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Draft 802.20 Permanent Document

<802.20 Requirements Document - Rev 5>

This document is a Draft Permanent Document of IEEE Working Group 802.20. Permanent Documents (PD) are used in facilitating the work of the WG and contain information that provides guidance for the development of 802.20 standards. This document is work in progress and is subject to change.

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1 Overview (open)

1.1 Scope (open)

This document defines system requirement for the IEEE 802.20 standard development project. These requirements are consistent with the PAR (IEEE SA Project Authorization Request) document (see section 1.3 below) and shall constitute the top-level specification for the 802.20 standard. For the purpose of this document, an "802.20 system" constitutes an 802.20 MAC and PHY implementation in which at least one Mobile station communicates with a base station via a radio air interface, and the interfaces to external networks, for the purpose of transporting IP packets through the MAC and PHY protocol layers.

Unresolved issues are found in Appendix B.

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1.2 Purpose (open)

This document establishes the detailed requirements for the Mobile Broadband Wireless Access (MBWA) systems.

1.3 PAR Summary (open)

The scope of the PAR (listed in Item 12) is as follows:

> *"Specification of physical and medium access control layers of an air interface for interoperable mobile broadband wireless access systems, operating in licensed bands below 3.5 GHz, optimized for IP-data transport, with peak data rates per user in excess of 1 Mbps. It supports various vehicular mobility classes up to 250 Km/h in a MAN environment and targets spectral efficiencies, sustained user data rates and numbers of active users that are all significantly higher than achieved by existing mobile systems."*

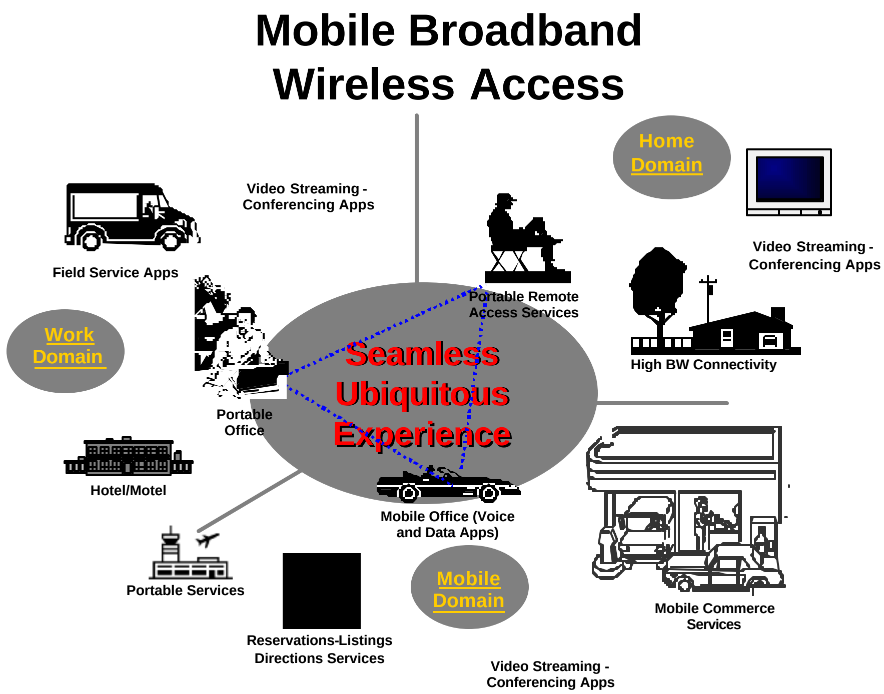
In addition, a table (provided in Item 18) lists "additional information on air interface characteristics and performance targets that are expected to be achieved."

Characteristic	***Target Value***
Mobility	*Vehicular mobility classes up to 250 km/hr (as defined in ITU-R M.1034-1)*

Sustained spectral efficiency	*> 1 b/s/Hz/cell*
Peak user data rate (Downlink (DL))	*> 1 Mbps**
Peak user data rate (Uplink (UL))	*> 300 kbps**
Peak aggregate data rate per cell (DL)	*> 4 Mbps**
Peak aggregate data rate per cell (UL)	*> 800 kbps**
Airlink MAC frame RTT	*< 10 ms*
Bandwidth	*e.g., 1.25 MHz, 5 MHz*
Cell Sizes	*Appropriate for ubiquitous metropolitan area networks and capable of reusing existing infrastructure.*
Spectrum (Maximum operating frequency) *Spectrum (Frequency Arrangements)*	*< 3.5 GHz* *Supports FDD (Frequency Division Duplexing) and TDD (Time Division Duplexing) frequency arrangements*
Spectrum Allocations	*Licensed spectrum allocated to the Mobile Service*
Security Support	*AES (Advanced Encryption Standard)*

** Targets for 1.25 MHz channel bandwidth. This represents 2 x 1.25 MHz (paired) channels for FDD and a 2.5 MHz (unpaired) channel for TDD. For other bandwidths, the data rates may change.*

2 Overview of Services and Applications (open)



The 802.20 Air-Interface (AI) shall be optimized for high-speed IP-based data services operating on a distinct data-optimized RF channel. The AI shall support compliant Mobile Terminal (MT) devices for mobile users, and shall enable improved performance relative to other systems targeted for wide-area mobile operation. The AI shall be designed to provide best-in-class performance attributes such as peak and sustained data rates and corresponding spectral efficiencies, system user capacity, air- interface and end-to-end latency, overall network complexity and quality-of-service management. Applications that require the user device to assume the role of a server, in a server-client model, shall be supported as well.

Applications: The AI all shall support interoperability between an IP Core Network and IP enabled mobile terminals and applications shall conform to open standards and protocols. This allows applications including, but not limited to, full screen video, full graphic web browsing, e-mail, file upload and download without size limitations (e.g., FTP), video and audio streaming, IP Multicast, Telematics, Location based services, VPN connections, VoIP, instant messaging and on- line multiplayer gaming.

Always on: The AI shall provide the user with “always-on” connectivity. The connectivity from the wireless MT device to the Base Station (BS) shall be automatic and transparent to the user.

2.1 Voice Services (open)

The MBWA will support VoIP services. QoS will provide latency, jitter, and packet loss required to enable the use of industry standard Codec’s. When the bandwidth required for a call cannot be reserved, the system will provide signaling to support call blocking.

