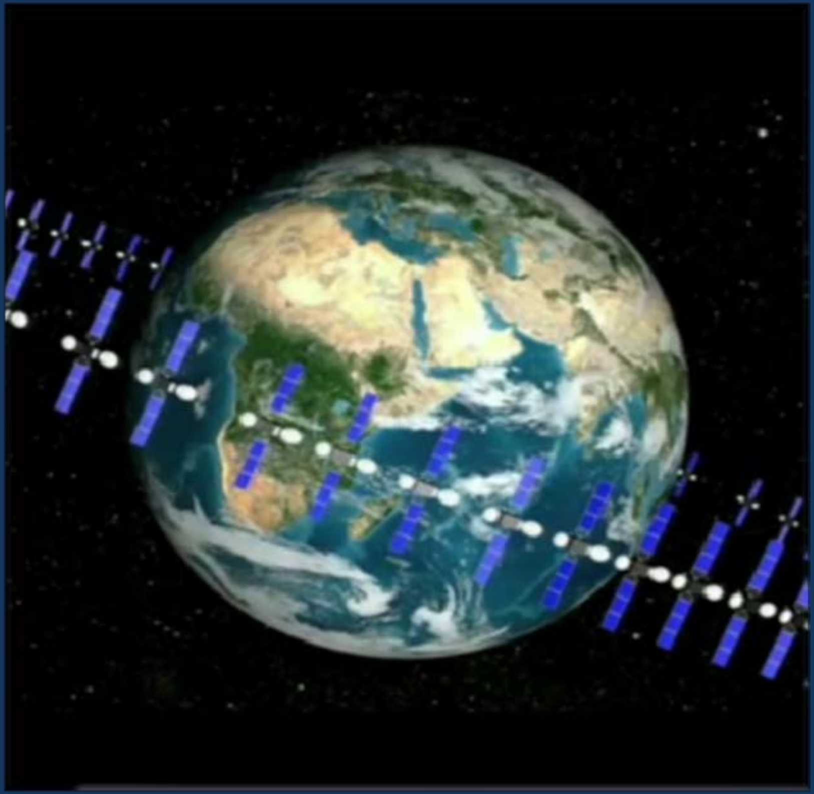
Agenda

- Day 1 - Basics of Satellite Communications
- Day 2 - Policy and Regulatory Guidelines for

  Satellite Services (Analog TV to DTT)*
- Day 3 - Network Planning and Satellite trends, Link budget*
- Day 4 - Vsat Installation and Maintenance
- Day 5 - Vsat Equipment and Bandwith Procurement

* - Eldo Kurian from Intelsat



Day 3
Network

Network planning

- Vsat network topologies
- Access Schemes
- Frequency Bands
- Baseband Signals
- Digital Communications Techniques
- Wimax
- Link Budget Analysis
- Satellite trends

Network planning

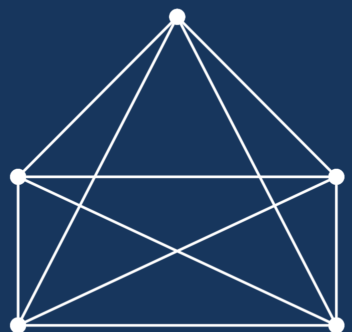
Vsat topology

- Basic concept for communications between 2 points is a direct connection. If the number of terminals increases more the complexity for the design and some specification shall be applied to define if A connects only with B or if also with B and C or this last is connected only via B.
- Assume for instance the connection of all the terminals among them e.g:
  - n x (n-1) / 2 (being n the nodes number)
  - for 5 nodes for instance will mean 10 connections, and so on

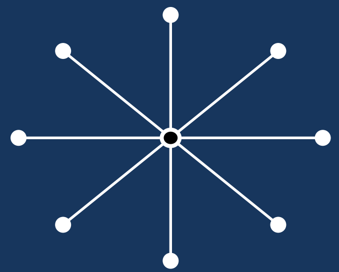
Network planning
Vsat topology

- 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 topologies to be used are in the following slide

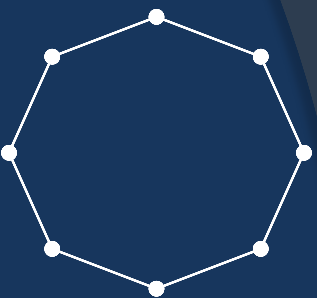
Network planning
Vsat topology



Mesh - Common WAN & MAN
complete redundancy

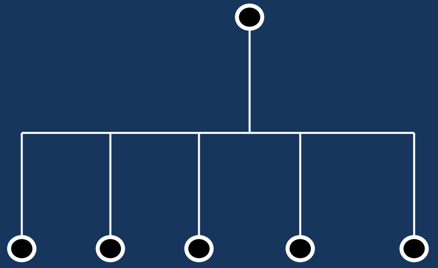


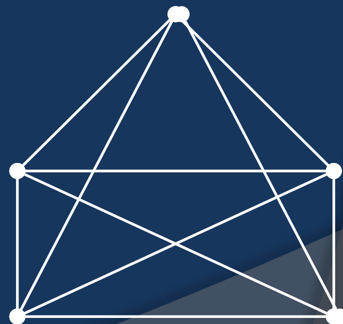
Star - Critical central node



Ring - common LAN
critical node fails

Bus - Common LAN, easy
nodes increase, any
node might control

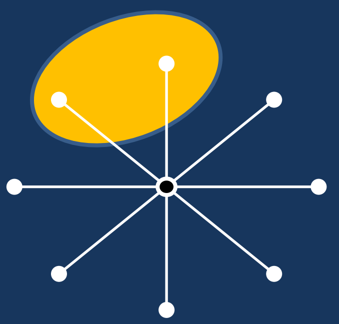




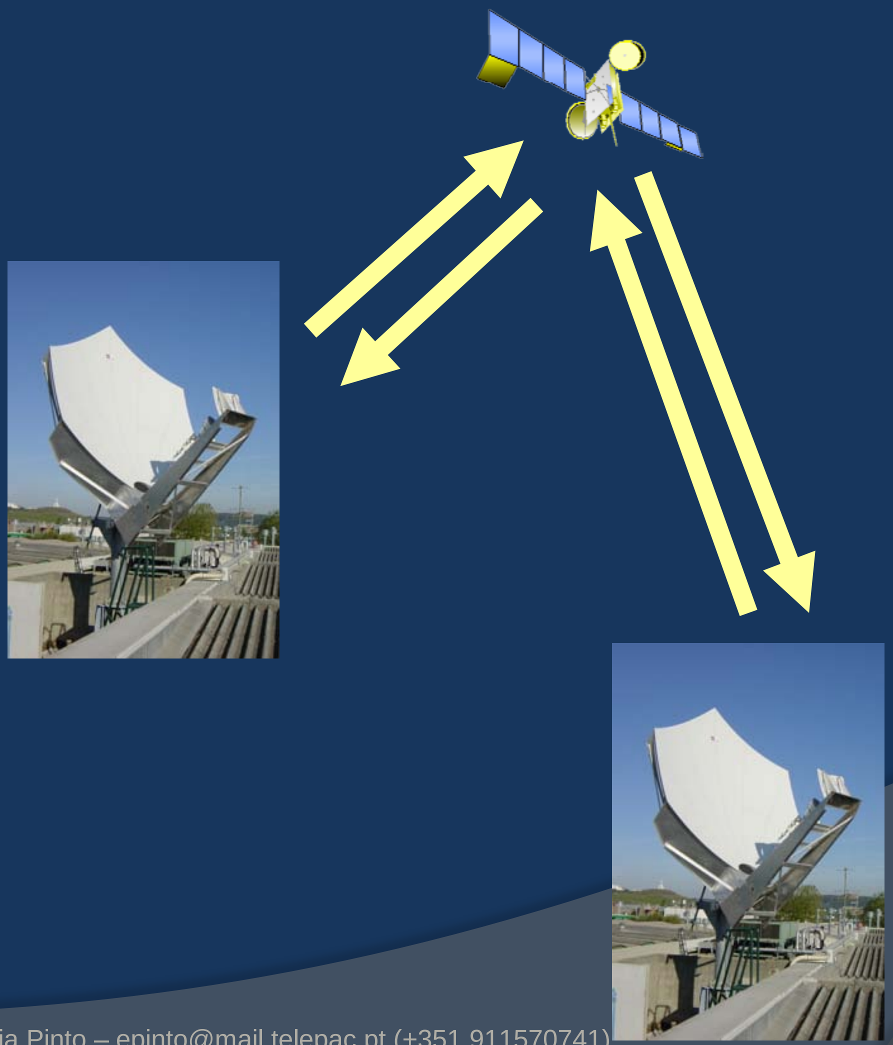
Hybrid - mesh through wired
ehternet and wireless
(sat, WiFi,WiMax)

