Wireless Local Area Network Requirements

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Methodology

- IEEE Project 802 Functional Requirements
- IEEE Project 802.11 Project Authorization Request
- Wireless Application Surveys
  - Over 50 anticipated wireless applications' MAC service requirements surveyed
- Good engineering/market judgement

MAC Requirement Measures

MSDU Size Distribution	Define distribution of MSDU size in octets.
MSDU Arrival Distribution	Define MSDU interarrival time probability distribution. Later we may wish to augment this description to describe specific, deterministic, request-response traffic models.
Nominal Transfer Delay	Transfer delay measures the time from when an MSDU is submitted for transmission at the source MAC interface until the completion indication is given by the destination MAC interface with only one intervening wireless "hop". Intermediate forwarding through a distribution system are not included in this measure. This is measured in milliseconds and by definition includes the transmission time for the MSDU itself as well as access delay to a shared wireless medium as well as (possible) additional delay due to MAC level ARQ and retransmission. This definition is equivalent to the time between the invocation of the MAC_data_request primitive at the transmitting MAC service layer boundary to the corresponding MAC_data_indication at the receiving MAC service layer boundary.
Transfer Delay Standard Deviation	The tolerated standard deviation in transfer delay of this application. This is measured in milliseconds.
Maximum Transfer Delay	The maximum tolerated MSDU transfer delay for the application. MSDUs delayed by more than this amount are considered by the application the same as lost MSDUs.
MSDU Loss Rate	Percentage lost MSDUs during an application session that the application can tolerate without unacceptable user performance. It is expected that higher layer protocols (e.g. transport) will provide additional, comprehensive end-to-end reliability. This is a measure of the detected MSDU loss rate, rather than undetected MSDU loss rate.
Service Initiation Time	The amount of time this application can tolerate in order to initiate link level MSDU delivery service between source and destination. This is measured in milliseconds. This can be considered additional delay required to set up the communication path between particular source and destination stations for the first time in a stream of MSDUs. Each subsequent MSDU does not suffer this additional delay. This measure can be considered a "connection setup time."
Station Speed	The possible movement speed of a station implementing this application.
Destination Distribution	The percentage of this application's traffic that will typically be directly destined for wireless stations within the BSA and/or ESA rather than stations on an interconnected wired backbone.

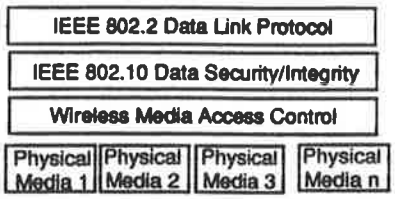
WLAN Configuration Measures

Number of stations	The typical number of stations for this configuration.
Station density	The number of stations per hectare.
Dimension	The typical linear dimension of the wireless service area. Measured in units of meters. Considered to be the maximum distance between any two communicating stations.
Application List	The list of applications that this configuration would typically use. It is our intention to construct traffic load models using this information.
Application Initiation Distribution	Time distribution of the service initiation times for these applications in this configuration.
Application Duration Distribution	Application duration distribution for each application in this configuration.

General Requirements

Data Delivery Services	The results of the application survey indicate the need for two classes of data delivery services: an asynchronous service for the substantial majority of anticipated applications requiring MSDU delivery services emphasizing low average transfer delay; and a synchronous service for the minority of applications requiring MSDU delivery services emphasizing low MSDU transfer delay jitter.
Station mobility	The standard shall support moving stations. The supported velocity required is "pallestrian speeds". Faster speeds may be optionally supported.
No end user license	The end user need not obtain a license to operate his wireless equipment in conformance with the standard. End user licensing is inconsistent with unrestricted portability.
Independent network operation	The standard shall support two or more networks in geographical proximity to operate independently, and without the need for external coordination. For example, two companies who share an office building should be able to operate their wireless networks independently without the need for coordination. This does not mean that one or more of the networks has to change to a different channel. It may mean that the performance may degrade. The degradation needs to be graceful.
Distribution system	The standard shall allow two or more stations to communicate wirelessly without the need for a wired distribution system. Users may (optionally) add a distribution system based on standard IEEE 802 LAN systems to extend the range and capacity of the wireless LAN. The same station implementation shall work in a system with and without a distribution system.
Power drain	Battery operation is a requirement for many applications, the standard must be designed to permit minimal power consumption implementations.
Size	The size of portable computers continues to decrease. The standard must be designed such that wireless LAN adaptors within portables can be implemented in very small sizes. A future goal is the support of credit card size devices (e.g. PCMCIA).
Security/Integrity	The inability of wireless media, in general, to control physical access to the media by alien stations requires special procedures for protecting transmitted information from unauthorized reception (e.g. transmission security) and unauthorized modification (e.g. transmission integrity).
Internetworking	Wireless networks will coexist and complement wired LANs and WANs and must provide seamless interconnectivity with both de jure and de facto LAN and WAN standards.
Multiple PHY Support	It is anticipated that for regulatory, safety, security, coverage, performance and consumer taste that a variety of PHYs will be required. The standard must support alternative PHYs throughout the electromagnetic spectrum.
Cost Effectiveness	The range of wireless applications is substantial. It is desired that the standard provide for both low cost, high volume implementations as well as higher cost, higher performance, lower volume implementations.

