Transmission Network planning

- Digital Technology
  - Modulation schemes
  - Voice and video compression
  - VoIP
  - Introduction to IP technology
- Frequency band planning
- C band vs Ku band
- Extended band operation
- Network design
  - Types of network and their parameters
  - Corporate networks (Cellular backhauls, IP trunking, SCPC links, DVB links, Video Distribution and Content Distribution Networks)

Digital Transmission

- With advent of transmission between computors, terminals and computors, digital voice (VoIP) etc the digital modulation become the more obvious choice to signal transmissions that are originally digital or used by digital equipments (case of analogous signals as telephone channel or television) in this case with large bandwiths that benefit in the analog-digital code process, highly efficient about the noise immunity related to interference .
- Although any multiplex technique – FDM or TDM – can be used in analog or digital modulation, TDM is more easy to implement with digital modulation (and FDM for the analog modulation)

…/…

Digital Transmission

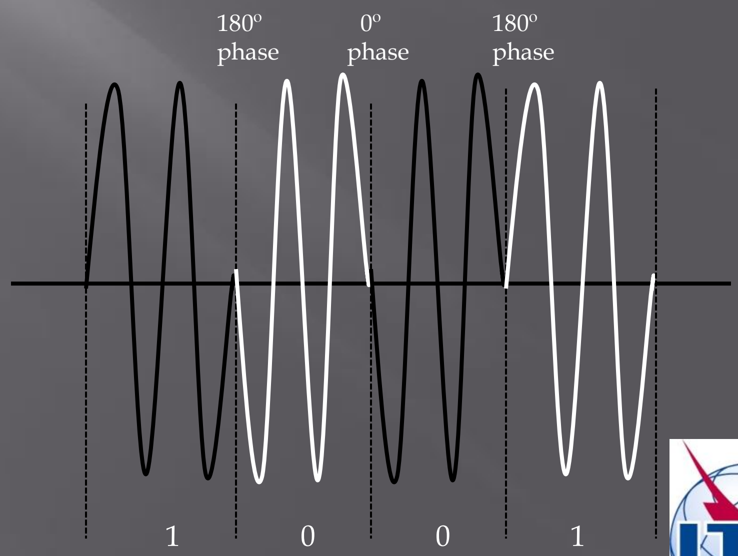
…/…

- To the ability that several earth stations have to acess satellite simultaneously with data, voice and television etc it is called Multiple Acess, and includes 3 techniques, "*FDMA-frequency division multiple access*", "*TDMA-time division multiple access*" e "*CDMA-code division multiple access*", whose differentiation we'll see later.
- The most usual digital transmission type in satellite communications, result of diferent combinations in the "codification, multiplex and modulation" of the original baseband signals and later acess method , namely SCPC – variant of FDMA – and the above referred TDMA, also known by SCPC/PSK/FDMA and TDM/PSK/TDMA

Digital Modulation

- While any feature of a signal – amplitude, frequency and phase – may be digitally modulated, phase modulation is almost universally used for satellites.For historical reasons, digital phase modulation is frequently called *phase shift keying* abbreviated PSK.An M-phase PSK modulator puts the phase of a carrier into one of the M states according to value of a modulating voltage.Two stage or biphase PSK is called BSK .

In this case of modulation (direct codification) the phase of the signal carrier is advanced ou delayed according with the equipment modulator (terminal equipment) , hence present case what matters are change state (phase)

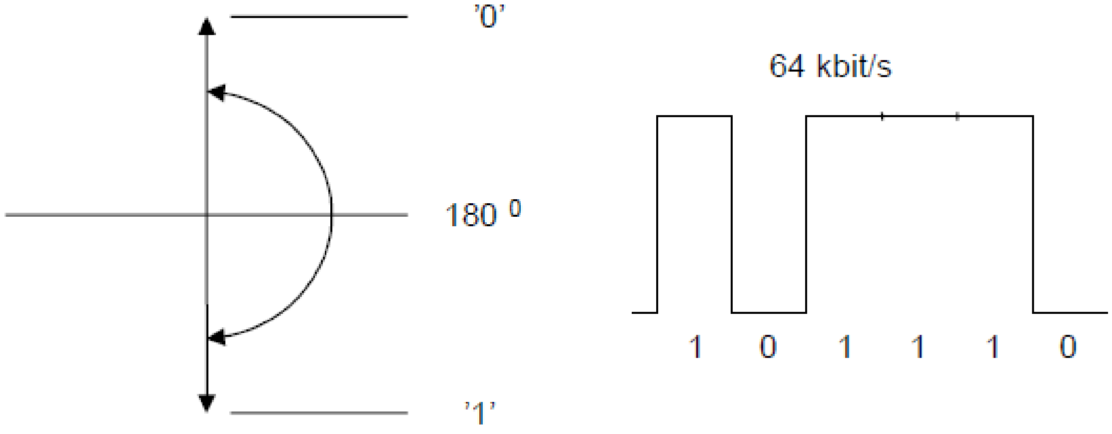


BPSK, QPSK Digital Modulaltion

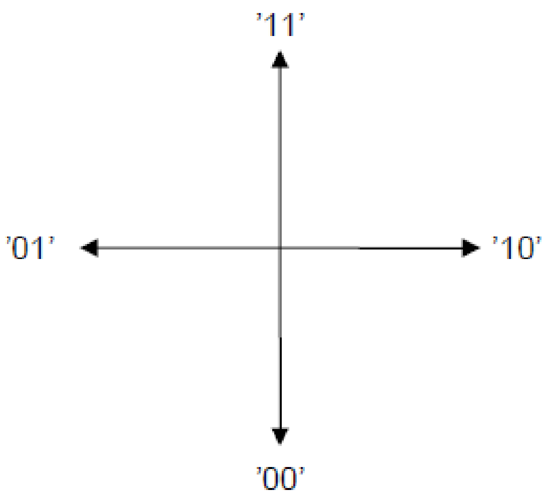
- Biphase or Binary Phase-Shift Keying (BPSK) modulation is the simplest form of PSK, where the phase shift changes with each new data bit. In this case, a binary source code is mapped one bit at a time into a pair of phase states with 180-degree phase difference.
- Quadrature Phase Shift Keying (QPSK) encodes each pair of bits into one of four phases, and one of the principal advantages of QPSK over BPSK is that QPSK achieves the same power efficiency as BPSK <u>with only half of the bandwidth</u>. QPSK is of particular importance for satellite data transmissions and, therefore. The name four-phase or quadriphase refers to the fact that one carrier is modulated along a 0-degree, 180-degree phase vector (the in-phase or cosine channel), and the other along a 90-degree, 270-degree phase vector (the quadrature or sine channel). Ideally, the two channels are independent.

BPSK, QPSK Digital Modulaltion

1) 2 Phase PSK



2) 4 Phase PSK



i.e. 2 BIT STREAM EACH AT 32 kbit/s.
EACH PHASE REPRESENTS 2 BITS (DIBITS)

Digital modulation performance

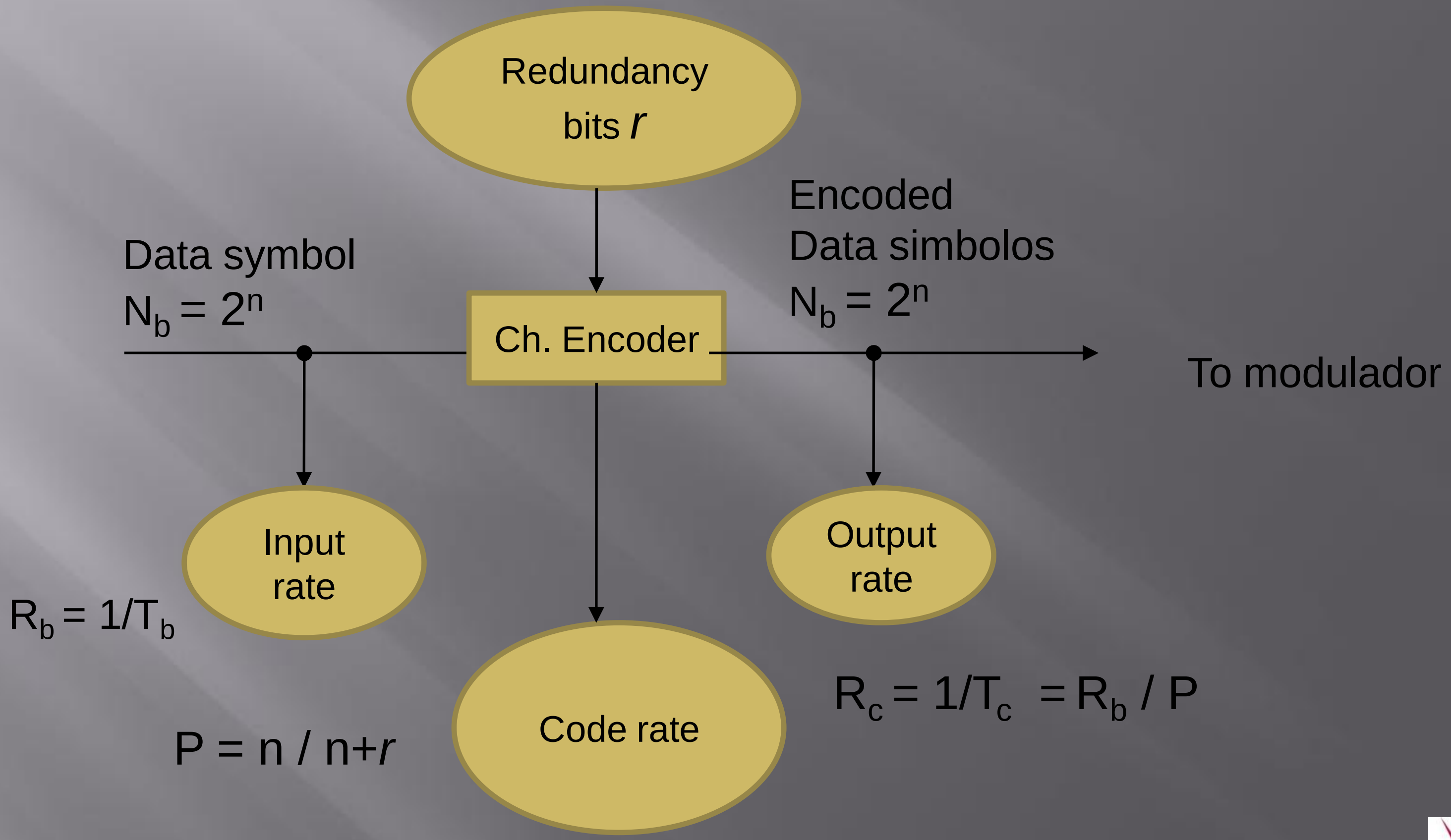
- In the digital modulation process the input *stream* determines what symbol (from the one's available among the M on the modulation employed) will be transmitted for instance - 0 or 1 (BPSK) , 00 or 01 or 10 or 11 (QPSK) or 000, 001…111(8PSK) - e.g the nº of bits needed for the transmission of the symbol that will be $N_b = \log_2 M$.
- Associated with modulation comes other component named "encoding" that changes the information bits in aggregated way or by convolution and in practice corresponds to the insertion of redundant bits (*r* redundant bits for *n* information bits)

…/…

Digital modulation performance …/…

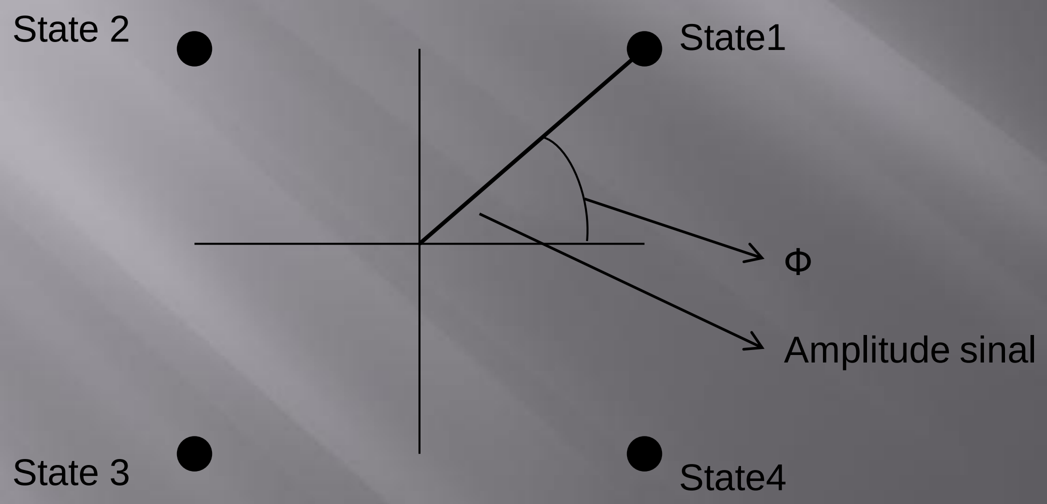
- The boundary between digital modulation and digital encoding is not well defined. In encoding for forward error correction (FEC) redundant bits are added to na incoming bit stream so that errors in transmission may be detected and corrected at the other end of the link.When the redundant bits are added at baseband and the composite (information bits plus redundant bits) bit stream is used to phase modulate a carrier and produce the transmitted symbols then the division between modulation and encoding is obvious. But the modulator itself may be designed to add redundant bits during the modulation process making encoding and modulation inseparable,

Channel Encoding



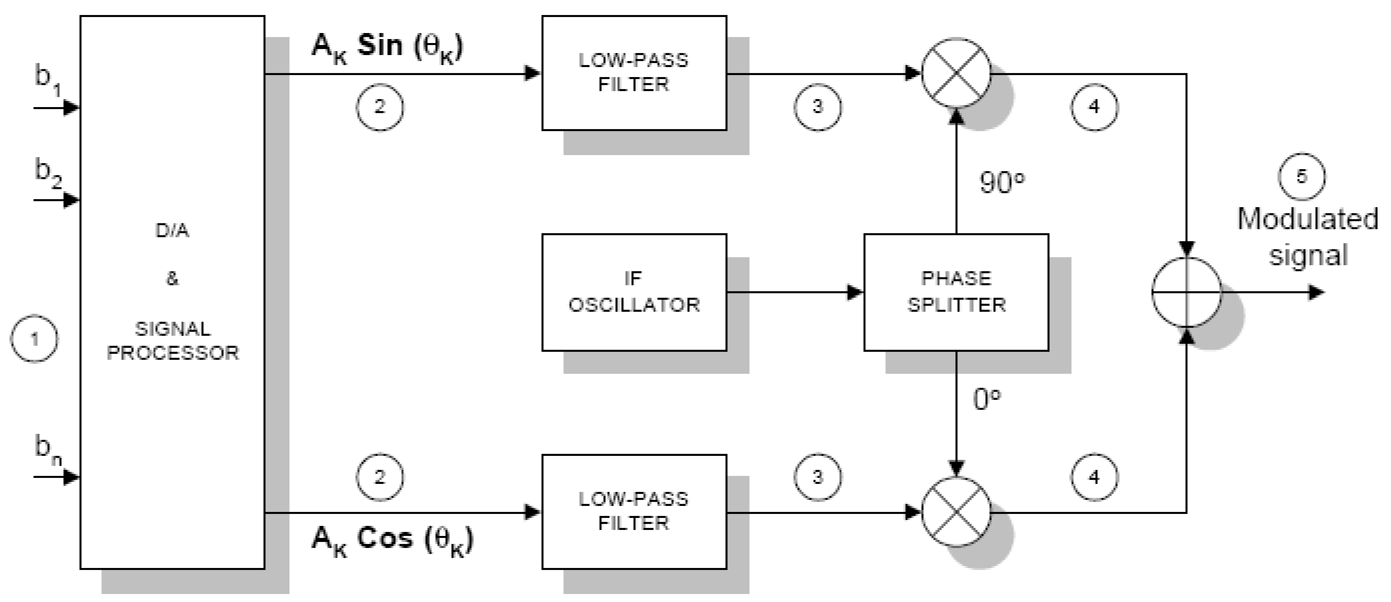
QPSK Modulator

- Representation of modulation diagram, known per "constellation" (screenshot of the measurement equipments display)



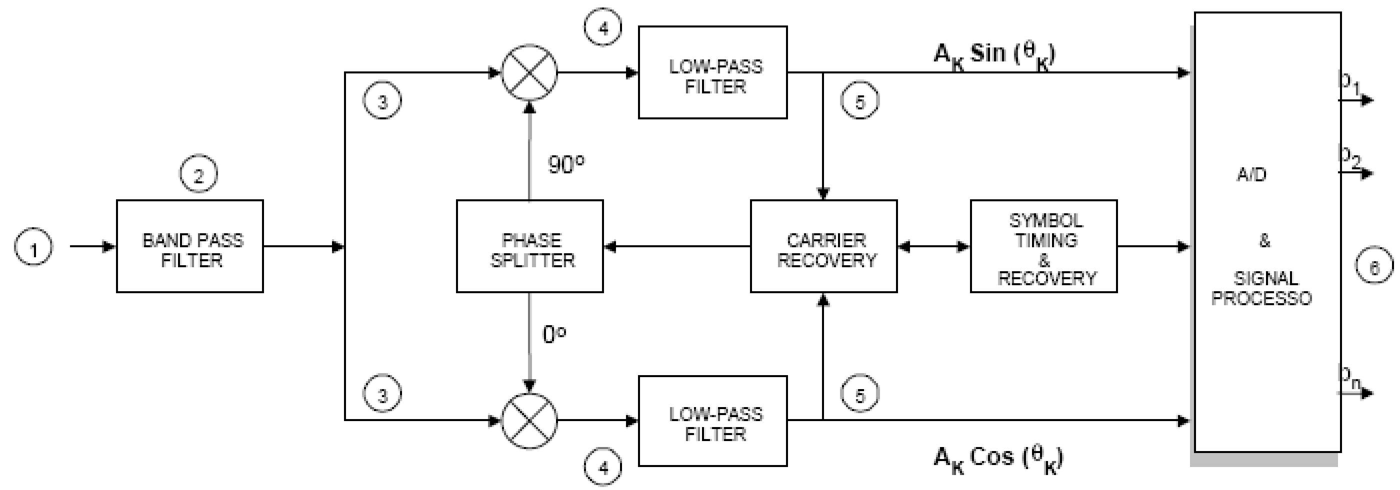
Symb. ch	00	01	11	10
Φº	45	135	225	315

A Modulator



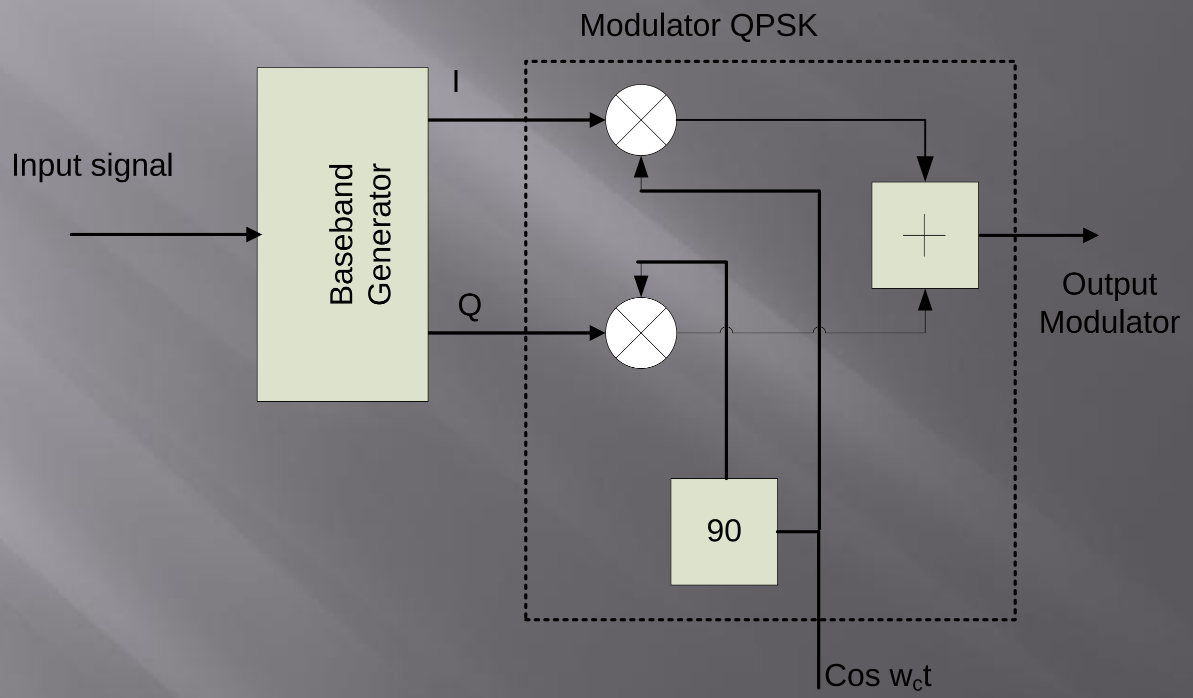
Block Diagram of a PSK Modulator

A demodulator



Block Diagram of a PSK Demodulator

B Modulator



Modulator QPSK
Input signal
Baseband Generator
I
Q
90
Output Modulator
Cos w_ct

B Demodulator

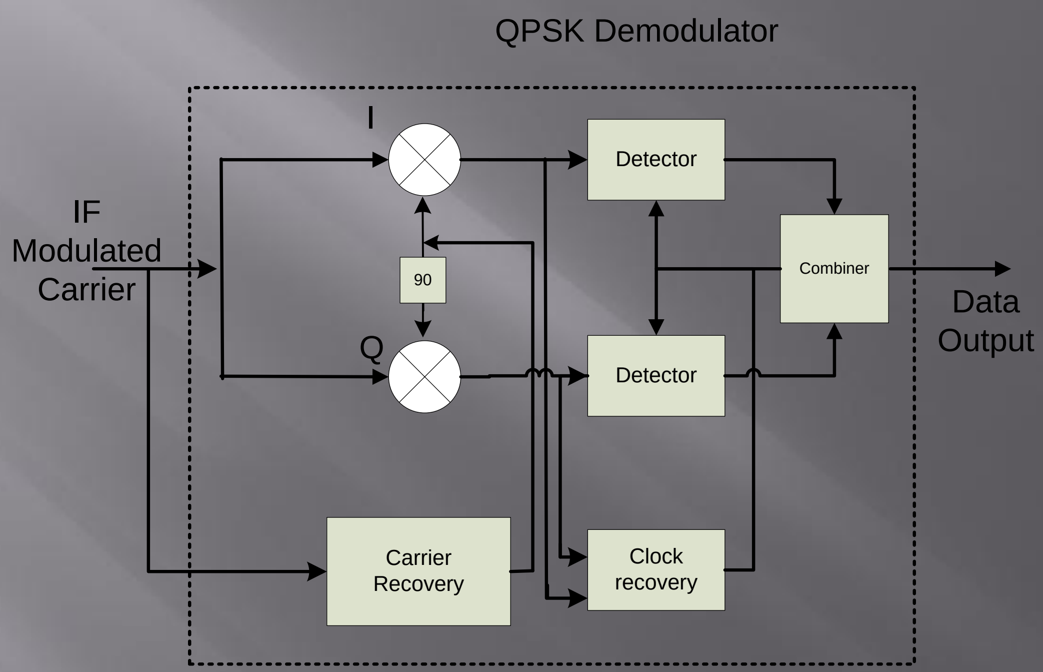


Figure of Merit
Digital radio link 1

- The fraction of the figure of merit for a digital radio link is its *bit error rate* (BER) also called the *bit error probability* (PE).Mathematically this is the probability that a bit sent over the link will be received incorrectly or alternatively the fraction of a large nº of transmitted bits that will be received incorrectly.Like a probability it is usual stated as a single nº - for example 1×10^{-4} or 0,0001. Physically a bit error ocurs because a *symbol error has* occured. Symbol errors arise from thermal noise, from external interference and from intersymbol interference.If only thermal noise is considered then the symbol error rate (SER) may be calculated unanbiguosly from E_b/N_0 the energy per symbol in joules divided by the noise density in W/Hz measured in the IF bandwith at the modulator input.The higher the value of Eb/N0 the lower the SER. E_b/N_0 may be detrmined from the input value of C / N expressed as a ratio

being $E_b = C\ T_b = C/\ R_b$ (energy received during symbol period)
com R_b a *symbol rate*
and $N_0 = N / B$ (noise density)

$$E_b / N_0 = (C / N) \cdot B / R_b$$

Figure of Merit
Digital radio link 2

- One way to detect errors is through:
  - Parity checking, involves breaking the data stream into a series of blocks, at the transmitter, the number of 1s in that block is counted, and if the number is even, an extra parity 1 is added. At the receiver, each block is checked to ensure that an odd number of 1s has arrived. An even number of 1s indicates presence of error(s) and an ARQ is sent
  - Code violation, refers to bit-to-bit encoding using polarity inversion whenever the bit “1” is sent.If two signals with same polarity have been received that could mean error (and ARQ)
  - CRC-Cyclic redundancy checking, in the transmission the bit feed a counter whose equivalent exists in the reception also allowing to compare them.Case there is differences it is sent ARQ
  - FEC-Forward error correction, based in concolutional code (use on the precedency data to an information to create the code) where the inform sent is enough to allow the error supression and even is correction wi ARQ

