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Draft 802.20 Permanent Document

<802.20 Requirements Document >

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 **1 Overview**

2 **1.1 Scope**

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

10 **1.2 Purpose**

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

13 **1.3 PAR Summary**

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

15

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

23

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

26

<i>Characteristic</i>	<i>Target Value</i>
<i>Mobility</i>	<i>Vehicular mobility classes up to 250 km/hr (as defined in ITU-R M.1034-1)</i>
<i>Sustained spectral efficiency</i>	<i>> 1 b/s/Hz/cell</i>

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

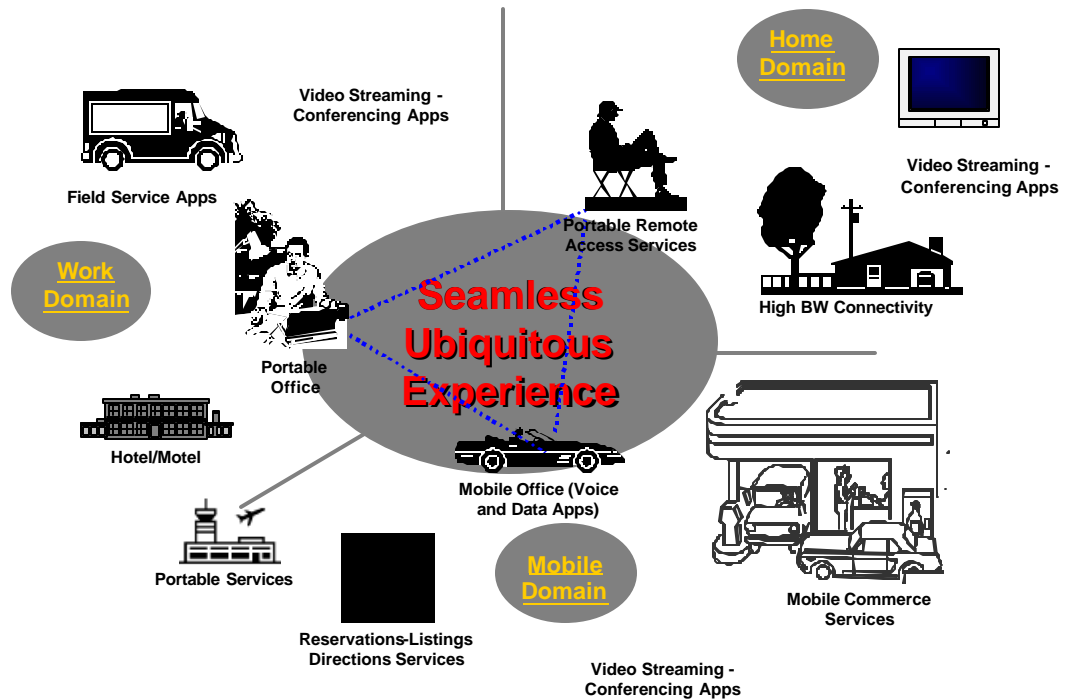
1

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

1 2 Overview of Services and Applications

2

Mobile Broadband Wireless Access



3
4

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

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

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

3 **2.1 Voice Services**

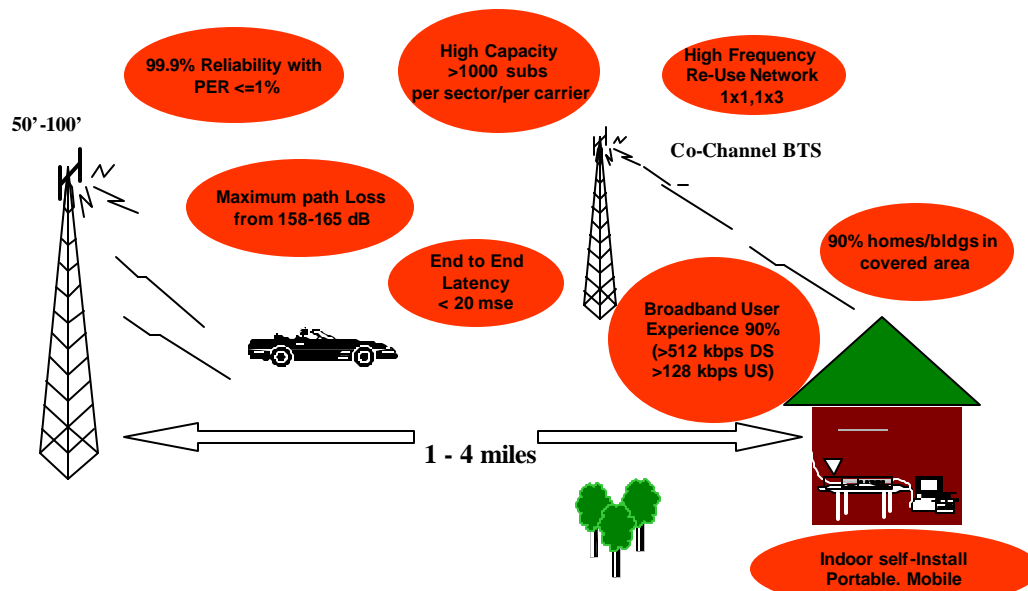
4 Call blocking is at higher level Sprint would like to see it included as a comment even though the
5 higher level will make the decision the MAC must be able to support the higher level function.

