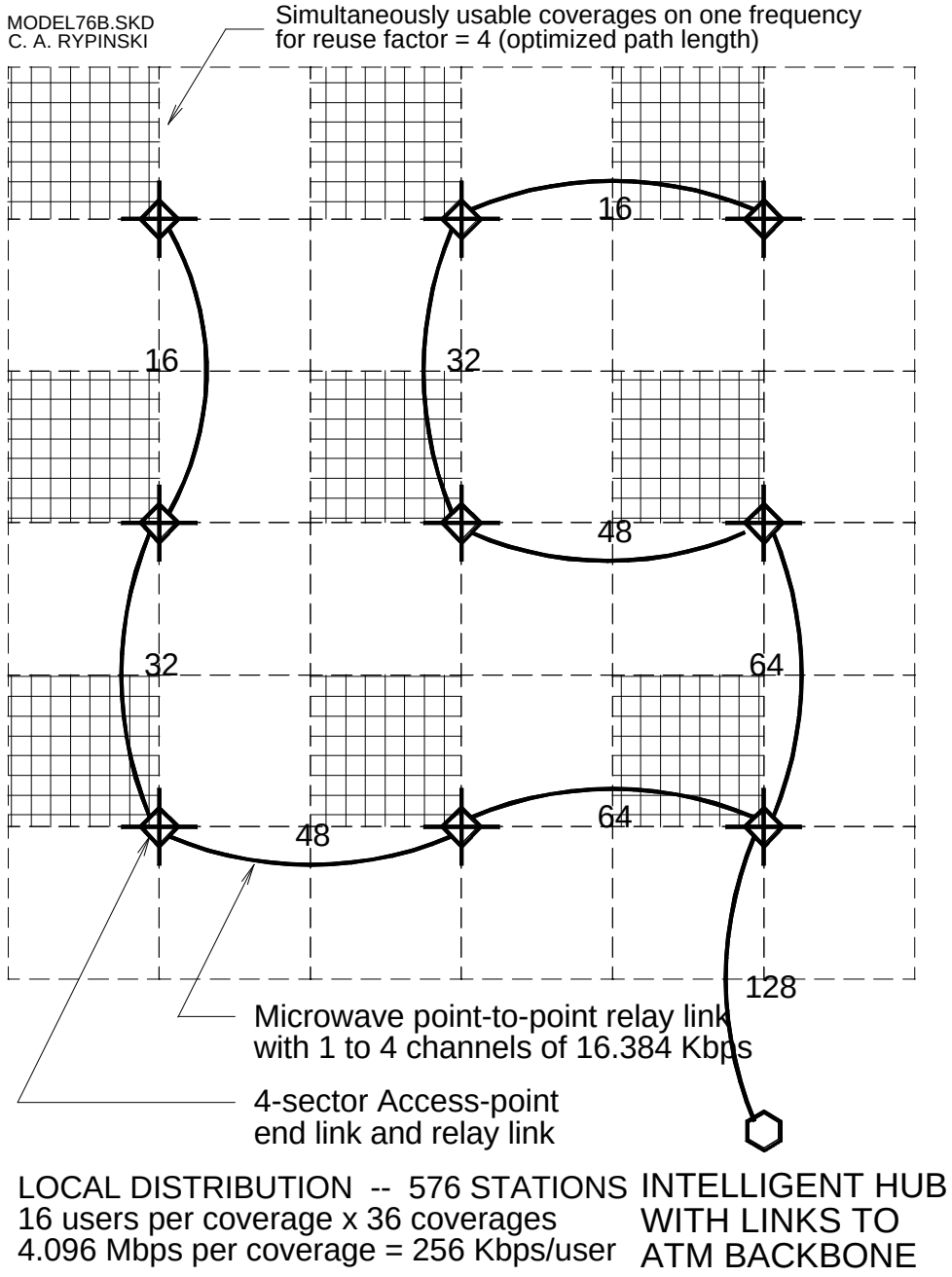
This paper is information backup for a TUTORIAL to be presented at IEEE 802 on Tuesday evening, 8 pm, July 8.