Network planning

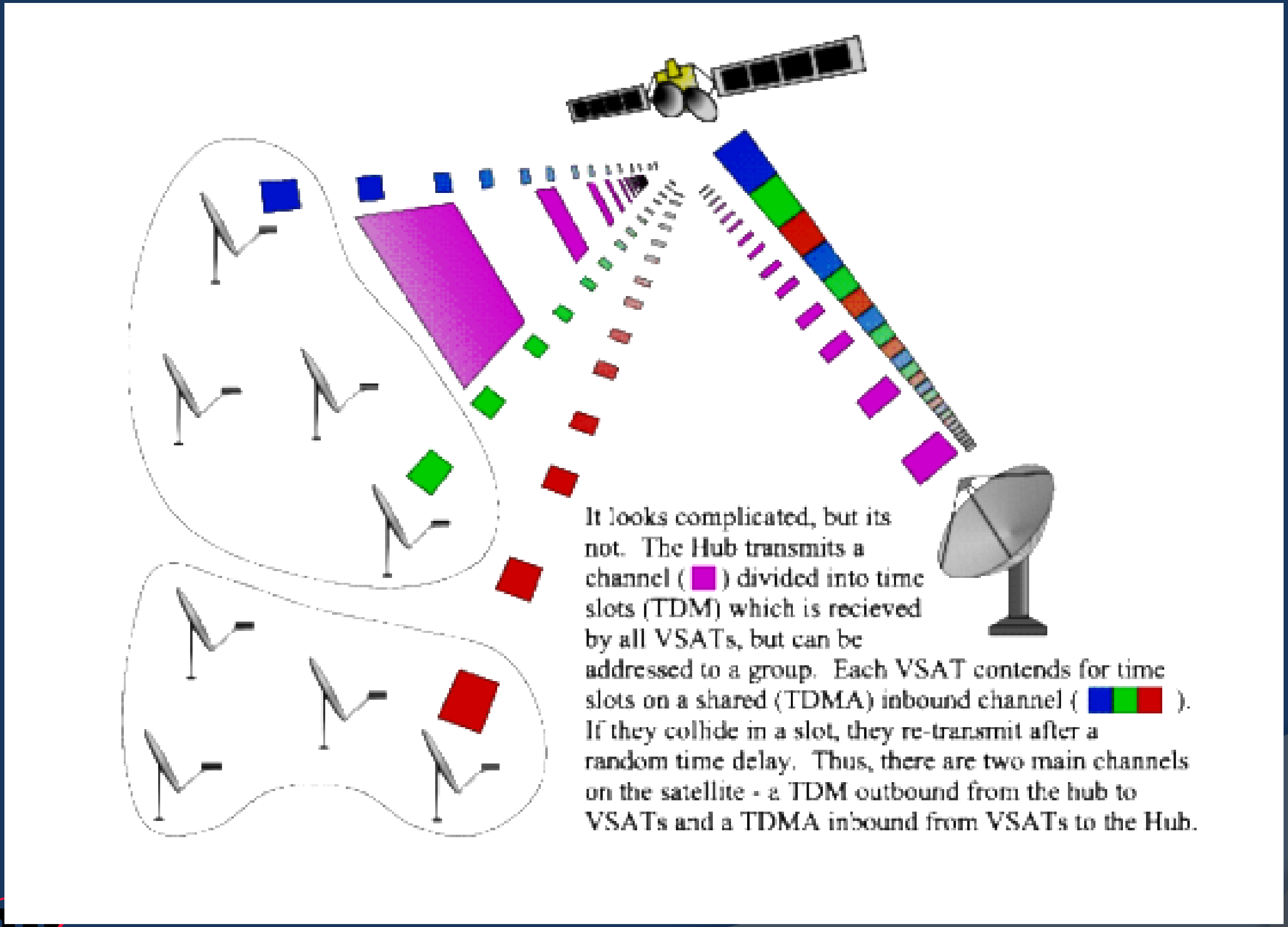
Point to point



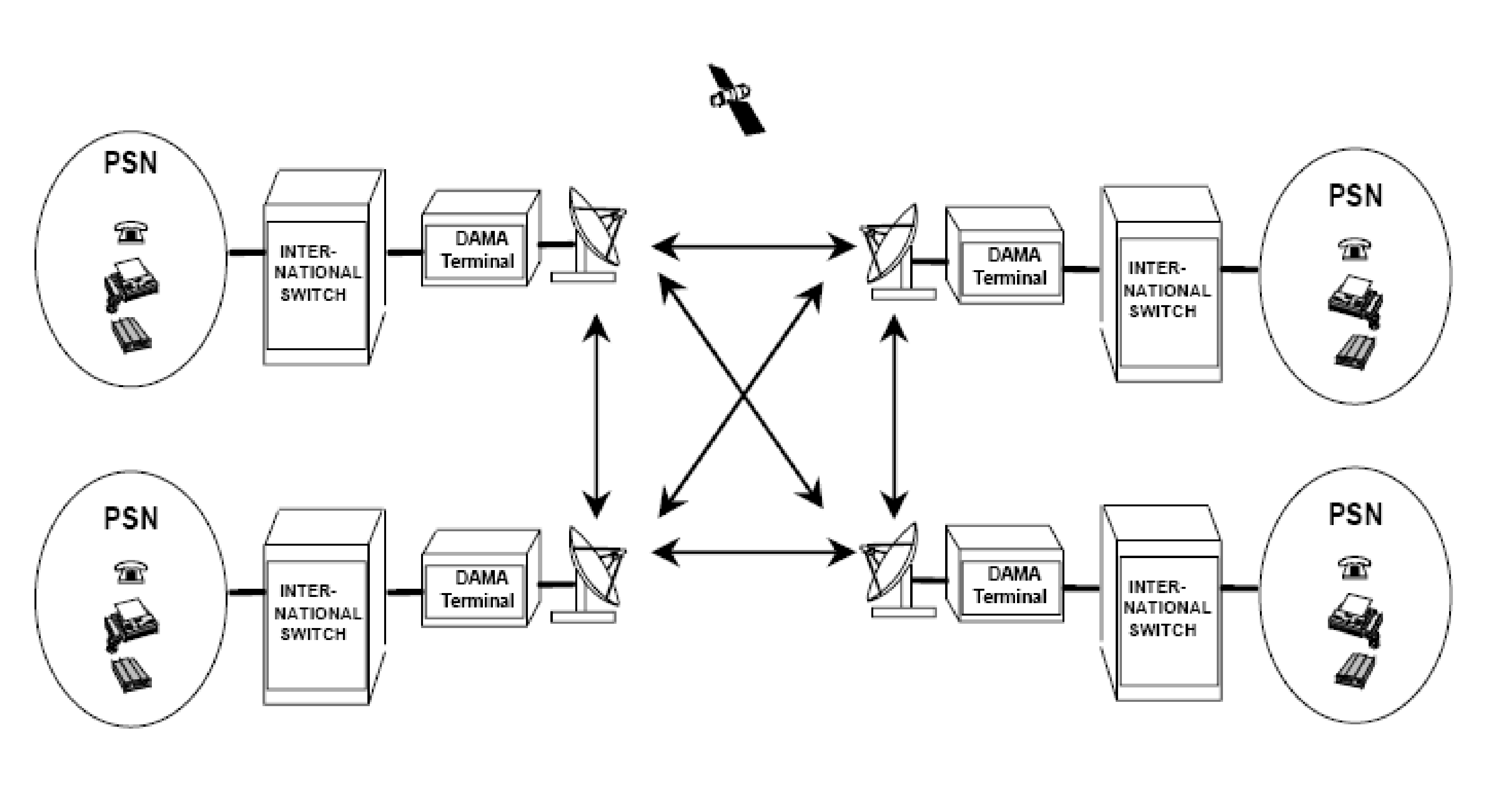
Star - Critical central node



Network planning
Star connection



Network planning
Mesh networrks



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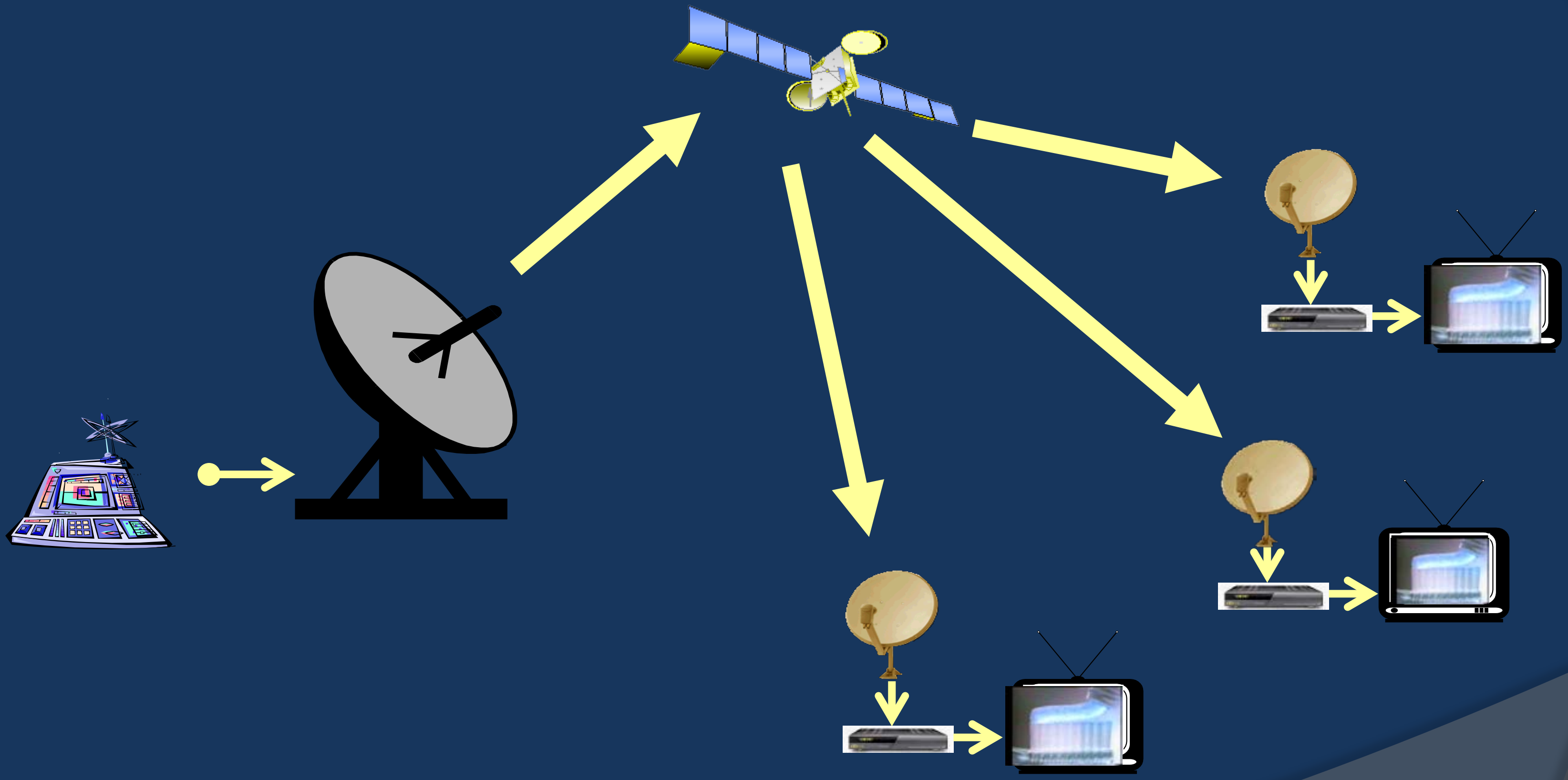
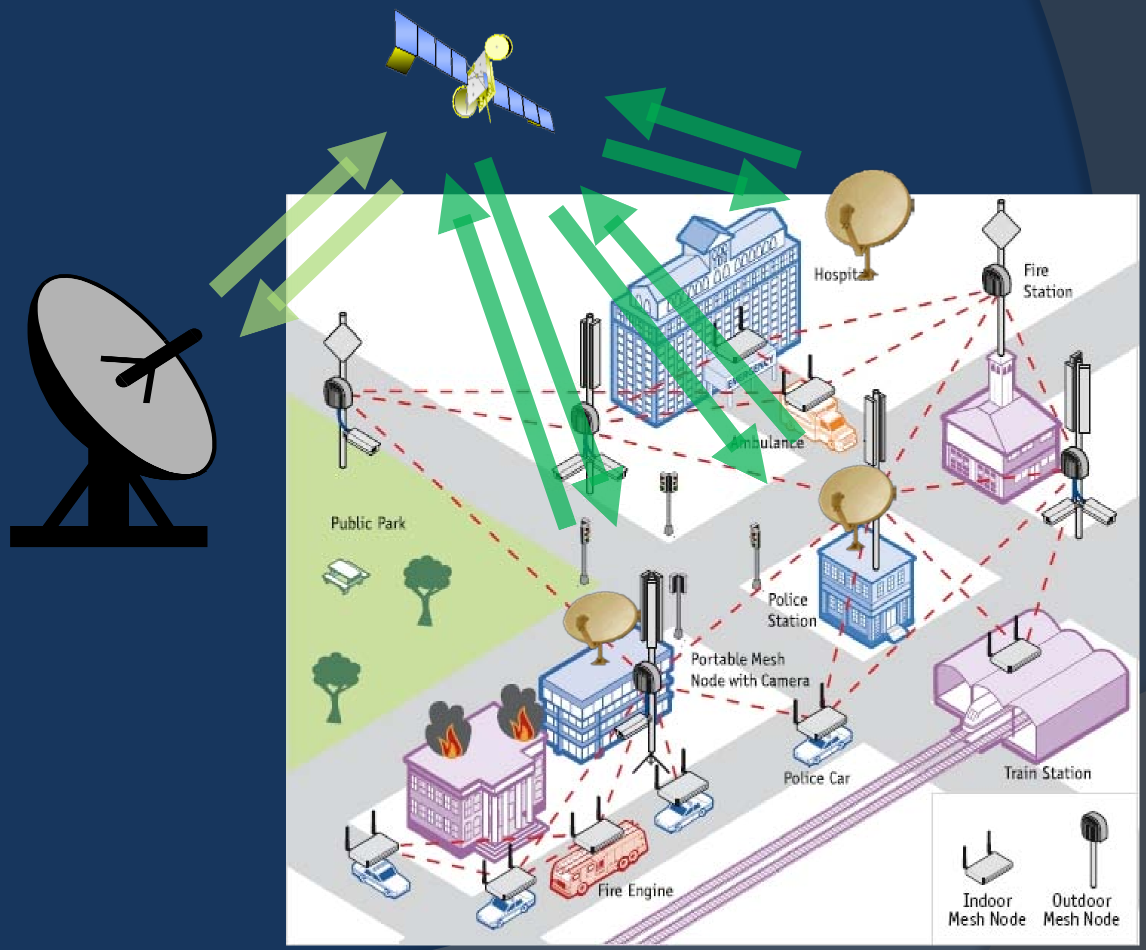
Network planning
Broadcasting network



Network planning
Hybrid network

Mesh network, but through wire and Wireless support



Network planning

Simple access, multiple access, multiplexing

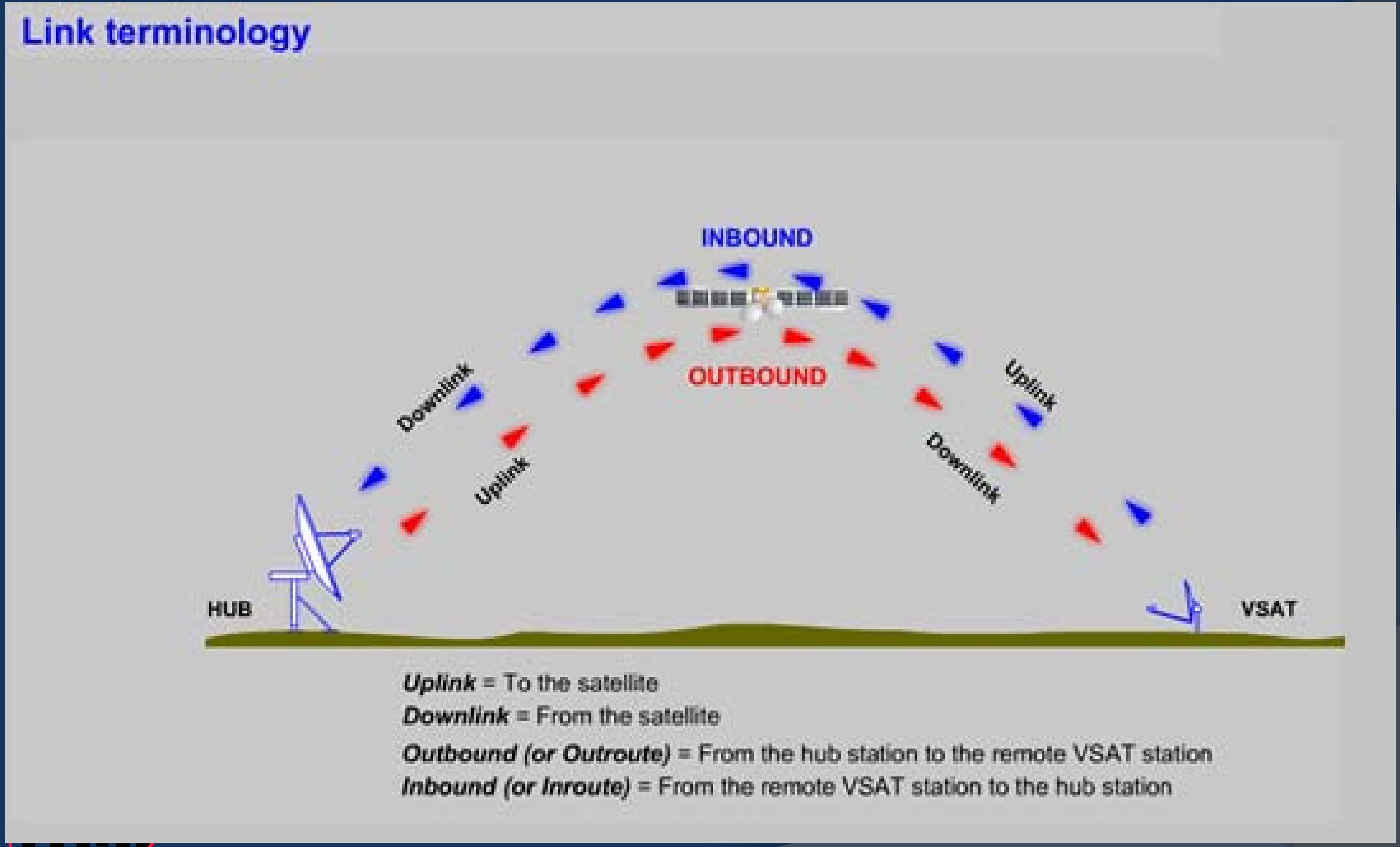
- The easiest and cheapest way to of interconnect one to one or one to more terminals is through a satellite link, but with simultaneously working terminals (versus single access) multiple access shall be employed.
- Multiplexing is different from multiple access: it is a concentration function which shares the bandwidth resource from the same places while and multiple access shares the same resource from different place

Netowrk planning

Simple access, multiple access, multiplexing

- Multiple access is the ability of a large number of terminals to simultaneously interconnect their respective voice, data and television through a satellite. The basic problem involved is how to permit a changing group of terminals to share a satellite in a way that optimizes, satellite capacity, spectrum utilization, satellite power, interconnectivity, flexibility, adaptability to different traffic mixes, cost and user acceptability ……

Network planning



Network planning

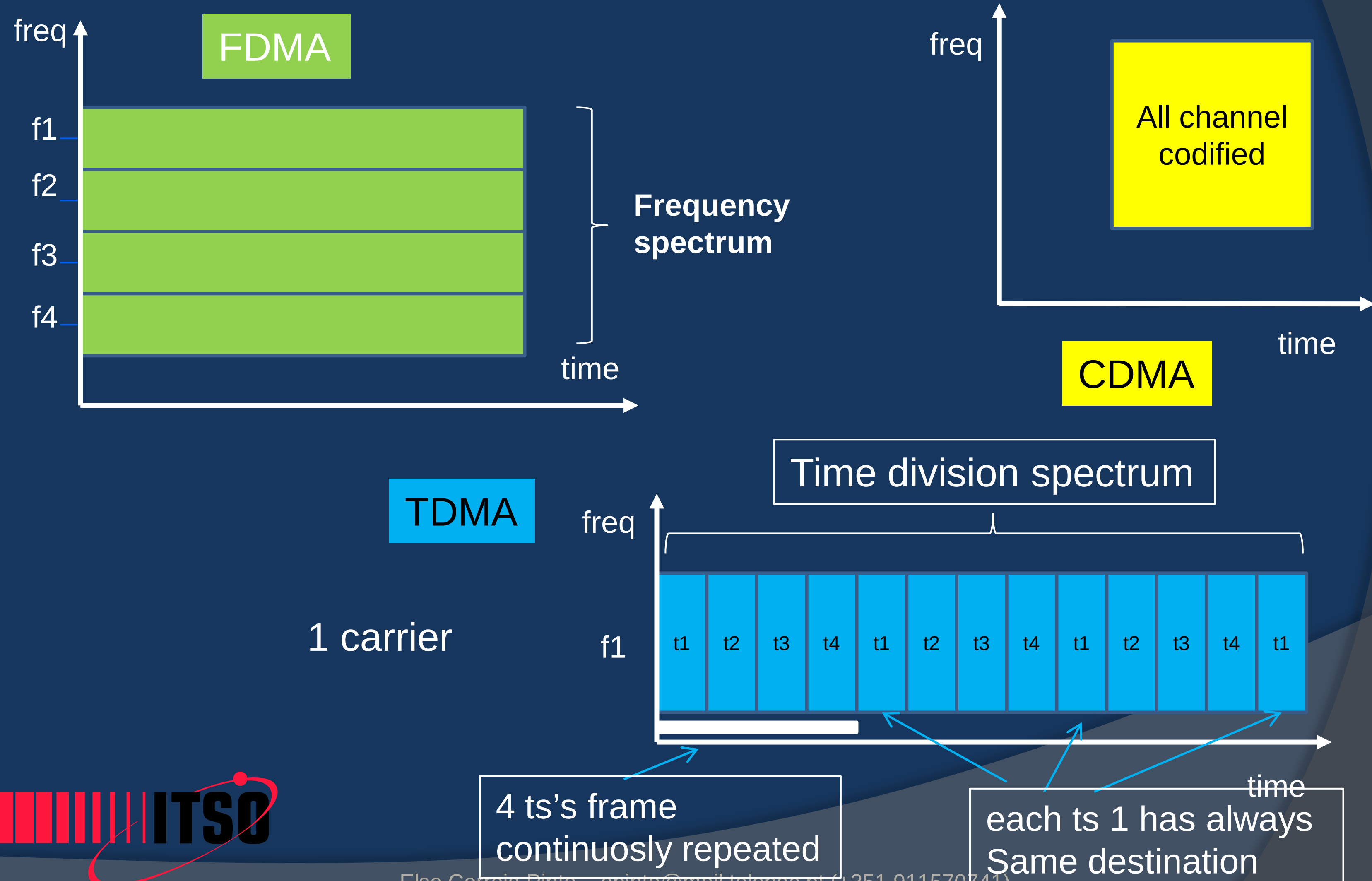
Acess types, multiple access

- In the downstream path same signal is distributed to all terminals, being the responsibility of each to determine and decode its component (whatever it would be in frequency, time, or hybrid domain)
- In the upstream path things are more complicated once the bandwidth has to be shared by all terminations. The scheme “multiple access” consists a group of stations each transmitting in its own frequency, time or hybrid e.g each station group has a differentiated link in the satellite reception channel.

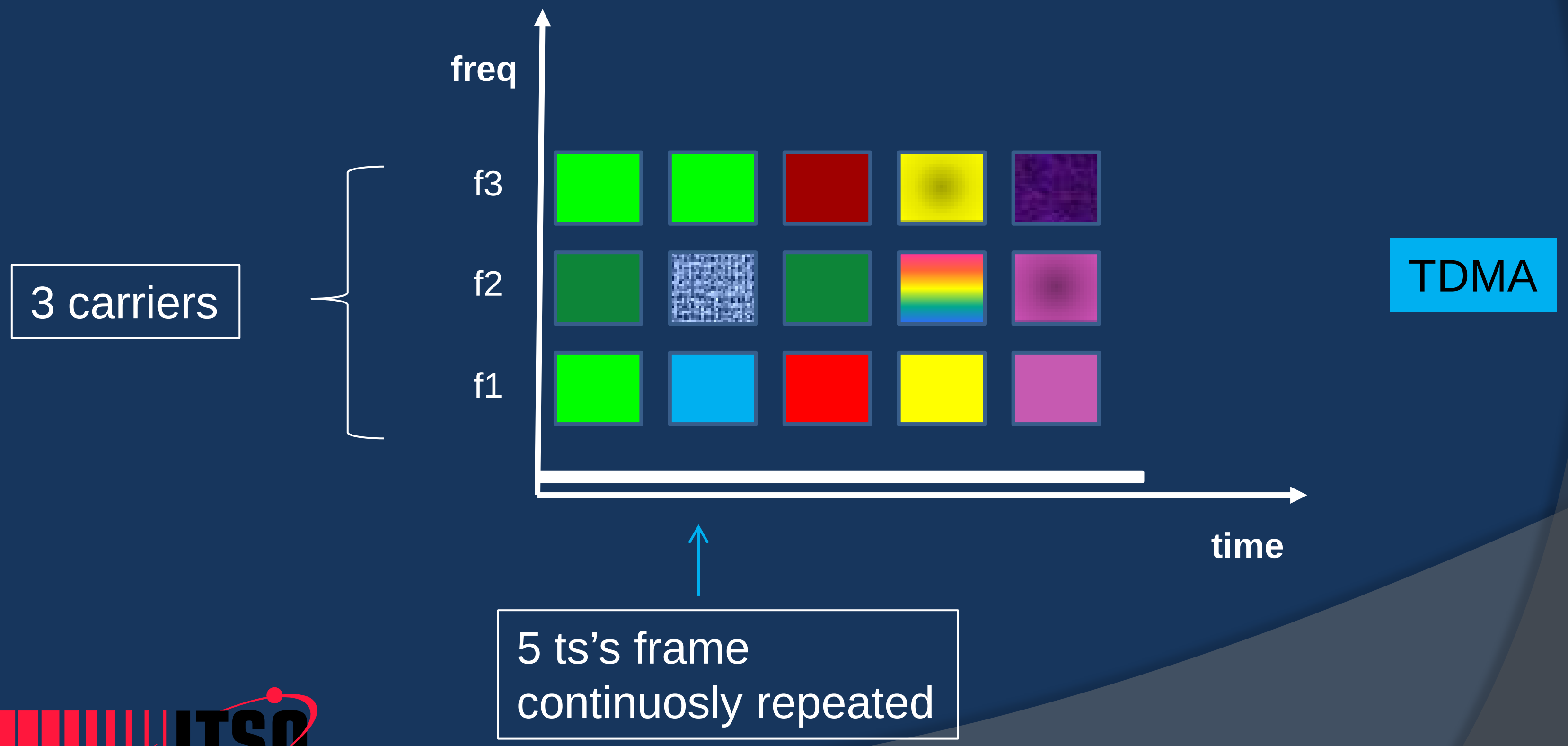
Network planning
Multiple access

- FDMA - Frequency Division Multiple Access the band allocated is divided into channels, each one occupying its frequency, being named FDMA / FA (fixed assignment) or FDMA / DA (demanded assigned) if the channel is permanently assigned or on request.
- TDMA - Time Division Multiple Access the common channel frequency in the upstream *is shared by all remote,* being each one being authorized (or synchronized) to transmit in it own time (or slot). This way the channel is shared in time division, possibilities are*:* TDMA / FA or TDMA / DA .
- CDMA - Code Division Multiple Access where all the stations use the same channel at same time, being made the separation through specific codes

Network planning
Multiple access



Network planning
3 carriers multiple access



Network planning
SCPC /TDM, DVB, TDM /TDMA, FDM /FDMA

The access type is choosed depending on:

- More suited to business, applications
- Bandwith (more burdensome component)
- Hub costs / terminal costs / flexibility
- Network monitoring ability
- QoS
- OPEX (operational costs)

Network planning
SCPC 1

- Multiple access FDMA systems, by engaging in transponder, more than one frequency potentiate interference, which although minimized with the use of decreasing the output power, has drawbacks. This difficulty - access with frequency sharing - was mitigated by implementation of a channel per carrier, SCPC - Single Channel per Carrier, which offers the following options:
    - *PA-pre assignement also called voice-activated allowing although digital signals and normally associated with the channel, through multipliers systems technologies with the DSI.*
    - *DA-demand assignement* (also known by DAMA or bandwirth on demand)

Network planning
SCPC 2

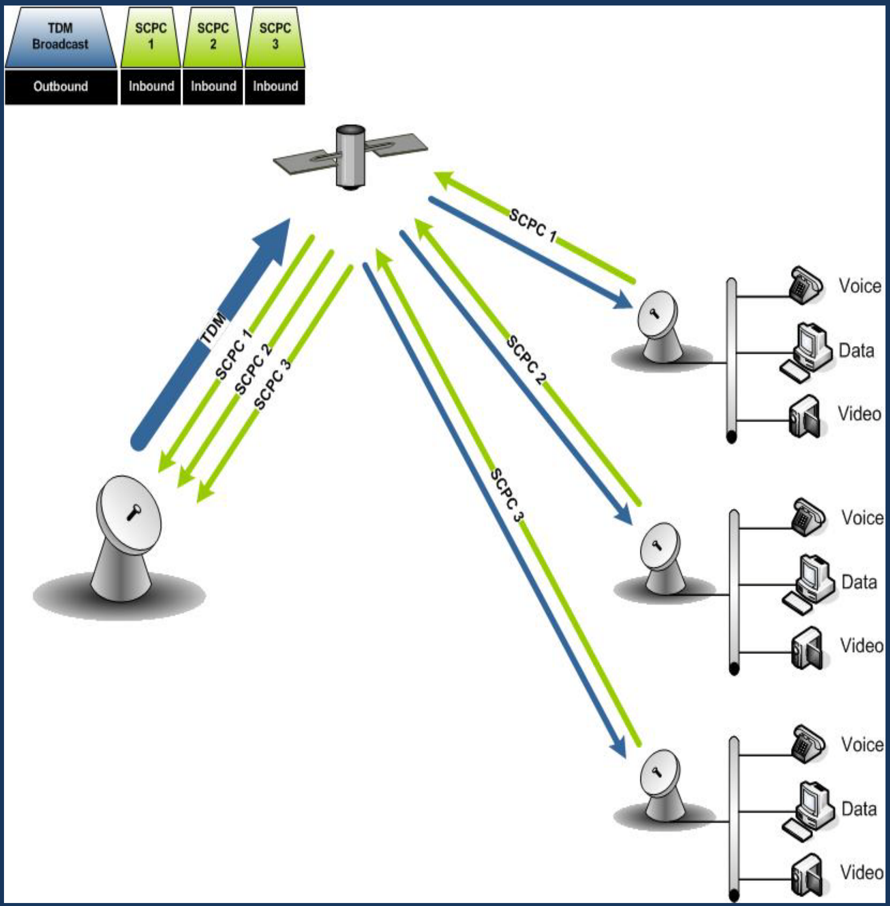
- With digital compression techniques in use, a 64 Kbps cct can drain more than 8 voice channels, even if giving with the video in which a 36 MHz transponder can support 4 carriers with 8.448 Mbps (with QPSK and FEC 3/4 and appropriate RS).
- If a group of channels modulate the carrier, we call it multi channel per carrier (MCPC). This is normally used for interconnect between networks as a transit network or local exchange to the access network.