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

9 **3 System Reference Architecture**

10 **3.1 System Architecture**

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



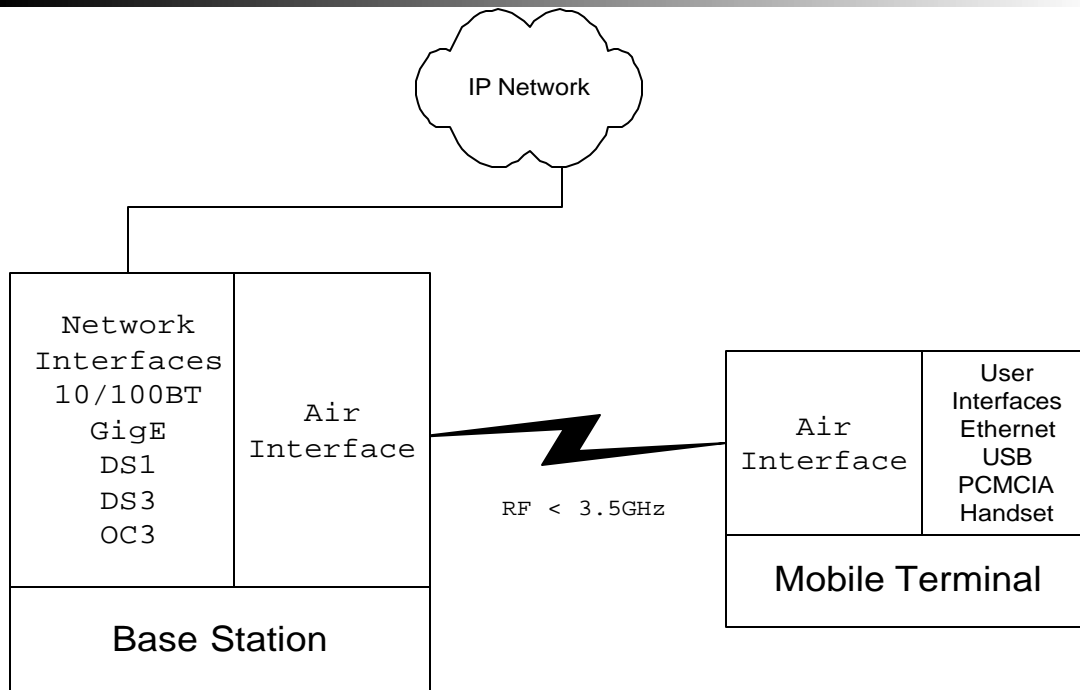
1 The AI shall support a layered architecture and separation of functionality between user, data
2 and control planes. The AI must efficiently convey bi-directional packetized, bursty IP traffic
3 with packet lengths and packet train temporal behavior consistent with that of wired IP
4 networks. The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

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

9 3.2 Definition of Interfaces

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

MBWA Interfaces



1 **4 Functional and Performance Requirements**

2 **4.1 System**

3 **4.1.1 Link Budget**

4 Link budget has been proposed at 150-170, 160-170 and removed.

5 The system link bud get shall be 160-170 dB for all devices and terminals at the data rates
6 specified in the earlier section assuming best practices in terms of base station design, user
7 terminal design, and deployment techniques.