SUMMARY

The goal sought is organization of a Study Group within IEEE IEEE 802.9 (under the 802 Standards Committee Rules) to determine and substantiate the interest and need for a Project to develop a Wireless IS MAC and PHY for the IEEE 802.9 IS LAN Standard.

The material presented is a substantial edit a general memo sent on May 17 to the interest mailing list on this subject.

Table of Contents **Page**



The above Figure (not referenced in text following) is a possible example of a continuous area coverage plan. The same radio frequency channel is reused in every fourth coverage as represented by the crosshatch squares for one frequency.

Access points are quadrant sectors with four sectors at each service location.

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MOTIVATION FOR THE NEW PROJECT

Given:

1. The rev 3 draft PAR in IEEE 802.11 addresses the NII band using its existing MAC. This MAC is unsuitable for reserved bandwidth services (e.g., video) and inefficient for continuous area coverage with coordination between coverage's.
2. IEEE 802.9 has already developed most of the functionality for integrated packet and reserved bandwidth services. This reusable work is a much larger part of the project than the development of an alternative physical medium.
3. No present standards group is known to be addressing the MAC and PHY areas with point-to-multi-point wireless cell relay technology, and with legacy interface compatibility at the station.

The substance of the following sections is that there is no redundancy with IEEE 802.11, there is substantial commonality and reusability with IEEE 802.9, and that there are no other known, like-type standards efforts under way including that of ETSI RES10 HIPERLAN /2.

The need for the service that can be performed by this type of Standard is ubiquitous. Most other wireless systems are independently designed functional subsets of what is proposed and what is necessary to develop a large wireless market.

There is no plan to unify a fragmented short reach radio system market. Without this unification it will not be possible to build a market for any one function of any substantial size. The absence of a volume market will prevent a variety of economies from ever developing.

Proposition: Those who believe that this fragmentation of the wireless market is either necessary, desirable or inevitable may be mistaken.

"STRAWMAN" CHARACTERISTICS FOR WISLAN PROJECT

July 3, 1997

Project Name:	**WISLAN**-PMP-Wireless end link (PMP =Point-to-Multi-Point) Air Interface and appropriate Medium Access Control (MAC) and Physical (PHY) Layers
Services:	802 LLC Packets, plural ISDN BRI and PRI with D-channel setup complementing but not replacing equivalent wired services.
Station types:	Initially supporting legacy data and telecom interfaces, but eventually extendible to ATM format user station communication interface.
Transport format:	48 octet payload standardized burst size and/or integer multiples. Default medium transfer rate is duplex 16.384 Mbps payload.
MAC:	Point-to-multipoint end-links particularly optimized for radio and optical wireless but usable on other types of transmission mediums
Topology:	Large scale "quilt work of coverage's" with multiple access points with intensive frequency reuse
FCC rules:	NII bands LB, MB, UB (5.15-5.35 and 5.7225-5.825 GHz) with bandwidth sufficient to reach maximum allowable transmitter power (>20 MHz).

Scope may also include:

- Cooperative functions between numbers of overlapping coverage wireless access-points
- Central functions common to the composite wireless network
- Physical layer level repeaters for relay links by wire, radio or infra-red between access points and hubs
- Provisions for peer-to-peer guest services within a centrally-controlled network
- Provisions for organized band sharing between technically like-type systems but with separate administration.
- Provisions for frequency division channelization and trunked or cooperative use of channels.
- Provisions for mapping and transporting specified ATM cell headers

DISCUSSION OF IEEE 802.11

This draft standard has received the approvals necessary to become a Standard. This level of acceptance was reached by a huge, skillful effort from the Committee Chairman and the key members. Despite this skill and effort, it is suitable for only a minor subset of all wireless applications, and in the long run will not be an adequate solution for the needs originally defined. This is the opinion of C. A. Rypinski which is now elaborated.

