New paradigm for the future Internet: piloting, 4G and Ethernet Carrier Grade

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Manual piloting

1905

1968

Self-piloting with a pilot

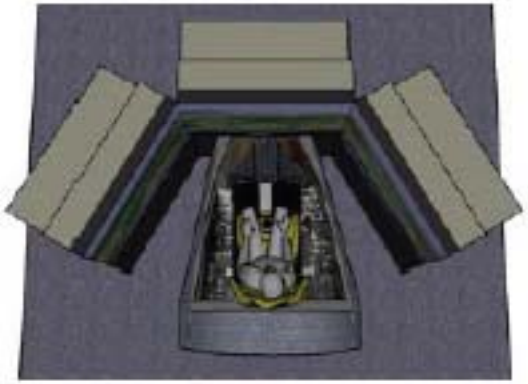
1980 -2012

2000 - 2012

Self-piloting without any pilot

2012

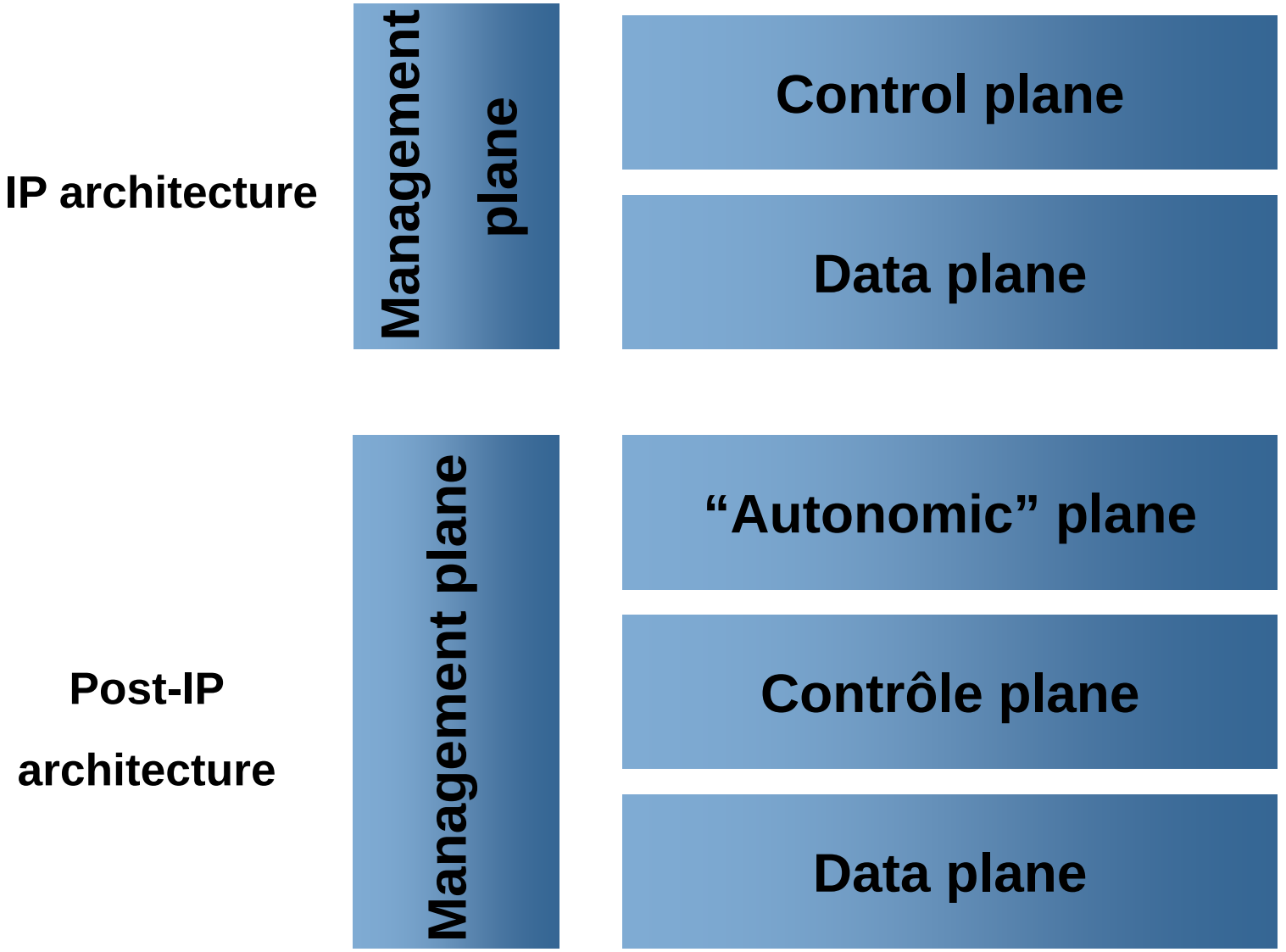
?



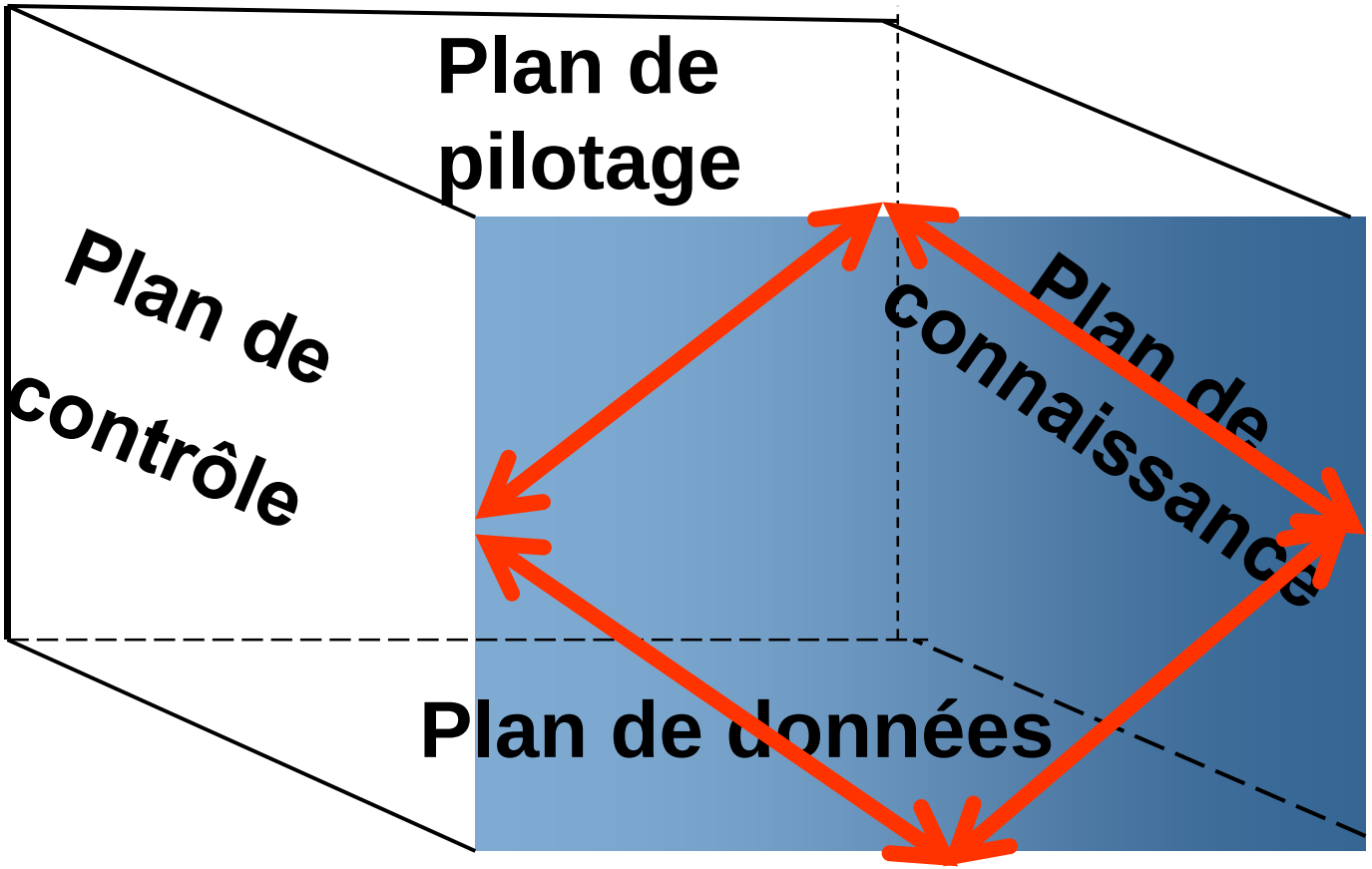
1- A problem of information

- **Knowledge plane**
  - Situated view on the network
- **Configuration plane**
  - An intelligence is needed to pilot the network
  - Configure the control algorithms
- **Information plane**
  - Proposed in IEEE 802.21
- **Governing plane**
  - ACF
- **Piloting plane**
  - Ginkgo-Networks