8 **4.1.2 Spectral Efficiency (bps/Hz/sector)**

9 Rewritten to accommodate Michael Youssefmir comments along with perceived meaning and Sprints
10 contribution.

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

16 Downlink > 2 bps/Hz/sector

17 Uplink >1 bps/Hz/sector

18 **4.1.3 Frequency Reuse**

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

21 **4.1.4 Channel Bandwidths**

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

23 **4.1.5 Duplexing**

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

26 **4.1.6 Mobility**

27 Support different modes of mobility from pedestrian (3 km/hr) to very high speed (250 km/hr)
28 but not optimized for only one mode. As an example, data rate gracefully degrades from
29 pedestrian to high speed mobility.

1 **4.1.7 Aggregate Data Rates – Downlink & Uplink**

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

6 The aggregate data rate for downlink and uplink shall be consistent with the spectral efficiency.
7 An example of a 5MHz FDD channel is shown in Table 1 below.
8

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

9

10 User Data Rates - - Downlink & Uplink
11

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

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

18 Sprint added a definition.

19 **4.1.8 Number of Simultaneous Sessions**

20 > 100 sessions per carrier for a 5Mhz system. “Simultaneous” will be defined as the number
21 active-state Mobile Terminal having undergone contention/access and scheduled to utilize AI
22 resources to transmit/Receive data within a 10 msec time interval.

23 **4.1.9 Latency**

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

26 The AI shall minimize the round-trip times (RTT) and the variation in RTT for
27 acknowledgements, within a given QoS traffic class, over the air interface. The RTT over the
28 airlink for a MAC data frame is defined here to be the duration from when a data frame is
29 received by the physical layer of the transmitter to the time when an acknowledgment for that
30 frame is received by the transmitting station. The airlink MAC frame RTT, which can also be
31 called the “ARQ loop delay,” shall be less than 10 ms. Fast acknowledgment of data frames
32 allows for retransmissions to occur quickly, reducing the adverse impact of retransmissions on

1 IP packet throughput. This particularly improves the performance of gaming, financial, and other
2 real-time low latency transactions.

3 **4.1.10 Packet Error Rate**

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

10 **4.1.11 Use of Multi Antenna Capabilities**
11

12 Support will be provided at the Base Station and the Mobile Terminal for advanced multi
13 antenna technologies to achieve higher effective data rates, user capacity, cell sizes and
14 reliability.

15 **4.1.12 Network availability**

16 *It has been proposed this be deleted as an operator Sprint feels it is a minimum target.*

17 The end to end system availability shall be 99.9%.

18 **4.1.13 QoS**

19 The AI shall support the means to enable end-to-end QoS within the scope of the AI and shall
20 support a Policy-based QoS architecture. The resolution of QoS in the AI shall be consistent
21 with the end-to-end QoS at the Core Network level. The AI shall support IPv4 and IPv6
22 enabled QoS resolutions, for example using Subnet Bandwidth Manager. The AI shall support
23 efficient radio resource management (allocation, maintenance, and release) to satisfy user QoS
24 and policy requirements
25

26 **4.1.14 Security**

27 Network security in MBWA systems is assumed to have goals similar to those in cellular or
28 PCS systems. These goals are to protect the service provider from theft of service, and to
29 protect the user's privacy and mitigate against denial of service attacks. Provision shall be made
30 for authentication of both base station and mobile terminal, for privacy, and for data integrity
31 consistent with the best current commercial practice. 802.20 security is expected to be a partial
32 solution complemented by end-to-end solutions at higher protocol layers such as EAP, TLS,
33 SSL, IPSec, etc.