3 System Reference Architecture (open)

3.1 System Architecture (open)

The 802.20 systems must be designed to provide ubiquitous mobile broadband wireless access in a cellular architecture. The system architecture must be a point to multipoint system that works from a base station to multiple devices in a non-line of sight outdoor to indoor scenario. The system must be designed to enable a macro-cellular architecture with allowance for indoor penetration in a dense urban, urban, suburban and rural environment.

Editors Note Diagram in Appendix B

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The AI shall support a layered architecture and separation of functionality between user, data and control planes. The AI must efficiently convey bi-directional packetized, bursty IP traffic with packet lengths and packet train temporal behavior consistent with that of wired IP networks. The 802.20 AI shall support high-speed mobility.

3.1.1 MBWA System Reference Architecture (open)

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“To be supplied by Mark Klerer and Joanne Wilson”

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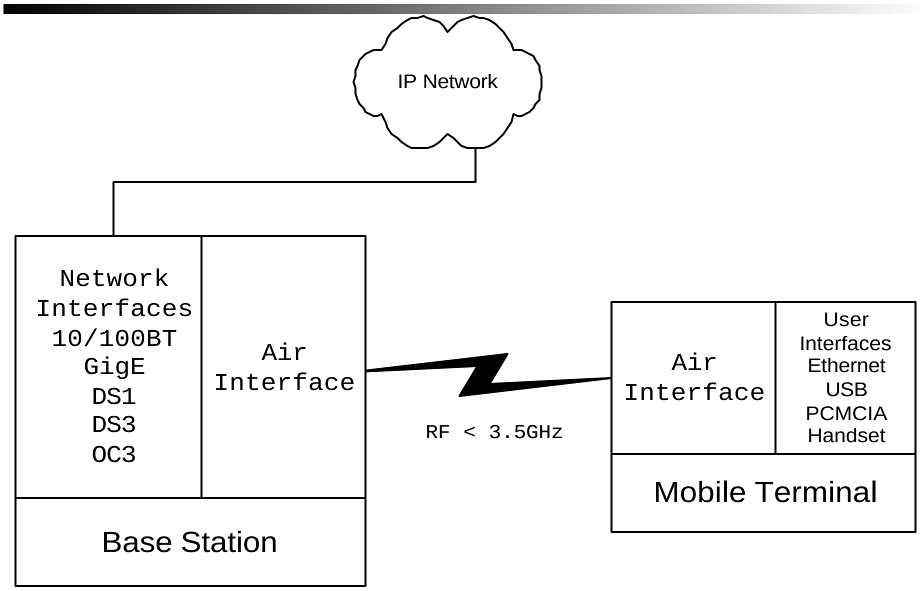
3.2 Definition of Interfaces (open)

Open interfaces: The AI shall support open interfaces between the base station and any upstream network entities. Any interfaces that may be implemented shall use IETF protocols as appropriate. Some of the possible interfaces are illustrated below.

MBWA Interfaces



4 Functional and Performance Requirements (open)

4.1 System (open)

4.1.1 System Gain and Spectral Efficiency will be discussed time to be set"section to be provided by Arif Ansari, Reza Arefi, Jim Mollenauer, and Khurram Sheikh". (open)

4.1.2 Spectral Efficiency (bps/Hz/sector) (open)

Rewriten to accommodate Michael Youssefmir comments along with perceived meaning and Sprints contribution. Michael Youssefmir to supply definition of expected aggregate throughput for Apendix B.

Sustained spectral efficiency is computed in a loaded multi-cellular network setting. It is defined as the ratio of the expected aggregate throughput (taking out all PHY/MAC overhead) to all users in an interior cell divided by the system bandwidth. The sustained spectral efficiency calculation shall assume that users are distributed uniformly throughout the network and shall include a specification of the minimum expected data rate/user.

Downlink > 2 bps/Hz/sector

Uplink >1 bps/Hz/sector

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Deleted: <#>Link Budget¶
Link budget has been proposed at 150-170, 160-170 and removed.¶
The system link bud get shall be 160-170 dB for all devices and terminals at the data rates specified in the earlier section assuming best practices in terms of base station design, user terminal design, and deployment techniques.¶

4.1.3 Frequency Reuse (open)

The AI shall support universal frequency reuse but also allow for system deployment with frequency reuse factors of less than or greater than 1.

Note to be reworded

4.1.4 Channel Bandwidths (open)

Unresolved

The AI shall support channel bandwidths in multiples of 5MHz in downlink and the uplink.

4.1.5 Duplexing (open)

The AI shall support both Frequency Division Duplexing (FDD) and Time Division Duplexing (TDD).

4.1.6 Mobility (open)

The AI shall support different modes of mobility from pedestrian (3 km/hr) to very high speed (250 km/hr) but shall not be optimized for only one mode. As an example, data rates gracefully degrade from pedestrian speeds to high speed mobility.

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4.1.7 Aggregate Data Rates – Downlink & Uplink (open)

Michael Youssefmir from Arraycomm asked the previous two tables be stricken. Sprint contributed the following table for 5 MHz channels in line with the spectral efficiency above. Kei Suzuki believes the numbers were not reflective of the Par. Shall the PAR be minimums?

The aggregate data rate for downlink and uplink shall be consistent with the spectral efficiency. An example of a 5MHz FDD channel is shown in Table 1 below.

Description	Downlink	Uplink
Outdoor to Indoor Expected Aggregate Data Rate	> 10 Mbps/Sector	> 5Mbps/Sector

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4.1.7.1 User Data Rates - – Downlink & Uplink (open)

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The AI shall support peak per-user data rates in excess of 1 Mbps on the downlink and in excess of 300 kbps on the uplink. These peak data rate targets are independent of channel conditions, traffic loading, and system architecture. The peak per user data rate targets are less than the peak aggregate per cell data rate to allow for design and operational choices.

Average user data rates in a loaded system shall be in excess of 512Kbps downlink and 128Kbps uplink. This shall be true for 90% of the cell coverage or greater.

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4.1.8 Number of Simultaneous Sessions (open)

Sprint added a definition.

> 100 sessions per carrier for a 5Mhz system. “Simultaneous” will be defined as the number active-state Mobile Terminal having undergone contention/access and scheduled to utilize AI resources to transmit/Receive data within a 10 msec time interval.

4.1.9 Latency (open)

The system shall have a one-way target latency of 20 msecs from the base station to the end-device when the system is under load.