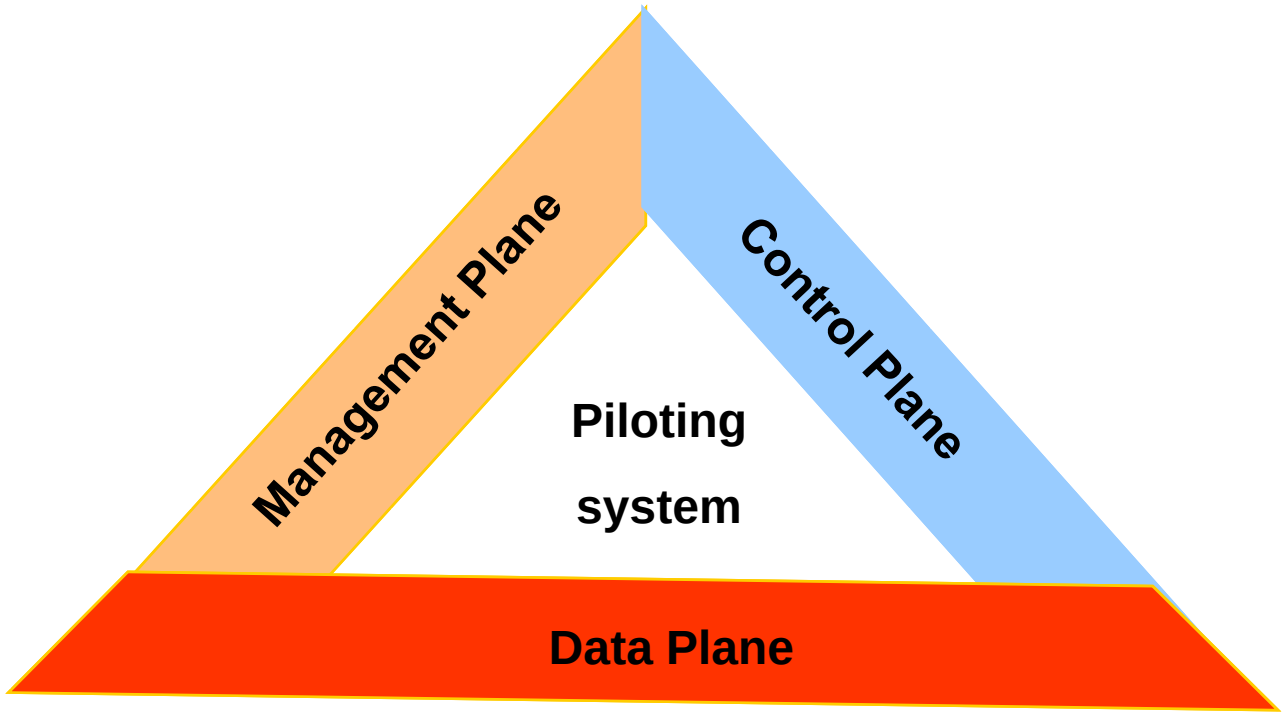
Post-IP architecture



Post-IP Architecture



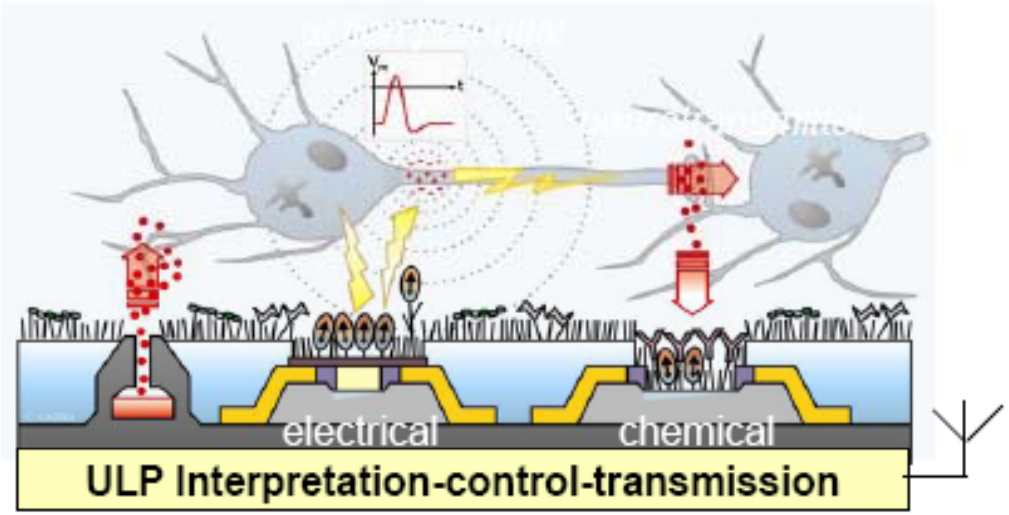
2- A Piloting System

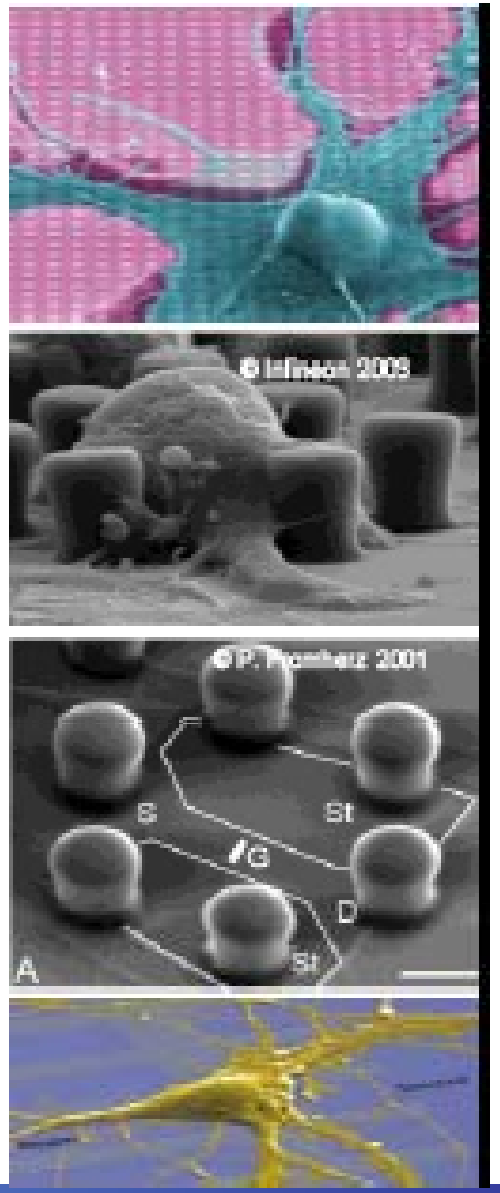


Automatic piloting system

- **Distributed**
  - scalable
  - address large and complex problems
  - solve problems locally
  - able to respond in milliseconds

BTH ? Beyong The Horizon





Interface nano :

biology-electronic

Solutions

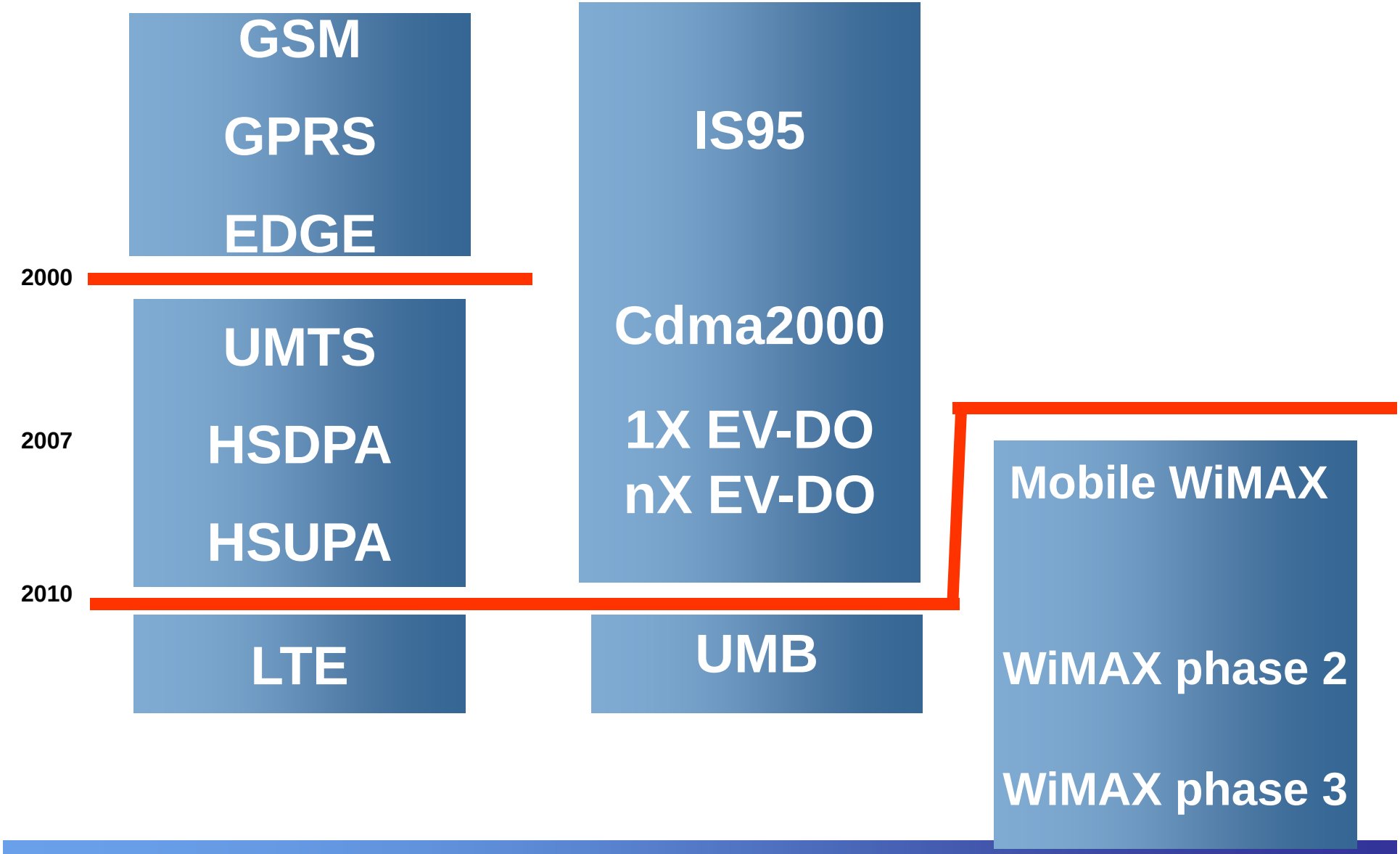
- **Distributed automates**
  - Reactivity quite good but no global piloting vision
- **PBM Policy-based Management**
  - Management, no control, no scalable
- **Autonomic solution**
  - A good beginning (not well defined)
- **Distributed intelligent agents**
  - A solution

4G

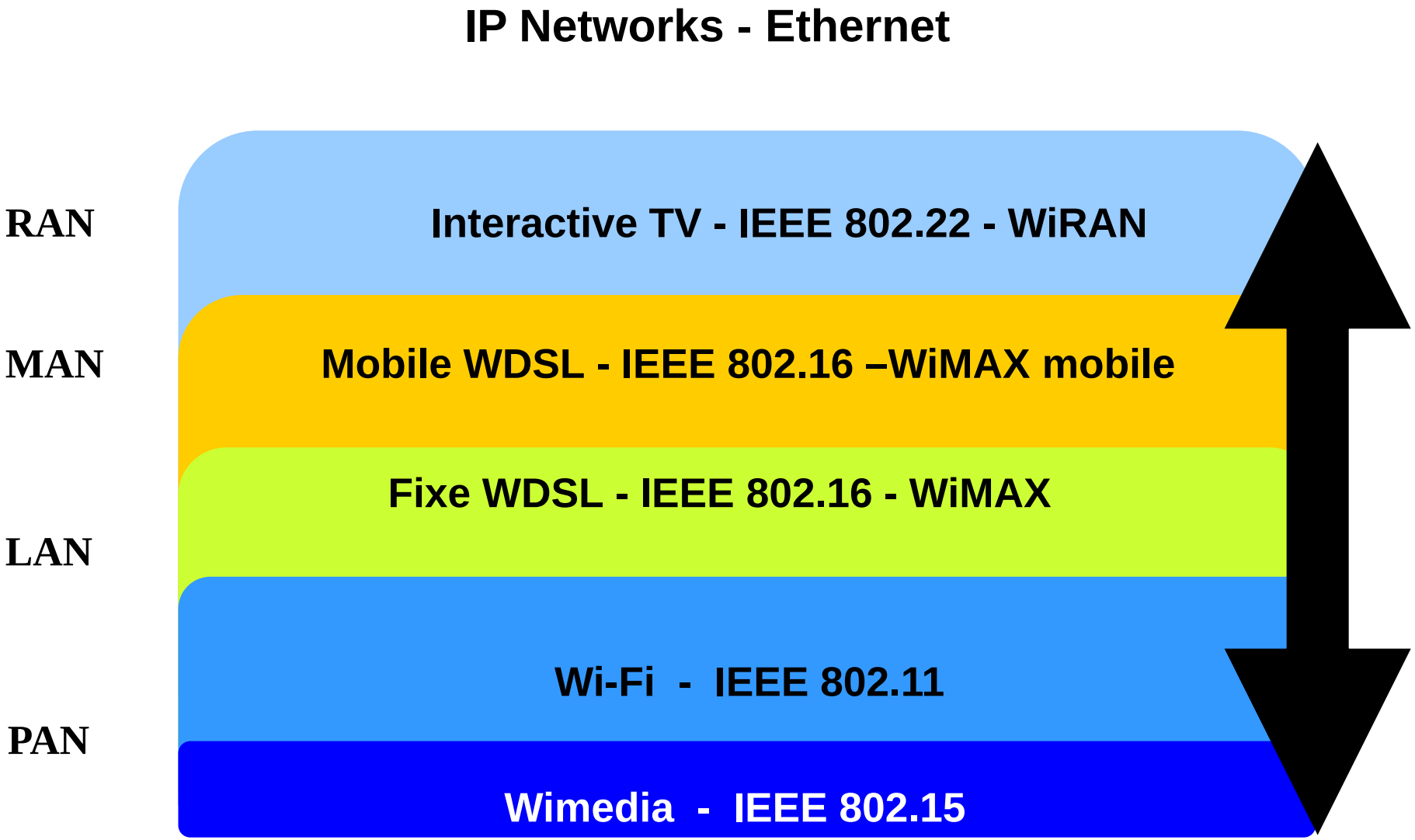
Generation

- **1st generation: analog circuit**
- **2nd generation: digital circuit**
  - 8 Kbps
- **3th generation: packet + ATM-based**
  - Downlink: from 384 Kbps to 42 Mbps
  - Uplink: from 64 Kbps to 5,76 Mbps
- **4th generation: multimedia + IP-based**
  - Downlink: from 100 Mbps to 1 Gbps
  - Uplink: from 50 Mbps to 300 Mbps