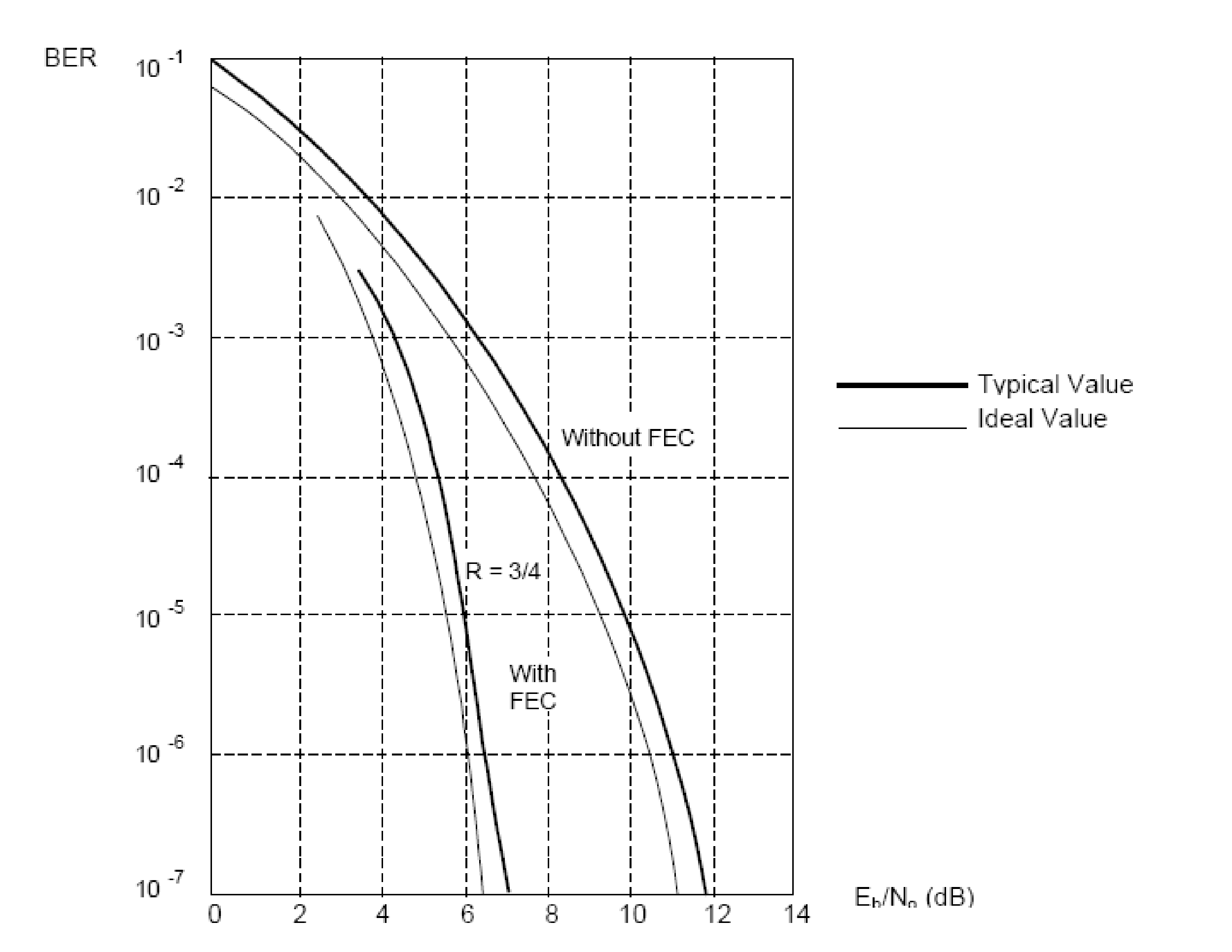
Digital modulation - parity

Ex. sequence to transmit “0111”
Parity “even” to the
combinations 5-6-7, 3-6-7, 3-5-7

ck1	ck2	b3	ck3	b5	b6	b7	
1	0	0	0	1	1	1	Ex. correct sequence
1	0	0	0	1	0	1	Ex. incorrect sequence in b6
1	0	0	0	1	1	0	Ex. incorrect sequence in b7

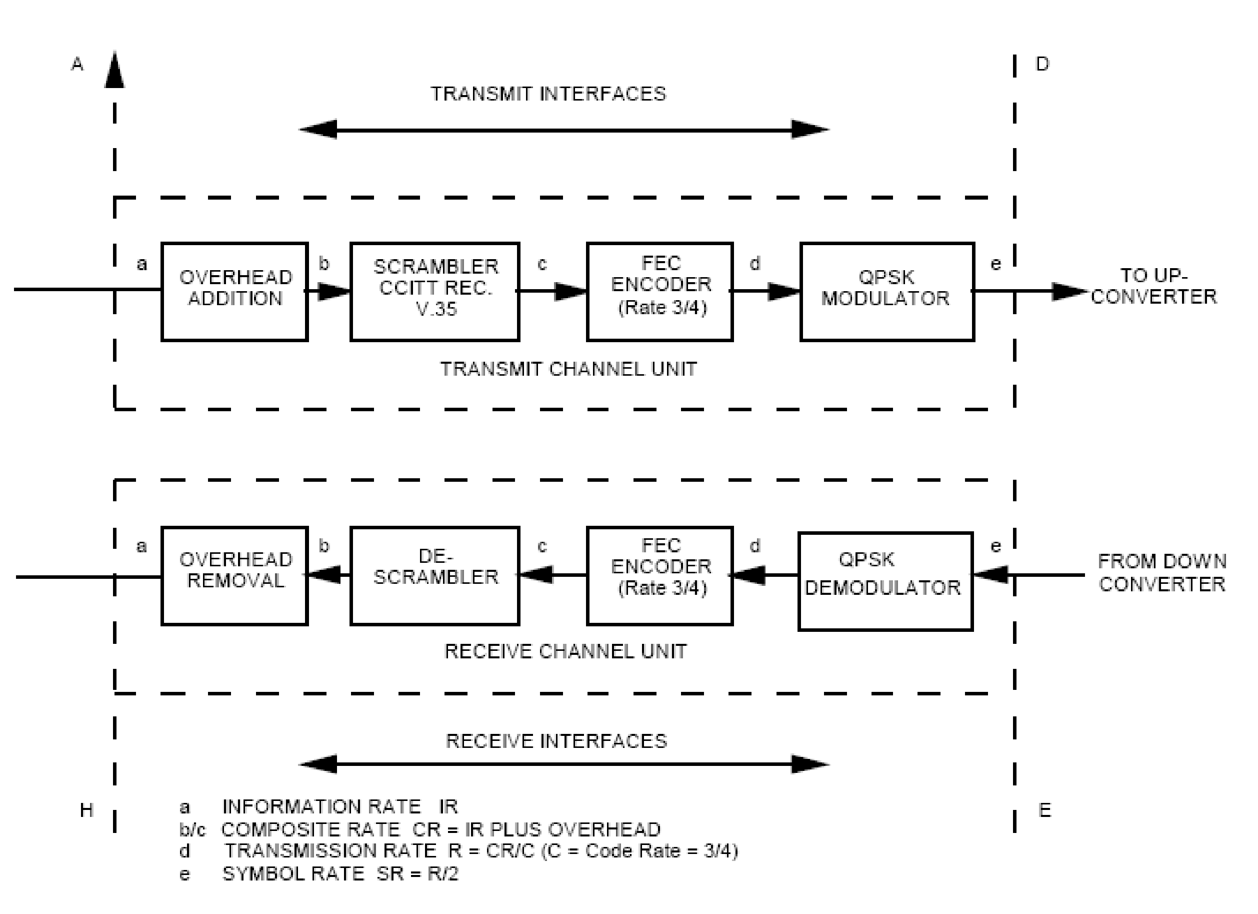
In the detection process we use the paity “even” being
Incorrect parity = “1” and correct parity = “0”

FEC



BER
10 -1
10 -2
10 -3
10 -4
10 -5
10 -6
10 -7
0
2
4
6
8
10
12
14
E_b/N_o (dB)
Without FEC
R = 3/4
With FEC
Typical Value
Ideal Value

FEC - IDR


A
D
TRANSMIT INTERFACES
a
OVERHEAD ADDITION
b
SCRAMBLER CCITT REC. V.35
c
FEC ENCODER (Rate 3/4)
d
QPSK MODULATOR
e
TO UP-CONVERTER
TRANSMIT CHANNEL UNIT
a
OVERHEAD REMOVAL
b
DE-SCRAMBLER
c
FEC ENCODER (Rate 3/4)
d
QPSK DEMODULATOR
e
FROM DOWN CONVERTER
RECEIVE CHANNEL UNIT
RECEIVE INTERFACES
H
E
a INFORMATION RATE IR
b/c COMPOSITE RATE CR = IR PLUS OVERHEAD
d TRANSMISSION RATE R = CR/C (C = Code Rate = 3/4)
e SYMBOL RATE SR = R/2

Voice & Video compression

- In order to more efficiently broadcast or record audio & video signals, the amount of information required to represent the audio signals may be reduced. In the case of digital audio signals, the amount of digital information needed to accurately reproduce the original pulse code modulation (PCM)
- Samples may be reduced by applying a *digital compression algorithm, resulting in a digitally* compressed representation of the original signal.
- The goal of the digital compression algorithm is to produce a digital representation of an audio & video signal which, when decoded and reproduced, sounds the same as the original ignal, while using a minimum of digital information (bit-rate) for the compressed (or encoded) representation.

Vc & Vd compression std's 1

MPEG stands for the Moving Picture Experts Group. is an ISO/IEC working group, established in 1988 to develop standards for digital audio and video formats

- MPEG1 – Designed for up to 1.5 Mbit/sec

  Standard for the compression of moving pictures and audio. This was based on CD-ROM video applications, and is a popular standard for video on the Internet, transmitted as .mpg files. In addition, level 3 of MPEG-1 is the most popular standard for digital compression of audio--known as MP3

- MPEG 2 – Designed for between 1.5 and 15 Mbit/sec

  Standard on which Digital Television set top boxes and DVD compression is based. It is based on MPEG-1, but designed for the compression and transmission of digital broadcast television. The most significant enhancement from MPEG-1 is its ability to efficiently compress interlaced video. MPEG-2 scales well to HDTV resolution and bit rates, obviating the need for an MPEG-3

Vc & Vd compression std's 2

- MPEG 4 – Standard for multimedia and Web compression.

  Is based on object-based compression, similar in nature to the Virtual Reality Modeling Language. Individual objects within a scene are tracked separately and compressed together to create an MPEG4 file. This results in very efficient compression that is very scalable, from low bit rates to very high. It also allows developers to control objects independently in a scene, and therefore introduce interactivity..

- DIV X

  Is a software application that uses the MPEG-4 standard to compress digital video, so it can be downloaded over a DSL/cable modem connection in a relatively short time with no reduced visual quality. The latest version of the codec, DivX 4.0, is being developed jointly by DivXNetworks and the open source community. DivX works on Windows 98, ME, 2000, CE, Mac and Linux.

Vc & Vd compression std's 3

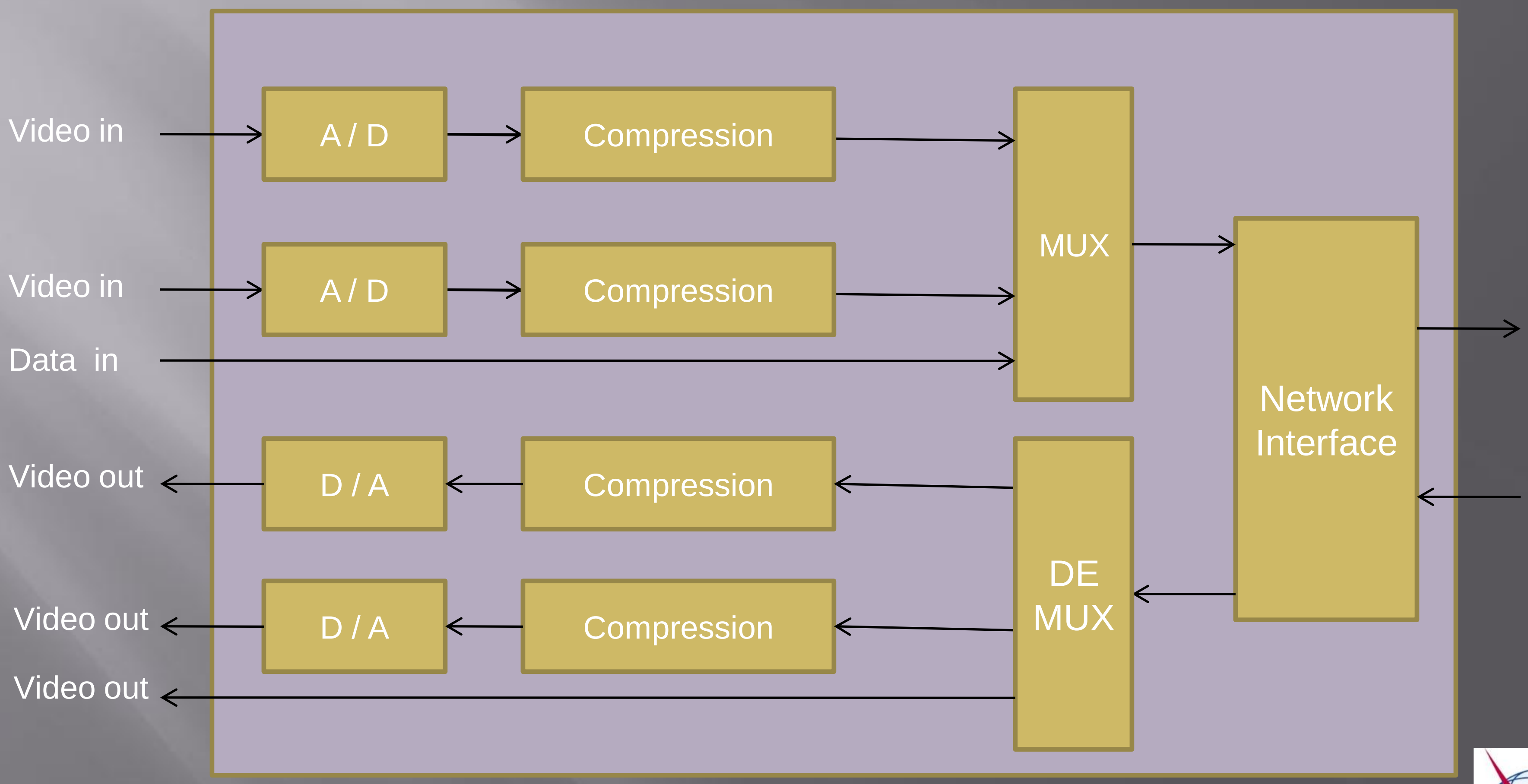
- JPEG – stands for Joint Photographic Experts Group.

  It is also an ISO/IEC working group, but works to build standards for continuous tone image coding. JPEG is a lossy compression technique used for full-color or gray-scale images, by exploiting the fact that the human eye will not notice small color changes.

- DV is a high-resolution digital video format used with video cameras and camcorders. The standard uses DCT to compress the pixel data and is a form of lossy compression. The resulting video stream is transferred from the recording device via FireWire (IEEE 1394), a high-speed serial bus capable of transferring data up to 50 MB/sec.
- H.261 – standard ITU para comunicações video em linhas RDIS (video conferência)

- H.263 – baseado no H.261 tem melhor resolução de video e suporta os protocolos CIF nomeadamente

Audio / Video CODEC



VoIP

Conversation is the “killer aplication” .This statement has characterised the telecommunications market sibe Alexander Bell invented the telephone 10 years ago. We believe that it will still the case in next 2st century. Globally voice minutes will almost double during the next ten years to reach 16 trillion on 2015

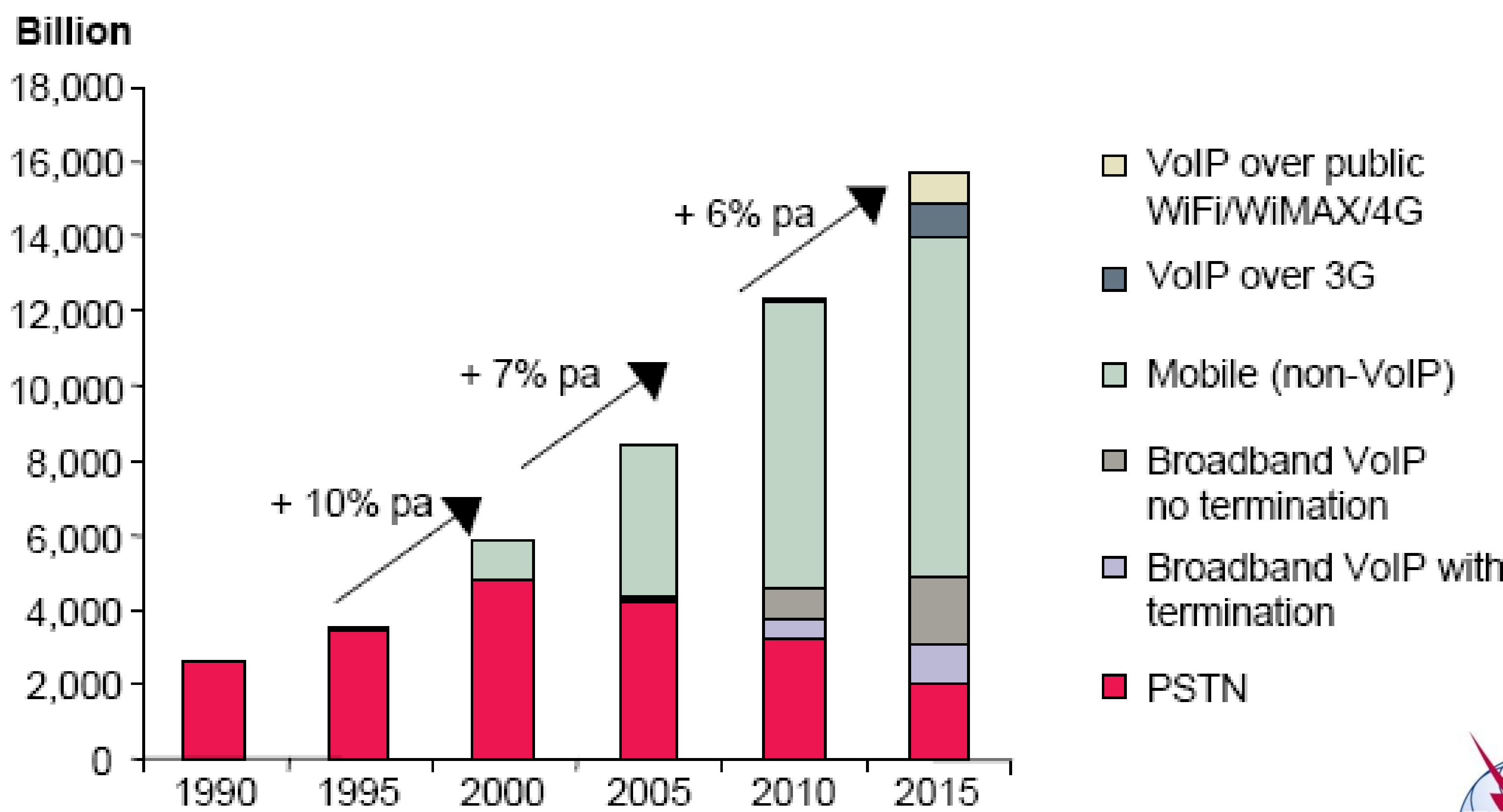
There arte 3 key reasons for this dramatic growth

- Grown on telephony in the developing world
- Emergency of mobile telephony
- Emergency of VoIP

The benefits of IP to conversation will not be as profound as mobile but they again change the way that people communicate. IP will allow conversation to ocurr in many more situations , such as clik-to-talk on websites , e-commerce, instant messaging , interactive gaming, or shared TV watching . By 2015 VoIP over both fixed and mobile will account for almost 30 % of all minutes

IP Technology

Figure 1 **Voice minutes**



Source: Ovum

VoIP components

- Voice quality
- Interoperability
- Security
- Integration with PSTN
- Flexibility
- H.323 standard

VoIP drivers
Layer model

IP Tecnology introduction 1

- For what reason does computers need “packet switching” to communicate instead of telephone“dial”?
- In opposite to the phone call that last in average 3 minues computers need instantaneously (seconds) exchange great amount of information.
- When shall be interrupt communications between computers?Is there any situations where there is advantage to keep the channel established for receotion and sent of data?
- In a phone call both interlocutors agree to terminate call.

  Independently the data instantaneously being sent by computer, against voice, the speed of call initiation has limits, and computers send information to several destinations in a short period of time, needing so s time of connection.