34 **4.1.14.1 Access Control**

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

1 **4.1.14.2 Privacy Methods**

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

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

6 **4.1.14.3 User Privacy**

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

8 **4.1.14.4 Denial of Service Attacks**

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

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

12 **4.1.14.5 Security Algorithm**

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

15 National or international standards bodies shall have approved the algorithms.

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

18 **4.1.15 Handoff Support**

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

23 **4.1.15.1 Soft Handoff**

24 **4.1.15.2 Hard Handoff**

25 **4.1.15.3 Hard Handoff Between Similar MBWA Systems**

26 **4.1.15.4 Hard Handoff Between Frequencies**

27 **4.1.15.5 IP-Level Handoff**

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

29 Version by Michael Youssefmir

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

4 Multiple IP addresses behind one terminal may also be supported.

5 In order to support high speed mobility in an all IP network Mobile IP will have to be supported
6 at a higher level. Integration of Foreign Agent or proxy Mobile IP into the base station or
7 terminal will be required to support a clientless solution. Multiple IP addresses behind a single
8 terminal shall also be supported.
9

10 **4.2 PHY/RF**

11 **4.2.1 Receiver sensitivity**

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

14 **4.2.2 Link Adaptation and Power Control**

15 The AI shall support automatic selection of optimized user data rates that are consistent with the
16 RF environment constraints and application requirements. The AI shall provide for graceful
17 reduction or increasing user data rates, on the downlink and uplink, as a mechanism to maintain
18 an appropriate frame error rate performance. The Radio system shall provide at least 99.9 link
19 reliability.

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

23 **4.2.3 Max tolerable delay spread Performance under mobility**

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

27 **4.2.4 Duplexing – FDD & TDD**

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

30 **4.3 Spectral Requirements**

31 The system shall be targeted for use in TDD and FDD licensed spectrum allocated to mobile
32 services below 3.5GHz. The AI shall be designed for deployment within existing and future
33 licensed spectrum below 3.5 GHz. The MBWA system frequency plan shall include both paired
34 and unpaired channel plans with multiple bandwidths, e.g., 1.25 or 5 MHz, etc., to allow co-

1 deployment with existing cellular systems. Channel bandwidths are consistent with frequency
2 plans and frequency allocations for other wide-area systems

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

4 **4.3.1 Adaptive Modulation and Coding**

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

6 **4.3.2 Layer 1 to Layer 2 Inter-working**

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

9 **4.4 Layer 2 MAC (Media Access Control)**

10

11 **4.4.1 Quality of Service and the MAC**

12 Several submissions for QoS have been sent now.

13 Michael Youssefmir wrote'

14 "The 802.20 air interface shall support standard Internet Differentiated
15 Services (DS) QoS to be compatible with other mobile network standards
16 such as 3GPP2. In particular, 802.20 shall support the standard
17 Expedited Forwarding (EF), Assured Forwarding (AF), and Best Effort (BE)
18 DS Per Hop Behaviors (PHBs) as defined by the RFC 2597 and RFC 2598.
19 802.20 shall also support configuration of the PHBs by a DS API that
20 shall be based on a subset of the information model defined in RFC 3289.
21

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

28 Bill Young Submitted.

29 Quality of Service and Class of Service

30

31 This section describes the quality of service and classes of services
32 for 802.20 systems. Terminology is borrowed from Internet Engineering
33 Task Force (IETF) and the IEEE 802.16.3 functional requirements.
34

35 802.20 protocols must support classes of service (COS) with various
36 quality of service guarantees. The 802.20 protocol standards must define
37 the interfaces and procedures that that facilitates the requirements for
38 the allocation and prioritization of resources. 802.20 protocols must
39 also provide the means to enforce QoS contracts and Service Level
40 Agreements (SLA). Table 1 provides a summary of the QoS requirements
41 that the PHY and MAC layers shall meet. Note that the parameters in the

1 table are measured between the MAC input and the upper layer at the
2 transmit station and the MAC output at the upper layer of the receiving
3 station for information transmission. For example, delay does not
4 include setup time, link acquisition, voice codec's, etc.

5
6 For QoS based connectionless services, the 802.20 protocols must support
7 resources negotiated on-demand. For example, the MAC protocol may
8 allocate bursts of PDUs to services that require changes in resource
9 allocation. Such allocation, for connectionless services, is thus
10 performed in a semi-stateless manner.

11
12 A connection-oriented service may require state information to be
13 maintained for the life of a connection. However, the 802.20 MAC layer
14 interface may provide a connection-less service interface that require
15 higher layer adaptation to maintain the state of the connection and
16 periodically allocate resources. For instance, the MAC may need to
17 maintain state information about the QoS data flow only for the duration
18 of an allocation.

19
20 Table 1: Services and QoS Requirements

21

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

22

23

24

Note: These parameters should be vetted by the group.

