Main Internet Evolution Trends

towards a convergent multiservice network

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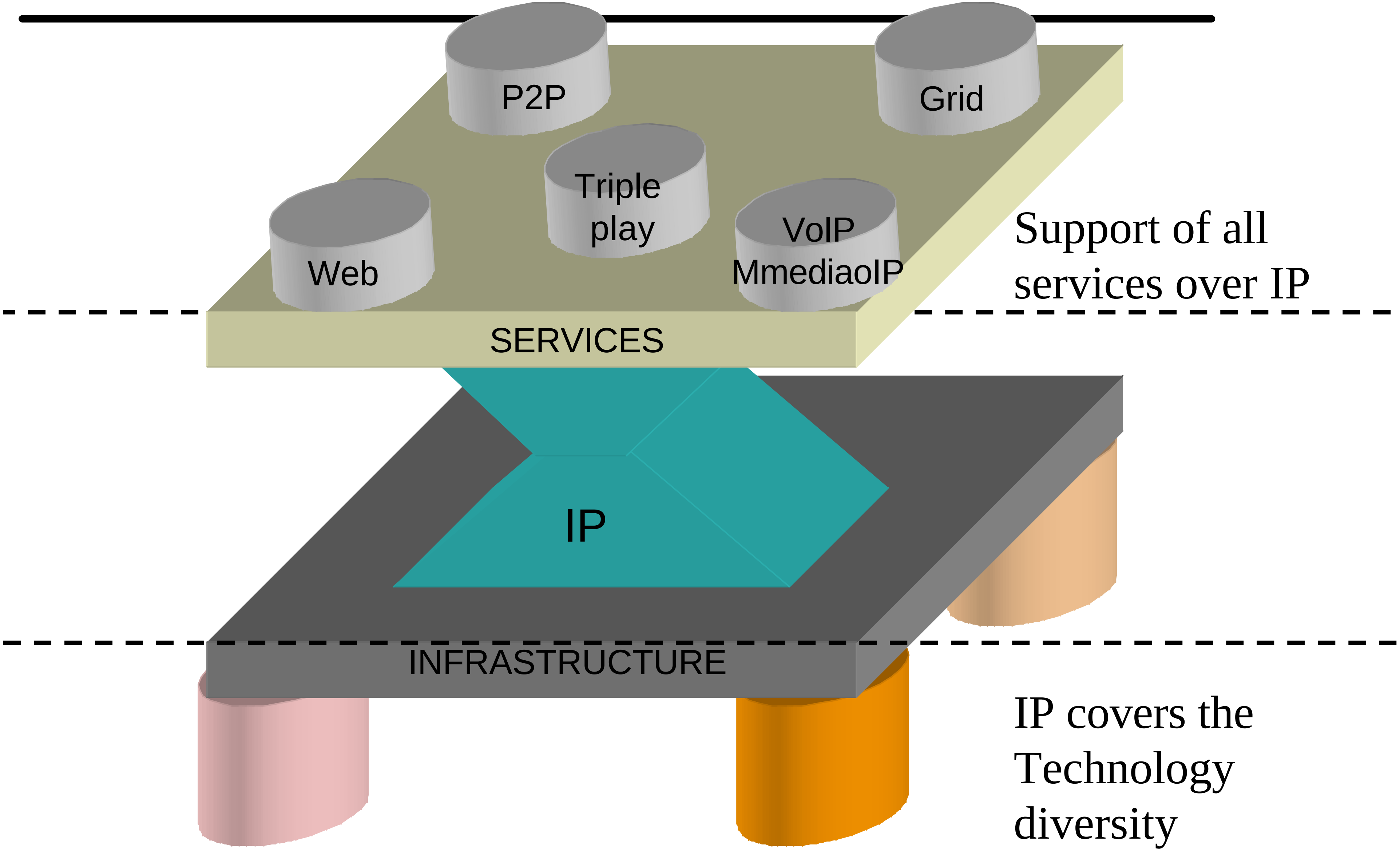
Case study : Internet

- **First generation, before 1992**
  - ***Research network***
  - ***Telnet, Email, File Transfer***
  - ***Low traffic, reduce number of users***
- **Second generation , the '90s**
  - ***Commercial services, ISPs***
  - ***Web and basic peer-to-peer***
  - ***Traffic and number of networks explosion***
  - ***Mainly Best Effort approach and simple engineering rules***
    - **Main issue: capacity**
- **Third generation, from now on**
  - ***Triple play (Internet/Telecom/Media convergence)***
  - ***New networking architectures are required***
  - ***New engineering rules are necessary***

Case study : Internet

- **Internet success**
  - ***Services***
    - **Web, E-mail, peer-to-peer, distributed games, triple play, etc.**
  - ***Very wide connectivity.***
  - ***Price.***
  - ***Simplicity.***
- **Internet limitations : the network**
  - ***Capacity.***
  - ***Quality of service.***
  - ***Security.***
  - ***Mobility***
  - ***Availability, reliability.***