IP Tecnology introduction 2

- The “packet switching” has 2 forms od operation – through virtual circuits (en-to-end connection) – e through datagrams (best effort connection).
  - In a virtual circuit there is the service call set as usual, but there are not so many physical access as the connections , so soem kind of circuits physical share shall be implemnted (in opposite to Circuit swithching) having each packet its destination adress what depends on the ID of the virtual circuit that has been affect to it in the initial phase.
  - In a datagram connection (best effort) the IP world is ecploited as well as other protocols. Althow there is also na access link , there is no more a connection oriented end-to-end once packet are sent to the network , without any more than its IP adresses and the work of the intermediation devices (routers) which decide best way of sent the packet to destination

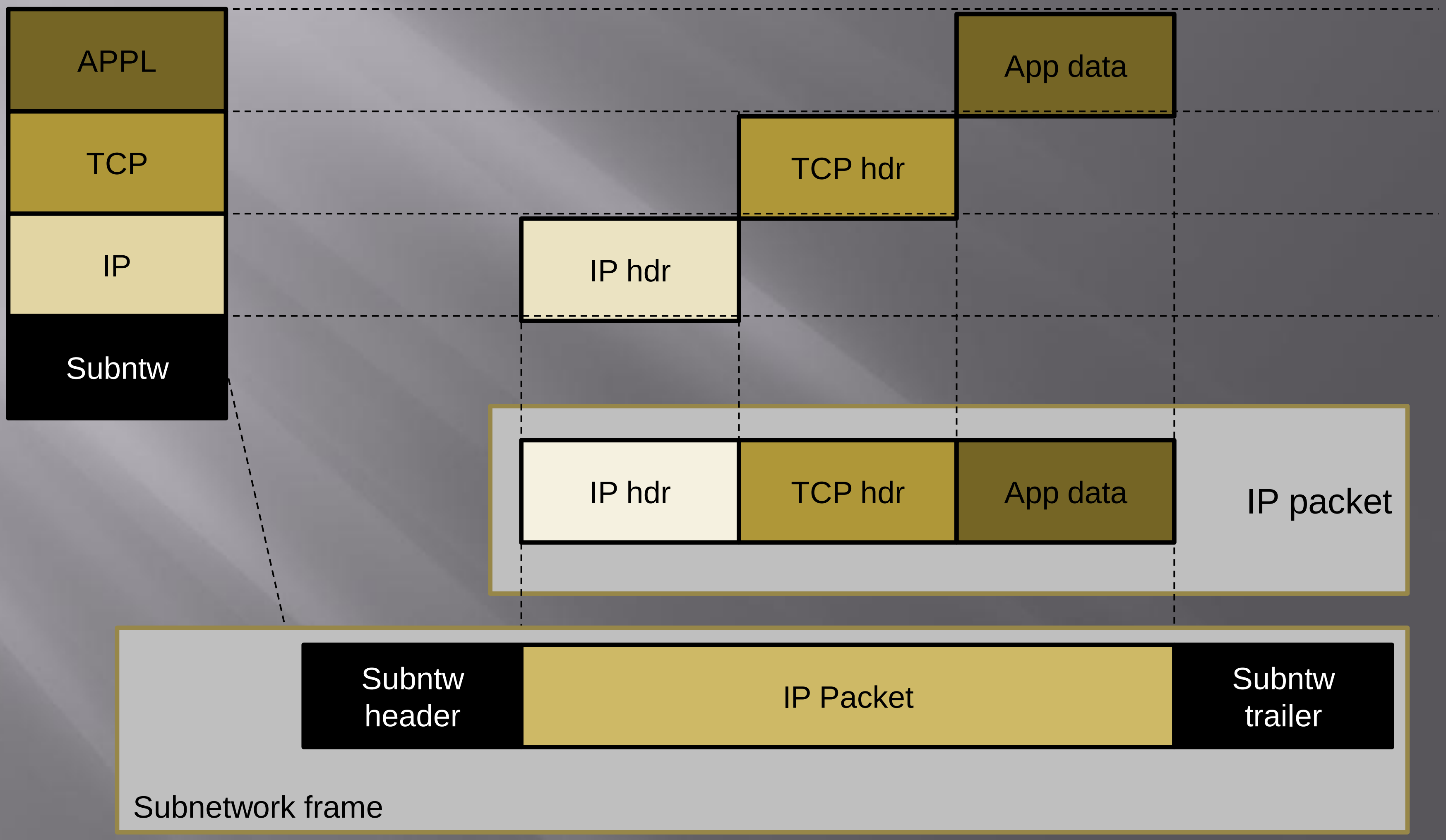
IP Tecnology introduction 3

- Packet switch responsible at network by the routing has been created at 1960 (Paul Baran) and used at ARPANET (Advanced research Projects Agency).
- At 1983 ARPANET satr use TCP/IP having adopted this protocol as the most suitable to packet switching in the real world.
- In the end decade ARPANET become one of the IP uesrs, deactivating his private ntw. At 1990.
- The massive use of Internet reach his maximum with the web pages development allied with use of protocols HTTP-Hiper text transfer protocol (allows one cliente app as Internet Explorer ask directly fpr pages to a one webserver based in HTYML and HTML-Hiper text markup Language which allows format documents with diferents information (multimedia, e.g sound, image, etc) so easly as interconnect documents, what virtualizes the ideia of a big net.
-

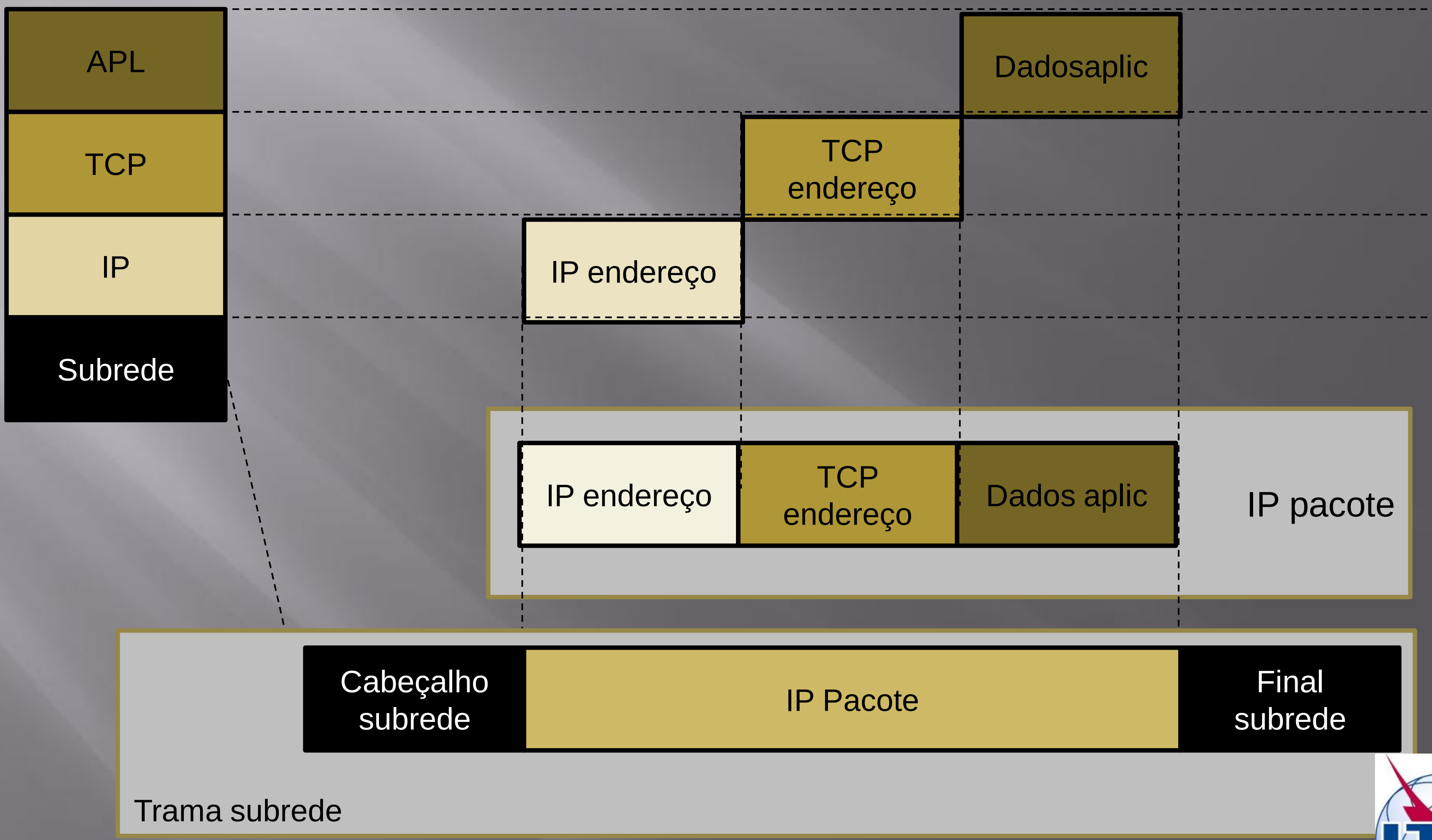
IP Tecnology introduction 4

- When routers speak itself or with small terminals – usually through a LAN they need to agree the way the packets are to be ssent. It is not enough the IP adress, once this is a high level adress, and qhat happens is that the original packets are encapsulated in a specific structure of the network support nemad frame, and is this that knows the router address .
- IP is one protocol by layer, designed to easy data exchange between 2 applications between 2 computers
- The so called sub-networks have its own adresses that the router do know and use to communicate within itself. This shall know the neighbour adresses and its sub-network adresses. To identify and record the the adresses of adjacent router they use specific techniques to learn them .
- We can make a parallel with real life for instance if a person that works on the building X, to speak with another working diferente building (Z for instance) have to know the stret and so on.

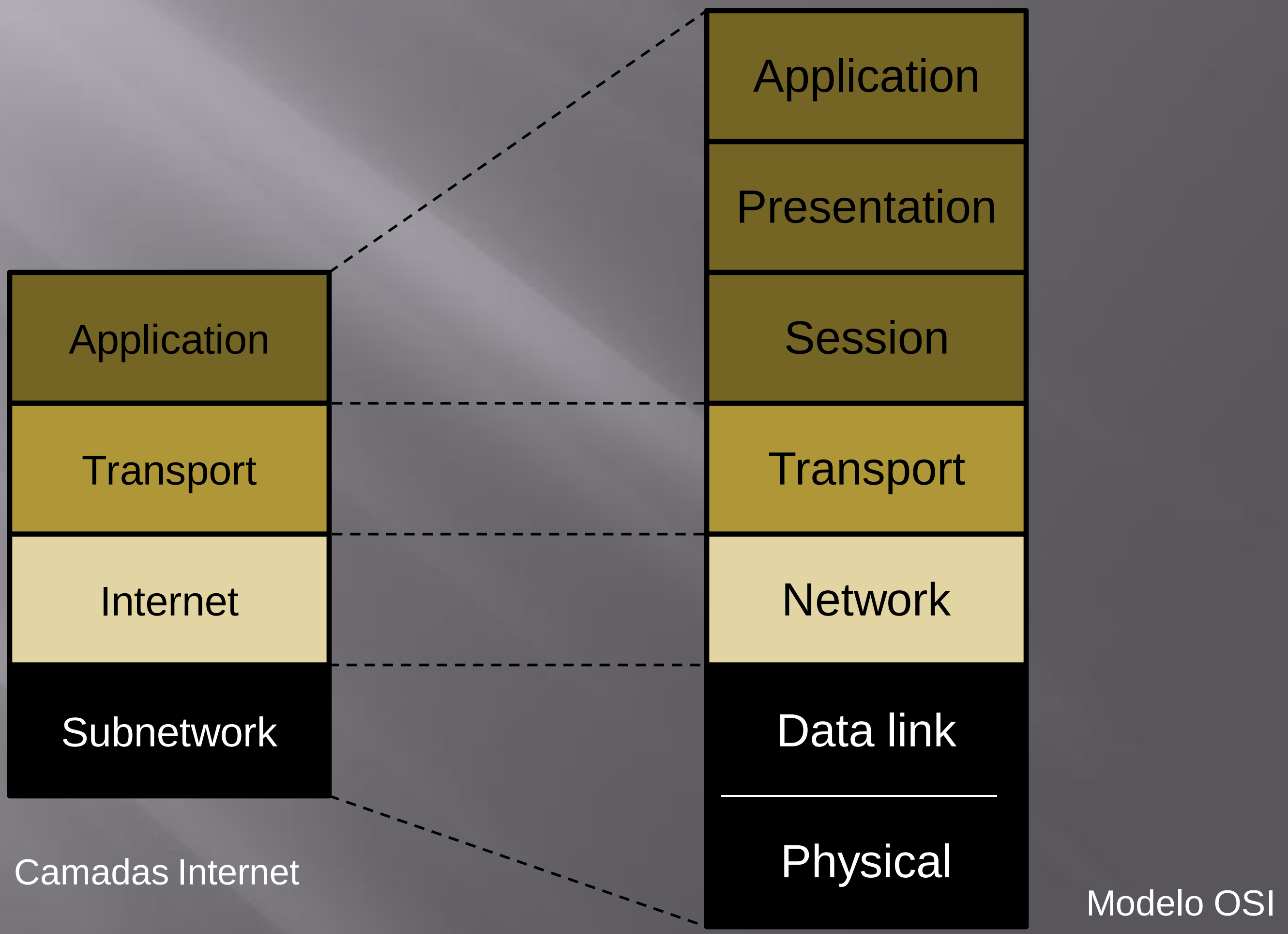
IP Layer


APPL
TCP
IP
Subntw
App data
TCP hdr
IP hdr
IP hdr
TCP hdr
App data
IP packet
Subntw header
IP Packet
Subntw trailer
Subnetwork frame

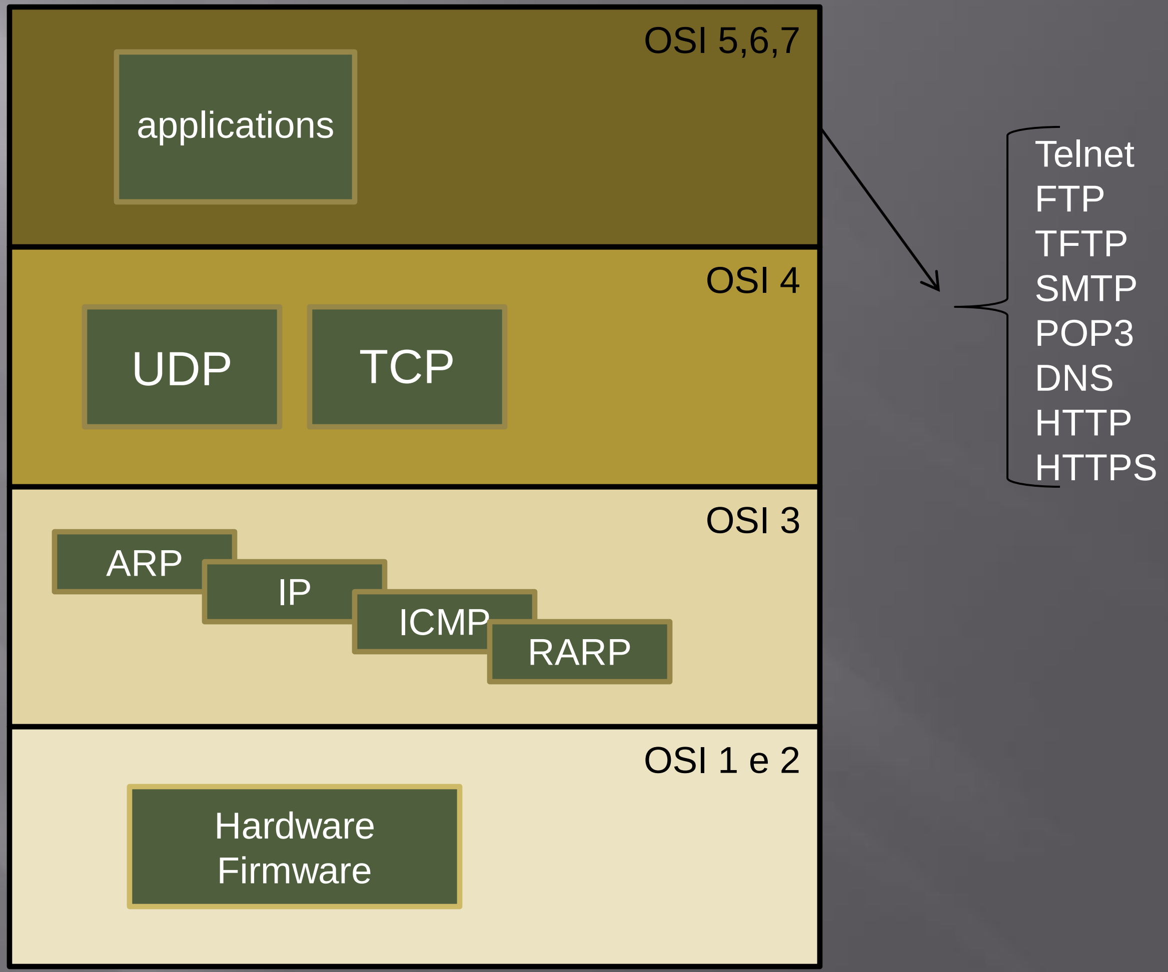
Introd. IP (Camadas & Encapsulamento 2)



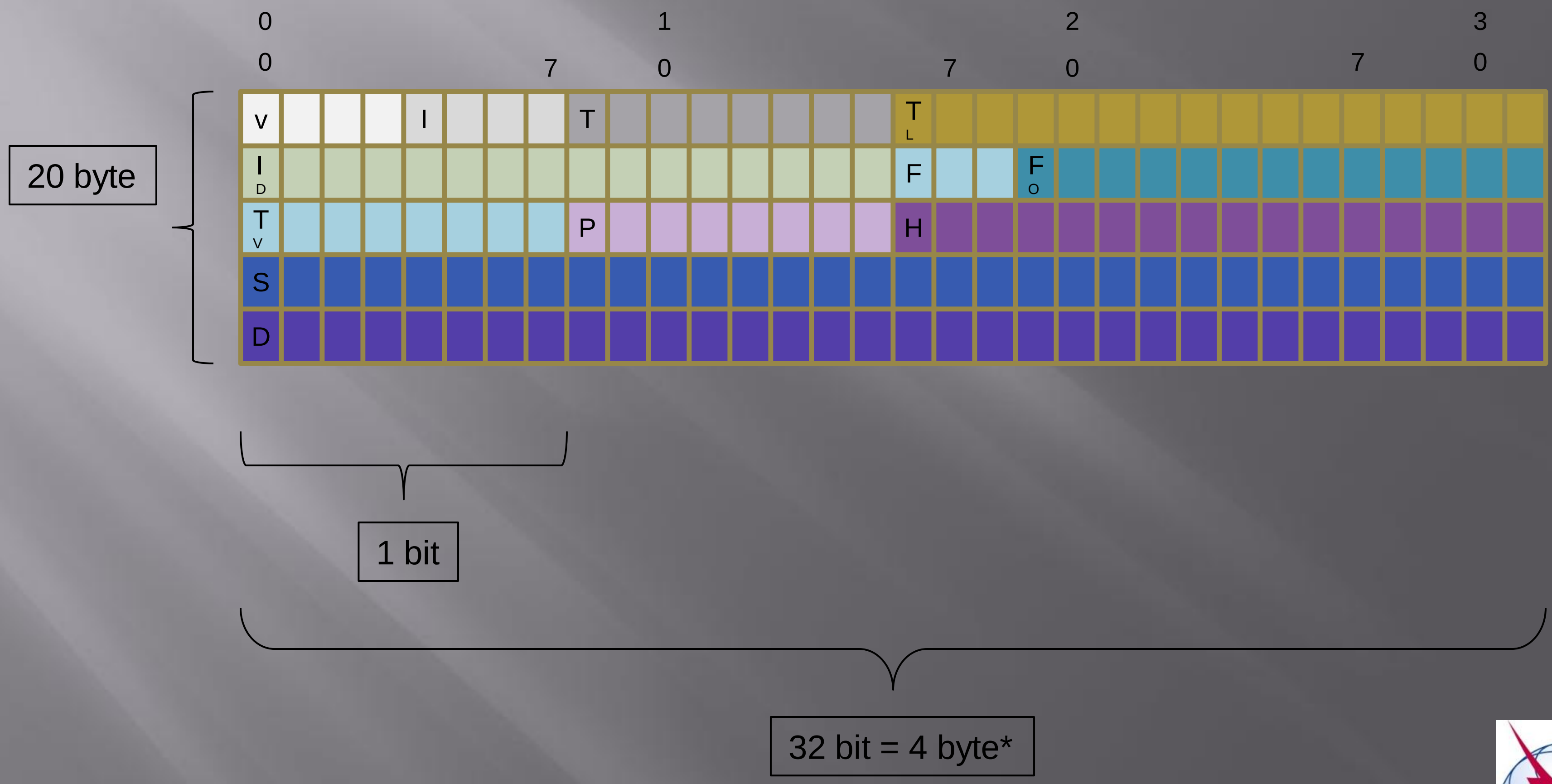
IP Layer Internet vs OSI)