1 Types and Classes of Service

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

6
7 Expedited Forwarding (EF): EF requires a constant periodic access to
8 bandwidth. The bandwidth requirements may vary within a specific range,
9 but delay and delay variance limits are specified. Examples that fall
10 into this category are voice-over-IP (VoIP), videoconferencing, video on
11 demand (VoD) and other multimedia applications.

12 Assured Forwarding (AF): In AF the bandwidth varies within a specified
13 range, but has loose delay and delay variance requirements.

14 Applications, which are limited in their bandwidth usage, may fall in
15 this category. AF services allow the traffic to be divided into
16 different classes. Using this capability, an ISP can offer a tiered
17 services model. For example there could be four classes platinum, gold,
18 silver and bronze with decreasing levels of service quality as well as
19 maximum allocated bandwidth, with platinum getting the high share of
20 resources and bronze getting lowest. This would facilitate premium
21 priced service level agreements.

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

29
30
31 Traffic Shaping For Service Level agreements

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

39
40 Parameters

41
42 802.20 protocols shall define a set of parameters that preserve the
43 intent of the QoS parameters for all IP based services supported.

44

1 Service and QoS Mapping

2

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

9

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

15

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

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

23 **4.4.1.1 Cos/QoS Matched-Criteria**

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

27 **4.4.1.2 Protocol Field Mapping**

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

30 L4 Protocol field (UDP/TCP port number)

31 L4 Header length

32 L4 TCP flags

33 L4 TCP options (if present)

34 L3 Protocol field

35 L3 Source address/network

36 L3 Destination address/network

37 L3 Total length

- 1 L3 Fragmentation (Initial 4 bits of two-byte field)
- 2 L3 DiffServe/TOS field (to include ECN)
- 3 L2 Ethernet hardware address (two groups, 3 bytes each / entire 6 byte address)
- 4 L2 Ethertype
- 5 L2 802.1Q/p
- 6 L7 Unencrypted HTTP version 1.x protocol fingerprinting (desired)

7 **4.4.1.3 Hardware Mapping**

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

9 **4.4.1.4 Additional Criteria**

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

12 Data tonnage-based L3 resource usage quotas

13 Airtime utilization-based PHY resource usage quotas

14 **4.4.1.5 CoS/QoS Enforcement**

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

16 Prioritization

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

21 Error Correction

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

24 Queuing

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

28 Suppression

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

3 Reservation

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

6 **4.4.1.6 Aggregate Bandwidth Partitioning**

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

11 **4.4.1.7 Interface Binding**

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

17 **4.4.1.8 Packet Mangling**

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

24 **4.4.1.9 Resource Scheduling**

25 PHY/MAC resource scheduling: System must possess ability to starve a Mobile Station's
26 resource allocation of PHY resources for an operator specified time value, with resolution of
27 10ms increments.

28 **4.4.1.10 Rate-limiting**

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

1 **4.4.1.11 ARQ/Retransmission**

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

7 **4.4.1.12 MAC Error Performance**

8 The packet error rate (PER), after application of appropriate error correction mechanism (e.g.,
9 forward error correction) but before ARQ, delivered by the PHY layer to the MAC layer, must
10 meet a requirement of 1% for tests conducted with 512 byte packets. The ratio of MAC
11 protocol services becoming available to unavailable must be 99.9% of the time, provided the
12 system and radios receive adequate power 100% of the time.

13 **4.4.1.13 Latency**

14 Delays are derived from filters, frame alignment, time-slot interchange, switch processing,
15 propagation, packetization, forward error correction, interleaving, contention/access, queue
16 depths, or any other lapse in time associated with transmission on the wireless medium.
17 Synchronous services, such as TCP applications or VoIP require short, predictable (i.e.,
18 constant) delay.

19 **4.4.1.13.1 End to End Latency**

20 The MAC protocol must guarantee periodic access to the medium. PHY resources dedicated
21 for this function must not impact system goodput capacity by more than 5%. The contention
22 access mechanism must not incur more than 15 msec system delay, excluding the time the
23 system is in a blocking state due to over-capacity on the contention medium. The first packet
24 pass-through initiated by the subscriber, while the mobile station is not in an active state, must
25 incur less than 20 msec one-way delay (inclusive of contention/access latencies). The first
26 packet pass-through initiated by the base station, while the mobile station is not in an active
27 state, must incur less than 20 msec one-way delay, exclusive of regular active-state latencies.
28 64-byte packet pass-through must comply with a maximum round trip delay of less than 20
29 msec, exclusive of input or output queue depth and contention delay.

