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## **Proposal for a Wireless Personal Area Network Physical Layer and Medium Access Control Protocol**

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## **Agenda**

- **Review CFA** (doc:IEEE 802.11-98/352)
  - Applications
  - Requirements
- **Physical Layer Proposal** (doc:IEEE 802.11-99/006)
- **Medium Access Control Protocol Proposal**
- **Questions**

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# Application Scenarios for WPAN and Digital Cameras

## Digital Cameras able to communicate via RF to:

- each other
- printers
- PCs or Set Top Boxes
- kiosks
- beacons

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# Requirements Summary

## RF Enabled Digital Imaging Devices require:

- Ease of use. Digital Image data transfers need to be easy to initiate and take less than 15 seconds.
- ad-hoc network capability. Should be able to enter, join or leave a network easily. User doesn't need to know IP addresses. It just happens.

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## Requirements Summary cont...

- a communications range 60 meters or less.
- dual transmit power levels ( High/Low).
- low power consumption.
- well defined (transmit)/(no transmit) boundary, based on RF energy strength.
- no roaming or hand-off between networks.

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## Requirements Summary cont...

- Support 12-20 Mbps Data Transfers
- Data types:
  - Bulk transfers ( Megabyte sized image files)
  - Isochronous data ( Packetized Video streams)
  - Asynchronous data ( e.g. interactive sessions )
- Low cost for consumer applications

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## RF PHY Characteristics

- 2.54 GHz License Free Band. Allows multiple channels in North America & Europe.
- Bi-directional, half Duplex
- Robust in the face of Microwave Oven Interference
- Inexpensive

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## MAC Characteristics

MAC protocol layer must:

- be RF multi-user friendly( e.g. Carrier Sense/Collision Avoidance).
- be able to select & negotiate the use of one of several available RF channels.
- support the creation of an ad hoc network.
- support high effective data rates.

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## MAC Characteristics cont. ...

- support bulk data, asynchronous data, and isochronous data transfers.
- support power management (e.g. Awake or Asleep).
- be transparent to upper layer protocols (e.g. TCP/IP).
- be inexpensive

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## Multi-Media-ISM (MM-ISM) Physical Layer Proposal

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## **Proposed MM-ISM Physical Layer Attributes**

- Operating Frequency Range
  - 2.4 GHz to 2.5 GHz ISM Band
- RF Modulation
  - Wideband CP-BFSK
- Baseband signal
  - Serial NRZ data stream

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## **Proposed MM-ISM Physical Layer Attributes cont...**

- Radio Power Consumption
  - < 300 milliwatts ( Transmit)
  - ~ 100 milliwatts (Receive)
- Bit Rate Modes
  - 20 Mbps
  - 1 Mbps

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## Proposed MM-ISM Physical Layer Attributes cont...

- Channel Bandwidth
  - 27 MHz ( 20 Mbps )
  - 1.33 MHz ( 1 Mbps)
  
- Number of Operating Channels
  - 11 overlapping 20 Mbps channels
  - 3 non-overlapping 20 Mbps channels
  - 41 non-overlapping 1 Mbps channels

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## 2.4 GHz ISM Band Channelization to Support 20 Mbps Data Rate

CHNL_ID	Frequency (MHz)	Regulatory Domain			
		FCC & ETSI & IC	Spain	France	Japan /MKK
1	2414	X			
2	2417	X			
3	2422	X			
4	2427	X			
5	2432	X			
6	2437	X			
7	2442	X			
8	2447	X			
9	2452	X			
10	2457	X	X	X	
11	2462	X	X	X	
12	2469	X		X	
13	2484				X

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## 2.4 GHz ISM Band Channelization to Support 1 Mbps Data Rate