The primary limitation of this standard is that was initially conceived as a distributed logic, peer-to-peer system with further changes later introduced to fix inherent limitations. It is also fatally hampered by the "listen-before-talk" access control that seems to come with distributed logic. When there is high usage of frequency spectrum, the status and suitability of a given channel for a particular station is not wholly knowable. In particular the possibility that the desired signal will be enough stronger than interfering signals cannot be known instantly at a source station. Much more can be known at a central control point where the status of all coverage on that channel is known continuously. Failure to algorithmically considered simultaneous status in contiguous coverage's greatly (<25x) decreases the capacity.

The described "extended service set" specifies nothing whatever about coordination of contiguous access points to reduce interference and the possibility of collision between adjoining coverage's on the same frequency.

To support a "contention-free" service, there is a "point control function" which requires stations within one coverage to defer to an in-progress reserved space transfer. There is no way for that reservation to propagate to any other coverage except from the listen-before-talk algorithm.

The access method is primarily dependent on a station anticipating channel use by observing and idle channel condition with a "clear channel assessment" function and then invoking random backoff delay. A priority scheme is used which further calibrates the interval for which the channel must be observed to be clear. Within the priority scheme there is also a randomized backoff.

The deferral system performance cannot match wired systems over the radio medium, in part because there is no simultaneous reverse path that enables collision detection, and without the reverse path, the system is a near Aloha type without slotting. There is no slotting to prevent one transmission from corrupting two others when the collision function is desensitized decreasing capacity from 30% to 15% of channel time..

Adaptive desensitization of signal-detect function degenerates into a system where little attention is paid to existing channel use. Failure to desensitize can result in "busy-lockout" from distant stations (the interference range is at least 4x the service range).

This deferral scheme penalizes honest users and benefits those who would jam the channel or who would bypass the LBT by a short on the radio RSSI line.

There is no capability for central management, very limited future capacity reservation and coordination between access points. High channel time usage requires means for a central controller to know the communication backlog and to assign use in sequence according to an algorithm considering function, message size, tolerable delay and backlog in category.

The basic limitations of 802.11 with respect to reservation-type services have been recited in a paper published in the Bell Labs Technical Journal for Autumn 1996 (*J. Sobrinho & A Krishnakumar, "Real-Time Traffic over the IEEE 802.11 MAC Layer").* This paper goes on to describe an improvement for connection-type services which will certainly work better than the present PCF but which still suffers from the absence for algorithmic central control.

Capacity Characteristic from Simulation

The 802.11 draft standard contains no provision for organized frequency reuse. A few years ago a simulation was done considering text book Rayleigh fading propagation and measured radio properties. The simulation assumed two clusters of users at various distances. Close together, each group got about 50% of the usable channel capacity, and far apart each got 100%. The limit on the cluster size is the largest at which all members of the peer group have a high probability radio path to all others in the group. The interference range is that at which at a transmitter has a significant possibility of inhibiting transmission at a few of the peer group stations after the "clear channel assessment" function.

Using the simulation results with a "square cell" carpet coverage, the diminution of capacity from each of the surrounding clusters could be estimated. It is not as simple as summing the % loss from each interfering group. Nonetheless it was found that in this context, ***the capacity of one cluster was reduced from 30-40% of the stand-alone channel rate to a few percent***. Expressed in another way, for each cluster to have a capacity within a few percent of the standalone value, at least 25 independent radio channels would be needed. Even then, there would have to be much more of a plan to cause the 25 channels to act as one system rather than 25 autonomous systems. In some judgments approaching a reuse value of 25 might be considered good enough, however much smaller values are possible when and if this optimization criteria is given large weight.

> *For these, and many other reasons, the CCA based MAC if 802.11 cannot efficiently use spectrum or meet needs much beyond those of ad hoc groups. In spite of many improvements, it cannot work better than its original concepts allow.*

Draft 802.11 PAR for NII Band

The following excerpt is reproduced from rev. 3 of the draft 802.11 Project authorization Request for a new PHY in the NII frequency band. This is not the last revision of this document in preparation.

