Range and Throughput Enhancement of HIPERLAN/2 Using Sectorised Antennas

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Introduction

- Wireless Local Area Networks (WLANs) provide wideband wireless connectivity between PCs, laptops, and other equipment within a building.
- HIPERLAN/2 will provide data rates up to 54 Mbps in the 5GHz band.
- The physical layer of HIPERLAN/2 is based on OFDM.
- The physical layer modes with different coding and modulation schemes are selected by a link adaptation scheme.

Sector Antennas

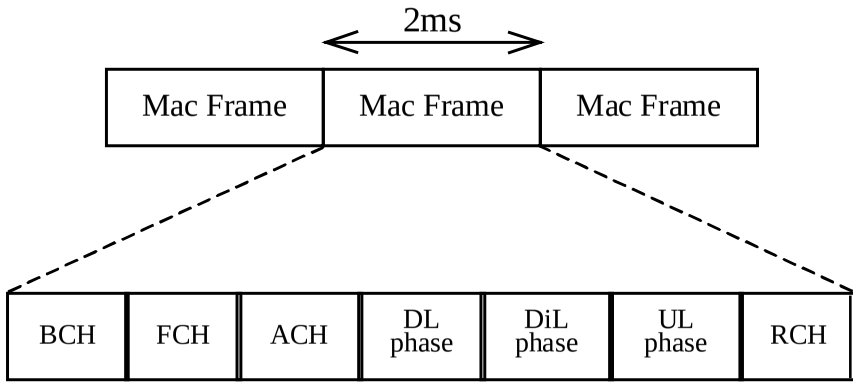
- HIPERLAN/2 facilitates optional use of SMART sector antennas at the AP.
- Advantages
  - Superior coverage
  - Save transmit power
  - Reduce interference
  - Antenna Gain due to smaller azimuth beamwidth
  - Performance Gain due to spatial filtering
- Sectorised antennas will allow the more frequent use of higher transmission modes.

Mode Dependent Parameters

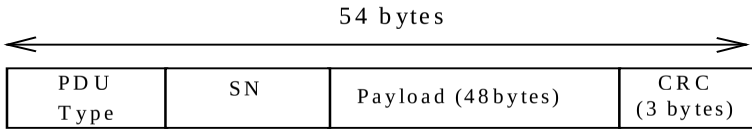
Mode	Modulation	Coding Rate R	Bit rate (Mbit/s)
1	BPSK	1/2	6
2	BPSK	3/4	9
3	QPSK	1/2	12
4	QPSK	3/4	18
5	16QAM	9/16	27
6	16QAM	3/4	36
7	64QAM	3/4	54

HIPERLAN/2 MAC

- TDD/TDMA approach
- 2ms MAC frame
- Control centralised to Access Point (AP)



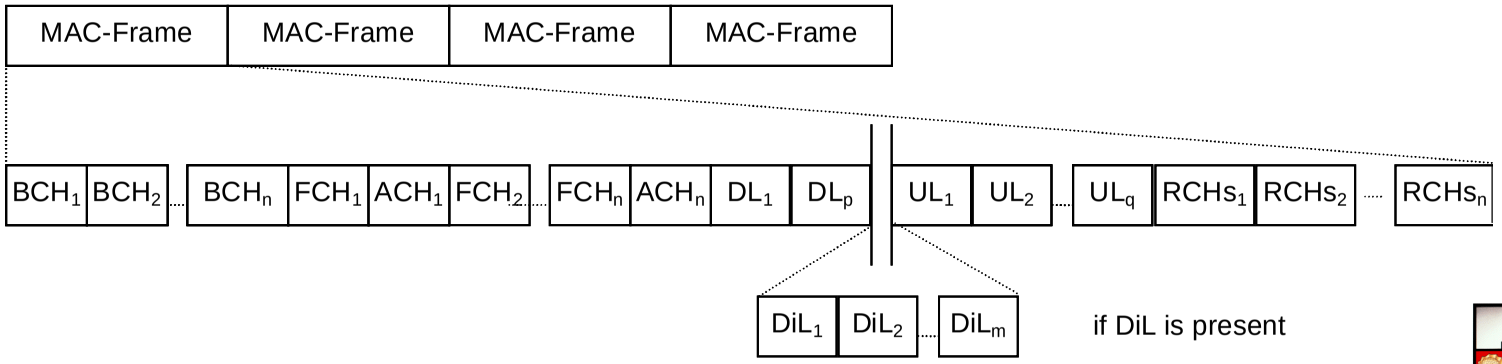
MAC Frame Structure



Long PDU (54 Bytes)

HIPERLAN/2 Sectorisation

- Explicit support for SMART sectorised antennas.
- Transmit separate BCH, ACH and FCH sequences for each sector employed.
- Sector ID at the BCH, support up to 7 sectors.