CHNL_ID	Frequency (MHz)	FCC & ETSI	Regulatory Domains		
			Spain	France	Japan/MKOC
15	2421	X			
16	2423	X			
17	2425	X			
18	2427	X			
19	2429	X			
20	2431	X			
21	2433	X			
22	2435	X			
23	2437	X			
24	2439	X			
25	2441	X			
26	2443	X			
27	2445	X			
28	2447	X			
29	2449	X			
30	2451	X			
31	2453	X			
32	2455	X			
33	2457	X			
34	2459	X			
35	2461	X			
36	2463	X			
37	2465	X			
38	2467	X	X		
39	2469	X	X	X	
40	2471	X	X	X	
41	2473	X	X	X	
42	2475	X	X	X	
43	2477	X	X	X	
44	2479	X	X	X	
45	2481	X	X	X	
46	2483	X	X	X	
47	2485	X	X	X	
48	2487	X	X	X	
49	2489	X	X	X	
50	2491	X	X	X	
51	2493	X	X	X	X
52	2495	X	X	X	X
53	2497	X	X	X	X
54	2499	X	X	X	X
55	2481	X	X	X	X
56	2483	X	X	X	X
57	2485	X	X	X	X
58	2487	X	X	X	X
59	2489	X	X	X	X

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## Proposed MM-ISM Physical Layer Attributes cont...

- TxRxTurnAroundTime < 10 usec
- RxTxTurnAroundTime < 10 usec
- EnergyDetectTime = 10 usec
- Slot Time < 20 usec
  - SlotTime = RxTxTurnAroundTime + EnergyDetectTime

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# Proposed MM-ISM Physical Layer Transmit Specification

- Transmit Power Levels
  - Maximum 10mW (10dBm) or -20dBW e.i.r.p
  - Reduced power mode
    - 15 dB below max. peak power of 10 dBm
- Transmit Spectrum Masks for:
  - 20Mbps
  - 1 Mbps

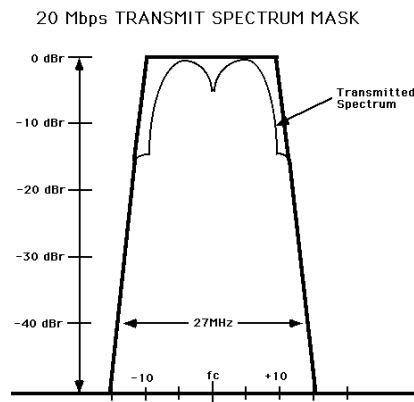
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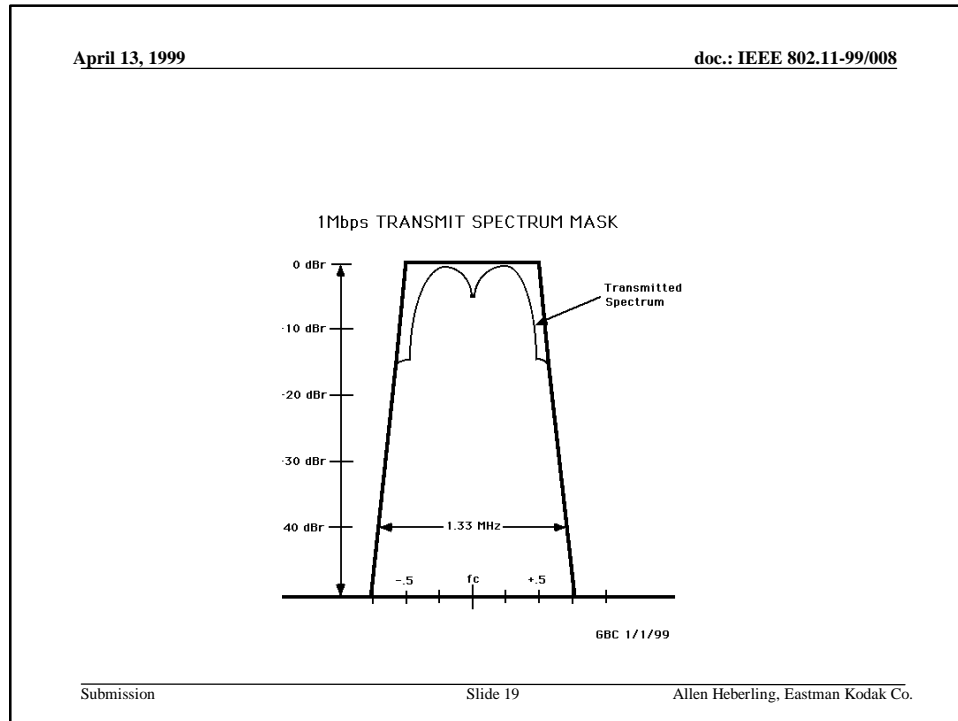