IEEE STANDARDS PAR FORM

TITLE:

[**Standard for Wireless Medium Access Method (MAC) and Physical Layer (PHY) Specifications - Supplement for High Speed Physical Layer (PHY) in the 5 GHz band**]

6. Scope of Proposed Project (*What is being done* including the technical boundaries of the project?)

[**To develop a High Speed (about 20 Mbit/s) PHY for use in fixed, moving or portable Wireless Local Area Networks. The PHY will be used in conjunction with the 802.11 Medium Access Control (MAC). The 802.11 MAC will be reviewed to assure it's capability to operate at the speeds targeted by the project.**]

7. Purpose of Proposed Project [*Why is it being done*, including the intended user(s) and benefits to that user(s)]

[**To create a high speed wireless access technology suitable for data, voice and image information services. This technology should be beneficial for improved access to the Global Information Infrastructure and wired LANs, as well as creation of high performance ad hoc networks.**

The project will focus on communication techniques which use the spectrum efficiently and enable a high aggregate throughput, as well as high speed for an individual network.]

In stating that the present 802.11 MAC will be reviewed for speed capability, misses the key limitations stated above. These goals are similar to and may be competitive with European HIPERLAN in the same frequency band.

EXTENDING 802.9 TO A RADIO PHY

The main point of associating the new PHY is that key elements of the entire standard are already understood and in documented in 802.9. It is now helpful to identify these reusable parts.

The Existing 802.9 Protocol Stack

Shown in **Figure 1** below is a fair copy of the protocol stack diagram for 802.9. 802.9 is a wireline interface definition for a twisted pair medium connecting one user station to a class of common equipment that would surely include a telecom switch. The transmitters on this medium are on continuously with a defined frame format with control fields and payload fields into which either connection-type of packet bits are loaded for transmission. The physical medium and the associated PHY layer protocol are all that is common between connection-type and packet services. The packet MAC is particular to this situation. The isochronous service see B and D channels just as they would for any other point-to-point isochronous transport.

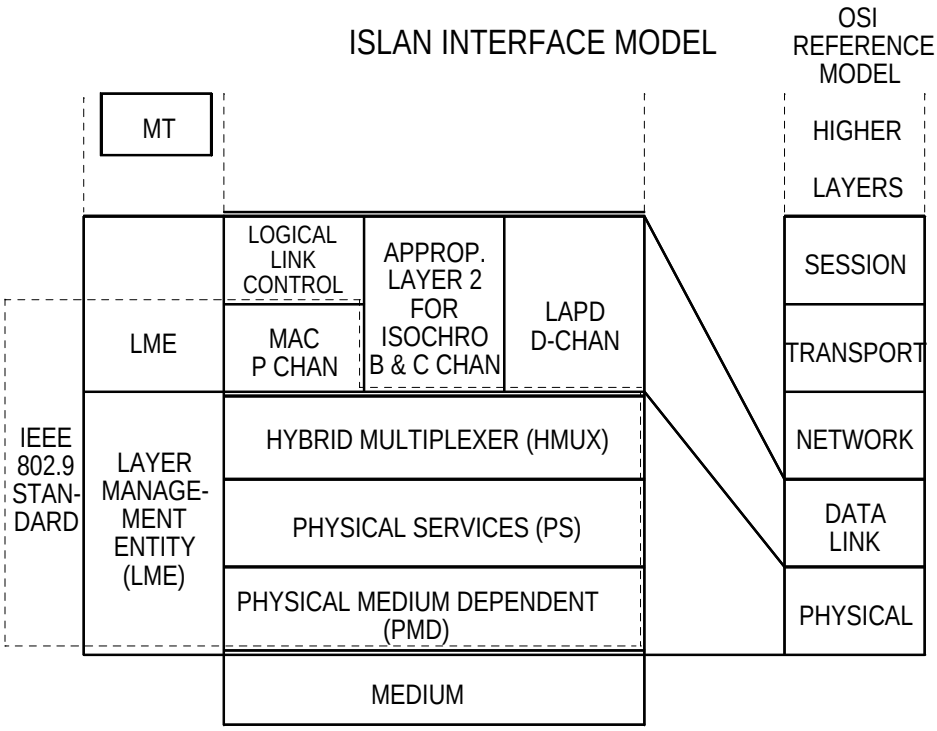

Figure 1 IEEE 802.9 Protocol Stack with Phy Multiplexing of Integrated Services

The portion of this stack covered by IEEE 802.9 is shown within the dotted line. A new stack is shown following in which the common elements are extended to included the medium access control above which the convergence between cells and packets/connections are independently provided.

