POINT-TO-MULTIPOINT WIRELESS SYSTEMS
Advanced Technology in Radio Communications

Pablo Corral González
Communications Engineering Department
Signal Theory and Communications
Universidad Miguel Hernández

LESSONS

POINT-TO-MULTIPOINT WIRELESS SYSTEMS

1.1 INTRODUCTION

1.2 FREQUENCY BANDS

1.3 ARCHITECTURES OF P-MP SYSTEMS

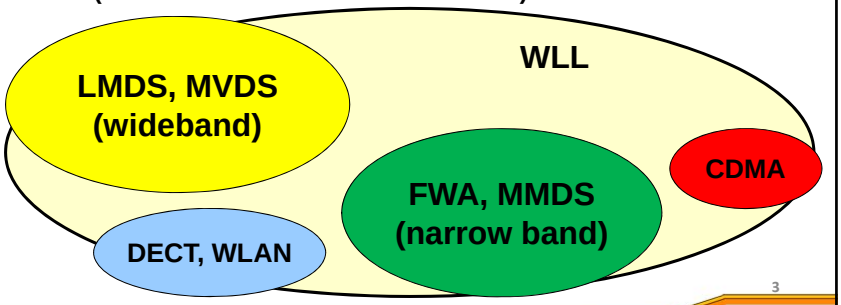
1.4 RADIO LINK CHARACTERISTICS

1.5 CELLULAR PLANNING IN P-MP

1.1.INTRODUCTION(1)

Definitions and acronyms

WLL (WIRELESS LOCAL LOOP)
FWA (FIXED WIRELESS ACCESS)
MMDS (MULTICHANNEL MULTIPOINT DISTRIBUTION SYSTEM)
LMDS (LOCAL MULTIPOINT DISTRIBUTION SYSTEM)
MVDS (MULTIPOINT VIDEO DISTRIBUTION SYSTEM)
DECT (DIGITAL ENHANCED CORDLESS TELECOMMUNICATIONS)
CDMA (CODE DIVISION MULTIPLE ACCESS)
WLAN (WIRELESS LOCAL AREA NETWORK)



1.1. INTRODUCTION(2)

MMDS systems

- Typical in US
- "Wireless cable"
- Frequency bands: 2,150 - 2,162 GHz and 2,500 - 2,686 GHz
  - Country size coverage : 50 - 70 km
- 31 analog channels of 6 MHz (186 MHz)
- Cheap digital compression equipment :
  - Increase of capacity (compression 5:1) → 155 channels
- Share band-width access systems
  - Bidirectional transmission of data
  - Downloading in 64-QAM (30 Mbit/s in every channel of 6 MHz)
  - Uploading in QPSK

1.1. INTRODUCTION(3)

LMDS system

- Point-to-multipoint video and data broadcasting
  - Bidirectional digital system
- Frequency bands: it depends on the country (~ 28 GHz)
  - Spain → 27,5 - 29,5 GHz
- Radio cells coverage ~ 4 km
- Dedicated access FDMA/QAM or shared access TDMA/QPSK
- Possibility of provisional use of the 28 GHz band for access in places where is not worth the use of cable solution :
  - "Provisionally for seven years as highest period since the awarding concession, in cities that are under 3.000 inhabitants".
  - "Permanently, in cities that are under 1.000 habitants".

1.1. INTRODUCTION(4)

MVDS system

- Recommended in Europe (CEPT T/R 52-01)
  Working in the United Kingdom
- Frequency bands: 40,5 - 42,5 GHz
  (channels of 39 MHz → 55 Mbit/s in QPSK)
- Coverage for modulations: QPSK, 8-PSK y 64-QAM:
  power transmission = 20 dBm ; availability: 99,9 % → 3 km
  power transmission = 24 dBm ; availability: 99,99 % → 1 km
- Broadcast channels + interactive channels
- FDMA/TDMA access and DVB-S schematic encoding

1.1. INTRODUCTION(5)

Competitives advantages for WLL operators

DEPLOYMENT:
- More quickly deployment than cable solutions.

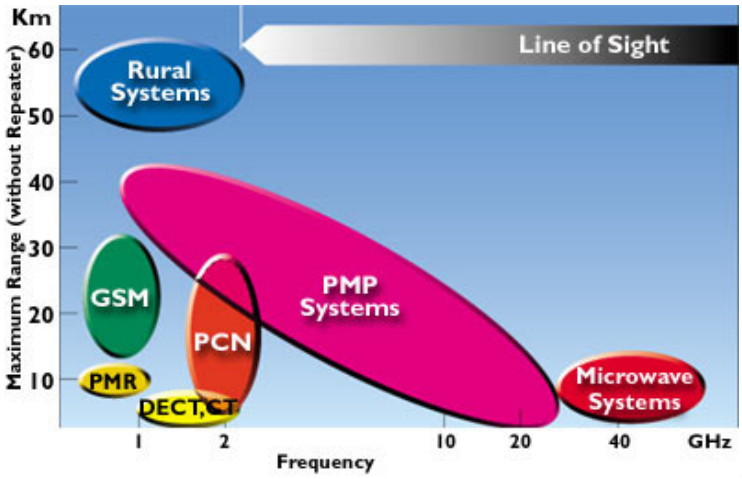
INSTALLATION:
- Cheaper installation. Progressive deployment.
- Small size of antennas and pylons.

CAPACITY:
- Avaliable bandwidth permits high speed transmissions for a huge amount of users.

FLEXIBILITY:
- Using sectorial antennas is possible to increase the offered services both to residential users and companies.
- Cellular structures permit to cover the new bandwith needs. Scalability.

1.1. INTRODUCTION(6)

Reach of WLL system



1.1. INTRODUCTION(7)

Objective sectors of WLL

- ☞ **BIG COMPANIES:**
  - **Based on point-to-multipoint solutions**
- ☞ **SME:**
  - **price reduction**
  - **flexibility**
- ☞ **SOHO ("Small Office Home Office"):**
  - **industrial states or multifamily homes**
  - **difficult access of optical fiber areas**
  - **bursty traffic models**
- ☞ **RESIDENTIAL:**
  - **historic sector**
  - **portfolio of services adapts to residential profile**

1.1. INTRODUCTION(8)

WLL services

- ☞ **VOICE/DATA (TELEPHONY, MODEM, FAX)**
- ☞ **INTERNET ACCESS**
- ☞ **PRIVATE NETWORKS INTERCONNECTION**
- ☞ **LANs INTERCONNECTION**
- ☞ **ISDN APLICATIONS**
- ☞ **VIDEO CONFERENCES**
- ☞ **BROADCAST TELEVISION**
- ☞ **INTERACTIVE VIDEO**
- ☞ **TELEWORKING**
- ☞ **DISTANCE EDUCATION**
- ☞ **TELEMEDICINE**

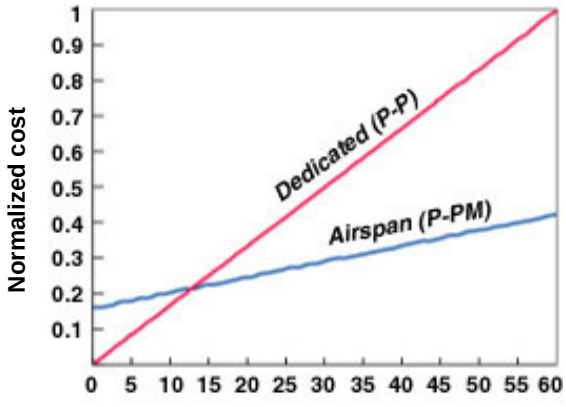
1.1. INTRODUCTION(9)

Network deployment

- COMPILATION OF DATA
- PARAMETERS AND ENVIRONMENT VARIABLES ANALYSIS
- GLOBAL DEFINITION
- DETAILED PLANNING
- IMPLEMENTATION
- NEW COSTUMERS REGISTRATION
- OPERATION AND MAINTENANCE
- NETWORK OPTIMIZATION