Network planning
SCPC 3

In summary

- Each remote access to common medium but in alternate way, without contention:
  - There is no bandwith sharing among remote
  - There is no frame in sense of packaging with contention
- There is no need of access control, because
  - Rhere is no *overhead and all burst* correponde traffic, allowing critical application in real time.
- Typical topology, star (with traffic stability or in other words geographic distribution) and point-to-point (SCPC duplex) without burst

Network planning
SCPC / TDM



Advantage	Disadvantage
Dedicated bandwidth for each remote inbound	Each remote requires its own space segment
Provides superior Quality of Service for critical applications	Expensive OPEX if each remote bandwidth is not fully utilized
Low Latency and Low Jitter	SCPC modems typically more expensive than TDMA modems
Best transmission method for real-time applications, voice, data, video, broadcast, etc.	Fixed data rates on the inbound links

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Network planning
DVB - S

DVB-S: Digital Video Broadcast for Satellite

Access6

- **DVB-S is a very specific implementation of TDM**
  - Defined by an ETSI (European) specification
  - Now used globally for digital TV via satellite
  - Originally intended for placing multiple digital TV channels on a single broadcast carrier, using MPEG-2 video compression
  - But it is quite versatile, and is now commonly used for VSAT outbound data carriers
  - Many low-cost, high performance receiver chips and cards support DVB-S
- **Related standards**
  - DVB-S2: A new version with more efficient modulation and forward error correction.
    - ***Beginning to be used for the outbound carrier in new VSAT systems***
  - DVB-RCS: Return Channel System using TDMA (enables two-way VSATs)
  - DVB-T: digital terrestrial broadcast television (mainly in Europe)
  - DVB-C: digital cable television

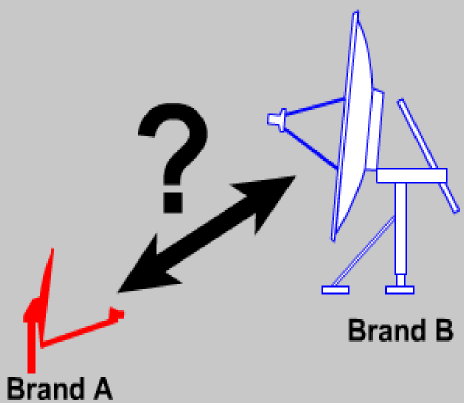
Network planning
Interoperability

Interoperability

Access14

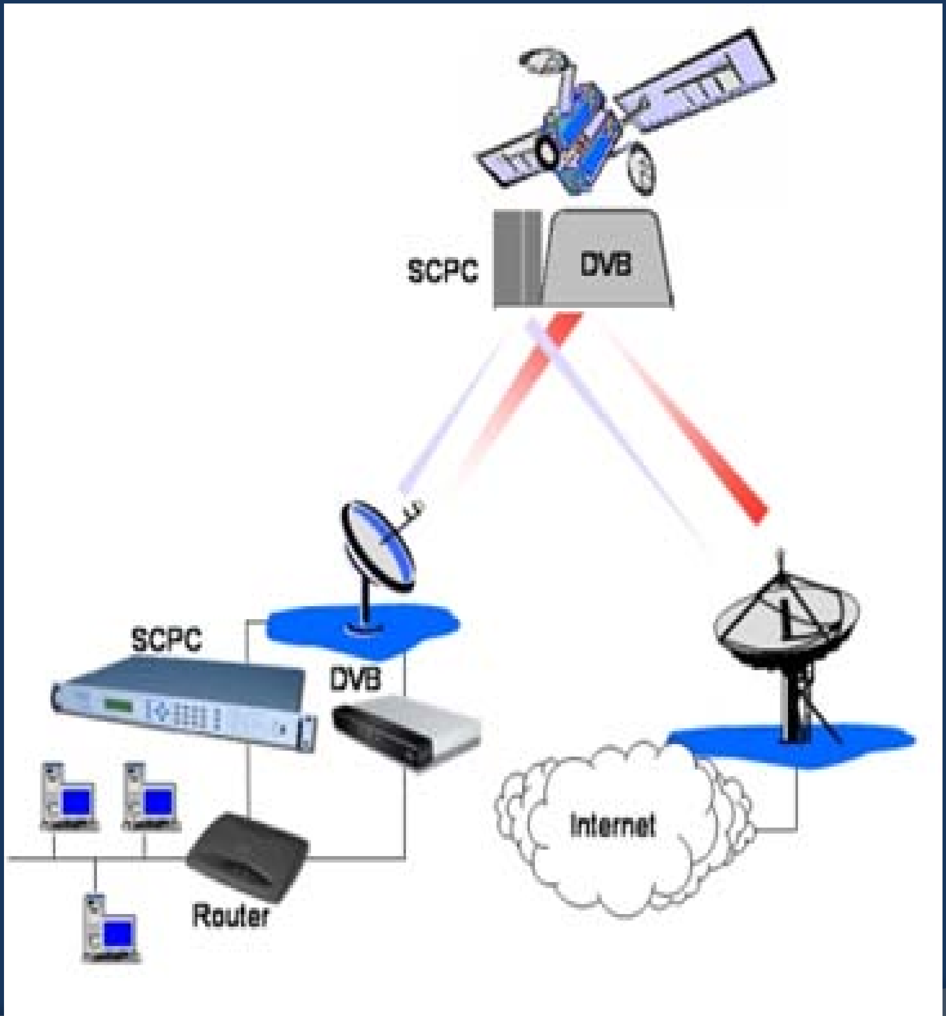
Historically, VSATs from different manufacturers would not work together. Recently, however, there have been some moves towards interoperability standards for TDM/TDMA VSATs.

- **DVB-RCS**
  - ETSI standard; fully defines interoperable TDM/TDMA VSAT.
  - The only standard that multiple manufacturers are following, including:
    Advantech AMT (formerly EMS Satellite Networks), Newtec, Nera, Gilat, Viasat
  - SatLabs Group performs interoperability testing.
  - Has a fraction of the market but is growing; costs may come down.
- **DOCSIS for satellite**
  - Not actually an interoperability standard.
  - Variation on the DOCSIS cable modem protocol, using same chips to reduce cost.
  - ViaSat is the main proponent.
- **TIA-1008 (IPoS)**
  - HNS opened its HughesNet (formerly DirecWay) protocols via the Telecommunications Industry Association (TIA).
  - No other manufacturers offer interoperable equipment (as of 2006).
- **Proprietary systems**
  - Hughes Network Systems and Gilat dominate by sheer numbers.



Network planning

SCPC / DVB



Advantage	Disadvantage
Ideal whenever the return channel has to be via satellite	Each remote requires its own SS
Unicast applications (push) or multicast real-time financial-apl, streaming radio, or bidirectional (pull, or browsing high speed)	
Low delay and jitter	The modem SCPC are typically more expensive than TDMA
The TV service datastreams are MPEG-2 (video and audio archived files). High speed IP service .	The inbound data rate are fixed

Network planning
TDMA 1

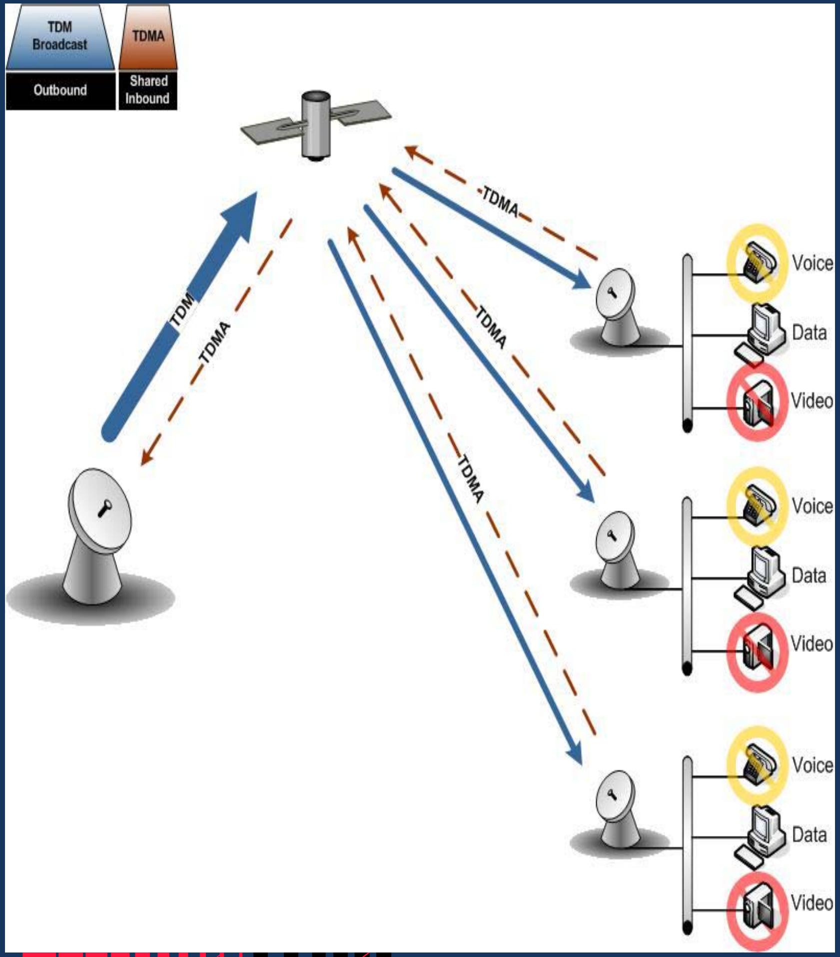
- Each terminal is required to transmit bursts in short non overlapping timing intervals which requires some form of *frame structure and a global timing synchronization mechanism.*
  - The frame is the time interval over whitch a signal format is established and repeated. A frame is subdivided into time slots and a burst consists of an exact number of slots and occupies a precise position in the frame *.*
  - Each burst must arrive at the satellite transponder at a prescribed time. This insures no *overlapping* with others terminals to guarantee a high transmission efficiency. A mechanism of synchronization provides timing information att all stations.

Network planning
TDMA 2

- The transponder works at saturation, and although this affects inter relation symbols, worsening the quality of the link (BER), has far less impact than in FDMA
- It is not necessary fine adjustment of the power at terminals
- Like all stations transmit and receive just one frequency installation tuning or removal terminal is simple
- Complementary techniques of digital multiplication of channels (DSI-Digital Speech Interpolation) are easy to implement
- Network timing is very demanding, terminal equipment are more expensive than in FDMA

Network planning

TDMA / TDM



Advantage	Disadvantage
Sharing of satellite bandwidth	Increased Latency and Jitter
Lower overall OPEX compared to dedicated pipes	Demanding remotes can burden the system
Good for low data rate applications	Fragmentation of packets. Less effective for voice and video
Low cost remotes	Expensive hub equipment
Large population of users	All remotes must be designed around worst case link

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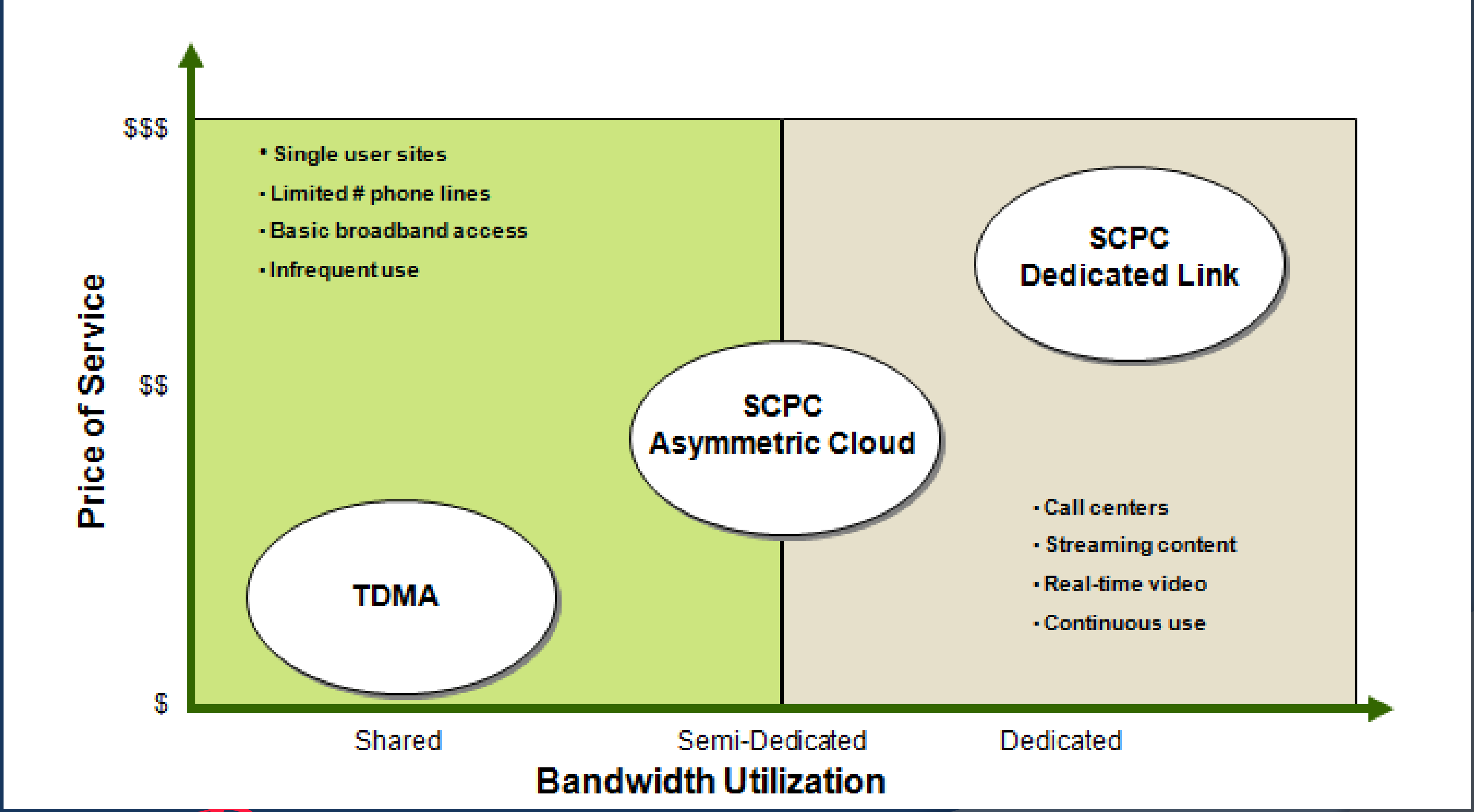
Network planning
Resumo acessos SCPC / TDMA



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Network planning
FDMA 1

- FDMA is a traditional technique where several terminals transmit simultaneously but on different frequencies into a transponder:
  - When using multiple channels per carrier to transit networks FDMA has significant problems with inter-modulation (IMP) and hence a few dB of back-off from saturation trasmission power is required to overcome the problem of non linearity at high power.
  - FDMA is attractive because of its simplicity for access by ground terminals. Single channel per carrier is commonly used for thin route telephony,
  - The single channel per carrier system, is used for reduced voice traffic, and access to mobile networks.
  - Not good for applications with different bandwidth requirements

Network planning frequency bands

- C band was the first to be used in satellite systems and only when this space has been scarce (where its re-use by terrestrial links worlwide increased the problem) Ku band has been adopted.
- Ku band is typically used for broadcasting and for Internet bidirectional communications , with the advantage of the satellite having high power transmitter (smaller antenna diameter and RF units easier to get)
- Ka Band is more popular for high speed Internet access rather than for classical satellite TV.