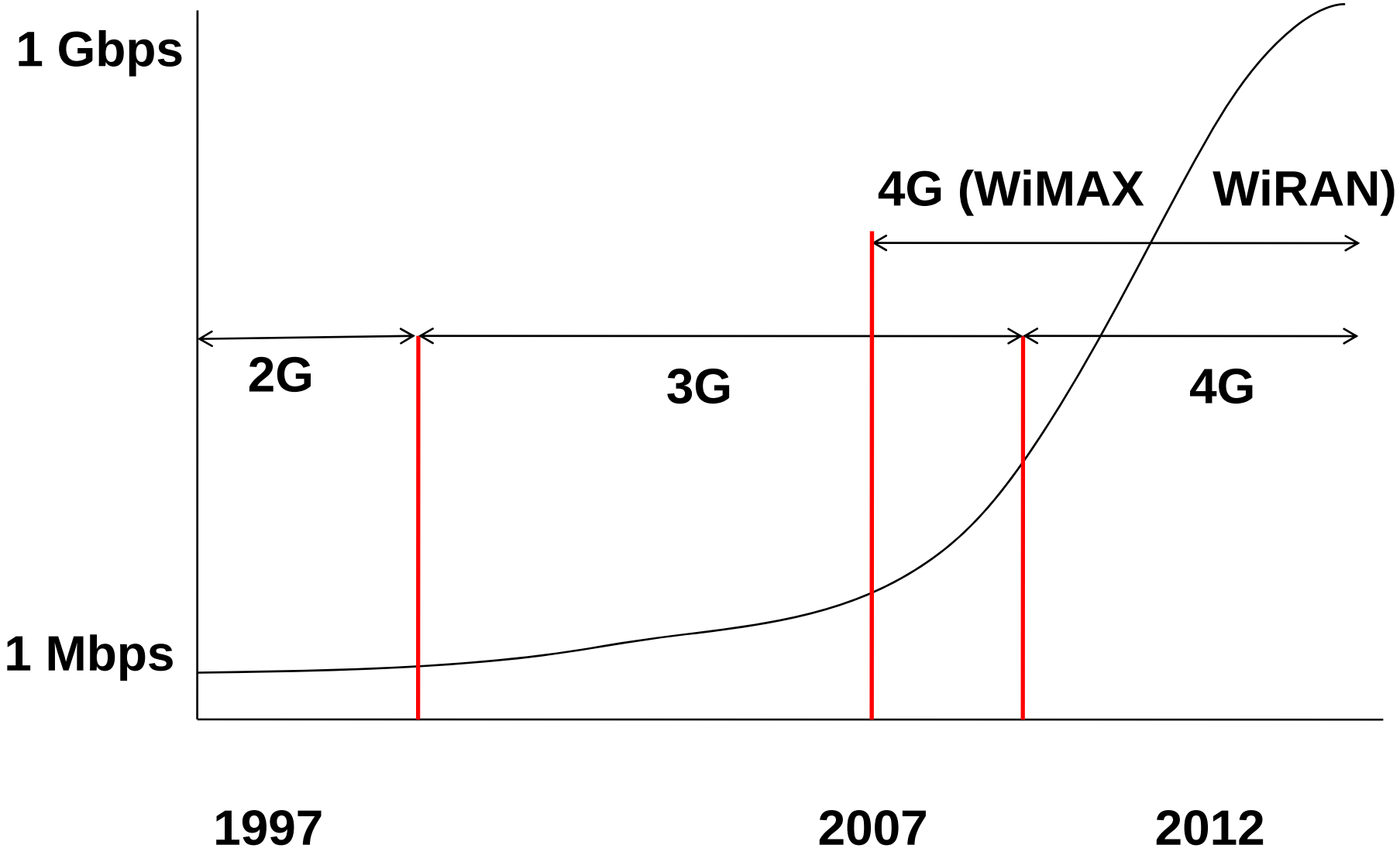
Wireless networks



Wireless Networks



Peak rate



The revolution

- **Today: the spectrum is totally full**
- **Tomorrow: the spectrum is quasi empty**

- **Cognitive radio**
  - The point in which a wireless machine and the related networks are sufficiently computationally intelligent about radio resources and related computer-to-computer communications to detect user communications needs as a function of use context, and to provide radio resources and wireless services most appropriate to those needs.
  - The spectrum is definitely inefficiently utilized (10% on the average)

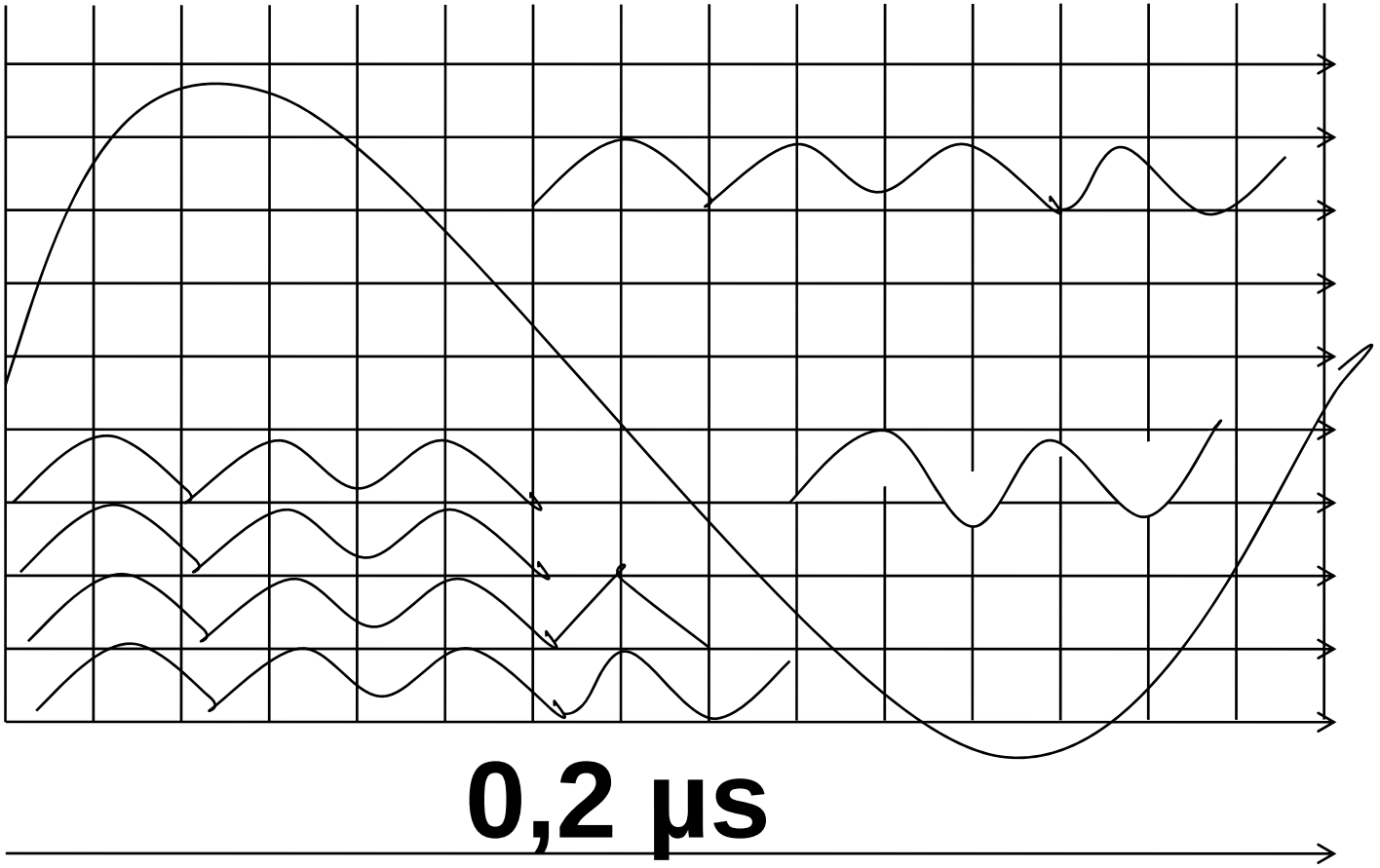
Cognitive radio

- **Main characteristics**

- **Spectrum Sensing: detecting the unused spectrum**
  - *Transmitter detection*:
  - *Cooperative detection*:
  - *Interference based detection*.
- **Spectrum Management: Capturing the best available spectrum to meet user communication requirements.**
  - *spectrum analysis*
  - *spectrum decision*