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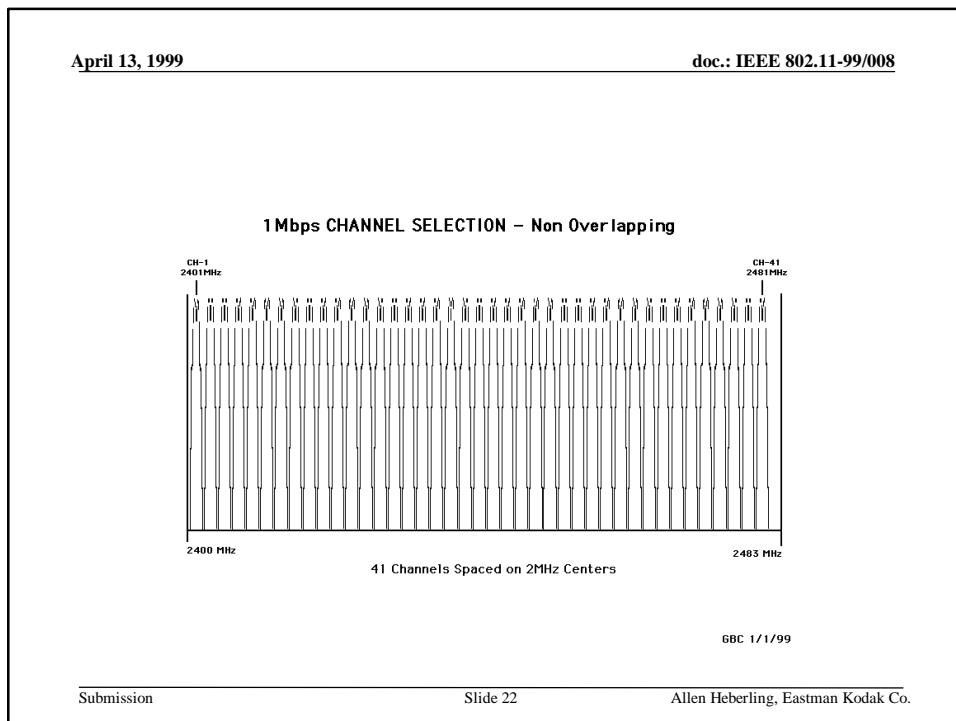
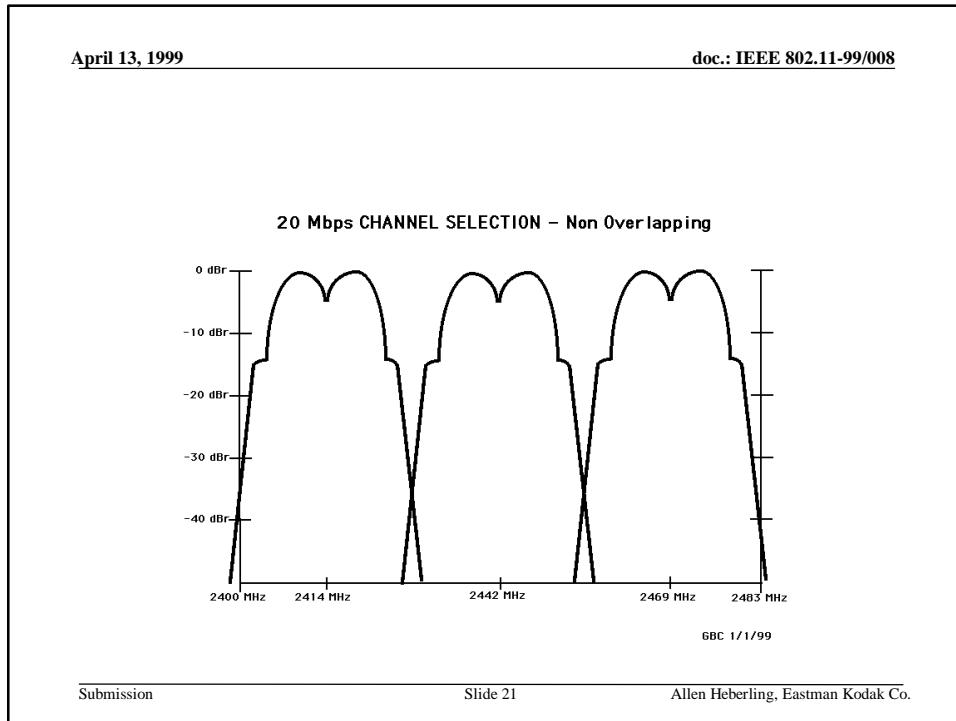
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## Proposed MM-ISM Physical Layer Receiver Specification

