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November 13, 2009

Via Electronic Filing
Ms. Marlene H. Dortch, Secretary
Federal Communications Commission
445 Twelfth Street, S.W.
Washington, DC 20554

Notice of *Ex Parte* Communication

RE: A National Broadband Plan for our Future: **GN Docket No. 09-51**

Dear Ms. Dortch:

In response to a request from Arnab Das, a member of the FCC's Omnibus Broadband Initiative (the "Broadband Initiative"), Clearwire is providing the attached documents for the record in this proceeding:

- An example of a mobile broadband link budget;
- Various link budget scenarios; and
- A powerpoint regarding Clearwire's 4G Backhaul network.

Pursuant to Section 1.1206(b)(2) of the Commission's Rules, notice of this *ex parte* communication is being filed electronically. If you have any questions regarding this matter, please do not hesitate to contact the undersigned at 202-351-5033.

Sincerely,

Cathy Massey

Cathleen A. Massey

cc: Arnab Das

Mobile Broadband Link Budget Example - for FCC

Nov, 12 2009

Specific example, to explore typical Fixed vs. Mobile difference. Assumes 1.5 Mbps DL, and 250 kbps UL cell edge tput requirement – for an underserved broadband market .

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Link Budget Example: Fixed CPE & Mobile USB Card Suburban, ~1.5 Mbps DL, ~250kbps UL cell edge

Approximate Cell Radius:
Mobile USB card – 0.9 km
Fixed CPE – 3.05 km

		5 Watt BTS (Suburban)		5 Watt BTS (Suburban)	
		USB card	CPE	USB Card	CPE
Transmitter		DL Traffic	DL Traffic	UL Traffic	UL Traffic
Power per Tx	dBm	37.0	37.0	23.0	30
Number of Tx		2	2	1	1
Total power out	dBm	39.0	39.0	23.0	30.0
Pilot boosting loss	dB	0.46	0.46		
Cable loss	dB	1.00	1.00	0.0	0.0
Antenna gain	dBi	16.0	16.0	0	12.0
Tx Div/BF gain (min)	dBi	0.0	0.0		
EIRP	dBm	**54.54**	**54.54**	**23.0**	**42.0**
Receiver					
Channel bandwidth	MHz	10.00	10.00	10.00	10.00
Occupied bandwidth	kHz	9187.50	9187.50	1575.00	1575.00
Noise figure	dB	6.0	5.0	4.0	4.0
Post combined CINR required	dB	0.89	0.89	1.90	1.90
Post combined sensitivity	dBm	-97.48	-98.48	-106.13	-106.13
Antenna gain	dBi	0.0	12.0	16.0	16.0
Cable loss	dB	0.0	0.0	1.0	1.0
System gain	dB	**152.02**	**165.02**	**144.13**	**163.13**
Inbuilding Penetration	dB	12.0	12.0	12.0	12.0
Lognormal Fade Margin	dB	5.6	5.6	5.6	5.6
MAPL	dB	**134.43**	**147.43**	**126.53**	**145.53**