1.1. INTRODUCTION(10)

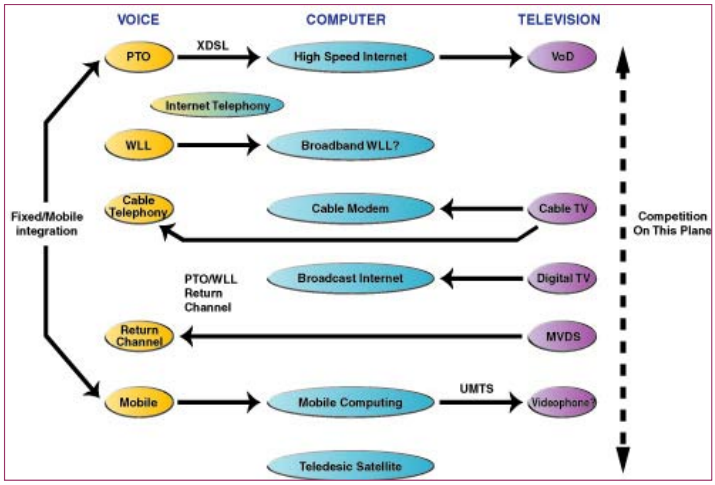
Cost comparative



Maintenance cost P-P = 5 x Maintenance cost P-MP

1.1. INTRODUCTION(11)

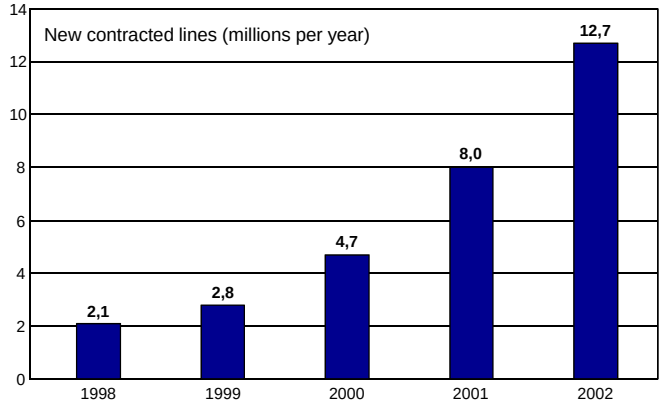
Network access competition



1.1. INTRODUCTION(12)

WLL market

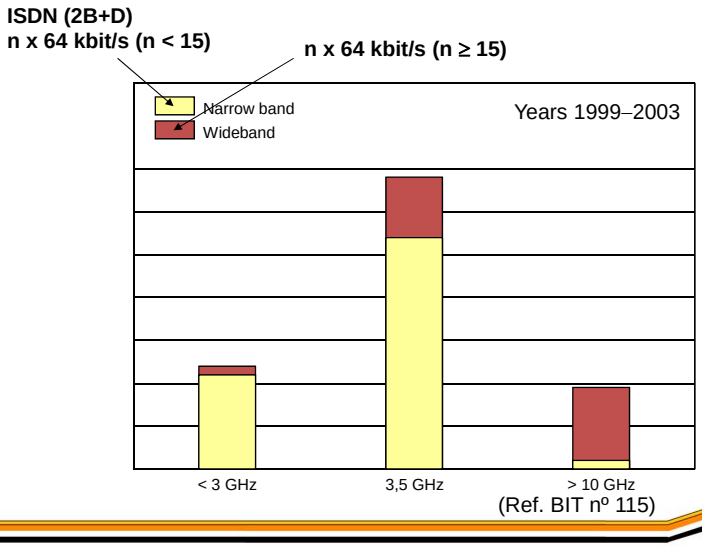
15 - 20 % of total market



(Ref. BIT nº 115)

1.1. INTRODUCTION(13)

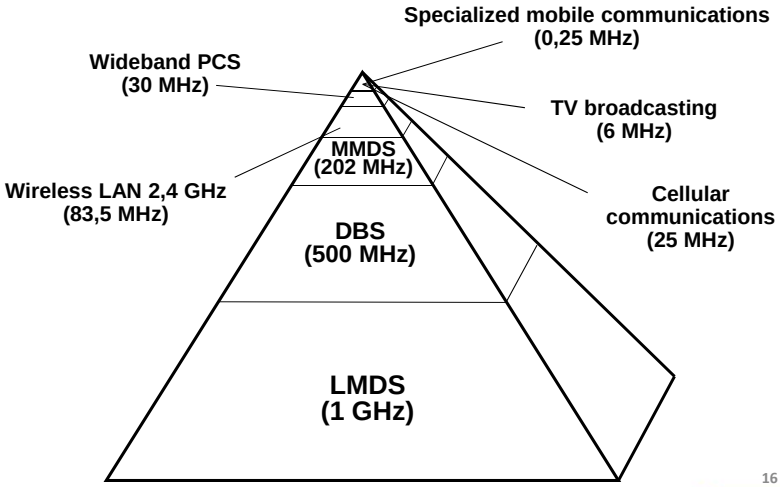
WLL market



(Ref. BIT nº 115)

1.2.FREQUENCY BANDS(1)

Comparative of band-width



1.2. FREQUENCY BANDS(2)

Types of licences

GENERAL AUTHORIZATIONS:

Telecommunications third party services, different from public telephone services, for establishment and private telecomunnications networks explotation without radio-electric spectrum used.

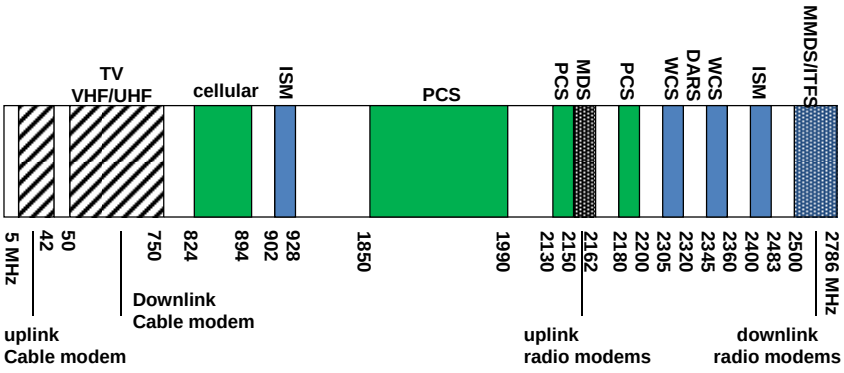
- **Type A: telephony services in closed users group**
- **Type B: private networks establishment or explotation**
- **Type C: public data transmission services**

INDIVIDUAL LICENCES:

- **Type A: basic telephony without explote or establish an own network**
- **Type B1: basic telephony exploting or establishing an own network**
- **Type B2: mobile telephony exploting or establishing an own network**
- **Type C1: carrier services with no use of radio-electric spectrum**
- **Type C2: carrier services using the radio-electric spectrum**