The Integrated Services Protocol Stack for the Radio PHY

The new protocol stack shown in **Figure 2** has some different requirements to meet. These include:

a) Use of the cell format for both isochronous and packet services

b) Defining a point-to-multipoint PHY-with concentration properties

c) Defining a MAC-PHY suited to cell format short burst radio transmission

d) Provisions for a higher level remote management function

e) Addressing of functions which must be supported in the air-interface but which are controlled by higher level functions common to multiple access points or even multiple independent systems

f) Handling of LAN multi-casting functions

g) Handling of special frequency reuse functions

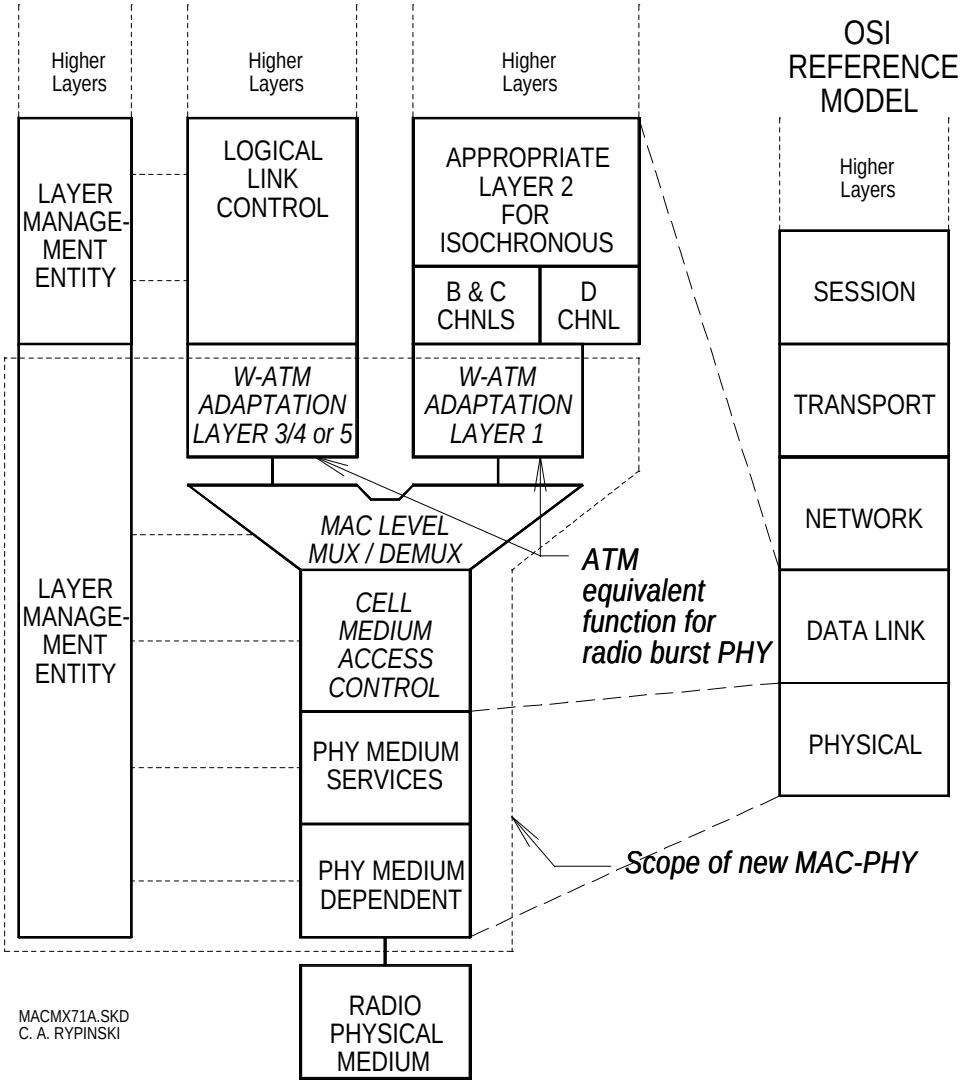

Figure 2 Protocol Stack for New ISLAN with MAC Level Multiplexing

Multi-media and QoS

The air interface defined above in 802.9 assumed a model with a generic central entity that provided essential higher level functions and which must be supported by the MAC and PHY. Among these are the processing of future reserved capacity and the allocation of capacity when demand approaches or exceeds supply. Without an entity that knows the utilization state of the system, it is not possible to provide the predictability of performance necessary for a variety of developing communication services including real-time video and multi-media.

Special Properties Required in the Radio MAC

The radio physical medium must have its own medium access control for point-to-multipoint cell relay. For a system plan provides intensive frequency reuse as the primary means of achieving high capacity from bounded spectrum, there are a number of considerations that are known to few who are experts on computer communication protocol. Similarly, the givens for telephony via radio with intensive frequency reuse are barely applicable to data communication (notable exception in work of D. C. Cox).

The organizing of the development of this type of system is commonly initiated by subdividing the work in a dozen or more subtasks. There is no way to get a good answer, if all of the key limitations are not known by all and from the beginning. Otherwise, it will be a variant of 802.11 or PCS without capability for the high bandwidth data and connection applications.

My participation in this work is assurance that these requirements will be described. There is no assurance that any of the presented considerations will be incorporated in the end result unless the Committee includes many with like objectives in this functional area.

Adaptation to Wireless ATM