Channel models

- Channel models have been specified by standards bodies to represent a wide range of environments.

Name	RMS delay spread	Characteristic	Environment
A	50 ns	Rayleigh	Office NLOS
B	100 ns	Rayleigh	Open space/Office NLOS
C	150 ns	Rayleigh	Large Open space NLOS
D	140 ns	Rician	Large Open space LOS
E	250 ns	Rayleigh	Large Open space NLOS

Link Adaptation

- The physical layer modes with different coding and modulation schemes are selected by a link adaptation scheme.
- Each packet (PDU) uses CRC-r codes for error detection, where r=24 or 16 for HIPERLAN/2.
- If a packet is detected to be erroneous by the CRC codes then the terminal will retransmit the packet.
- In HIPERLAN/2 a selective repeat ARQ scheme has been chosen for error control.

Link Adaptation (2)

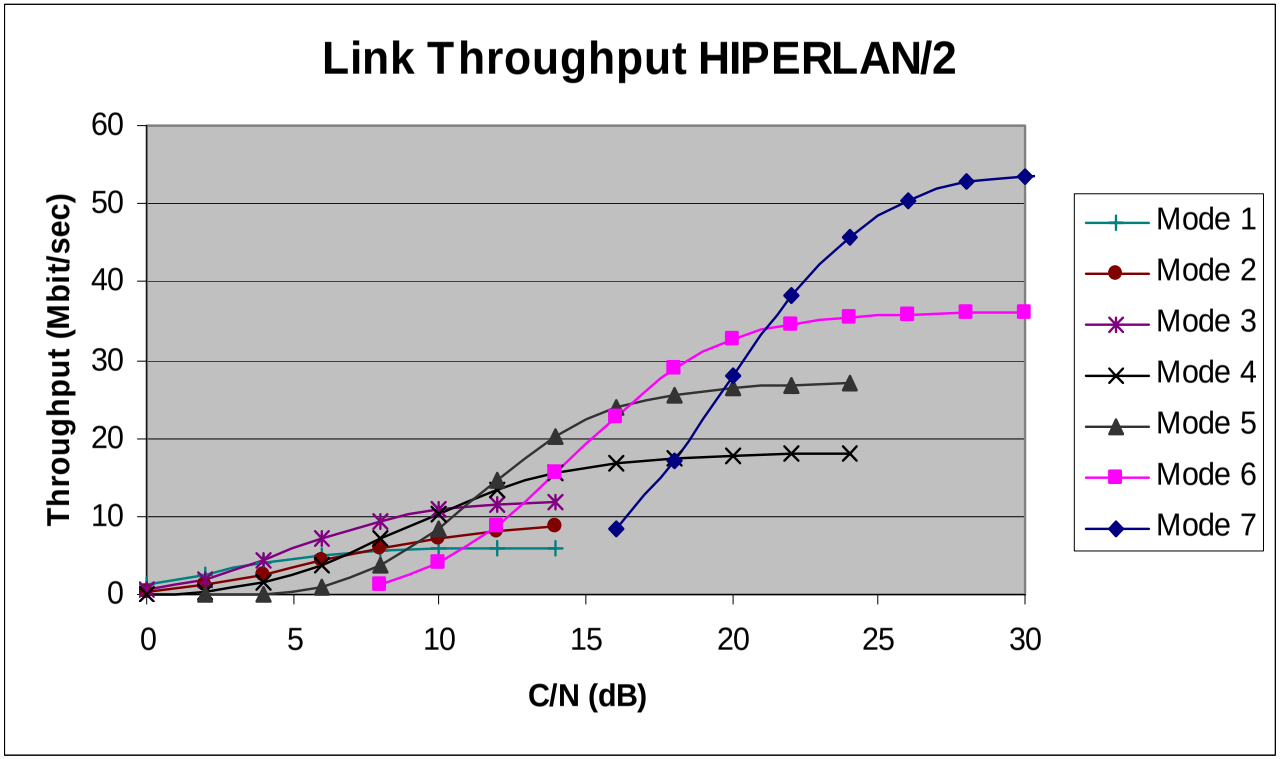
- A simple approximation of the throughput when retransmission is employed is given by:

$$Throughput = R*(1-PER)$$

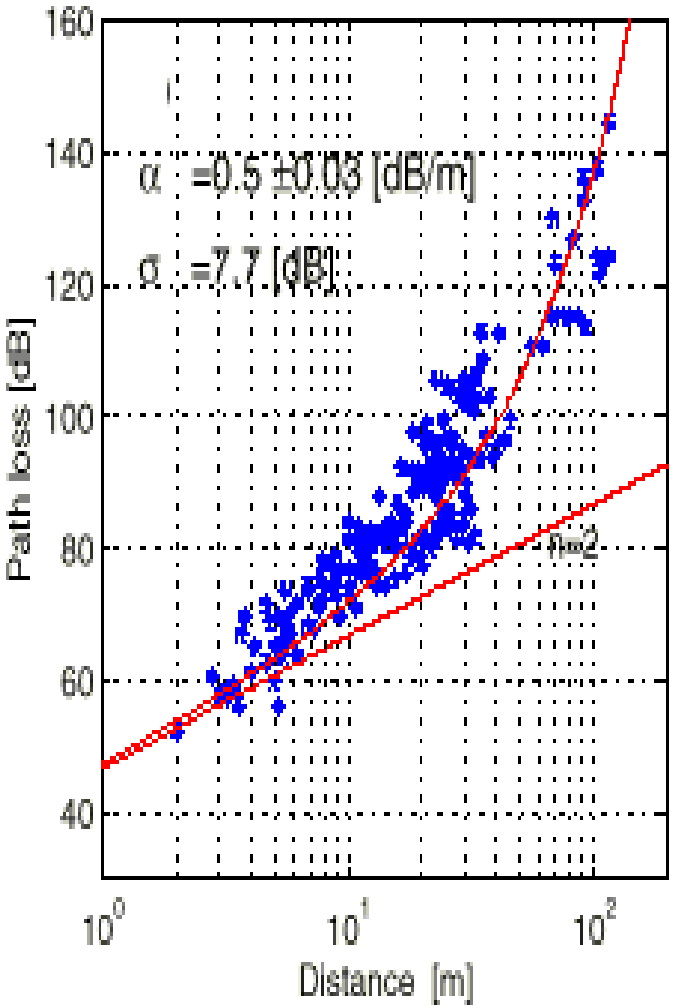
where *R* and *PER* are the bit rate and packet error rate for a specific mode respectively.

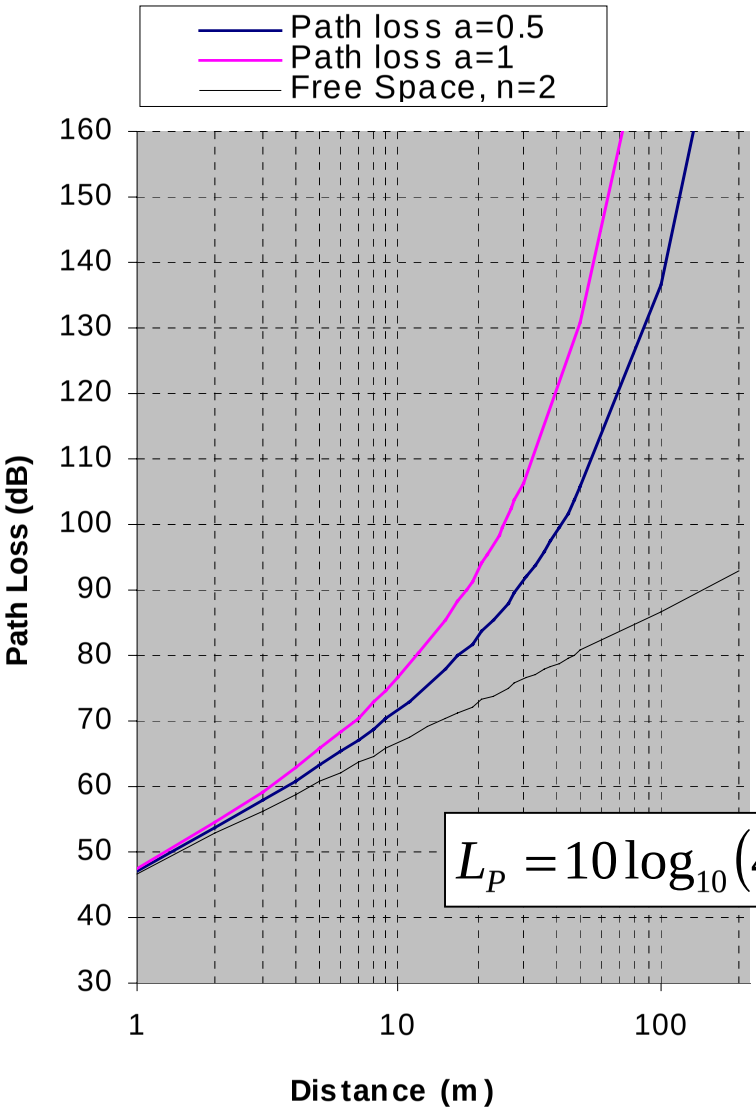
- In the case of perfect link adaptation, the mode with the highest throughput would be chosen for each instantaneous C/N value.
- Due to time variations in link quality, the PHY mode is adapted every 5-10 MAC frames for HIPERLAN/2.