The AI shall minimize the round-trip times (RTT) and the variation in RTT for acknowledgements, within a given QoS traffic class. The RTT over the airlink for a MAC data frame is defined here to be the duration from when a data frame is received by the physical layer of the transmitter to the time when an acknowledgment for that frame is received by the transmitting station. The airlink MAC frame RTT, which can also be called the “ARQ loop delay,” shall be less than 10 ms. Fast acknowledgment of data frames allows for retransmissions to occur quickly, reducing the adverse impact of retransmissions on IP packet throughput. This particularly improves the performance of gaming, financial, and other real-time low latency transactions.

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4.1.10 Packet Error Rate (open)

Joseph Cleveland to provide initial exploder response.

The physical layer shall be capable of adapting the modulation, coding, and power levels to accommodate RF signal deterioration between the BS and user terminals. The air interface shall use appropriate ARQ schemes to ensure that error rates are reduced to a suitably low level in order to accommodate higher level IP based protocols (for example, TCP over IP). The packet error rate for 512 byte IP packet shall be less that 1 percent after error correction and before ARQ.

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4.1.11 Supoport for Multi Antenna Capabilities (open)

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Interconectivity at the PHY/MAC will be provided at the Base Station and/or the Mobile Terminal for advanced multi antenna technologies to achieve higher effective data rates, user capacity, cell sizes and reliability. As an example, MIMO operation.

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4.1.12 Antenna Diversity (open)

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At a minimum, both the Base Station and the Mobile Terminal shall provide two element diversity. Diversity may be an integral part of an advanced antenna solution.

4.1.13 Best Server Selection (open)

In the presence of multiple available Base Stations, the system Phy/MAC will select the best server based upon system loading, signal strength, capacity and tier of service. Additional weighting factors may also include back haul loading and least cost routing.

4.1.14 QoS (open)

The AI shall support the means to enable end-to-end QoS within the scope of the AI and shall support a Policy-based QoS architecture. The resolution of QoS in the AI shall be consistent with the end-to-end QoS at the Core Network level. The AI shall support IPv4 and IPv6 enabled QoS resolutions, for example using Subnet Bandwidth Manager. The AI shall support efficient radio resource management (allocation, maintenance, and release) to satisfy user QoS and policy requirements

4.1.15 Security (open)

Network security in MBWA systems shall protect the service provider from theft of service, the user's privacy and mitigate against denial of service attacks. Provision shall be made for authentication of both base station and mobile terminal, for privacy, and for data integrity consistent with the best current commercial practice. 802.20 security is expected to be a partial solution complemented by end-to-end solutions at higher protocol layers such as EAP, TLS, SSL, IPSec, etc.

4.1.15.1 Access Control (open)

A cryptographically generated challenge-response authentication mechanism for the user to authenticate the network and for the network to authenticate the user must be used.

4.1.15.2 Privacy Methods (open)

A method that will provide message integrity across the air interface to protect user data traffic, as well as signaling messages from unauthorized modification will be specified.

Encryption across the air interface to protect user data traffic, as well as signaling messages, from unauthorized disclosure will be incorporated.

4.1.15.3 User Privacy (open)

The system will prevent the unauthorized disclosure of the user identity.

4.1.15.4 Denial of Service Attacks (open)

It shall be possible to prevent replay attacks by minimizing the likelihood that authentication signatures are reused.

It shall be possible to provide protection against Denial of Service (DOS) attacks.

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It has been proposed this be deleted as an operator Sprint feels it is a minimum target¶
The end to end system availability shall be 99.9%.

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Deleted: is assumed to have goals similar to those in cellular or PCS systems. These goals are to

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4.1.15.5 Security Algorithm (open)

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The authentication and encryption algorithms shall be publicly available on a fair and non-discriminatory basis.

National or international standards bodies shall have approved the algorithms.

The algorithms shall have been extensively analysed by the cryptographic community to resist all currently known attacks.

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4.1.16 Handoff Support (open)

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Move to Layer 3 + Support

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Handoff methods are required in MBWA systems to facilitate providing continuous service for a population of moving Mobile Stations. Mobile stations may move between cells, between systems, between frequencies, and at the higher layer between IP Subnets. At the lowest layers, handoffs can be classified as either soft or hard handoffs, depending on whether there is a momentary service disruption or not.

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4.1.16.1 Soft Handoff (open)

4.1.16.2 Hard Handoff (open)

4.1.16.3 Hard Handoff Between Similar MBWA Systems (open)

4.1.16.4 Hard Handoff Between Frequencies (open)

4.1.16.5 IP-Level Handoff (open)

Kei Suzuki Asked this be removed. Sprint would like it to be considered even though it is above level 2.

Version by Michael Youssefmir

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In supporting high speed mobility in an all IP network, the MBWA air interface shall be designed in a manner that does not preclude the use of MobileIP or of SimpleIP for the preservation of IP session state as a subscriber's session is handed over from one base station or sector to another.

Multiple IP addresses behind one terminal may also be supported.

Deleted: In order to support high speed mobility in an all IP network Mobile IP will have to be supported at a higher level. Integration of Foreign Agent or proxy Mobile IP into the base station or terminal will be required to support a clientless solution. Multiple IP addresses behind a single terminal shall also be supported.¶
¶

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4.2 PHY/RF (open)

4.2.1 Receiver sensitivity (open)

Blocking and selectivity specifications shall be consistent with best commercial practice for mobile wide-area terminals.

4.2.2 Link Adaptation and Power Control (open)

Integrate 4.3.1. (open)

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The AI shall support automatic selection of optimized user data rates that are consistent with the RF environment constraints and application requirements. The AI shall provide for graceful reduction or increasing user data rates, on the downlink and uplink, as a mechanism to maintain an appropriate frame error rate performance.

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Link adaptation shall be used by the AI for increasing spectral efficiency, data rate, and cell coverage reliability. The AI shall support adaptive modulation and coding, adaptive bandwidth allocation, and adaptive power allocation.

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4.2.3 Performance under mobility (open)

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The system is expected to work in dense urban, suburban and rural outdoor-indoor environments and the relevant channel models shall be applicable. The system shall NOT be designed for indoor only and outdoor only scenarios.

4.2.4 Duplexing – FDD & TDD (open)

The 802.20 standard shall support both Frequency Division Duplex (FDD) and Time Division Duplex (TDD) frequency arrangements.