- Minimum Input Level Sensitivity
  - < 10E-06 BER with -80dBm measured at antenna
- Maximum Input Level
  - < 10E-06 BER with -10dBm measured at the antenna
- Receiver Adjacent Channel Rejection
  - 20 Mbps
  - 1 Mbps

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## MM-ISM Physical Layer PICS Proforma A.4.6

Item	Phy Feature	References	Status	Support		
				Yes	No	N/A
	PLCP Sublayer Procedures	15.2				
DS1	Preamble prepend on Tx	15.2.1	M	X		
DS1.1	PLCP frame format	15.2.2.2, 15.2.3	M	X		
DS1.2	PLCP integrity check generation	15.2.3, 15.2.3.6	M	X		
DS1.3	TX Rate change capability	15.2.3.3, 15.2.5	M	X		
DS1.4	Supported Data Rates	15.1, 15.2.3.3	M	X		
DS1.5	Data whitener scrambler	15.2.4	M			
DS1.6	Scrambler initialization	15.2.4	M			
DS2	Preamble process on RX	15.2.1				
DS2.1	PLCP frame format	15.2.2, 15.2.3	M	X		
DS2.2	PLCP integrity check verify	15.2.2, 15.2.3.6	M	X		
DS2.3	RX Rate change capability	15.2.3.3, 15.2.5	M	X		
DS2.4	Data whitener descrambler	15.2.4	M			
DS3	PN code sequence	15.4.6.3	M		X	
DS4	Chipping continue on power Down	15.2.6	O		X	

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## MM-ISM Physical Layer PICS Proforma A.4.6 cont...

Item	Phy Feature	References	Status	Support		
				Yes	No	N/A
DS7	CCA functionality	15.4.8.4				
DS7.1	Energy Only (RSSI above threshold)	15.4.8.4	DS7:O.2			
DS7.2	802.11 DSSS correlation	15.4.8.4	DS7:O.2			
DS7.3	both methods	15.4.8.4	DS7:O.2			
DS7.4	Hold CCA busy for fragment duration of a correctly received PLCP but carrier lost during reception of MPDU	15.2.7	M	X		
DS7.5	Hold CCA busy for fragment duration of a correctly received but out of spec PLCP		M	X		
DS8	Transmit antenna selection	15.4.5.5	O			X
DS9	Receive antenna diversity	15.4.5.5, 15.4.5.6, 15.4.5.7	O			X
DS10	antenna port(s) availability	15.4.6.9	O			X
DS10.1	50 ohm impedance	15.4.6.9	DS10:M	X		
DS11	transmit power level support	15.4.5.8	O			
DS12	radio type (temperature range)	15.4.6.10				
DS12.1	Type 1	15.4.6.10	DS12:O.3			
DS12.2	Type 2	15.4.6.10	DS12:O.3			

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## MM-ISM Physical Layer PICS Proforma A.4.6 cont...

Item	Phy Feature	References	Status	Support		
				Yes	No	N/A
DS13	Spurious Emissions conformance	15.4.6.5	M	X		
DS14	Tx-Rx turnaround time	15.4.6.6	M			
DS15	Rx-Tx turnaround time	15.4.6.6	M			
DS16	Slot Time	15.4.6.8	M			
DS17	Energy Detect time	15.4.6.8	M			
		15.4.8.4				
DS18	minimum transmit power level	15.4.7.2	M			
DS19	transmit spectral mask conformance	15.4.7.4	M			
DS20	transmitted center frequency tolerance	15.4.7.5	M			
DS21	chip clock frequency tolerance	15.4.7.6	M			
DS22	transmit power on ramp	15.4.7.7	M			
DS23	transmit power down ramp	15.4.7.7	M			
DS24	RF carrier suppression	15.4.7.8	M			
DS25	transmit modulation accuracy	15.4.7.9	M			
DS26	receiver minimum input level sensitivity	15.4.8.1	M			
DS27	receiver maximum input level	15.4.8.2	M			
DS28	receiver adjacent channel rejection	15.4.8.3	M			
DS29	MIB	13.1, 15.3.4	M			