Throughput with Link Adaptation



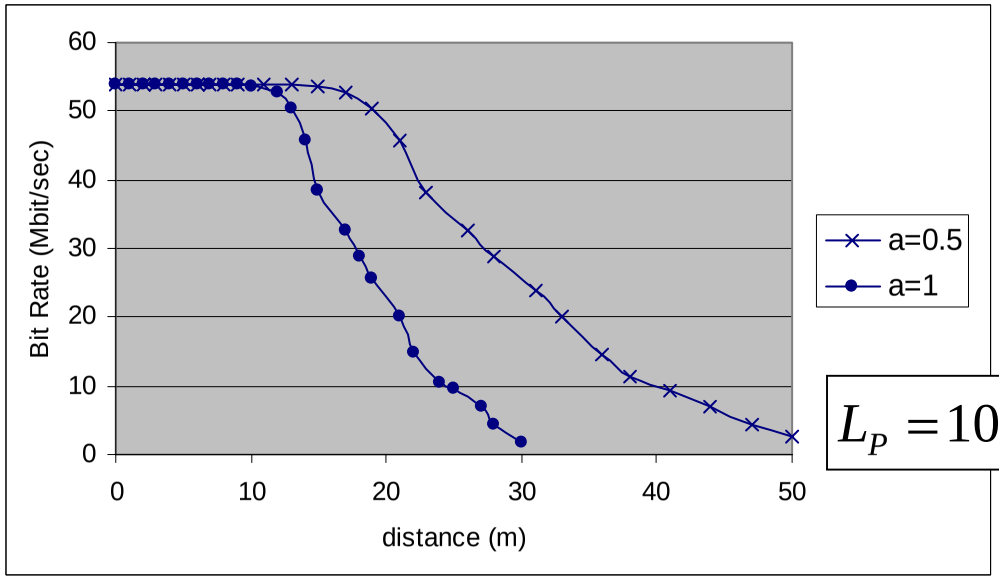
- Channel model A.





$$L_P = 10\log_{10}\left(4\pi d/\lambda\right)^2 + \alpha\, d$$

Range (One AP)



$$L_P = 10\log_{10}\left(4\pi d/\lambda\right)^2 + \alpha d$$

- Maximum output power =23dBm (indoor applications).
- If a receiver threshold of -85dBm is assumed,

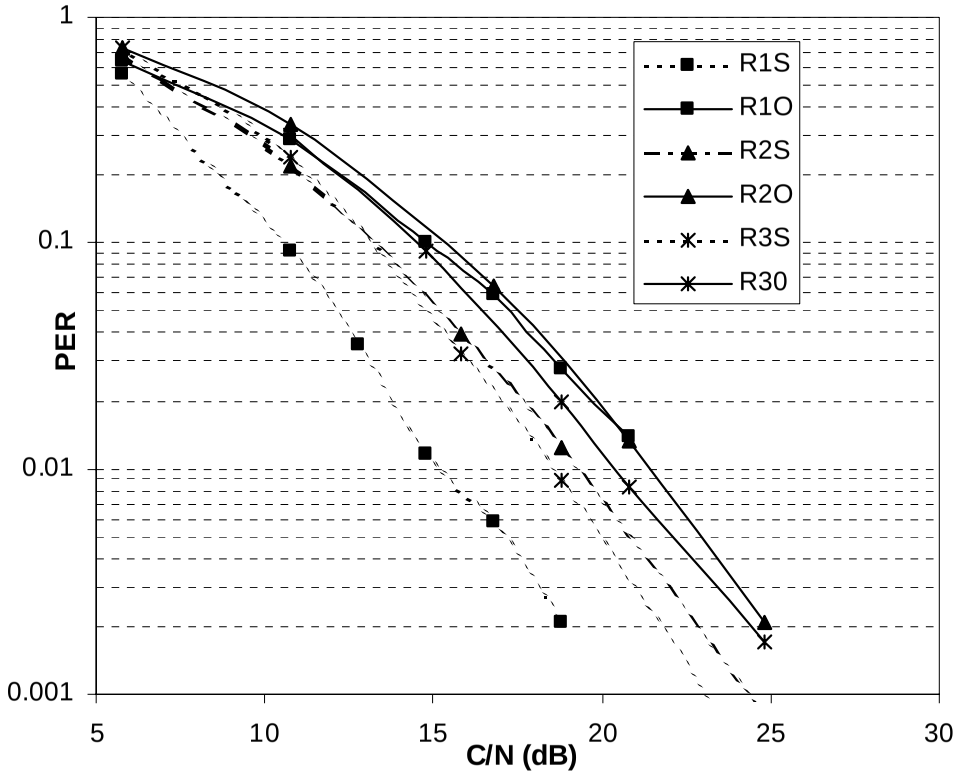
  MPL = 23 - (-85) = 108 dB.