Network planning
C band

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

Network planning
Ku band

- Down Link : 11,7 - 12,2 GHz
- Up Link : 14,0 - 14,5 GHz
- Advantages : Less sensitive to terrestrial link interferences
  Small antenna diameter(90cm)
  Cheap and easy to install RF units

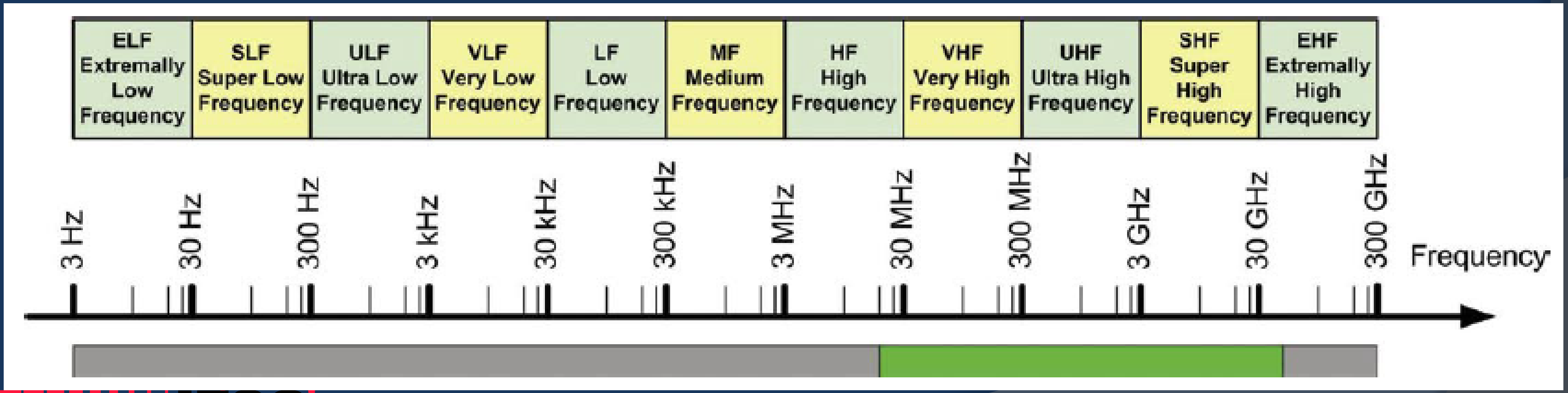
- Disadvantages : Expensive space segment
  Less imunity to heavy rain, although being compensated with larger diameter antenna

Network planning
Ka band

- Down Link : 19,7 – 20,2 GHz
- Up Link : 29,5 - 30 GHz
- Advantages : Very interesting to high rate Internet
  Low cost terminals
  Easy to reconfigure remote terminal data rate
- Disadvantages : Because of high attenuation by heavy rain, it is not advisable for TV in areas with heavy rainfall

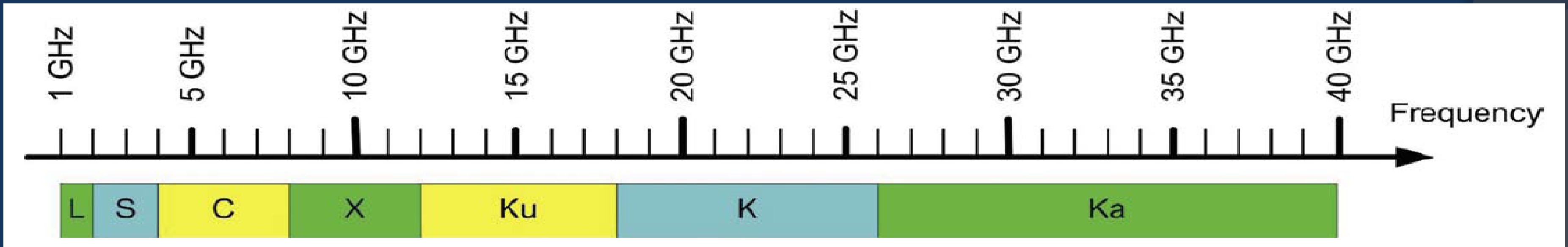
Network planning
Spectrum 1

We can see below the range of frequency that we can use for satellite communication, a green bar starting at around 20 MHz and ending at about 40 GHz. Occasionally also lower and Ku Band terms. By expanding the green bar we see the actual satellite bands

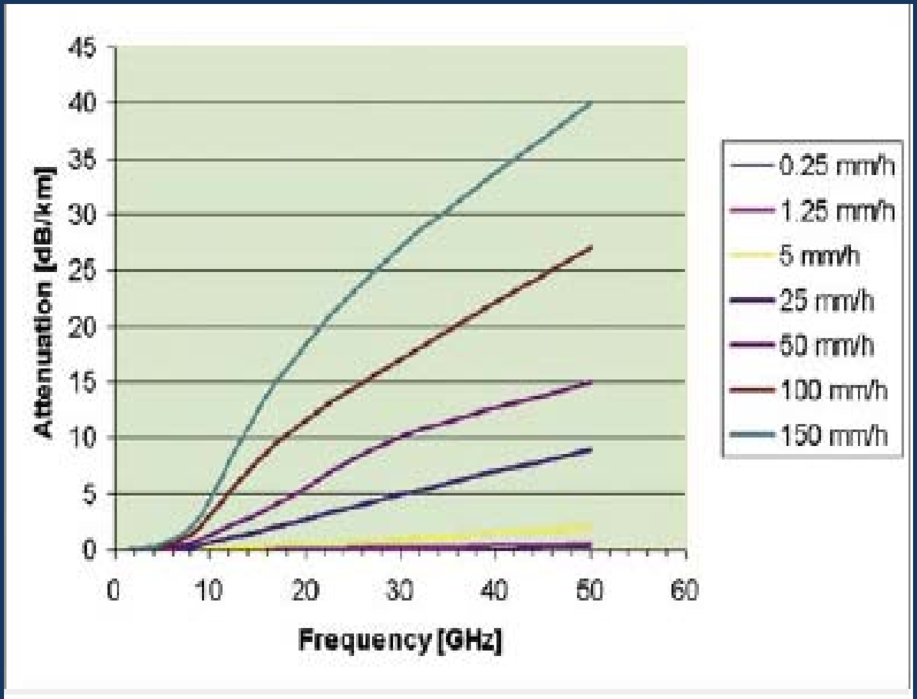


Network planning Spectrum 2

Ku Band starts at 12 GHz while some of the Ku Band transponders transmit even below 11 GHz, so formally in X Band. Indeed, the downlink uses both Ku Band and X Band but the uplink uses only Ku Band. For this reason, we call them Ku Band satellites or transponders. Moreover, we should also keep in mind that we can not use the whole band (Ku, C or whatever) for the satellite downlink. A part of the band has to be reserved for the uplink, and some parts of the bands are dedicated for military or professional services (e.g. radars).



Network planning Ka band restrictions



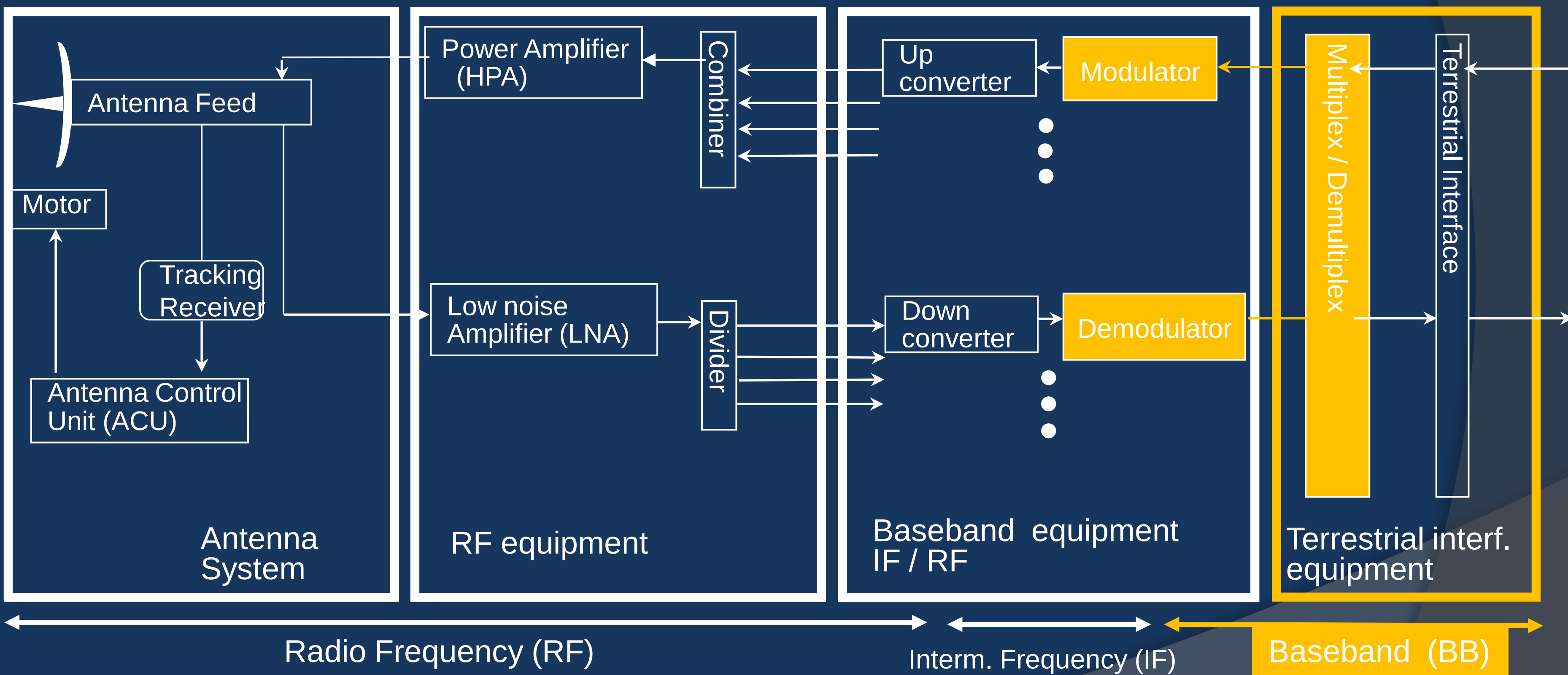
However, what can be easly seen is that the space for TV or data channels is much greater in Ka band than in C, and Ku has no problem in using frequencies up to 50 GHz or so. Attenuation of less than 1 dB is not a big deal. Unfortunately this is not the whole picture. Atmosphere containing water vapor is one thing, and raining is another thing. Attenuation caused by rain dramatically increases with frequency, as you can see

Network planning

Transfer information at Base band

- Only one link per line
- Add Modulation for multi-line communications
- Modulation
  - Altering one waveform (carrier) in accordance with the characteristics of another waveform ~

Network planning baseband signals

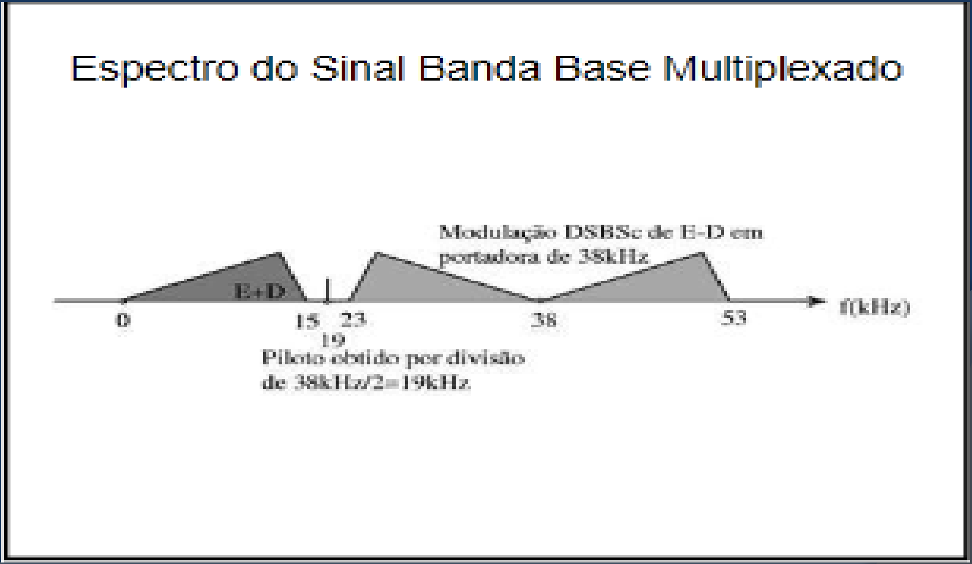


Network planning baseband signals

- The signal to be transmitted can be digital, such as data flowing between computers, printed text, communications between remote terminal and computers, or analog such as telephone or TV, channels.
- Whatever will be digital or analog information signals, they must be gathered to carry on several telephone channels or several data circuits, in other words information occupy a defined bandwidth, that

Network planning baseband signals

- When using the shift in frequency and the Channel Translating Process, the bandwidth is shifted to a frequency also designed by channel baseband



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Network planning baseband signals

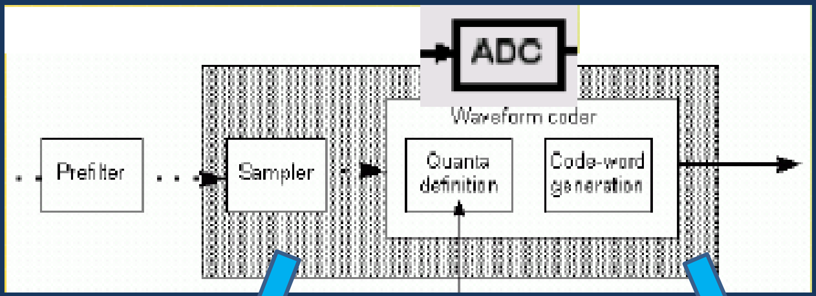
- When using bits of information e.g. 0's and 1's, to translate information we got from discrete signals previously sampled and quantized, information signals are referred to as TDM baseband signals once we are not limited in frequency.
- A baseband signal can be all-information or it can contain redundant bits making it a coded signal but it is still at baseband and still has fairly low frequency contents.

Network planning baseband signals structuring

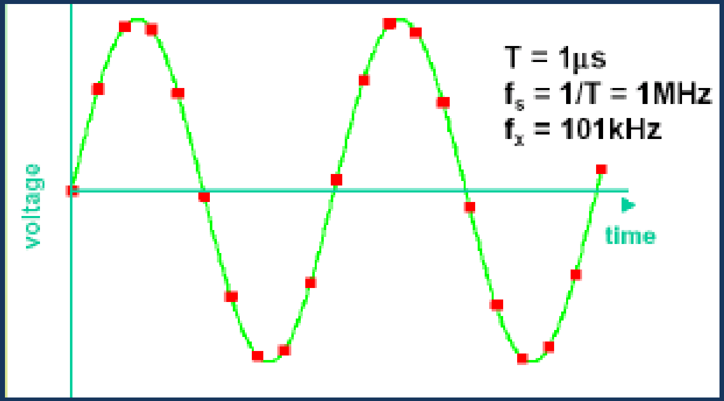
The main steps involved in the baseband signals structuring are:

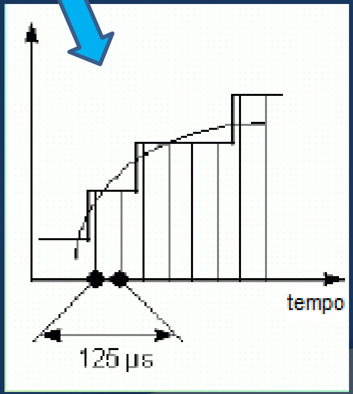
- Sampling, quantizing and encoding (analog to digital)
- Multiplexing from basic hierarchy to higher order
- Source encoding - to alter the information source for efficient transmission over the medium, that is minimize the source bit rate.
- Channel encoding - to make efficiente use of the communication channel resources, e.g. bandwidth and power, redundancy bits are inserted for purposes of error control and error correction.
- Modulation - process of converting the information so that can be successfully sent through radio.

Network planning
bb signals - sampling, quantizing



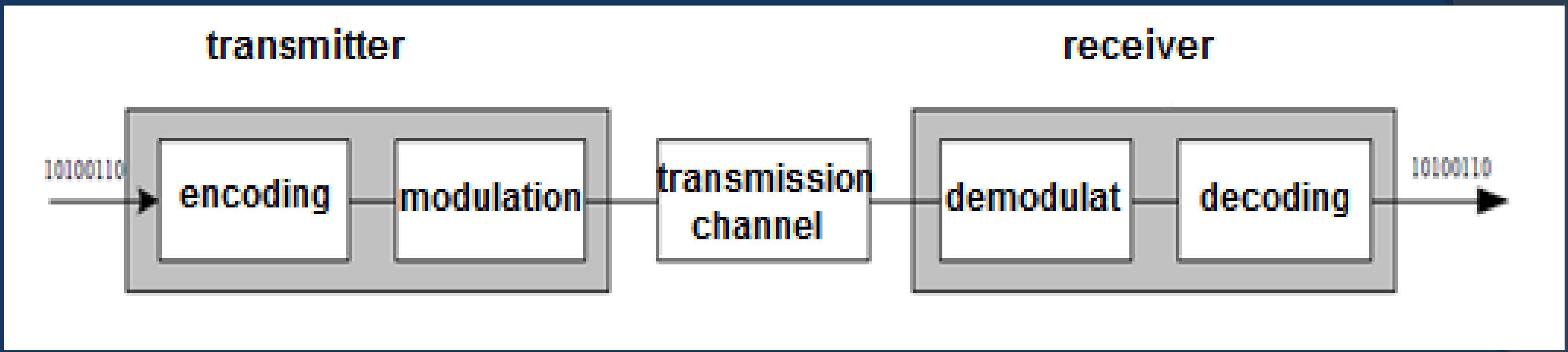
1 . Sampling continuos signals
2 . Quantif. / Codific. samples & trans^{tion}
3 . Nyquist criteria assures recovering original signal





Analog signal → converted into discret signals, by M levels. Quantization level to a sequence of N binary bits :
- Nº levels = M = 2^N
- Nº bits = N = $\log_2$ M
Nyquist criteria
- N bits per sample

Network planning
bb signals - codific, mod & transmissão



Transmitter - line encoding (NRZ, Manchester..) +
modulation + bandwidth filter+ “raised filter cosine”
Transmission channel – deals with attenuation, phase distortion,
limited bw, noise & ISI
Receiver - equalizer (distortion compensation) +
“raised cossine filter” + demodulator + decoding