1.2. FREQUENCY BANDS(3)

MMDS system



1.2. FREQUENCY BANDS(4)

Spanish regulation

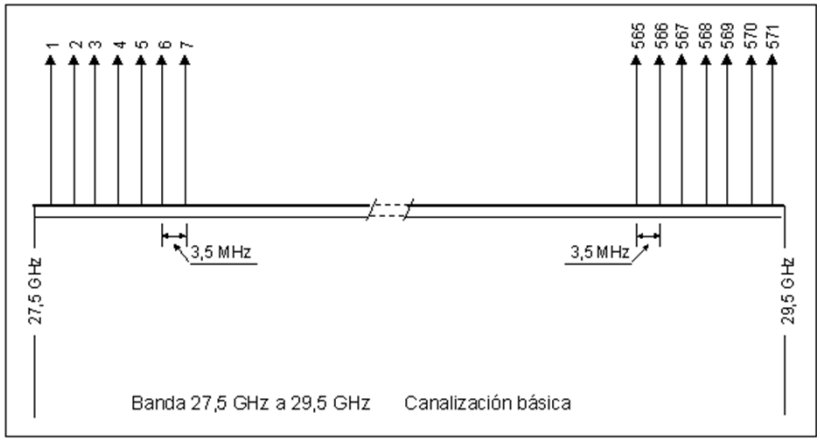
CNAF

UN – 64	12,996 GHz	SDVM secundary / temporary
UN – 79	27,5 – 29,5 GHz	SDVM, 4 frequency blocks (LMDS)
UN – 92	**24,5 – 26,5 GHz**	**p-mp fixed service. WLL. ORDEN October 7, 1999. Individual licences C2.**
UN – 94	40,5 – 42,5 GHz	SDVM according to T/R 52-01 from CEPT (Europe regulation)
UN – 107	**3,4 – 3,6 GHz**	**p-mp radiolinks (a liberar para WLL). ORDEN October 7, 1999. Individual licences C2.**
UN – 109	2421, 2449, 2477 MHz	Short range video links

- **Narrow band systems:** **3,4 to 3,6 GHz** **FWA**
- **Wideband systems:** **24,5 to 26,5 GHz** **FWA**
  27,5 to 29,5 GHz **SDVM (LMDS)**
  40,5 to 42,5 GHz **SDVM (MVDS)**

1.2. FREQUENCY BANDS(5)

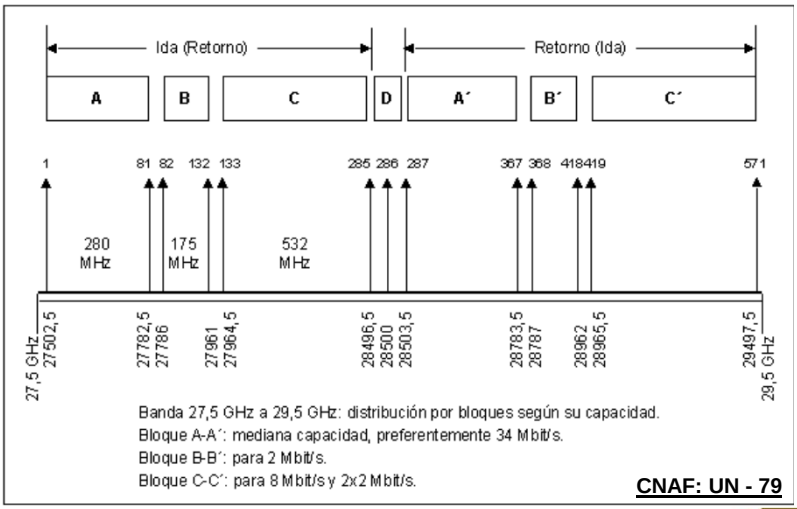
LMDS frequencies



CNAF: UN - 79

1.2. FREQUENCY BANDS(6)

LMDS frequencies

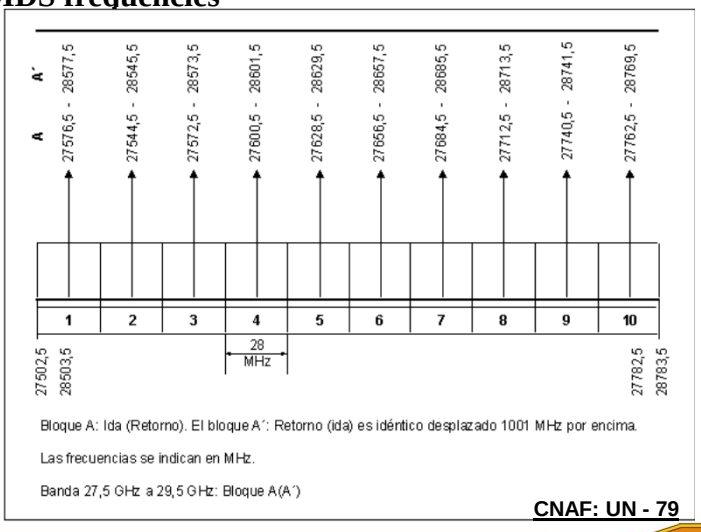


Banda 27,5 GHz a 29,5 GHz: distribución por bloques según su capacidad.
Bloque A-A´: mediana capacidad, preferentemente 34 Mbit/s.
Bloque B-B´: para 2 Mbit/s.
Bloque C-C´: para 8 Mbit/s y 2x2 Mbit/s.

CNAF: UN - 79

1.2. FREQUENCY BANDS(7)

LMDS frequencies



Bloque A: Ida (Retorno). El bloque A´: Retorno (ida) es idéntico desplazado 1001 MHz por encima.

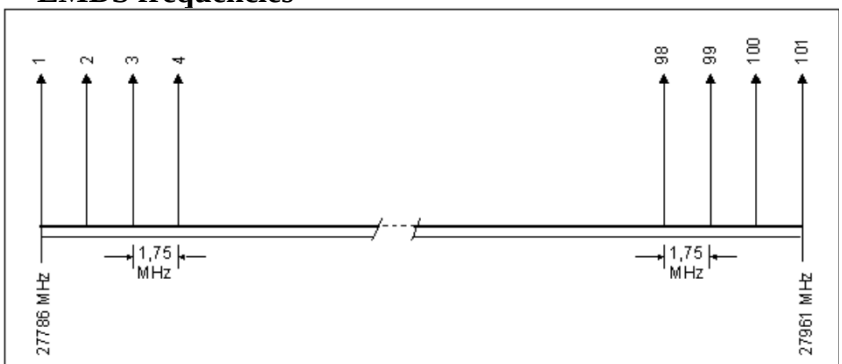
Las frecuencias se indican en MHz.

Banda 27,5 GHz a 29,5 GHz: Bloque A(A´)

CNAF: UN - 79

1.2. FREQUENCY BANDS(8)

LMDS frequencies



Fn = 27784,25 + n 1,75.

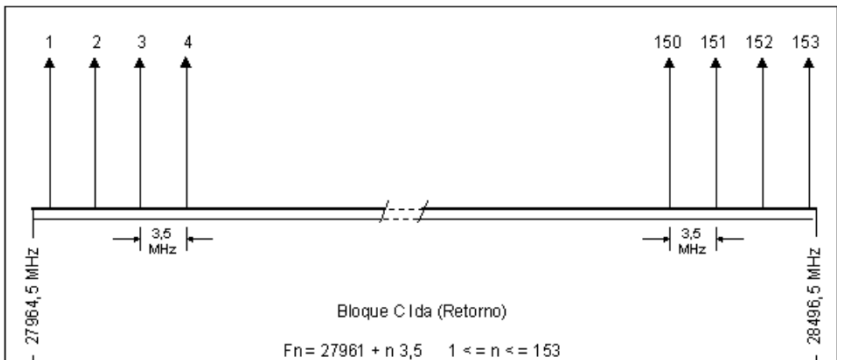
Bloque B: Ida (retorno). El bloque B´Retorno (Ida) está desplazado 1001 MHz por encima.

Banda 27,5 - 29,5 GHz: Bloque B(B´): 2 Mbit/s.

CNAF: UN - 79

1.2. FREQUENCY BANDS(9)

LMDS frequencies



Bloque C Ida (Retorno)

Fn = 27961 + n 3,5 1 < = n < = 153

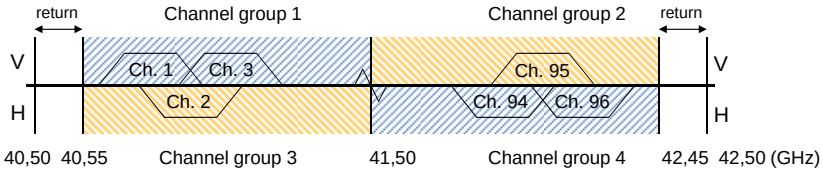
El bloque C´ Retorno (Ida) es idéntico al C, desplazado 1001 MHz por encima.