Channel Scenarios

- 60° switch sectorised antenna.
- Six channels based on real measurements made in three office environmnts (R1-R3).

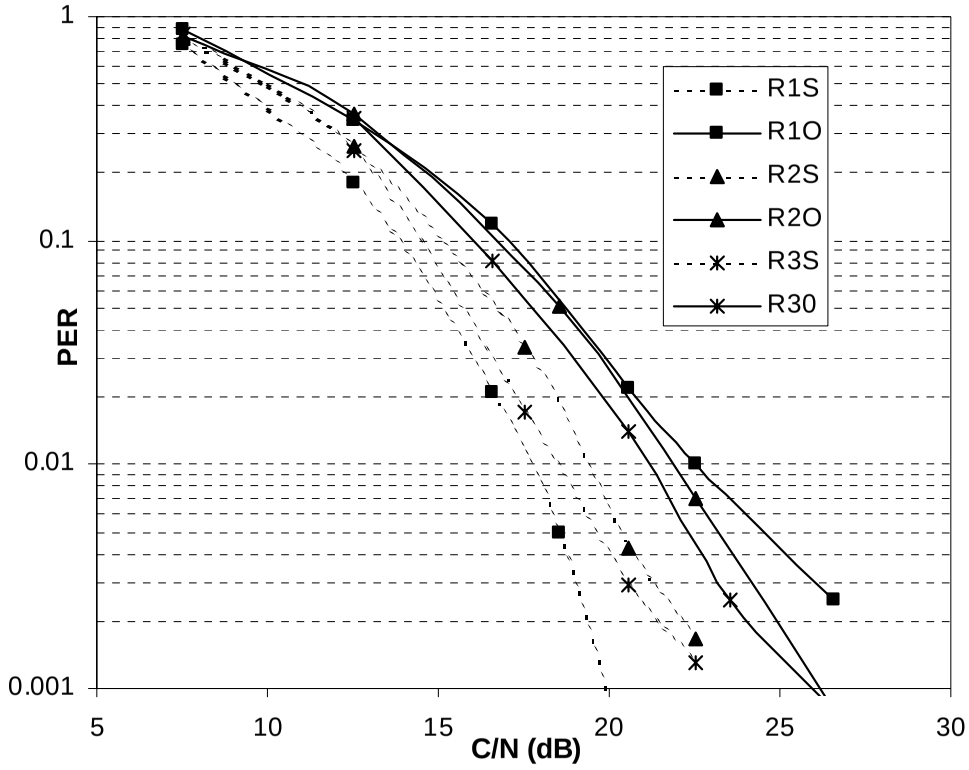
Name	AP Antenna	RMS Delay Spread (ns)	Sector Gain (dB)
A	Omni	50 (Rayleigh)	-
R1O	Omni	18 (Rician)	-
R1S	Sectorised	9 (Rician)	7.25
R2O	Omni	29 (Rayleigh)	-
R2S	Sectorised	24 (Rayleigh)	4.3
R3O	Omni	38 (Rayleigh)	-
R3S	Sectorised	32 (Rayleigh)	3.5