4.3 Spectral Requirements (open)

The system shall be targeted for use in TDD and FDD licensed spectrum allocated to mobile services below 3.5GHz. The AI shall be designed for deployment within existing and future licensed spectrum below 3.5 GHz. The MBWA system frequency plan shall include both paired and unpaired channel plans with multiple bandwidths, e.g., 1.25 or 5 MHz, etc., to allow co-deployment with existing cellular systems. Channel bandwidths are consistent with frequency plans and frequency allocations for other wide-area systems

The design shall be readily extensible to wider channels as they become available in the future.

4.3.1 Adaptive Modulation and Coding (open)

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The system will have adaptive modulation and coding in both the uplink and the downlink

4.3.2 Layer 1 to Layer 2 Inter-working (open)

Move to System Reference Architecture Section

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The interface between layers 1 and 2 is not an exposed interface; it may be handled at the implementer's discretion.

4.4 Layer 2 MAC (Media Access Control) (open)

4.4.1 Quality of Service and the MAC (open)

Several submissions for QOS have been sent now.

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Michael Youssefmir wrote'
"The 802.20 air interface shall support standard Internet Differentiated Services (DS) QoS to be compatible with other mobile network standards such as 3GPP2. In particular, 802.20 shall support the standard Expedited Forwarding (EF), Assured Forwarding (AF), and Best Effort (BE) DS Per Hop Behaviors (PHBs) as defined by the RFC 2597 and RFC 2598. 802.20 shall also support configuration of the PHBs by a DS API that shall be based on a subset of the information model defined in RFC 3289.

The 802.20 air interface will provide an API to higher layer entities for the purpose of requesting QoS attributes on a per-session basis. The API will also provide a mechanism for the air interface to inform higher layer entities whether a particular QoS request is to be honored. It is the responsibility of higher layer entities to take appropriate action based on such messages."

Bill Young Submitted.
Quality of Service and Class of Service

This section describes the quality of service and classes of services for 802.20 systems. Terminology is borrowed from Internet Engineering Task Force (IETF) and the IEEE 802.16.3 functional requirements.

802.20 protocols must support classes of service (COS) with various quality of service guarantees. The 802.20 protocol standards must define the interfaces and procedures that that facilitates the requirements for the allocation and prioritization of resources. 802.20 protocols must also provide the means to enforce QoS contracts and Service Level Agreements (SLA). Table 1 provides a summary of the QoS requirements that the PHY and MAC layers shall meet. Note that the parameters in the table are measured between the MAC input and the upper layer at the transmit station and the MAC output at the upper layer of the receiving station for information transmission. For example, delay does not include setup time, link acquisition, voice codec's, etc.

For QoS based connectionless services, the 802.20 protocols must support resources negotiated on-demand. For example, the MAC protocol may allocate bursts of PDUs to services that require changes in resource allocation. Such allocation, for connectionless services, is thus performed in a semi-stateless manner.

A connection-oriented service may require state information to be maintained for the life of a connection. However, the 802.20 MAC layer interface may provide a connection-less service interface that require higher layer adaptation to maintain the state of the connection and periodically allocate resources. For instance, the MAC may need to maintain state information about the QoS data flow only for the duration of an allocation.

Table 1: Services and QoS Requirements

Service	Maximum Error Rate	Maximum Access Delay (One Way)
Full Quality Telephony (Vocoder MOS> 4.0)	BER 10-4	20 ms
Standard Quality Telephony (Vocoder MOS < 4.0)	BER 10-3	40 ms
Time Critical Packet Services	BER 10-4	20 ms
Non-time Critical Packet Services – best effort	BER 10-3	Not applicable

Note: These parameters should be vetted by the group.

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Types and Classes of Service

The fundamental direction for the QoS model is that will be exported to MBWA endpoints will be IP based and conform to IETF DiffServ QoS model in conjunction with other IP based protocols. The DiffServ QoS model defines traffic for all services as follows:

Expedited Forwarding (EF): EF requires a constant periodic access to bandwidth. The bandwidth requirements may vary within a specific range, but delay and delay variance limits are specified. Examples that fall into this category are voice-over-IP (VoIP), videoconferencing, video on demand (VoD) and other multimedia applications.

Assured Forwarding (AF): In AF the bandwidth varies within a specified range, but has loose delay and delay variance requirements. Applications, which are limited in their bandwidth usage, may fall in this category. AF services allow the traffic to be divided into different classes. Using this capability, an ISP can offer a tiered services model. For example there could be four classes platinum, gold, silver and bronze with decreasing levels of service quality as well as maximum allocated bandwidth, with platinum getting the highs share of resources and bronze getting lowest. This would facilitate premium priced service level agreements.

Best Effort Service (BES): The bandwidth varies within a wide range and is allowed to burst up to the maximum link bandwidth when EF and AF services are not using bandwidth. The bandwidth and delay requirements may or may not be specified. Higher variations of delay may be acceptable since applications that utilize BES allow for a lower grade of service due to preemption by EF and AS traffic. Current Internet service is an example of best effort service.

Traffic Shaping For Service Level agreements

The 802.20 protocols shall enable the provisioning and signaling of parameters for the guaranteeing of minimum allocated bandwidth used by applications as set by the SLA. This would be accomplished through access throttling, discarding packets and dynamically assigning available bandwidth. The number of service levels, data rates and congestion control parameters will be called out in the 802.20 specifications.

Parameters

802.20 protocols shall define a set of parameters that preserve the intent of the QoS parameters for all IP based services supported.

Service and QoS Mapping

The classes of service and QoS parameters of all services shall be translated into a common set of parameters defined by 802.20. A QoS base IP network may employ the Resource Reservation Protocol (RSVP) to signal the allocation of resources along a routed IP path. If 802.20 is to be a link in the IP network, an IWF must interface with 802.20 to negotiate resource allocation.

The basic mechanism available from 802.20 systems for supporting QoS requirements is to allocate bandwidth to various services. 802.20 protocols should include a mechanism that can support dynamically variable bandwidth channels and paths (such as those defined for IP environments).

Sprint submitted what is in the body before the other submissions.

The System MUST support grouping of transmission properties into service classes, so enabling upper layer entities and external applications can be mapped to request transmission intervals capable of exhibiting desired QoS parameters in a globally consistent manner. The QoS sub-system will adopt a "Matched Criteria" and "Enforcement" methodology, such that packets and flows characteristics being fed into the system that match a pre-defined rule set will be enforced accordingly.