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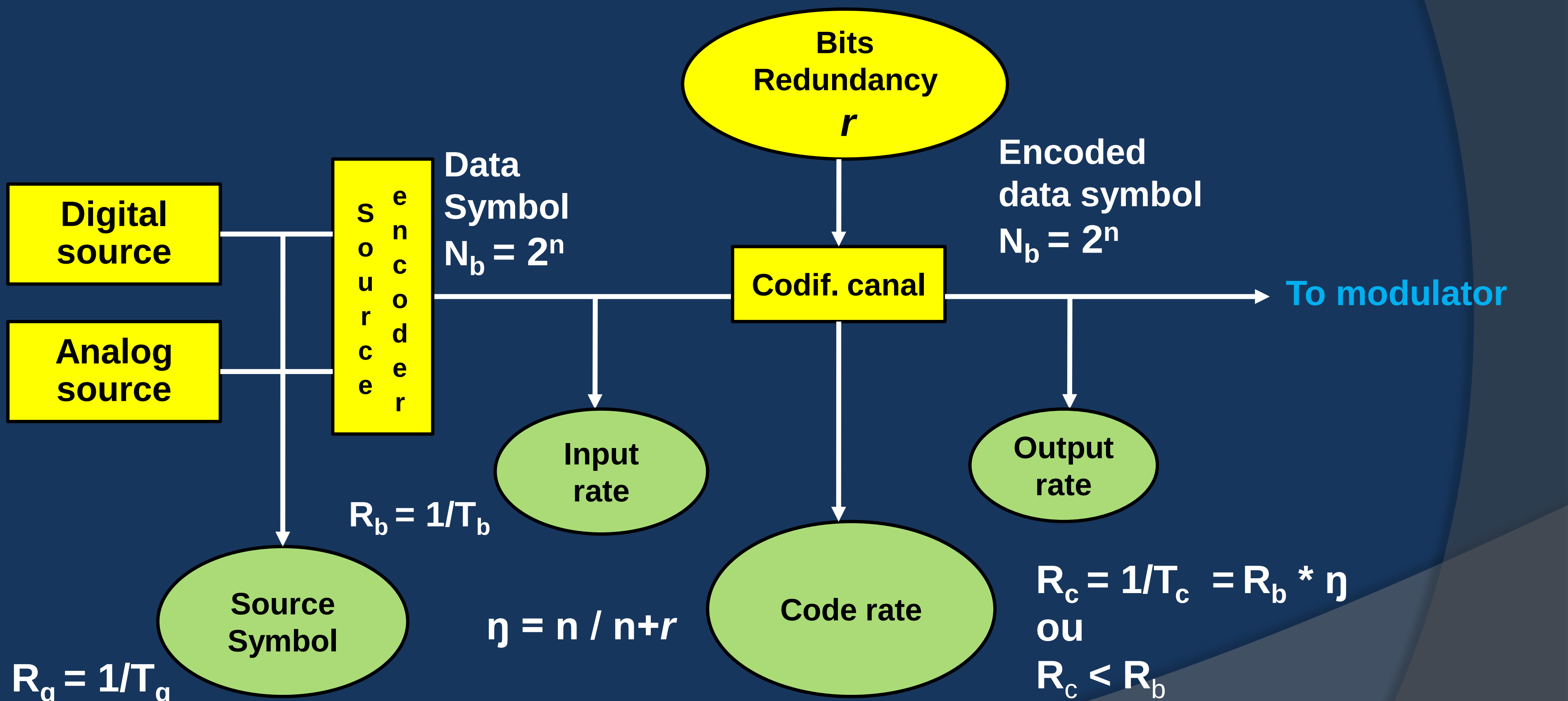
Network planning
baseband signals - line characterisitcs

- Use of electrical pulse to codify bits “0” and “1”
- Pulses are directly in the medium
- Usually square wave
- Data stream spectrum adapted to frequency response of medium
- Data stream shall follow some timing rules for transitions to avoid synch loss and clock timimg is embeded in data stream for recovery
- Vulnerable to environmental noise, interferences and ISI - Intersymbol interference

Network planning



Network planning

baseband signals - NRZ code

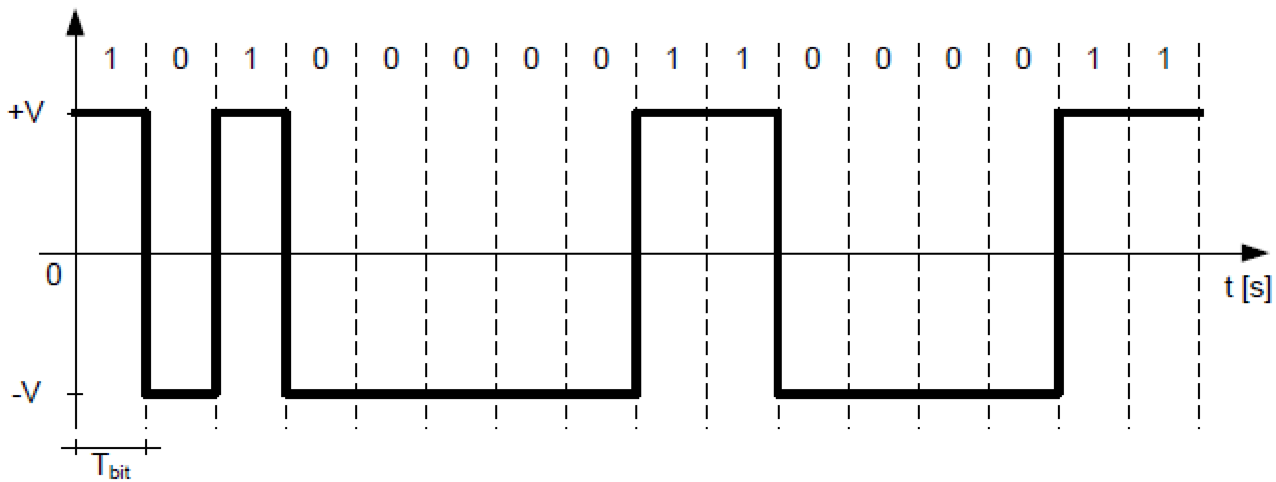
$$\alpha = roll - off$$

$$0 = ideal$$

$$1 = duplabw$$

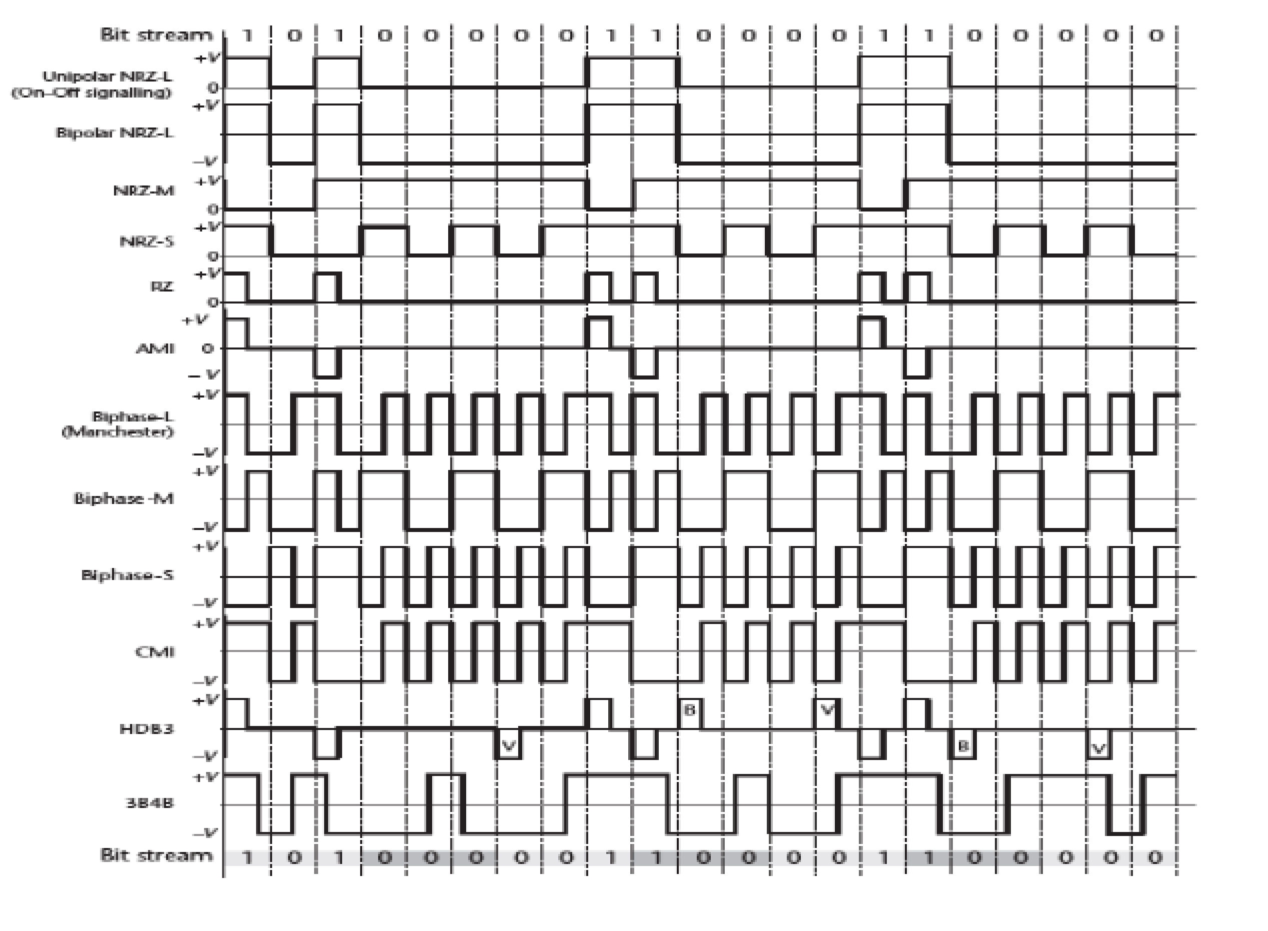
NRZ-Bipolar ou NRZ-Polar

NRZ - Bipolar / NRZ - Polar



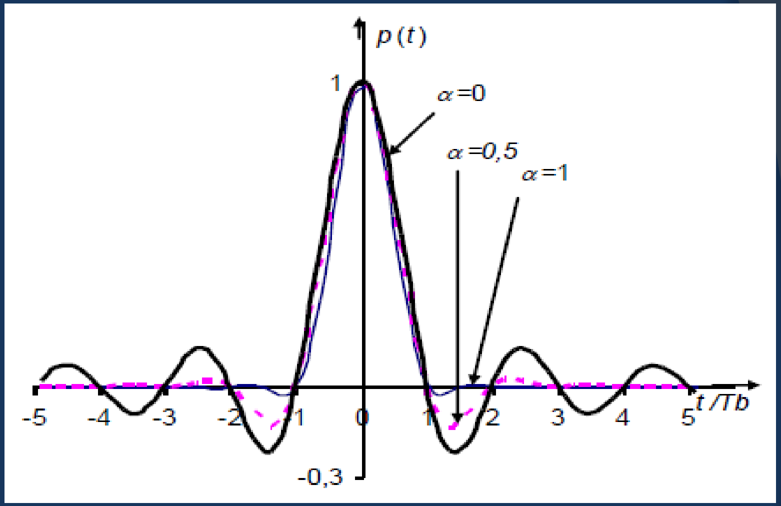
1º spectral zero	bandwidth	average energy per bit
$B_T = R_b$	$B_T = \frac{R_b}{2}(1+\alpha)$	$E_b = V^2 \cdot T_{bit}$

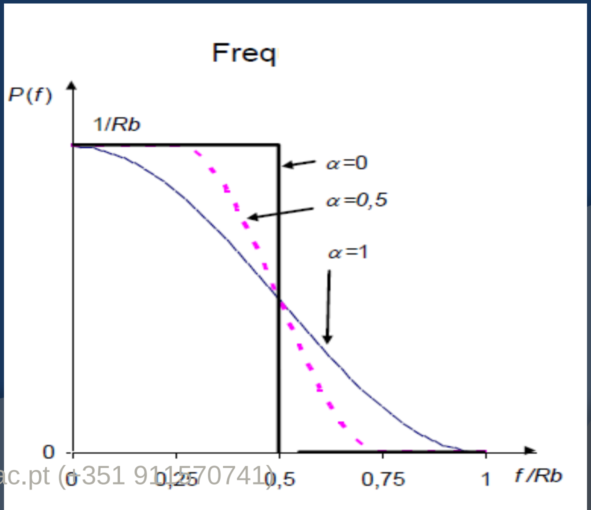
Network planning
baseband signals – most common codes



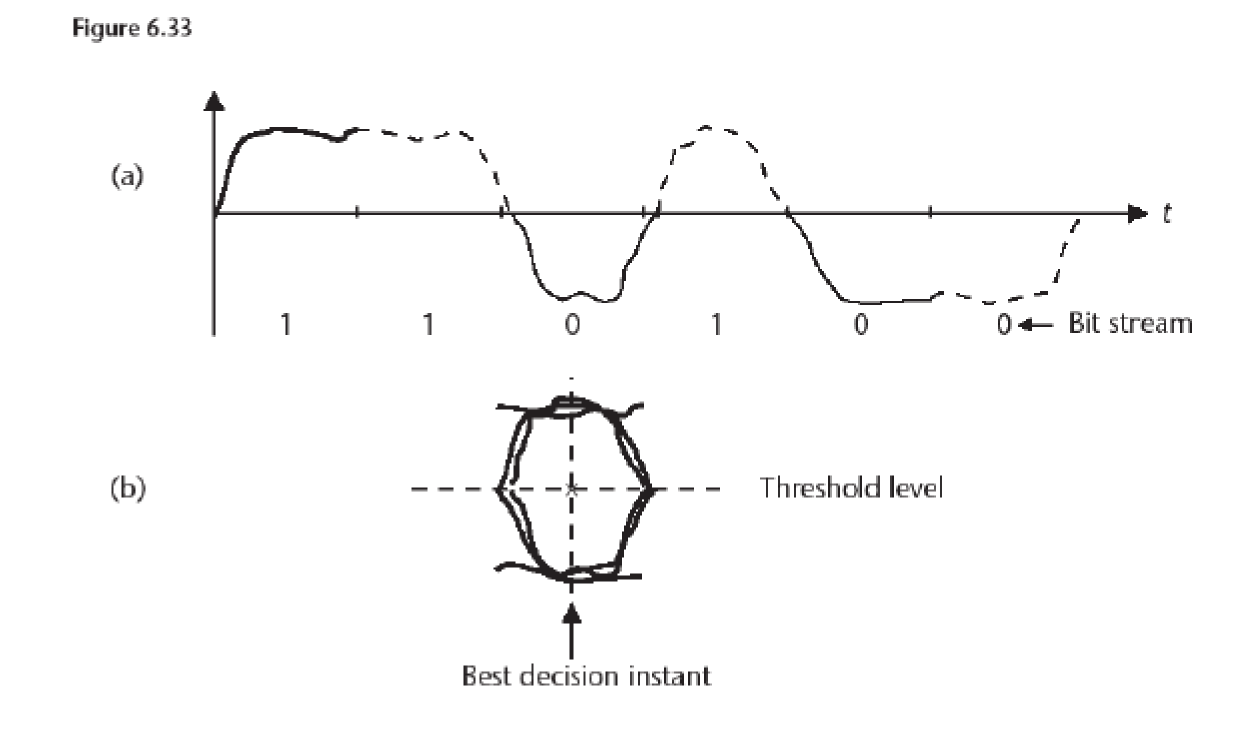
Network planning
bb signals - ISI interference 1

In a baseband system ISI can be avoided by an appropriate choice of lowpass filter, according to Nyquist criteria, called "raised cosine filter" whose objective is to create in the receiver a pulse whose shape is "sin x / x", where Tb is the bit period, so that at the instant one pulse is sampled the "tails" from all preceeding pulses which have zero value



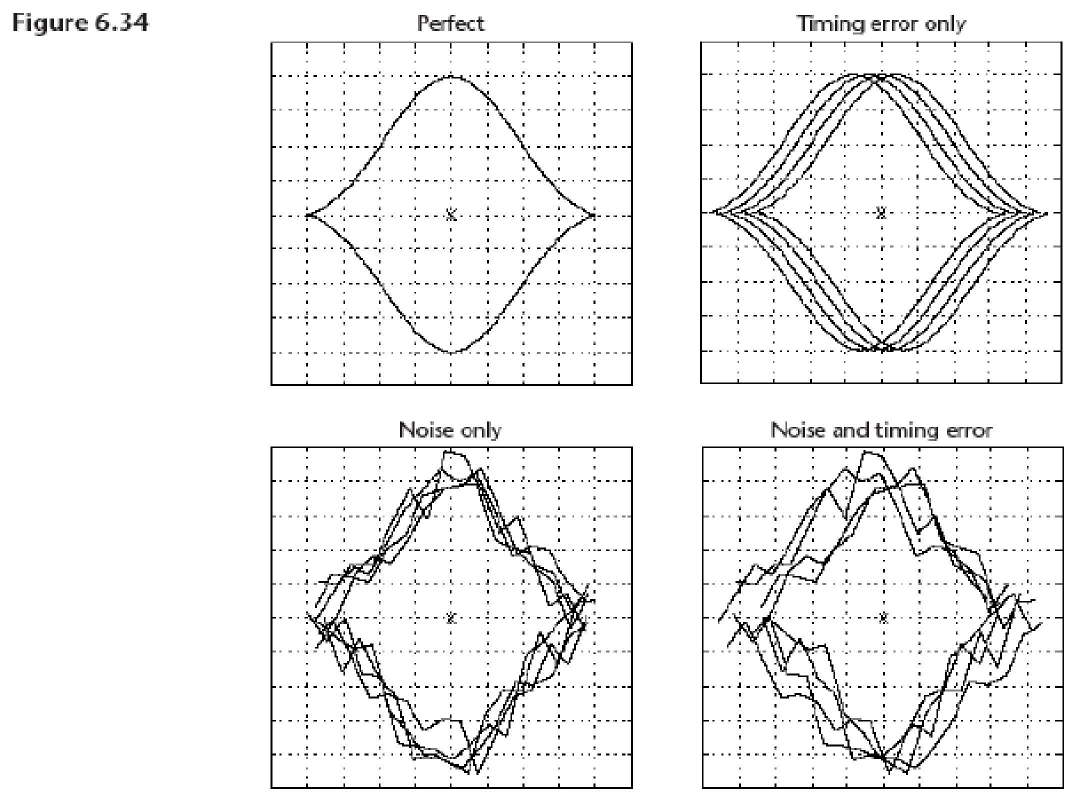


Network planning
bb signals - ISI interference 2



Eyediagram, does evaluate the ISI in a digital transmission

Network planning
bb signals - ISI interference 3



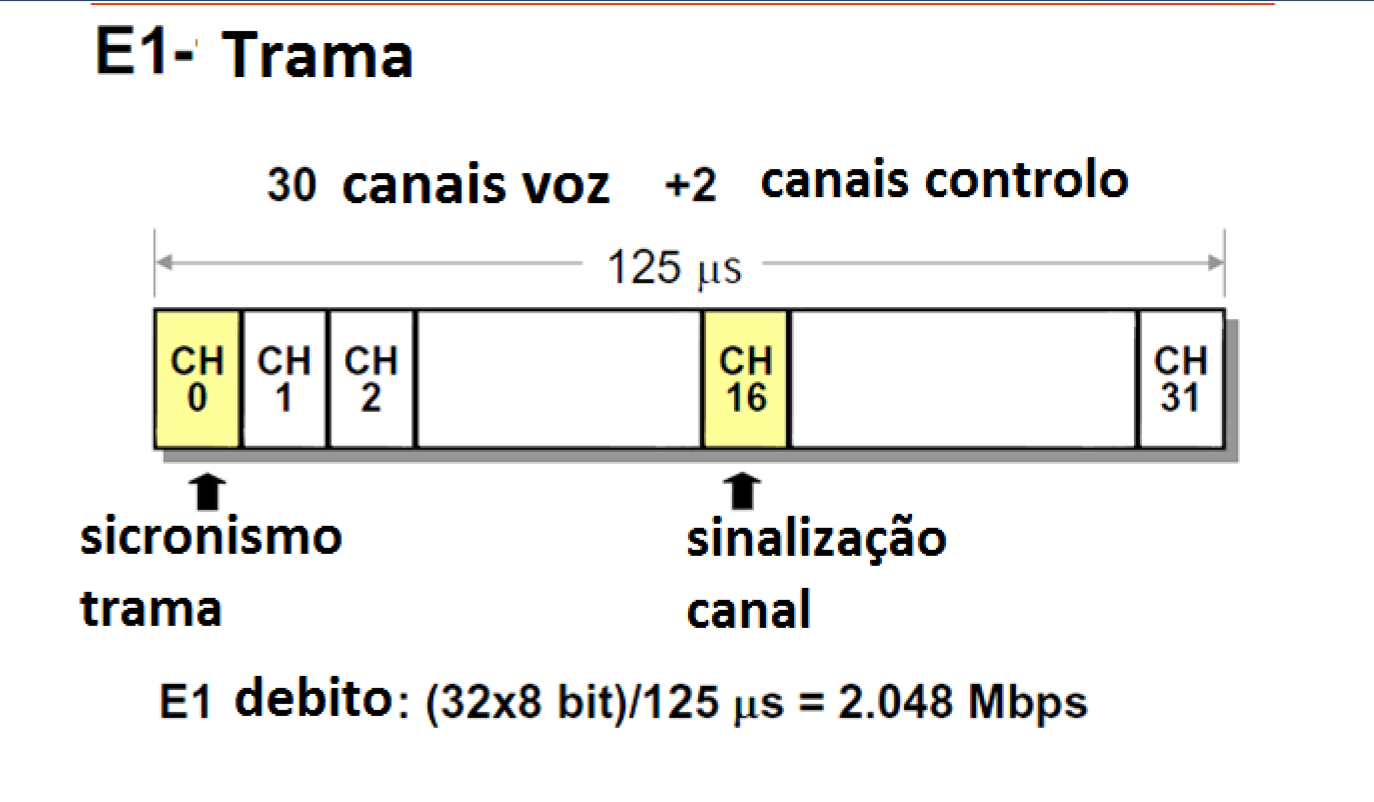
Taken from *Communication Engineering Principles*, © Ifiok Otung, published 2001 by Palgrave