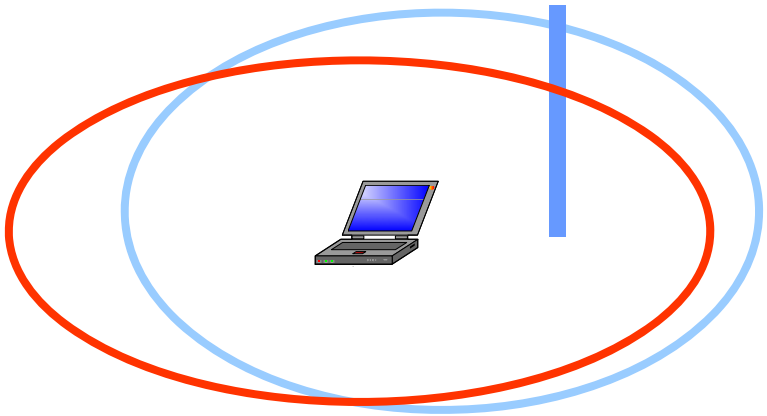
example

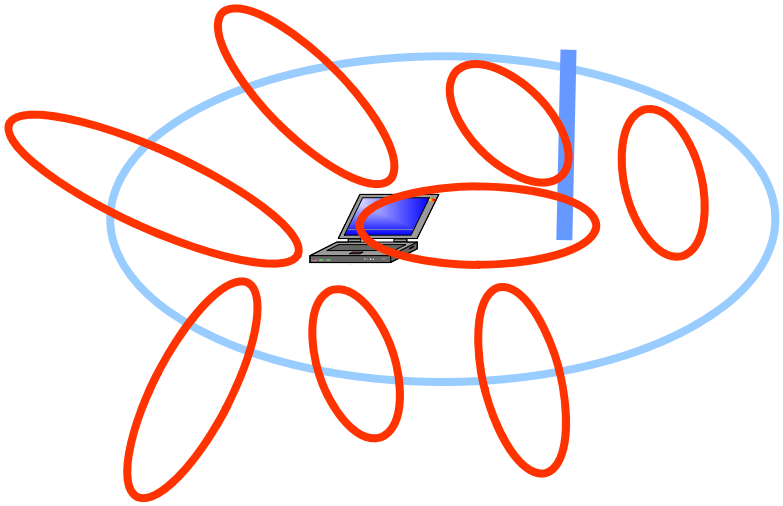
- TV chanel of 5 MHz



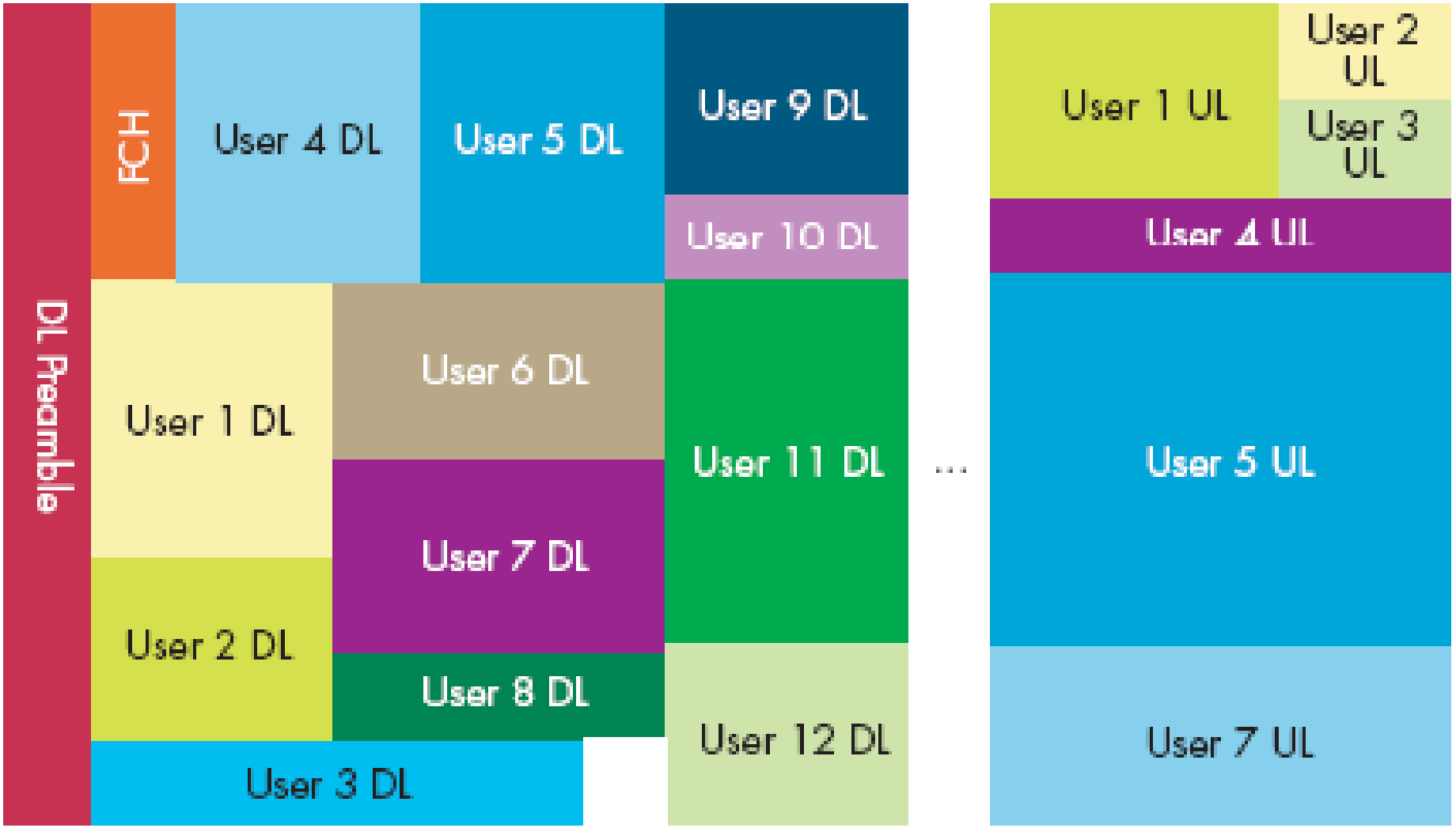
The revolution

- **Intelligent antenna**
  - Antenna technology that does spatial beamforming and spatial coding to cancel interference.





SOFDMA



Scalable orthogonal frequency-division multiple access

Alcatel source

4G

- **Native IP**
  - Definitely different of UMTS, HSDPA, etc.

Generation

- 2nd generation: GSM
- 2.5 generation : GPRS
- 2.9 generation : Edge
- 3th generation : UMTS – UMTS Release 5
- 3.5 generation : HSDPA (3G+) – UMTS Release 6
- 3.7 generation : HSDPA – UMTS Release 7
- 3.9 generation : HSUPA –UMTS Release 8
- 4th generation : HSOPA (super 3G) – UMTS Release 9
- 4.x generation : LTE

Generation

- IS95
- cdma 2000
- cdma 1x EV-DO
- cdma 1x EV-DO RevA
- cdma 1x EV-DO RevB
- cdma nx EV-DO
- cdma 2000 AIE
- UMB (normalized by 3GPP2, April 2007)

HSDPA

- **High-Speed Downlink Packet Access**
  - Downlink speed:
    - 1.8 Mbps,
    - 3.6 Mbps,
    - 7.2 Mbps
    - 14.4 Mbps
    - 42 Mbps

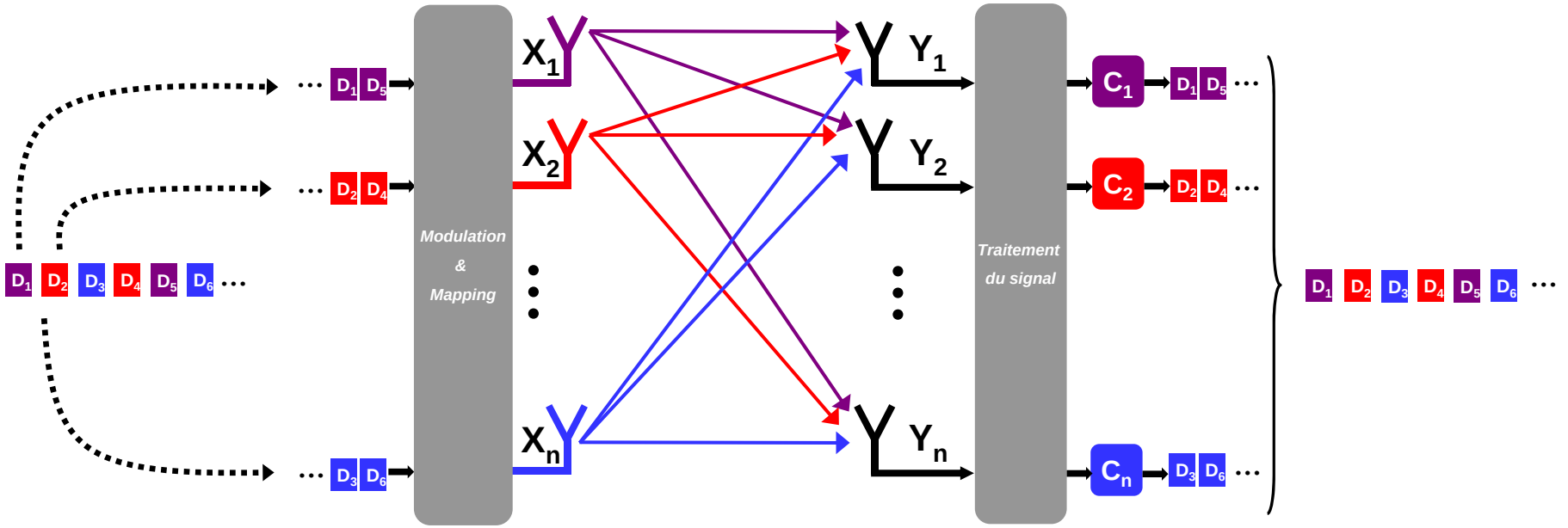
HSDPA

Differences with UMTS

- **Retransmissions using H-ARQ techniques: Hybrid Automatic Repeat Request**
  - Two packets in error may be sufficient to be corrected
- **Scheduling within the *Node B* : FPS (Fast Packet Scheduling)**
  - 500 times per second, indication of the quality of the signal: scheduling as a function of the quality every 2 seconds.
- **Modulation and coding: AMC (Adaptive Modulation and Coding)**
  - Optimization of the coding as a function of the QoS of the channel : QPSK, 16QAM, etc.

HSDPA

- **HSDPA (UMTS Release 7) 42 Mbps**
  - MIMO (Multiple In Multiple Out)
    - Transmission speed = f($Nb_{antenne}$)
    - Diversity



HSUPA

- **High-Speed Uplink Packet Access**
- **Utilization of the same HSDPA improvements but uplink**
  - Objective: 5,76 Mbps

HSOPA

- **High Speed OFDM Packet Access**
  - 4G or « Super 3G »
  - New generation: incompatible with previous version at the physical layer
  - Radio interface: OFDMA
  - 50 Mbps uplink and 100 Mbps downlink
  - 200 clients for 50 MHz
  - Multi-technology in the terminal to accept HSDPA and HSUPA terminals

LTE

- **Long Term Evolution**
  - Normalization 3GPP (September 2007)
  - On the market end 2009/2010
  - 50 Mbps uplink (with 20 MHz)
  - 100 Mbps downlink (with 20 MHz)
  - OFDMA
  - Same model as Wi-xx by using different sizes of the cells: from picocell (PAN) to regional cell (RAN)

UMB

- **Ultra Mobile Broadband**
  - Normalization April 2007, 3GPP2
  - On the market beginning 2010
  - 100 Mbps uplink, 200 Mbps downlink
  - OFDMA
  - Same model as Wi-xx by using different sizes of the cells: from the pico cell (PAN) to regional cell (RAN)

Wi-xx family

4G example: IEEE 802.22

- Digital dividend: Band of 120 to 300 MHz within the 54 – 862 MHz TV band
- Cognitive radio
- Intelligent antenna
- 4th generation
  - IP technology
  - OFDM
- QoS support at the MAC layer
- Very easy deployment
- Radio characteristics are controlled by the sender
- GPS/Galileo to determine where the terminal is
- Range: 40 kilometers
- Bandwidth: 180 MHz