Performance with Sectorised Antennas



Mode 4: Channel Scenarios R1-R3

Performance with Sectorised Antennas

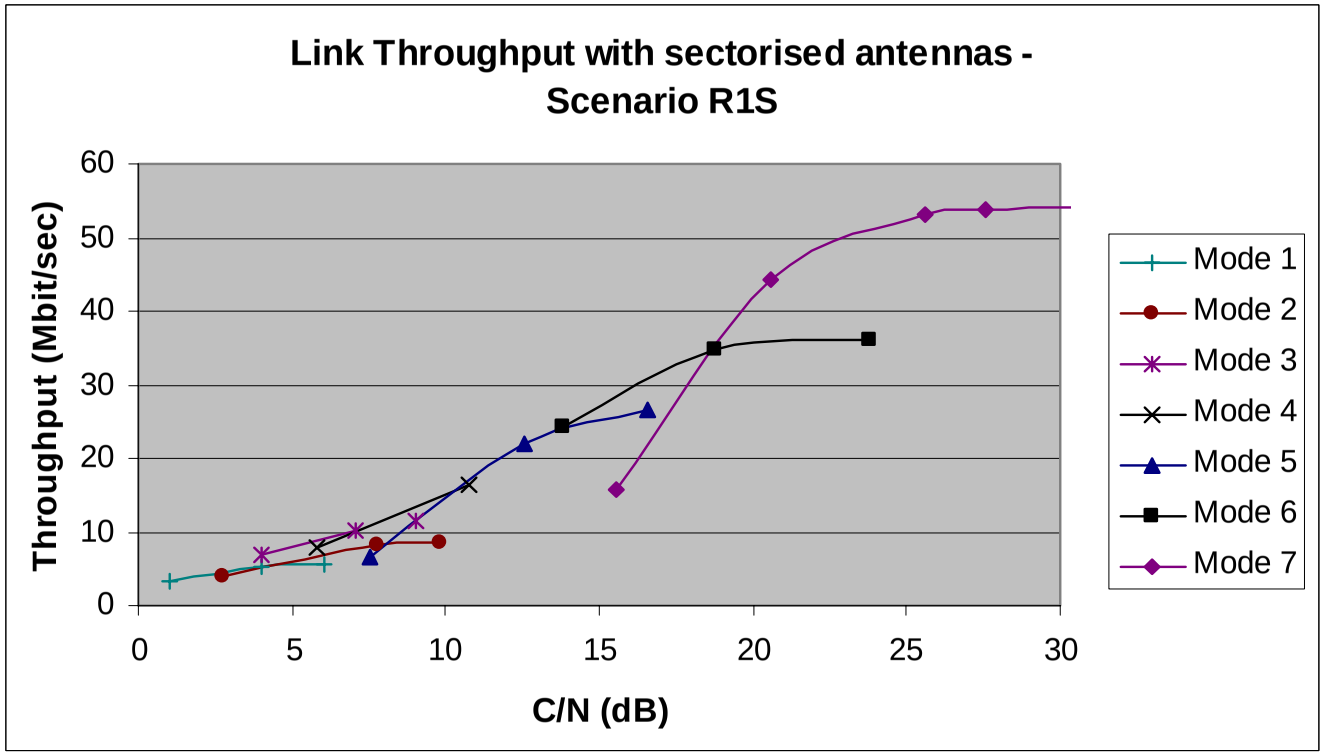


Mode 5: Channel Scenarios R1-R3

Performance Results

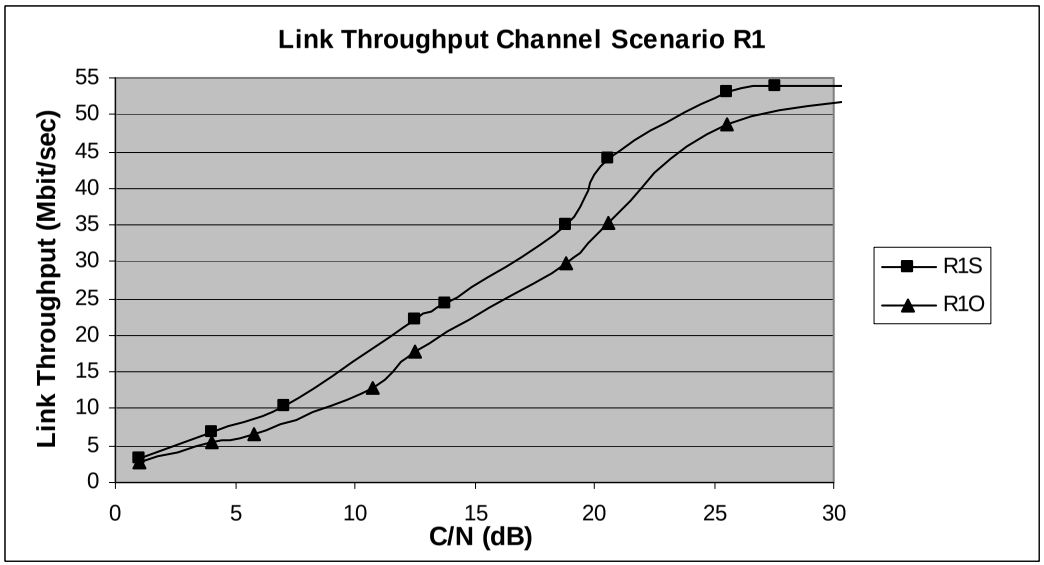
- Performance Gains of 1.7-6.7 dB at target PER= 1% are possible compared to the omni directional case.
- In channels with a dominant multipath component (R1) the choice of best sector reduces multipath activity and improves Rician statistics.
- Antenna Gains of 3.5-7.25 dB were observed.
- When the antenna is used to receive, the azimuth gain is less than the theoretical 7.8dB due to energy falling outside the strongest sector.
- If the antenna is used to transmit, the full azimuth gain of 7.8dB can be achieved. Mostly exploited as a power saving due to the EIRP limits in the 5 GHz band.