Banda 27,5 - 29,5 GHz: Bloque C (C´): 8 Mbit/s, 2 x 2 Mbit/s.

CNAF: UN - 79

1.2. FREQUENCY BANDS(10)

MVDS frequencies

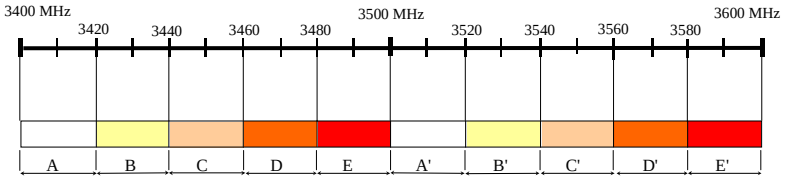


CEPT Channeling proposal - T/R 52-01

Polarization	Downlink freq. (GHz)	Uplink freq. (GHz)
V	41,50 - 42,45	40,50 - 40,55
H	41,50 - 42,45	40,50 - 40,55
V	40,55 - 41,50	42,45 - 42,50
H	40,55 - 41,50	42,45 - 42,50

1.2. FREQUENCY BANDS(11)

FWA frequencies to 3,5 GHz

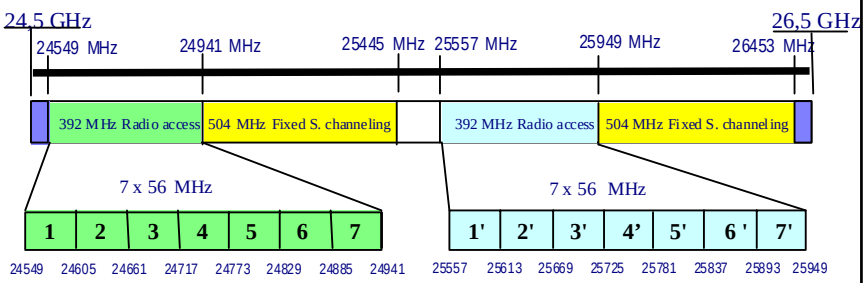


CNAF: UN - 107

- **Blocks A-A', B-B', ..., E-E' : 20 MHz + 20 MHz with 100 MHz divisions**

1.2. FREQUENCY BANDS(12)

FWA frequencies to 26 GHz



CNAF: UN - 92

Fn = Fr - 1008 + 112n ,	Fn' = Fr + 112n	n = 1, ..., 8 (112 MHz steps)
Fn = Fr - 980 + 56n ,	Fn' = Fr + 128 + 56n	n = 1, ..., 16 (56 MHz steps)
Fn = Fr - 966 + 28n ,	Fn' = Fr + 42 + 28n	n = 1, ..., 32 (28 MHz steps)
Fn = Fr - 959 + 14n ,	Fn' = Fr + 49 + 14n	n = 1, ..., 64 (14 MHz steps)
Fn = Fr - 955,5 + 7n ,	Fn' = Fr + 52,5 + 7n	n = 1, ..., 128 (7 MHz steps)
Fn = Fr - 953,75 + 3,5n ,	Fn' = Fr + 54,25 + 3,5n	n = 1, ..., 256 (3,5 MHz steps)

Fr = 25501 MHz

1.2. FREQUENCY BANDS(13)

Tenders announced by public Department

- Department of public works: 6 radio access licences (17 offers)

  - C2 type individual licences for establishment and explotation of radio access public networks
  - 20 years with a once extendable to 10 more years
  - To deploy the network within a period of 1 year (over 200.000 inhabitants)

- 3,4 - 3,6 GHz band:

  Abranet, Airtel, Aló 2000, Firstmark Communications, Milenio, Sky Point, Telefónica. (7 offers)

- 26 GHz band:
  (7 previous),
  Banda 26, Broadnet Consorcio, Mill Telecom España. (10 offers)

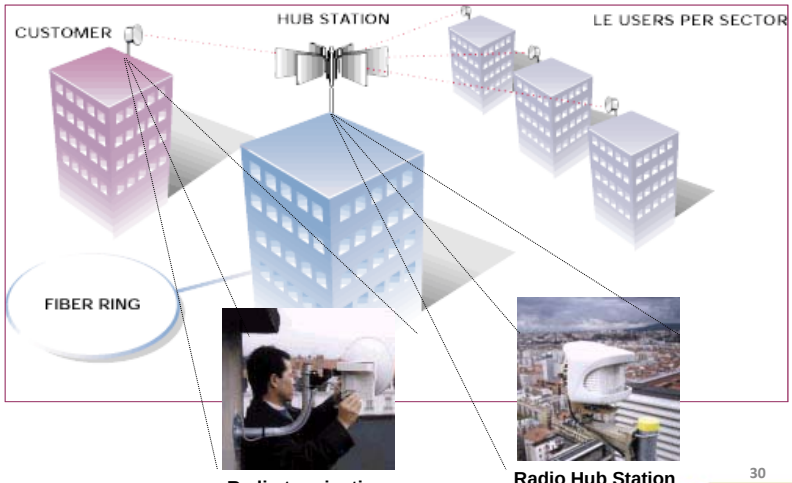
1.2. FREQUENCY BANDS(14)

3,5 GHz vs 26 GHz

- Technology maturity: equipment costs
- Taken decissions
- Propagation characteristics: rain, vegetation
- Antenna's directivity: beam width
- Bandwidth: capacity
- Diagrams of modulation

1.3.P-MP ARCHITECTURES(1)

P-MP wireless system

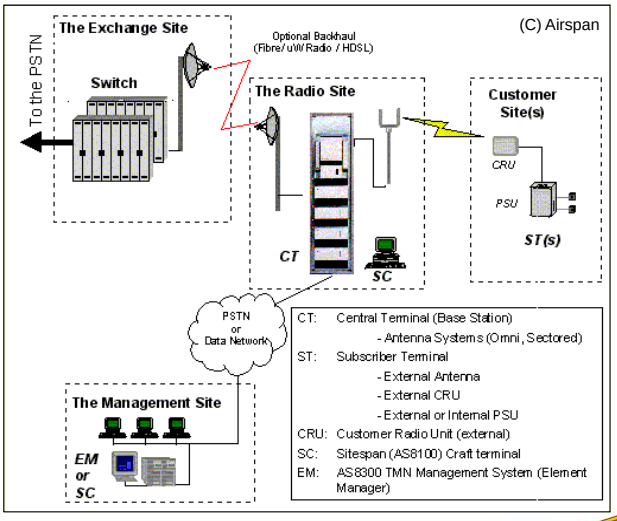


Radio termination

Radio Hub Station

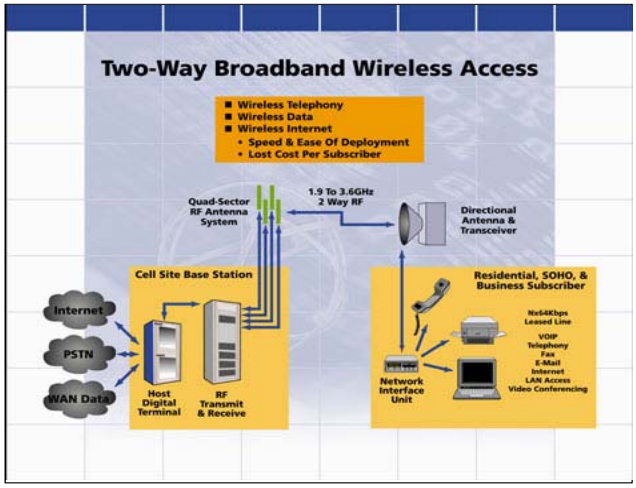
1.3.P-MP ARCHITECTURES(2)

