

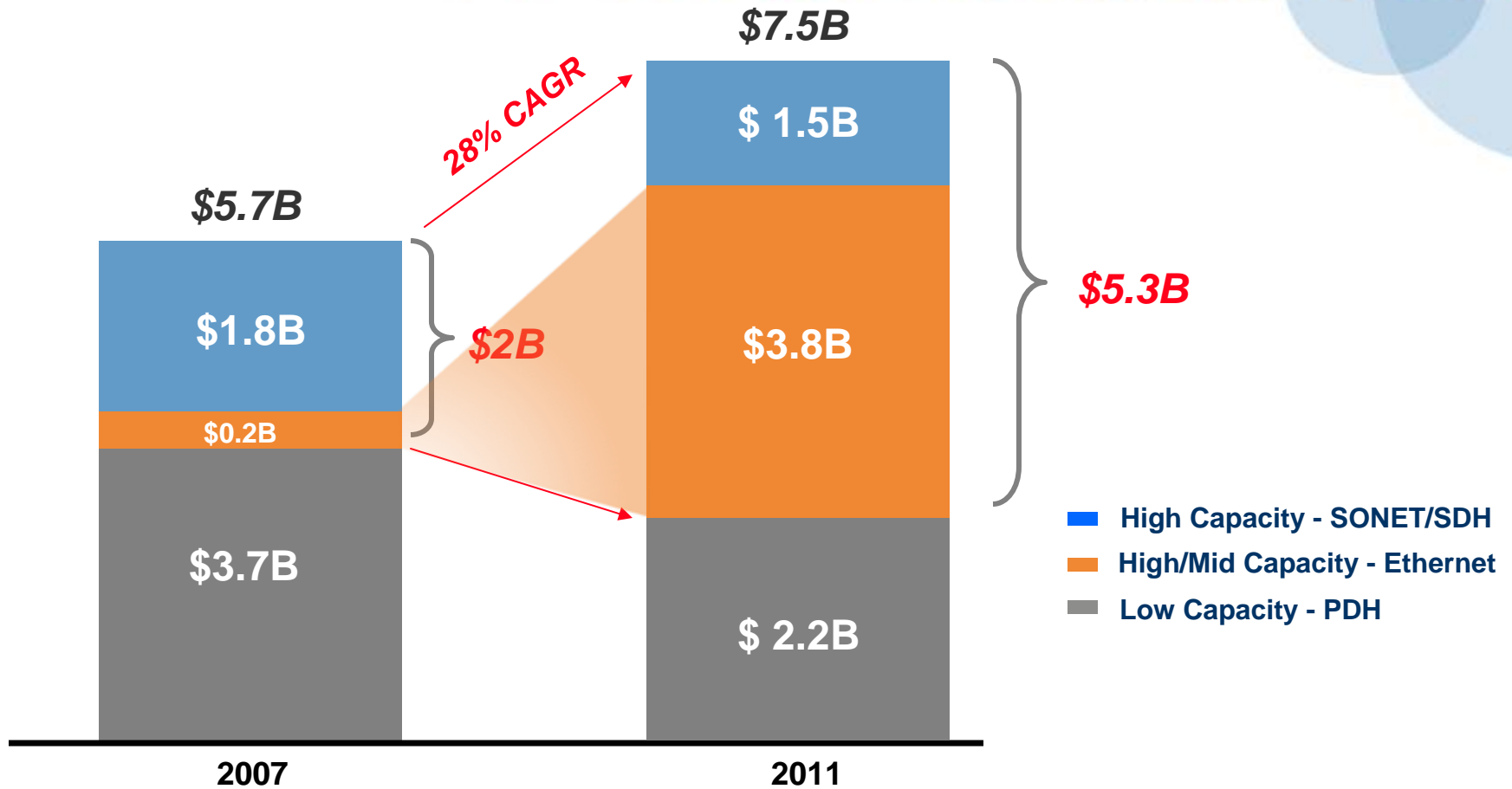


Adaptive Coding & Modulation

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Microwave is Going IP/Packet