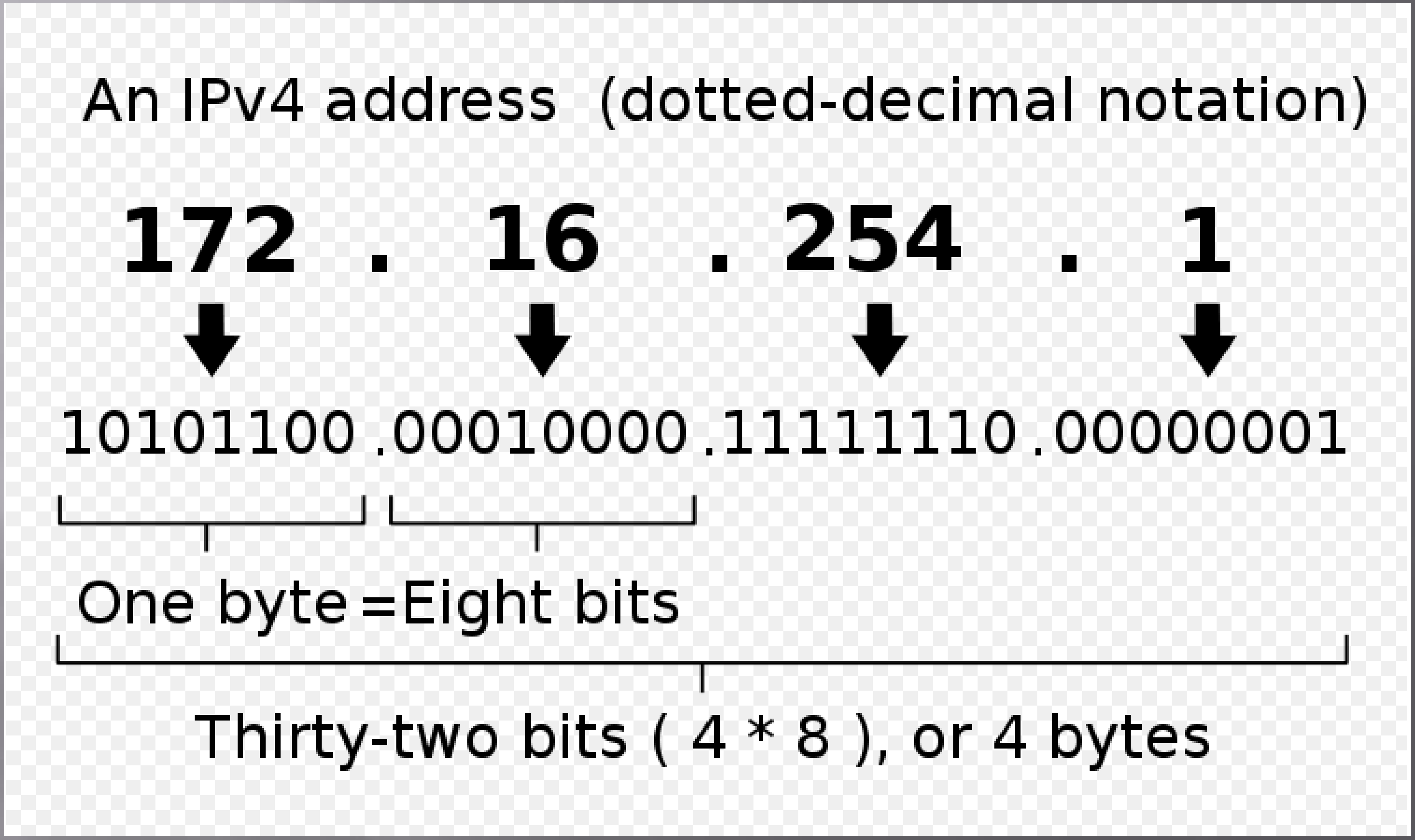
IP TCP architecture



IP Adress



IPv4 adress

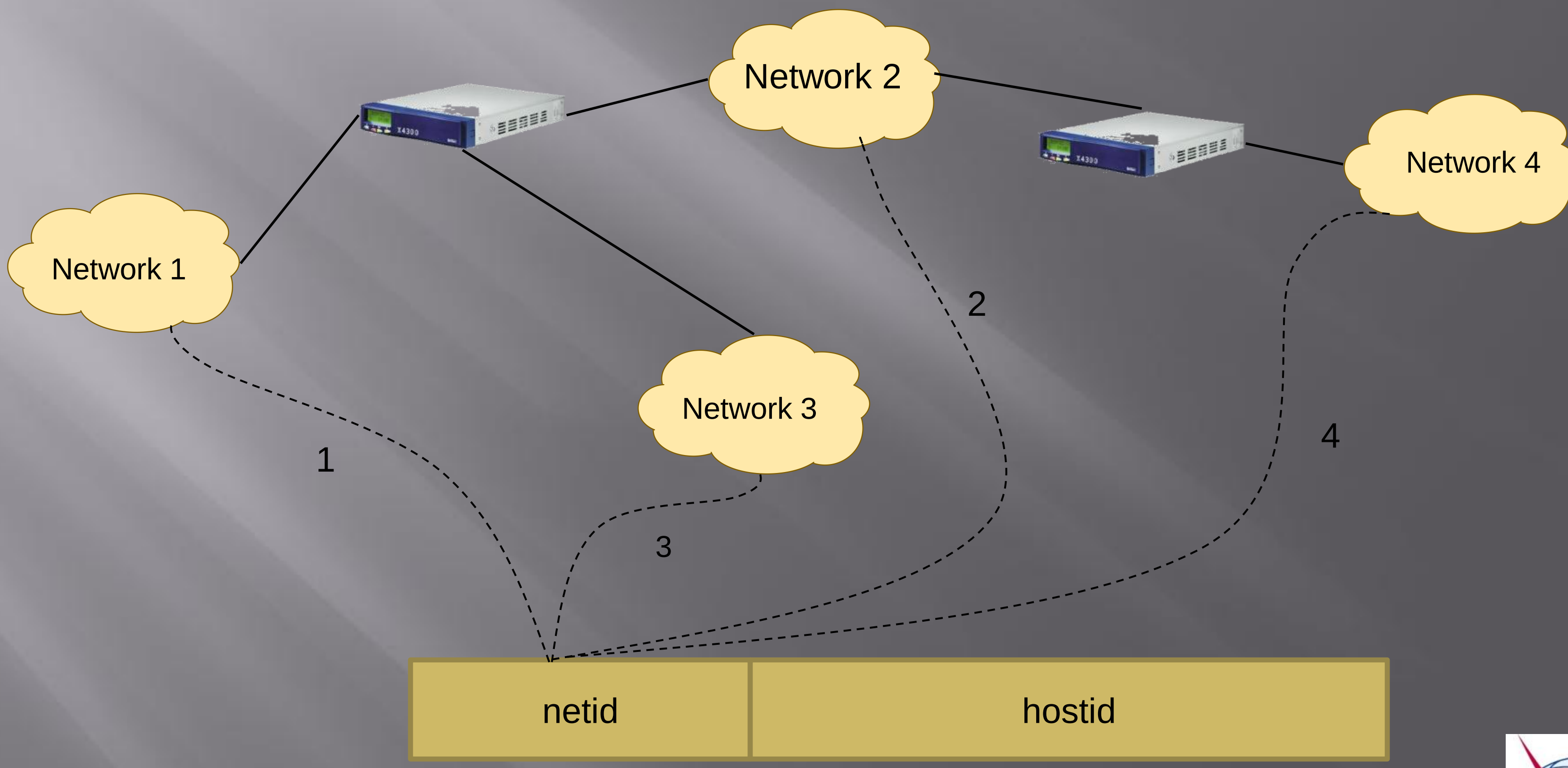


Porque os especialistas prevêm que o espaço de endereçamento IPv4 se esgote em Abril 2012
- neste momento há 300 milhões de endereços disponíveis - investe-se no IPv6 (128 bit = 16 byte)

IP – network example

- One virtual network includes several nets interconnected through “router” “gateways”
- To route IP datagrams router must distinguished them among several logical nets so the IP adresses must have that information
- One nº (n) of bits on the adress bit - *netid* – identifies the a network, and the remainning (32-n) identifie the active element - *hostid* - in the network
- The layered adress makes the function of “*router*” easier, once they have only to remember the information of “*netid”*, what is in much less dimension than “*hostid”.*

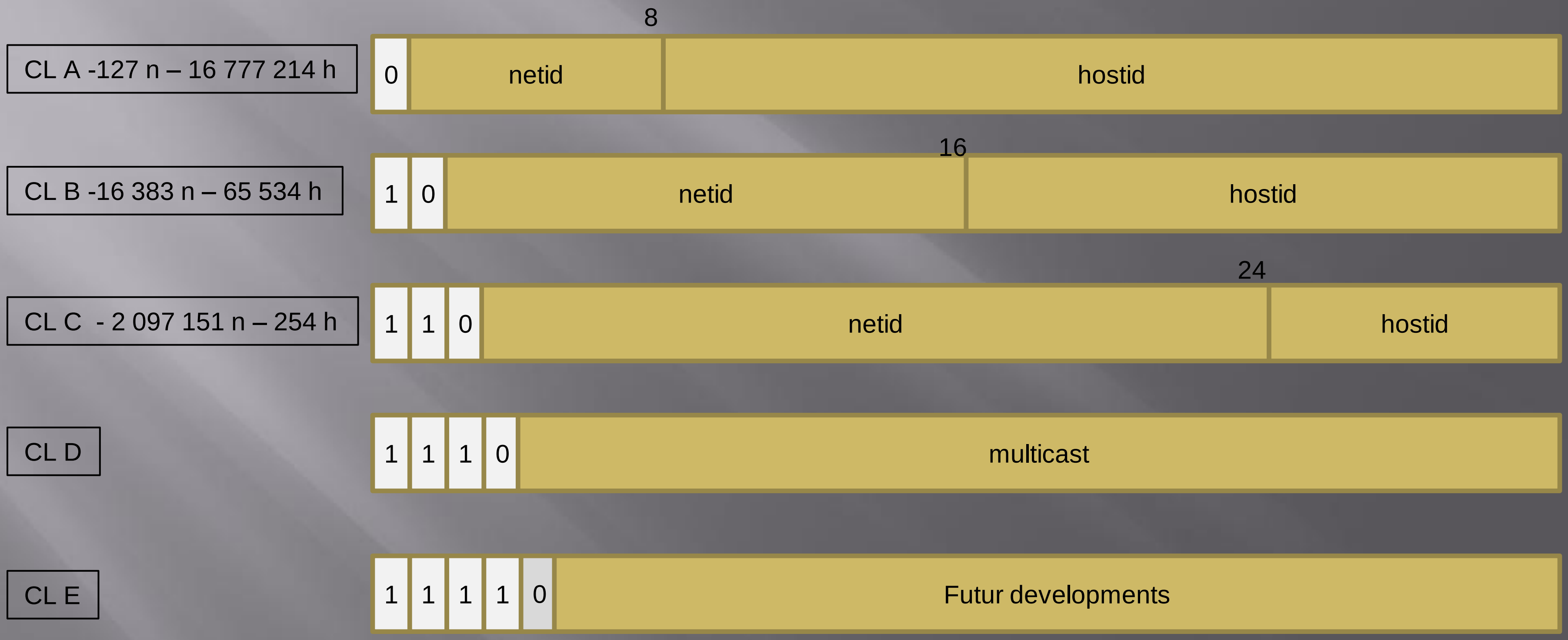
Introduction IP – network example



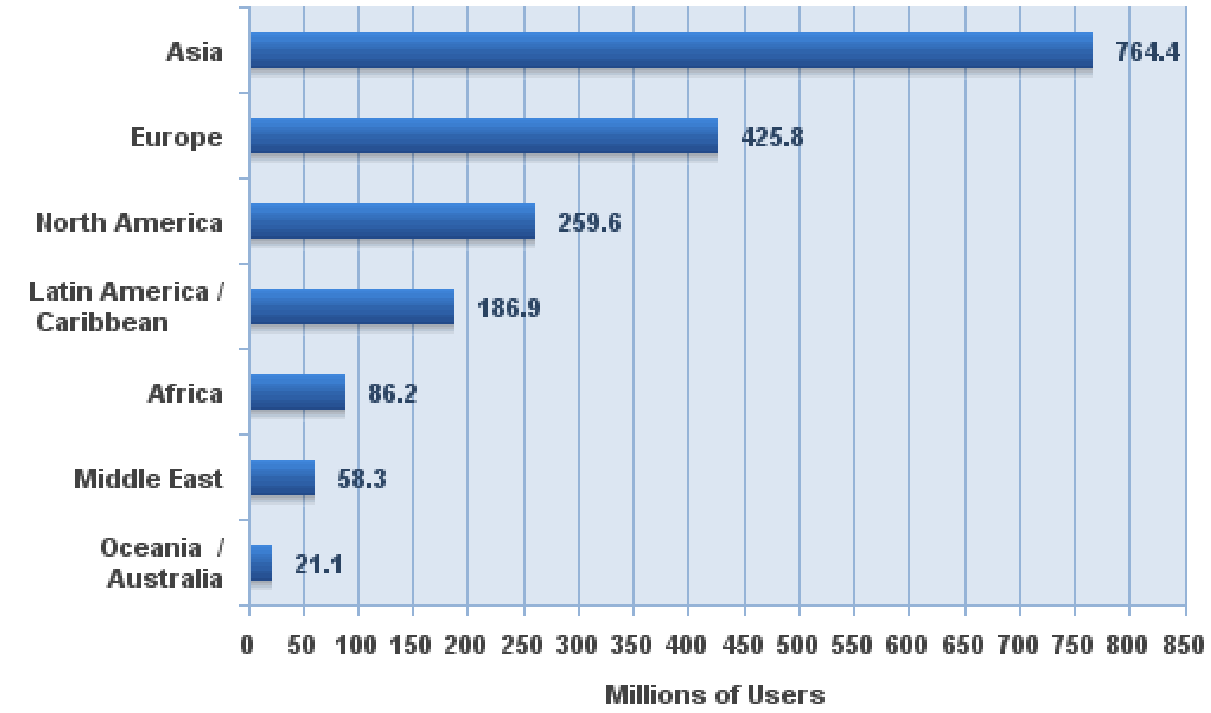
IP Adress classes

- All active elements (host) connected to the same network have the same *netid* but diferent *hostid* , being presented in hexadecimal nºs (split in groups of 4 binary digits to be easier)
- All the networks with the same *netid* have a common prefix, that allows to identify *(1st, 2nd, 3rd byte)* the adress class :
  - Class A – The 1st byte used to *netid* and remaining to *hostid*
  - Class B – The 1st and 2nd byte used to *netid* and remaining to *hostid*
  - Class C – The 1st, 2nd and 3rd byte used to *netid* and remaining to *hostid*
  - Class D – *netid* start by 1 1 1 0
  - Class E - *netid* start by 1 1 1 1 0

IP adress classes



Internet users - 2009



Source: Internet World Stats - www.internetworldstats.com/stats.htm
Estimated Internet users are 1,802,330,457 for December 31, 2009

Frequency band planing
Why?

- Due to the existance of multiple radio transmission systems (terrestrial, fixed, maritime, navigational, astronomics, audio and video broadcasting , mobile systems, radio amateurs and satellite) and to avoid mutual interference, it is fundamental that spectrum be carefully managed (administrated and controlled) national or internacional what can be reached on 3 level:

  - ITU-R (International Telecom Union) (see note)
  - CEPT (Conference of European Post and Telecom)
  - Nacional Regulatory and radiocommunications Agencies (FCC….)

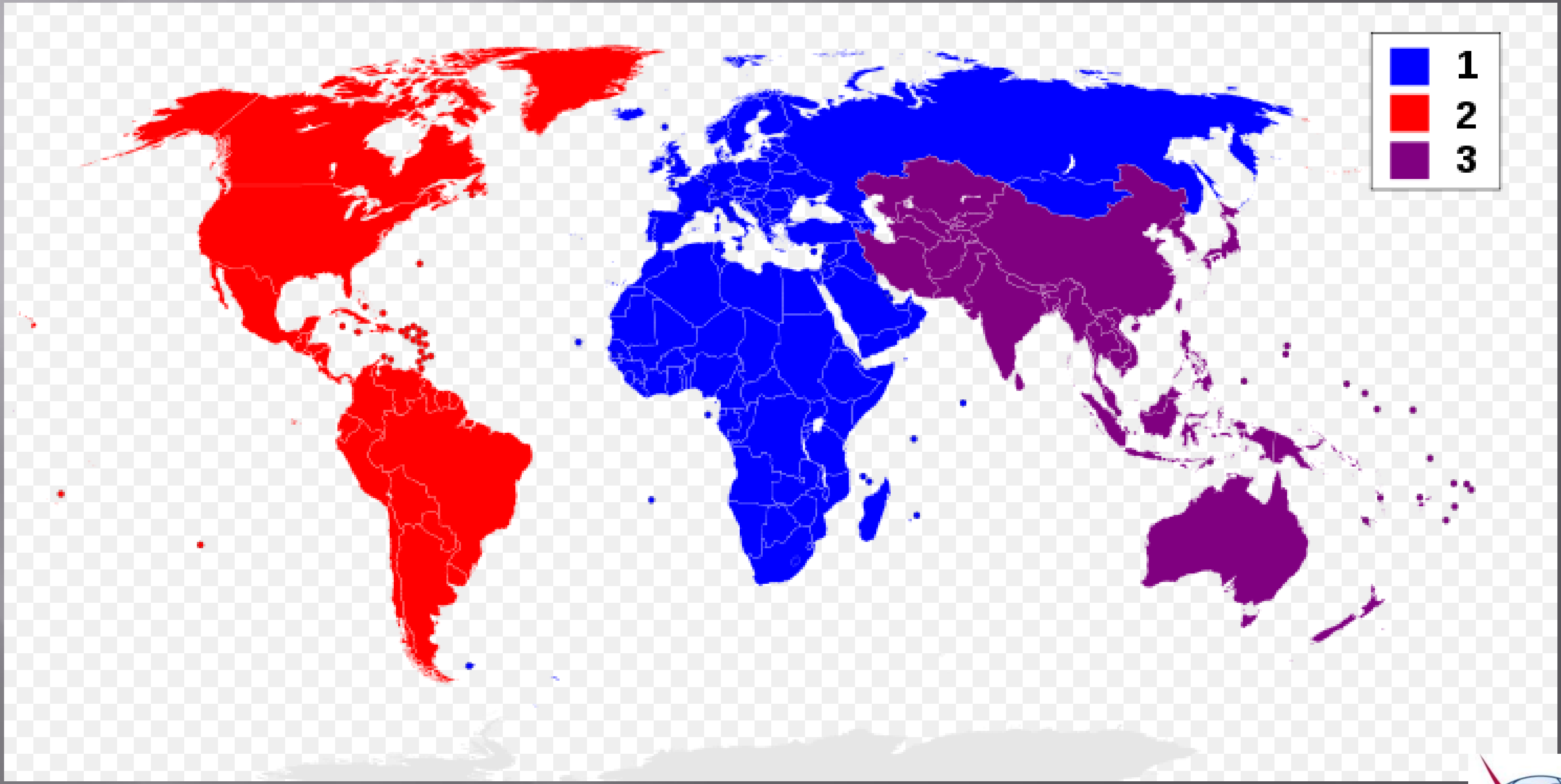
ITU Regions

The band agreed is adjusted every 4 years at WARC-World Administrative radio Conference, being that the world is divided in 3 regions which correspond respectively to America, Europe, Afirca and Asia Pacific, and each country does follow the region to waht is insert.

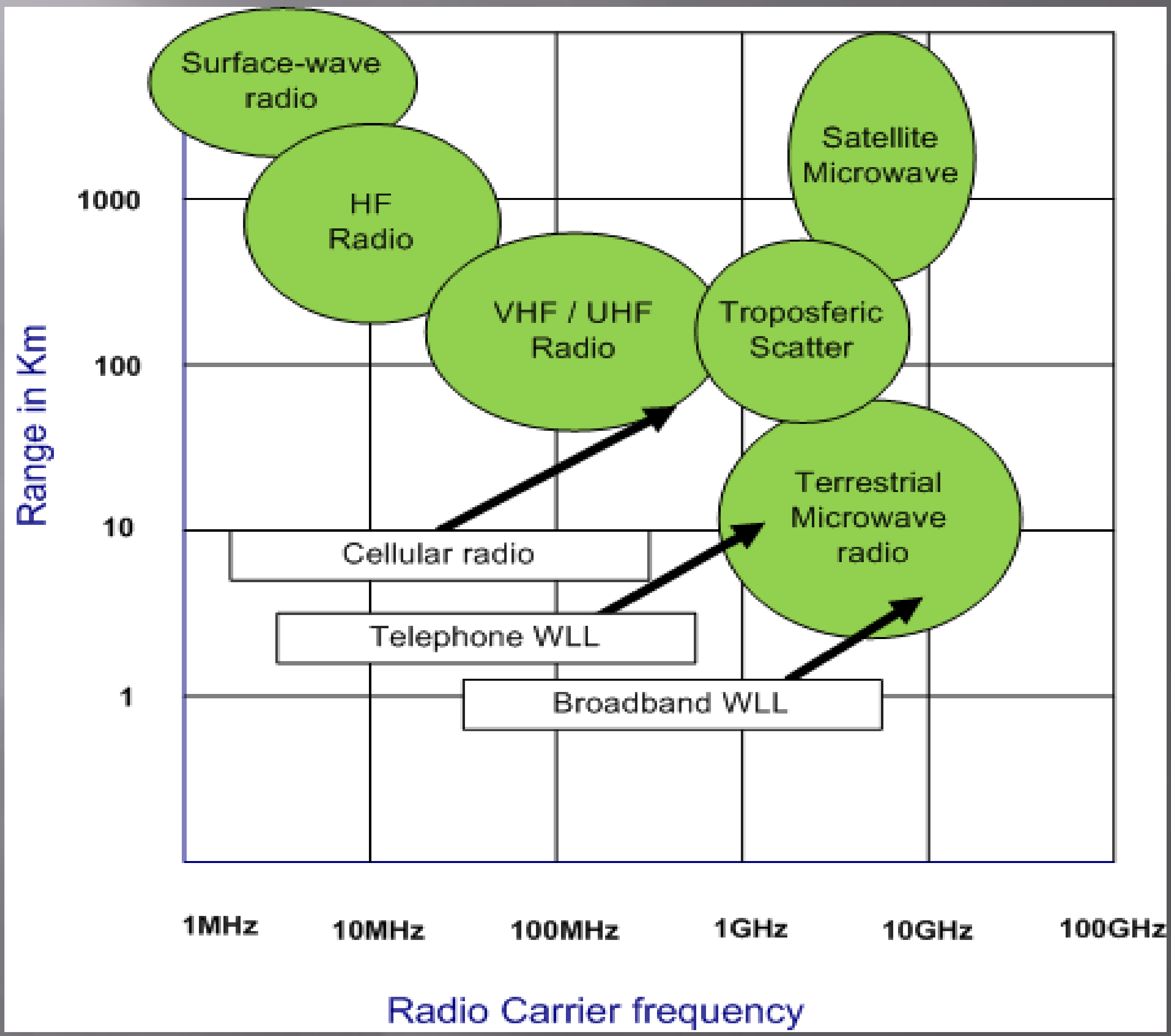
The following systems are world known:

- Long distance point-to-point radio (up to 100Km)
- Short distance point-to-point radio (up to 20 Km)
- Point to multipoint - wll (wireless local loop)
- Uplink e downlink satélite
- Broadcasting (televison, radio)
- Mobile networks (dcs, php, gsm, pcs)
- Military sytems

Regional band harmonized Structure ITU-R



Frequency band planing



Spectrum allocation

The spectrum allocation shall identify the band name (e.g 26 GHz) the mimimum and maximum frequencies (e.g 24,5-26,5 GHz) as well as the structure of the band bem como a estrutura da banda.

The following elements correspond to other possibilities:

- Unidirecional communications (simplex)
- Bidirecional communications (duplex)
- idem (half-duplex)
- bandwith
- Spectral mask
- Spurious emmisions
- Satellite transmssion management

Spectrum alocation - simplex

In a simplex system - today used mainly for broadcasting applications – it is used a “radio channel” for the communication what means the inmformation to be transmitted depends on the spectrum bandwith which has been allocated for the channel

The radio band is sub-divided among the several channel which has allocated the central frequency and all the bandwith, being the channel structure defined by a grid (“*raster”*), that defines the total bandwith and the spacing (save guard band) between adjacent channel

Spectrum alocation - duplex

Full-duplex system allow communications in 2 ways simultaneously using 2 radio channel separated, so the bandwith is the double of simplex. In practice are used 2 channel at position non adjacent being definied the space between frequencies as the *gap* of frequencies (central frequency) of reception and transmission channel. This spacing is calculated to maximize the use of available spectrum.

Half-duplex system allow both way communications but not simultaneously because de same radio channel is used for both ways.