Network planning
digital com. techniques - multiplexing

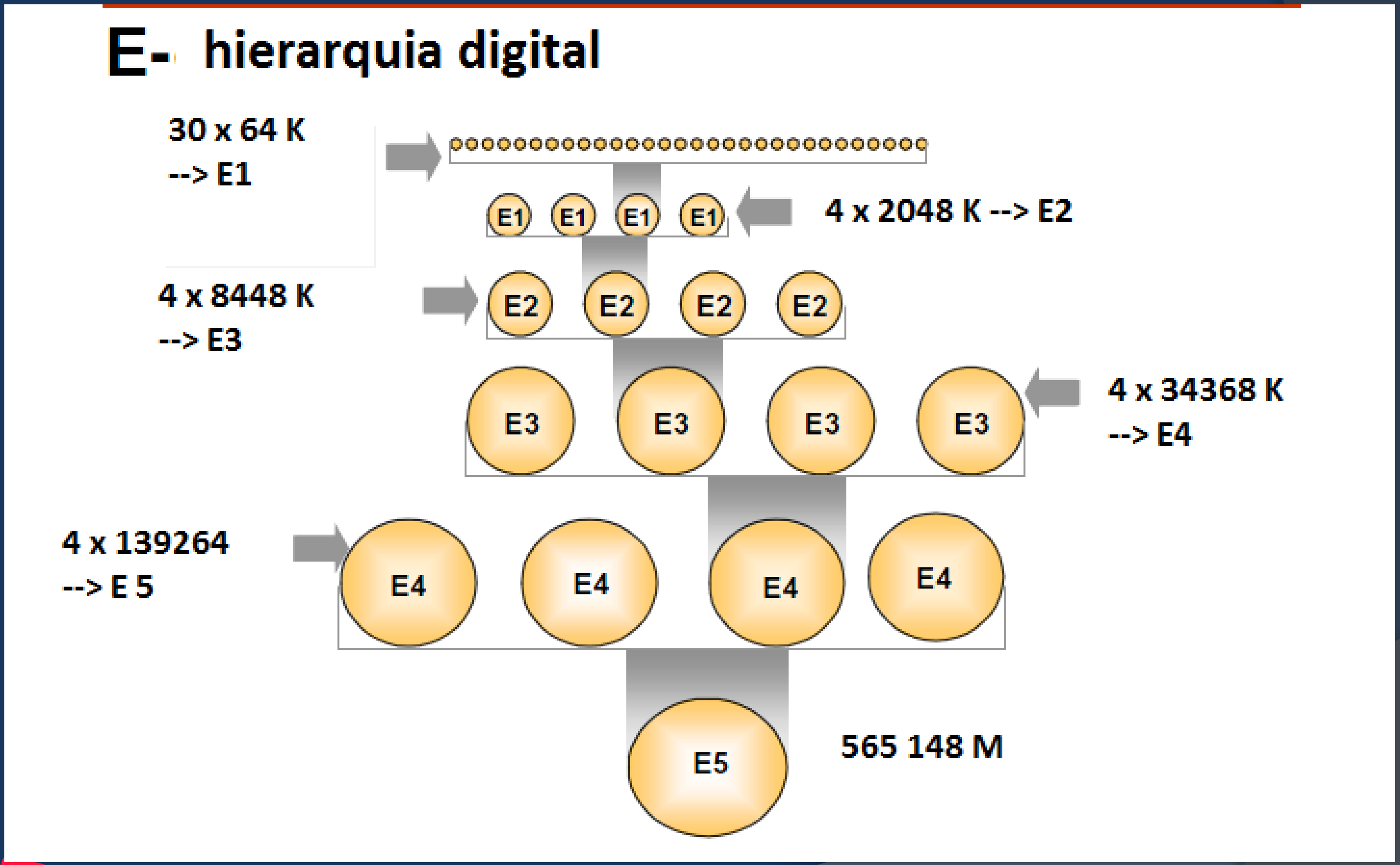
- A group of signals previously digitized are combined so as to be transmitted in a process named “multiplexing” where many channels share the medium by “taking turns”, each one being connected very briefly then replaced by the next.
- At the receiving end of the link a matching demultiplexer carries out the reverse operation. Here the receiver must know the sequence of the “8 bits words” it receives , which is done by inserting a sychronizing word in the traffic at the multiplexer that can be recognized at the remote end and is used as reference
- There are also extra words whose information is often referred to as “overhead” because it is carried along with the traffic, and has nothing to do with the traffic information

Network planning
digital E1 structure

We reached the 1st hierarchy in digital transmission, e.g 2,048 Mb/s (not 64*30) because overhead.

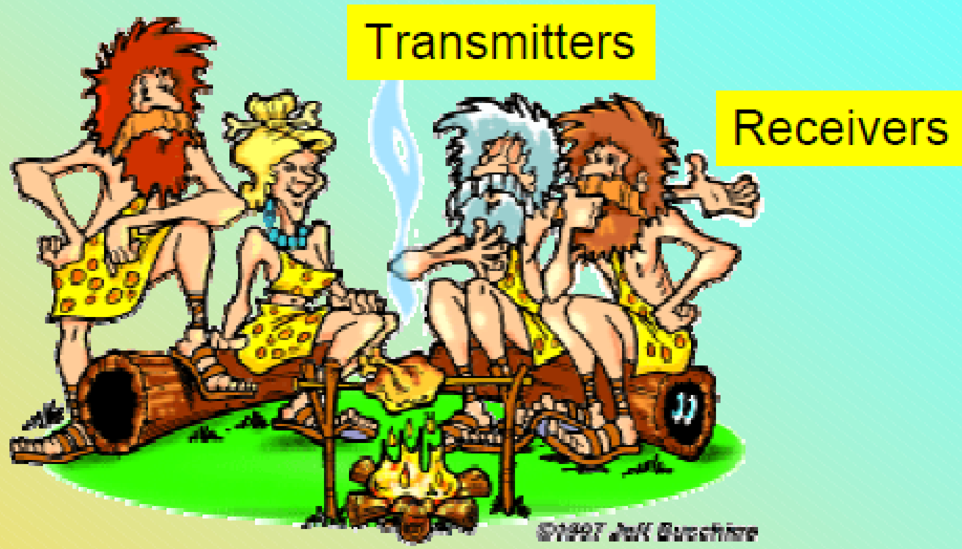


Network planning
higher digital hierarchy



Network planning
Analog communications

Early Wireless Communications - Analog



Multiple Conversations can mean a loss of information

- Goal is too find a means of differentiating connections
- Higher pitch can be distinguished from lower pitch – multiplexing ~

Network planning
Digital communications

Early Digital Wireless Communications

- Communication Goals
  - Speed
  - Accuracy
- Select a stable carrier - Smoke / Light / Electromagnetic Radiation
- Check the Path Loss & Distortion
- Efficiently modulate the carrier
- Prevent Interference from adjacent carriers

Network planning
Digital Communications techniques

- With advent of transmission between computers, between terminals and computers, digital voice (VoIP) etc, the digital modulation is the most obvious choice to assure transmissions that were originally digital or used by digital equipments. Even in case of analog signals - as telephone channel or television - with large bandwidth requirements, there is benefit from analog to digital code processing (and digital to analog conversion). Although this process can be costly in terms of bandwidth, offers improved noise performance, and immunity to interference.

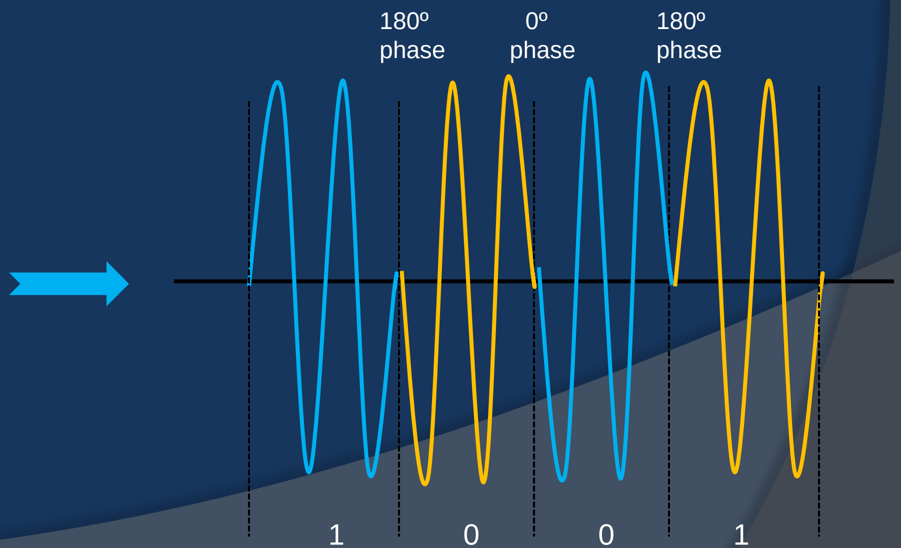
Network planning
Digital Communications techniques

- Digital transmission leads naturally to TDM and TDMA, respectively, being Time division Multiplex and Time Division Multiple Access, techniques used to transmit a signal through a transponder allowing just one signal at a time, thus avoiding intermodulation problems..
- Although any multiplexing technique - or TDM or FDM - can be used in analogue or digital modulation, the TDM is easier to implement with digital modulation (and similarly the FDM easier with analog modulation).

Network planning
modulation techniques

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 phase or biphase PSK is called BSK .

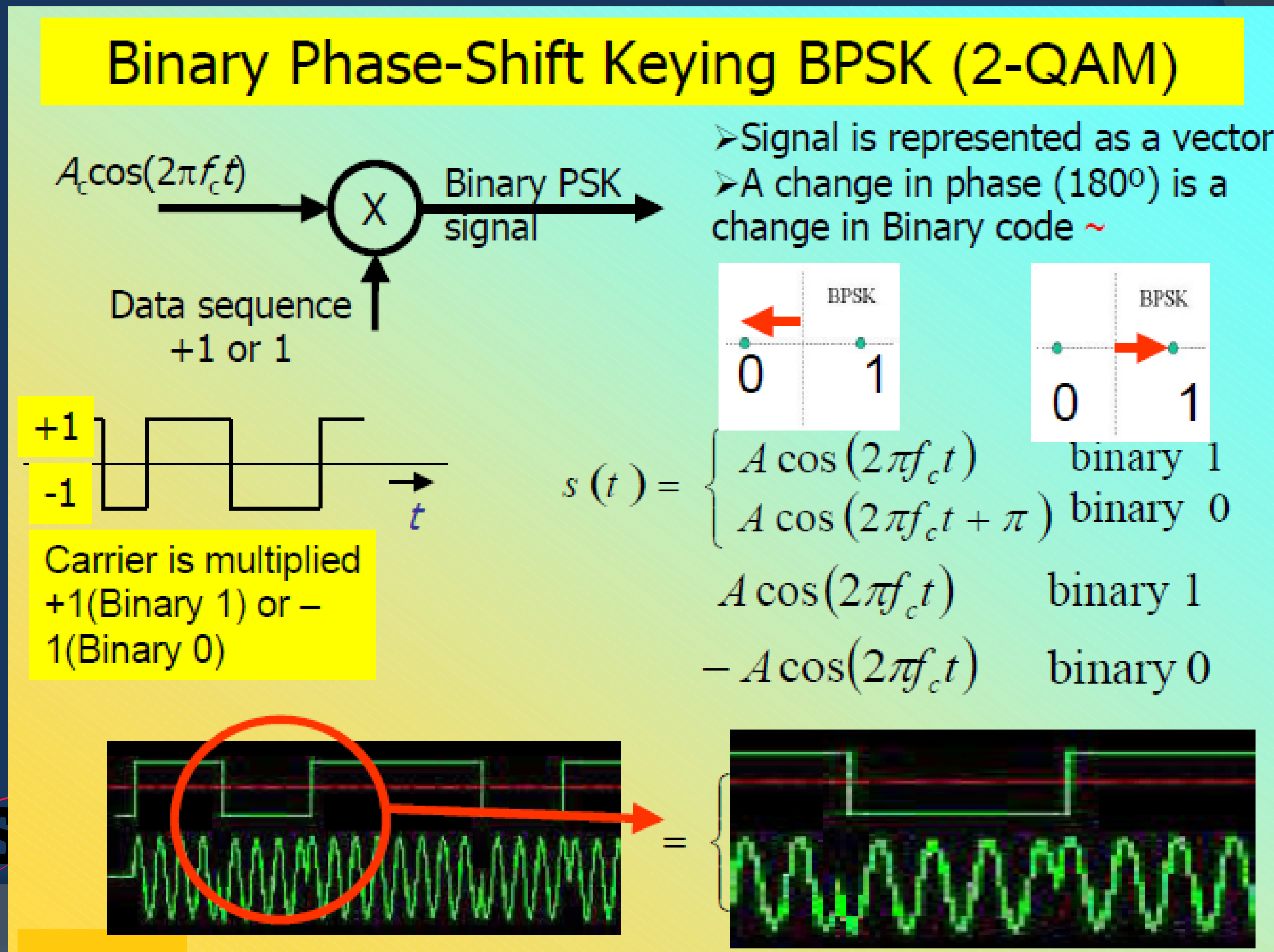
In this case of modulation (direct codification) the phase of the signal carrier is advanced or delayed depending on the type of modulation equipment (terminal equipment) , hence in the present case what matters are change state (phase)



Network planning
modulation techniques 1

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. However this type of modulation is not effective when you want to achieve high data rates, i.e. it is necessary to encode more than a bit at the same time, appearing modulations with States M, namely QPSK ..

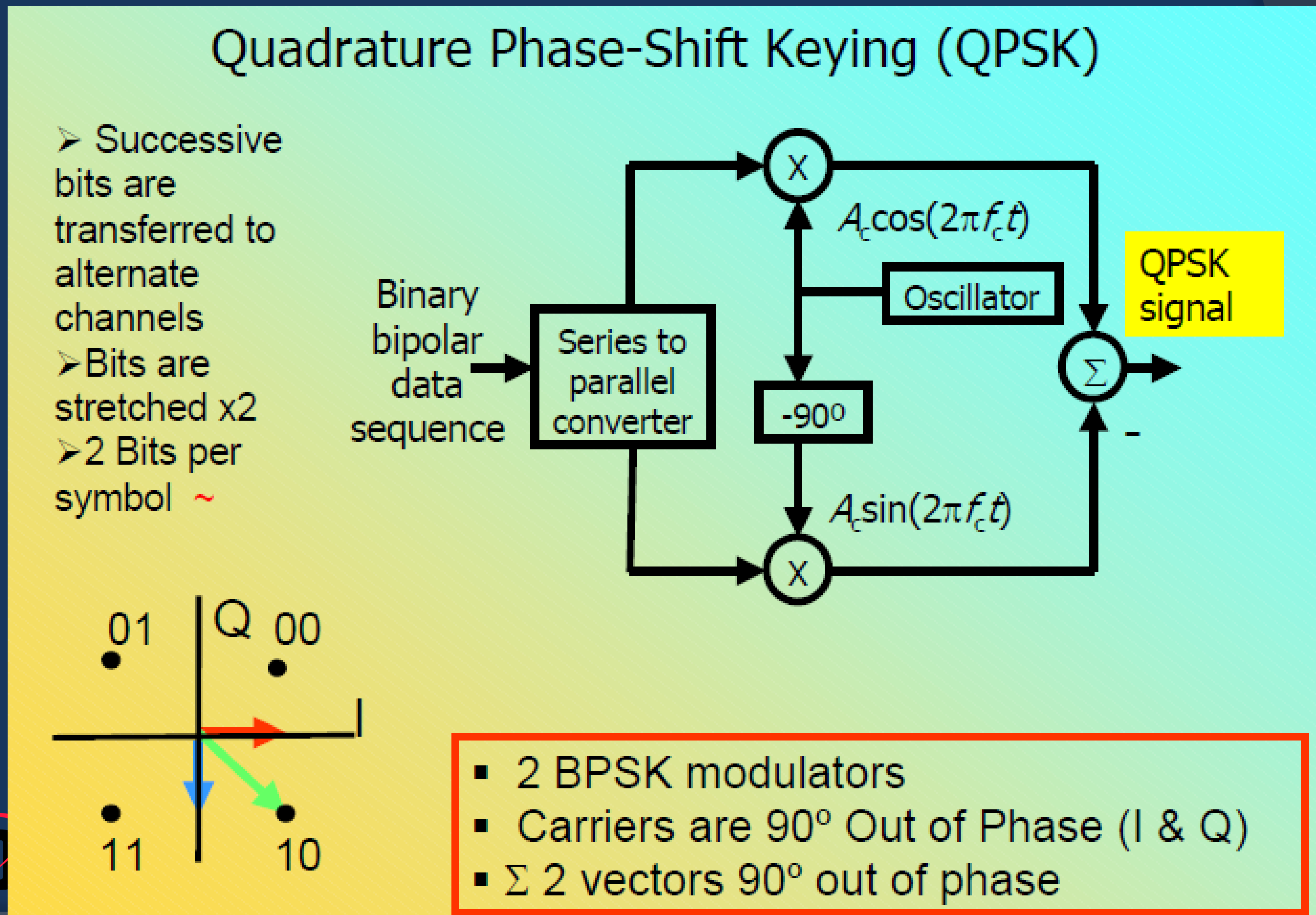
Network planning modulation techniques - BPSK



Network planning modulation techniques 2

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 with only half of the bandwidth. 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.