Source: SkyLight Research, Infonetics Research and Ceragon analysis



Packet radios enable better spectral efficiency



10MHz

ACM Point	Modulation	Capacity (Mbps)
1	QPSK	13 – 18
2	8 PSK	19 – 27
3	16 QAM	28 – 40
4	32 QAM	32 – 46
5	64 QAM	42 – 61
6	128 QAM	50 – 71
7	256 QAM	54 – 78
8	256 QAM	61 – 87

20MHz

ACM Point	Modulation	Capacity (Mbps)
1	QPSK	28 - 40
2	8 PSK	39 - 56
3	16 QAM	57 - 81
4	32 QAM	67 - 96
5	64 QAM	93 - 133
6	128 QAM	102 - 146
7	256 QAM	118 - 169
8	256 QAM	131 - 187

30MHz

ACM Point	Modulation	Capacity (Mbps)
1	QPSK	39 – 55
2	8 PSK	62 - 89
3	16 QAM	93 - 133
4	32 QAM	120 - 171
5	64 QAM	142 - 202
6	128 QAM	164 - 235
7	256 QAM	185 - 264
8	256 QAM	204 - 292

40MHz

ACM Point	Modulation	Capacity (Mbps)
1	QPSK	57 - 82
2	8 PSK	84 - 121
3	16 QAM	126 - 180
4	32 QAM	158 - 226
5	64 QAM	194 - 277
6	128 QAM	220 - 315
7	256 QAM	247 - 352
8	256 QAM	274 - 391

50MHz

ACM Point	Modulation	Capacity (Mbps)
1	QPSK	65 - 93
2	8 PSK	105 - 150
3	16 QAM	131 - 188
4	32 QAM	167 - 239
5	64 QAM	221 - 315
6	128 QAM	264 - 377
7	256 QAM	313 - 448
8	256 QAM	342 - 489

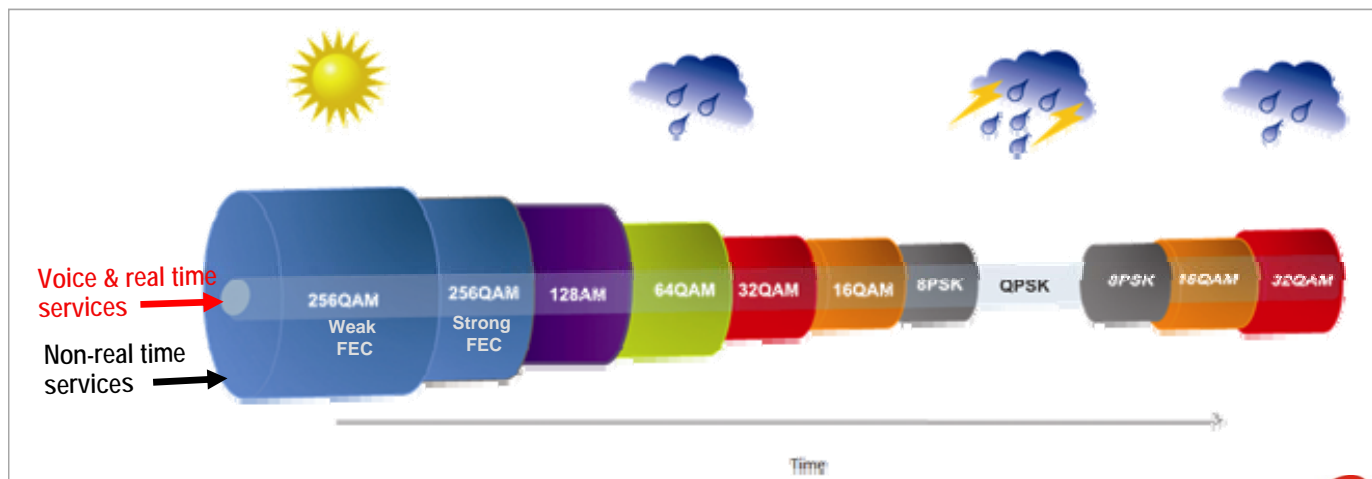
56MHz (FCC 18GHz 80MHz Chn.)