Spectrum allocation – mask 1

- To guarantee several operators or several equipment of one operator share the same radio band is necessary that specifications and technical standard be respected (imposed by FCC, IEEE, ETSI..) according to a spectral mask.
- In fact shall be assured radio emissions of one transmitter doesn’t interfere with operation of third party, that could work in adjacent channel.This way the spectral mask defines the maximum power can be radiated in every frequncies of the same channel

Spectrum allocation - satellite

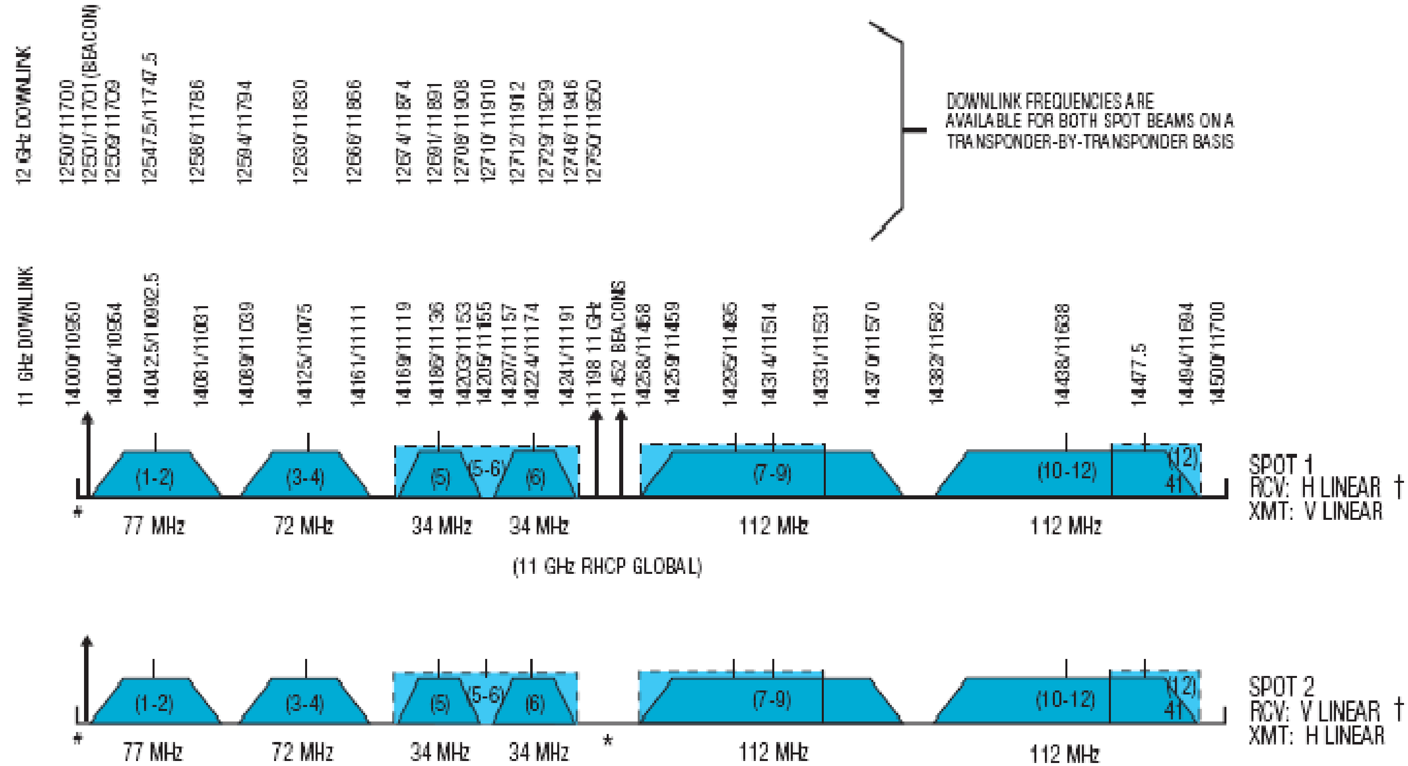
- Being the satellite transmission one variant of fixed radio communications, it is very important what is being done at both terminations, or earth stations as well as in the satellite itself. This communications as we’ve seen are mainly PTP, PMP and bradcast.
- The band allocation and new satellite planing is made annualy at the GTM-Global Traffic Meeting in Washington, where the operators identify for a large period (5-10 years) is needs in telecommunications

bands planning (Intelsat)

Frequency	UL or DL	Remarks
3400-4200 MHz	Downlink	Normal Band C
5850-7075 MHz	Ulpink	S Band+ C + C upper
7520-7750 MHz	Downlink	lower Ku Band
7900-8400 MHz	Ulpink	Lower Ku Band
12,20-12,75 GHz	Downlink	Upper Ku band , D Band
13,75-14,40 GHz	Ulpink	Ku Band
18,80-19,30 GHz	Downlink	Ka Band
28,60-29,10 GHz	Ulpink	Ka Band

Intelsat VIII Transponder Layout

(Ku-Band)



Notes:
1. Refer to the IESS-417 document for more detailed information.
2. * On spot 11 GHz downlink there is a 250 MHz gap between (5-6) and (7-8) (7-9) (11,200-11,450 MHz).
3. # On spot 12 GHz downlink there is a 9 MHz Guardband before (1-2) to accommodate the beacon.
4. †The polarization senses of each spot beam can be changed by ground command independent of the other spot beam.
5. The 11 GHz or 12 GHz spot frequencies may be selected independently for each beam and each channel.
6. The 12 GHz beacons are transmitted through the communications antennas and are of the same transmit polarization.

Transponder Saturation e.i.r.p. at Beam Edge in dBW

Description	Intelsat VI	Intelsat VII	Intelsat VII-A	Intelsat VIII	Intelsat VIII-A	Intelsat IX	Intelsat X
C-Band Global	26.5; 23.5 in Channel 9	26; 29 in Channel 12[1]	29[1]	29	N/A	31	32
C-Band Spot	N/A	33.3; 36.3 in Channel 12[2]	36.1[2]	N/A	N/A	N/A	N/A
C-Band Hemi and Zone	31; 28 in Channel 9	33[4]	33[4]	34.5	37.5 for Hemi only	36/37[4,5]	37
Ku-Spot 1 or East Spot	44.7[3]	43.4 at 35W 44.6 at 50W	44.7 at 49W 47.2 at 2 x 49W	44.0	49.7	47	47.7
Ku-Spot 1X	N/A	N/A	44.8 at 49W 47.1 at 2 x 49W	N/A	N/A	N/A	N/A
Ku-Spot 2 or West Spot	41.7[3]	41.4 at 35W 42.6 at 50W	43.7 at 73W 46.1 at 2 x 73W	44.0	N/A	47	47.7
Ku-Spot 2X	N/A	N/A	43.4 at 73W 45.6 at 2 x 73W	N/A	N/A	N/A	N/A
Enhanced Ku-Spot 2/2A	N/A	41.2 at 50W	42.2 at 73W 44.3 at 2 x 73W	N/A	N/A	N/A	N/A
Ku-Spot 3	N/A	43.0; 43.3 in ch 7-9, 10-12 at 35W 44.5; 44.8 in ch 7-9, 10-12 at 50W	41.0 at 49W 42.7 at 73W 43.2 at 2 x 49W 44.9 at 2 x 73W	N/A	N/A	N/A	S3/3X: 46.7

NOTE: [1] Intelsat VII/VII-A Global transponder e.i.r.p. in Channel 9A is 28.5/28.0 dBW and in Channel 9B is 26.0/26.0 dBW.
[2] Intelsat VII and VII-A C-Spot transponder e.i.r.p. in Channel 9A is 36.5/35.2 dBW and in Channel 9B is 34.3/33.2 dBW.
[3] The Intelsat VI e.i.r.p. for Channel (9-12) is 3 dB higher.
[4] Refer to the IESS 410 document for more detailed information.
[5] The Intelsat 902-905 and 907 satellites have a minimum beam-edge e.i.r.p. of 37 dBW; the Intelsat 901 and 906 satellites have a minimum beam-edge e.i.r.p. of 36 dBW.

Comparison of the Communications Subsystems

Description	Intelsat VI	Intelsat VII	Intelsat VII-A	Intelsat VIII	Intelsat VIII-A	Intelsat IX		Intelsat X
Prime Contractor	Hughes Aircraft Company	SS/Loral	SS/Loral	Lockheed Martin	Lockheed Martin	SS/Loral	SS/Loral	ASTRIUM
Spacecraft Designation	601, 603, 605	701, 702, 704, 705, 709	706, 707	801, 802	805	902-905 & 907	901 & 906	10-02
Year of First Launch	1989	1993	1995	1997	1998	2001	2001	2004
Number of Transponders: C-Band Ku-Band	38 10	26 10	26 14	38 6	28 3	47 14	42 14	45 16
Maximum Marketable Capacity (in equivalent 36 MHz units)	C-Band: 64 Ku-Band: 24	C-Band: 42 Ku-Band: 20	C-Band: 42 Ku-Band: 28	C-Band: 64 Ku-Band: 12	C-Band: 36 Ku-Band: 6	C-Band: 76 Ku-Band: 22	C-Band: 72 Ku-Band: 23	C-Band: 61 Ku-Band: 32
C-Band Beam Coverages	2 Hemi, 4 Zone, Global A and B	2 Hemi, 4 Zone, Global A and B, C-Spot A and B	2 Hemi, 4 Zone, Global A and B, C-Spot A and B	2 Hemi, 4 Zone, Global A and B	Landmass Hemi A and B	2 Hemi, 4 or 5 Zone, Global A and B	2 Hemi, 4 Zone, Global A and B	3 Hemi, 2 Zone Global A and B
Ku-Band Beam Coverages	West Spot and East Spot	Spot 1, Spot 2, Enhanced Spot 2/2A, and Spot 3	Spot 1/1X, Spot 2/2X, Enhanced Spot 2/2A, and Spot 3	Spot 1 and Spot 2	Spot 1	Spot 1 and Spot 2	Spot 1 and Spot 2	Spot 1 Spot 2 Spot 3/3X
Operating Frequency Band for C-Band (in MHz)	Uplink: 5850 to 6425 Downlink: 3625 to 4200	Uplink: 5925 to 6425 Downlink: 3700 to 4200	Uplink: 5925 to 6425 Downlink: 3700 to 4200	Uplink: 5850 to 6425 Downlink: 3625 to 4200	Uplink: 5890 to 6650 Downlink: 3400 to 4200	Uplink: 5850 to 6425 Downlink: 3625 to 4200		Uplink: 5850 to 6425 Downlink: 3625 to 4200
Operating Frequency Band for Ku-Band (in GHz)	Uplink: 14.0 to 14.5 Downlink: 10.95 to 11.2 plus 11.45 to 11.7	Uplink: 14.0 to 14.5 Downlink: 10.95 to 11.2 or 11.7 to 11.95 or 12.5 to 12.75 plus 11.45 to 11.7	Uplink: 14.0 to 14.5 Downlink: 10.95 to 11.2 or 11.7 to 11.95 or 12.5 to 12.75 plus 11.45 to 11.7	Uplink: 14.0 to 14.5 Downlink: 10.95 to 11.2 or 11.7 to 11.95 or 12.5 to 12.75 plus 11.45 to 11.7	Uplink: 14.0 to 14.25 Downlink: 12.5 to 12.75	Uplink: 14.0 to 14.5 Downlink: 10.95 to 11.2 plus 11.45 to 11.7		Uplink: 13.75 to 14.5 Downlink: 10.95 to 11.2 plus 11.45 to 11.7 plus 12.5 to 12.75
Extent of Frequency Reuse in Hemi/Zone	6-fold; with a 4-fold option on a Channel-by-Channel	4-fold with enhanced Zone connectivity	4-fold with enhanced Zone connectivity	6-fold; with a 5-fold option for the POR	2-fold in Hemi only	6-fold; except in Channels (1-2) and (3-4) which are 7-fold	6-fold	5 fold

C Band versus Ku Banda 1

C band was the first to be used in satellite systems and only when this space has been scarcy (where his re-use by terrestrial links worlwide increased the problem) Ku band has been adopted.

Ku band is tipically used for broadcasting and for Internet bidirecional communications , with the advantage of the satellite having high power transmitter (size of antenna diameter and RF unit more easy)

C Band versus Ku Banda 2

C band

- Down Link : 3,7 - 4,2 GHz
- Up Link : 5,9 - 6,4 GHZ
- Advantages : More imune to heavy rain
  bandwith cheaper
  satellite footprint global
- Disadvantages : larger antenna diameter
  expensive RF units
  expensive hardware
  more prone to terrestrial link interferences

C Band versus Ku Banda 3

Ku band

- Down Link : 11,7 - 12,2 GHz
- Up Link : 14,0 - 14,5 GHz
- Advantages : more prone to terrestrial link interferences
  less diameter antenna (+/- 90 cm)
  easier and cheap RF units
- Disadvantages : expensive bandwith
  less imune to heavy rain,
  although may be balanced through > diam
  antennas

Extended Band

	DOWNLINK FREQ (GHz)	UP-LINK FREQ (GHz)
S BAND	2.555 to 2.635	5.855 to 5.935
Extended C Band (Lower)	3.4 to 3.7	5.725 to 5.925
C Band	3.7 to 4.2	5.925 to 6.425
Extended C Band (Upper)	4.5 to 4.8	6.425 to 7.075
Ku Band	10.7 to 13.25	12.75 to 14.25
Ka Band	18.3 to 22.20	27.0 to 31.00

Network Design

- Basic concepts
- Single access
  - Unidirecional
  - Broadcasting
  - Bidirecional
- Multiple access
  - FDMA
  - TDMA
  - CDMA
- Multibeam satellite *(regenerative multibeam)*

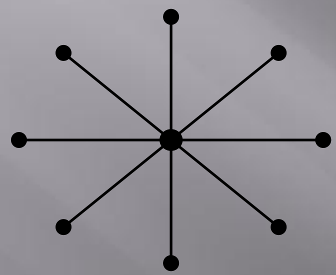
Network design 1 (basic)

- Basic concept for communications between 2 point is a direct connection. If the number of terminals increases more the complexity for the design and some specification shall be apllied to define if A connects only with B or if also with B and C or this last is connected aonly via B.
- Assume for instance the connection of all the terminals among them e.g:
  - n x (n-1) / 2 (sendo n o nº de nós)
  - o que para 5 nós daria 10 ligações e assim sucessivamente

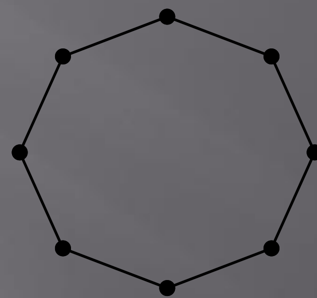
Network design 2 (basic)

- We are discussing the type of network and its associated cost of implementation
- The covered area can be LAN, WAN, MAN if we refer to a dispersion of users of up to 5Km, about 50Km or above.
- Generically the topology to be used is in the following slide

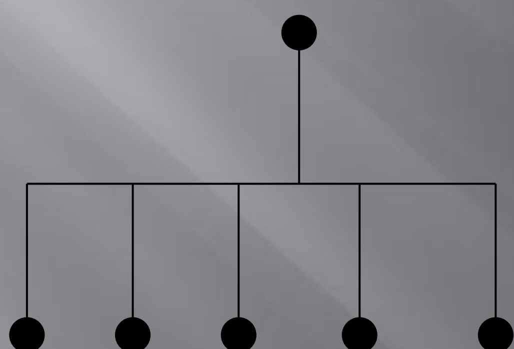
Network design 3 (basic)



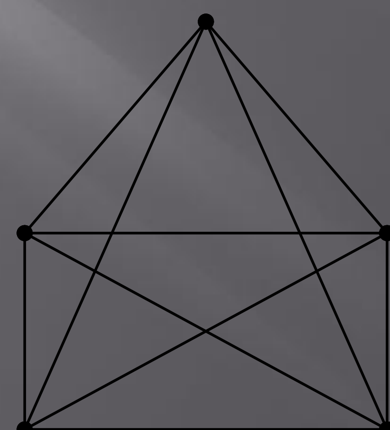
Star – critical central node



Ringl – Very common LAN
critical if 1 node fails



Bus - Common LAN, easy node increase
allow control by one node



Hybrid – Common WAN and MAN,
allow complete redundancy

Network design 1 (single access)

The easiest and cheap way of direct interconnect one-to-one or more terminals is through a satellite link. Such situation is not although the most used once there are several terminals simultaneously working .

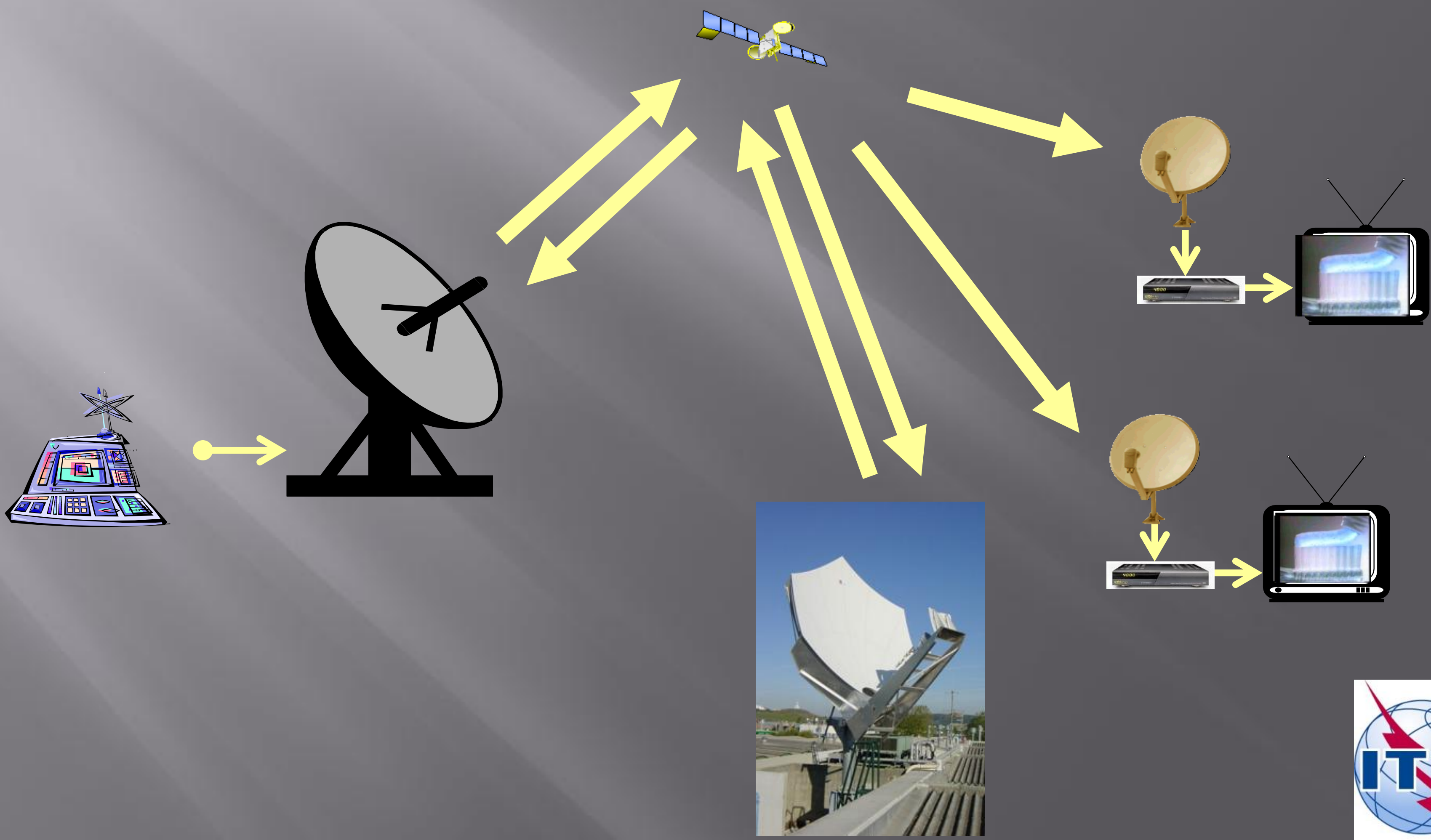
Unidirecional link

- The transponder (repeatear) shall assure separation between input and output signals once both are continually presents and the antenna doesn’t has enough narrow, beams.

Network design 2 (single access)

- Broadcasting link
  - Reception area is shared by several terminals located in the *downlink* area*.* If the transmission terminalis in the same area, there is a double function, being mandatory to exist a *duplexer* and diferent tunning for the *uplink* and *downlink*
- Bidirecional Link between 2 terminals
  - Basically implies double equipment compared with unidirecional *(2 uplink e 2 downlink e 2 transponder)* being actually used the simplest configuration with one transponder (repeater) and 2 antenas (with *duplexer* and dual polarizations)

Network design 3 (Single acess)



Network design 4 (Multiple acess)

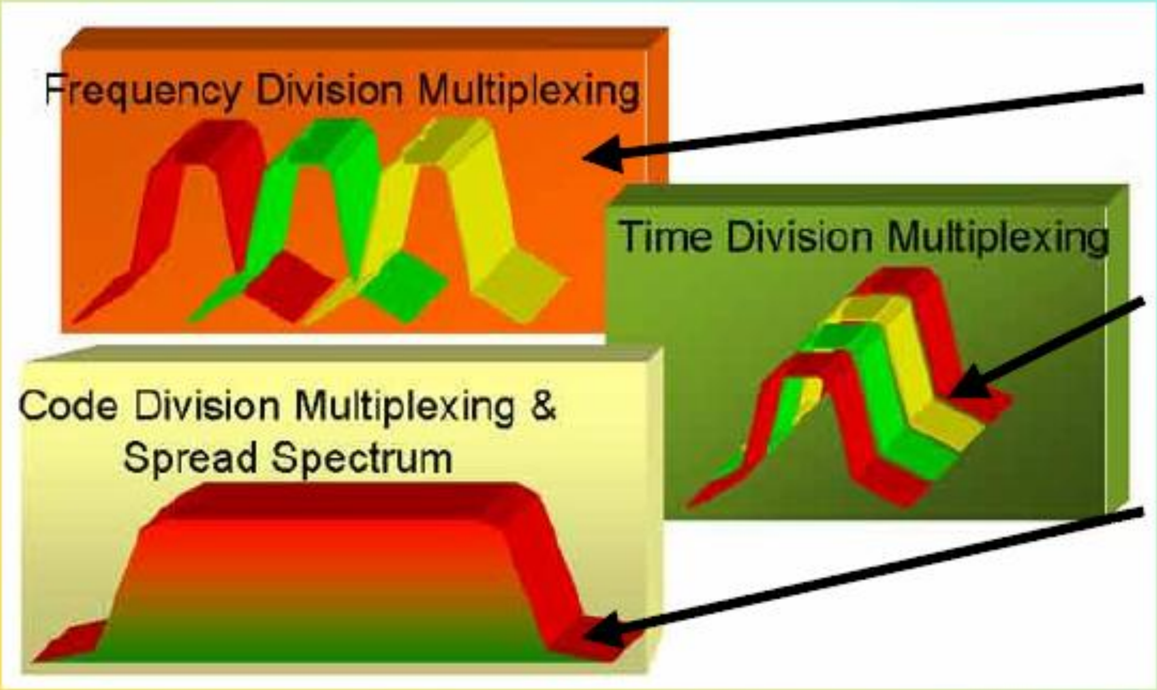
- Multiple access is the ability of a large number of earth stations to simultaneously interconnect their respective voice, data and television through a satellite, the basic problem involved is how to permit a changing group of earth stations to share a satellite in a way that optimizes, <u>satellite capacity , spectrum utilization, satellite power, interconnectivity, flexibility, adaptability to diferente traffic mixes, cost and user acceptability</u>
- In the downstream way same signal is distributed to all terminals, being responsability of each to determine and decode its component (whenever it would be in frequency, time, or hybrid domain)
- In the upstream way things are more complicated once the bandwith has to be shared by all terminations and the transmission with interference. The scheme “multiple access” consists in each group of stations transmit in its own frequency, time or hybrid e.g each station group launch diferenciated link in the satellite recpetion channel.