IEEE 802.22

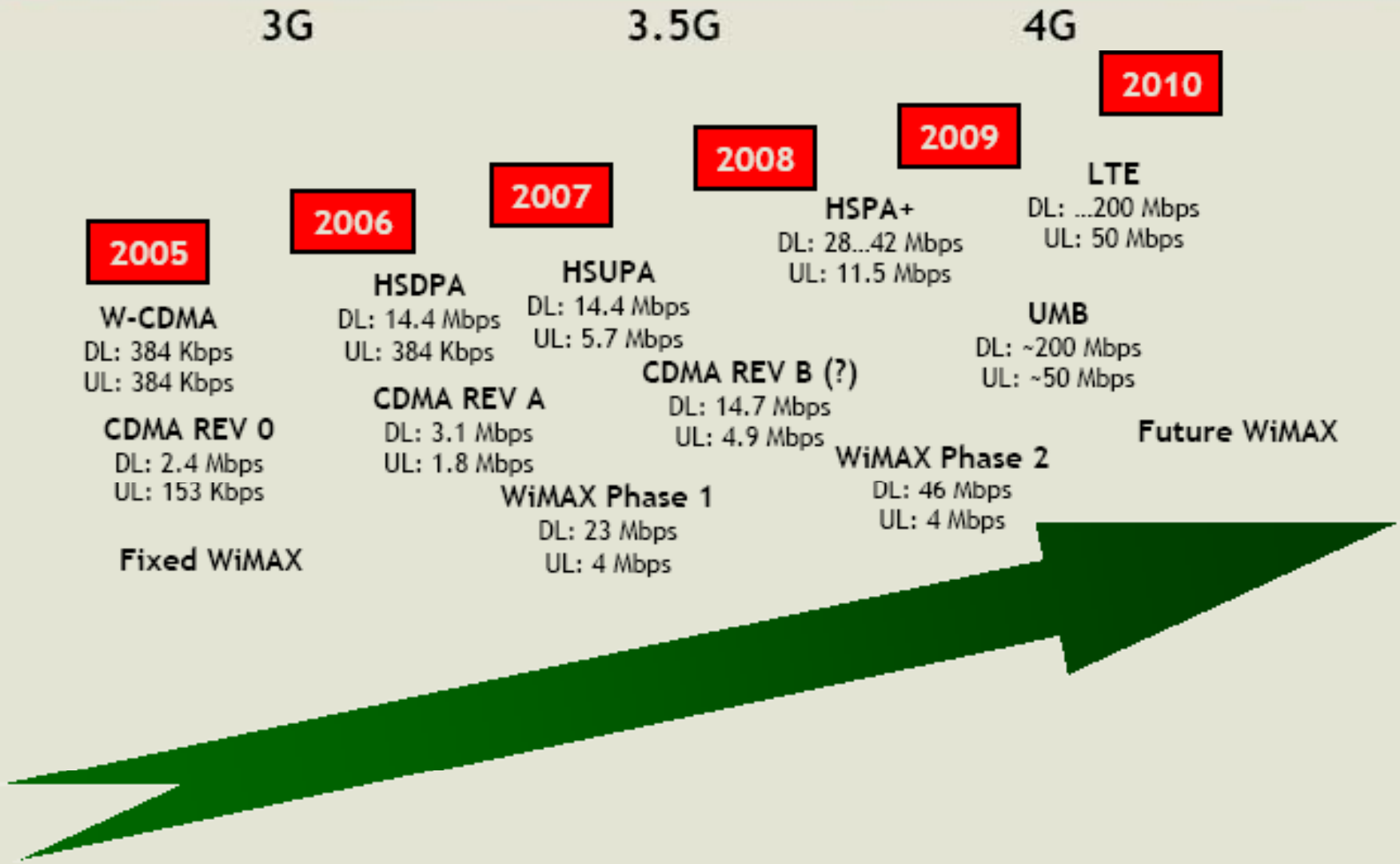
- **Piloting**
  - The frequency to be chosen (assuming intelligent antenna)
  - Scheduling within the "*Node B*" : FPS (Fast Packet Scheduling)
    - 500 times per second, indication of the quality of the signal: scheduling as a function of the quality every 200 millisecond.
  - Modulation and coding: AMC (Adaptive Modulation and Coding)
    - Optimization of the coding as a function of the QoS of the channel : QPSK, 16QAM, 64QAM.
- **Simulation study with a cognitive frequency choice, (but far from cognitive radio):**
  - Equivalent telephony 1 000 000 clients instead of 100 000.

WiMAX Phase 2

- IEEE 802.16m: Advanced Air Interface
- Standard on November 2008, approval February 2009
- SOFDMA
- Increase of the throughput using Cognitive Radio
- Smart antenna
- 1 Gbit/s dowlink and 100 Mbit/s uplink

- WiMAX Phase 3 : 10 Gbit/s downlink and 1Gbit/s uplink

A Smooth Evolution to 4G



Conclusion

- **Fixed machines should disappear**
- **Cable on the local loop should disappear (even optic fiber access)**
- **Electronic commerce should become mobile**
  - Everywhere
  - Every time
  - Using image and video high definition

Questions

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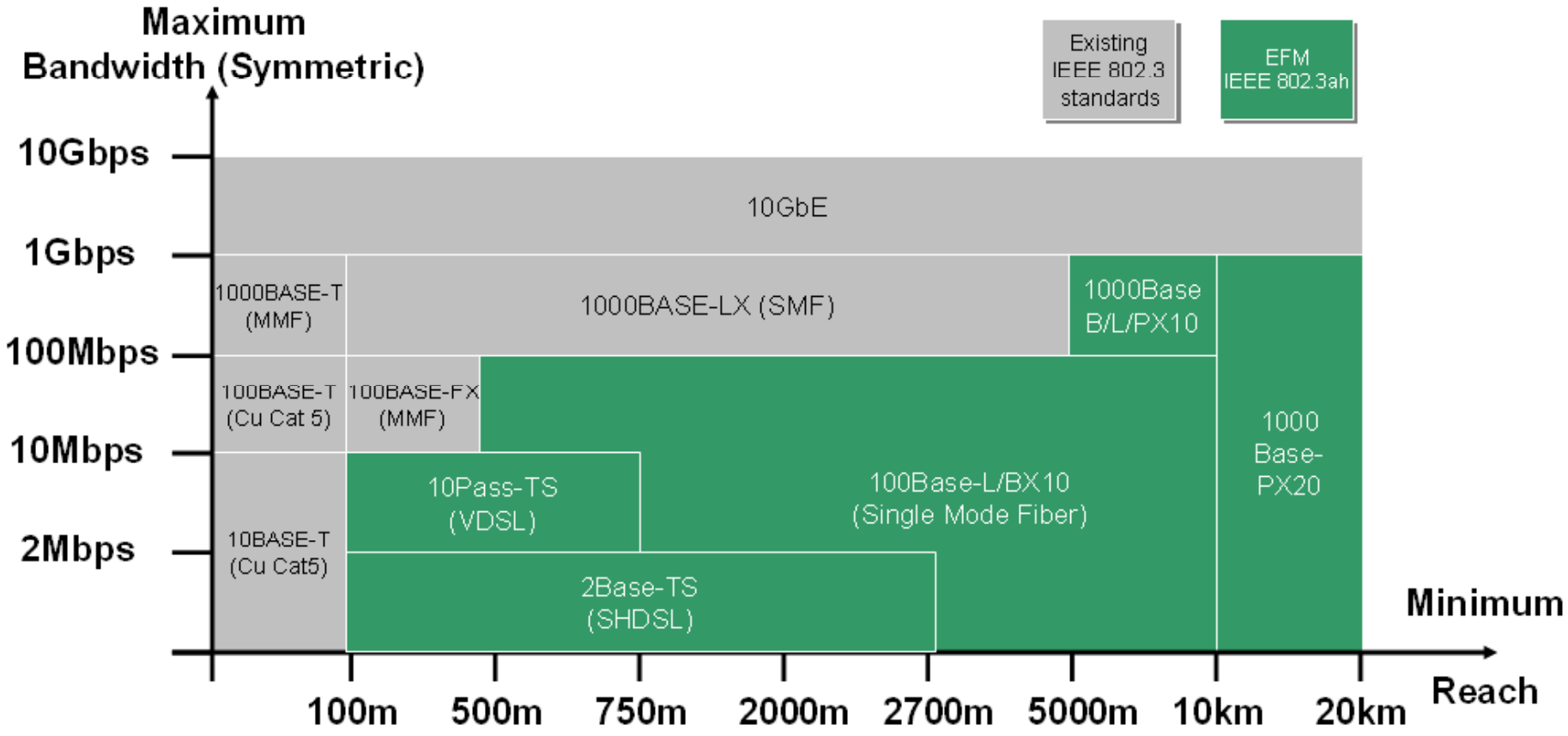
Ethernet Carrier Grade

Ethernet


Maximum
Bandwidth (Symmetric)
Existing
IEEE 802.3
standards
EFM
IEEE 802.3ah
10Gbps
1Gbps
100Mbps
10Mbps
2Mbps
10GbE
1000BASE-T
(MMF)
1000BASE-LX (SMF)
1000Base
B/L/PX10
100BASE-T
(Cu Cat 5)
100BASE-FX
(MMF)
1000
Base-
PX20
10Pass-TS
(VDSL)
100Base-L/BX10
(Single Mode Fiber)
10BASE-T
(Cu Cat5)
2Base-TS
(SHDSL)
Minimum
Reach
100m
500m
750m
2000m
2700m
5000m
10km
20km

Carrier Grade

- **Scalability**
  - Several million users
- **Protection**
  - Five « 9 » = 99,999 percent network availability
  - Link recovery
    - Achieved with SONET/SDH within 50 ms
    - n:m:l technology
- **Hard Quality of Service**
  - Strong guaranty on some services

Ethernet Carrier Grade

- **Service management**
  - Respect of the SLA (Service Level Agreement)
  - Locate and diagnosis the faults
- **TDM support**
  - Virtual leased line
- **How to add this carrier-grade functionality to Ethernet equipment without losing the cost-effectiveness and simplicity**

Ethernet Carrier Grade

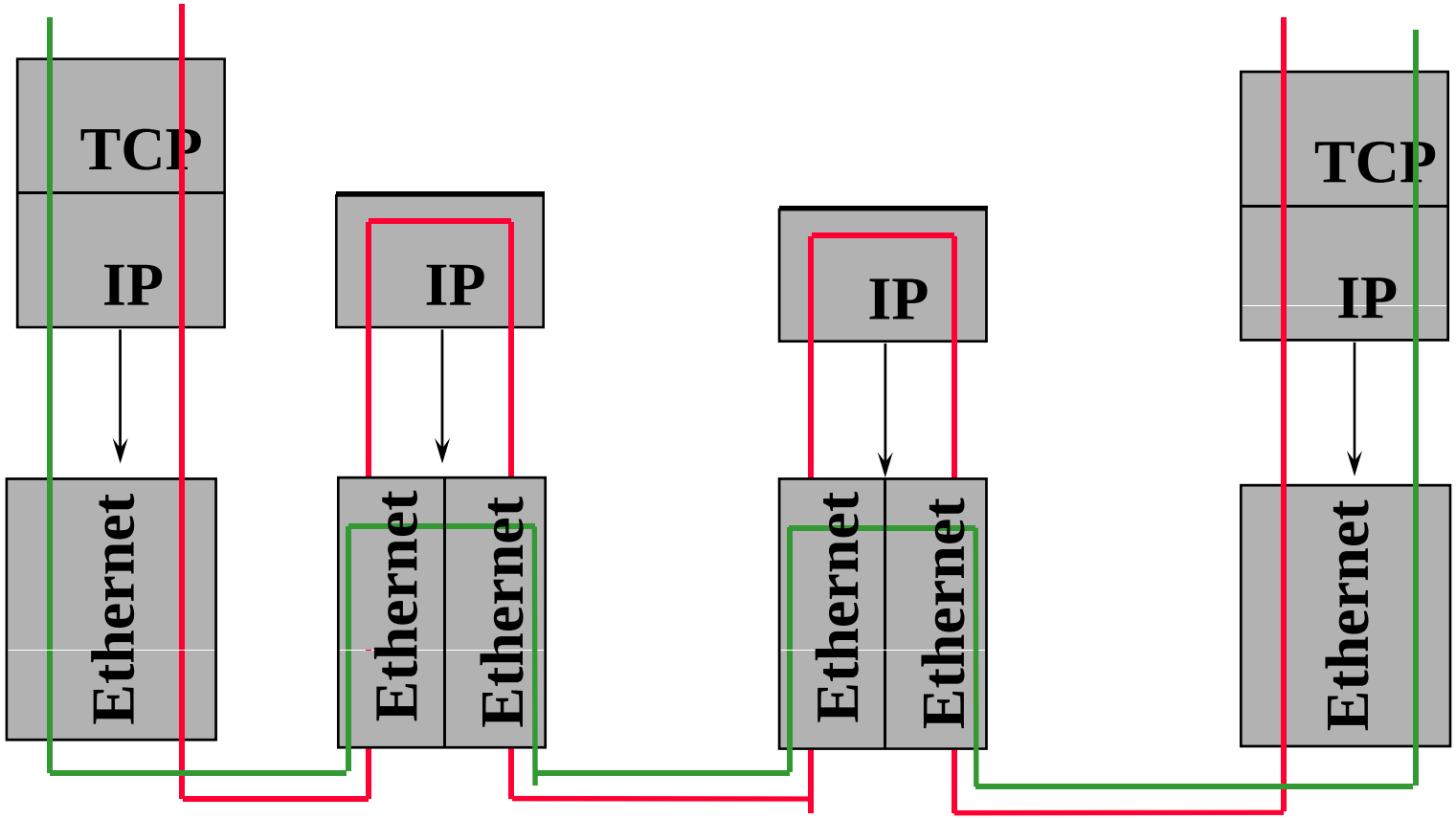
- **Three solutions**
  - Ethernet/MPLS
  - Ethernet MEF
  - Ethernet GVLAN (Generalized VLAN)

