Commonality between LMDS and MMDS Standards

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Need for standardization

- Standards can load to Lower cost of BWA CPE components and assemblies
- Same high volume RF and digital ICs from other systems can be used in LMDS systems
  - Use RF ICs and components from DBS systems, MMDS systems, cable data modems, ISM band systems and PCS and cellular systems
  - Lowers development cost and time
- Multiple standards may be needed for certain perameters to address different applications
  - IF frequency : 950-2150, 200-600MHz etc.
  - Channel bandwidth 2xN MHz

Comparison of various broadband access technologies

Table 1.1 Comparison of various high speed technologies

Perameter	ISDN	xDSL		MMDS	LMDS	Unlicensed Band radios	Fiber	Satellite
Deployment cost	high	high	high	low to very low	medium		very high	very high
Deployment time	medium	medium	medium	low	low	low	high	low
CPE cost	medium	medium	low	low-medium	high	medium		high
Data rate	128 Kbs	1-6 Mbs	>1 Mbs 5-42 MHz - up	0.2-2 M Mbs	1-10 Mbs 1100 MHz-A	>1 Mbs 84 MHz@2.4 GHz		.1-10 Mbs
				132 MHz -ITFS	150 MHz-B	125 MHz @5.8 GHz		
Total Capacity	high	high	medium	Medium	high	medium	high	medium
	near central office	near CO	large	50-100Km	2-6 Km	2-10 Km	small	large
Symmetry	yes	may be	no	may be	yes	yes	yes	no
Other Advantages				technology ready today				
		businesses near CO (central office)	Business/Residential		Business	Pt. to Pt. radios	backhaul	
				International	International backhaul	WLAN		
Other issues		not good far from CO		freq. Coordination with ITFS				telephone return only

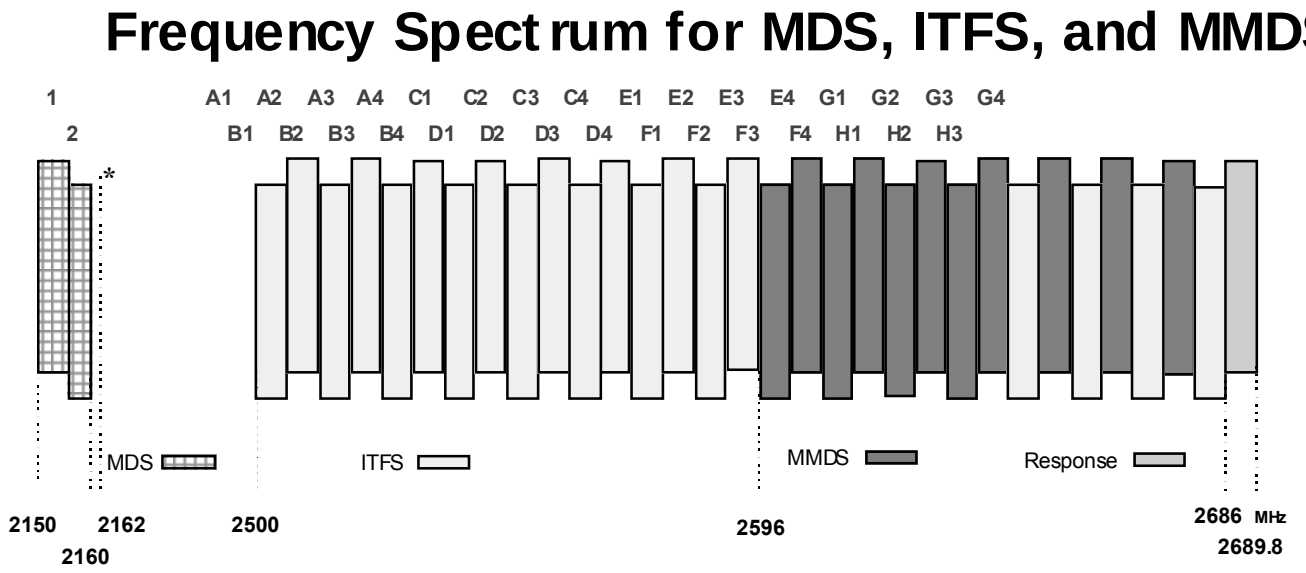
Comparison of various broadband access technologies (continued)

- Cable modem and xDSL will capture some share of the Broadband access business
- BWA technologies ie. LMDS and MMDS have lower deployment costs and time than XDSL and cable modem technologies
- BWA technologies ie. LMDS and MMDS compete well with XDSL and cable modem if the LMDS standards are set to lower equipment cost
- LMDS standards need to be defined soon since the competeting technologies are already being deployed