Network design 5 (Multiple acess)

There are 3 main basic forms of multiple acces:

- FDMA - Frequency Division Multiple Access the band spectrum allocated is divided into channels, having each one one own frequency.If the channel is permanently assigned (*Fixed assignment)* or on request (*Dynamic Demand assignement*so we have FDMA/FA ou FDMA/DA
- TDMA - Time Division Multiple Access the common channel frequency in the *upstream* is shared by all remote, being each one authorized to trasmit in it own time (slots). This way the channel is shared in *time division*. Also the alternatives TDMA/FA ou TDMA/DA
- CDMA – Code Division Multiple Access all the stations use the same channel at same time, being the separação made through codes

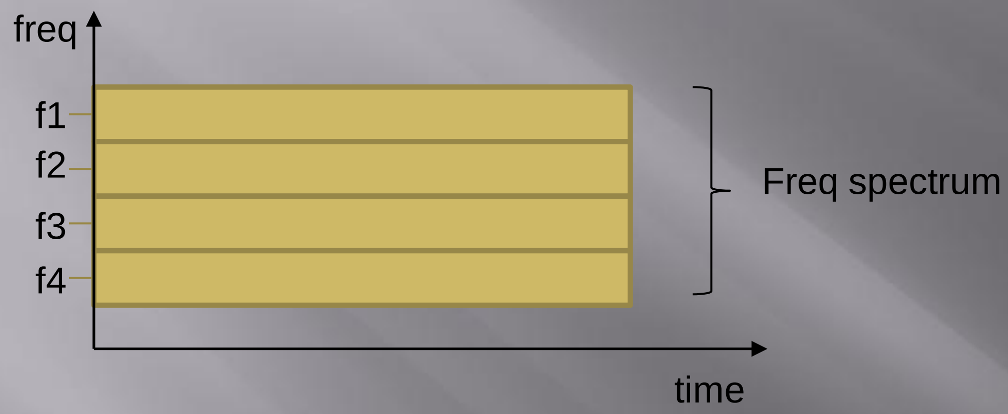
Network design 5 (Multiple acess overview)

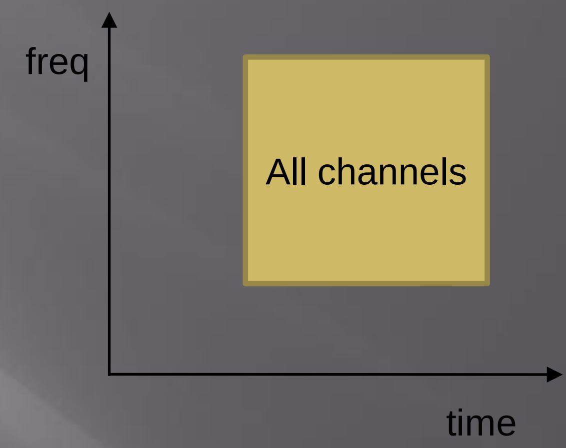


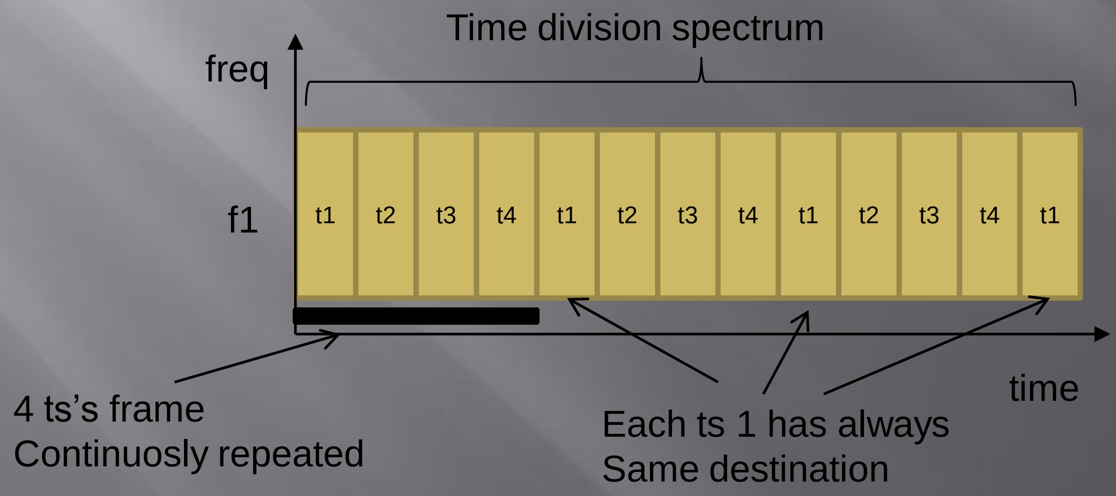
- FDM - Different Frequencies
- TDM - Different Times
- CDM - Different Codes -

- Carriers can have multiple modulation techniques

FDMA_TDMA_CDMA







Network Design (FDMA)

Modulation schemes

- Multichannel per carrier analog transmission (FDM/FM/FDMA) f_1 f_2 ……f_n
- Multichannel per carrier digital transmission (TDM/PSK/FDMA) f_1 f_2 ……f_n
- Signle channel per carrier transmission(SCPC/FM/FDMA or SCPC/PSK/FDMA) f_1 f_2 ……f_n

Pros / cont

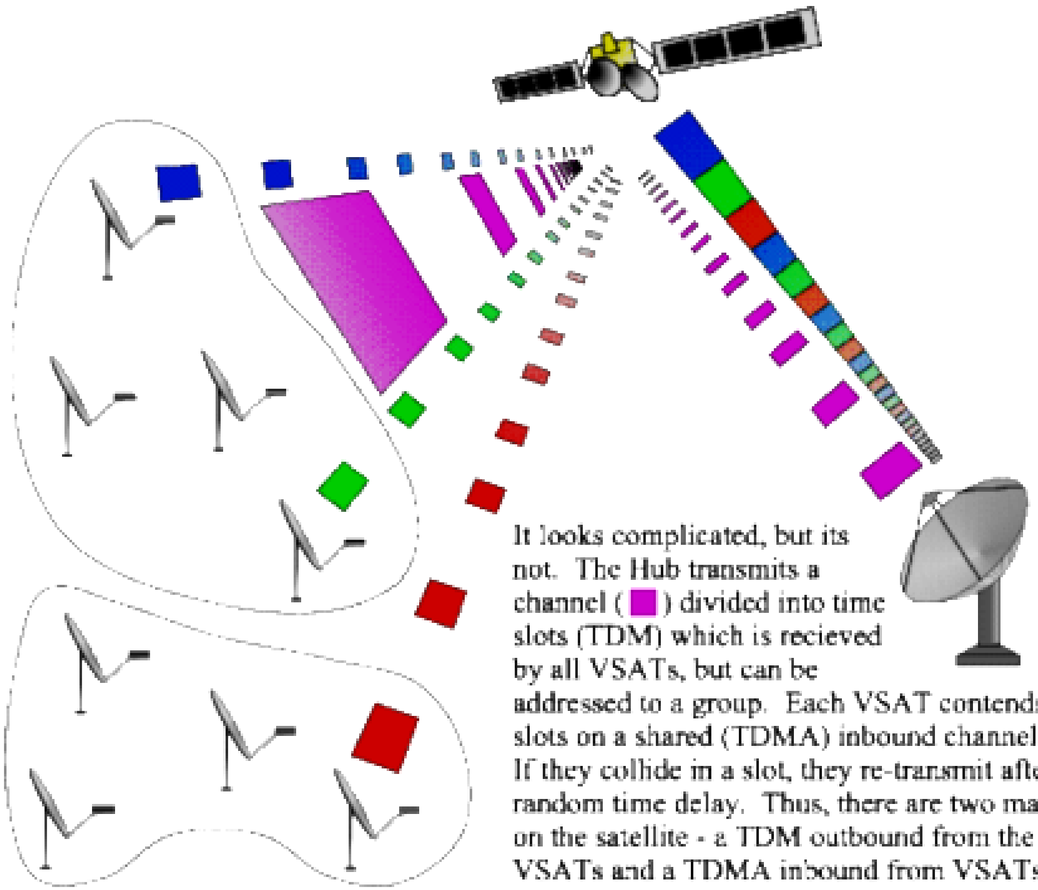
- Involves well mastered techniques and no synchronization is needed, between diferent stations
- Need for linear transponder or back off operation
- Loss in transponder capacity relative to a single access
- Lack of flexibility when need change frequencies allocated to different sations

Nework Design (TDMA)

Modulation schemes

- In TDMA each earth station is required to transmit bursts in short non overlapping timing intervals what requires some form of *frame structure* and a global *timing synchronization* mechanism.
  - The *frame* is the time interval over whitch a signal format is established and repeated. A frame is subdivided into time slots and a burst consists of na exact number of slots and occupies a precise position in the frame .
  - Each burst must arrive at the satellite transponder at a prescribed time, relative to the reference burst transmitted by the referece station. This insures no *overlapping* with others terminals to guarantee a high transmission eficiency.A mechanism of *synchronization* provides timing information att all station so that they remain within their prescribed slots. This also minimizes satellite drifts (0,1º means 75Kmx75Kmx85 Km)

TDMA Structure (Frame, Synch)



It looks complicated, but its not. The Hub transmits a channel ( ) divided into time slots (TDM) which is recieved by all VSATs, but can be addressed to a group. Each VSAT contends for time slots on a shared (TDMA) inbound channel ( ). If they collide in a slot, they re-transmit after a random time delay. Thus, there are two main channels on the satellite - a TDM outbound from the hub to VSATs and a TDMA inbound from VSATs to the Hub.

Network Design (TDMA)

Pros / cont

- No intermodulation products are generated within the transponder and the satellite operates at saturation output power.
- No pfrecise adjustment of carrier power transmitted by earth station is necessary
- All stations transmit and receive on a single frequency , wathever the destination of bursts is, simplifying RF tuning
- Faciliites provided by digital techniques can be used , such storage, coding, DSI
- Requirements for network synchronization and the increase complexity of ground station equipment.

Network Design (CDMA)

Modulation scheme

- With code division multiple access all users simultaneously operate within the same frequency band and each user occupies all teh time the entire transponder bandwith.
- Each user combines the signal to be trasnmitted with a signature sequence which displays two main correlation properties:
  - Each sequence can easly be distinguished from a time shift version of itself
  - Each sequence can be easly distinguished from e other one in the set

Network Design (CDMA pros_cont)

Pros / cont

- The appeal of CDMA lies in its potential for uncoordinated access, but requires a large processing gain.
- More strenght to noise interference in all multiple access scheme – once is based on the principle that 2 signals not related, the original and a sequence of p-r (pseudo-random wide spectrum noise) produce a signal whose sprectrum is the convolution of its components spectrum - according the original signal bandwith shorter compared with the one of sequence p-r, the output will be the bandwith of sequence p-r and so noise will be spread equally through all band allowing a final result more consistent

Network design (multifeixes)

Multibeam satellite

- The necessity of sharing the electromagnetic sprectrum between all Radiocommunications Services results in the allocation of a limited number of frequency bands to each service.On the other hand the available power on-board a satellite is limited. The communication capacity of a satellite link is therefore constrained either by the limited EIRP or by the bandwith limitation, originating satellite equipped with antennas delivering several beams so called multibam satellite

Multibeam with regeneration

- Due to diversity of services – stations with processing capability of large traffic (*trunk stations)* and stations on the clients premises but with less traffic (*Vsat stations*) conduct to the possibility of using on-board regeneration including FEC capacity baseband switching and even modulation conversion .

Corporate Networks

Telecommunications

- *Mobile Backbone*
- Private line
- IP Trunking
- SCPC
- Broadband global maritime

Media services

- SNG
- IPTV
- Video on local fiber
- DVB-*Digital video broadcasting* (distribuição video)

Corporate Services

- Intelsat One (broadband)
- DVB (video and content distribution)

Corporate Networks

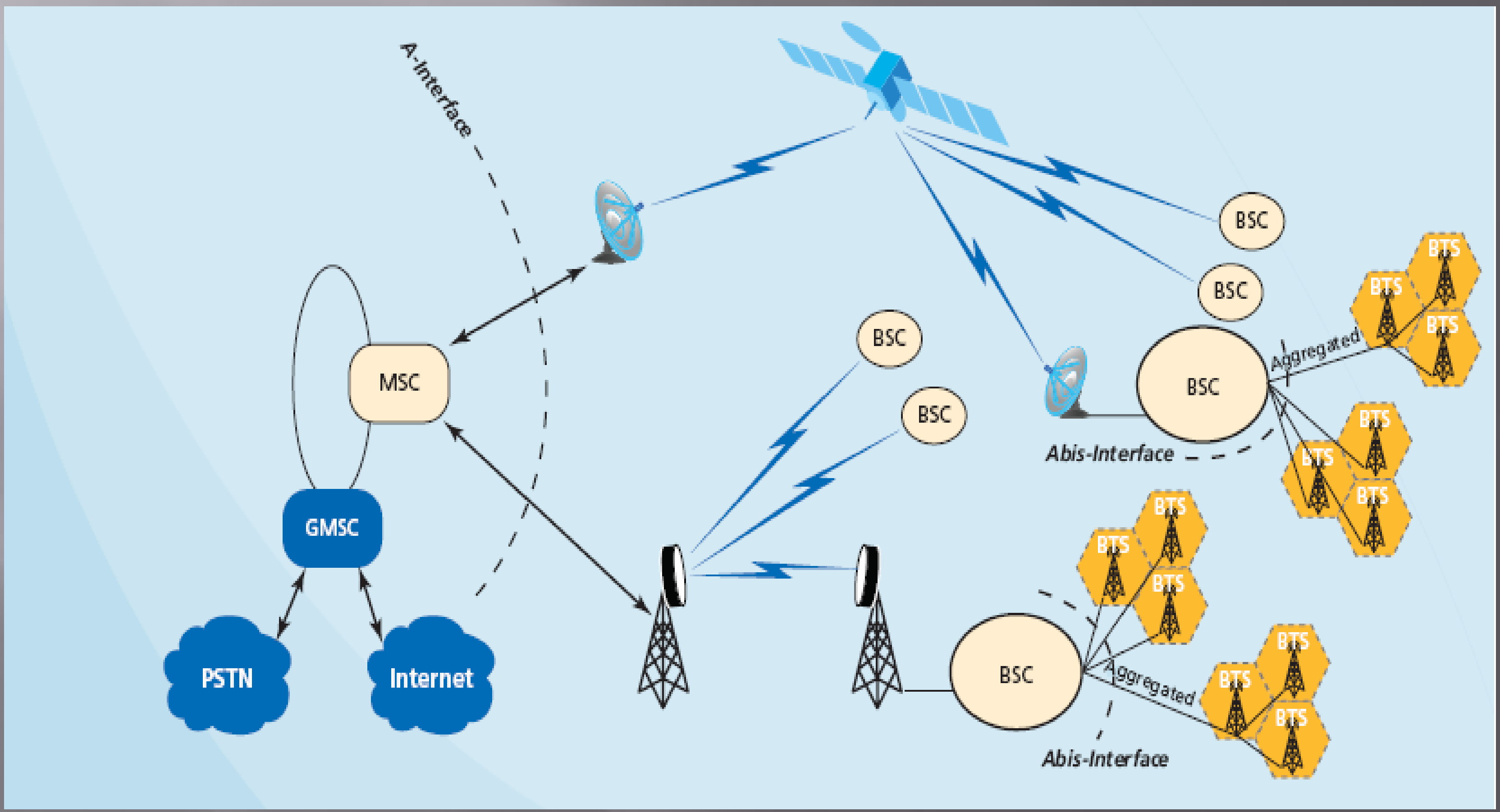
Cellular Backhaul

- Cellular companies are developing strategies to economically extend the reach of mobile services to population ”islands” not readily accessible by traditional network infrastructure. The economic challenge is particularly evident in reaching relatively remote areas where the low volume of user traffic requires tight control of capital and operational costs of providing connectivity from the remote cell towers back into the mobile network.

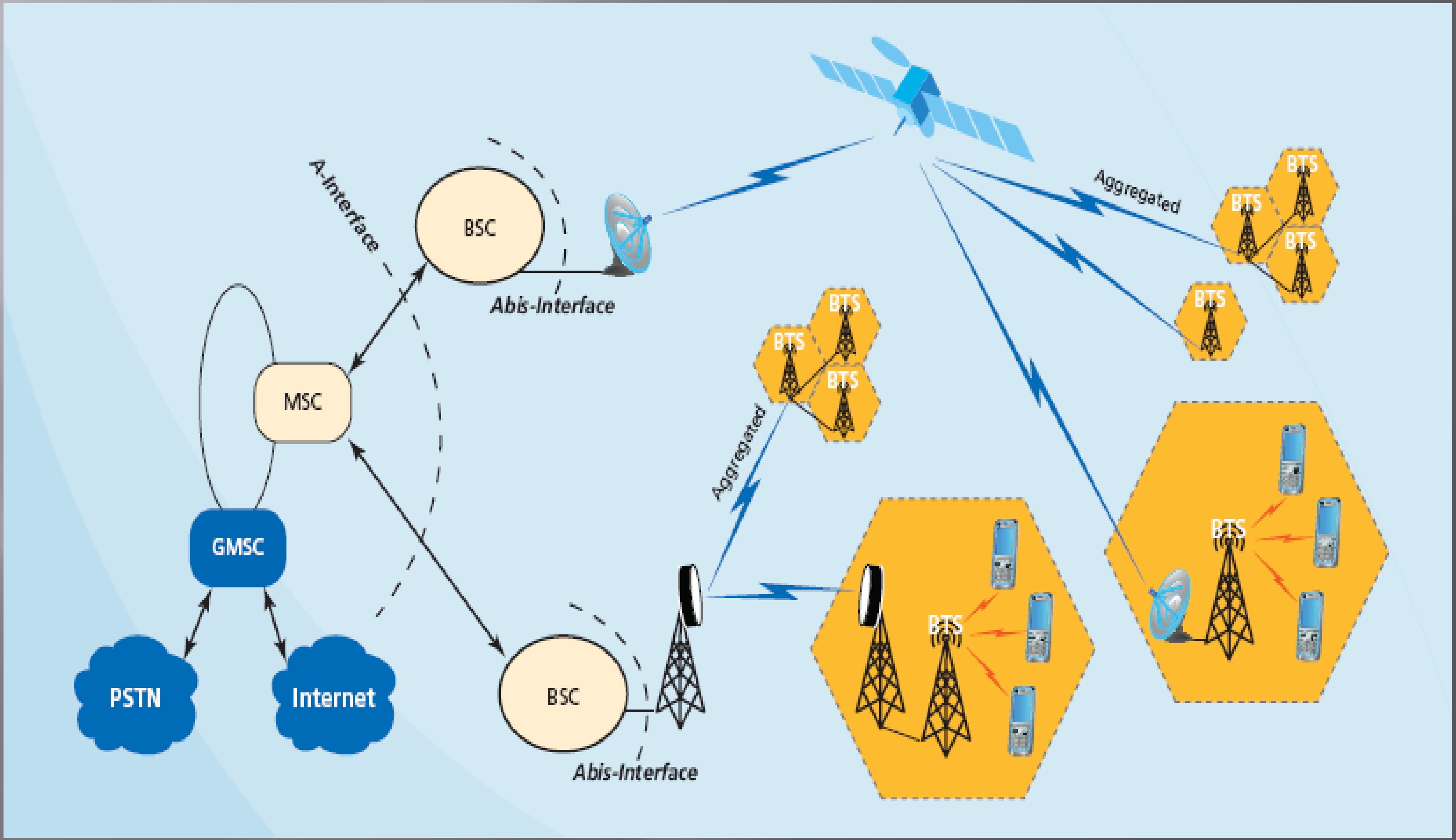
- Developing regions are also benefiting from the economics of mass-produced mobile technology, making it viable to provide telecommunications services in areas with minimal infrastructure

- This network shall be flexible (pontual bandwith increase, traffic balance, emergencies) cost-efective versus the alternative (fiber for instance), minimize point of fail (compared with hop in terrestrial link) etc

Mobile network Backhaull BSC_MSC



Mobile network Backhaull BSC_MSC

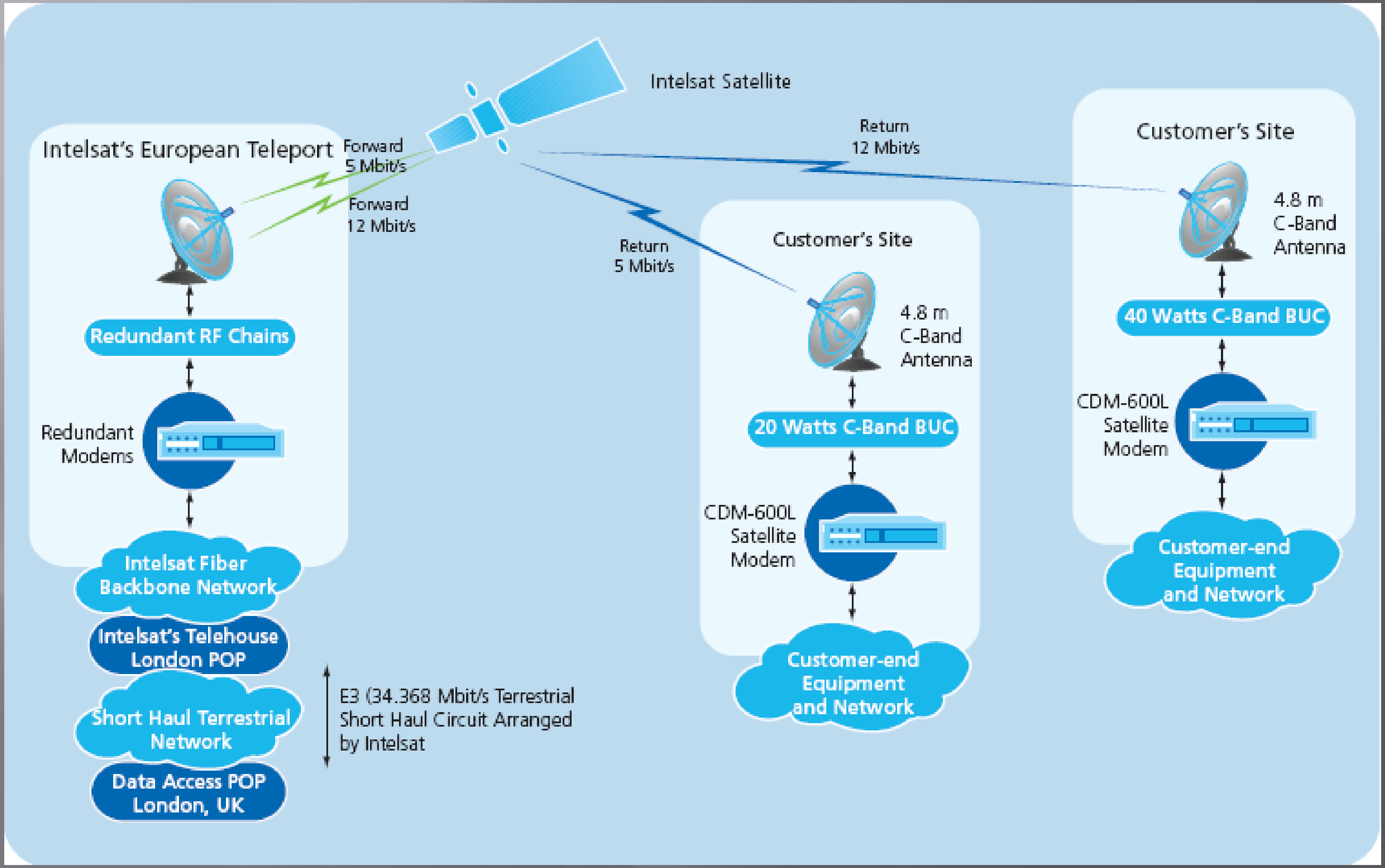


Private Line 1

We are talking about PTP dedicated connection to supply global communications to “*Service Providers*” , corporations, *OI’s* , *final users* namely at:

- LAN to LAN connectivity between remote locations
- Bulk data transfer
- Remote database access
- Videoconferencing
- *Backup (Disaster recovery)*
- *CSS-Customer service and support*
- VoIP