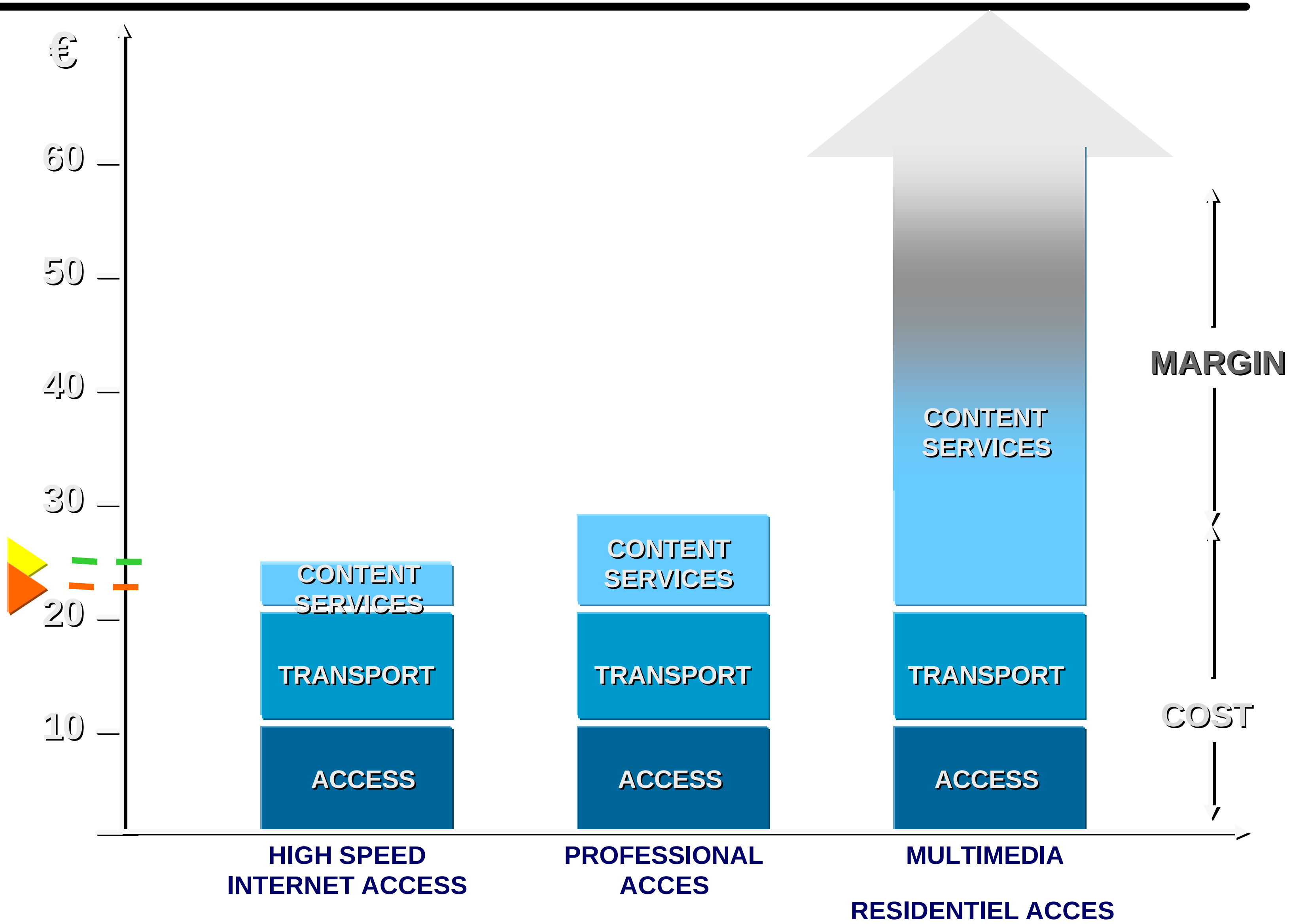
Towards IP Multiservice Networks



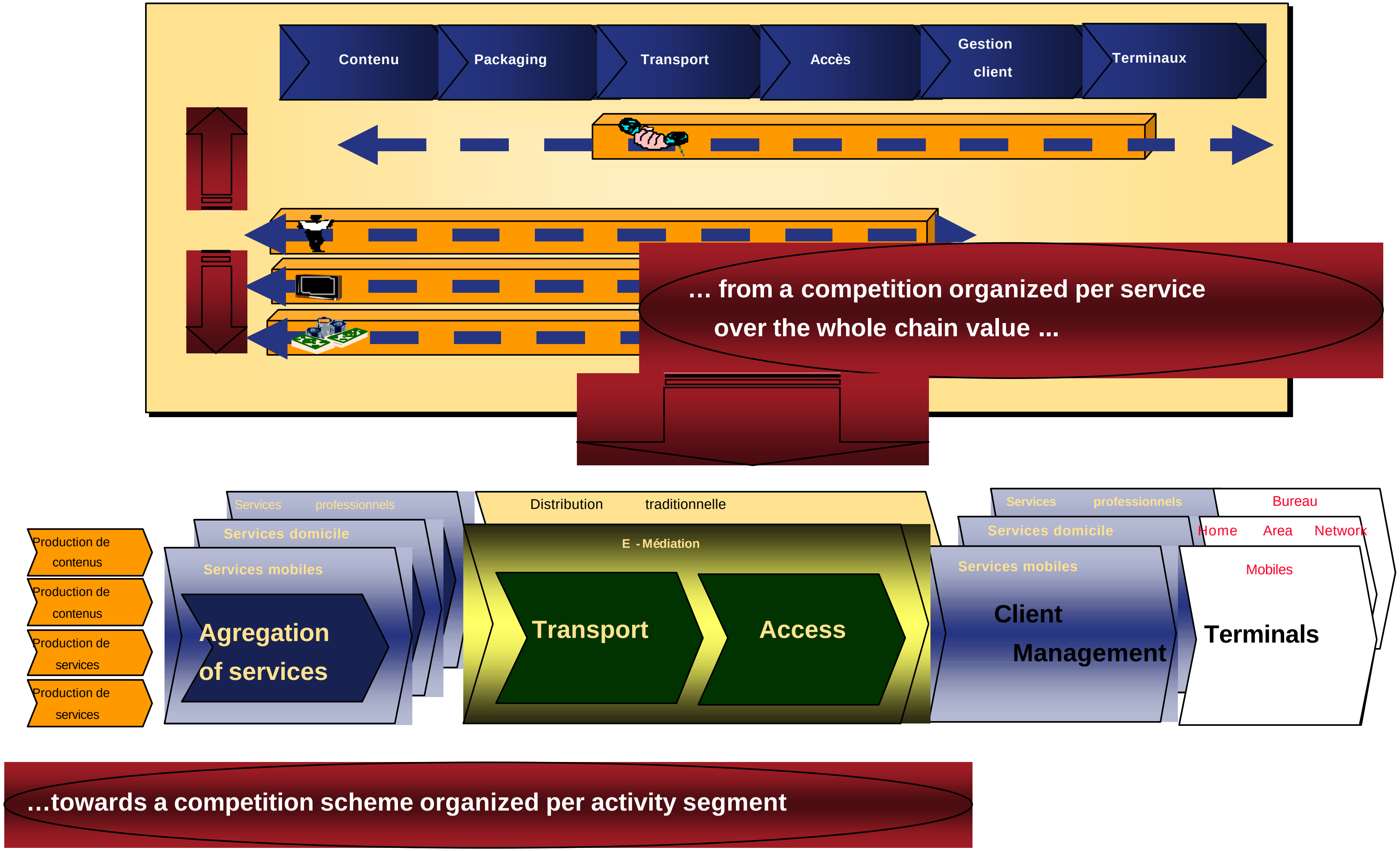
Support of all services over IP

IP covers the Technology diversity

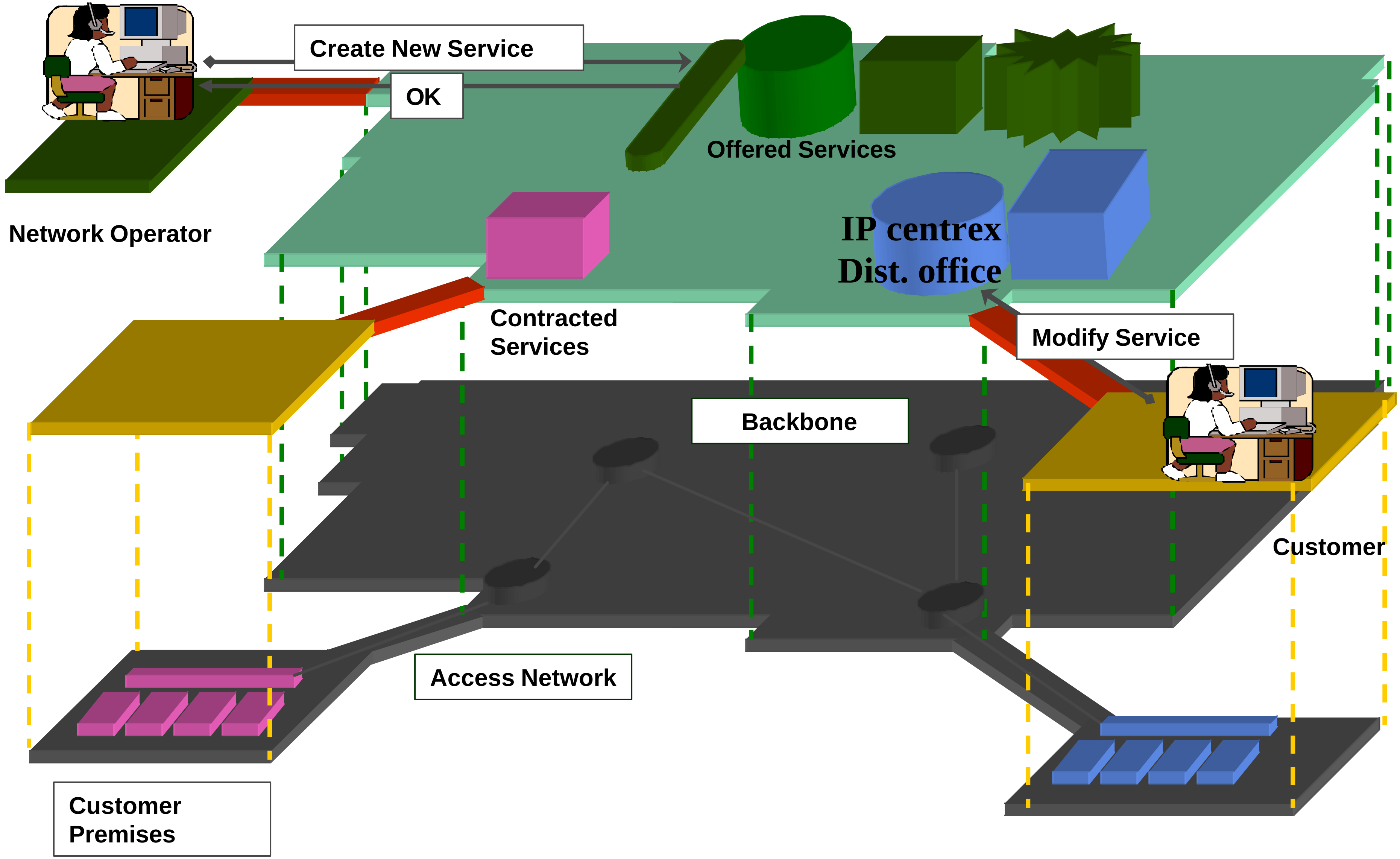
Network margins going down: telecom operators interested in services and content



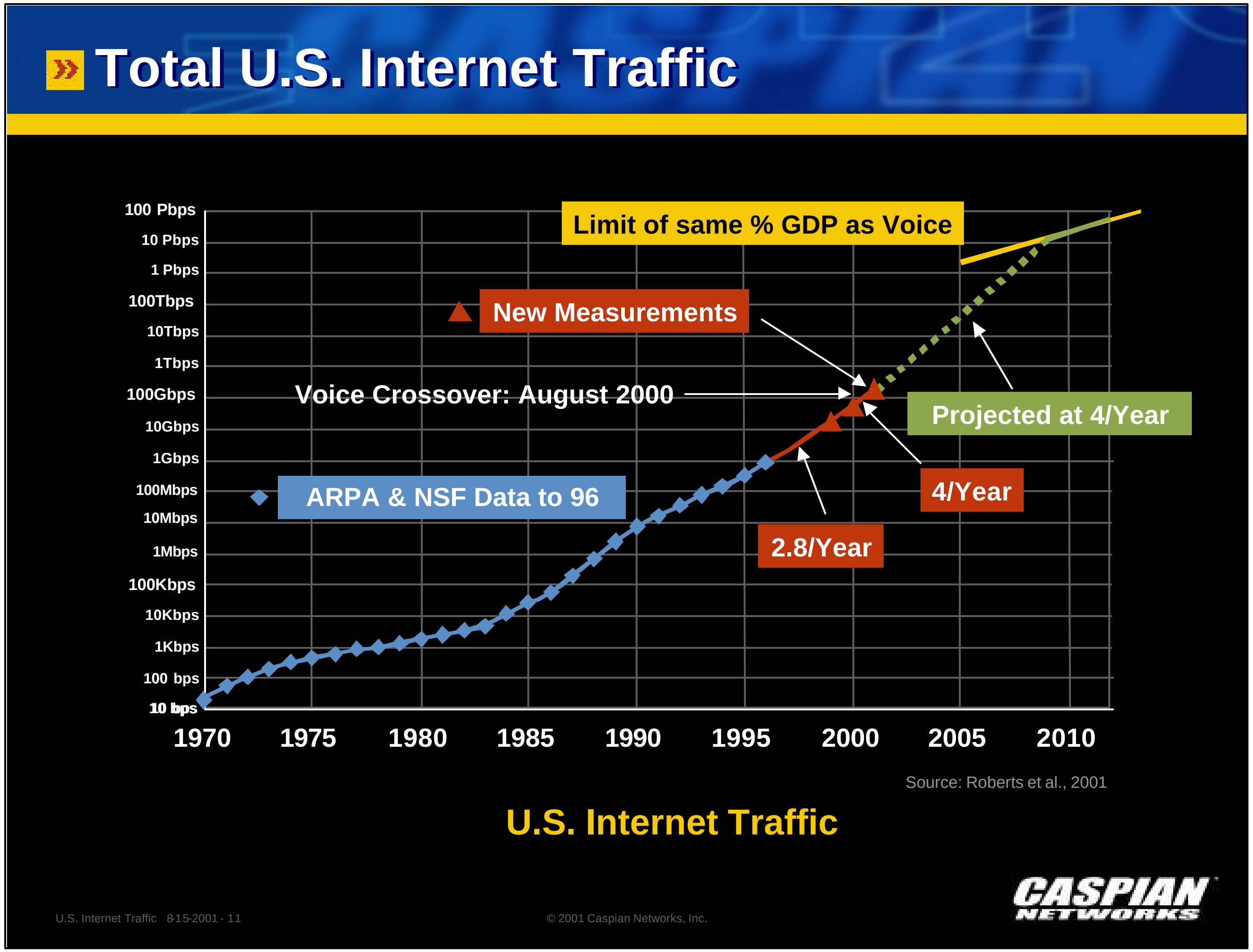
A new organization of the chain of value



Any service, any time, everywhere



Internet traffic evolution



The traffic should continue to grow

- **The users are still auto-controlled**
  - ***New applications generating higher amount of traffic are today available***
    - **Sophisticated : VTHD distributed computing and display : 700 Mbps**
    - **Mass : Video-conferencing, Distributed games, Media distribution, Interactive video**
  - ***They are not used because of the lack of QoS, which is usually related with a lack of network capacity***
- **Access technologies evolution**
  - ***xDSL, HFC, WLL, Wi-Fi, Satellite, PLC, NG-SDH, Ethernet based access/metro networks, A-PON, E-PON, Metro DWDM***

Capacity cost

- **The transmission cost of the Mbps is being reduced drastically in the core (D-WDM).**
- **The switching cost is not being reduced at the same rate.**
- **The routing tables are growing fast**
- **The transmission cost remains high in the access**
  - ***Specially in the mobile domain***
- **In the access, the bit rates remain relative low, and important multiplexing jitter is introduced when no traffic management mechanisms are available**

Consequences

- **A trivial one: more bandwidth is required. We need a scalable approach to deploy bandwidth**
  - ***The technology to face this point is becoming mature: DWDM***
- **A complex one: the routing is becoming a bottleneck. Many Internet packet lost are due to routing instability**
  - ***New IP architectures are required***
- **Differentiated IP services are required, it is not profitable to upgrade the QoS for all the traffic**
  - ***Per traffic profile, per required QoS, specific functionalities***
  - ***Differentiated billing***
  - ***Policy Enabled Networks***

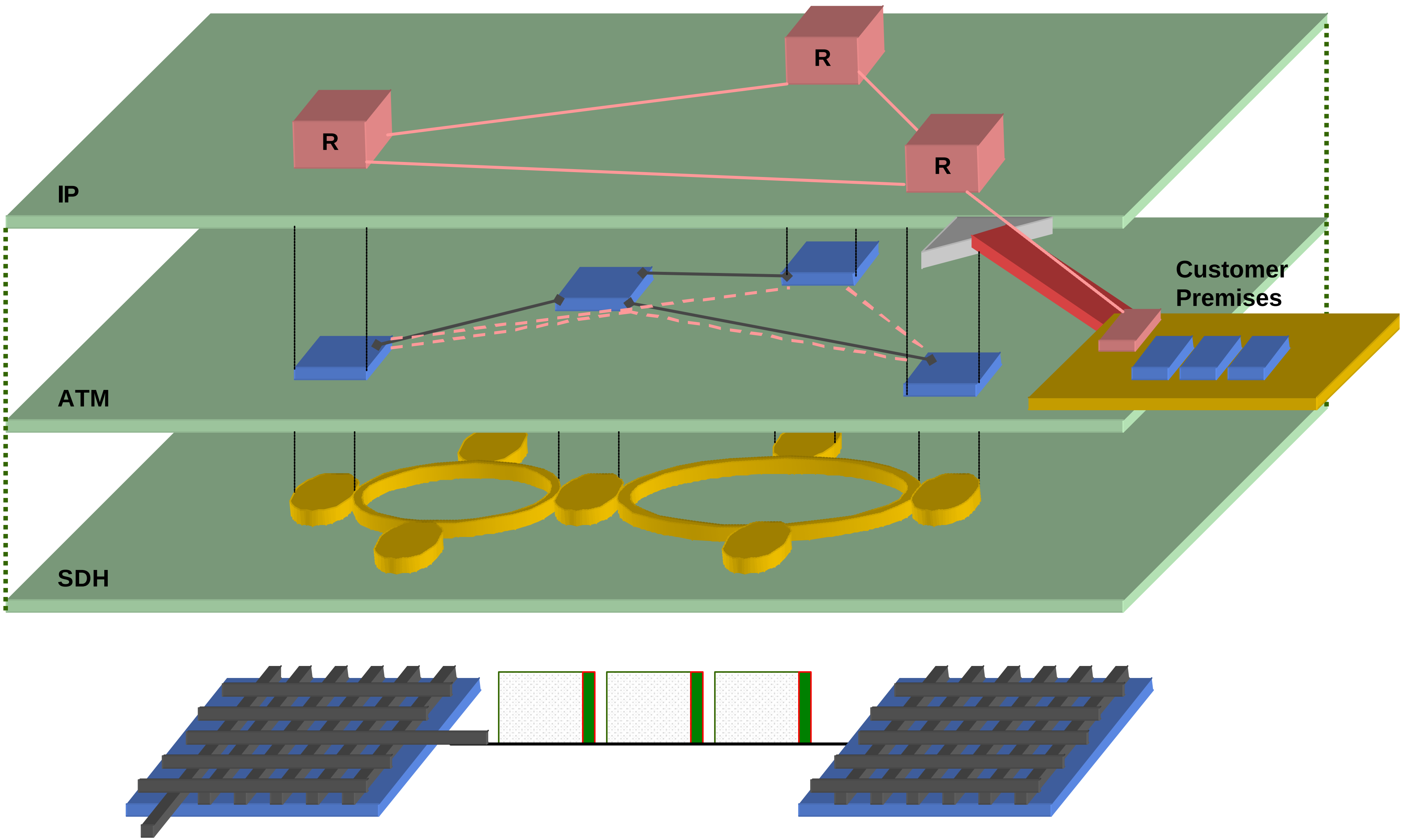
Examples of Internet evolutions

- From a data network towards a multiservice-multimedia network
- From unicast to multicast routing
- The usage of new lower layer technologies (IP/ATM, IP/SONET, IP/DWDM, etc.)
- From legacy dial-up to ADSL, HFC, WLL, Wi-Fi, FTTx, PLC, satellites, etc.
- From isolation towards service integration with, for example, the telephony network: NGN architectures
- Towards the provisioning of telecommunication services for private companies: IP VPNs
- From software based to hardware based routers architectures (Giga/Tera routers, flow based routers, etc.)