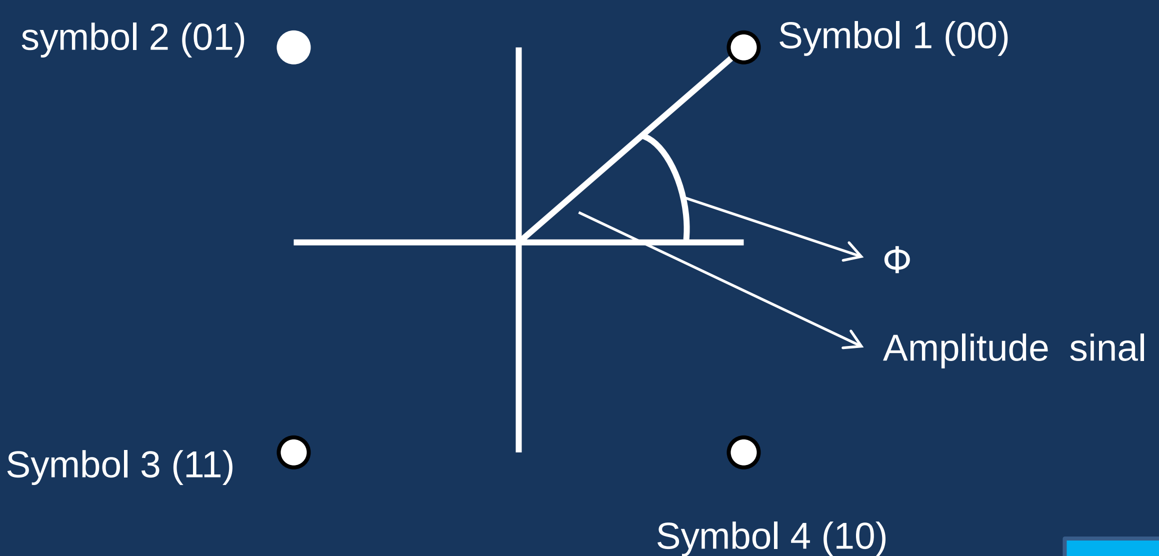
Network planning modulation techniques - QPSK



Planeamento rede

técnicas de modulação - QPSK

Representation of modulation diagram, known per "constellation" (screenshot of polar representation - magnitude and phase - of the measurement equipments display)



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

Network planning
bits and symbol

Symbols and bits

Mod10

- A ***bit*** is a unit of data. ***Bit rate*** means how many bits per second go through the link. Units are bits per second (bps). 1000 bps = 1 kbps. 1000 kbps = 1 Mbps.
- A ***symbol*** is a unit of modulation. ***Symbol rate*** means how often the modulation changes state. Units are symbols per second (sps). 1000 sps = 1 ksps. 1000 ksps = 1 Msps.

Some examples:

BPSK	**Each symbol can have 2 states and represents 1 bit**	**Bit rate = 1 x Symbol rate**	**512 kbps = 512 ksps**
QPSK	**Each symbol can have 4 states and represents 2 bits**	**Bit rate = 2 x Symbol rate**	**512 kbps = 256 ksps**
16PSK	**Each symbol can have 16 states and represents 4 bits**	**Bit rate = 4 x Symbol rate**	**512 kbps = 128 ksps**

This factor is called the ***order*** of the modulation and its symbol is ***M***.
E.g. 16PSK is an M-ary PSK modulation with M = 16.

Bits	1 0	0 1	1 1	0 1	1 0	0 0	1 1	0 1	0 0	1 0	0 0	1 1	0 1	0 1	1 0	0 0	1 1	0 1	0 0
QPSK Symbols	2	1	3	1	2	0	3	1	0	2	0	3	1	1	2	0	3	1	0

Network planning

Typicl bit rates

Typical bit rates

A wide range of bit rates is used in satellite communications. Here are some typical applications and their data rates:

• Digitized voice	4.8 kbps
• VSAT inbound carrier (transmitted by remote terminal)	64 - 512 kbps
• Video with MPEG2 encoding	2 - 4 Mbps
• VSAT outbound carrier (transmitted by hub)	5 - 36 Mbps
• Full transponder with multiplexed video	36 - 72 Mbps

Mod1

Network planning

digital modulation - design trade off

Required IF bandwidth (~ 1.3 symbol rate)

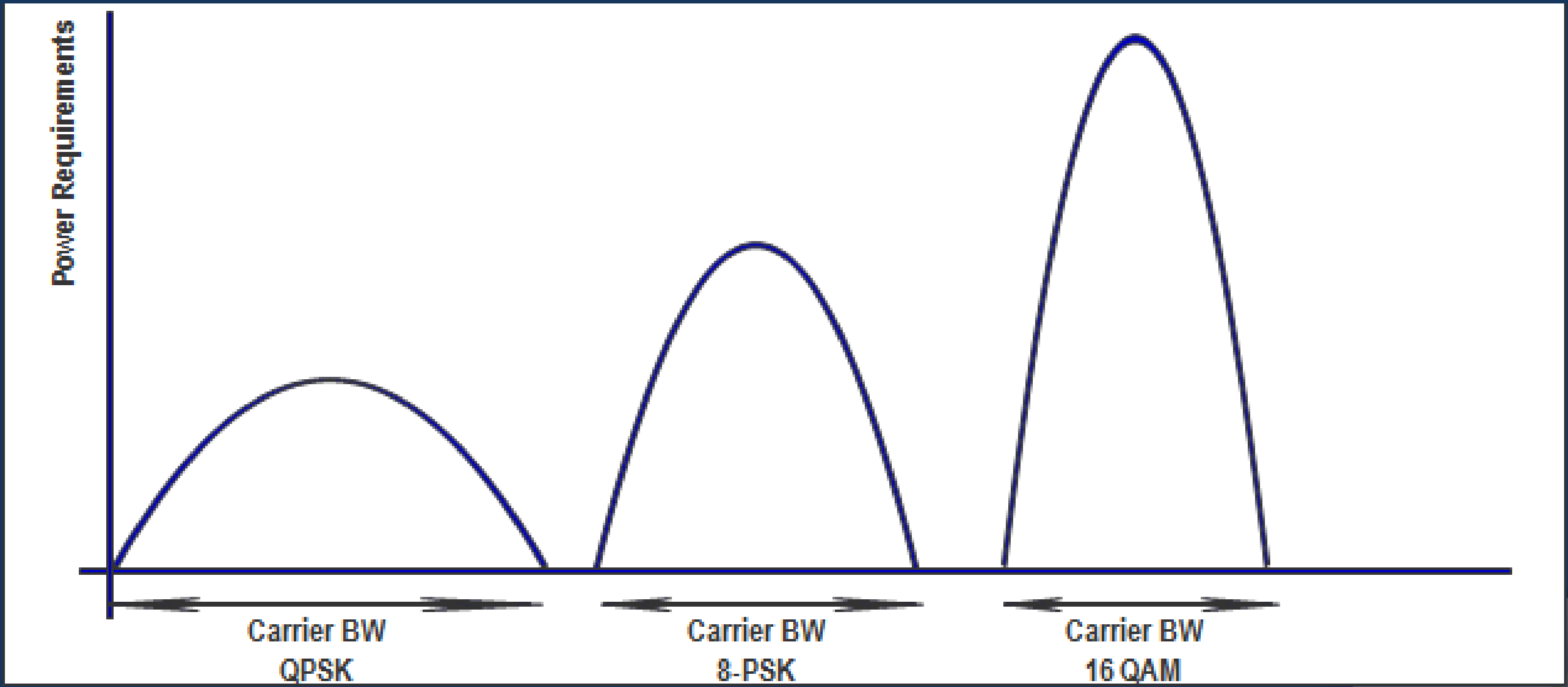
- Assume Bit rate 26 Mbits/s
- BPSK → (1 bit / symbol) → 26 * 1.3 = 33.8 MHz
- QPSK→ (2 bit / symbol) → 26 * 1.3 / 2 = 16.9 MHz
- 8PSK→ (3 bit / symbol) → 26 * 1.3 / 3 = 11.3 MHz
- 16QAM→(4 bit / symbol)→ 26 *1.3 / 4 = 8.65 MHz

So

- More complex modulation requires less bandwidth & less power, see example nest slide

Network planning

modulation techniques - differente sat carrier



Network planning

FEC encoders 1

- Associated with modulation and usually unseparated, there are other components designed generally as encoders which change information bits, in agreggate or by convolutional way (in practice means the adition of r redundancy bits to n information bits) and prepare bitstream to latter error correction.
- There are two main satellite encoders type, known by FEC - Forward Error Correction and TPC-Turbo Product Coding

Network planning

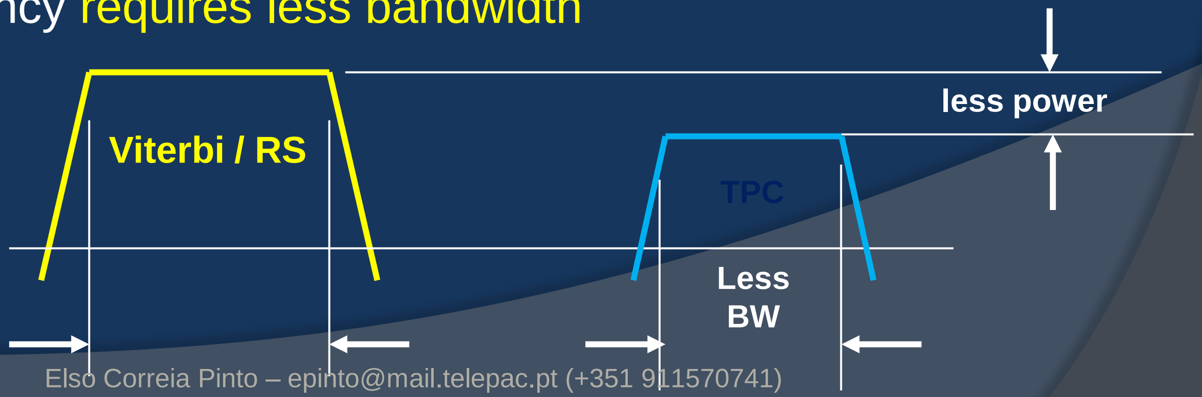
FEC encoders 2

- As referred based on convolutional codes (they use the precedent data to support and create one code to be used next transmission) where the information to be sent is broad enough to allow the error elimination and even correct it without ARQ (automatic repeat request) need.
- It is used to improve signal quality transmission, increasing the information bits, or improving the transmission rate $(T_R = D_R * 1 / FEC)$
- It s used simultaneously with other codification:
  - Reed Solomon – allowing global optimization in transmission rate $(T_R = D_R * 1 / FEC * 1 / RS)$
  - Turbo Product Coding – allowing global signal lower loss power

Network planning

TPC encoders

- Iterative decoding process
- Process produces a likelihood and confidence level measure for each bit
- Two parallel decoders “collaborate” and reach joint decision on bit value
- Low latency (vs. TCC, Vit/RS)
  - Due to the fact that there is no need to buffer for interleaving
- Turbo Product Coding
  - Lower Eb/No requires less power
  - Higher efficiency requires less bandwidth



Network planning

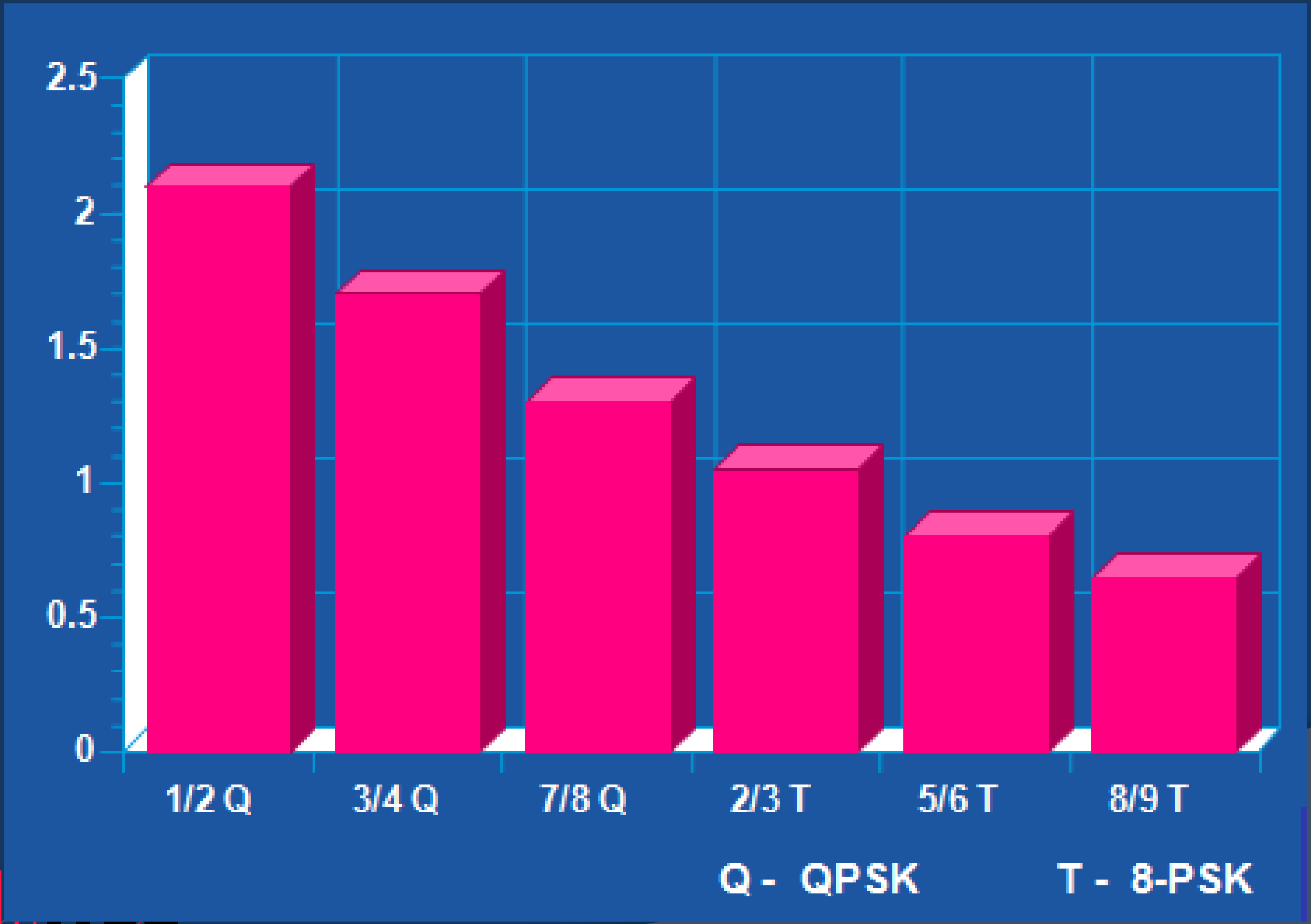
FEC encoders

FEC 1 / 2	1	E	2	E	3	E	4	E	5	E	6	E	7	E
FEC 3 / 4	1	2	3	E	4	5	6	E	7	8	9	E	10	11
FEC 7 / 8	1	2	3	4	5	6	7	E	5	E	6	E	7	8

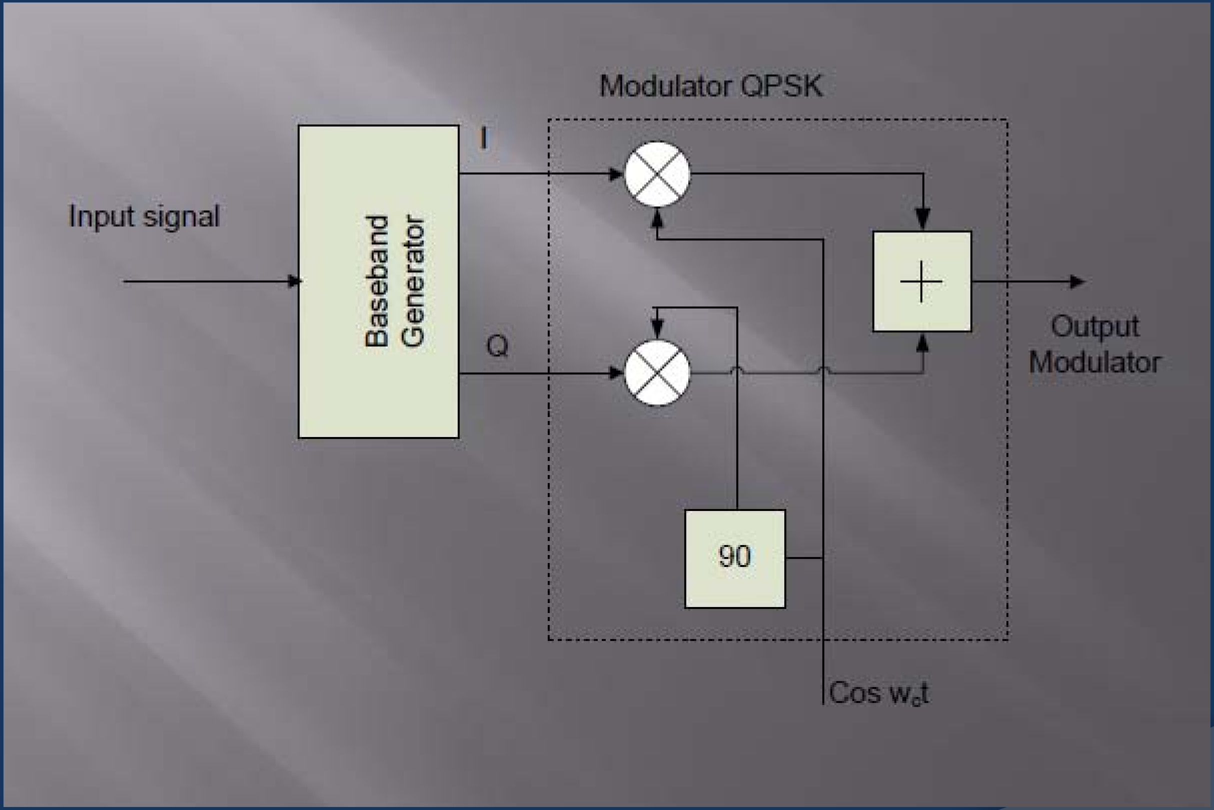
x	Data bit
E	Extra bit

Network planning

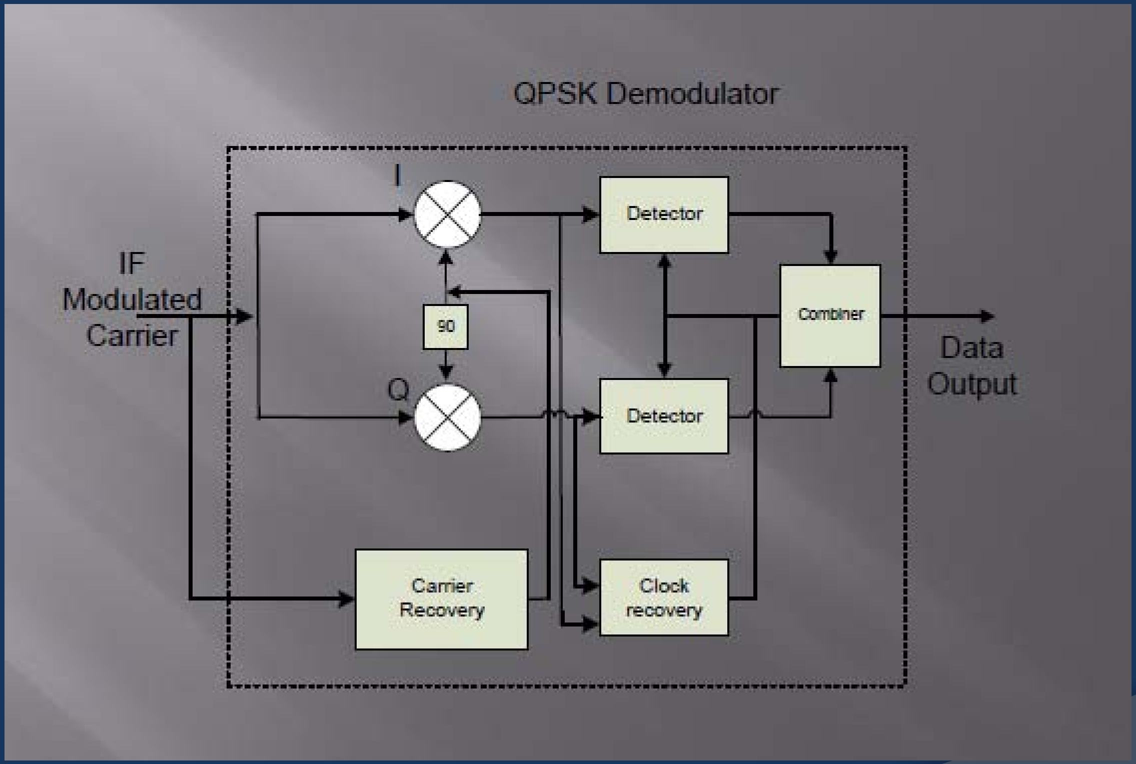
FEC and modulation



Network planning
modulation techniques - QPSK modulator



Network planning
modulation techniques - QPSK demodulator



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Network planning
link budget analysis 1