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## Proposed MM-ISM Physical Layer Attributes

### - Interoperability

OK = Fully Interoperable

X = No Interoperability

1 = There is sensing (CCA) that another BSS is functioning

	<b>TX</b>	<b>DSSS</b>	<b>FH</b>	<b>MM-ISM</b>
<b>RCV</b>				
<b>DSSS</b>		OK	X	1
<b>FH</b>		X	OK	X
<b>MM-ISM</b>		1	X	OK

Table 1 - Interoperability Matrix

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## Proposed MM-ISM Physical Layer Attributes cont...

### - Co-existence

OK = Co-exist w/o interference(defer)  
OK' = Co-exist with interference  
C = Co-exist by deferring on CCA

	TX	DSSS	FH	MM-ISM
RCV				
DSSS		OK	OK'	C
FH		OK'	OK	OK'
MM-ISM		C	OK'	OK

Table 2 - Co-existence Matrix

## Multi-Media ISM (MM-ISM) Medium Access Control Protocol Proposal

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## Two MAC Layer proposals:

1) Adopt a Full Featured 802.11 MAC.

or

2) Develop and Adopt an 802.11 MAC Lite

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## Full Featured 802.11 MAC Protocol Pros & Cons

### Pros

- IEEE 802.11 Standards support.
- Full featured MACs are available.

### Cons

- Current implementations do not support 20Mbps data rates.
- Cost to implement in a HW architecture.

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# 802.11 MAC Lite Protocol Pros & Cons

## Pros

- Less complexity.
- Potentially less expensive to implement.
- Maintains Frame formats.

## Cons

- reduced capability
- time to develop

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# 802.11 MAC Lite Protocol Capabilites A.4.4.1 Preliminary

Item	Protocol Capability	References	Status	Support		
				Yes	No	N/A
	Are the following MAC protocol capabilities supported?					
PC1	Authentication Service	5.4.3.1, 5.4.3.2, 5.7.6, 5.7.7, 8.1, Annex C	M		X	
PC1.1	Authentication State	5.5	M		X	
PC1.2	Open System Authentication	8.1.1	M		X	
PC1.3	Shared Key Authentication	8.1.2, 8.3	PC2:M		X	
PC2	Wep Privacy Algorithm	5.4.3.3, 8.2, Annex C	O		X	
PC2.1	Wep Encryption Procedure	8.2.3, 8.2.4, 8.2.5	PC2:M		X	
PC2.2	Wep Decryption Procedure	8.2.3, 8.2.4, 8.2.5	PC2:M		X	
PC2.3	Security Services Management	8.3	M		X	

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# 802.11 MAC Lite Protocol Capabilities A.4.4.1 cont...

Item	Protocol Capability	References	Status	Support		
				Yes	No	N/A
	Are the following MAC protocol capabilities supported?					
PC3	Distributed Coordination function	9.1, 9.2 Annex C	M	X		
PC3.1	Net Allocation Vector (NAV) Function	9.2.1, 9.2.5, 9.3.2.2	M	?		
PC3.2	Interframe Spacing & Timing	9.2.3, 9.2.5 9.2.10	M	X		
PC3.3	Random Backoff Function	9.2.4	M	X		
PC3.4	DCF Access Procedure	9.2.5.1 9.2.5.5	M	X		
PC3.5	Random Backoff Procedure	9.2.5.2	M	X		
PC3.6	Recovery Procedures and Retransmit Limits	9.2.5.3	M	X		
PC3.7	RTS/CTS Procedure	9.2.5.4 9.2.5.6 9.2.5.7	M		X	
PC3.8	Directed MPDU Transfer	9.2.6	M	X		
PC3.9	Broadcast & Multicast MPDU Transfer	9.2.7	M	X		
PC3.10	MAC Level Acknowledgment	9.2.2, 9.2.8	M	X		
PC3.11	Duplicate Detection & Recovery	9.2.9	M	X		

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# 802.11 MAC Lite Protocol Capabilities A.4.4.1 cont...