The above Station protocol stack addresses existing application communication interfaces. There is no visibility or coordination of the backbone technology employed which will presumably be those now employed for either data or telecom. A similar stack will be necessary at any central hub for legacy interfaces to external networks. If the backbone is ATM, then the translation will not require resizing of payloads. ATM compatibility will require only header assembly and processing.

COMPARING 802.11, WISLAN AND WIRELESS ATM

Existing work on wireless ATM is highly relevant technology until the station protocol stack is reached. Wireless ATM delivers the cells to the user station requiring the station to process headers. This means that the station might have to deal with external networks to negotiate virtual circuit/path identifications using setup messages. The wired header function is a subset of the channel overhead that is required for the radio medium, and it is insufficient to alone deal with point-to-multipoint end links. Because of the relatively higher value of radio channel time, some effort is required to minimize repeat transmission of information already known.

There are good reasons for not using the existing ATM header in the radio medium, even though the factual information that it contains must be passed as a subset.

The anticipated result of this project would be something highly compatible with wireless ATM, but ***using cell relay technology for communication with existing higher level protocols in the station***. ***This what the 802.9 Standard does above the transport level.***

The different protocol possibilities may be compared as follows:

WATM: The implication of wireless ATM is that the ATM cells with header are relayed to/from the user station. The setup of the virtual circuits is then negotiated between the user station and the outside network. This can create variability in station protocol dependent on the type of backbone used. It may also be considerably less efficient in the use of the medium because of complete acceptance of ATM cell philosophical concepts.

WISLAN: This protocol terminates and relays connections of either/both ATM and legacy packet and data backbones at the central hub, then relay cell payloads through the radio system to the user station. At the interface user station interface, there are separate legacy protocol stacks for connections and packets. The setup and processing of virtual circuits in external networks stops at the central hub. The user station does separately and in parallel what it would do for ordinary packets and ordinary telecom connections with existing wired interconnect..

All of this would be accomplished with an access method fully taking into account the functional needs for intensive frequency reuse and continuous area coverage from a fixed amount of radio spectrum. These points are not known to be adequately considered in any other protocol.