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6M DL, IM UL Fixed

		Downlink	Uplink
Transmitter			
Power per Tx	dBm	37	30
Number of Tx		2	1
Total power out	dBm	40.01029996	30
Pilot boosting loss	dB	0.4578	
Cable loss	dB	1	0
Antenna gain	dBi	16	12
EIRP	dBm	54.55249996	42
Receiver			
Channel bandwidth	MHz	10	10
Subcarrier spacing	kHz	10.9375	10.9375
Total subcarriers		1024	1024
Guard subcarriers		184	184
Used subcarriers		840	840
Total pilot subcarriers		120	280
Total data subcarriers		720	560
Subcarriers per subchannel		28	24
Pilot subcarriers per slot		4	8
Data subcarriers per slot		24	16
Total subchannels		30	35
Allocated subchannels		30	12
Allocated subcarriers		840	288
Occupied bandwidth	kHz	9187.5	3150
MCS		16QAM-CTC1/2	16QAM-CTC1/2
Number of Rx		2	2
Thermal noise kT	dBm/Hz	-174	-174
Noise figure	dB	6	4
Noise floor (power)	dBm	-98.36802648	-105.0168945
AWGN SNR Required (SISO)	dB	8.6	8.6
AWGN Rx sensitivity (SISO)	dBm	-89.76802648	-96.41689446
Rx implementation margin	dB	1	0
MIM	dB	0	0
Fast Fade margin	dB	5	5
Interference Margin	dB	1	0
Diversity gain	dB	3	3
Beamforming gain	dB	0	0
HARQ gain	dB	3	3
Post combined CINR required	dB	9.6	7.6
Post combined sensitivity	dBm	-88.76802648	-97.41689446
Antenna gain	dBi	12	16
Cable loss	dB	0	1
System gain	dB	155.3205264	154.4168945
Limiting link budget	dB	154.4168945	

Coverage Estimates	Total system margins System + Pen margins, dB	Final MAPL dB	Cell Radius km	Cell Area km^2
Urban	20.63	133.7868945	0.600198	0.936618
Suburban	17.63	136.7868945	1.724345	7.730754
Rural	14.63	139.7868945	5.948568	92.00219

Cost231-Hata Pathloss Exp 3.52249

6M DL, 1M UL Mobile

		Downlink	Uplink
Transmitter			
Power per Tx	dBm	37	23
Number of Tx		2	1
Total power out	dBm	40.01029996	23
Pilot boosting loss	dB	0.4578	
Cable loss	dB	1	0
Antenna gain	dBi	16	0
EIRP	dBm	54.55249996	23
Receiver			
Channel bandwidth	MHz	10	10
Subcarrier spacing	kHz	10.9375	10.9375
Total subcarriers		1024	1024
Guard subcarriers		184	184
Used subcarriers		840	840
Total pilot subcarriers		120	280
Total data subcarriers		720	560
Subcarriers per subchannel		28	24
Pilot subcarriers per slot		4	8
Data subcarriers per slot		24	16
Total subchannels		30	35
Allocated subchannels		30	12
Allocated subcarriers		840	288
Occupied bandwidth	kHz	9187.5	3150
MCS		16QAM-CTC1/2	16QAM-CTC1/2
Number of Rx		2	2
Thermal noise kT	dBm/Hz	-174	-174
Noise figure	dB	6	4
Noise floor (power)	dBm	-98.36802648	-105.0168945
AWGN SNR Required (SISO)	dB	8.6	8.6
AWGN Rx sensitivity (SISO)	dBm	-89.76802648	-96.41689446
Rx implementation margin	dB	1	0
MIM	dB	0	0
Fast Fade margin	dB	5	5
Interference Margin	dB	1	0
Diversity gain	dB	3	3
Beamforming gain	dB	0	0
HARQ gain	dB	3	3
Post combined CINR required	dB	9.6	7.6
Post combined sensitivity	dBm	-88.76802648	-97.41689446
Antenna gain	dBi	0	16
Cable loss	dB	0	1
System gain	dB	143.3205264	135.4168945
Limiting link budget	dB	135.4168945	

Coverage Estimates	Total system margins System + Pen margins, dB	Final MAPL dB	Cell Radius km
Urban	20.63	114.7868945	0.173342
Suburban	17.63	117.7868945	0.498004
Rural	14.63	120.7868945	1.71799