4.4.1.1 Cos/QoS Matched-Criteria (open)

The system must be able to fingerprint ingress traffic based upon the matched criterias as defined below. The system shall be designed such that one or multiple (as many as 8) matched criterias can be placed into an enforcement policy.

4.4.1.1.1 Protocol Field Mapping (open)

Flexible bit-based masking of multiple fields at every layer MUST be made available for purposes of identifying packets. These matched criterions include but are not limited to:

L4 Protocol field (UDP/TCP port number)

L4 Header length

L4 TCP flags

L4 TCP options (if present)

L3 Protocol field

L3 Source address/network

L3 Destination address/network

L3 Total length

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L3 Fragmentation (Initial 4 bits of two-byte field)

L3 DiffServe/TOS field (to include ECN)

L2 Ethernet hardware address (two groups, 3 bytes each / entire 6 byte address)

L2 Ethertype

L2 802.1Q/p

L7 Unencrypted HTTP version 1.x protocol fingerprinting (desired)

4.4.1.1.2 Hardware Mapping (open)

The system shall be able to differentiate policies bound to groups of Mobile Stations.

4.4.1.1.3 Additional Criteria (open)

Additional criterion must be evaluated by both Mobile and Base Station: Ingress Flow rates (source/destination IP address and port numbers) Ingress Aggregate data rates

Data tonnage-based L3 resource usage quotas

Airtime utilization-based PHY resource usage quotas

4.4.1.2 CoS/QoS Enforcement (open)

The following "ENFORCEMENT" actions will be available to handle matched-criteria.

Prioritization

The system must make available no less than eight node-based priority queues. Mobile Nodes provisioned with the highest priority will have a more heavily weighted probability for service. Conversely, Mobile Nodes provisioned for the lowest available priority wll only be given service if PHY/MAC resources are available.

Error Correction

Higher coding / ARQ: The system must have the ability to increase the probability of a successful packet transmission.

Queuing

The system must make available no less than sixteen flow-based operator-defined priority queues. Latency, priority, jitter, error-correction, maximum throughput and queue depths will be considered for the development of these queues.

Suppression

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Hard drop: The system MUST be able to block matched packet prior to transmission over either uplink or downlink air interfaces.

Reservation

When requested a fixed amount of bandwidth must be allocated for use. If the reservation request can't be fulfilled the MAC must signal back so it can be handled at higher layer.

4.4.1.2.1 Aggregate Bandwidth Partitioning (open)

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Partitioning: The system must allow for partitioning of the aggregate bandwidth pipe. While the base station equipment is operating in a resource under-utilized state, any unused bandwidth must be made available to Mobile Stations requiring the resources regardless of which partition the CPE has been provisioned for (soft partitioning).

4.4.1.2.2 Interface Binding (open)

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Policy enforcement shall be implemented on CPE packet input and base station packet output, as applicable, such that PHY/MAC resources are not unnecessarily utilized. Packet-queuing and queue-depths must be configurable for both base station WAN ingress and mobile station LAN ingress interfaces. Queue depth configuration will be available in increments of datagrams and time.

4.4.1.2.3 Packet Mangling (open)

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Packet/Frame manipulation: IP Diffserve/TOS field modification to any predetermined operator value. For customer redirection, the destination address of IP packets shall be modified to any predetermined operator value (captive portal, acceptable usage policy violation, etc). For bridged environments, the system MUST possess the ability to modify the 802.1p priority field to any predetermined operator specified value. Marking will take place at either the Mobile or Base Station, as appropriate.

4.4.1.2.4 Resource Scheduling (open)

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PHY/MAC resource scheduling: System must possess ability to starve a Mobile Station's resource allocation of PHY resources for an operator specified time value, with resolution of 10ms increments.

4.4.1.2.5 Rate-limiting (open)

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Throughput rate limiting: System must allow for an endpoint node egress to be rate limited in increments of 8kbs, with classifications for peak and best-effort minimum resource allocation. During under-load conditions, unused bandwidth must be made available to satisfy active CPE bursting requirements.

4.4.1.3 ARQ/Retransmission (open)

The AI shall support ARQ/retransmission. The system must not induce more than 10ms latency for the retransmission of a lost block of data. Dropped data segments shall not hinder the timely delivery of any subsequent datagrams (successfully reconstructed datagrams shall not wait in queue for the reconstruction of datagrams that encountered dropped packets and are waiting to be re-sent).

4.4.1.3.1 End to End Latency (open)

The MAC protocol must guarantee periodic access to the medium. PHY resources dedicated for this function must not impact system goodput capacity by more than 5%. The contention access mechanism must not incur more than 15 msec system delay, excluding the time the system is in a blocking state due to over-capacity on the contention medium.

The first packet pass-through initiated by the subscriber, while the mobile station is not in an active state, must incur less than 20 msec one-way delay (inclusive of contention/access latencies). The first packet pass-through initiated by the base station, while the mobile station is not in an active state, must incur less than 20 msec one-way delay, exclusive of regular active-state latencies.

64-byte packet pass-through must comply with a maximum round trip delay of less than 20 msec, exclusive of input or output queue depth and contention delay.

4.4.1.3.2 End to End Latency Variation (open)

Contention/access delays must remain constant, regardless of the number of mobile stations already in an active state.

4.4.1.4 Protocol Support (open)

The system must support transport of variable length Internet Protocol packets ranging from 46 to 1500 bytes. Segmentation and re-assembly techniques may be used to arrange traffic on the medium.

The system must be able to support the optional suppression of any and all L2 and L3 broadcasts, as applicable, at the Mobile or Base Stations (see QoS section Matched Criteria).

The system must be capable of passing IPSec traffic (RFC2401), and as such, be capable of functioning with off-the-shelf VPN software and hardware. The system must be capable of passing additional encapsulation protocol types: GRE (RFC1701), L2TP (RFC2261), PPTP (RFC2637).

4.4.1.5 Addressing (open)

For external Mobile Stations with Ethernet adapters, the system must be capable of limiting the number of customer hardware MAC addresses learned by the Mobile Station. This value must be configurable per Mobile Station and in real-time without reboots.