Link Throughput with Sectorised Antennas



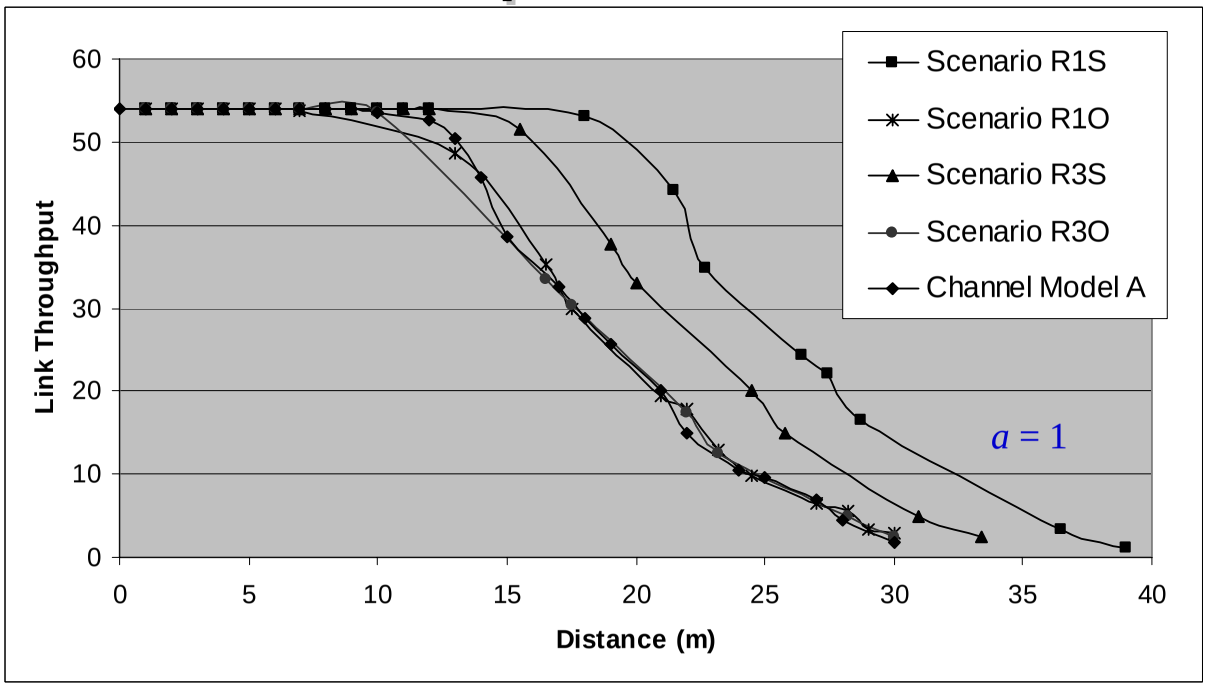
- Link throughput for HIPERLAN/2 with sectorised antennas for office environment R1S.

Link Throughput with Sectorised Antennas



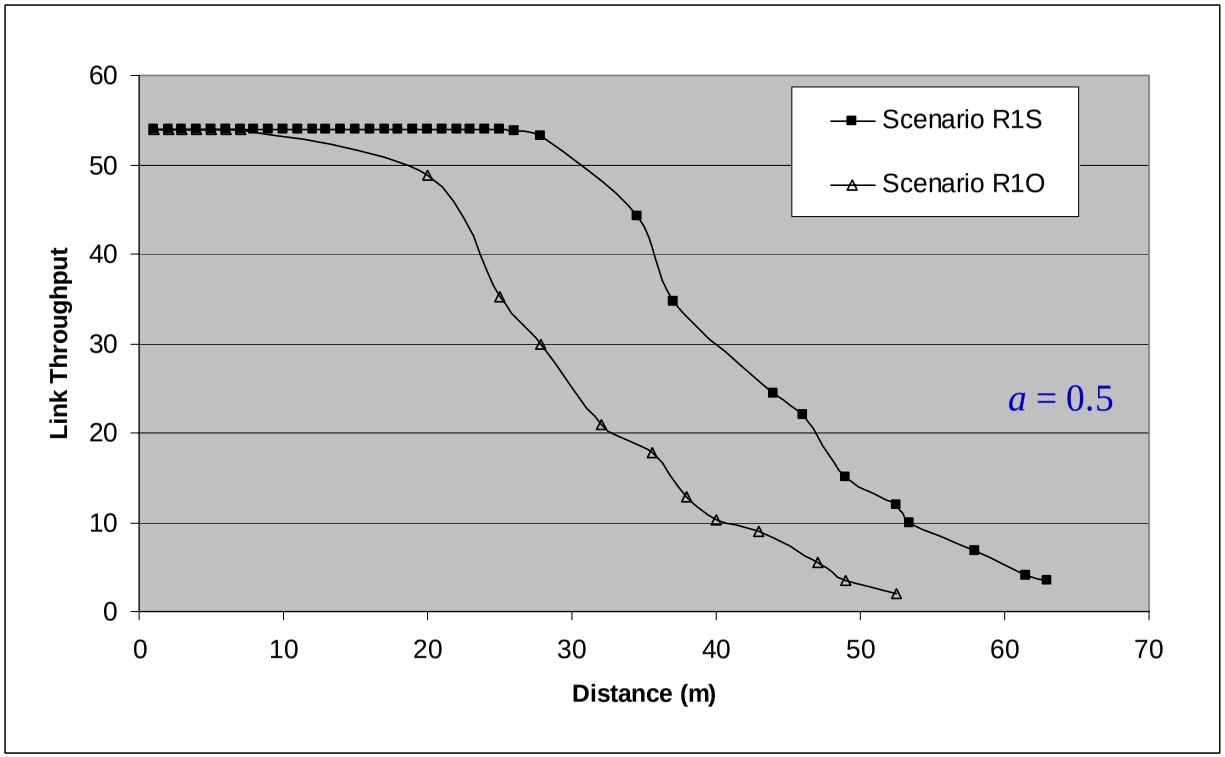
- Comparison of link throughput -offices R1S and R1O.
- Antenna sectorisation improves link throughput (by up to 10 Mbps) by allowing the link adaptation mechanism to make use of higher modulation modes.
- Link throughput is also increased because of the lower PER of each mode for a specific C/N value.