Private line 2



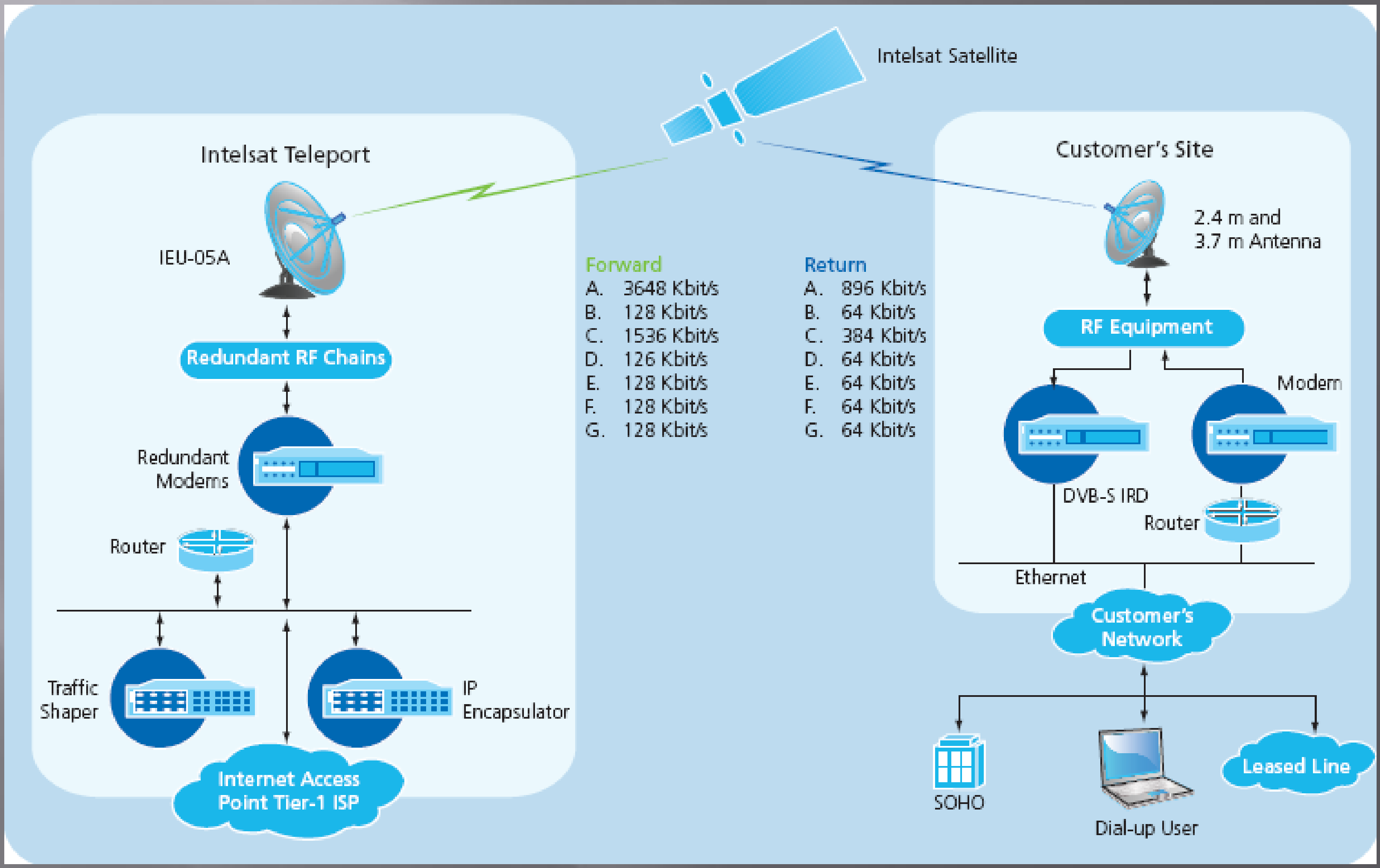
IP Trunking 1

- It is a wholesale, end-to-end service designed to expand customers' infrastructure and resources. Intelsat provides telecommunications carriers, ISPs and corporate network providers with direct, high-speed Internet backbone access in terrestrially-challenged service areas, with needs in medium and high speed data rate, with 2 alternatives:

  - shared access solutions with the cost-effective DVB solution is designed for lower data rates, providing customers with a shared forward and dedicated return carrier (using SCPC) for accessing the Internet. Sharing the forward carrier, customers are allowed to more effectively use capacity between multiple locations while maintaining CIR on the return carrier

  - Dedicated access solutions for large bandwidth requirements, a dedicated forward and return carrier is recommended, to provide high-speed access to the Internet using Committed Information Rates; supporting customers requiring connections up to STM-1 (155 MBs) for single or multiple locations.

IP Trunking 2



SCPC

As we have seen systems of multiple access as FDMAbecause use more than one carrier on the transponder potentiate interference, hence has been minimized through the output back off, didn’t overcome completly the problem.That dificulty – in access with frequency share – was mitigated with the implementation of one channel per carrier – SCPC – to very specific aplications, namely

- *PA-pre assignement* commonly voice activated allowing digital signals usually associated to channel multipliers owhatever, DSI-Digital Speach Interpollation and DCME-Digital Circuit Multiplication equipment
- *DA-demand assignement* (also known by DAMA-Demand Assignement Multiple Access or bandwirth on demand)

SCPC / DAMA – Intelsat ….

- Mesh connectivity between multiple Earth stations, and is therefore a flexible and cost-effective multiple-access technology. Thin Route-on-Demand is beneficial for thinroute operators looking to replace analog FDM/FM and SCPC circuits.
- Because Thin Route-on-Demand can provide direct connectivity among large communities of users, transit charges can be reduced or eliminated. Thin Route-on-Demand provides new users the opportunity of getting globally connected through the use of smaller Earth stations.

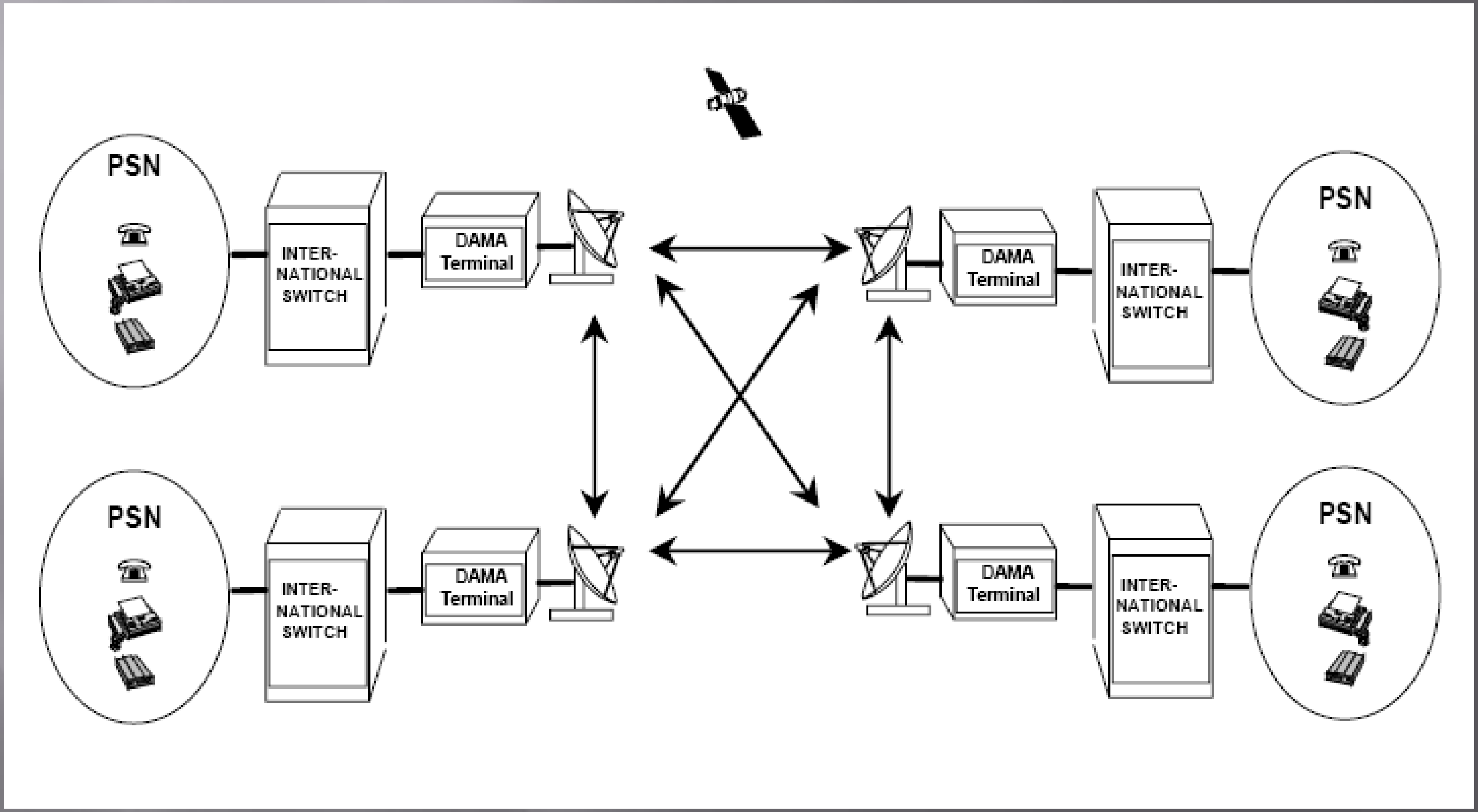
…/…

SCPC / DAMA – Intelsat ……

…/…

- The OIS maintains a record for every call made, and bills customers for the answered call duration.
- The type of traffic – small or medium – oringinally made through analogue systems FDM/FM, is migrated for SCPC, and supporting direct connectivity among users communities decreasing or eliminating costs associated with transit taxes. There are the following possibilities of service:
  - Low and medium traffic telephonic service through gateways for PSTN
  - Rural telephony through VSAT
  - 64 Kbs data applications (or higher rate) on request

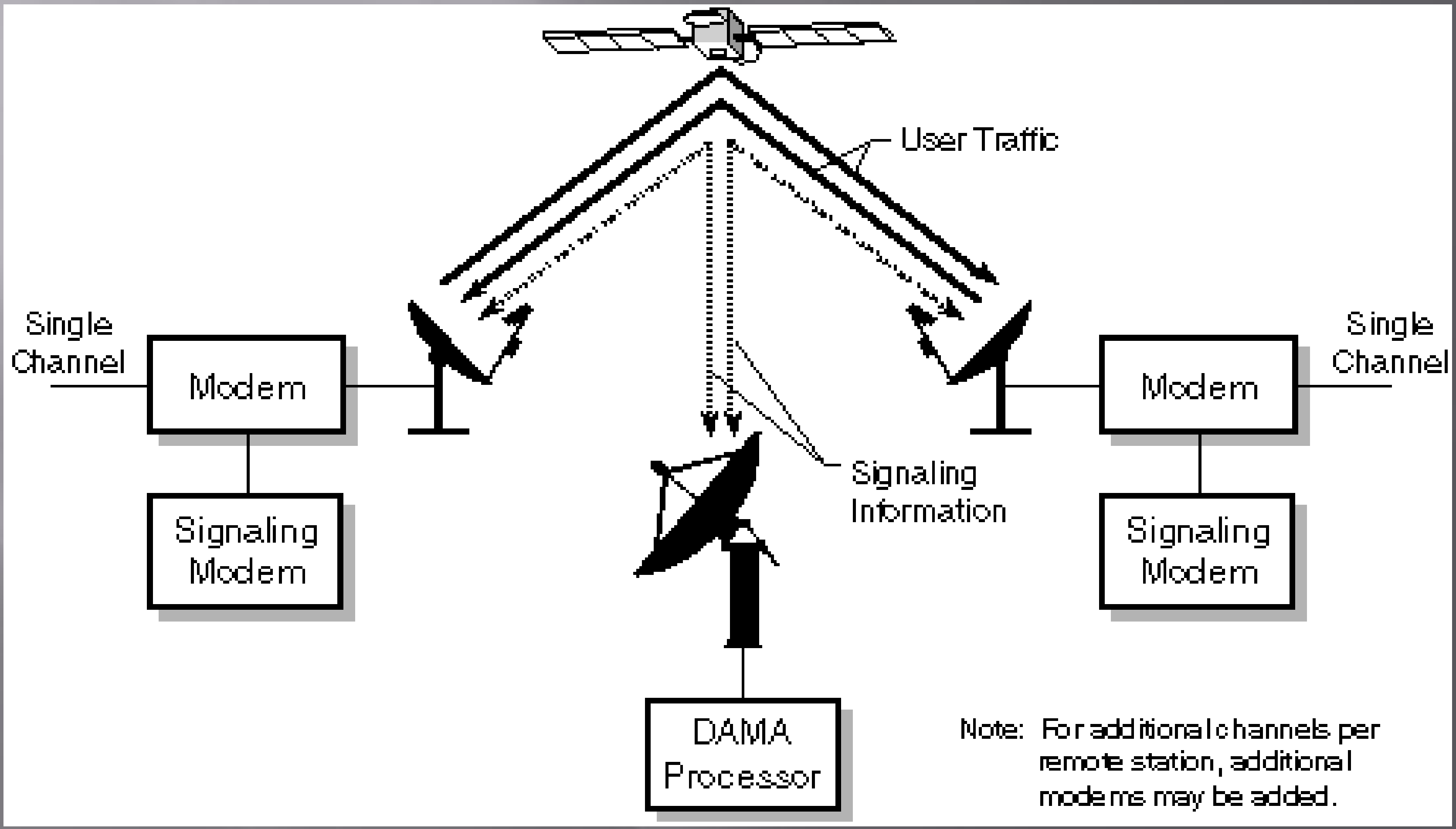
DAMA – Intelsat



DAMA – Typical user

- Reuse of capacity among the users within same customer network, combined with efficient modulation techniques
- Relative low hub cost makes it possible to establish a cluster of hubs, backing up an expansion due to customer needs, allowing one hope connections directly to each terminal
- Real time processing applications with QoS, Voice, internet, video, ERP etc
- In cases where there is time diversity between the remote terminals, the DAMA functionality improves the efficiency and utilisation of space segment.
- For user wants bursting (higher data rate if available) capabilities within his own controlled bandwidth allocation. Also wants a dedicated network/bandwidth with no sharing of resources with other customers.
- Banda dedicada sem partilha de terceiros, desde que requerida, mas libertada quando não em utilização

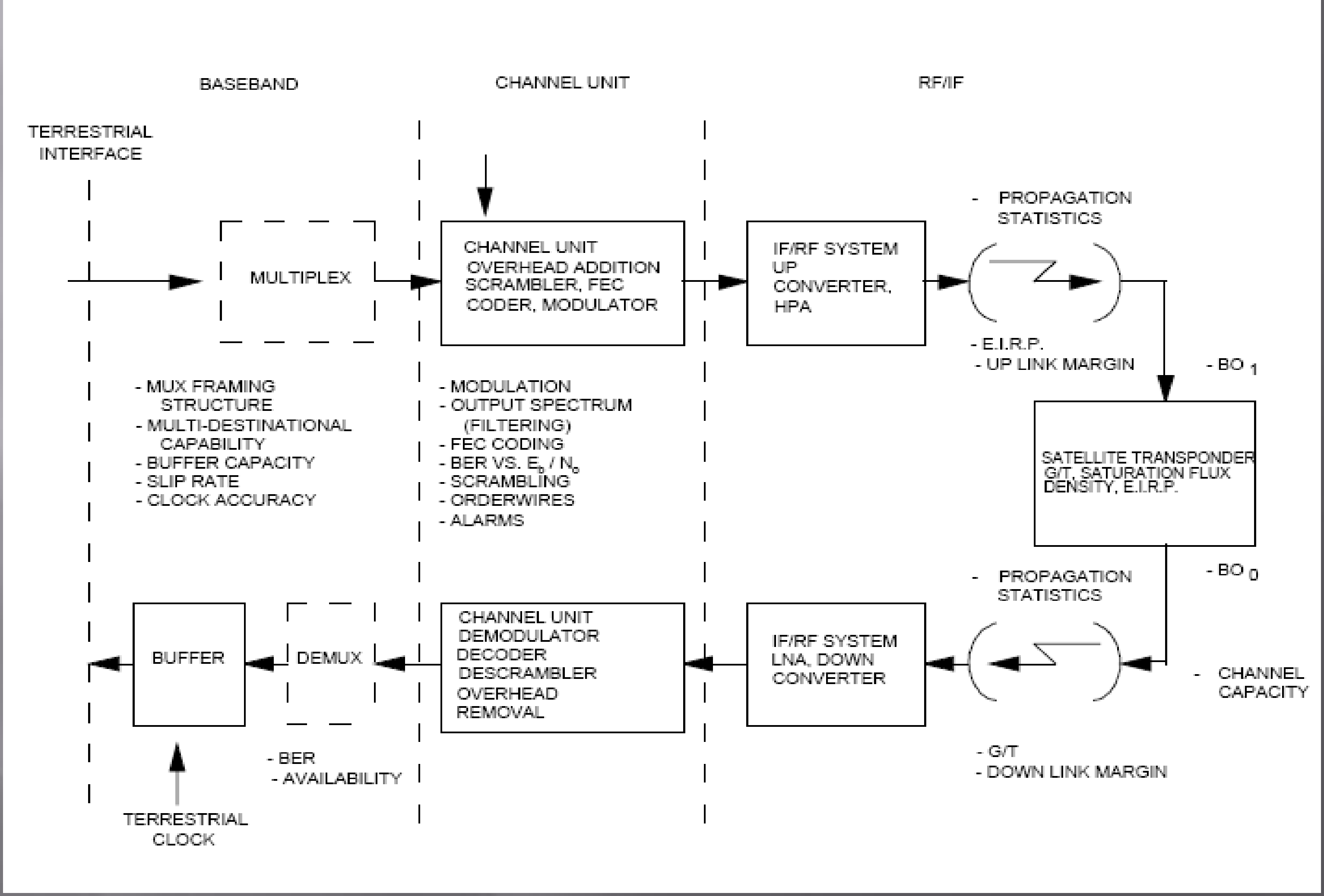
SCPC / DAMA – generic



IDR – *Intermediate Data Rate*

- INTELSAT's newest, high-quality digital carrier service, communication s PIP with several interfaces and through several levels (layer 2,3,4,5)
- Voice and data services , data rate of 64Kbps up to 44,736 Mbps, well suited to applications that require low BER/ high availability performance such as:
  - Internet bb access
  - Internet bb access NAC-to-NAC
  - Multicasting and Multimedia
  - High data rate trunking
  - International Public Switched network
- Possibility using DCME-Digital Circuit Multiplication Equipment to band optimize
- Sistemas aprovados em STA, B, C, E2, E3, F2 e F3 em banda C e E1 e F1 em banda Ku

IDR Connection



IDR parameters FEC ¾

Information Rate(IR) (Bit/s)	Overhead Rate(OH) (Kb/s)	Data Rate Bit/s (IR + OH)	Transmission Rate(TR) (Bit/s)	Occupied Bandwidth (Hz)	Allocated Bandwidth (Hz)
64 k	0	64 k	85.3 k	51.2 k	67.5 k
192 k	0	192 k	256.00 k	153.6 k	202.5 k
384 k	0	384 k	512.00 k	307.2 k	382.5 k
512 k	34.1	546.1 k	728.18 k	436.9 k	517.5 k
1.024 M	68.3	1.092 M	1.456 M	873.8 k	1057.5 k
1.544 M	96	1.640 M	2.187 M	1.31 M	1552.5 k
2.048 M	96	2.144 M	2.859 M	1.72 M	2002.5 k
6.312 M	96	6.408 M	8.544 M	5.13 M	6007.5 k
8.448 M	96	8.544 M	11.392 M	6.84 M	7987.5 k
32.064 M	96	32.160 M	42.880 M	25.73 M	30125.0 k
34.368 M	96	34.464 M	45.952 M	27.57 M	32250.0 k
44.736 M	96	44.832 M	59.776 M	35.87 M	41875.0 k

IBS – Intelsat Business Services 1

- Intelsat service that defines transition from analogic to digital where user as the flexibility of using its layer above 1 (see introduction IP slide) .
- Mainly to corporate, private, national or international small antenna diameter, eventually installed on the clients premises

IBS – Intelsat Business Services 2

- Carrier adjusted to *information rate, overhead* e FEC rate *of ½ e ¾* ,with 64 Kbps increments, up to 8448 Kbps
- QPSK/FDMA,TDM/QPSK/FDMA, QPSK/TDMA modulation
- Individual carriers or leased transponder.
- Open network (IESS309) or closed operation allowing in both case add CME-*Circuit Multiplication Equipment*
- Quality threshold BER a 10^{-10} for more than 99.6% of the year. Clear sky BER <<10^{-10}

IBS Applications

Data communications

- Private Line
- Internet
- LAN, WAN, MAN…interconnection

Voice

- PBX interconnection
- High audio quallity

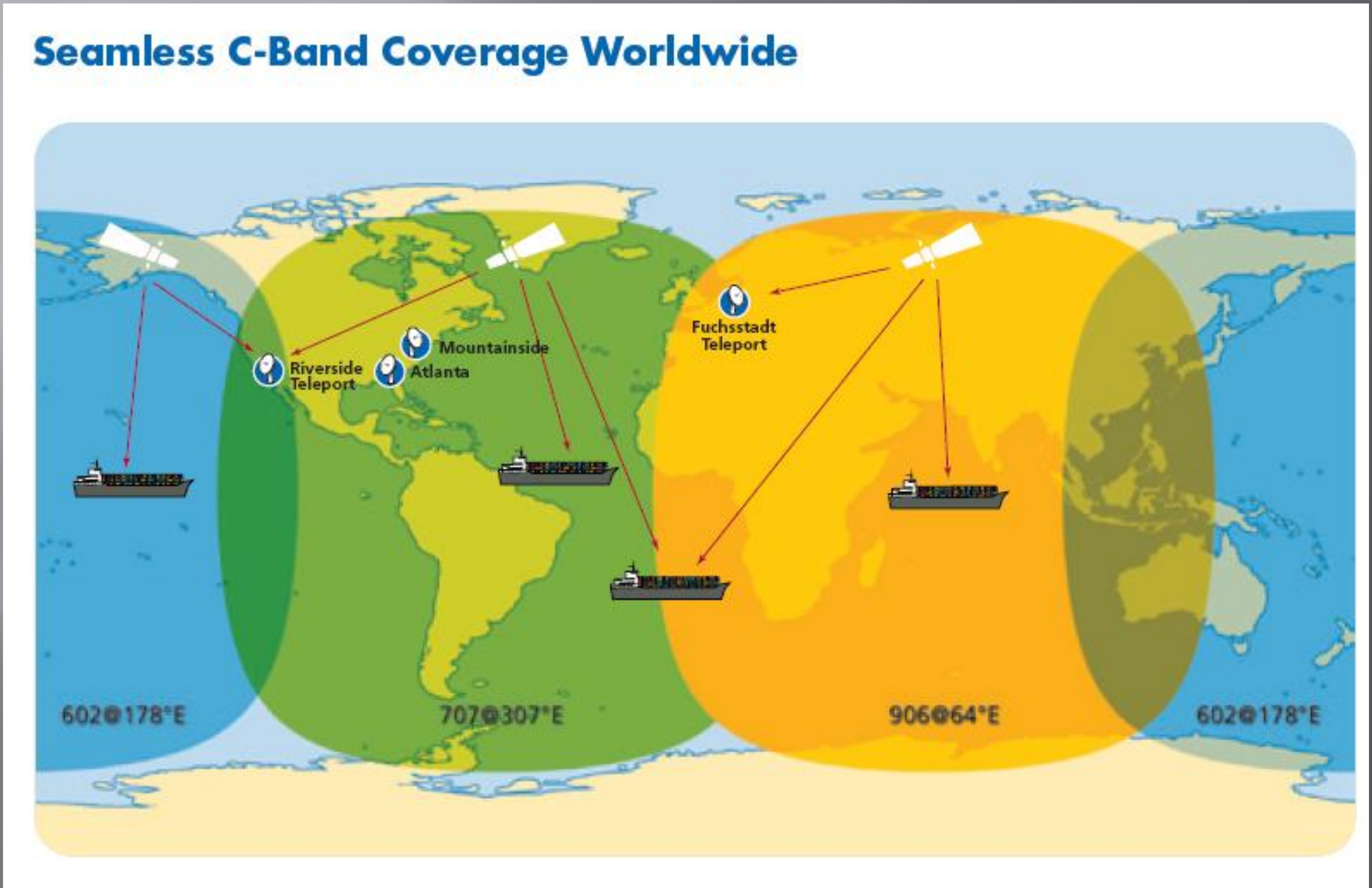
Video

- Videoconferencing
- Digital TV

Maritime Communications (broadband)