FWA system



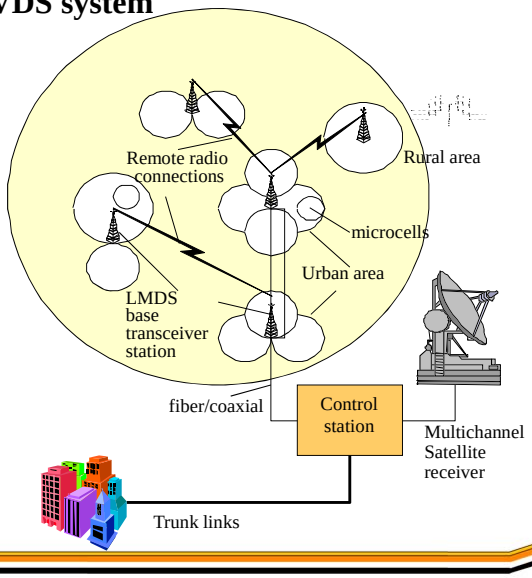
1.3.P-MP ARCHITECTURES(3)

MMDS system



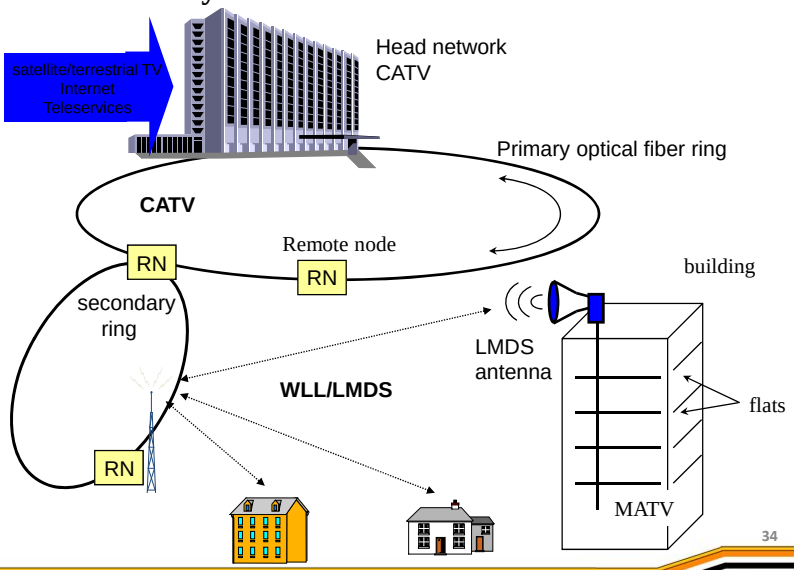
1.3.P-MP ARCHITECTURES(4)

LMDS/MVDS system



1.3.P-MP ARCHITECTURES(5)

CATV/WLL hybrid network

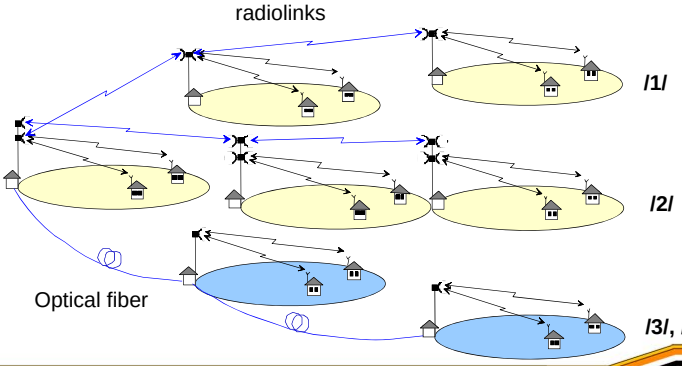


1.3.P-MP ARCHITECTURES(6)

Supply by cable/radio

•Radio supply:
- clear: retransmission of downlink + grouping of uplink /1/
- unclear: signal reformated/remultiplexing /2/

• cable supply:
- clear: radio-fiber system (base station → pasive repeaters) /3/
- unclear: SDH connections transporting ATM traffic /4/

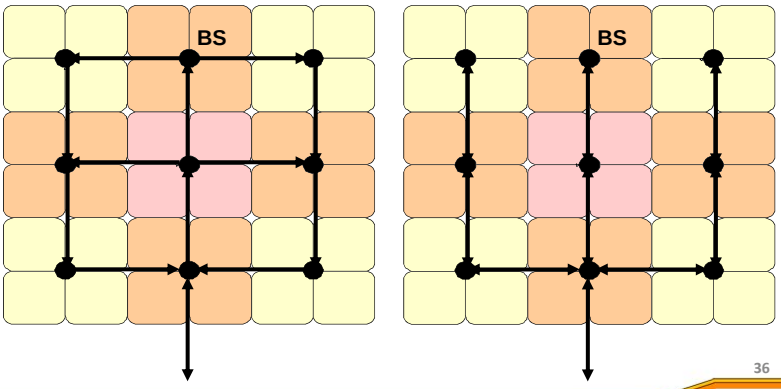


1.3.P-MP ARCHITECTURES(7)

Base Station supply structures

• unclear supply network
• diversity capacity (several routes)
• adequate for cable (radio links)

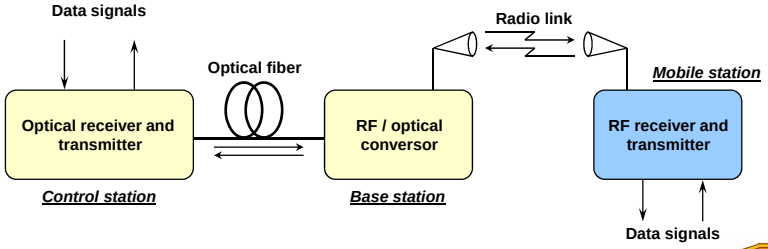
• clear supply network
• "daisy-chain" configuration
• not adequate for (optical fiber)



1.3.P-MP ARCHITECTURES(8)

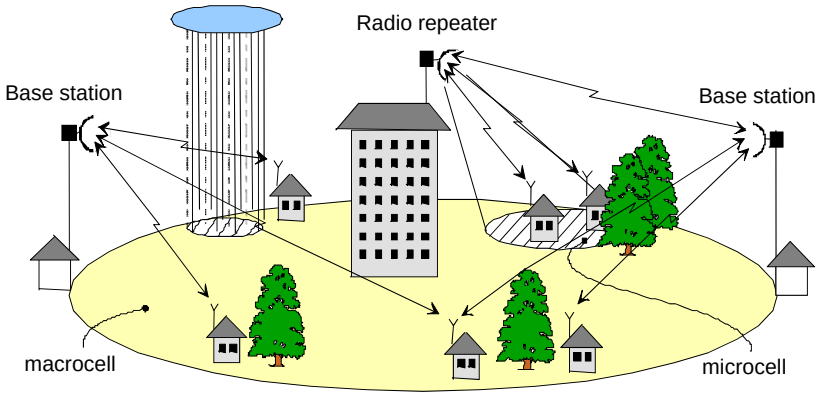
Applications of the radio-fiber systems

- Remote antennas supply
- cellular systems: pasive picocells
- WLL/LMDS (26/28 GHz) and MVDS (40 GHz)
- MBS (60 GHz)
- Wireless local area networks (2,4 GHz)
- vehicles control (63-64 GHz, 76-77 GHz)



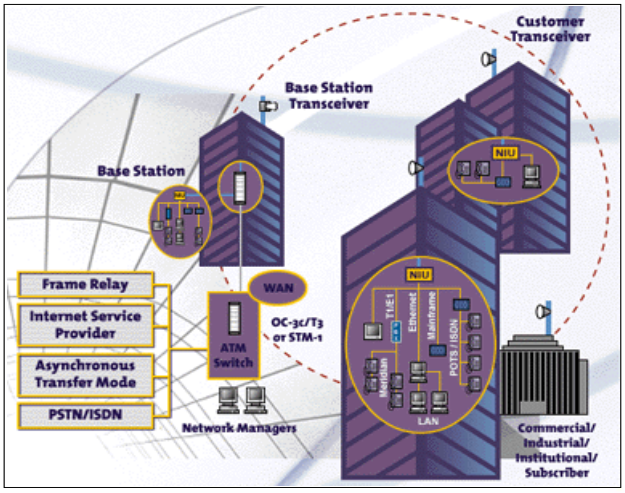
1.3.P-MP ARCHITECTURES(9)