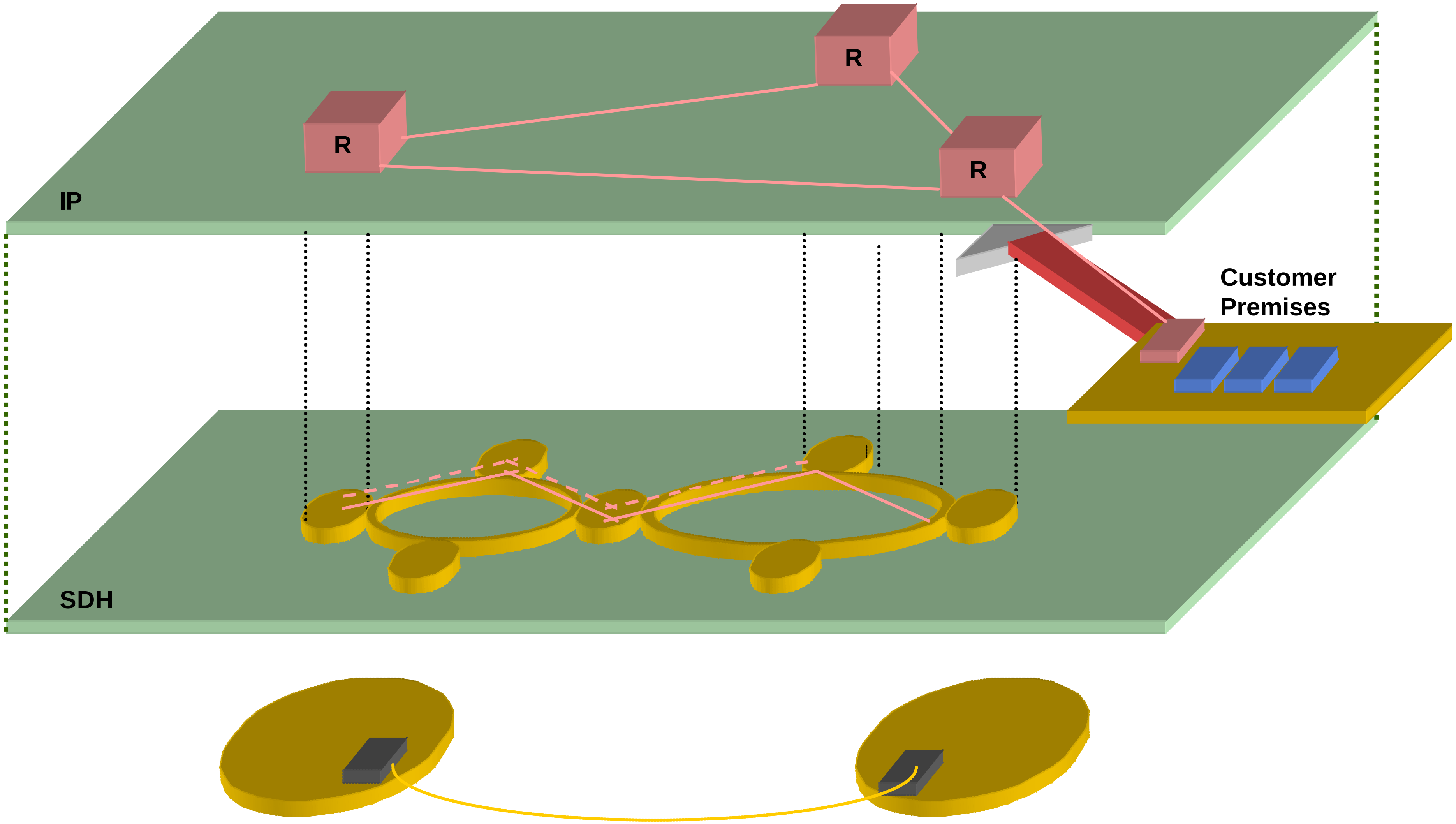
The Backbone

Different Approaches to Increase Backbone Capacity

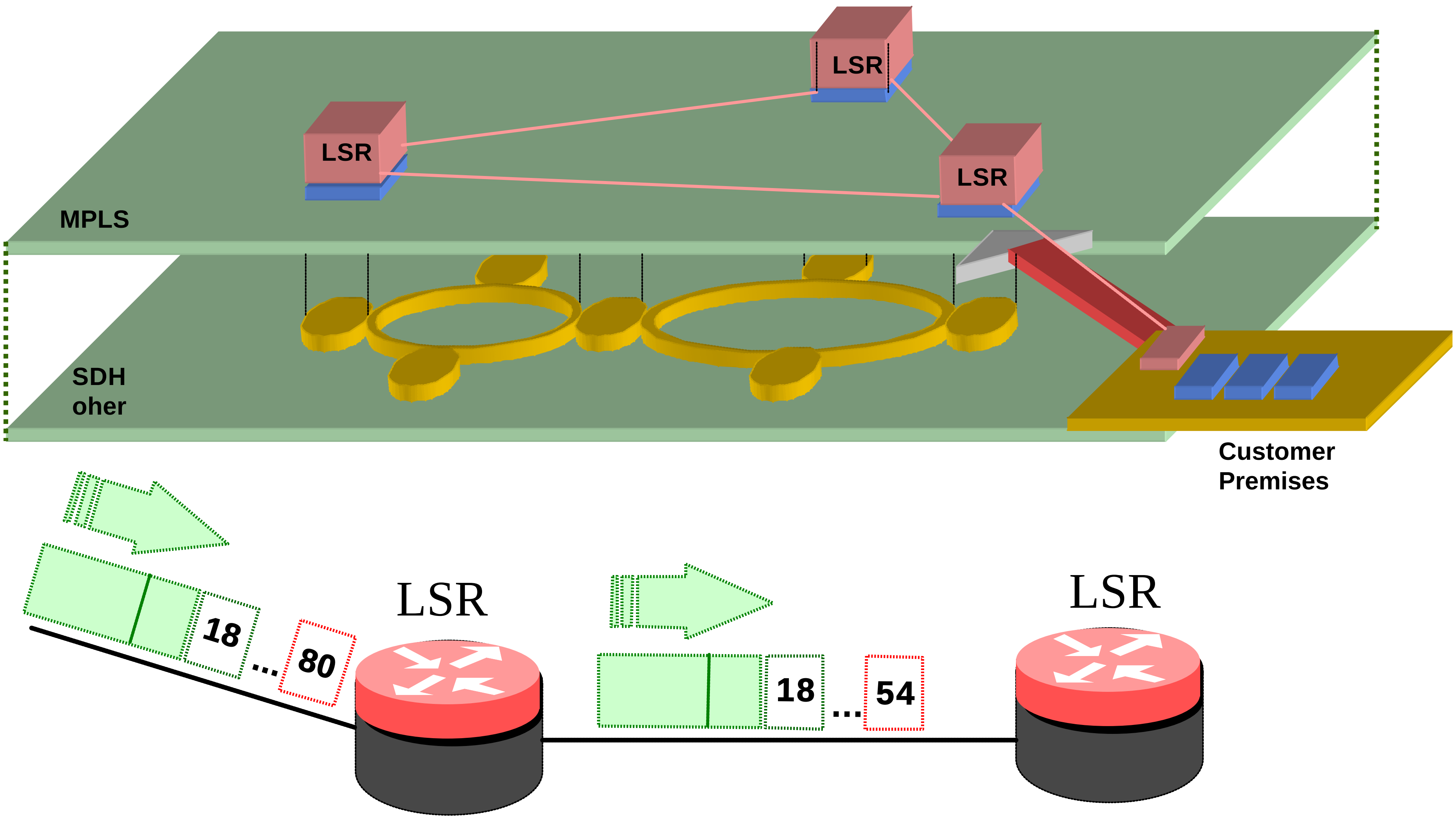
Increasing Capacity for IP transport, Option I: IP over ATM



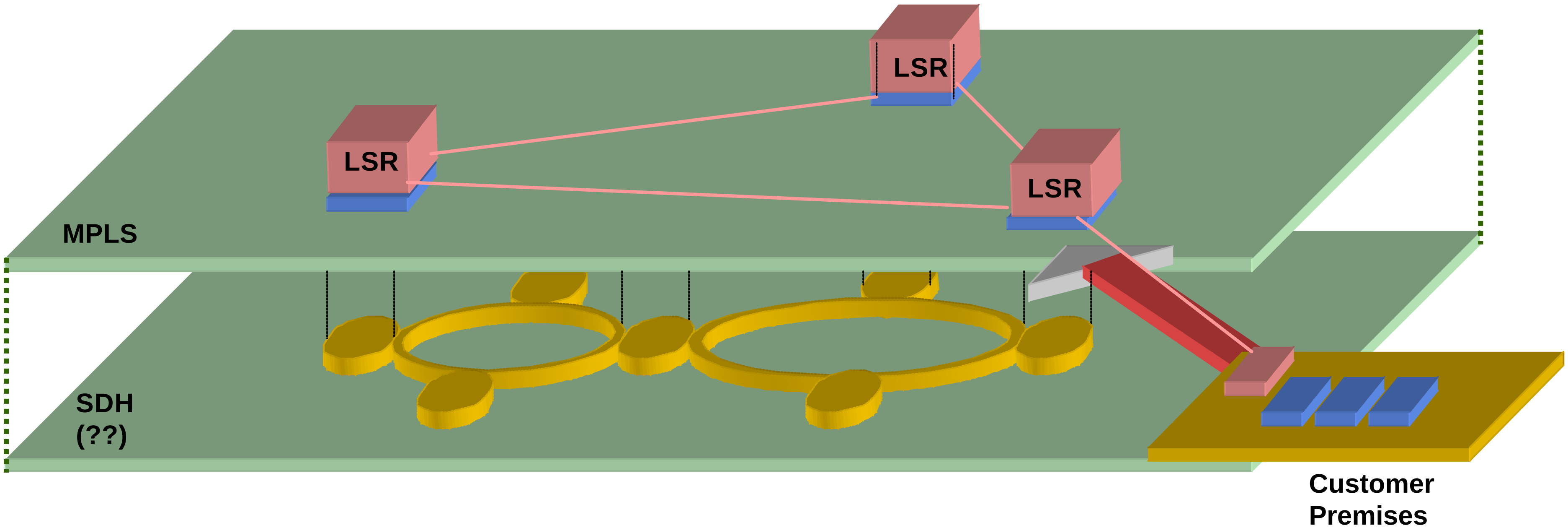
Increasing Capacity for IP transport, Option II: IP over SONET (SDH)