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Deleted: <#>MAC Error Performance¶
The packet error rate (PER), after application of appropriate error correction mechanism (e.g., forward error correction) but before ARQ, delivered by the PHY layer to the MAC layer, must meet a requirement of 1% for tests conducted with 512 byte packets. The ratio of MAC protocol services becoming available to unavailable must e 99.9% of the time, provided the system and radios receive adequate power 100% of the time.¶
<#>Latency¶
Delays are derived from filters, frame alignment, time-slot interchange, switch processing, propagation, packetization, forward error correction, interleaving, contention/access, queue depths, or any other lapse in time associated with transmission on the wireless medium. Synchronous services, such as TCP applications or VoIP require short, predictable (i.e., constant) delay.¶

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4.4.1.6 Support/Optimization for TCP/IP (open)

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The MAC protocol shall provide an efficient method of TCP acknowledgement transmission in such a way that does not hinder the ability of a system to deliver peak per-user capacity.

In the event the Base Station terminates the last-mile IP session, the TCP stack must support Explicit Congestion Notification as defined by RFC3168. At no time will the Base Station block packets classified with the ECN flag.

4.5 Layer 3+ Support (open)

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The system must support both IPv4 and IPv6.

4.5.1 OA&M Support (open)

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The following values must be made available in real-time with redisplay intervals of no less than 1000 msecs, with the option to be displayed in both cumulative and delta modes:

Aggregate base station bytes served at each coding/modulation configuration

Correctable and uncorrectable block errors

Identity of specific Mobile Stations which exhibit a higher than average packet error rate

PHY/MAC/NET based usage consumption statistics per Mobile Station

Successful and failed service requests for both up and downlink directions

Unique number of active Mobile Stations, as well as which specific stations are active, for both up and downlink directions

Number of ungraceful session disconnections

4.5.2 Scheduler (open)

The AI specification shall not preclude proprietary scheduling algorithms, so long as the standard control messages, data formats, and system constraints are observed.

4.5.3 MAC Complexity Measures (open)

To make the MBWA technology commercially feasible, it is necessary the complexity is minimized at the MAC, consistent with the goals defined for the technologies. This section defines complexity measures to be used in estimating MAC complexity. \

4.6 User State Transitions (open)

The AI shall support multiple protocol states with fast and dynamic transitions among them. It will provide efficient signaling schemes for allocating and de-allocating resources, which may include logical in-band and/or out-of-band signaling, with respect to resources allocated for end-user data. The AI shall support paging polling schemes for idle terminals to promote power conservation for MTs.

4.7 Resource Allocation (open)

The AI shall support fast resource assignment and release procedures on the uplink and Duplexing – FDD & TDD

5 References (open)

- 802.20 - PD-02: Mobile Broadband Wireless Access Systems: Approved PAR (02/12/11)
- 802.20 - PD-03: Mobile Broadband Wireless Access Systems: Five Criteria (FINAL) (02/11/13)
- C802.20-03/45r1: Desired Characteristics of Mobile Broadband Wireless Access Air Interface (Arif Ansari, Steve Dennett, Scott Migaldi, Samir Kapoor, John L. Fan, Joanne Wilson, Reza Arefi, Jim Mollenauer, David S. James, B. K. Lim, K. Murakami, S. Kimura (2003-05-12))
- C802.20-03/47r1: Terminology in the 802.20 PAR (Rev 1) (Joanne Wilson, Arif Ansari, Samir Kapoor, Reza Arefi, John L. Fan, Alan Chickinsky, George Iritz, David S. James, B. K. Lim, K. Murakami, S. Kimura (2003-05-12))

Appendix A Definition of Terms and Concepts

- *Active users* - An active user is a terminal that is registered with a cell and is using or seeking to use air link resources to receive and/or transmit data within a short time interval (e.g., within 100 ms).

- *Airlink MAC Frame RTT* - The round-trip time (RTT) over the airlink for a MAC data frame is defined here to be the duration from when a data frame is received by the physical layer of the transmitter to the time when an acknowledgment for that frame is received by the transmitting station.

- *Bandwidth or Channel bandwidth* - Two suggested bandwidths are 1.25 MHz and 5 MHz, which correspond to the bandwidth of one channel (downlink or uplink) for paired FDD spectrum.

- *Cell* - The term "cell" refers to one single-sector base station or to one sector of a base station deployed with multiple sectors.

- *Cell sizes* – The maximum distance from the base station to the mobile terminal over which an acceptable communication can maintained or before which a handoff would be triggered determines the size of a cell.

- *Frequency Arrangements* – The frequency arrangement of the spectrum refers to its allocation for paired or unpaired spectrum bands to provide for the use of Frequency-Division Duplexing (FDD) or Time-Division Duplexing (TDD), respectively. The PAR states that the 802.20 standard should support both these frequency arrangements.

- *Interoperable* – Systems that conform to the 802.20 specifications should interoperate with each other, e.g., regardless of manufacturer. (Note that this statement is limited to systems that operate in accordance with the same frequency plan. It does not suggest that an 802.20 TDD system would be interoperable with an 802.20 FDD system.)

- *Licensed bands below 3.5 GHz* – This refers to bands that are allocated to the Mobile Service and licensed for use by mobile cellular wireless systems operating below 3.5 GHz.

- *MAN* – Metropolitan Area Network.

- *Mobile Broadband Wireless Access systems* – This may be abbreviated as MBWA and is used specifically to mean "802.20 systems" or systems compliant with an 802.20 standard.

- *Optimized for IP Data Transport* – Such an air interface is designed specifically for carrying Internet Protocol (IP) data traffic efficiently. This optimization could involve (but is not limited to) increasing the throughput, reducing the system resources needed, decreasing the transmission latencies, etc.

- *Peak aggregate data rate per cell* – The peak aggregate data rate per cell is the total data rate transmitted from (in the case of DL) or received by (in the case of UL) a base station in a cell (or in a sector, in the case of a sectorized configuration), summed over all mobile terminals that are simultaneously communicating with that base station.

- *Peak data rates per user (or peak user data rate)* – The peak data rate per user is the highest theoretical data rate available to applications running over an 802.20 air interface and assignable to a single mobile terminal. The peak data rate per user can be determined from the combination of modulation constellation, coding rate and symbol rate that yields the maximum data rate.

- *Insert sector definition replace cell with sector where appropriate as commented on the exploder.*

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- *Spectral efficiency* – Spectral efficiency is measured in terms of bits/s/Hz/cell. (In the case of a sectorized configuration, spectral efficiency is given as bits/s/Hz/ sector.)