802.11: CCA distributed logic access method, no provision for connection-type services, and contention free services at best only control one group. There is no provision at all for frequency reuse or coordination between nearby separate radio coverage's.

The 802.9 approach will have much more immediate market and much lower transitional cost. It will be possible to defer transition to ATM backbones using legacy backbones. When the transition to ATM backbones does come. It will not require change in the access method to provide cell payload relay to the user.

RELATED WORK AND PUBLICATIONS

The following reference is believed essential to understanding of the context:

Bell Labs Technical Journal, Lucent Technologies, Volume 1, No.2, Autumn 1996
E. Ayanoglu et al; "Mobile Information Infrastructure"
J. R. Carpenter & M. J. Stima, "New Wireless Business Communication Directions"
J. Sobrinho & A Krishnakumar, "Real-Time Traffic over the IEEE 802.11 MAC Layer"

The following reference includes not only European work but also useful papers from other continents:

"Wireless ATM Workshop," Espoo Finland, Sept 2-3 "96, VTT Information Technology
Subject headings (15 papers/163 pages):
Introduction and Motivation for Wireless ATM
Description of Systems Built
The Magic WAND Project (ACTS)
Bell Laboratories Platinum System and Research Report
Other Described Systems
Standardization Effort

The WAND (wireless ATM network demonstration) project is the large scale European effort to come up with wireless ATM definitions and technology with user trials starting Q1 1998. It includes other frequencies and services beside those in the 5 GHz band. Parallel work (now coordinated with the ATM Forum) on a wireless ATM MAC/PHY is active in ETSI RES10 as HIPERLAN /2.

The built-system-descriptions were: 1) "ORL Radio ATM" (Olivetti Research—Cambridge UK), 2) "AWA ATM Wireless Access System," (NEC USA), 3) "Wireless ATM Research in Bell Laboratories" (Lucent Technologies), and 4) Bell Labs Platinum system. All of these have interesting features, and are probably well behind the date of publication in the reported status.

A nine page overview and summary of this meeting by C. A. Rypinski is available on request (by e-mail).

There have been wireless sessions within a few ATM based seminars, but it is not within available resources to identify these.

These papers are a positive indication, but aren't the necessary showing of economic importance and market that is required to justify a PAR. Most of the services, applications and markets for wireless ATM would apply equally to the 802.9 radio MAC/PHY.

TIME SCHEDULE

Should the Study Group be approved in July, the next step is for it to draft the PAR including a demonstration that the IEEE 802 *"five criteria"* are met. The PAR could be drafted before and presented at the November Plenary. The first full working meeting can take place after PAR approval either in November or more likely in January '98. Sometimes, the work can fly when the large Companies are already working on it and have market pressure.

The approval process can take several months to more than a year depending more on the completeness, accuracy and of the first draft submitted. It is hard to get down to the drafting of a standards document until a fair measure of consensus is reached.

The early existence of a credible standards effort in this area will somewhat inhibit the business growth of proprietary solutions. More importantly, it will minimize the differences between such proprietary efforts, and it will bring more into the public domain than a wait of another year or two while presently active Companies continue private development.

Time is important. There will be considerable value in starting now even though completion may be years away.

ACTION REQUEST

Those who wish to advance this project by indicating support and probable participation in the Study Group and a resulting Standards Project should indicate this to:

Professor Dhadesugoor Vaman, Chairman of IEEE 802.9

<dvaman@ati.stevens-tech.edu>

or in the alternative to the undersigned.

Chandos A. Rypinski, <rypinski@microweb.com>

LACE, Inc. and Ubiquity Communication, Inc.

Bio note: *Rypinski has served on the IEEE 802 Standards Committee since 1984 on 802.4, 802.6, 802.9 and 802.11. This includes all of the Committees dealing with IS or with the radio physical medium. He is also a Director of WINForum, an industry group that has played an important part in assisting the FCC in defining unlicensed radio services particularly including the NII band. He is also on the WINForum Sharing Rules Development Committee. He is a Life Fellow and Centennial medalist of the IEEE and a Fellow of the Radio Club of America.*