Cost231-Hata Pathloss Exp 3.52249

Cell Area
km^2
0.078123
0.64482
7.67387

3M DL, 500k UL Fixed

		Downlink	Uplink
Transmitter			
Power per Tx	dBm	37	30
Number of Tx		2	1
Total power out	dBm	40.01029996	30
Pilot boosting loss	dB	0.4578	
Cable loss	dB	1	0
Antenna gain	dBi	16	12
EIRP	dBm	54.55249996	42
Receiver			
Channel bandwidth	MHz	10	10
Subcarrier spacing	kHz	10.9375	10.9375
Total subcarriers		1024	1024
Guard subcarriers		184	184
Used subcarriers		840	840
Total pilot subcarriers		120	280
Total data subcarriers		720	560
Subcarriers per subchannel		28	24
Pilot subcarriers per slot		4	8
Data subcarriers per slot		24	16
Total subchannels		30	35
Allocated subchannels		30	12
Allocated subcarriers		840	288
Occupied bandwidth	kHz	9187.5	3150
MCS		QPSK-CTC1/2	QPSK-CTC1/2
Number of Rx		2	2
Thermal noise kT	dBm/Hz	-174	-174
Noise figure	dB	6	4
Noise floor (power)	dBm	-98.36802648	-105.0168945
AWGN SNR Required (SISO)	dB	2.9	2.9
AWGN Rx sensitivity (SISO)	dBm	-95.46802648	-102.1168945
Rx implementation margin	dB	1	0
MIM	dB	0	0
Fast Fade margin	dB	5	5
Interference Margin	dB	1	0
Diversity gain	dB	3	3
Beamforming gain	dB	0	0
HARQ gain	dB	3	3
Post combined CINR required	dB	3.9	1.9
Post combined sensitivity	dBm	-94.46802648	-103.1168945
Antenna gain	dBi	12	16
Cable loss	dB	0	1
System gain	dB	161.0205264	160.1168945
Limiting link budget	dB	160.1168945	

Coverage Estimates	Total system margins System + Pen margins, dB	Final MAPL dB	Cell Radius km	Cell Area km^2
Urban	20.63	139.4868945	0.871189	1.973321
Suburban	17.63	142.4868945	2.50289	16.2876
Rural	14.63	145.4868945	8.634356	193.8355

Cost231-Hata Pathloss Exp 3.52249

3M DL, 500k UL Mobile

		Downlink	Uplink
Transmitter			
Power per Tx	dBm	37	23
Number of Tx		2	1
Total power out	dBm	40.01029996	23
Pilot boosting loss	dB	0.4578	
Cable loss	dB	1	0
Antenna gain	dBi	16	0
EIRP	dBm	54.55249996	23
Receiver			
Channel bandwidth	MHz	10	10
Subcarrier spacing	kHz	10.9375	10.9375
Total subcarriers		1024	1024
Guard subcarriers		184	184
Used subcarriers		840	840
Total pilot subcarriers		120	280
Total data subcarriers		720	560
Subcarriers per subchannel		28	24
Pilot subcarriers per slot		4	8
Data subcarriers per slot		24	16
Total subchannels		30	35
Allocated subchannels		30	12
Allocated subcarriers		840	288
Occupied bandwidth	kHz	9187.5	3150
MCS		QPSK-CTC1/2	QPSK-CTC1/2
Number of Rx		2	2
Thermal noise kT	dBm/Hz	-174	-174
Noise figure	dB	6	4
Noise floor (power)	dBm	-98.36802648	-105.0168945
AWGN SNR Required (SISO)	dB	2.9	2.9
AWGN Rx sensitivity (SISO)	dBm	-95.46802648	-102.1168945
Rx implementation margin	dB	1	0
MIM	dB	0	0
Fast Fade margin	dB	5	5
Interference Margin	dB	1	0
Diversity gain	dB	3	3
Beamforming gain	dB	0	0
HARQ gain	dB	3	3
Post combined CINR required	dB	3.9	1.9
Post combined sensitivity	dBm	-94.46802648	-103.1168945
Antenna gain	dBi	0	16
Cable loss	dB	0	1
System gain	dB	149.0205264	141.1168945
Limiting link budget	dB	141.1168945	