- *Sustained spectral efficiency* – Sustained spectral efficiency is computed in a network setting. It is defined as the ratio of the expected aggregate throughput (bits/sec) to all users in an interior cell divided by the system bandwidth (Hz). The sustained spectral efficiency calculation should assume that users are distributed uniformly throughout the network and should include a specification of the minimum expected data rate/user.

- *Sustained user data rates* – Sustained user data rates refer to the typical data rates that could be maintained by a user, over a period of time in a loaded system. The evaluation of the sustained user data rate is generally a complicated calculation to be determined that will involve consideration of typical channel models, environmental and geographic scenarios, data traffic models and user distributions.

- *Targets for 1.25 MHz channel bandwidth* – This is a reference bandwidth of 2 x 1.25 MHz for paired channels for FDD systems or a single 2.5 MHz channel for TDD systems. This is established to provide a common basis for measuring the bandwidth-dependent characteristics. The targets in the table indicated by the asterisk (*) are those dependent on the channel bandwidth. Note that for larger bandwidths the targets may scale proportionally with the bandwidth.

- *Various vehicular mobility classes* – Recommendation ITU-R M.1034-1 establishes the following mobility classes or broad categories for the relative speed between a mobile and base station:

    - Stationary (0 km/h),
    - Pedestrian (up to 10 km/h)
    - Typical vehicular (up to 100 km/h)

- High speed vehicular (up to 500 km /h)
- Aeronautical (up to 1 500 km/h)
- Satellite (up to 27 000 km/h).

Appendix B Unresolved issues

Coexistence and Interference Resistance

Since MBWA technology will be operative in licensed bands some of which are currently being utilized by other technologies, it is important that coexistence and interference issues be considered from the outset, unlike the situation in unlicensed spectrum where there is much more freedom of design. Of particular interest is adjacent channel interference; if MBWA is deployed adjacent to any of a number of technologies, the development effort should evaluate potential effects.

Interference can be grouped as co-channel and adjacent channel interference; evaluation of all combinations of technologies likely to be encountered should be part of the 802.20 processes. Furthermore, 802.20 technology is described in the PAR to encompass both TDD and FDD techniques. These should be evaluated separately, and requirements provided below.

- 5.1 Coexistence Scenarios
- FDD Deployments
- In this section, scenarios should be developed with 802.20 deployed as FDD, following the FDD "rules" for each of the 2G and 3G technologies likely to be encountered in practice.
-
- 802.20 and AMPS
- 802.20 and IS-95
- 802.20 and GSM
- 802.20 and LMR
- 802.20 and CDMA2000
- 802.20 and WCDMA
- 802.20 and 1xEVDO
- 802.20 and HSDPA
- 802.20 and 1xEV/DV
- 5.1.2 TDD Deployments
- In this section, scenarios should be developed with 802.20 deployed as TDD, following any TDD "rules" for each of the 2G and 3G technologies likely to be encountered in practice. Since the majority of existing technologies are deployed as FDD solutions, some new

ground is being explored here, and it will be necessary to make sure that the 802.20 technology will not seriously impact the existing services.

- 802.20 and AMPS
- 802.20 and IS-95
- 802.20 and GSM
- 802.20 and LMR
- 802.20 and CDMA2000
- 802.20 and WCDMA
- 802.20 and 1xEVDO
- 802.20 and HSDPA
- 802.20 and 1xEV/DV
- Adjacent Channel Interference
- Definitions and Characteristics
- Requirements
- Co-channel Interference
- Definitions and Characteristics
- Requirements
- TDD Interference in Traditionally FDD Bands
- Since 802.20 is listed as being both TDD and FDD, it should be evaluated in a scenario where TDD 802.20 technology is deployed in a traditionally FDD frequency band. 802.20 should develop appropriate scenarios and requirements so that the new technology meets all necessary coexistence requirements that may be placed upon it.
- Definition and Characteristics
- Requirements

Interworking: *The AI should support interworking with different wireless access systems, e.g. wireless LAN, 3G, PAN, etc. Handoff from 802.20 to other technologies should be considered and where applicable procedures for that hand-off shall be supported. [Dan Gal* *dgal@lucent.com]:* This issue is quite **critical** to the successful deployment of 802.20 systems in existing and future markets worldwide. The purpose of defining Coexistence requirements in this document is to assure that 802.20 systems would not cause interference to or be susceptible to interference from other wireless systems operating in the same geographical area. Detailed quantitative RF emission limits need to be specified as well as received interference levels that the 802.20 receivers would have to accept and mitigate.

System Context Diagram needed

This section presents a high-level context diagram of the MBWA technology, and how such technology must "fit into" the overall infrastructure of the network. It shall include data paths, wired network connectivity, AAA functionality as necessary, and inter-system interfaces. Major System Interfaces shall be included in this diagram.

5.1.1 MBWA-Specific Reference Model (open)

To facilitate a layered approach, the 802.20 specification shall incorporate a reference partitioning model consisting of the MAC and PHY. This layered approach shall be generally consistent with other IEEE 802 standards and shall remain generally within the scope of other IEEE 802 standards as shown in figures 1 &2.