- The quality of a digital connection also known as BER Bit Error Rate - shows the probability of 1 bit sent on a link, being received incorrectly, or alternatively the fraction of bits (a high number of bits transmitted) received incorrectly.
- For instance BER = 1 x 10^{-4} means the probability of receiving 1 error is of 0,0001 ou seja 0,01%.
- Errors occur because the symbols in that have been encoded the signals at the terminal, were received incorrectly due to thermal noise, external interference, or interference between symbols.

Network planning
link budget analysis 1

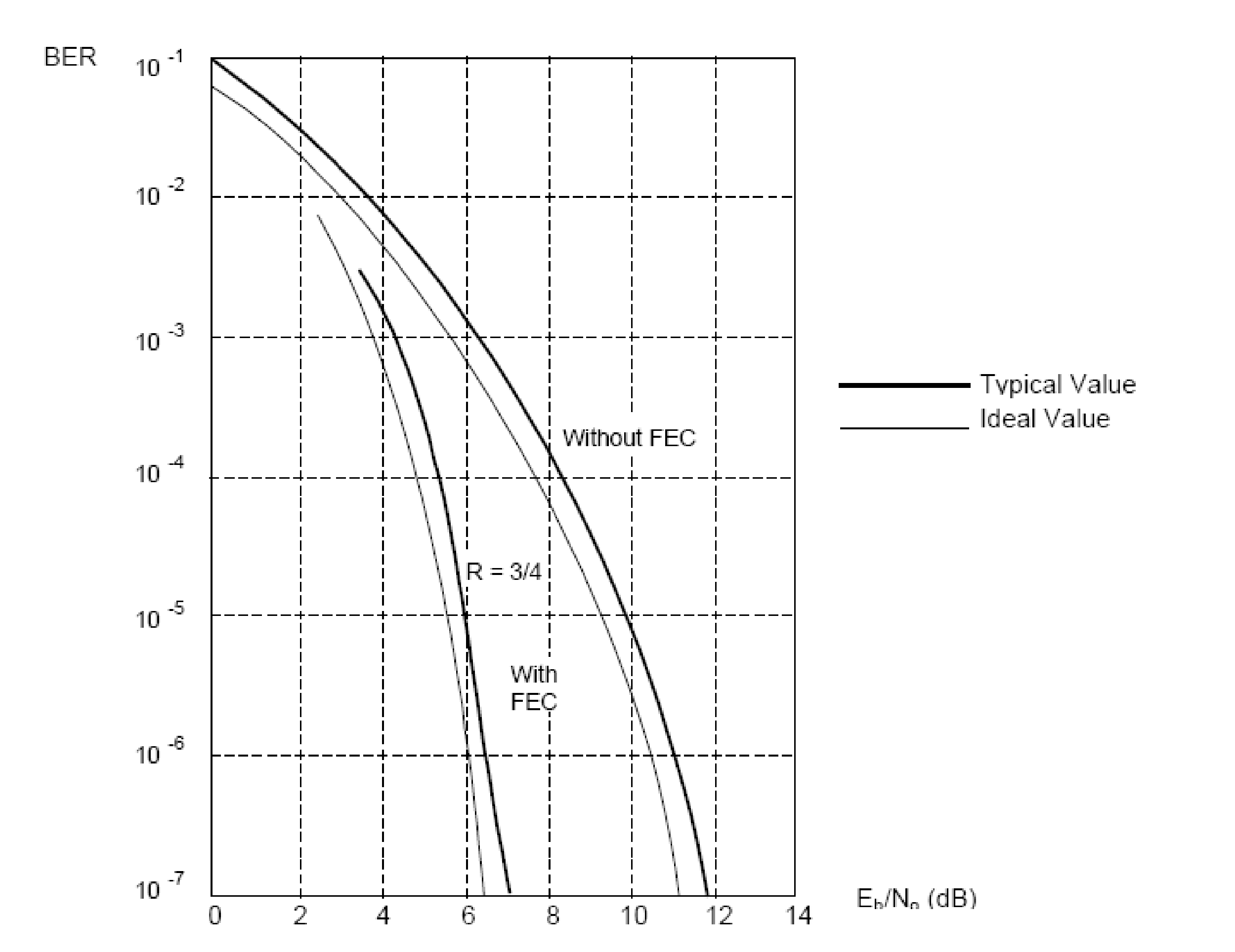
The *Symbol error rate* is entended as:

- E_b / N_0 (the relation between the transmitted bit-energy in joule- the noise density - W / Hz.
- What relation does it have with carrier , isto é C / N?
- Being $E_b = C.T_b = C . (1/ R_b)$ where R_b = *symbol rate*
- Being $N_0 = N / B$,

So → $E_b / N_0 = (C / N) . (B / R_b)$

Network planning

FEC and modulação influence on BER



WiMax

WiMax frum was founded at 2011 by industry groups to promote conformity and interoperability of the standard IEEE 802.16-2001 as BWA - Broadband Wireless Access.

Currently constituted as the forum has more than 200 members.

Leads the process of harmonization of BWA and is considered the foremost authority on the subject.

Promotes cooperation between ofornecedores, builders, regulators etc

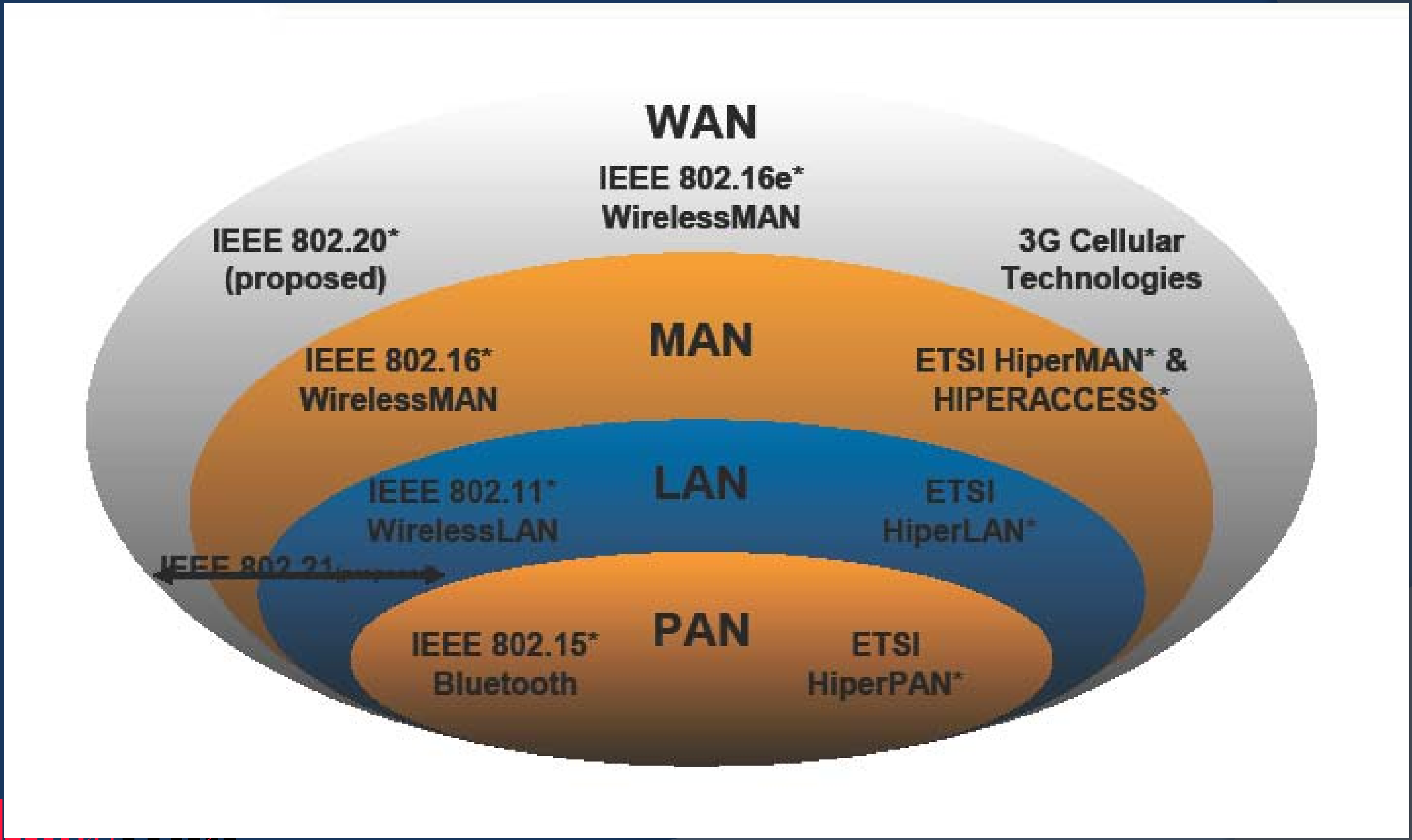
Promotes acceptance of WiMax products processes between all SP's

Design procedures procedures for product interoperability and compatibility BWA.

WiMax

- The return on investments in WiFi spots, given its coverage, has not been interesting, instead of develop standards that guarantee a greater distance, more or less equivalent to the MAN mean WMAN.
- The 802.16 Standard, was already deemed by Intel as "the most important thing after Internet".
- The initial version was working on 10 - 66 GHz range required towers in line-of-sight (LOS), but the version of 802.16 uses the frequency of 2-11GHz so facilitating regulatory issues and does not require LOS.
- Has range of 50 miles, versus 200-500 m from WiFi and 70 Mbps data speed ...
- The 802.16 version uses the frequency below 6 GHz

WiMax


WAN
IEEE 802.16e*
WirelessMAN
IEEE 802.20*
(proposed)
3G Cellular
Technologies
MAN
IEEE 802.16*
WirelessMAN
ETSI HiperMAN* &
HIPERACCESS*
LAN
IEEE 802.11*
WirelessLAN
ETSI
HiperLAN*
IEEE 802.21
PAN
IEEE 802.15*
Bluetooth
ETSI
HiperPAN*

WiMax

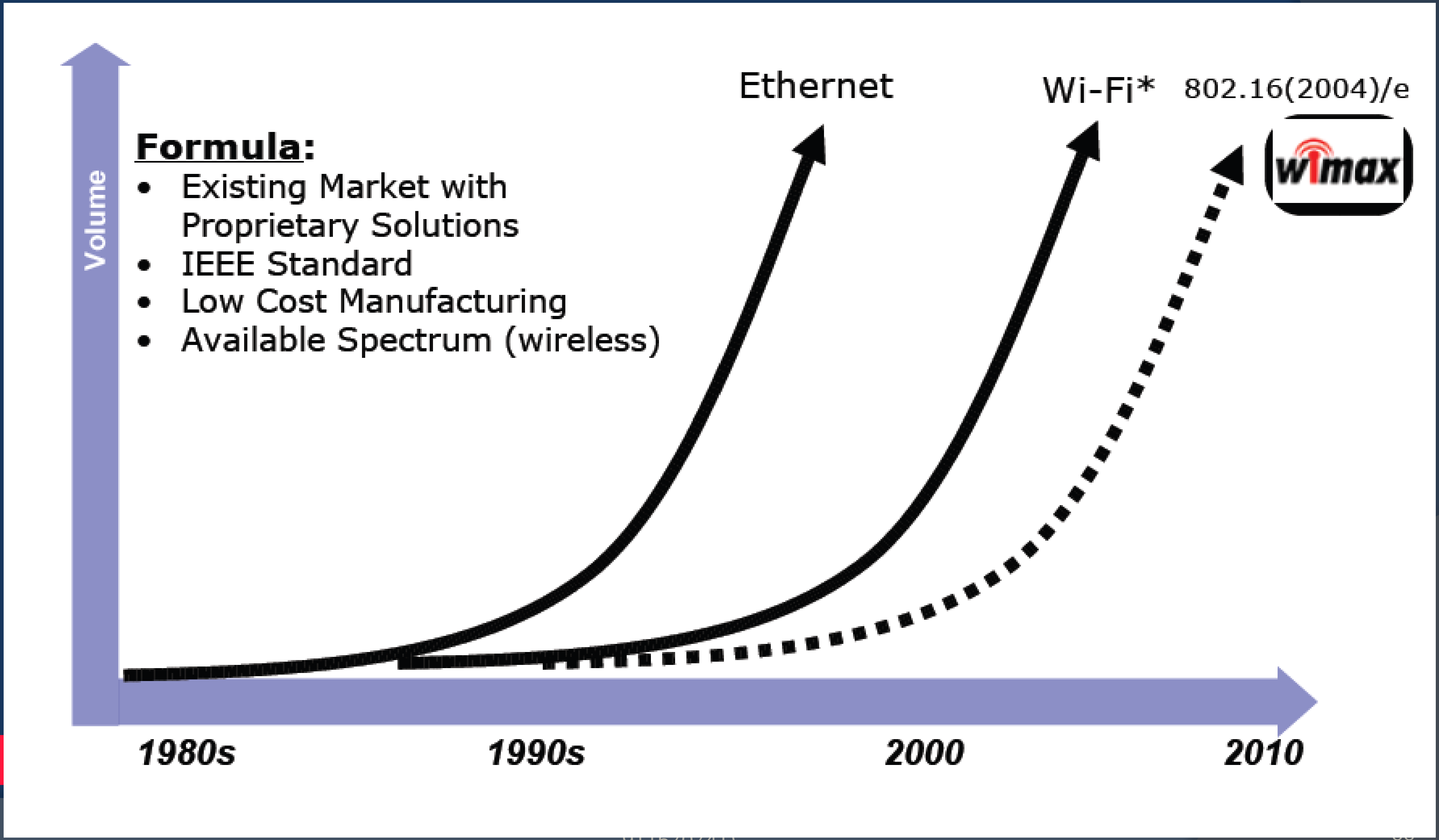
	802.11	802.16	Technical Explanation
Range	• Optimized for users within a 100 meter radius • Add access points or high gain antenna for greater coverage	• Optimized for typical cell size of 7-10 km • Up to 50 km range • No "hidden node" problem	• 802.16 PHY tolerates 10 more multi-path delay spread than 802.11
Coverage	• Optimized for indoor environments	• Optimized for outdoor environments (trees, buildings, users spread out over distance) • Standard support for advanced antenna techniques & mesh	• 802.16: 256 OFDM (vs. 64 OFDM) • Adaptive modulation
Scalability	• Channel bandwidth for 20 MHz is fixed	• Channel b/w is flexible from 1.5 MHz to 20 MHz for both licensed and license exempt bands • Frequency re-use • Enables cell planning for commercial service providers	• Only 3 non-overlapping 802.11b channels; 5 for 802.11a • 802.16: limited only by available spectrum
Bit rate	• 2.7 bps/Hz peak data rate; Up to 54 Mbps in 20 MHz channel	• 3.8 bps/Hz peak data rate; Up to 75 Mbps in a 20 MHz • 5 bps/Hz bit rate; 100 Mbps in 20 MHz channel	• 802.16: 256 OFDM (vs. 64 OFDM)
QoS	• No QoS support today -> 802.11e working to standardize	• QoS designed in for voice/ video, differentiated services	• 802.11: contention-based MAC (CSMA) • 802.16: grant request MAC

WiMax

Broadband wireless services:

	Service provider
802.16e	Evolving from fixed wireless ISPs
802.20	Start-up wireless operator or evolving cellular operator
3G	Cellular voice operator adding data support
	Technology
802.16e	Extension to 802.16a MAC and PHY
	Optimised to integrate with fixed stations
	Packet oriented
	Low latency
802.20	New PHY and MAC
	Optimised for packet data and smart antennas
	Optimised for full mobility at high speed
	Packet oriented
	Low latency
3G	W-CDMA or CDMA2000
	Evolution of voice-optimised GSM and CDMA
	Circuit oriented, though evolving to packets on the downlink
	High latency data architecture
	Spectrum
802.16e	Licensed bands between 2GHz and 6GHz
802.20	Licensed bands below 3.5GHz
3G	Licensed bands below 2.7GHz

Wimax
Standards and interoperability



Link budget analysis

- Presentation of Mr. Eldo Kurian, through the use of Intelsat app. LST

Trends in SATCOM

- Presentation of Mr. Eldo Kurian, in a separated pdf file named “ITSO presentation Nov- 2012”