802.11 Architecture



MAC/LLC Interface

```
MA-UNITDATA.request (
                        source_address,
                        destination_address,
                        data,
                        priority,
                        service_class
                        )

MA-UNITDATA.indication (
                          source_address,
                          destination_address,
                          data,
                          reception_status,
                          priority,
                          service_class
                          )

MA-UNITDATA-STATUS.indication (
                                source_address,
                                destination_address,
                                transmission_status,
                                provided_priority,
                                provided_service_class
                                )
```

MAC/PHY Interface

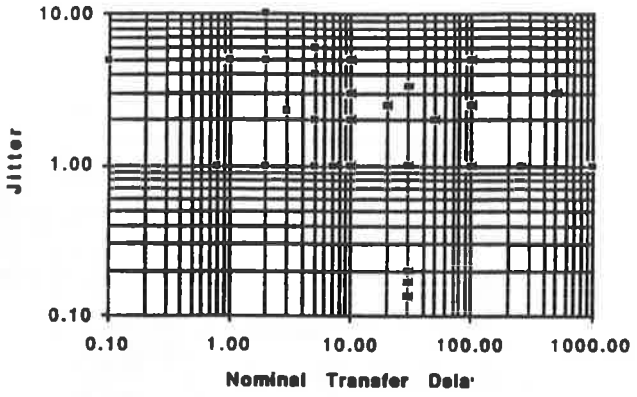
Signal Name	Direction	Description
Transmit Symbol	MAC-PHY	Data symbols transmitted by a station's MAC Layer Entity.
Transmit Clock	MAC-PHY	Clocking for transmitted symbols from MAC Layer Entity to PHY Layer.
Receive Symbol	PHY-MAC	Data symbols received and decoded by a station's PHY Layer Entity and supplied to the its' MAC Layer Entity.
Receive Clock	PHY-MAC	Clocking for received symbols from the PHY Layer Entitly to the MAC Layer Entity. Implict is the assumption that PHY performs clock recovery.
Quality of Service	PHY-MAC	Indication of the channel signal propagation characteristics. PHY Layer dependent interpretation.
Signal Detect	PHY-MAC	A channel busy indication supplied from the PHY Layer to the MAC Layer.
Channel Select	MAC-PHY	For PHY Layers where multiple channels can be selected this signal permits the station's MAC Layer Entity to "tune" the PHY Layer Entity to the desired channel. This signal is PHY Layer interpretation dependent. For FDMA radio PHY Layers, this signal can represent frequency information; for CDMA radio PHY Layers this signal can represent coding sequence information. For Infrared PHY Layers, this signal may be ignored since that PHY Layer may not support selectable channels.

Summary Application Measures

	Mean Value	Median Value	Standard Deviation
MSDU Size Distribution	759.96	512.00	736.17
MSDU Arrival Distribution	5359.76	60.00	25119.21
Nominal Transfer Delay	62.09	20.00	155.10
Transfer Delay Standard Deviation	100.52	20.00	250.47
Maximum Transfer Delay	749.00	250.00	1509.31
MSDU Loss Rate	0.23%	0.10%	0.33%
Service Initiation Time	908.49	1000.00	390.85
Station Speed	2.54	2.00	2.96
Destination Distribution	0.48	0.50	0.45
MSDU Jitter	2.40	2.00	1.94