Ethernet/MPLS

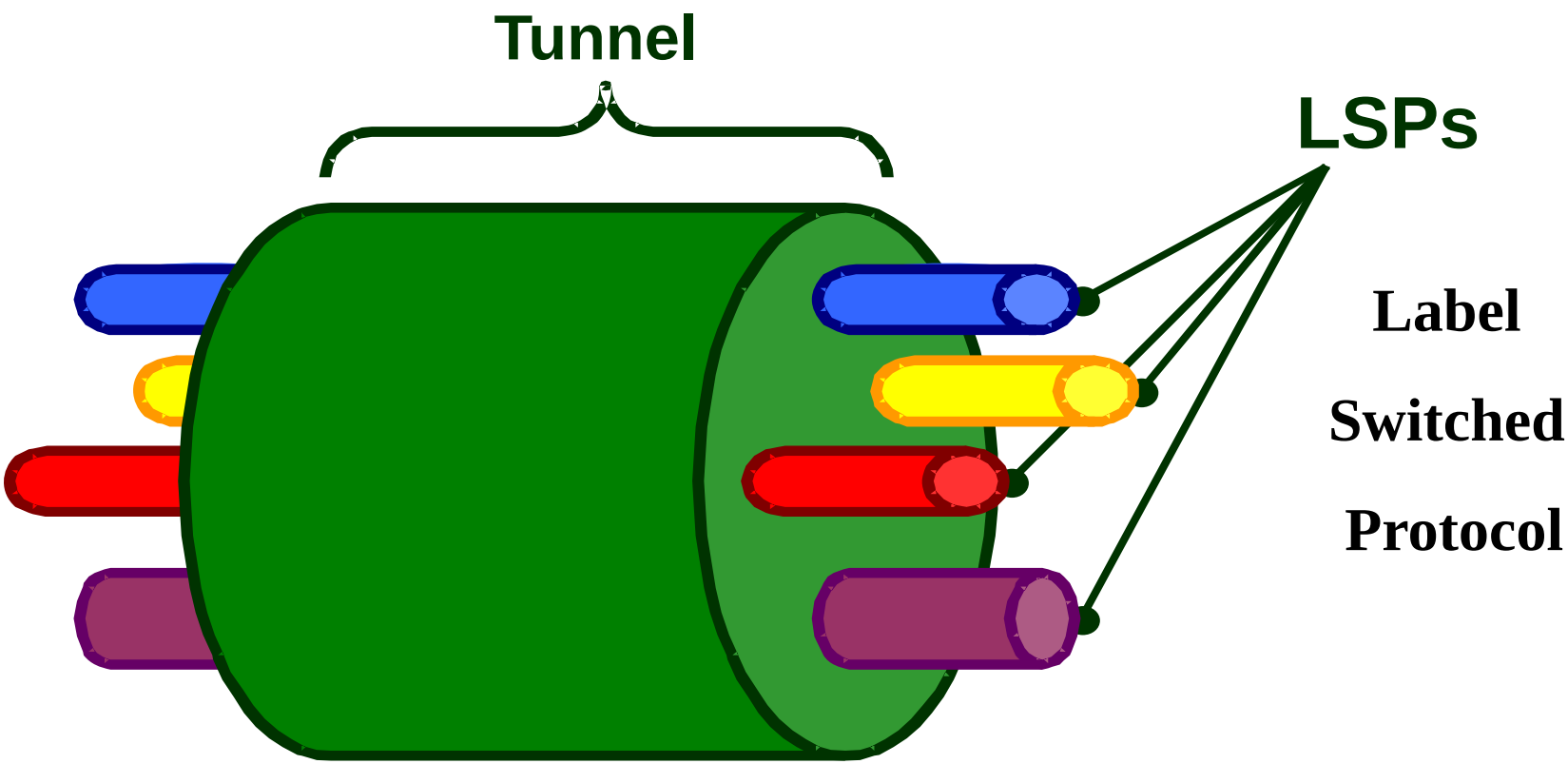
- **First solution**
  - IP signaling to open a path (LSP)
  - Label all along the path (MPLS Label or Shim Label)
  - Ethernet switching along the path

MPLS

- Multiprotocol Label Switching

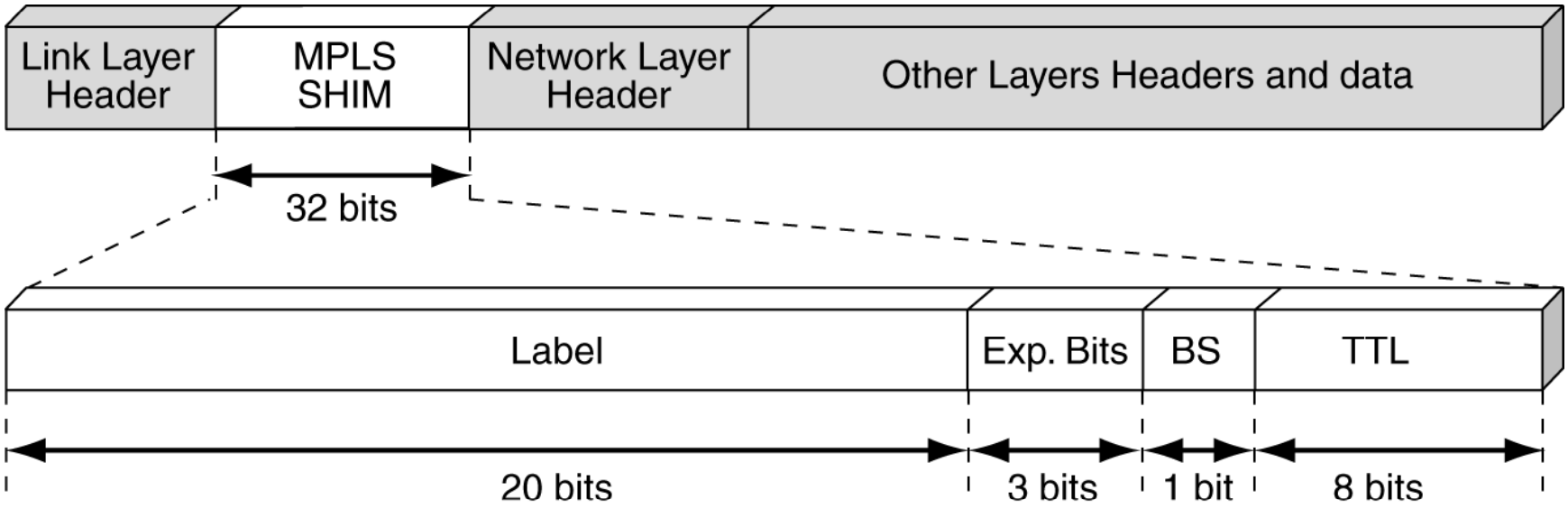


MPLS : conceptual view



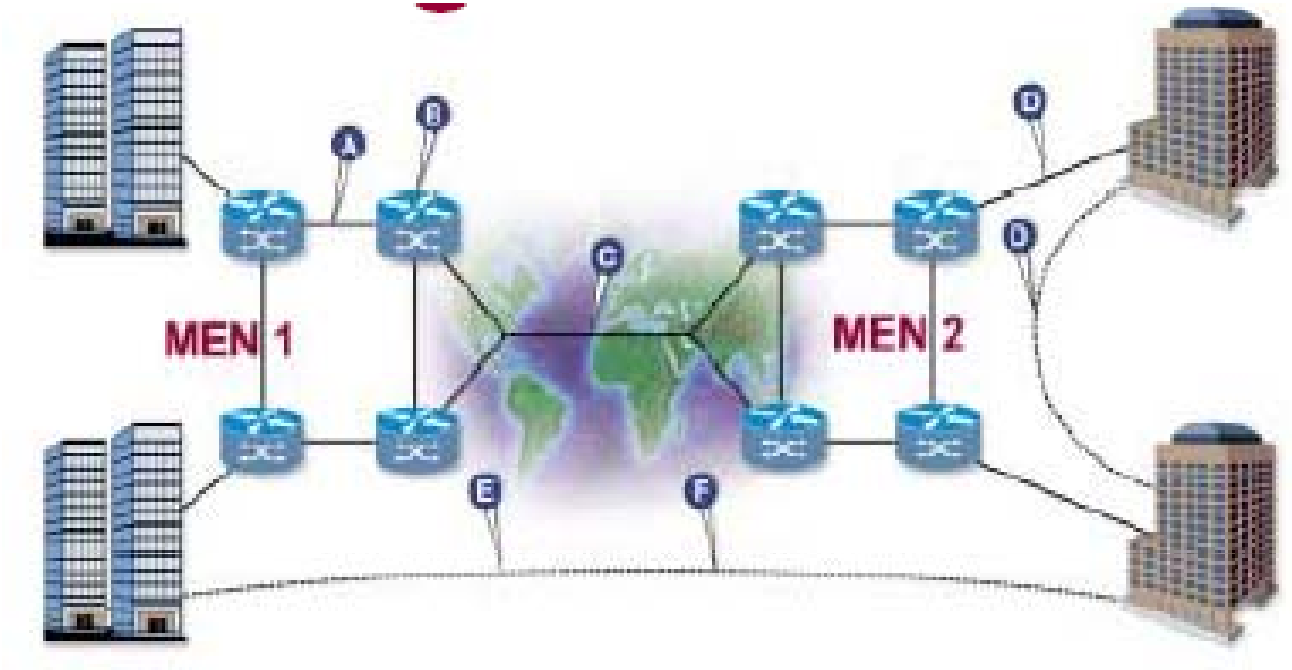
FEC (Forwarding Equivalence Class)

Ethernet frame



Metro Ethernet Forum (MEF)

2rd Solution provided by the MEF for MAN and WAN



MEF : Metro Ethernet Forum

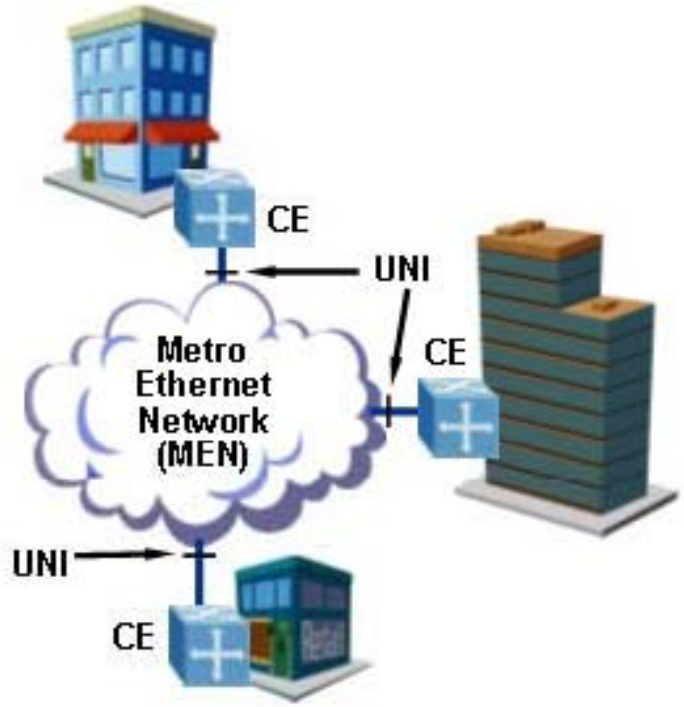
Interface and service

Interface UNI (User Network Interface)