- Maritime market demands robust, secure, ubiquitous broadband connectivity traditionally delivered by terrestrial networks, but now satellite platforms offer the performance and reliability of land-based VSAT networks, where IntelsatONESM Global Maritime product offers a unique always-on, true broadband access service worldwide
- In general terms shall be assured , allways on broadband access global coverage, with integrated management (GNMS-*Global Network Management System*) automatic beam switching (ABS-*Automatic beam Switch)* at effective costs
- Intelsat ofers global services at IS-602, IS-707 and IS-906, through dedicated hubs at Fuchsstadt and Riverside Teleports

Maritim Mobile Broadband



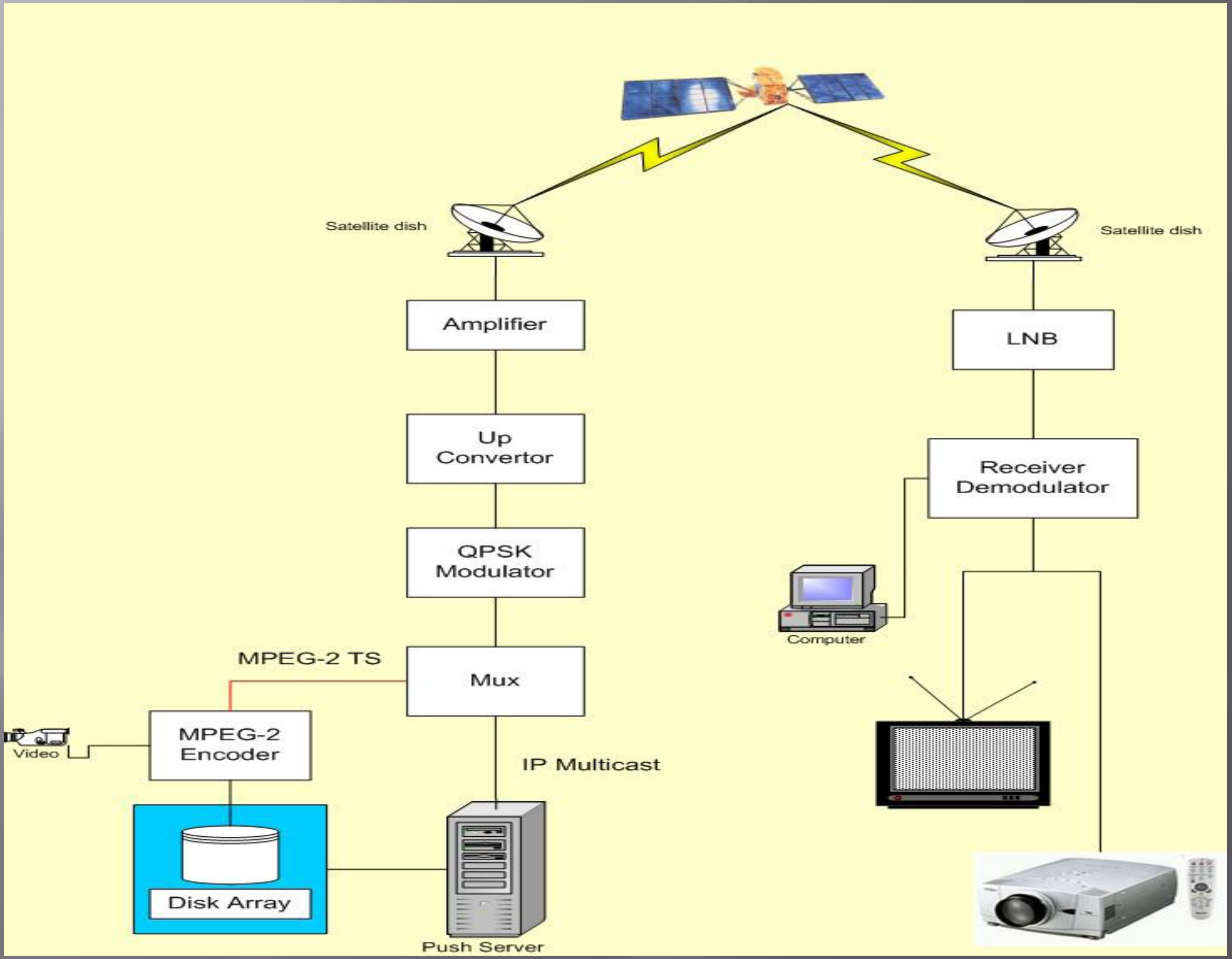
Video Broadcasting special solution event

DVB

Standard for *Digital Video Broadcasting* involves today several manufactors and vendors in a consorcium started 1993

- It comprises 3 sub-standards according to the main transmission medium,e.g:
  - Satellite (DVB-S QPSK modulation)
  - Terrestrial (DVB-T QAM modulation) and
  - Cable (DVB-C OFDM modulation)
- Uses MPEG 2 modified (transmission standards, modulation systems, error correction, integrated receiver_decoder and service information) to codify and data transport.
- Assure HDTV distribution (DTH-Direct to Home) and all broadband interactive services.

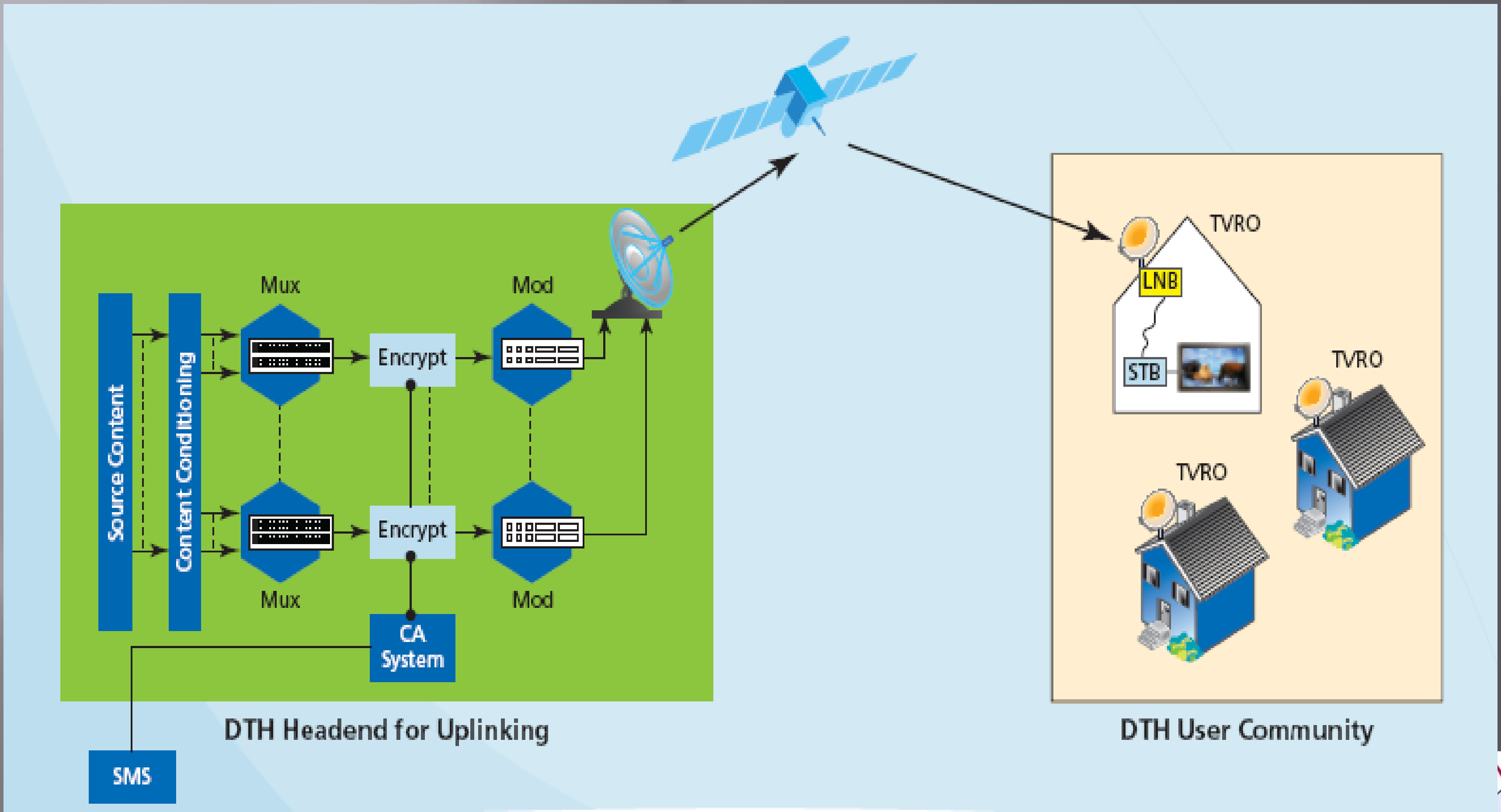
DVB - link


Satellite dish
Satellite dish
Amplifier
LNB
Up Convertor
Receiver Demodulator
QPSK Modulator
Computer
MPEG-2 TS
Mux
MPEG-2 Encoder
Video
IP Multicast
Disk Array
Push Server

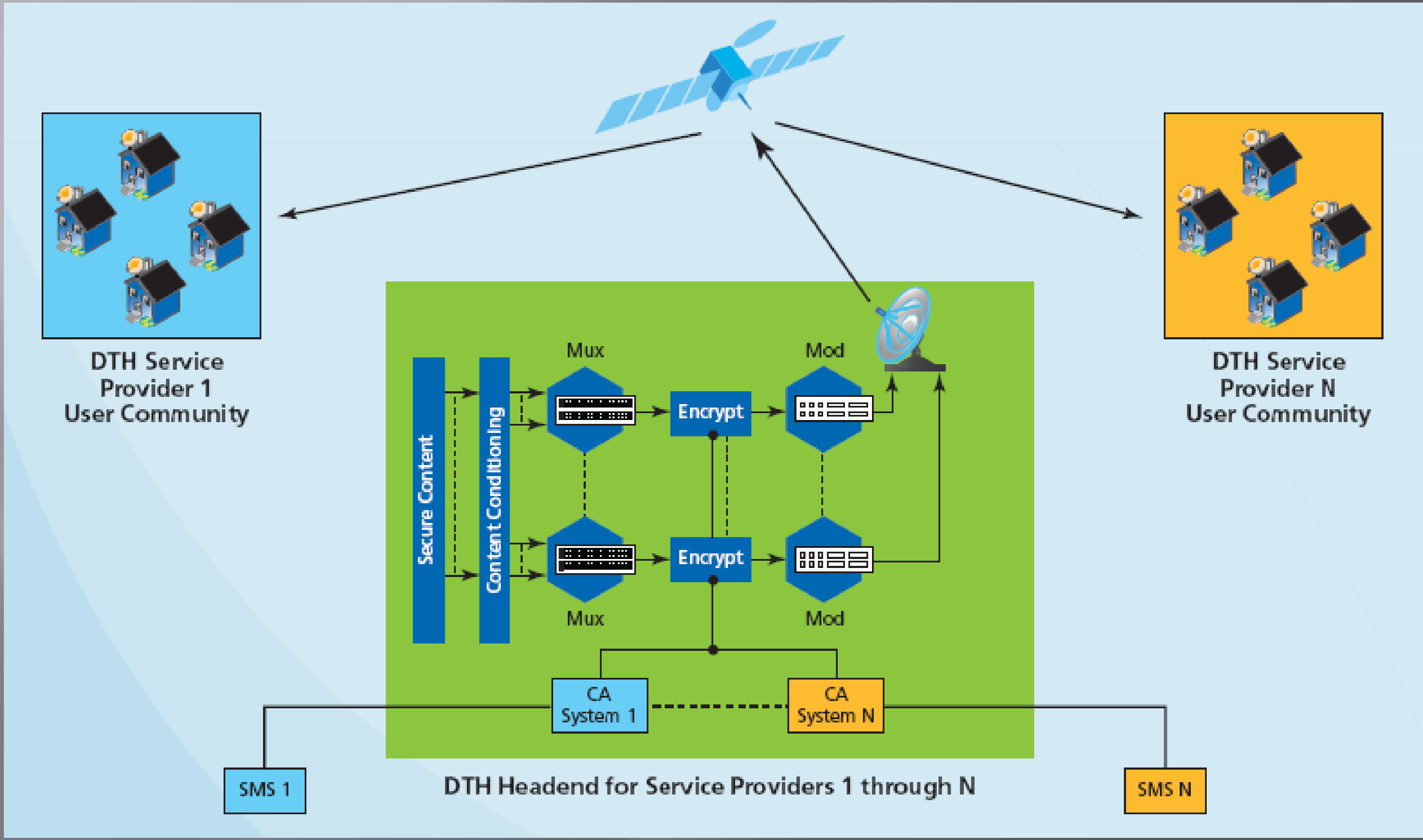
Intelsat DTH - Direct To Home

- Enable the delivery of video, and other content, directly to a user's home via a satellite link.
- In most cases the content is available in an encoded (compressed) format, such as MPEG2 at certain data rate.
  - If a format other than MPEG2 is required, such as MPEG4, the video needs to be transcoded (decoded and re-encoded).
  - If the format is correct, but the data rate is too high, transrating (rate reduction) equipment is required. If the video is in an uncompressed format, MPEG2 or MPEG4 encoders are required.
- If in the correct format, the content is aggregated using multiplexers. There is one multiplexer corresponding to each satellite transponder. The content is aggregated to a data rate fully utilizing the transponder bandwidth and power.
- Content is encrypted (scrambled) to preclude unauthorized viewing.
  - For a given DTH service provider, the user community is managed with a SMS (subscriber management system), which interacts w the encryption system via a conditional access (CA) system.

Intelsat Direct To Home (private)



Intelsat Direct To Home (shared)



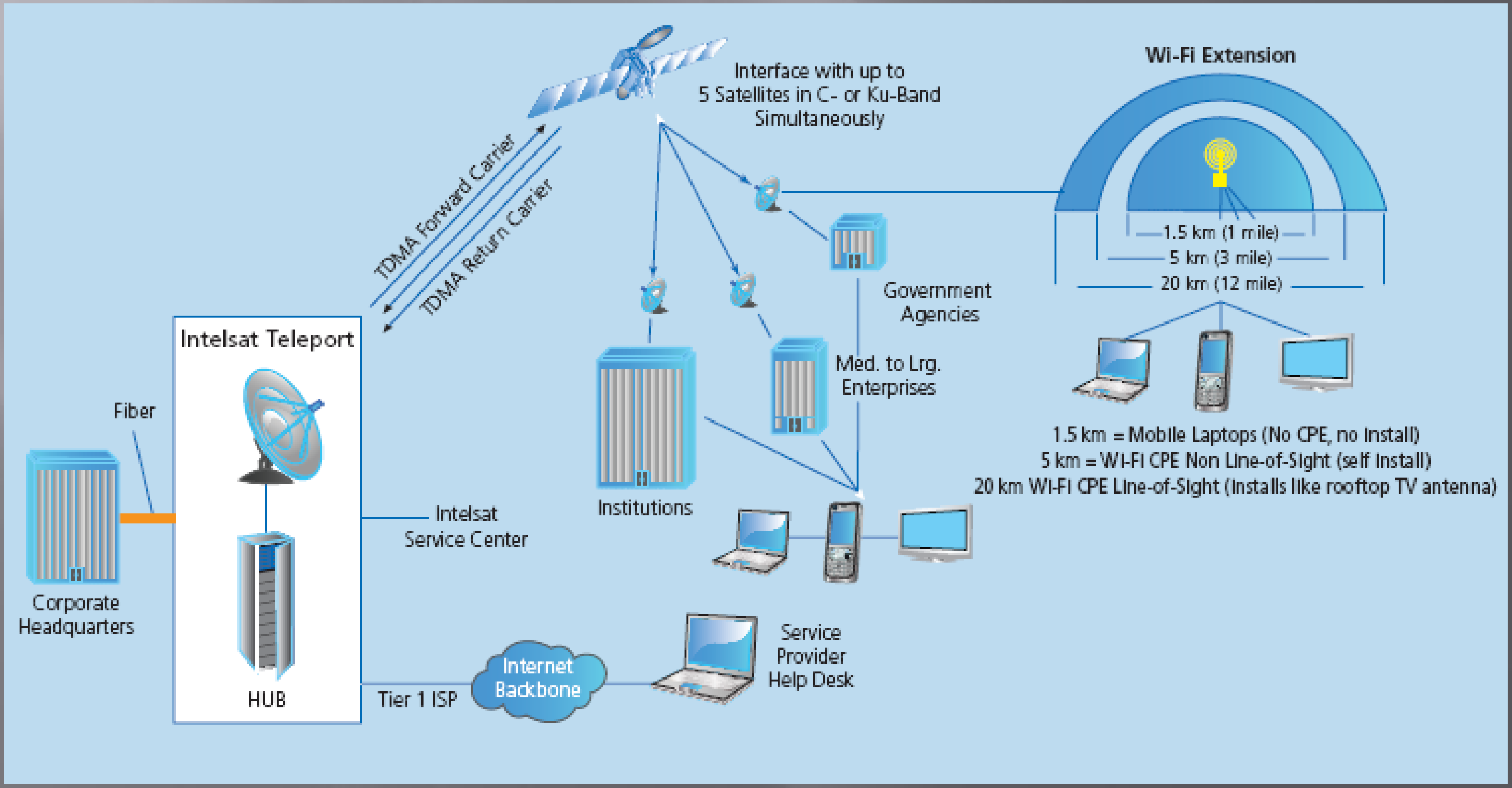
Intelsat Direct To Home (consumer equipment)

- TVRO
  - DTH systems typically use Ku-band capacity. One benefit of this is the ability to use small TVRO sizes; usually less than 1m in size, and often in the order of 65 cm.
- STB
  - The STB has a number of functions. It demodulates the satellite signal that has been converted to a lower frequency care of the LNBF. The resultant digital signal contains the multiplexed content and entitlement messages, but in a scrambled form.
- Middleware
  - Provides an interactive program guide to the viewer. The program guide displays available channels for the viewer to scroll through, and also provides a means of selecting pay-per-view content (movies and special events).

Corporate services overview

Includes:

Web Browsing, Digital Media Streaming, File Transfer, VoIP, VPN, Extranet_Intranet, Video Conferencing and Distant Learning

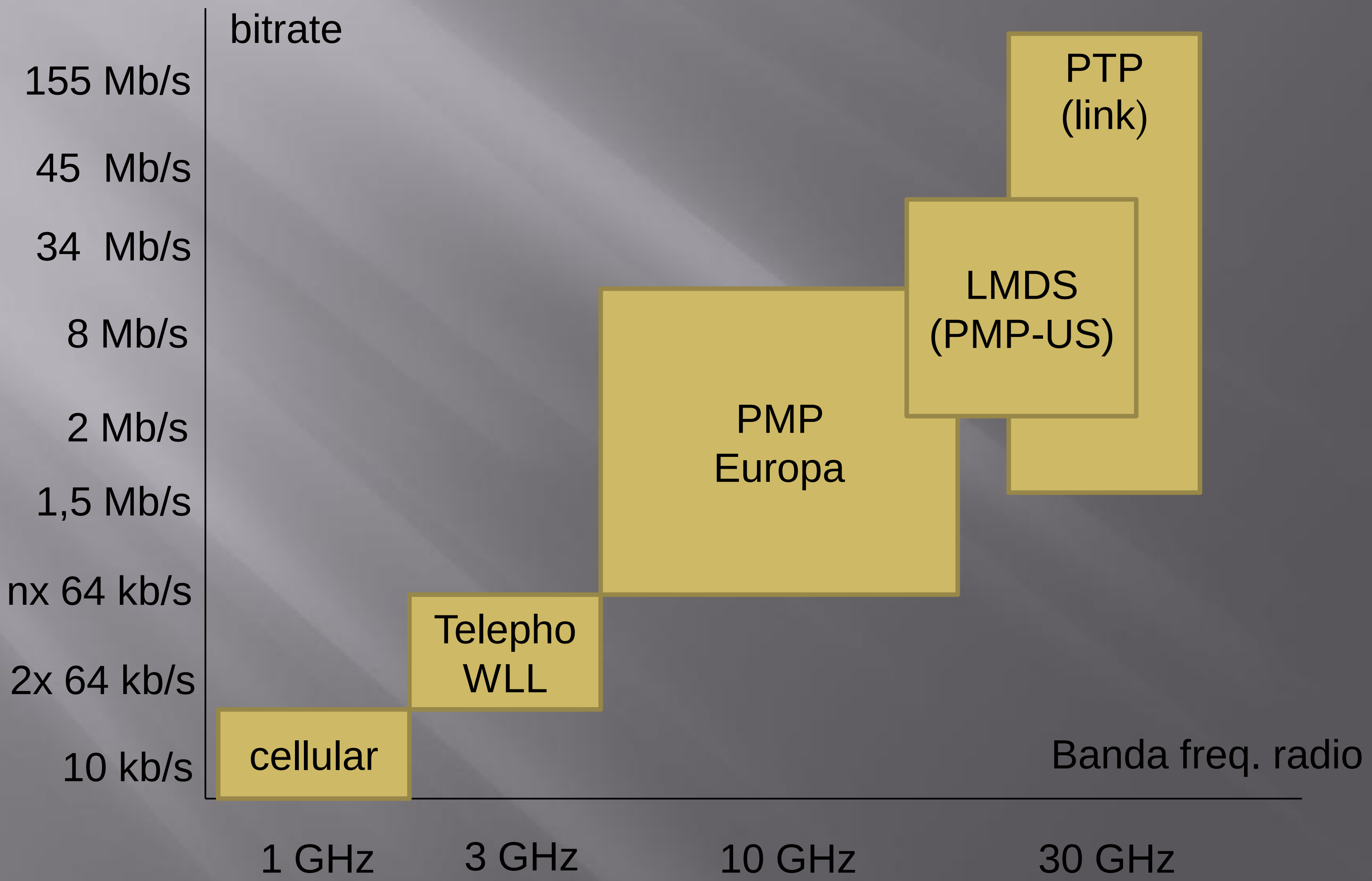


Video distribution (corporative networks)

Video descarregado de “Vbrick corporate ”

Corporative network

Network design-max bitrate



……. Not allways as planned

End 3rd day

Panic??