Increasing Capacity for IP transport, Option III: MPLS

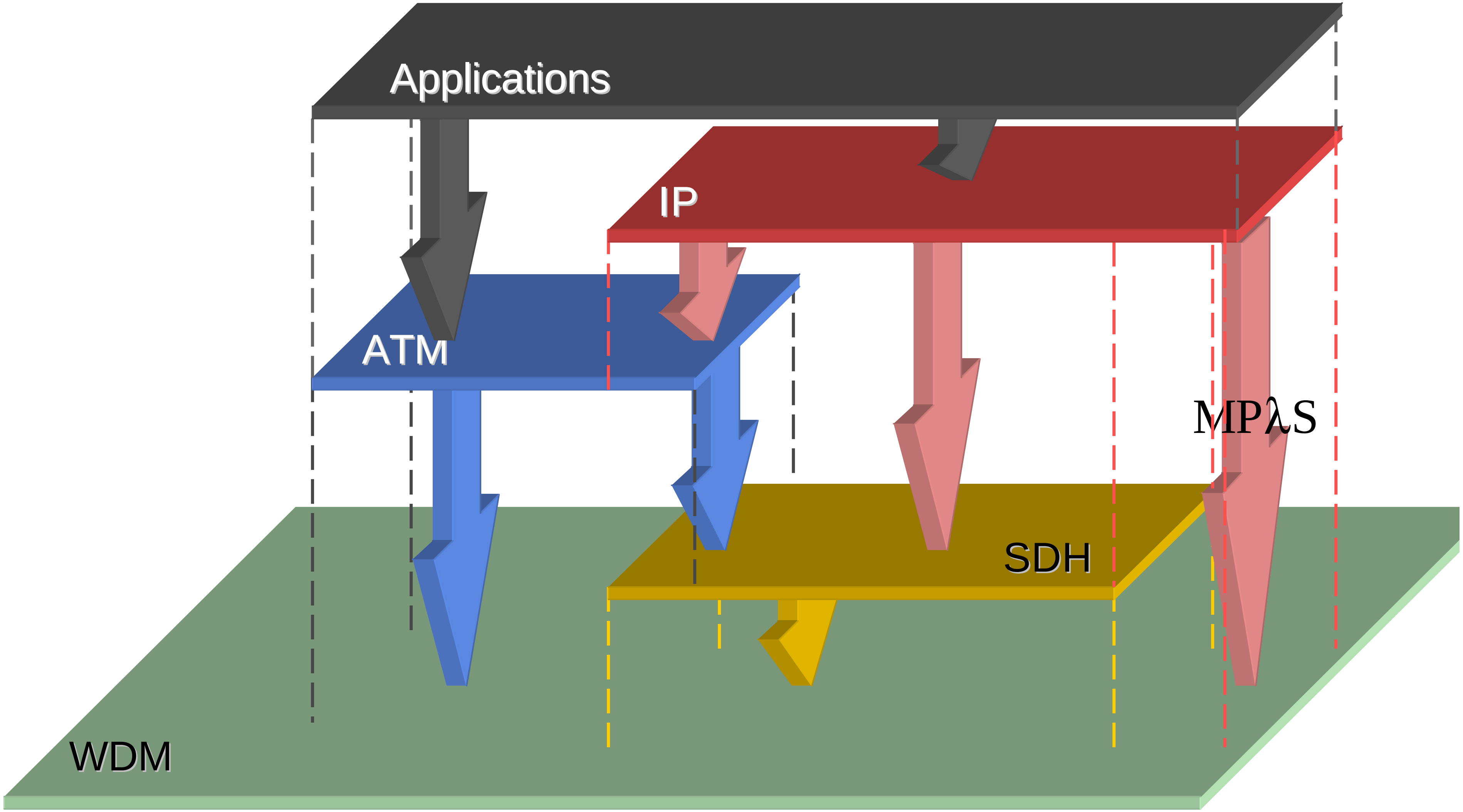


Switching Capacity, not an issue any more, but MPLS still needed

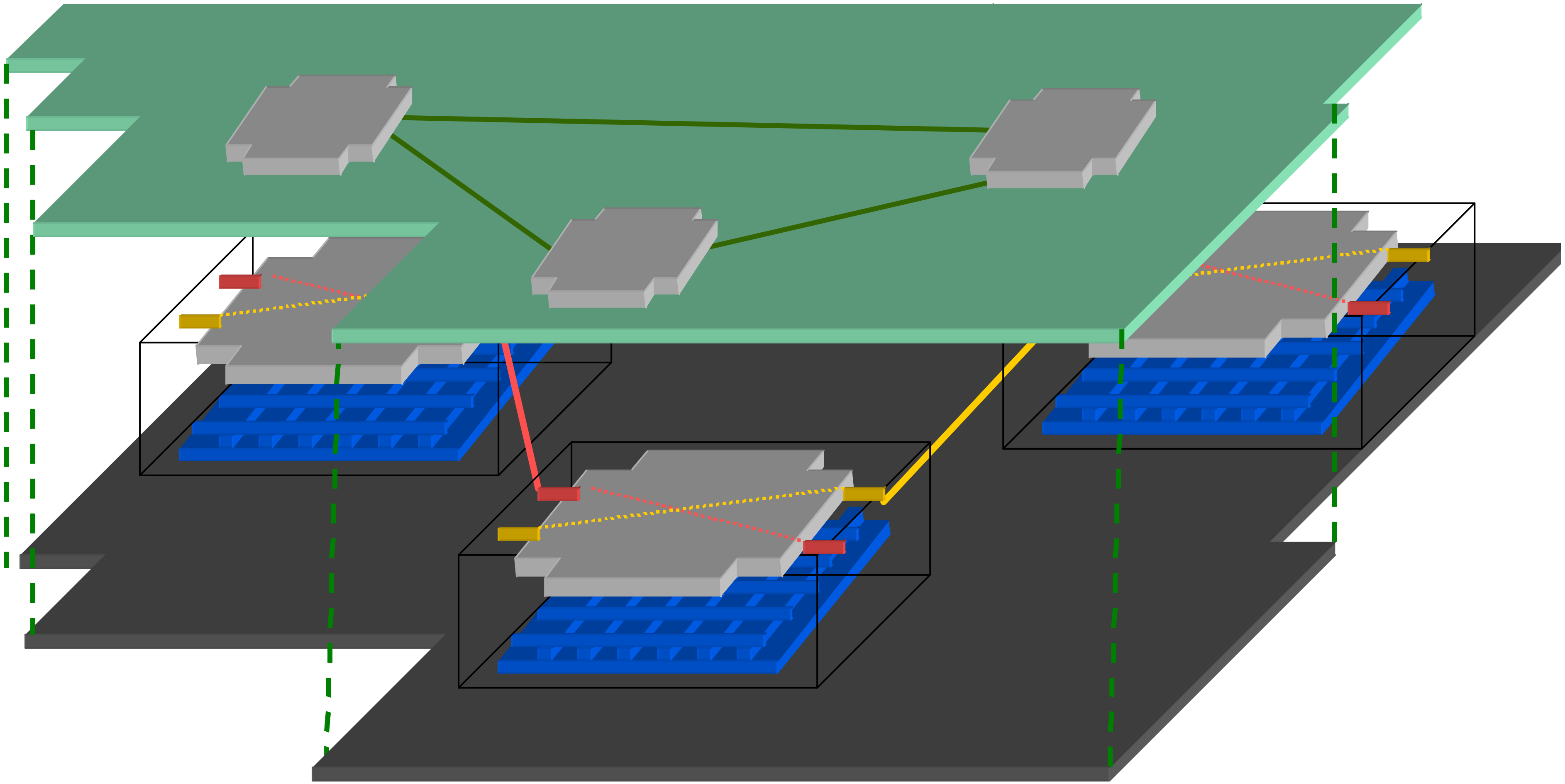


- QoS
- Managed VPN
- Traffic Engineering
- Multicast

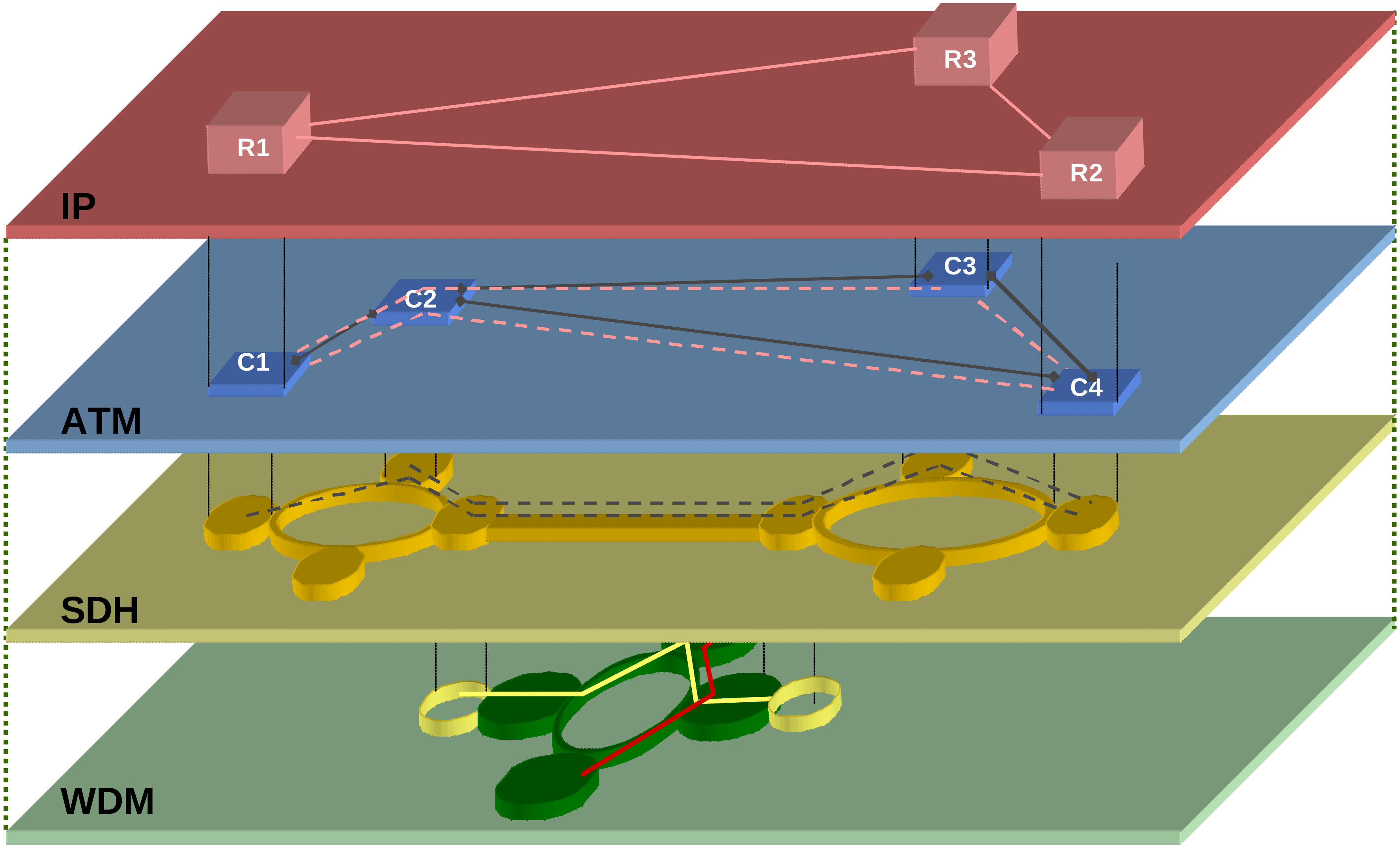
Synthesis



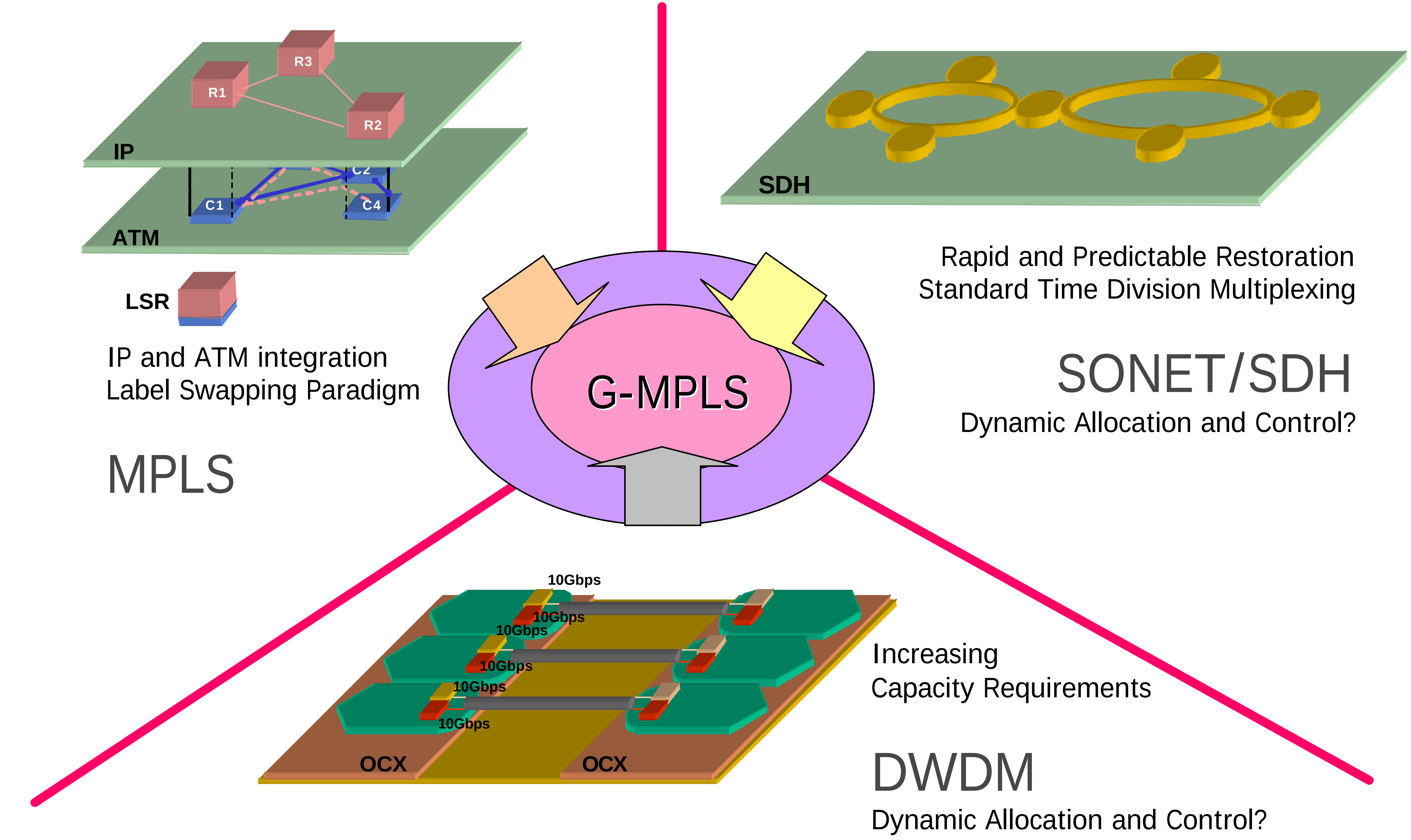
Generic / Hybrid Switches



Overlay Networks



Main trends



R3
R1
R2
IP
C2
C1
C4
ATM
LSR
IP and ATM integration
Label Swapping Paradigm
MPLS
SDH
Rapid and Predictable Restoration
Standard Time Division Multiplexing
SONET/SDH
Dynamic Allocation and Control?
G-MPLS
10Gbps
10Gbps
10Gbps
10Gbps
10Gbps
10Gbps
OCX
OCX
Increasing
Capacity Requirements
DWDM
Dynamic Allocation and Control?