2 types of service:

E-Line (Ethernet Line)

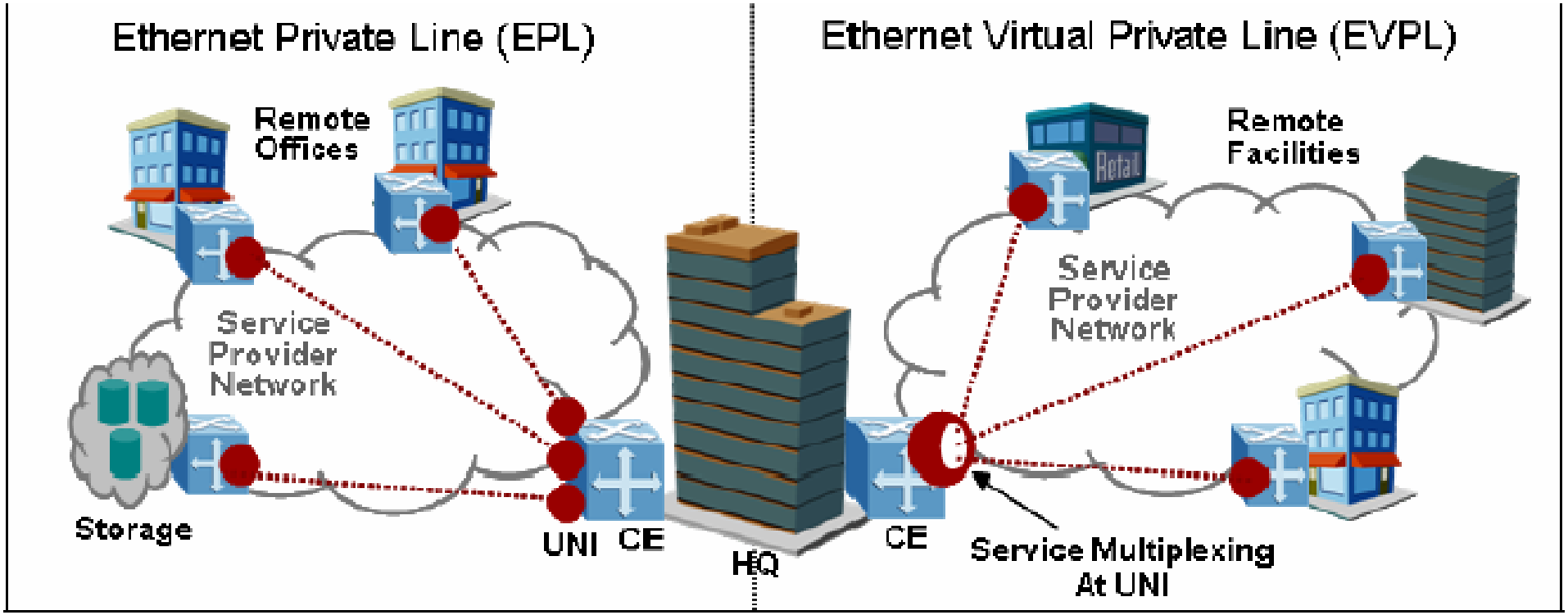
E-LAN (Ethernet LAN)



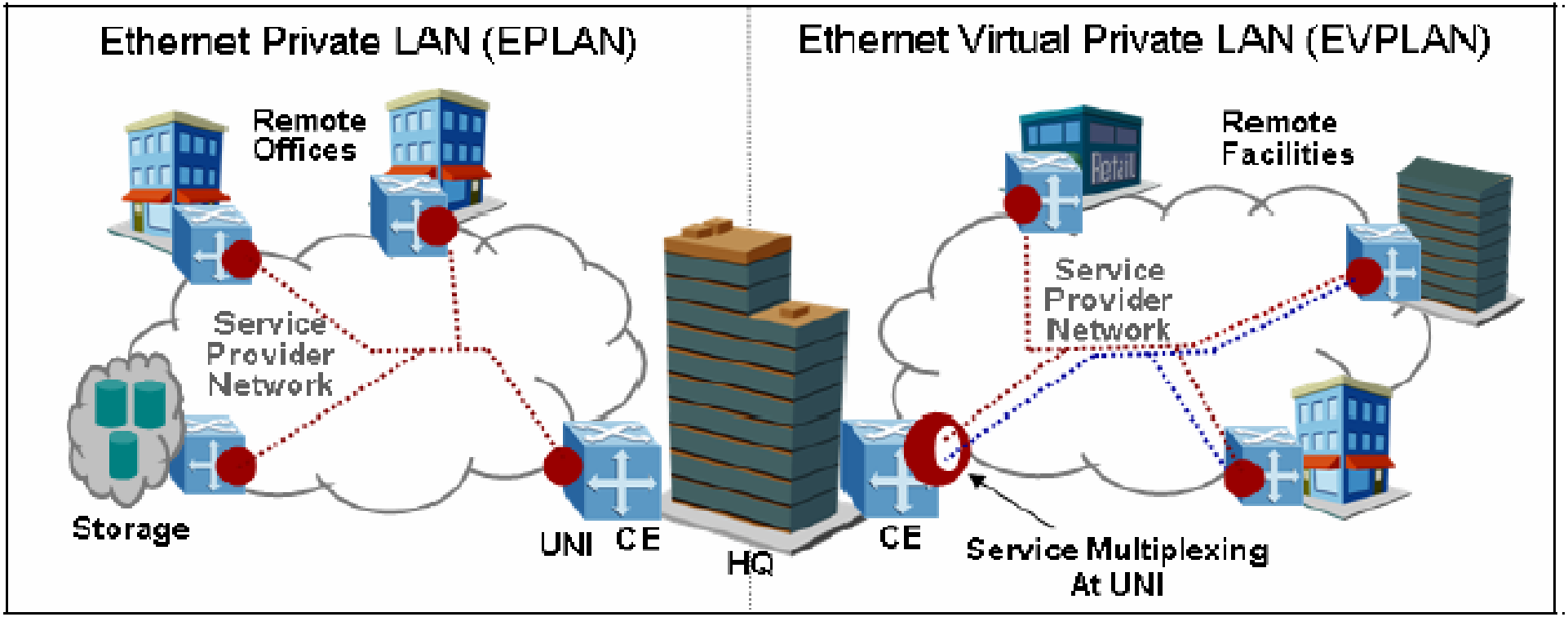
C-Ethernet services

E-Line (Point-to-Point)	E-LAN (Multipoint-to-Multipoint)
Ethernet Private Line (EPL)	Ethernet Private LAN (EPLAN)
Ethernet Virtual Private Line (EVPL)	Ethernet Virtual Private LAN (EVPLAN)

EPL et EVPL

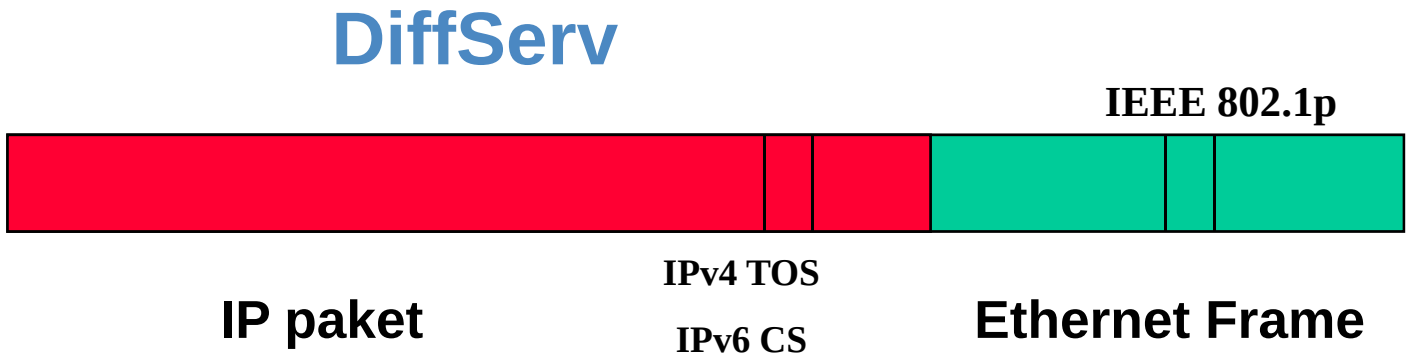

Ethernet Private Line (EPL)
Remote Offices
Service Provider Network
Storage
UNI
CE
HQ
Ethernet Virtual Private Line (EVPL)
Retail
Remote Facilities
Service Provider Network
CE
Service Multiplexing At UNI

EPLAN et EVPLAN



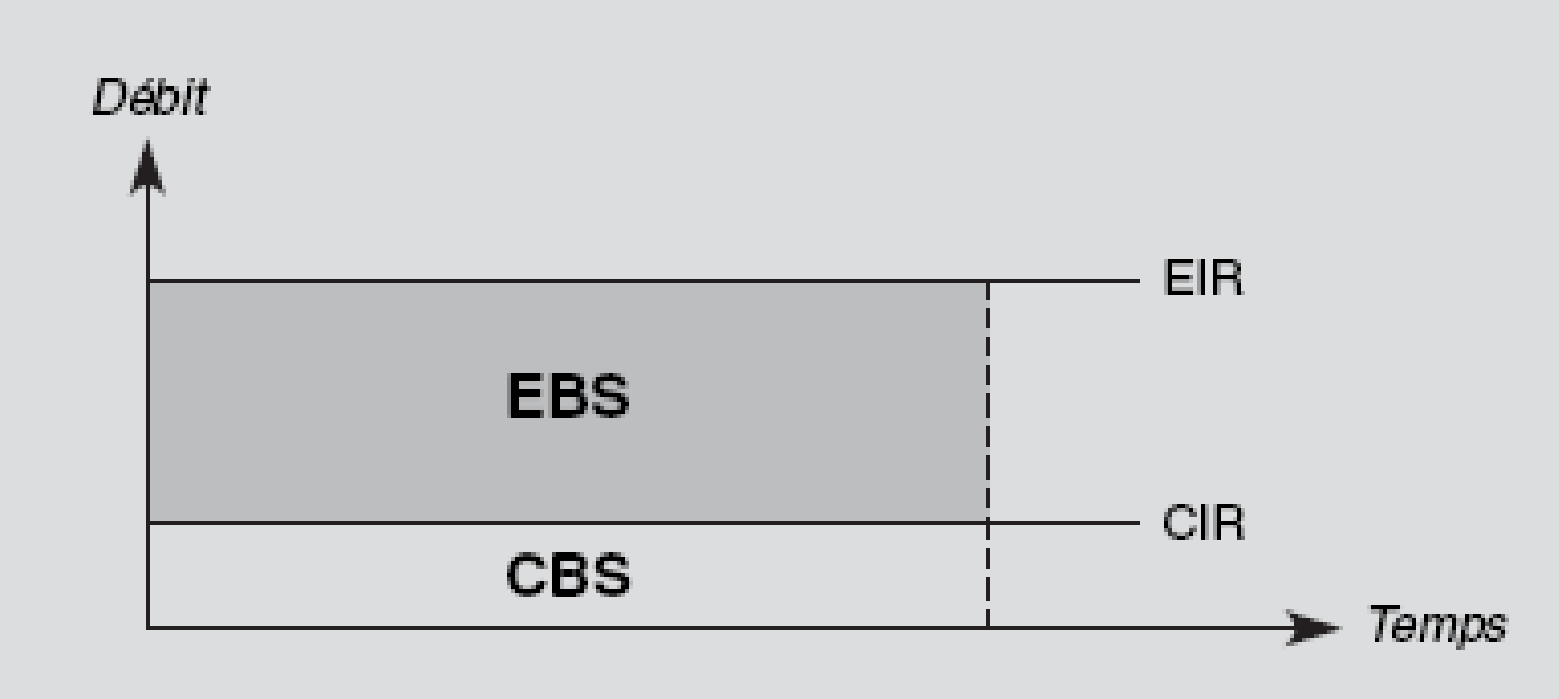
Ethernet with QoS

- Field IEEE 802.1p
  - 802.1p 6 DiffServ Expedited Forwarding
  - 802.1p 5/4/3 DiffServ Assured Forwarding
  - 802.1p 2 Best effort