Coverage Estimates	Total system margins System + Pen margins, dB	Final MAPL dB	Cell Radius km	Cell Area km^2
Urban	20.63	120.4868945	0.251606	0.164594
Suburban	17.63	123.4868945	0.722853	1.358543
Rural	14.63	126.4868945	2.493665	16.16775

Cost231-Hata Pathloss Exp 3.52249

1.5M DL, 250k UL Fixed

		Downlink	Uplink
Transmitter			
Power per Tx	dBm	37	30
Number of Tx		2	1
Total power out	dBm	40.01029996	30
Pilot boosting loss	dB	0.4578	
Cable loss	dB	1	0
Antenna gain	dBi	16	12
EIRP	dBm	54.55249996	42
Receiver			
Channel bandwidth	MHz	10	10
Subcarrier spacing	kHz	10.9375	10.9375
Total subcarriers		1024	1024
Guard subcarriers		184	184
Used subcarriers		840	840
Total pilot subcarriers		120	280
Total data subcarriers		720	560
Subcarriers per subchannel		28	24
Pilot subcarriers per slot		4	8
Data subcarriers per slot		24	16
Total subchannels		30	35
Allocated subchannels		30	12
Allocated subcarriers		840	288
Occupied bandwidth	kHz	9187.5	3150
MCS		QPSK-CTC1/2-Rep2	QPSK-CTC1/2-Rep2
Number of Rx		2	2
Thermal noise kT	dBm/Hz	-174	-174
Noise figure	dB	6	4
Noise floor (power)	dBm	-98.36802648	-105.0168945
AWGN SNR Required (SISO)	dB	-0.110299957	-0.110299957
AWGN Rx sensitivity (SISO)	dBm	-98.47832644	-105.1271944
Rx implementation margin	dB	1	0
MIM	dB	0	0
Fast Fade margin	dB	5	5
Interference Margin	dB	1	0
Diversity gain	dB	3	3
Beamforming gain	dB	0	0
HARQ gain	dB	3	3
Post combined CINR required	dB	0.889700043	-1.110299957
Post combined sensitivity	dBm	-97.47832644	-106.1271944
Antenna gain	dBi	12	16
Cable loss	dB	0	1
System gain	dB	164.0308264	163.1271944
Limiting link budget	dB	163.1271944	

Coverage Estimates	Total system margins System + Pen margins, dB	Final MAPL dB	Cell Radius km
Urban	20.63	142.4971944	1.060649
Suburban	17.63	145.4971944	3.047203
Rural	14.63	148.4971944	10.5121

Cost231-Hata Pathloss Exp 3.52249

Cell Area
km^2
2.924939
24.14216
287.3111

1.5MDL, 250k UL Mobile

		Downlink	Uplink
Transmitter			
Power per Tx	dBm	37	23
Number of Tx		2	1
Total power out	dBm	40.01029996	23
Pilot boosting loss	dB	0.4578	
Cable loss	dB	1	0
Antenna gain	dBi	16	0
EIRP	dBm	54.55249996	23
Receiver			
Channel bandwidth	MHz	10	10
Subcarrier spacing	kHz	10.9375	10.9375
Total subcarriers		1024	1024
Guard subcarriers		184	184
Used subcarriers		840	840
Total pilot subcarriers		120	280
Total data subcarriers		720	560
Subcarriers per subchannel		28	24
Pilot subcarriers per slot		4	8
Data subcarriers per slot		24	16
Total subchannels		30	35
Allocated subchannels		30	12
Allocated subcarriers		840	288
Occupied bandwidth	kHz	9187.5	3150
MCS		QPSK-CTC1/2-Rep2	QPSK-CTC1/2-Rep2
Number of Rx		2	2
Thermal noise kT	dBm/Hz	-174	-174
Noise figure	dB	6	4
Noise floor (power)	dBm	-98.36802648	-105.0168945
AWGN SNR Required (SISO)	dB	-0.110299957	-0.110299957
AWGN Rx sensitivity (SISO)	dBm	-98.47832644	-105.1271944
Rx implementation margin	dB	1	0
MIM	dB	0	0
Fast Fade margin	dB	5	5
Interference Margin	dB	1	0
Diversity gain	dB	3	3
Beamforming gain	dB	0	0
HARQ gain	dB	3	3
Post combined CINR required	dB	0.889700043	-1.110299957
Post combined sensitivity	dBm	-97.47832644	-106.1271944
Antenna gain	dBi	0	16
Cable loss	dB	0	1
System gain	dB	152.0308264	144.1271944
Limiting link budget	dB	144.1271944	