The Access Network

Technologies for the Access Network

Targets of the Access Network

- **Concentrate traffic towards service nodes**
  - ***Traffic concentration = Cost savings***
  - ***Reduce CAPEX***
- **Provide the different type of interfaces users are waiting for (Telephony, Leased lines (PDH, SDH), Frame Relay, ATM, Ethernet, etc.)**
- **Provide enough control to solve the difficult tradeoff between guaranteeing QoS and optimizing the deployed resources.**
  - ***Of special importance in the access where bandwidth remain low compare with the backbone and expensive***
- **Provide evolved Management and Operation and maintenance mechanisms**
  - ***Reduce OPEX***

Access Networks Evolution Context

- **Requirements**
  - ***More bandwidth***
  - ***Bi-directional services***
  - ***Mobility***
  - ***Simultaneity and convergence of different services***
  - ***Lower prices***
- **Legacy access networks**
  - ***Twisted Pairs based***
  - ***Broadcast cables (CATV)***
  - ***Low speed mobility based on 2nd generation systems***

How to reduce the gap to maximize the incomes
with minimum investments

Access Networks Evolution Context

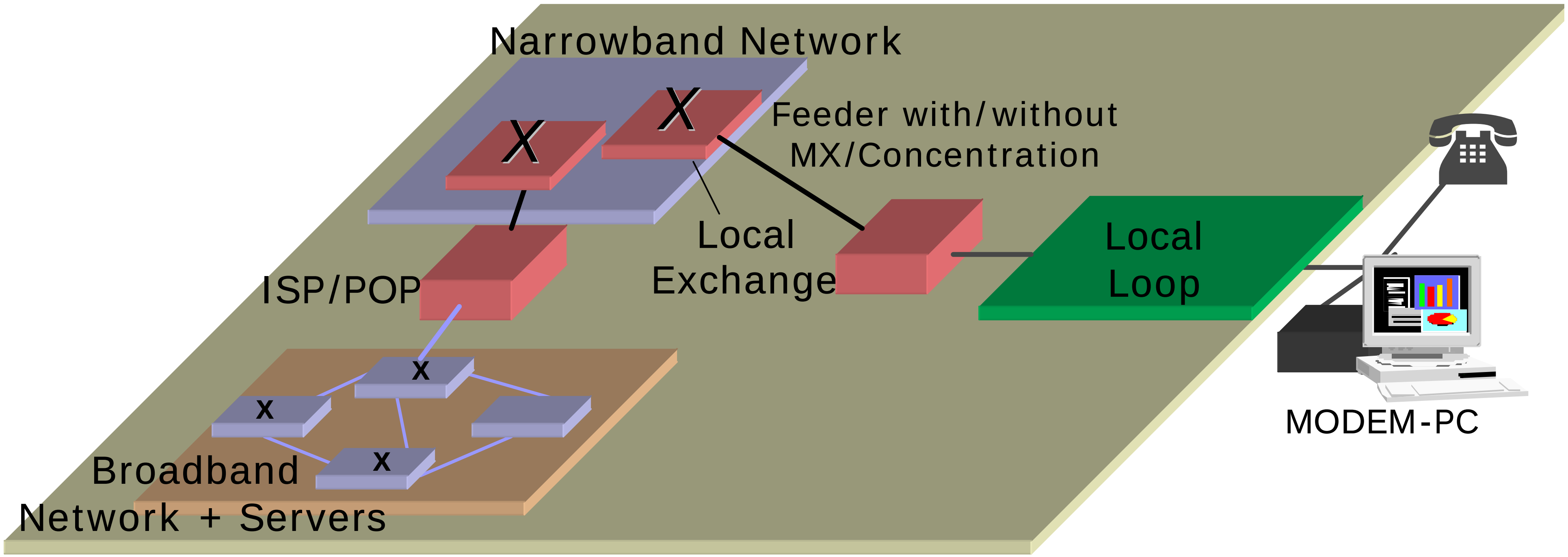
- **New technologies and regulatory conditions**
  - *xDSL and Unbundling of the local loop*
  - *LMDS and WLL frequencies allocation (e.g. for LMDS),*
  - *802.11, Wi-Fi*
  - *HFC-Hybrid Fiber Coax*
  - *FTTx, PON, Metro WDM*
  - *Next Generation SDH rings*
  - *Ethernet rings*
  - *Satellites (LEO/MEO/GEO)*
  - *3rd Generation Mobile Systems (UMTS)*
  - *Power Line Communication (PLC)*
- **Historical non competing operators would like to compete on every service on every market.**

How to take advantage of new technologies to develop new business cases: e.g. the triple play

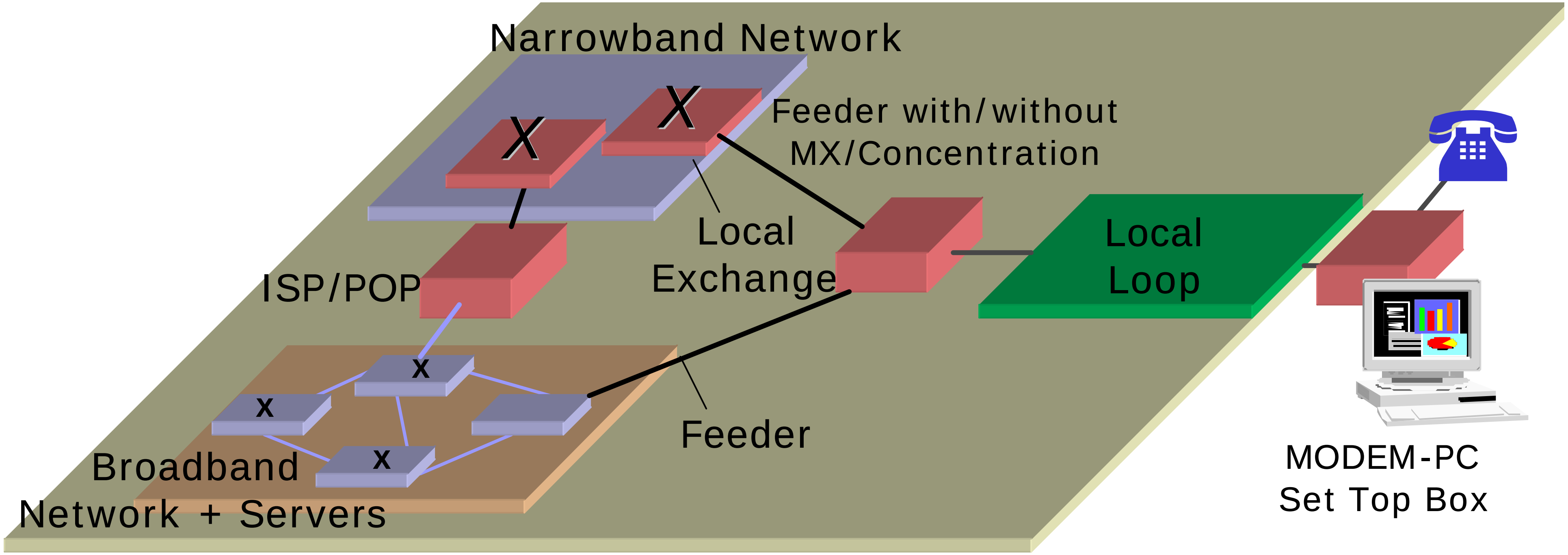
Why is the access network so critical

- **The key problem illustrated by a simple example:**
  - ***The French fixed telephony network***
    - **Around 1200 switches**
    - **Around 34 million users**
  - ***The core interconnects the switches***
  - ***The access has to reach 34 M clients !***
- **High infrastructure cost**
  - ***Important civil engineering cost***
  - ***Constraints related with this civil engineering: permission to dig, high points for antennas, etc***
- **Huge complexity of OAM, e.g. if high quality services with dynamic provisioning are provided**

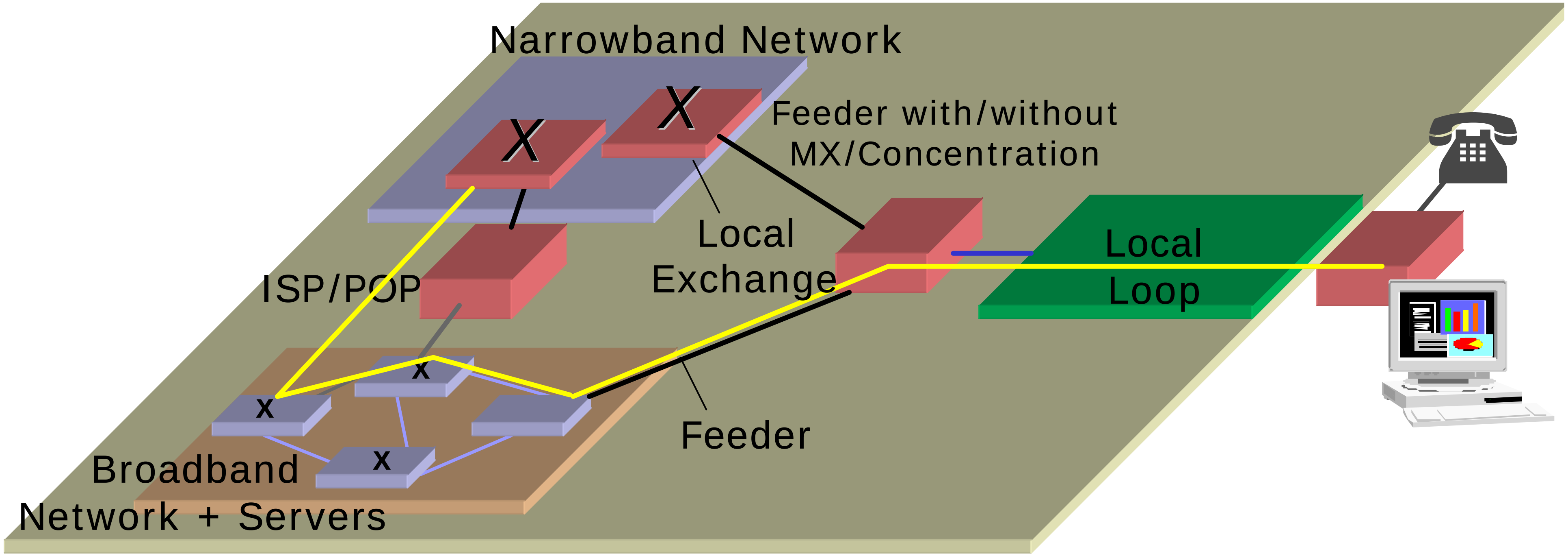
Narrowband Broadband “integration”



Narrowband Broadband "integration"