ACM Point	Modulation	Capacity (Mbps)
1	QPSK	75 - 108
2	8 PSK	113 - 162
3	16 QAM	152 - 217
4	32 QAM	204 - 292
5	64 QAM	253 - 362
6	128 QAM	304 - 435
7	256 QAM	345 - 493
8	256 QAM	381 - 545

- Ethernet capacity depends on average packet size
- In initial release up to 16 T1s are supported

Adaptive Coding and Modulation

- Utilize **highest possible modulation** considering the changing environmental conditions
- **Hitless & errorless switchover** between modulation schemes
- **Maximize spectrum usage** - Increased capacity over given bandwidth
- Service differentiation with **improved SLA**
- Increased **capacity** and **availability**



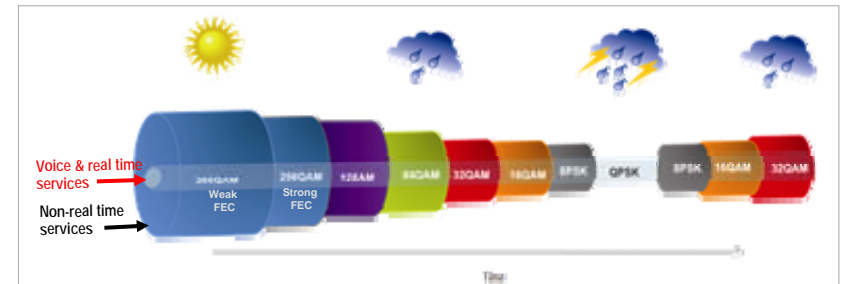
Enhanced ACM Support



- **8 modulation/coding working points** (~3db system gain for each point change)
- **Hit-less** and **Error-less** modulation/coding changes based on signal quality
- T1 traffic has priority over Ethernet traffic
- Each T1 service is assigned a priority - enables differentiated T1 dropping during severe link degradation
- Integrated QoS with intelligent congestion management - ensures high priority Ethernet traffic is not affected during link fading

Throughput per radio carrier:

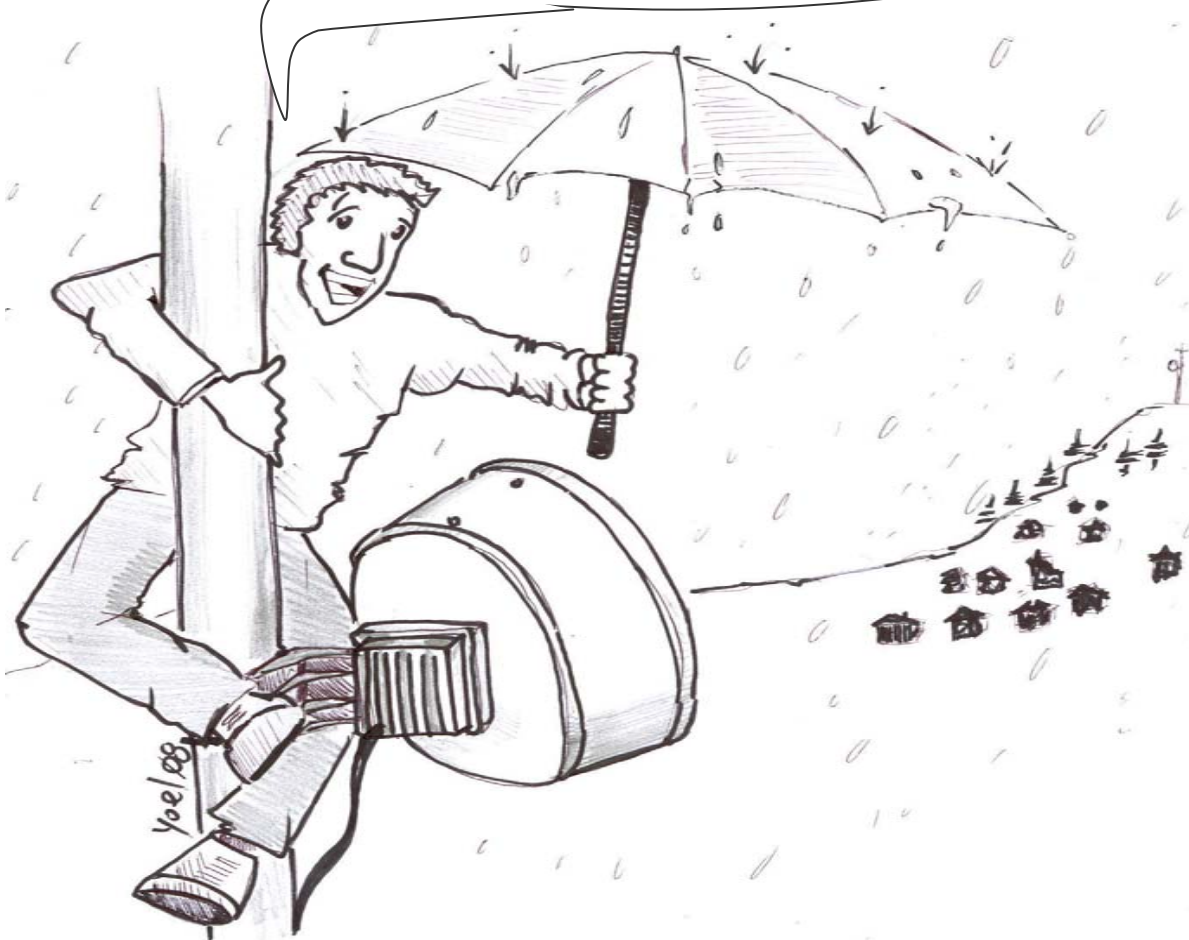
- 15 to 75 Mbps @ 10MHz Channel
- 35 to 160 Mbps @ 20MHz Channel
- 45 to 250 Mbps @ 30 MHz Channel
- 70 to 330 Mbps @ 40 MHz Channel
- 80 to 500 Mbps @ 50/56 MHz Channel