MMDS status

- MMDS frequencies auctioned in 1996
- Most MMDS spectrum is currently being used for wireless cable TV services
- FCC approved two way rules in Sep.98
- Two way rules are complex, allowing more freedom in band plan but protecting current ITFS and other licensee from interference
- A number of operators offering high speed internet services commercially
- Many trials are underway for two way data, voice and video services

Band plan for MDS, MMDS and ITFS spectrum



*Top 2 MHz not available in all markets

Synergy between MMDS and LMDS spectrum and applications

- See more details in ADC paper on this subject presented at the WCA symposium on Oct. 24, 1998
- Same customers and applications-data, voice, video
- similar needs for backhaul, CPE modem, base station gateways etc.
- MMDS spectrum is good for long distance communication- need few cells
- LMDS spectrum is good for communication over short distances - need many cells
- LMDS and MMDS spectrum used together can lower system deployment costs and increase coverage
-

Advantages and disadvantages of MMDS spectrum

- Propagation over long distances up to 100 km. with single tower
- Less attenuation due to rain, foliage
- RF component costs lower at 2.5 GHz
- Equipment readily available today
- Limited capacity without sectorization, cellularization which adds complexity and cost
- Interference issues with other MMDS and ITFS licensees
- Large upstream bandwidth in MMDS band requires careful planning, filtering etc.
- Cellularization later on may require retuning the entire network (every CPE)

Advantages and disadvantages of LMDS spectrum

- Very large bandwidth available for data, IP telephony, video conferencing services
- Large capacity
- Higher RF component costs
- Small cell size, 2-8 Km.
- Does not cover entire metropolitan area of a large city without adding many cells at high cost

Benefits of using MMDS, LMDS and unlicensed bands together

- Complete coverage of a large city right in the beginning
- Lower infrastructure and deployment costs
- More types of services can be offered ie. lower cost services with MMDS network and high bandwidth services with LMDS network
- Can grow subscribers and services by adding additional LMDS cells
- More options to address interference with other ITFS and MMDS licensees
- Lower back haul costs - LMDS and MMDS cells can be used for back haul

Attributes of competitive broadband wireless service

- Lower infrastructure cost - Phased deployment, lower risk
- Lower Operating Cost - Compared to wire-line
- Time to Market - Fewer right-of-way issues, permits, etc.
- More readily scaleable - Can grow with “take” rate
- Better neighbor relations - No need to “invade’ backyards
- High data rate capacity - Can add “new” services
- Large coverage- cover entire metropolitan area

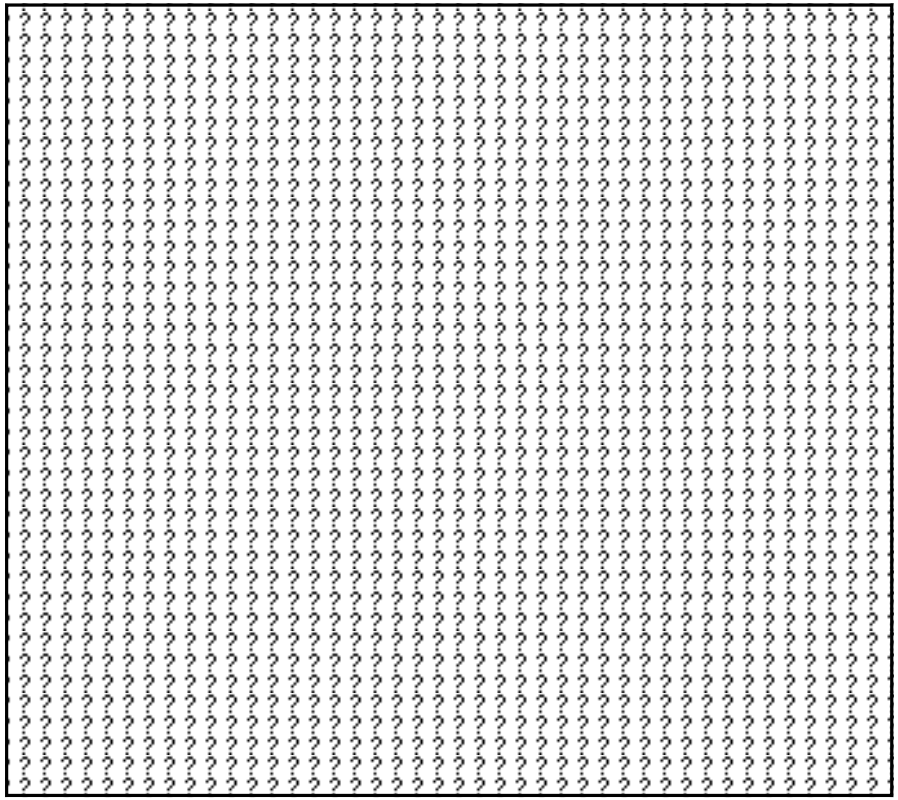
Service to be offered and their bandwidth needs