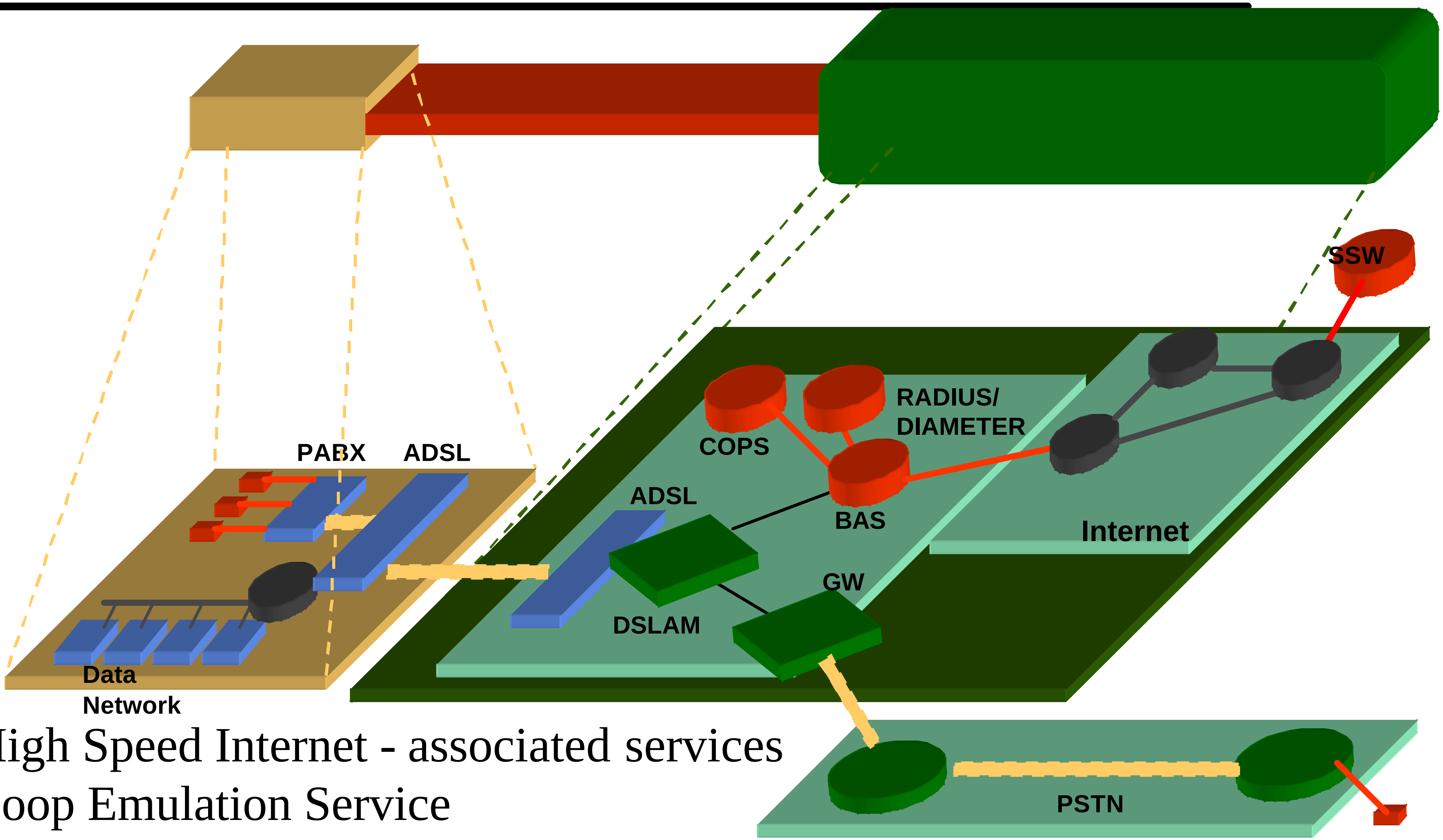


Narrowband Broadband "integration" - VoDSL



Tomorrow the Broadband Network will offer the Narrowband services

ADSL Access

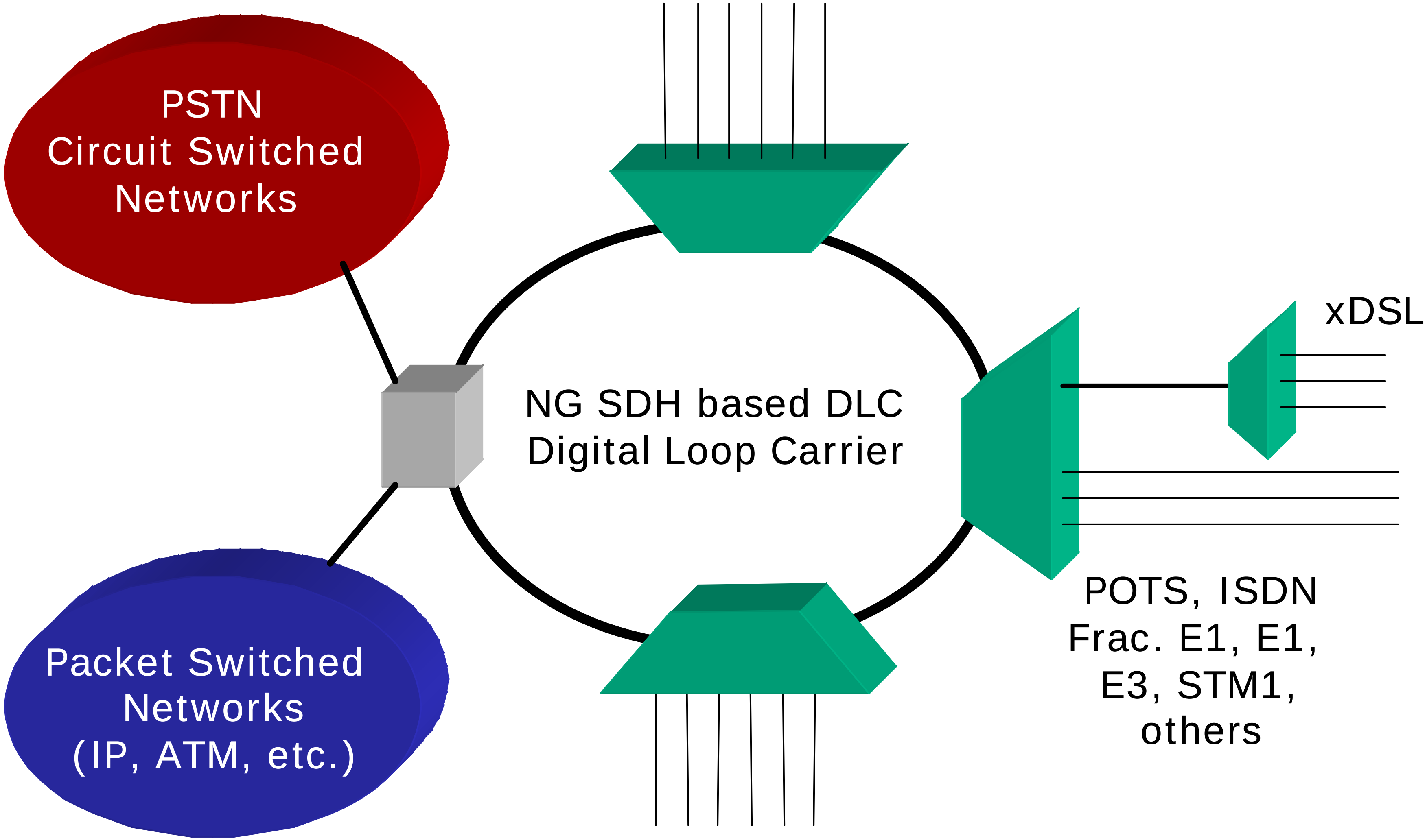


High Speed Internet - associated services

Loop Emulation Service

Leased Lines, TLS

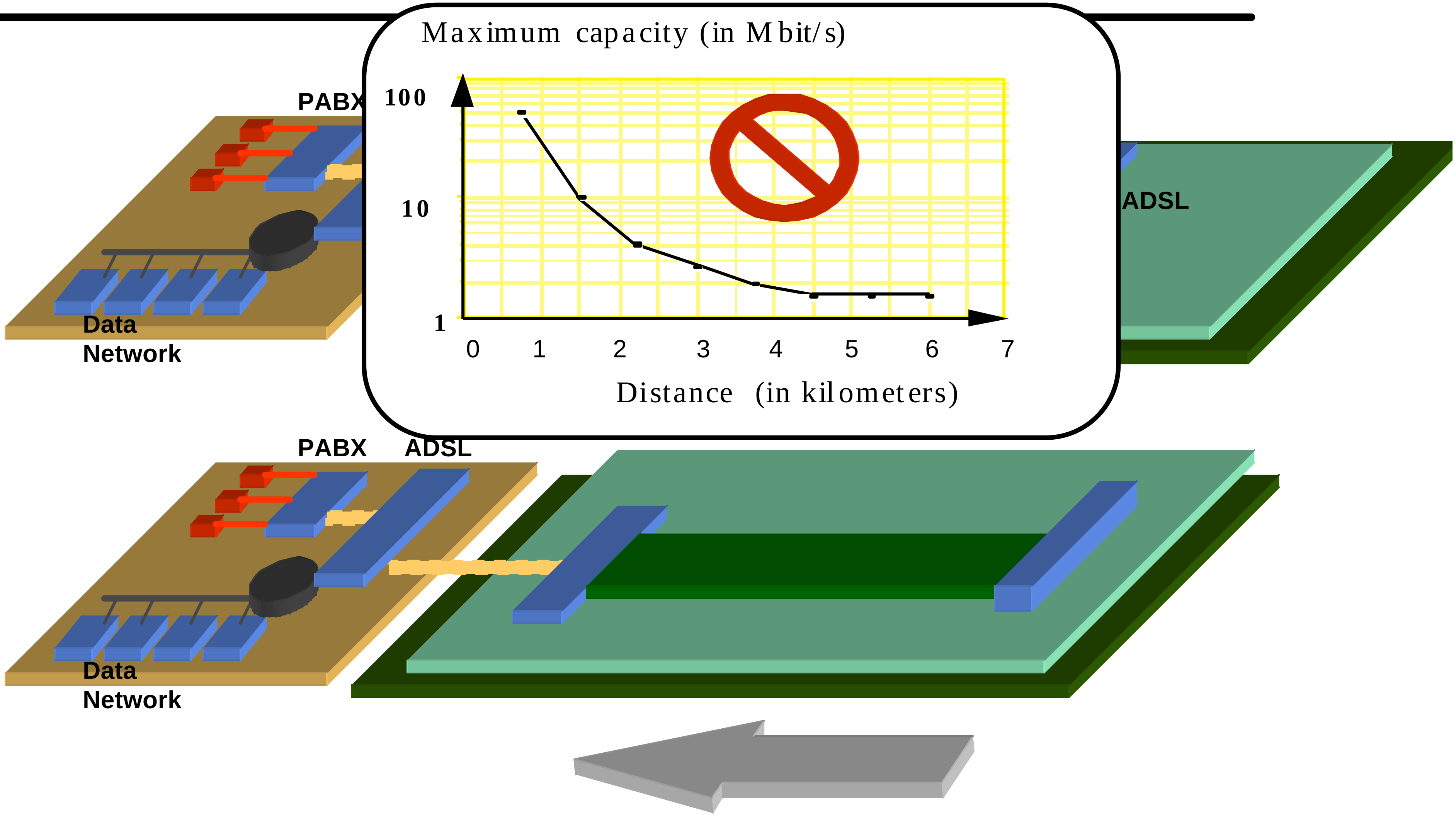
Local Loop and Broadband Services



Which choice for the DSLAM

- **Should the DSLAM integrate BAS functionalities ?**
  - ***Better distribution of the intelligence, access control, security, etc.***
  - ***Increase operation and management complexity***
- **Should the DSLAM integrate its own VoDSL functionalities?**
- **Which role for the DSLAM in the triple play architecture? Media channels control?**
- **Should the DSLAM perform ATM or Ethernet concentration?**
- **Should the DSLAM provide ATM/SDH or Ethernet uplinks ?**
- **QoS managed through bandwidth allocation (importance of ATM) or through classes of services differentiation (easier to manage through Ethernet or IP) ?**