Typical cellular structure



1.3.P-MP ARCHITECTURES(10)

Network architecture



1.3.P-MP ARCHITECTURES(11)

System architecture

(BS, Base Station)

(NN, Network Node)

(BST, Base Station Transceiver)

(CPE, Customer Premise Equipment)

(NIU, Network Interface Unit)

(CT, Customer Transceiver)

1.3.P-MP ARCHITECTURES (12)

Network node functions

- ☞ TO CREATE AN INTERFACE IN ADDITION TO THE CABLE NETWORK
- ☞ DATA FLOW PROCESSING
- ☞ CHANNELING, MULTIPLEX/DEMULTIPLEX
- ☞ CODING/DECODING
- ☞ ROUTING
- ☞ MODULATION/DEMODULATION

1.3.P-MP ARCHITECTURES(13)

Network management

MISTAKES:
- statistics captures and operation failures detection

OPERATION/CONFIGURATION:
- limit value checks, configuration problems
- automatic detection of new equipment connections in network

PERFORMANCES:
- monitoring (power level, IP traffic, ...)
- modification of parameters

ACCOUNTS/RATE-SETTINGS:
- maintenance and statistics consulting

SECURITY:
- encrypt transmissions
- user authentications

SNMP (Simple Network Management Protocol)

1.3.P-MP ARCHITECTURES(13)

Wireless network technologies

- Modulation techniques of floating rate (adaptives)
- Frequencies reutilization
- FEC modulation and encoding
- “phase array” active antennas
- signal distributions with phase hooking
- “frequency hopping” algorithm
- MPEG-2 traffic integration

1.4.RADIO LINK CHARACTERISTICS(1)

Typical LMDS link parameters

Parameter	uplink	downlink
Transmitted power:	+14 dBm	+27 dBm
Channels for each amplifier:	1	3
transmitter antenna gain:	34 dBi	17 dBi
EIRP:	16 dBW	6,2 dBW
Radiolink loss (2 km):	130,6 dB	130,6 dB
Loss by rain (99,99 %):	18,5 dB	18,5 dB
receiver antenna gain:	17 dBi	34 dBi
Noisse figura:	5 dB	7 dB
Channel bandwidht:	8,5 MHz	33 MHz
CNR:	14,2 dB	11,8 dB
CIR:	14 dB	14 dB
effective CNR:	11,2 dB	9,8 dB

(Ref. ACTS Project 215)
CRABS (Cellular Radio Access for Broadband Services)

1.4.RADIO LINK CHARACTERISTICS(2)

Uplink

			Uplink		
Carrier to noise ratio	C/N	+	11.2		dB
Modulation			D(E)QPSK		
Demodulation			Coherent		
External channel code			RS(53,63)	RS(188,204)	
Internal channel code			-		
Spectrum efficiency	R_b/B		1.68	1.84	b/s/Hz
	R_b/B,dB	-	2.3	2.7	
Energy by bit by noisse density	E_b/N_0	=	8.9	8.5	dB

1.4.RADIO LINK CHARACTERISTICS(3)

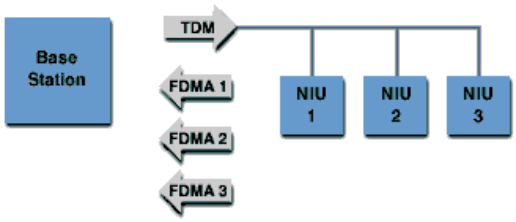
downlink

			downlink				
Carrier to noise ratio	C/N	+	9.8		6.7		dB
Modulation			QPSK				
Demodulation			Coherent				
External channel coder			RS(188,204)				
Internal channel code			3/4-rate	7/8-rate	1/2-rate	2/3-rate	
			Convolutional				
Spectrum efficiency	R_b/B		1.38	1.61	0.92	1.23	b/s/Hz
	R_b/B,dB	-	1.4	2.1	0.0	0.9	
Energy by bit by noisse density	E_b/N_0	=	8.4	7.7	6.7	5.8	dB

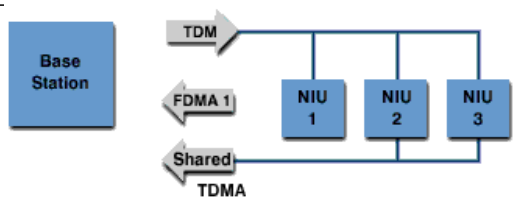
1.4.RADIO LINK CHARACTERISTICS(4)

Access techniques

❍ FDMA ACCESS:

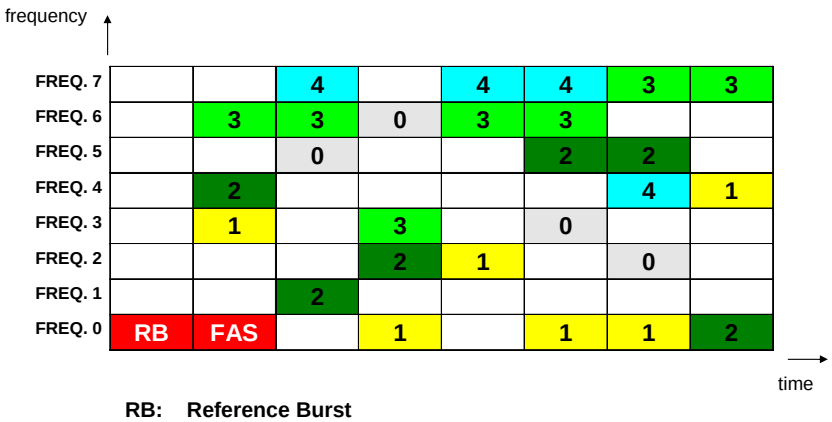


❍TDMA ACCESS :



1.4.RADIO LINK CHARACTERISTICS(5)

TDMA multi-frequency frame



RB: Reference Burst
FAS: First Access Slot

1.4.RADIO LINK CHARACTERISTICS(6)

Access method depending on the traffic

Factor	Low capacity connections	High capacity connections
tipical bandwidth in connections	Variable, until 10 Mbit/s	Fixed, under 25,6 Mbit/s
Shared access save costs	yes	No
Licence price per connection	low	high
Preferred diagram modulation	QPSK	QAM
Decision factor of diagram modulation	Shared aerial interface (TDMA)	Minimized used spectrum (FDMA)

1.4.RADIO LINK CHARACTERISTICS(7)

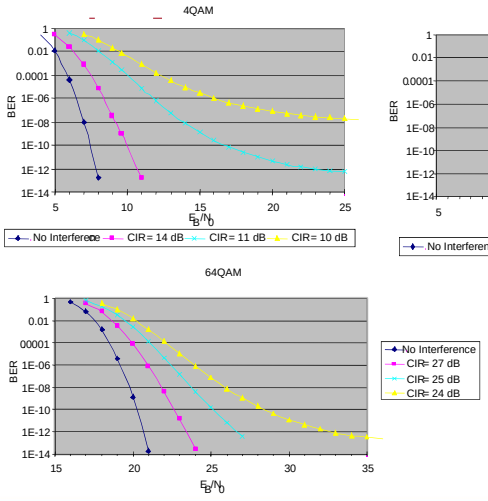
Access possibilities

- **shared access using TDMA/QPSK**
- **fixed rate connections, low bandwidth and symmetric**
- **variable rate connections, low bandwidth and asymmetrics**
- **dedicated access using FDMA/QAM**
- **fixed rate connections and high bandwidth**
- **shared access using TDMA/QAM** ?