Coverage Estimates	Total system margins System + Pen margins, dB	Final MAPL dB	Cell Radius km
Urban	20.63	123.4971944	0.306323
Suburban	17.63	126.4971944	0.880054
Rural	14.63	129.4971944	3.035971

Cost231-Hata Pathloss Exp 3.52249

Cell Area
km^2
0.243968
2.013689
23.96452

Clearwire 4G Backhaul Concepts - for FCC

Nov, 12 2009

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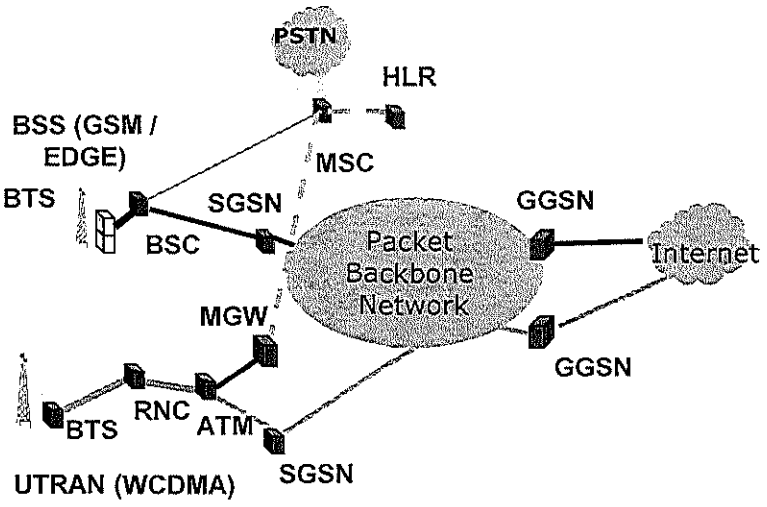
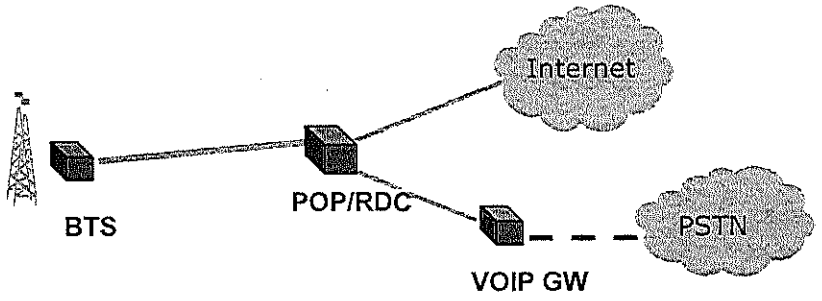
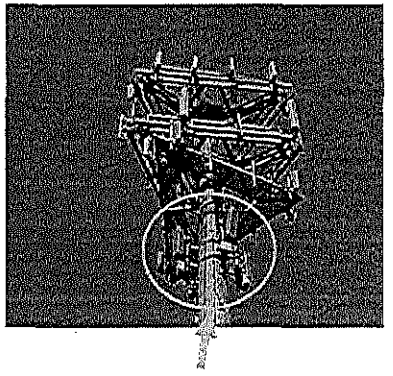
A Low Cost and Scalable Network