- Voice
  - need medium amount of symmetric u/s / d/s bandwidth
- Data - Web browsing
  - need more d/s than u/s bandwidth
- Data - File transfer
  - need symmetric u/s / d/s bandwidth
- One way video
  - Need large d/s bandwidth for many TV channels
  - Offering all video data and voice services on MMDS network can put capacity constraints
- Video conferencing
  - need large amount of symmetric u/s / d/s bandwidth

Hardware Cost Drivers

- System architecture, standards
- RF Hardware
  - Antenna
  - Radio Transceiver
    - Modularity , Discreet vs. MMIC technology,
- Modem, Controller
- Network management, software
- Base station transmitter
- Backhaul- Fiber, ATM, Wireless
- Applications- Billing, Gatekeeper, VOIP gateway etc.

Proposed concept of using MMDS, LMDS and unlicensed bands together



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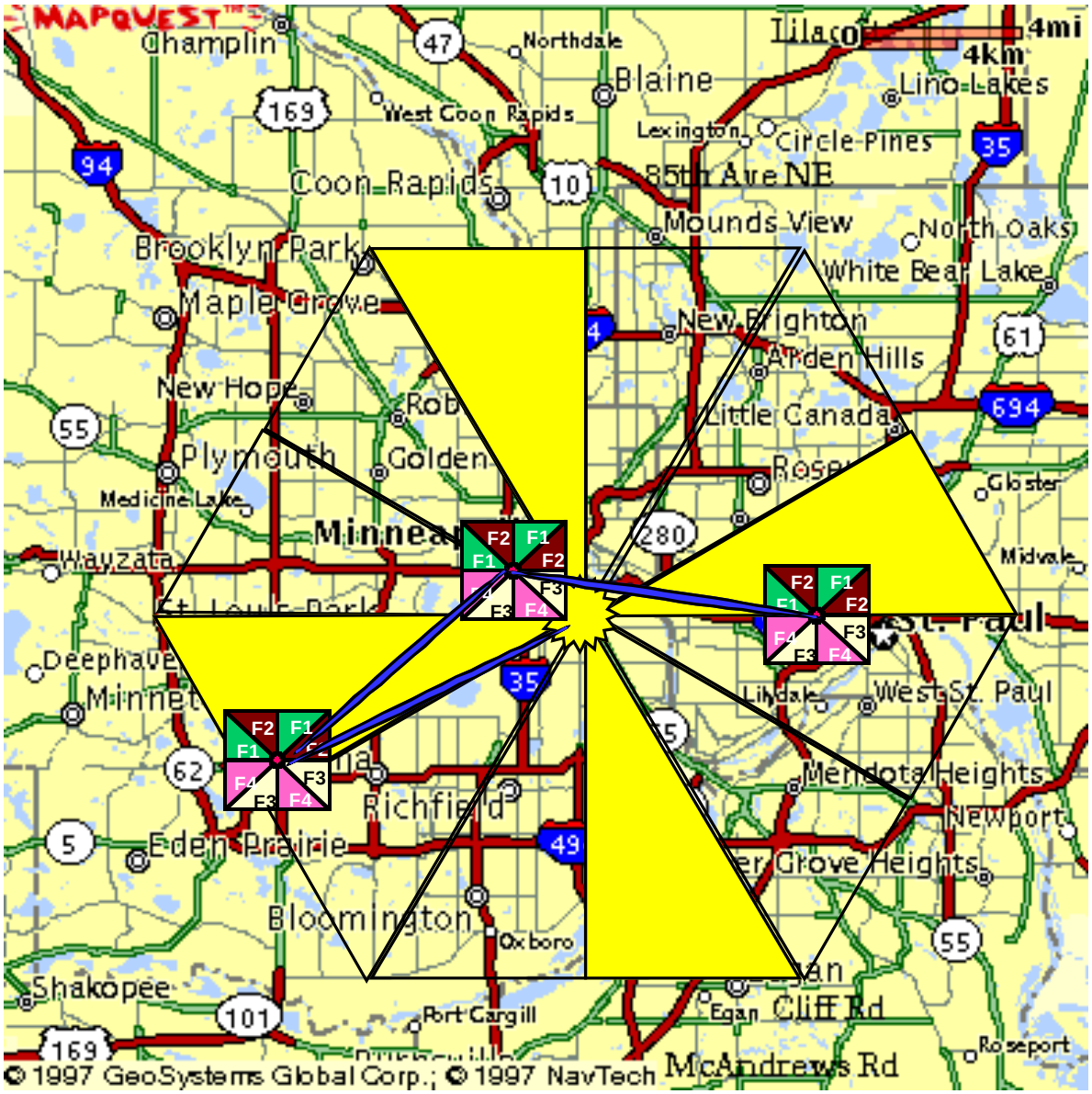
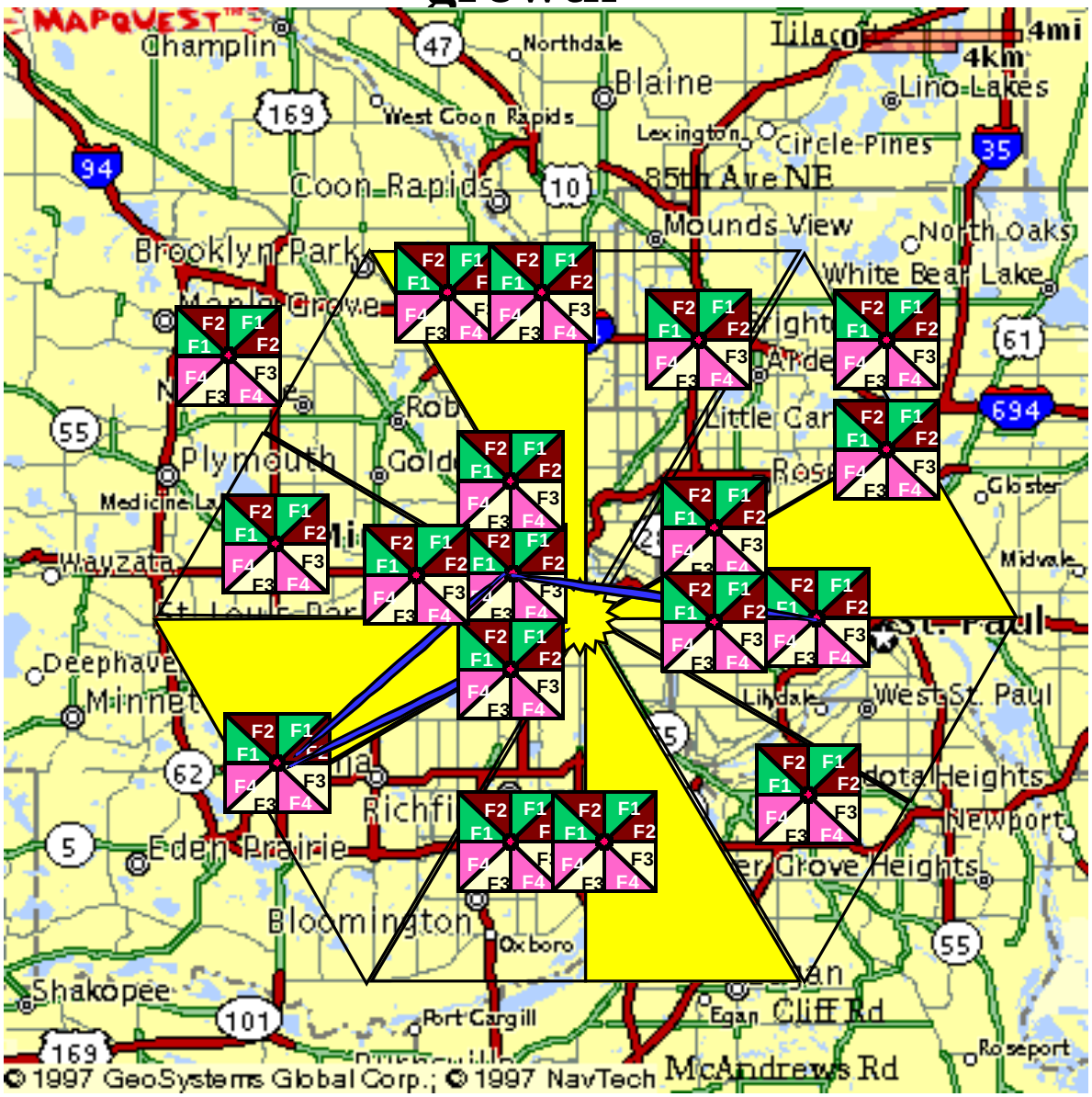
Example of combined combined MMDS / LMDS / Unlicensed band network