30 **4.4.1.13.2 End to End Latency Variation**

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

33 **4.4.1.14 Protocol Support**

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

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

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

7 **4.4.1.15 Addressing**

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

11 **4.4.1.16 Support/Optimization for TCP/IP**

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

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

17 **4.5 Layer 3+ Support**

18 The system must support both IPv4 and IPv6.

19 **4.5.1 OA&M Support**

20 The following values must be made available in real-time with redisplay intervals of no less than
21 1000 msecs, with the option to be displayed in both cumulative and delta modes:

22 Aggregate base station bytes served at each coding/modulation configuration

23 Correctable and uncorrectable block errors

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

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

26 Successful and failed service requests for both up and downlink directions

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

29 Number of ungraceful session disconnections

1 **4.5.2 Scheduler**

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

4 **4.5.3 MAC Complexity Measures**

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

8 **4.6 User State Transitions**

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

14 **4.7 Resource Allocation**

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

17 **5 References**

18

- 19 • 802.20 - PD-02: Mobile Broadband Wireless Access Systems: Approved PAR
20 (02/12/11)
- 21 • 802.20 - PD-03: Mobile Broadband Wireless Access Systems: Five Criteria (FINAL)
22 (02/11/13)
- 23 • C802.20-03/45r1: Desired Characteristics of Mobile Broadband Wireless Access Air
24 Interface ([Arif Ansari](#), [Steve Dennett](#), [Scott Migaldi](#), [Samir Kapoor](#), [John L. Fan](#), [Joanne](#)
25 [Wilson](#), [Reza Arefi](#), [Jim Mollenauer](#), [David S. James](#), [B. K. Lim](#), [K. Murakami](#), [S. Kimura](#)
26 (2003-05-12))
- 27 • C802.20-03/47r1: Terminology in the 802.20 PAR (Rev 1) ([Joanne Wilson](#), [Arif Ansari](#),
28 [Samir Kapoor](#), [Reza Arefi](#), [John L. Fan](#), [Alan Chickinsky](#), [George Iritz](#), [David S. James](#), [B.](#)
29 [K. Lim](#), [K. Murakami](#), [S. Kimura](#) (2003-05-12))

30

31

1 **Appendix A Definition of Terms and Concepts**

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

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

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

- 12 • *Cell* - The term “cell” refers to one single-sector base station or to one sector of a base
13 station deployed with multiple sectors.

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

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

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

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

- 27 • *MAN* – Metropolitan Area Network.

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

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

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

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

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

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

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

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

- 28 • *Various vehicular mobility classes* – Recommendation ITU-R M.1034-1 establishes the
29 following mobility classes or broad categories for the relative speed between a mobile and
30 base station:
 - 31 ○ Stationary (0 km/h),
 - 32 ○ Pedestrian (up to 10 km/h)
 - 33 ○ Typical vehicular (up to 100 km/h)
 - 34 ○ High speed vehicular (up to 500 km /h)
 - 35 ○ Aeronautical (up to 1 500 km/h)

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- 1 ○ Satellite (up to 27 000 km/h).
- 2

1 **Appendix B** **Unresolved issues**

2 Coexistence and Interference Resistance

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

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

12 • 5.1 Coexistence Scenarios

13 • FDD Deployments

14 • In this section, scenarios should be developed with 802.20 deployed as FDD, following the
15 FDD “rules” for each of the 2G and 3G technologies likely to be encountered in practice.