Legacy Wireless: Data and Voice Network

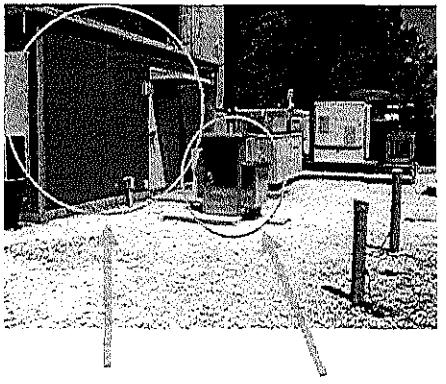


Clearwire 4G: Data and Voice Network





Clearwire Base Station



3G Cellular Shelter

4G Clearwire Cabinet

	Clearwire 4G	Cellular 4G
Antennas per site	3	9
Tower Cabling	3 fiber cables	9 – 12 Coax
Ground Space	4'X3'	10'X12'

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4G Backhaul Options

- Copper leased lines
  - Highest OpEx , $$$ per Mb
- Fiber to sites
  - High CapEx, high OpEx, $$ per Mb
- Microwave
  - High CapEx, low OpEx, lowest $ per Mb

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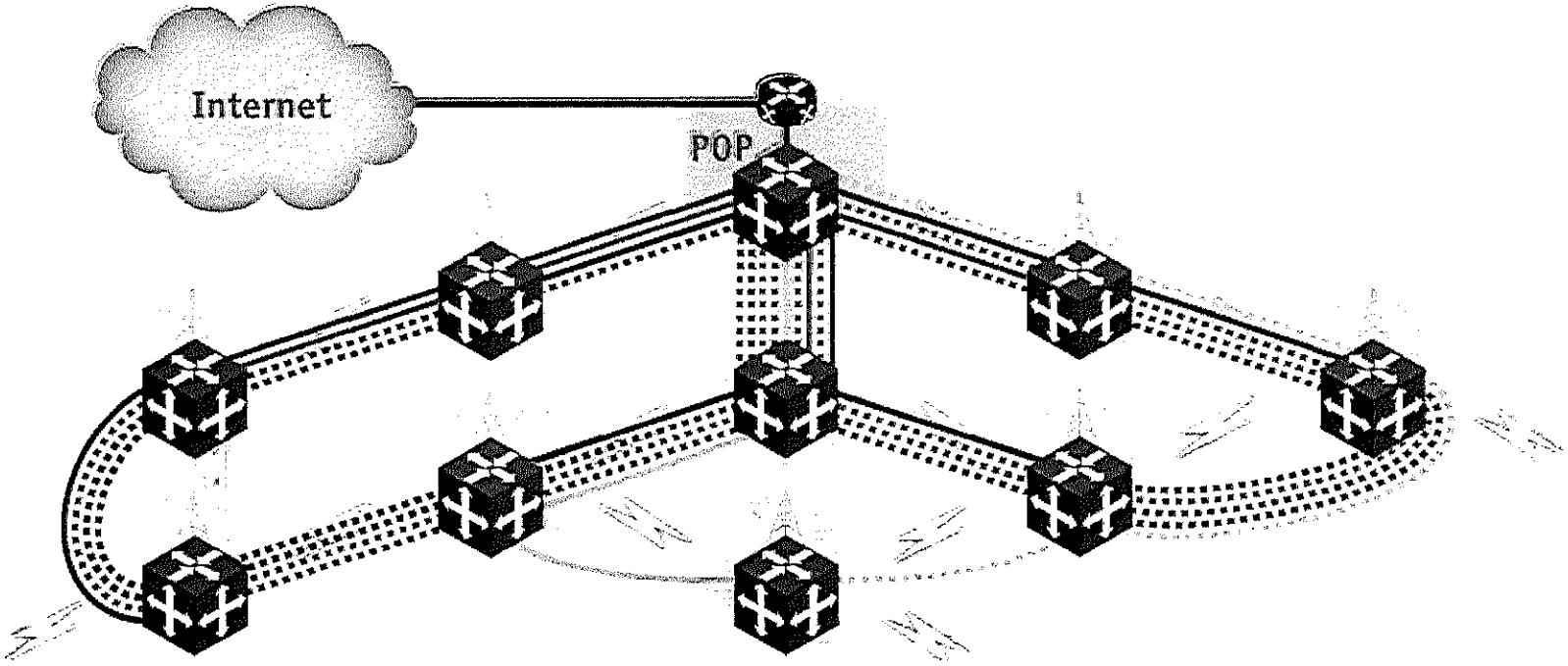
IEEE 802.1Qay PBB-TE (PBT)