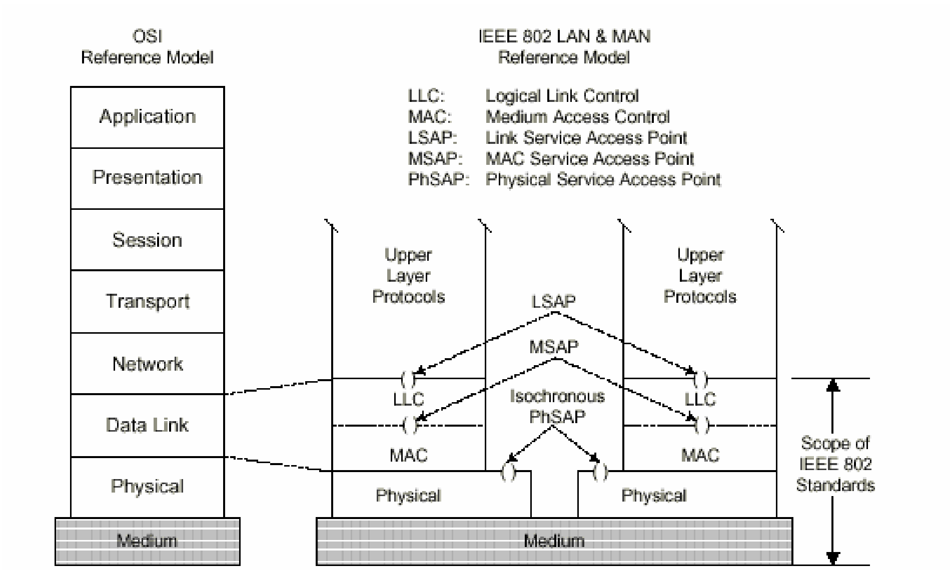
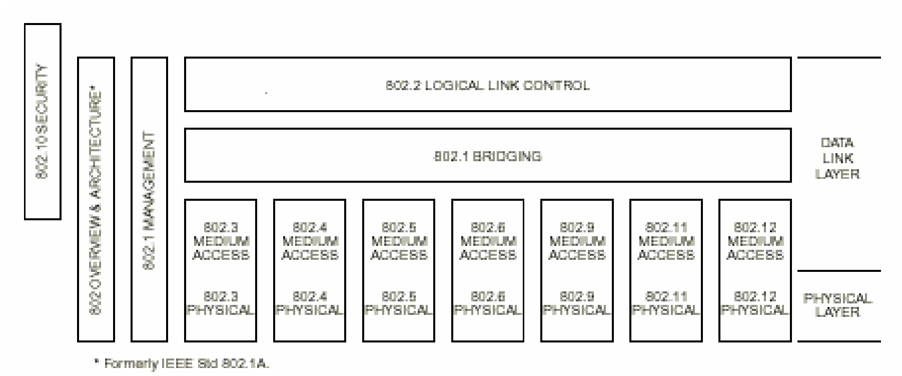


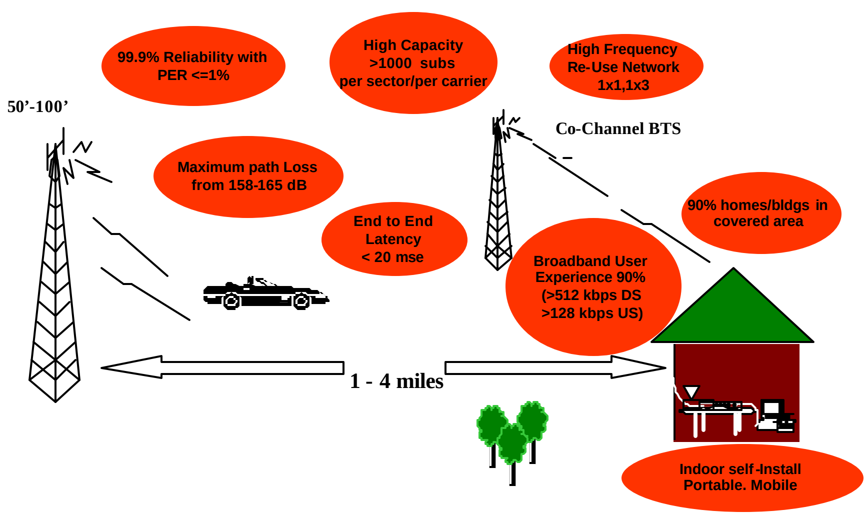
Figure 1—IEEE 802 RM for end stations (LAN&MAN/RM)



Call blocking is at higher level Sprint would like to se it included as a comment even though the higher level will make the decision the MAC must be able to support the higher level function.

When the bandwidth required for a call cannot be reserved, the system will provide signaling to support call blocking.

2. Interworking



[Dan Gal dgal@lucent.com*]:* Interworking between 802.20 systems and other wireless systems is highly

desirable and may give it a competitive edge. Systems that have disparate physical layers can still interwork via the higher protocol layers. Current interworking solutions exist for CDMA2000/802.11b and for GSM-GPRS/802.11b. Multi-mode devices, such as 802.11b+802.11a or more recently, 802.11b/g are now available. Existing applications (such as Windows XP mobility support) provide for transparent roaming across systems, automatically handling the applications' reconfiguration so as to keep sessions working seamlessly.

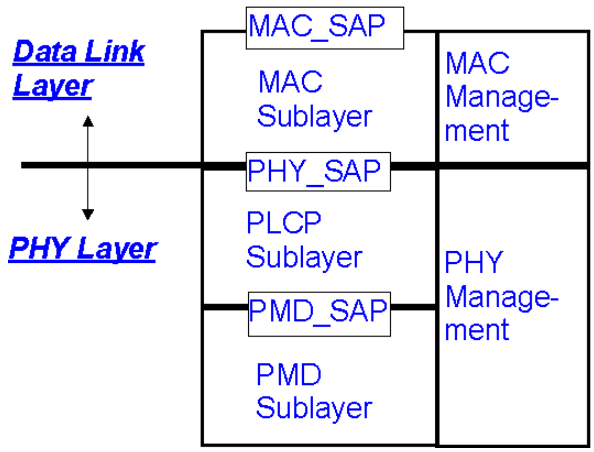
Building support for interworking in 802.20 – right from the first release of the standard – would add significantly to its market appeal.

To aid the discussion in this document and in the 802.20 specifications, a straw man Reference Partitioning of the 802.20 functionality is shown in Figure 1. This reference partitioning model is similar to those used in other 802 groups.

The 802.20 reference model consists of two major functional layers, the Data Link Layer (DLL) and the Physical Layer (PHY).

The Data Link Layer is functionally responsible for a mobile station's method of gaining access to the over-the-air resource. The Data Link Layer consists of the MAC Sub layer, and the MAC Management Sub layer. The MAC Sub layer is responsible for the proper formatting of data, as well as requesting access to the over-the-air resource. The MAC Management Sub layer is responsible for provisioning of MAC Layer Parameters and the extraction of MAC monitoring information, which can be of use in network management.

The Physical Layer consists of the Physical Layer Convergence Protocol, the Physical Medium Dependent, and the Physical Layer Management Sub layers. The Physical Layer Convergence Protocol Sub layer is responsible for the formatting of data received from the MAC Sub layer into data objects suitable for over the air transmission, and for the deformatting of data received by the station. The Physical Medium Dependent Sub layer is responsible for the transmission and reception of data to/from the over-the-air resource. The Physical Layer Management sub layer is responsible for provisioning of the Physical Layer parameters, and for the extraction of PHY monitoring information that can be of use in network management.



MAC_SAP: MAC Service Access Point
PHY_SAP: PHY Service Access Point
PLCP: PHY Layer Convergence Protocol, contains FEC
PMD: Physical Medium Dependent (radio)

Figure 1 – Reference partitioning