16 •

17 • 802.20 and AMPS

18 • 802.20 and IS-95

19 • 802.20 and GSM

20 • 802.20 and LMR

21 • 802.20 and CDMA2000

22 • 802.20 and WCDMA

23 • 802.20 and 1xEVDO

24 • 802.20 and HSDPA

25 • 802.20 and 1xEV/DV

26 • 5.1.2 TDD Deployments

27 • In this section, scenarios should be developed with 802.20 deployed as TDD, following any
28 TDD “rules” for each of the 2G and 3G technologies likely to be encountered in practice.
29 Since the majority of existing technologies are deployed as FDD solutions, some new

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

- 3 • 802.20 and AMPS
- 4 • 802.20 and IS-95
- 5 • 802.20 and GSM
- 6 • 802.20 and LMR
- 7 • 802.20 and CDMA2000
- 8 • 802.20 and WCDMA
- 9 • 802.20 and 1xEVDO
- 10 • 802.20 and HSDPA
- 11 • 802.20 and 1xEV/DV
- 12 • Adjacent Channel Interference
- 13 • Definitions and Characteristics
- 14 • Requirements
- 15 • Co-channel Interference
- 16 • Definitions and Characteristics
- 17 • Requirements
- 18 • TDD Interference in Traditionally FDD Bands
- 19 • Since 802.20 is listed as being both TDD and FDD, it should be evaluated in a scenario
20 where TDD 802.20 technology is deployed in a traditionally FDD frequency band. 802.20
21 should develop appropriate scenarios and requirements so that the new technology meets all
22 necessary coexistence requirements that may be placed upon it.
- 23 • Definition and Characteristics
- 24 • Requirements

25 Interworking: *The AI should support interworking with different wireless access systems,*
26 *e.g. wireless LAN, 3G, PAN, etc. Handoff from 802.20 to other technologies should be*
27 *considered and where applicable procedures for that hand-off shall be supported.*[Dan Gal

1 dgal@lucent.com]: This issue is quite **critical** to the successful deployment of 802.20 systems in existing
 2 and future markets worldwide. The purpose of defining Coexistence requirements in this document is to
 3 assure that 802.20 systems would not cause interference to or be susceptible to interference from other
 4 wireless systems operating in the same geographical area. Detailed quantitative RF emission limits need to
 5 be specified as well as received interference levels that the 802.20 receivers would have to accept and
 6 mitigate.

7 **5.1.1 MBWA-Specific Reference Model**

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

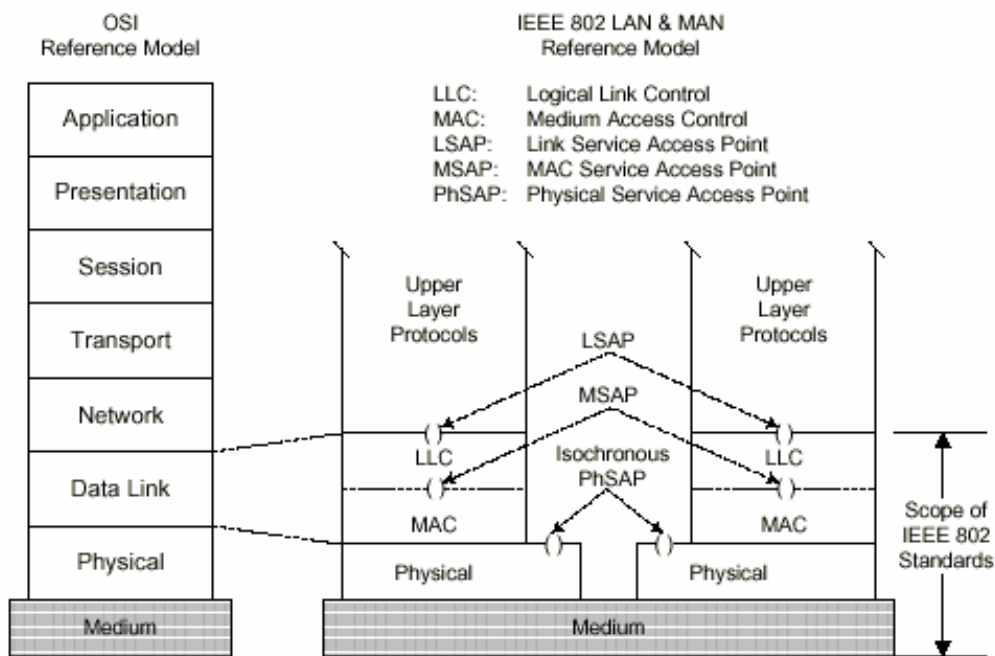
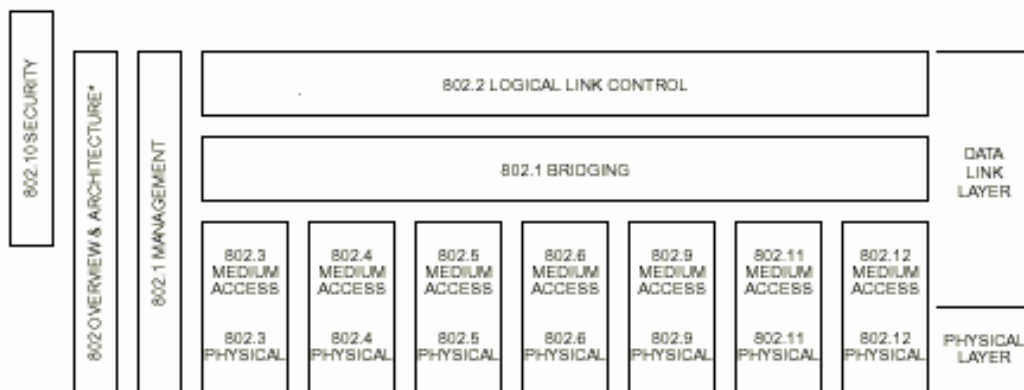