- *The flow control technique is identical to the flow control of Frame Relay*
  - CIR (Committed Information Rate)
  - CBS (Committed Burst Size)
  - EIR (Excess Information Rate)
  - EBS (Excess Burst Size)
  - CM (Color Mode)

Ethernet flow control

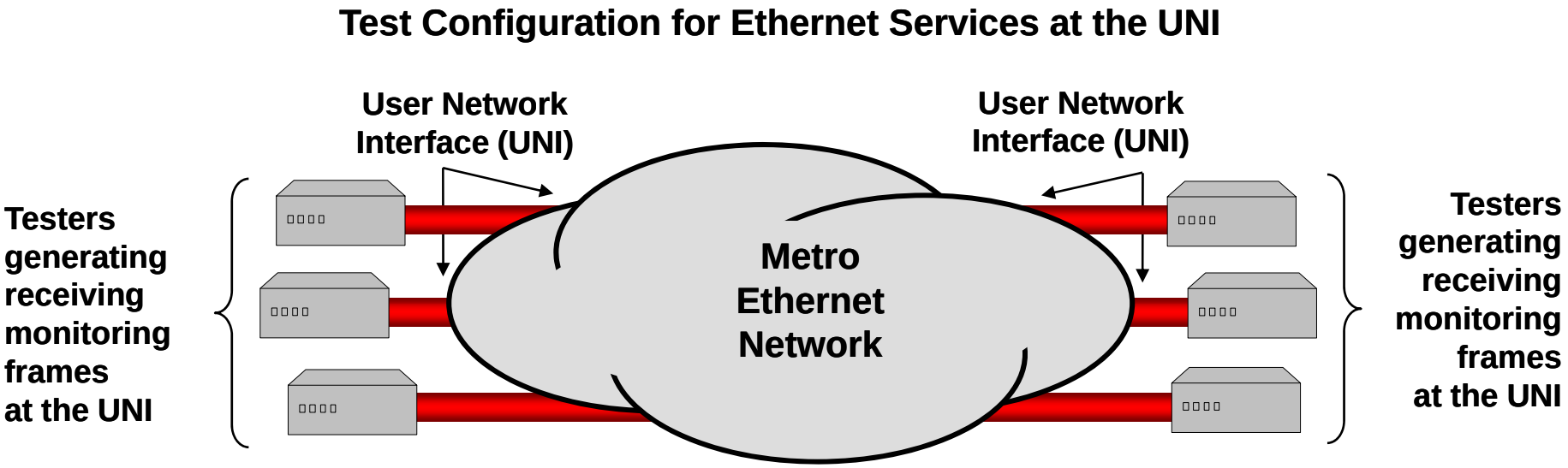


Green: Conformance to CIR/CBS = Guarantee

Yellow: Conformance to EIR/EBS = No Guarantee

Red: no conformance = Reject

Test configuration

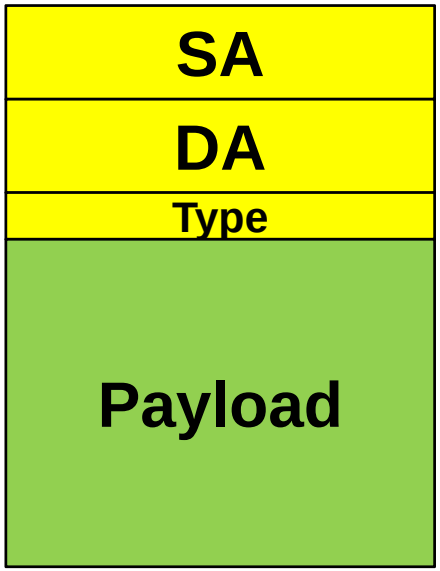


Ethernet carrier grade

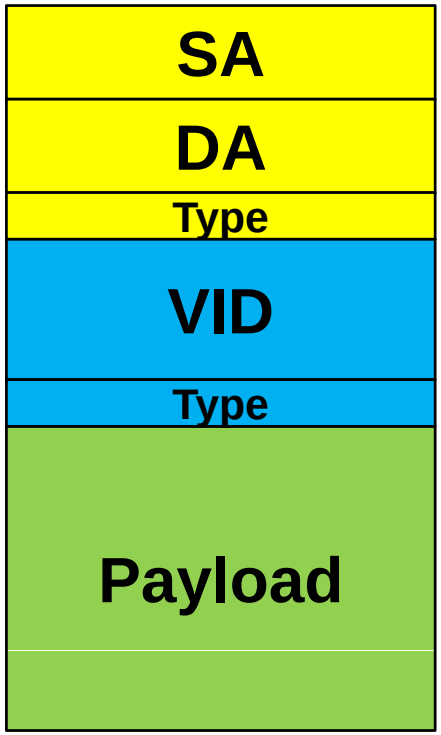
- **3th solution**
  - Q-tag (defined in IEEE 802.1Q) permitting to define VLANs
  - Management and performance are enhanced

- **Two solutions to support this hierarchical approach**
  - IEEE 802.1ad (also known as Q-in-Q, stacked VLANs or Provider Bridges), extends the original concept of VLANs.
  - the service provider can still only create 4 094 customer VLANs

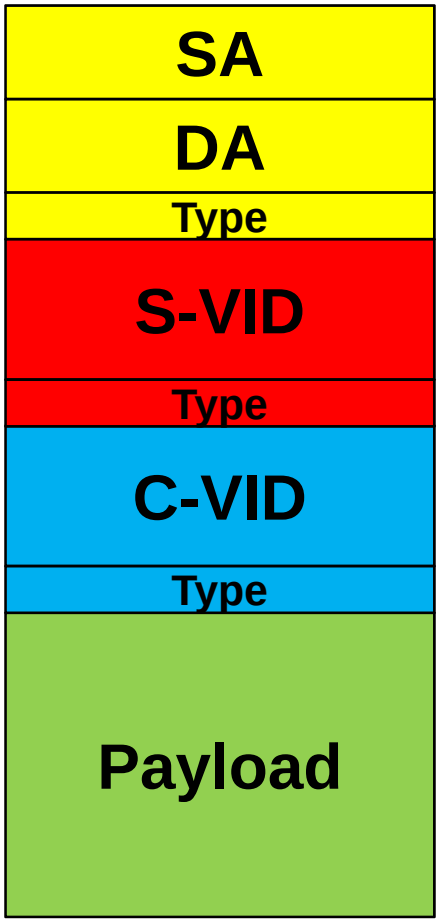
Q-in-Q



802.1



802.1q



802.1ad

SA: Source Address

DA: Destination address

VID: VLAN ID

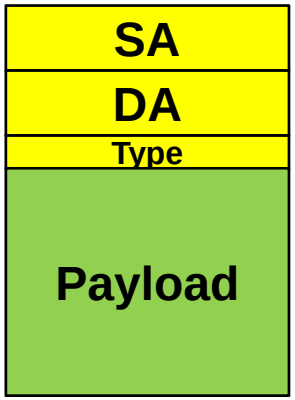
S-VID: Service VID

C-VID: Customer VID

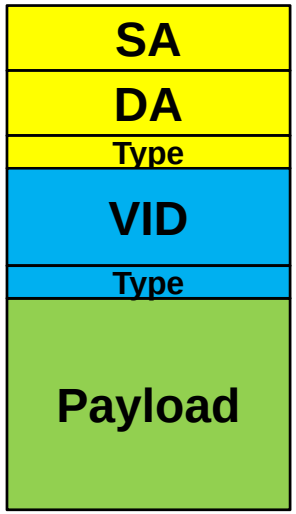
MAC-in-MAC

- **IEEE 802.1ah (also known as MAC-in-MAC or Provider Backbone Transport), which encapsulates the customer MAC header with a service provider MAC header.**
  - 16 million service instances can be supported
  - Security is enhanced: clear demarcation point between the customer and service provider networks
  - Robustness: isolated from broadcast storms and potential forwarding loops created in the end customers' networks.

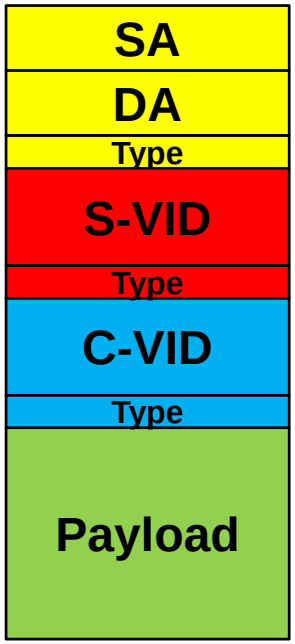
MAC-in-MAC



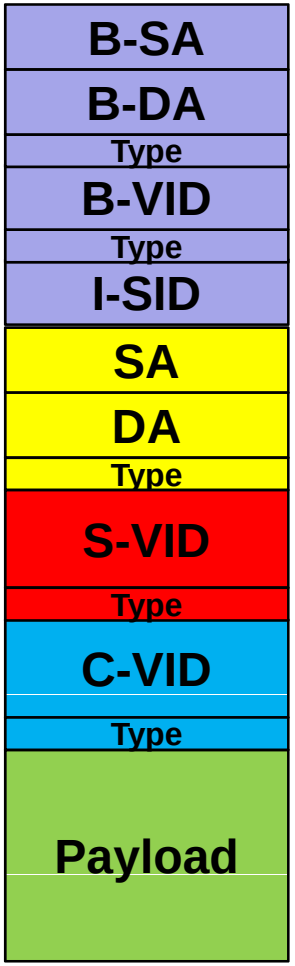
802.1



802.1q



802.1ad



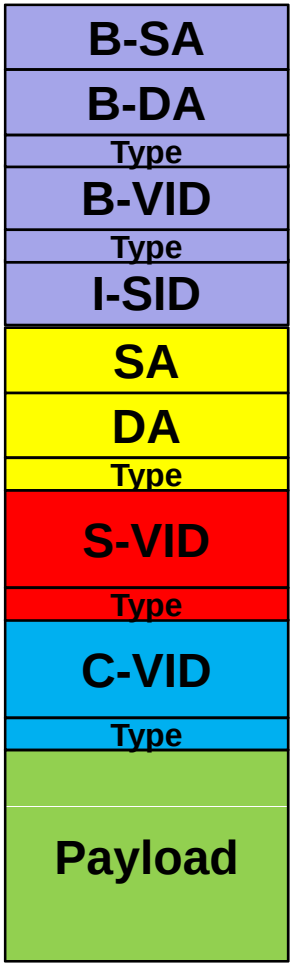
802.1ah

SA: Source Address
DA: Destination address
VID: VLAN ID
S-VID: Service VID
C-VID: Customer VID
B-SA: Backbone SA
B-DA: Backbone DA
B-VID: Backbone VID
I-SID: Service

Ethernet Carrier Grade

- From a non connected technique to a switched technique
- PBT(Provider Backbone Transport)

Ethernet PBT



Provider Backbone Transport

- Forwards traffic on full MAC + VLAN (60 bits) addresses
- VLAN Tag is no longer network global: scaling issues are removed
- A range of VLANs can be used for bridging and another range for PBT