Item	Protocol Capability	References	Status	Support		
				Yes	No	N/A
	Are the following MAC protocol capabilities supported?					
PC4	Point Coordinator	9.1, 9.3 Annex C	CF1:O		X	
PC4.1	Maintenance of CFP Structure & Timing	9.3.1, 9.3.2	PC4:M		X	
PC4.2	PCF MPDU Transfer from Point Coordinator	9.3.3	PC4:M		X	
PC4.3	PCF MPDU Transfer to Point Coordinator	9.3.3	PC4:M		X	
PC4.4	Overlapping PC Provisions	9.3.3.2	PC4:M		X	
PC4.5	Polling List Maintenance	9.3.4	PC4.3:M		X	
PC5	CF-Pollable	9.1, 9.3 Annex C	CF2:O		X	
PC5.1	Interpretation of CDF Structure & Timing	9.3.1, 9.3.2	PC5:M		X	
PC5.2	PCF MPDU Transfer to/from CF-Pollable STA	9.3.3	PC5:M		X	
PC5.3	Polling List Update	9.3.4	PC5:M		X	
PC6	Fragmentation	9.2, 9.4 Annex C	M	X		
PC7	Defragmentation	9.2, 9.5, Annex C	M	X		

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# 802.11 MAC Lite Protocol Capabilities A.4.4.1 cont...

Item	Protocol Capability	References	Status	Support		
				Yes	No	N/A
	Are the following MAC protocol capabilities supported?					
PC8	MAC Data Service	9.1.5, 9.8 Annex C	M	X		
PC8.1	Reorderable-Multicast Service Class	9.8	M	X		
PC8.2	Strictly-Ordered Service Class	9.8	O			
PC9	MultiRate Support	9.6, Annex C	M	X		
PC10	Multiple Outstanding MSDU Support	9.8, Annex C	O			
PC10.1	Multiple Outstanding MSDU Transmission Restrictions	9.8				
PC11	Timing Synchronization	11.1, Annex C	M	X		
PC11.1	Timing in an Infrastructure network	11.1.1.1	CF1:M			
		11.1.4				
PC11.2	Timing in an Independent BSS	11.1.1.2,	CF2:M	X		
		11.1.4				
PC11.3	Beacon Generation Function	11.1.2	M	X		
PC11.4	TSF Synchronization & Accuracy	11.1.2	M	X		
PC11.5	Infrastructure BSS Initialization	11.1.3	CF1:M			
PC11.6	Independent BSS Initialization	11.1.3	CF2:M	X		
PC11.7	Passive Scanning	11.1.3	CF2:M			
PC11.8	Active Scanning	11.1.3	CF2:M	X		
PC11.9	Probe Response	11.1.3	M	X		
PC11.10	Hop Synchronization Function	11.1.5	CF3:M		X	

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# 802.11 MAC Lite Protocol Capabilities A.4.4.1 cont...

Item	Protocol Capability	References	Status	Support		
				Yes	No	N/A
	Are the following MAC protocol capabilities supported?					
PC12	Infrastructure Power Management	11.2.1, Annex	M	X		
PC12.1	Station Power Management	11.2.1.1,	CF2:M	X		
		11.2.1.8				
PC12.2	TIM Transmission	11.2.1.2	CF1:M			
		11.2.1.3				
PC12.3	Access Point Function During Contention Period	11.2.1.4	CF1:M			
PC12.4	Access Point Function During CFP	11.2.1.5	PC4:M			
PC12.5	Receive Function During Contention Period	11.2.1.6	CF2:M			
PC12.6	Receive Function During CFP	11.2.1.7	PC5:M			
PC12.7	Aging Function	11.2.1.9	CF1:M			
PC13	Independent BSS Power Management	11.2.2, Annex	CF2:M	X		
PC13.1	Initialization of Power Management	11.2.2.2	CF2:M	X		
PC13.2	STA Power State Transitions	11.2.2.3	CF2:M	X		
PC13.3	ATIM & Frame Transmission	11.2.2.4	CF2:M	?		
PC14	Association & Reassociation	5.4, 5.7, 11.3, Annex C	M		X	
PC14.1	Association State	5.5	M		X	
PC14.2	STA Association Procedure	11.3.1	CF2:M		X	
PC14.3	AP Association Procedure	11.3.2	CF1:M		X	
PC14.4	STA Reassociation Procedure	11.3.3	CF2:M		X	
PC14.5	AP Reassociation Procedure	11.3.4	CF1:M		X	

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