Figure 1—IEEE 802 RM for end stations (LAN&MAN/RM)

12



* Formerly IEEE Std 802.1A.

13

1 **5.1.2 MBWA-Specific Reference Model**

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

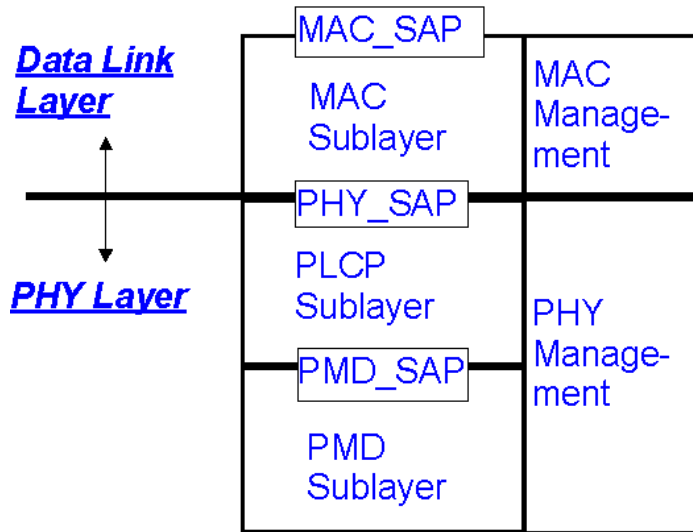
5 The 802.20 reference model consists of two major functional layers, the Data Link Layer
6 (DLL) and the Physical Layer (PHY).

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

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

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

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Figure 1 – Reference partitioning

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.

16
17

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

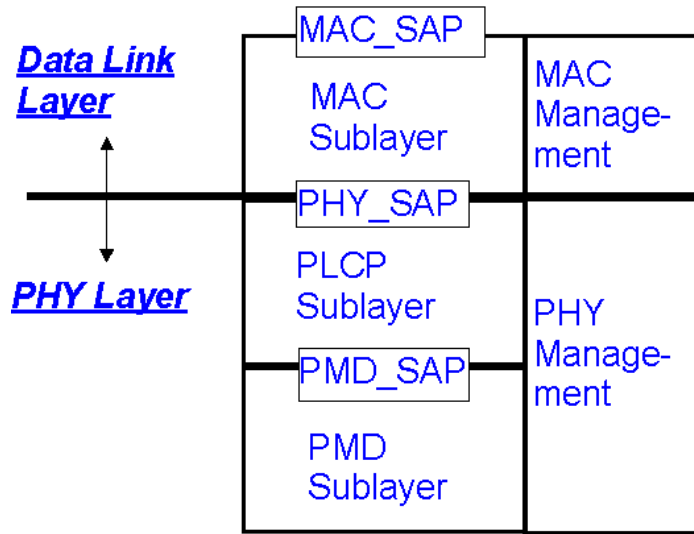
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13 Dependent, and the Physical Layer Management Sub layers. The Physical Layer Convergence
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15 into data objects suitable for over the air transmission, and for the deformatting of data received
16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

20

21



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

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- 3
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Figure 1 – Reference partitioning

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