ADSL, Constraints

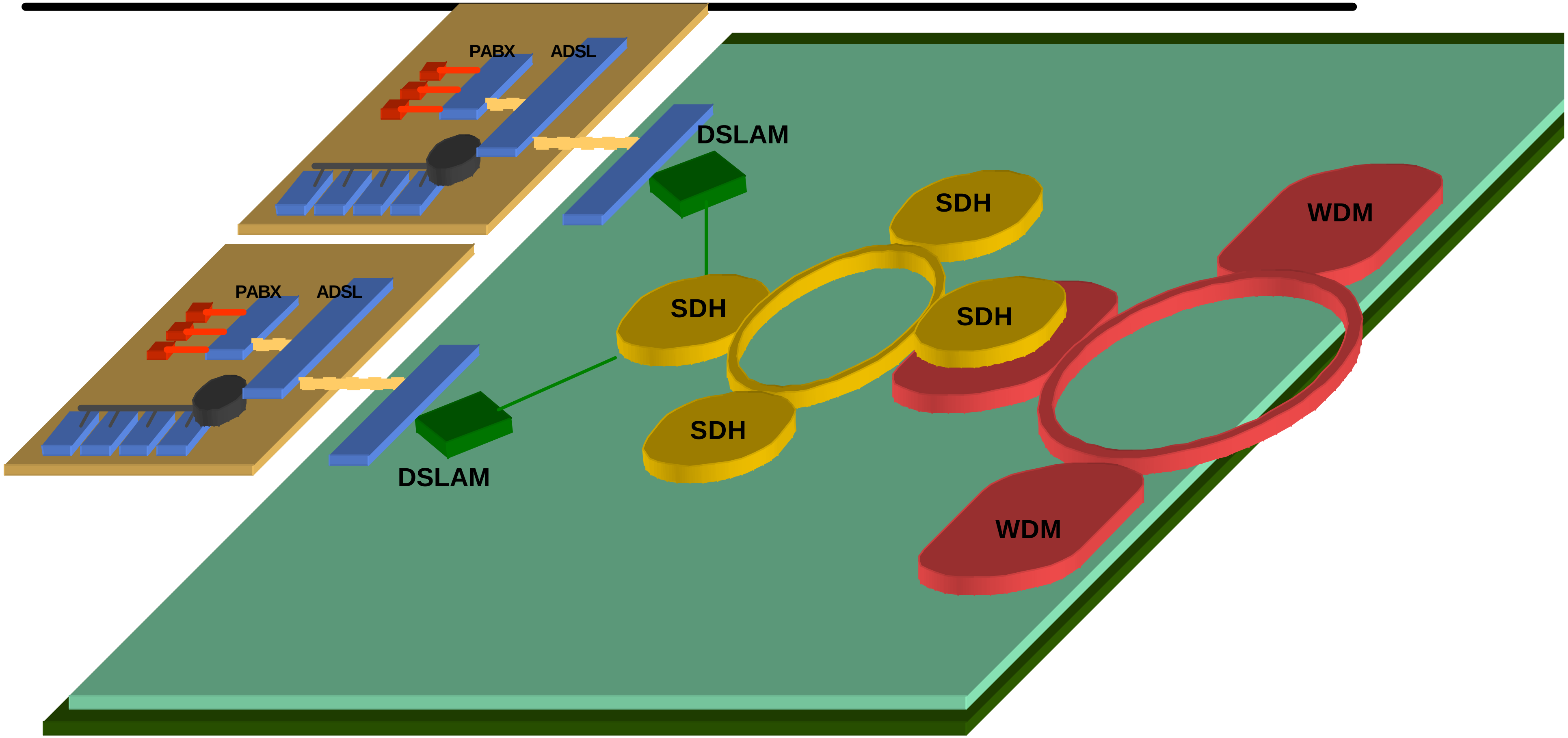


Fiber To The X, FTTx

- **X=E, Exchange**
- **X=C, Cabinet, Curb**
- **X=B, Building**
- **X=O, Office**
- **X=H, Home**

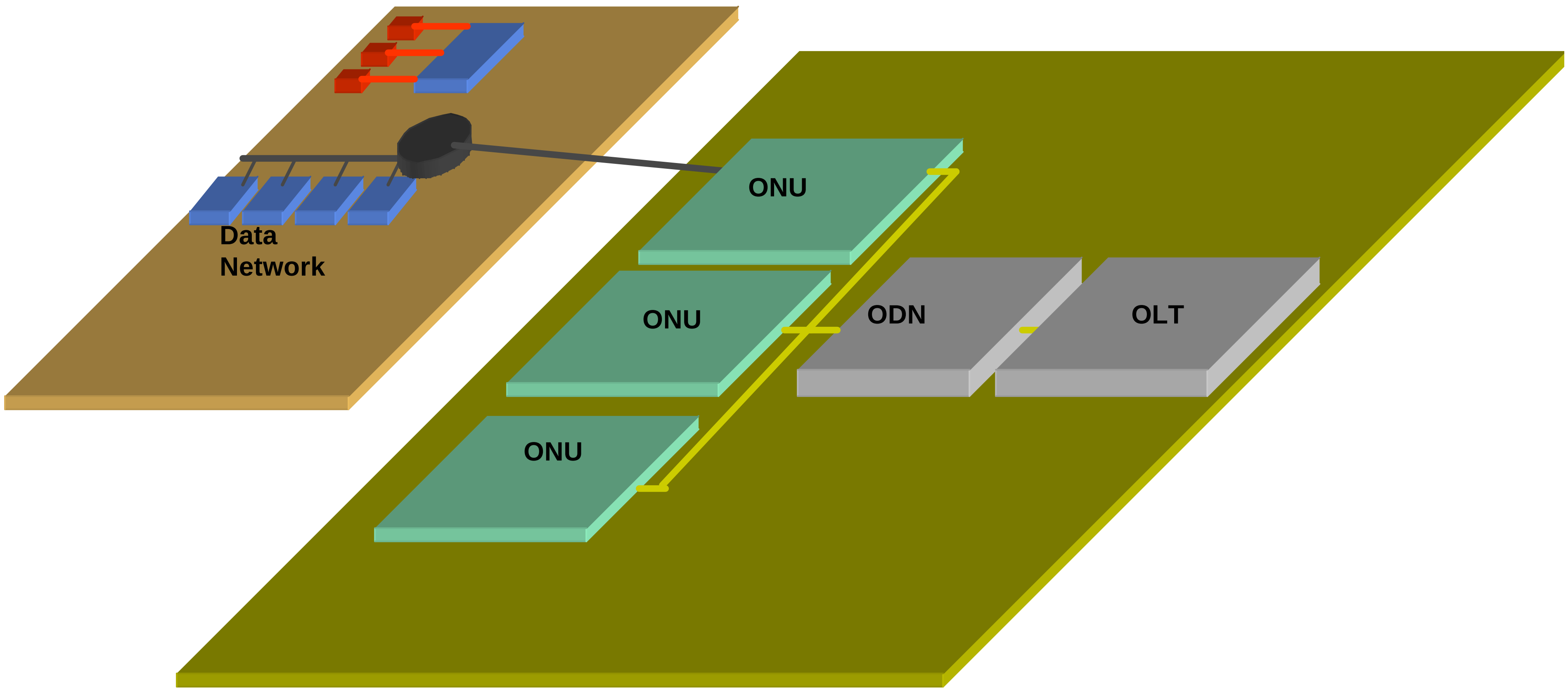
- **FTTx, x different from E**
  - ***Requires remote DSLAMs***
  - ***VDSL could be used for higher bandwidth on twisted pairs***

Metro WDM



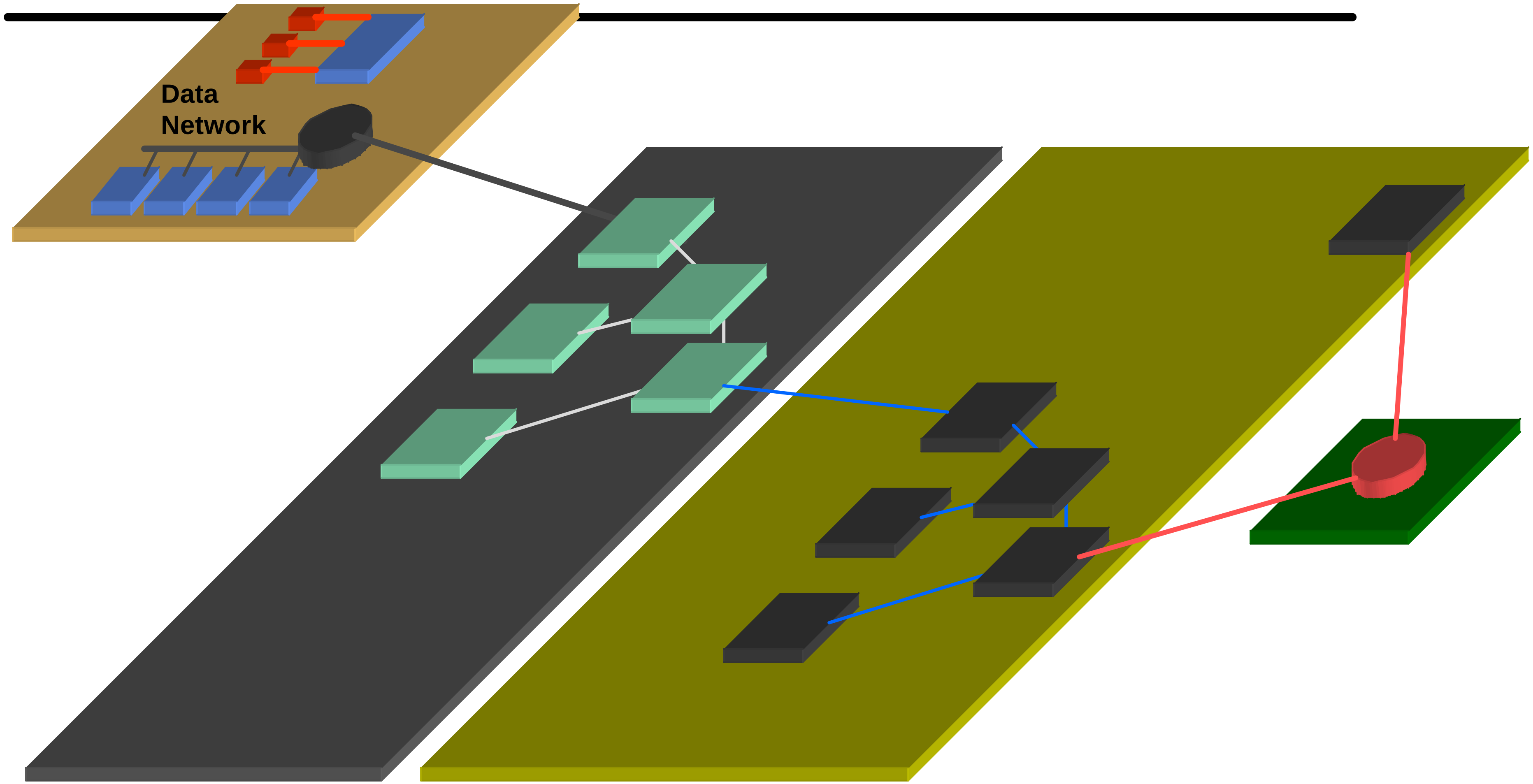
Metro DWDM could also replace SDH rings

PON : Passive Optical network

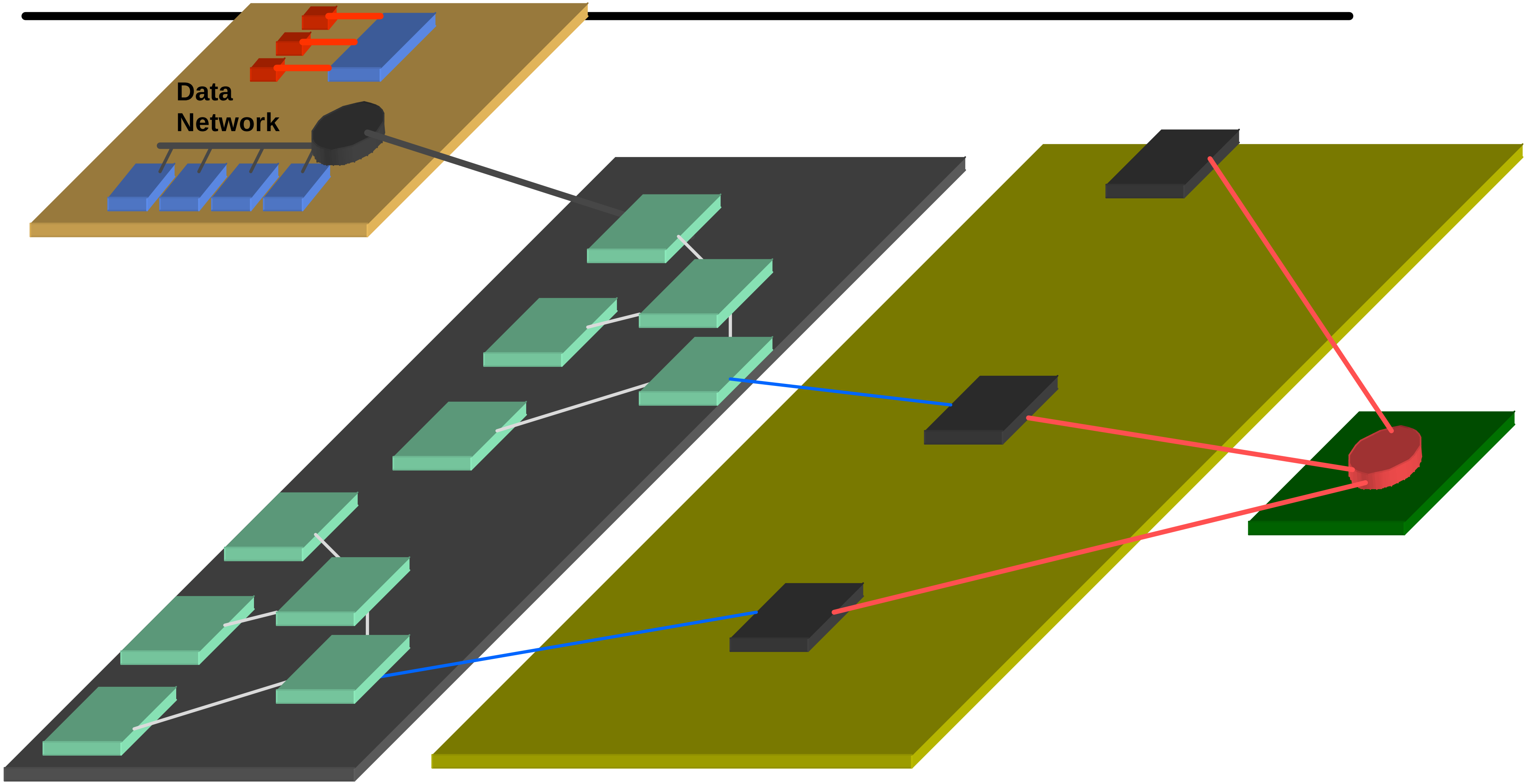


Super-PONs, 100Km range, could totally transform the network architecture by minimising the required switching equipment