- Overlay MMDS and LMDS network on top of each other
- MMDS network used for less dense rural areas and to increase overall coverage area
- LMDS network used in densely populated down town areas and business parks
- Add additional LMDS cells as needed to increase capacity and to offer higher bandwidth services
- No new CPE equipment needed
- Minor modification to Hub equipment

Combined MMDS, LMDS cell structure



Combined MMDS / LMDS network with planned growth



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Link budget calculations for MMDS and LMDS networks

	LMDS		MMDS	
	downstream	upstream	downstream	upstream
Tx Power Level	27 dBm	21 dBm	44 dBm	28 dBm
Tx Antenna Gain	21 dBi	38 dBi	18 dBi	20 dBi
EIRP	48 dBm	59 dBm	62 dBm	48 dBm
Path length	3 km	3 km	40 km	40 km
Frequency	28 GHz	31 GHz	2.7 GHz	2.2 GHz
Free Space Path loss	131 dB	132 dB	133 dB	131 dB
Rx Antenna Gain	38 dBi	21 dBi	20 dBi	18 dBi
Rx level	-45 dBm	-52 dBm	-51 dBm	-65 dBm
Symbol rate	26.74 Mbaud	6.24 Mbaud	5.056 Mbaud	640 kbaud
Channel bandwidth	36 MHz	7.8 MHz	6 MHz	800 kHz
Bit Rate	42 Mbps	10 Mbps	27 Mbps	1 Mbps
Noise figure	8 dB	8 dB	5 dB	5 dB
Noise level	-92 dBm	-98 dBm	-102 dBm	-111 dBm
Carrier to noise ratio	47 dB	46 dB	51 dB	46 dB
Minimum SNR	10 dB	15 dB	23 dB	15 dB
fade	27 dB	27 dB	27 dB	27 dB
margin	10 dB	4 dB	1 dB	3 dB

Capacity calculations for MMDS and LMDS networks

Capacity					
LMDS cell			**MMDS cell**		
			upstream bandwidth		
			total bandwidth	12	MHz
upstream bandwidth	150	MHz	bandwidth per ch	800	kHz
ch bw	7.8	MHz	no. of freq chs	15	freq channels
no. of channels	19		reuse factor	4	
ch bit rate	10	Mbps	total chs	60	
frequency reuse/cell	1		data rate per ch	1	Mbps
total bit rate	190	Mbps	total data rate	60	Mbps
data rate per line	250	kbps	data rate per line	10	kbps
no. of lines	760	lines	total lines per cell	6000	10 kb lines
no. subs per line	5		no. subs per line	5	
subs per cell	3800		subs per cell	30000	
number of cells	3		number of cells	1	
total subs	11400	subs/region	total subs	30000	subs/region
downstream			downstream		
no. of 36 MHz chs	8	channels	no. of 6 MHz chs	4	channels
bit rate per channel	42	Mbps	bit rate per channel	27	Mbps
reuse	1		reuse	4	
total bit rate	336	Mbps/cell	total bit rate	432	Mbps/cell
total subs	11400	subs/region	total subs	30000	subs/region
cells	3		cells	1	
subs per cell	3800		subs per cell	30000	
subs per line	5		subs per line	5	
lines per cell	760		lines per cell	6000	
line bit rate	442	kbps	line bit rate	72	kbps

Cost comparison of 2.5 and 28 GHz components and systems

ITEM	RELATIVE LMDS VS MMDS COST
CPE components	
low noise amplifier	1.7
power amplifier	2.8
mixers	1.6
gain blocks	1.6
filters	1.5
housing	1.8
total CPE cost	1.8
Base station cost	1.6
Modem, gateway	1.2
router	1.0
Deployment	
Base station quantity	2.5
CPE quantity	1.0
base station cost	4.1
CPE cost	1.8
Instalation cost	2.5
Total deployment cost	**2.1**

Comparison of MMDS, LMDS and combined MMDS / LMDS networks

	MMDS	LMDS	COMBINED MMDS/LMDS
COST	1	2.5	0.5
COVERAGE	70%	10%	70%
CAPACITY	50,000	200,000	250,000

Conclusions

- Proper BWA standards will allow more commonality between LMDS, MMDS systems, lowering system cost
- LMDS standards activity should look at all fixed broadband wireless systems with similar applications ie LMDS, MMDS, etc.
- There is lot of synergy between MMDS and LMDS spectrum and combined use of MMDS, LMDS and Unlicensed bands for broadband wireless services offers following benefits:
  - improved broadband services at lower infrastructure costs
  - increased capacity and coverage in the beginning of network deployment
  - increased options for network growth and offering more new services
  - allows more options for handling interference issues related upstream ITFS and MMDS channels