1.5.CELLULAR PLANNING IN P-MP SYSTEMS(1)
Cell design

- **level power: fading margin, CNR**
- **performances of base station and user antennas: directivity, discrimination to the crossed polarization, ...**
- **modulation tolerance/FEC vs interferences: CIR**
- **Cost by cell y total cost**
- **quality of service (QoS): have an influence factors such as beam obstruction, cell overlaps or redundancy of the system**

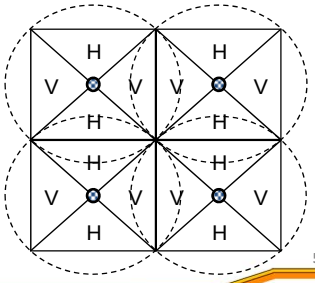
1.5.CELLULAR PLANNING IN P-MP SYSTEMS(2)
CIR peformances of different modulations



1.5.CELLULAR PLANNING IN P-MP SYSTEMS(3)

Re-using frequencies optimization

- multisource and crossed polarization minimization effects
  - high directional antennas in high positions
  - beam width control of the antennas and F/B rate
- directivity antennas maximization
  - Sector design (for example. 4 sectors/cell – beam width of 90º)
- isolation maximization between adjacent sectors
  - use of different polarizations



1.5.CELLULAR PLANNING IN P-MP SYSTEMS(4)

Calculus of distance factor

- CIR tolerance determines a distance factor in the re-using of frequencies.
- required distance factor:

$$D = 2^{M/2+1}$$

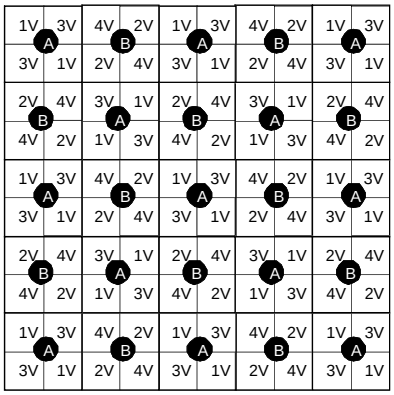
M: modulation order (f. e. M = 2 for 4QAM)

Modulation	minimum CIR (BER=10^{-12})	required D
4QAM	12 dB	4
16QAM	18 dB	8
64QAM	24 dB	16

1.5.CELLULAR PLANNING IN P-MP SYSTEMS(5)

Re-using of frequencies 1 to 4 (1 polarization)

90º sectors



Cell A

Sector	Frequency Channel 1	2	3	4
1	V			
2			V	
3	V			
4			V	

(i)

Cell B

Sector	Frequency Channel 1	2	3	4
1		V		
2				V
3		V		
4				V

(ii)

- 1/4 of frequencies for each sector
- 100% of re-using
- Factor D = 5
- 14 dB interference cocanal insulation

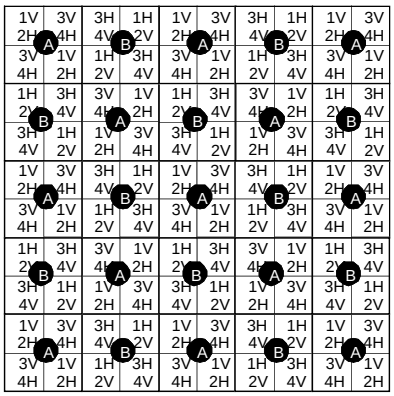
INTERFERENCES:

- adjacent sectors: co-polar (i)
- opposite sectors: co-polar and cochannel (ii)

1.5.CELLULAR PLANNING IN P-MP SYSTEMS(6)

Re-using of frequencies 1 to 2 (2 polarizations)

90º sectors



Cell A

Sector	Frequency Channel 1	2	3	4
1	V	H		
2			V	H
3	V	H		
4			V	H

(i)

(ii)

Cell B

Sector	Frequency Channel 1	2	3	4
1	H	V		
2			H	V
3	H	V		
4			H	V

(iii)

- 1/2 of frequency for each sector
- 200% of re-using
- Factor D = 5
- 14 dB interference cocanal insulation

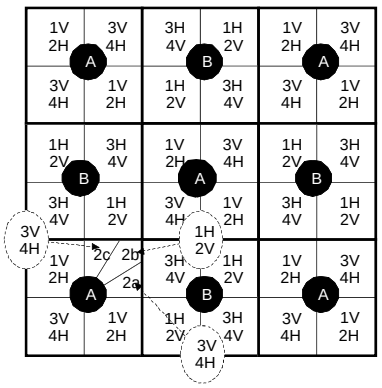
INTERFERENCES:

- adjacent sectors: co-polar (i) + cross-polar (ii)
- opposite sectors: co-polar and cochannel (iii)

1.5.CELLULAR PLANNING IN P-MP SYSTEMS(7)

Re-using of frequencies with 30º sectioning

90º sectors



Cell A

Sector	Frequency Channel 1	2	3	4
1	V	H		
2a			V	H
2b	H	V		
2c			V	H
3	V	H		
4			V	H

Cell B

Sector	Frequency Channel 1	2	3	4
1	H	V		
2			H	V
3	H	V		
4			H	V

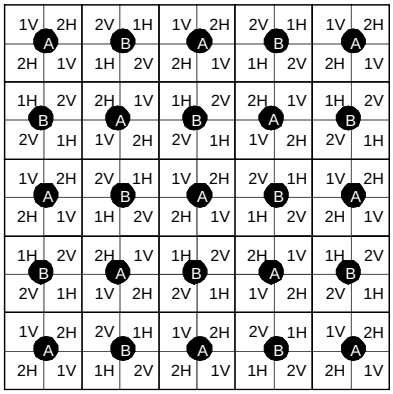
INTERFERENCES:

- adjacent sectors: co-polar + cross-polar
- opposite sectors: co-polar and cochannel

1.5.CELLULAR PLANNING IN P-MP SYSTEMS(8)

Re-using of 2 frequencies and 2 polarizations

90º sectors



Cell A

Sector	Frequency Channel 1	2
1	V	
2		H
3	V	
4		H

Cell B

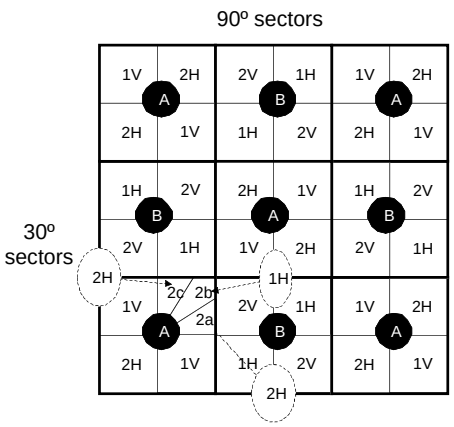
Sector	Frequency Channel 1	2
1	H	
2		V
3	H	
4		V

INTERFERENCES:

- adjacent sectors: cross-polar
- opposite sectors: co-polar and cochannel

1.5.CELLULAR PLANNING IN P-MP SYSTEMS(9)

Re-using of 2 frequencies with 30º sectioning



Cell A

Sector	Frequency Channel 1	2
1	V	
2a		H
2b	H	
2c		H
3	V	
4		H

Cell B

Sector	Frequency Channel 1	2
1	H	
2		V
3	H	
4		V

INTERFERENCES:

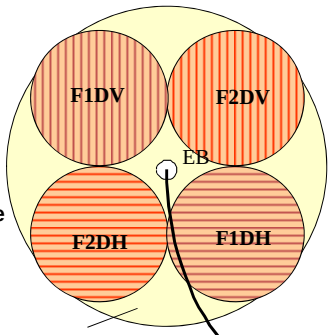
- **adjacent sectors: co-polar + cross-polar**
- **opposite sectors: co-polar and cochannel**

1.5.CELLULAR PLANNING IN P-MP SYSTEMS(10)

Cellular planning

Broadcasting services:

- **Initially, you can cover all cell through an omnidirectional antenna**
- **low bandwidth services: sub-cells division (traffic increase)**
- **only transmission in channels that have a petition**



Initial omnidirectional coverage: F1DV and F1DH

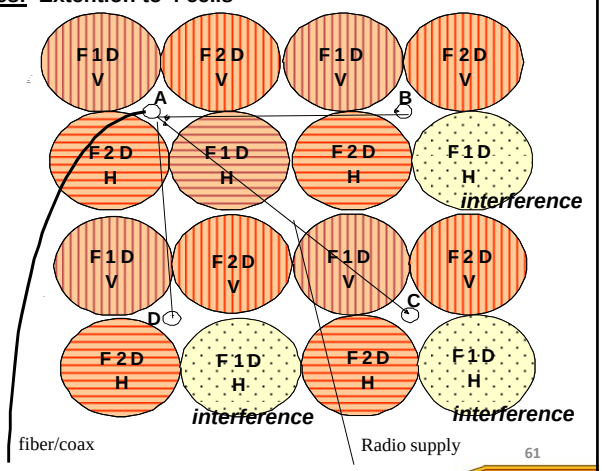
1.5.CELLULAR PLANNING IN P-MP SYSTEMS(11)

Cellular plannig

Broadcasting services: Extention to 4 cells

"master" station: A

"slaves" stations: B, C y D

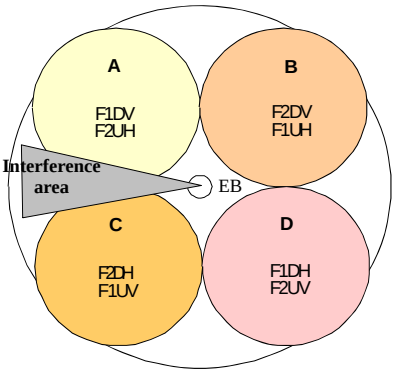


1.5.CELLULAR PLANNING IN P-MP SYSTEMS(12)

Cellular planning

ATM data services:

- more complex planning:
  - bi-directional data
  - only individual traffic
- co-canal interferences of adjacent sectors caused by diffusion (F2DH → F2UH):
  - interference magnitude (object distance)
  - antenna diagrams



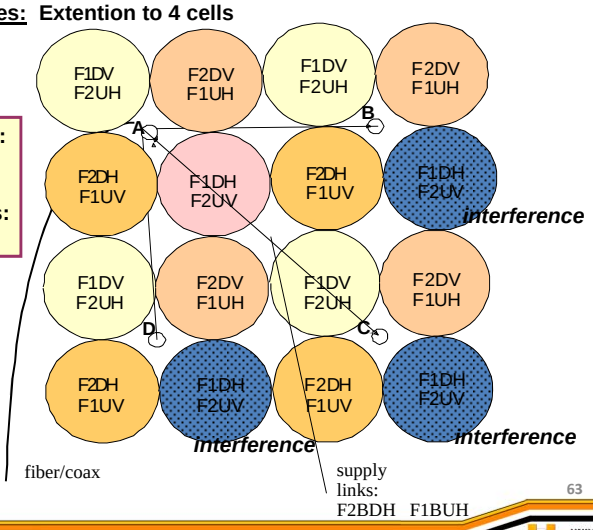
1.5.CELLULAR PLANNING IN P-MP SYSTEMS(13)

Cellular planning

ATM data services: **Extention to 4 cells**

"master" station: A

"slaves" stations: B, C y D



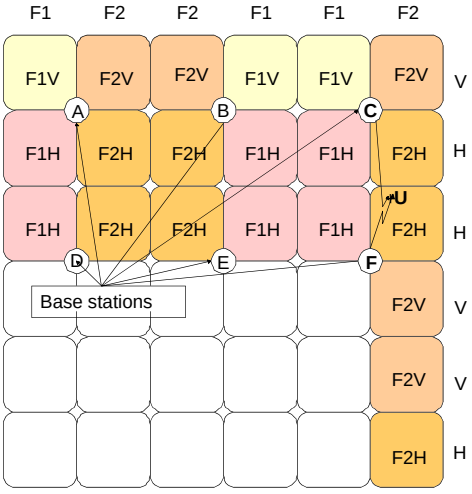
1.5.CELLULAR PLANNING IN P-MP SYSTEMS(14)

Cellular planning

- **interference problem solutions**

Now, user U can receive signals from F and C station, although the antenna is pointing out to F station.

- downlink: CIR = 14 dB
- uplink: CIR = 12 dB



1.5.CELLULAR PLANNING IN P-MP SYSTEMS(15)

Coverage simulation

LMDS parameters system:

	downlink (EB to TU)	uplink (TU to EB)
Carrier frequency	28 GHz	28 GHz
Bandwidth	40 MHz	2 MHz
Power transmission	+27 dBm	+15 dBm
Transmitter antenna gain	12 dBi	36 dBi
Receiver antenna gain	36 dBi	12 dBi
Background noise	-98 dBm	-111 dBm
Receiver noise figura	8 dB	8 dB
SNR requiered	13 dB	13 dB
Fading margin	5 dB	5 dB

1.5.CELLULAR PLANNING IN P-MP SYSTEMS(16)

Coverage simulation

1.5.CELLULAR PLANNING IN P-MP SYSTEMS(17)

Coverage simulation

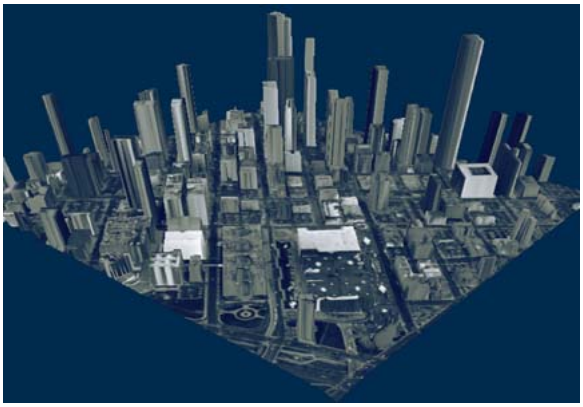
Coverage results:

Description	Coverage
Default system	65,4 %
Without reflections	62,1 %
Without rain	68,9 %
Mast height TU (+25 cm)	67,6 %
Diversity in BS	78,7 %
Diversity in BS and gain (+10 dB)	85,0 %
Diversity in BS and gain (+10 dB)	88,9 %
Diversity in BS and gain (+20 dB)	94,3 %

1.5.CELLULAR PLANNING IN P-MP SYSTEMS(18)

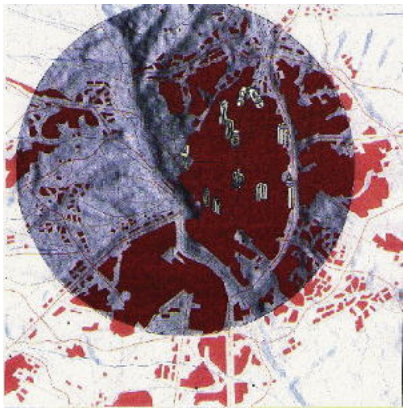
Building Simulation

- **Simulation of height buildings**
- **Computing simulation**
- **Situation of base stations**

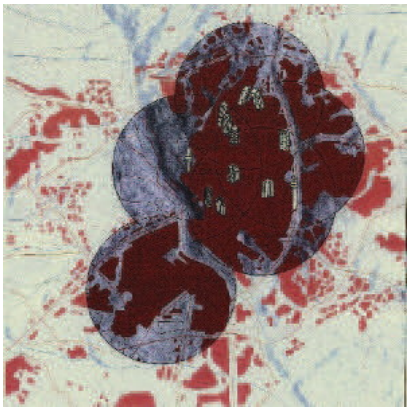


1.5.CELLULAR PLANNING IN P-MP SYSTEMS(19)

Coverage measures for different modulations



QPSK



64QAM

(experimental proof realized in Madrid)