Who needs all those added capabilities anyway?

ACM?

We have other ways to deal with rain-related attenuation...



Examples, OC3 vs GIGE, Link Distances



Radio Configuration	OC3 Radio 99.999%	GIGE, Max Capacity No ACM, 99.999%	GIGE with ACM 99.999%	GIGE Max Capacity Availability with ACM
18 GHz, 2FT, 50 MHz	3.5 mi 64 QAM, 155 Mbps	2.4 mi 256 QAM, 400+ Mbps	4.3 mi QPSK, 75 Mbps	99.992%
11 GHz, HP, 3FT, 30 MHz	10 mi 128 QAM, 155 Mbps	8.6 mi 256 QAM, 250 Mbps	15.4 mi 16 QAM, 110 Mbps	99.987%
6 GHz, HP, 6FT, 30 MHz	21.8 mi 128 QAM, 155 Mbps	18.5 mi 256 QAM, 250 Mbps	29.3 mi 32 QAM, 140 Mbps	99.990%

Decreased tower loads: Wind, Space, Weight...



Without Adaptive Modulation: requires **4 ft** antennas

Modulation	Average Throughput (Mbps)	Availability (%)	Unavailability of modulation
Outage – 5 minutes and 15 seconds			
256QAM (2)	500	99.999	4min, 28sec

With Adaptive Modulation: requires **1 ft** antennas

Modulation	Average Throughput (Mbps)	Availability (%)	Unavailability of modulation
Outage – 5 minutes and 15 seconds			
QPSK	100	99.999	5min, 3sec
8PSK	125	99.998	9min, 3sec
16QAM	200	99.997	11min, 4sec
32QAM	250	99.996	16min, 42sec
64QAM	300	99.995	24min, 35sec
128QAM	350	99.992	37min, 35sec
256QAM (1)	400	99.989	55min, 33sec
256QAM (2)	500	99.985	1hr, 18min, 13sec

2.8 miles path, 400 Mbps throughput setting, 256QAM modulation

Assumed rain zone K, 23 [GHz] band

ACM gives Network planners' a new tool to optimize their network



- 1. Re-use existing PDH channels**
- 2. Some data better than no data!**
- 3. Longer Hops or higher availability**
- 4. Decreased tower loads**
- 5. Lower rent fees and equipment costs**

ACM based microwave flexes the network



Thank You!
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