- Improved resiliency : no flooding/broadcasting
- Simple La 2 carrier ethernet transport
  - low cost : switches instead of routers at cell sites
  - scalable : same designs for 50 or 1000 site markets
- Configurable bandwidth for services and tunnels

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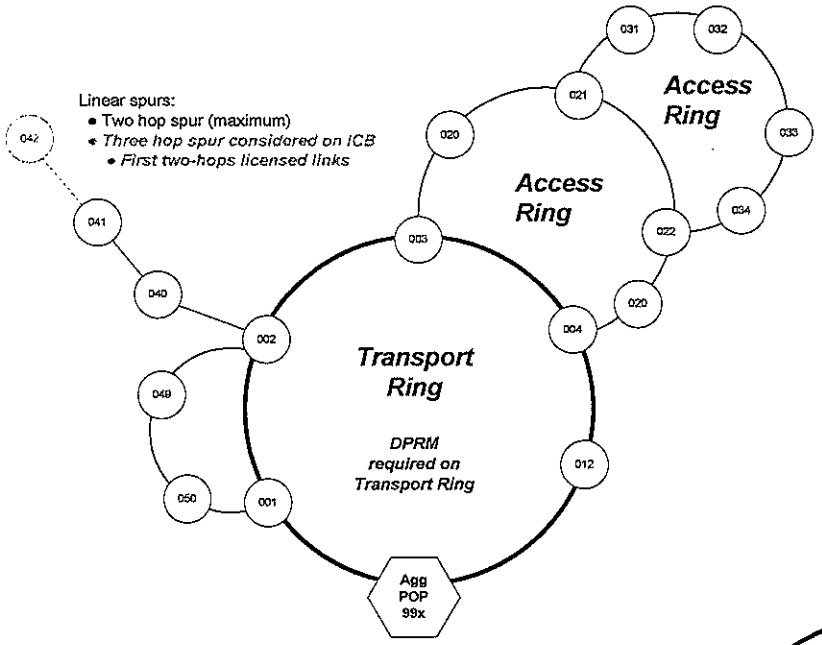
Ring Topology



Transport and Agg POP(s)

- Microwave aggregation sites with dark fiber transport

Backhaul Network Topology

a. *Transport Rings*

- Bandwidth sized to carry aggregated traffic

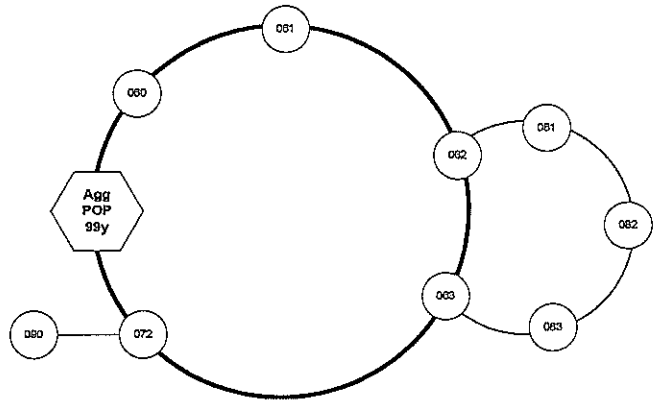
b. *Access Rings*

- Maximum two deep from Transport Ring

c. *Spurs*

- Generally 2-hops per Linear Spur

MAN Network



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