- **53 Applications surveyed**

MSDU Jitter vs. Transfer Delay



- Jitter = MSDU Delay StdDev/Nominal delay
- Note two major categories:
  - Jitter < 1: "Synchronous Quality of Service"
  - Jitter ≥ 1: "Asynchronous Quality of Service"

Summary Measures for Asynchronous Service

	Range	Mean Value	Median Value	Standard Deviation
MSDU Size Distribution	10 octets 4096 octets	726.26	512.00	730.75
MSDU Arrival Distribution	2 msec 180000 msec	6038.66	100.00	26829.22
Nominal Transfer Delay	2 msec 500 msec	66.19	10.00	164.45
Transfer Delay Standard Deviation	10 msec[1] 1500 msec	112.64	30.00	283.79
Maximum Transfer Delay	60 msec[1] 2000 msec	837.59	250.00	1582.49
MSDU Loss Rate	10^{-3} [2]	0.13%	0.10%	0.19%
Service Initiation Time	250 msec 2000 msec	896.81	1000.00	414.07
Station Speed	2 m/s 10 m/s	2.30	2.00	2.69
Destination Distribution	Mixed	0.48	0.50	0.44

Summary Measures for Synchronous Service

	Range	Mean Value	Median Value	Standard Deviation
MSDU Size Distribution	512 msec 2048 octets	1024.00	512.00	793.19
MSDU Arrival Distribution	5 msec 60 msec	41.67	60.00	28.40
Nominal Transfer Delay	30 msec	30.00	30.00	0.00
Transfer Delay Standard Deviation	5 msec	5.50	6.00	0.84
Maximum Transfer Delay	30 to 60 msec	55.00	60.00	12.25
MSDU Loss Rate	10^{-2}	1.00%	1.00%	0.00%
Service Initiation Time	1000 msec	1000.00	1000.00	0.00
Station Speed	2 m/s 10 m/s	4.42	2.25	4.41
Destination Distribution	Mixed	0.50	0.50	0.55

Proposed Asynchronous Service Standard

	Minimum Required	Suggested Maximum
MSDU Size Distribution	128 octets	2048 octets
MSDU Arrival Distribution	2 msec	No limit
Nominal Transfer Delay	2 msec	250 msec
Transfer Delay Standard Deviation	5 msec	500 msec
Maximum Transfer Delay	250 msec	1000 msec
MSDU Loss Rate	.001	.01
Service Initiation Time	0 msec	500 msec
Station Speed	0 m/s	2 m/s
Destination Distribution	Mixed	Mixed

Proposed Synchronous Service Standard

	Minimum Required	Suggested Maximum
MSDU Size Distribution	128 octets	2048 octets
MSDU Arrival Distribution	10 msec	No limit
Nominal Transfer Delay	10 msec	100 msec
Transfer Delay Standard Deviation	5 msec	50 msec
Maximum Transfer Delay	10 msec	100 msec
MSDU Loss Rate	.001	.01
Service Initiation Time	500 msec	1000 msec
Station Speed	0 m/s	2 m/s
Destination Distribution	Mixed	Mixed

Summary Configuration Data

	Mean	Median	Standard Deviation
Number of Stations	573.38	25.00	1616.50
Station Density	1357.50	60.00	3710.75
Dimension	389.85	100.00	895.47

Configuration Classes

Number of stations	21 or 5000	36 or 1000	45	116 or 5000
Station density	≤10/hectare	≤100/hectare	≤1000/hectare	>1000/hectare
Dimension (Median)	100	100	50	15
Dimension (Mean)	819	230	159	42

- **Examine data more closely based on density**

Data Security

Security	**Unauthorized reading of data - IEEE 802.10**
Integrity	**Unauthorized modification of data - IEEE 802.10**
Service Denial	**Prevent jammers as best as possible: access control**
Authentication	**Validation of stations and distribution system**

Network Management

Network Management

Power Management	**System must provide for minimum power consumption in order to minimize power drain in battery operated machines**

Range Extension

Range Extension	**Must support BSA of size ≤ 100m extending to ESA of size ≥ 1000m**
Roaming	**Station must continue to operate throughout ESA while in motion retaining active communication liaisons**
Co-located Networks	**Adjacent, overlapping networks must operate with at most incremental performance degration due to shared PHY channel**
Internetworking	**MAC must export standard LLC interface to support higher layer protocols and standard IEEE 802.2D internetworking**