Range and Throughput Enhancement- Uplink

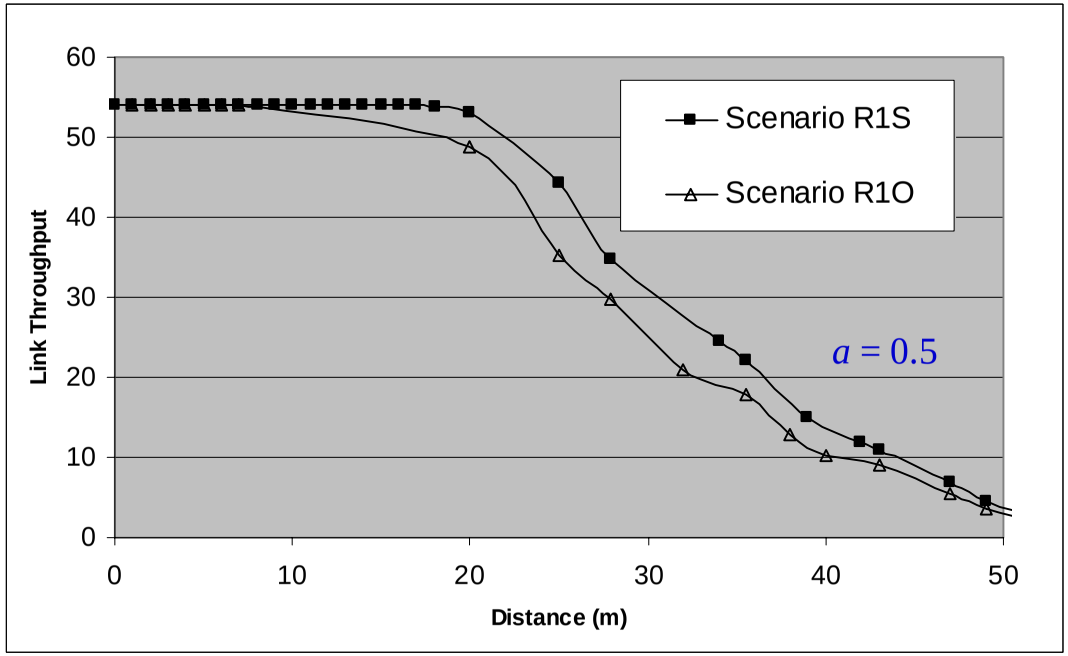


- Sectorised antennas increased the operating range and link throughput in the Uplink.

Range and Throughput Enhancement- Uplink



Power saving and Throughput Enhancement -Downlink



- Antenna gain can mainly be exploited as power saving at the access point

Conclusions (1)

- Sectorisation improves performance by allowing the link adaptation mechanism to make use of higher modulation modes more frequently.
- Significant gains in the range 3.5-7.25 dB were achieved in all scenarios from the azimuth antenna gain.
- Further performance gain by spatial filtering is achievable.
- In channels with a dominant multipath component the correct choice of sector reduces multipath activity and improves Rician statistics.
- Throughput results over distance for one AP showed that range can be increased in the uplink.

Conclusions (2)

- In the downlink, antenna gain can mainly be exploited as power saving at the access point.
- Link throughput improvements still apply for the downlink case.
- The antenna gain at the AP means that simpler power amplifiers can be used. The increased peak to average power ratio of the OFDM signal results in reduced efficiency of the RF power amplifier due to the back off that is required.
- In the uplink the antenna gain could be also translated into a battery power saving at the MT (which is likely to be a portable device).