The Access Network : CATV

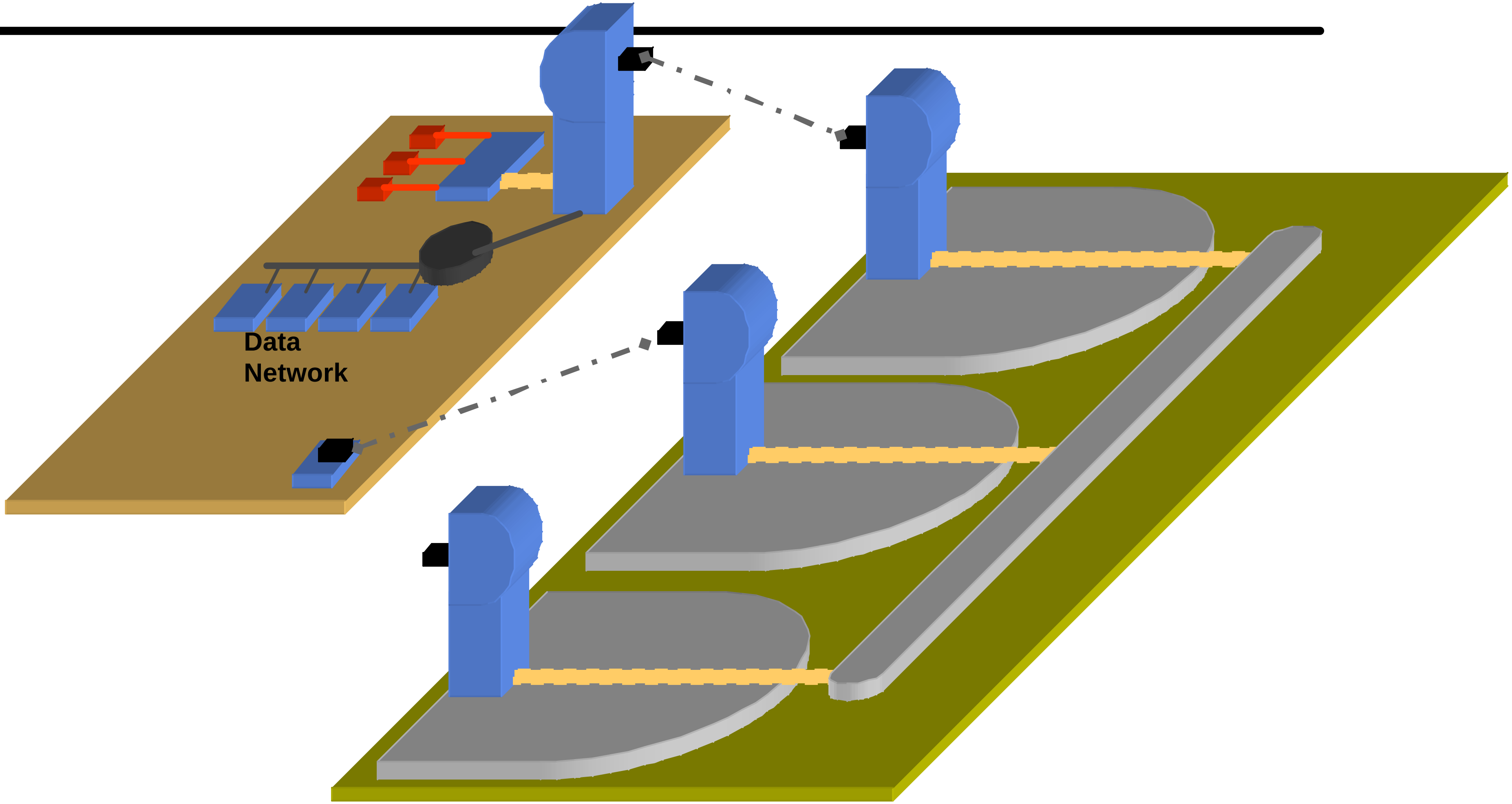


The Access Network : HFC - Hybrid Fiber Coax



DOCSIS 1,0, 1.1(QoS), 2,0
Convergence: MGCP based

The Access Network : WLL, Wire-less Loop



The Access Network : WLL, Wire-less Loop

- **Point to multipoint : 34Mbps per cell sector (e.g. LMDS)**
  - ***24 GHz or equivalent: Line of sight, high cost of CPE***
  - ***3.5 GHz: reduce bandwidth e.g. in France***
- **Which role for 802.11, Wi-Fi ?**
  - ***Security***
  - ***Bandwidth Sharing***
  - ***Operation and management***
  - ***Future Regulation ?***
  - ***Availability of frequencies (military usage in several countries)***
  - ***Planning***

A Main Challenge

Horizontal and Vertical Integration

Quality of Service, Measurements and Traffic Engineering

From concepts to a network architecture

Losses Delay

Int-Serv

Resource allocation

Policy

Diff-Serv

MPLS

COPS

Load sharing

SLA

Monitoring

Reliability - Protection

Scheduling

Dropping

IPPM

RTFM

Architecture Targets

- **To reach a good trade-off between two contradictory targets**
  - ***Provide the QoS the users are looking for (willing to pay for)***
  - ***Optimize the network resources***

- **Simplify Operation and Maintenance, reduce the OPEX**

Do we need to optimize the network?

Resources over-dimensioning

vs

Evolved Traffic Management

QoS requirements

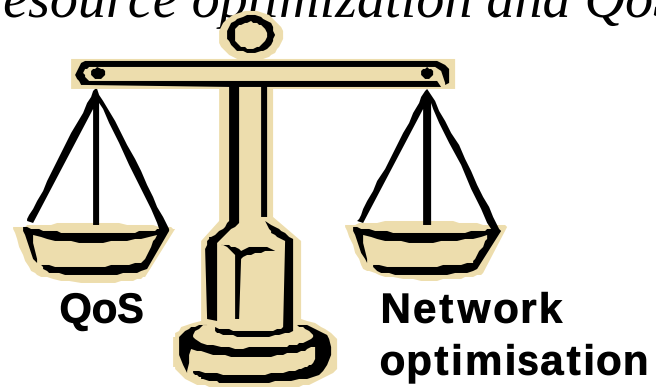
- **Streaming Flows**
  - ***Intrinsic bit rate***
  - ***Network delay and delay variation constraints***
  - ***Information lost constraints***
- **Elastic flows**
  - ***Adaptive bit rate***
  - ***No direct tight constraints on network delay***
    - **Indirect impact on available bandwidth**
  - ***Information losses can be recovered***
    - **Impact on realized bandwidth**

What is QoS?

- **Quantitatively, QoS may be evaluated by means of the following criteria (this list is not exhaustive) :**
  - ***Delay aspect :***
    - **End-to-end delay**
    - **End-to-end delay variation**
  - ***Data integrity aspect :***
    - **Packet loss ratio**
    - **Packet error ratio**
    - **Packet misinsertion rate**
  - ***Bandwidth***
  - ***Reliability and availability***

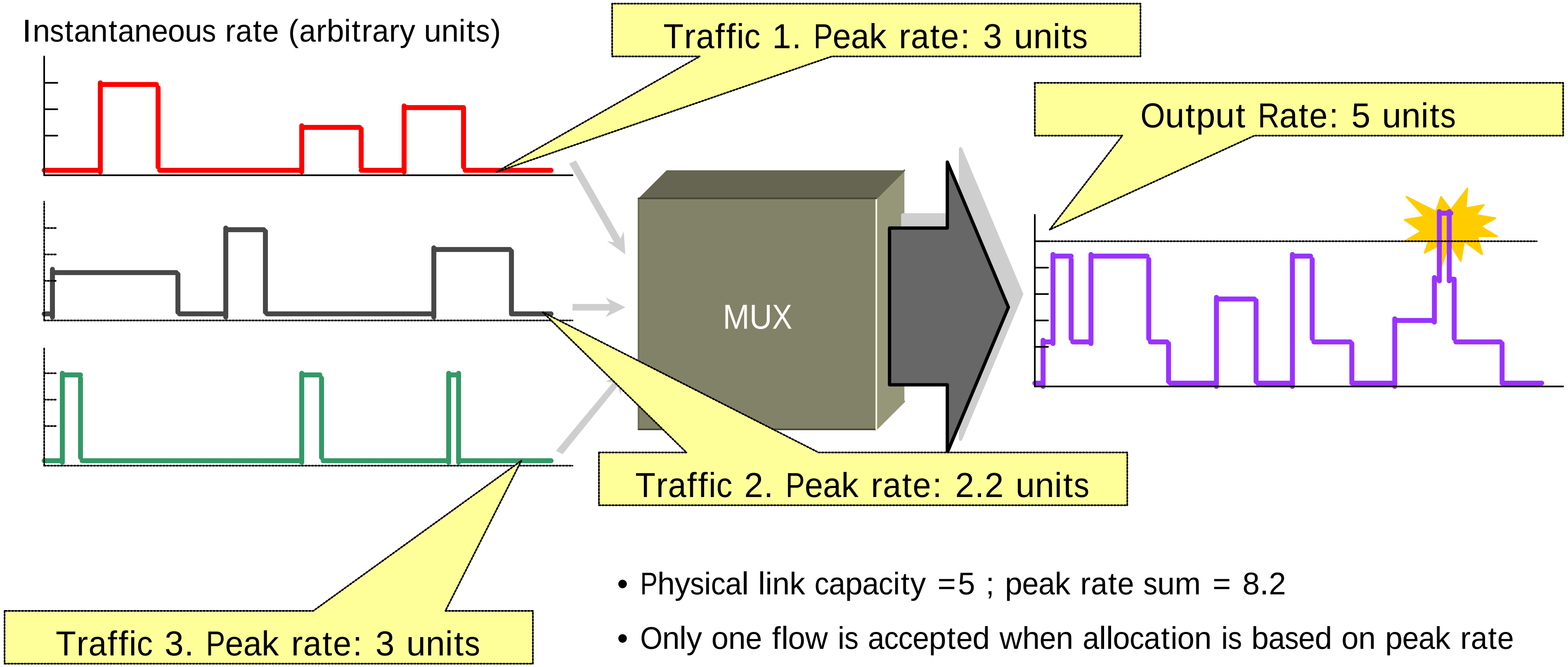
The QoS issue

- **Guaranteed QoS** implies **Resource Allocation**
- **Optimizing** the utilization of network resources implies that these **resources should be shared** between all data flows.
- Network resources **optimization** is, usually, required for a **cost reduction** purpose.
- A **tradeoff** is thus to be found between QoS and optimization of network resources.
  - *This is done through **statistical multiplexing** used with some other functionalities in order to perform resource optimization and QoS provisioning.*



Refresher: Statistical Multiplexing

Network Utilization / QoS trade-off illustrated.



- Physical link capacity =5 ; peak rate sum = 8.2
- Only one flow is accepted when allocation is based on peak rate
- All flows are accepted with dynamic allocation and statistical multiplexing

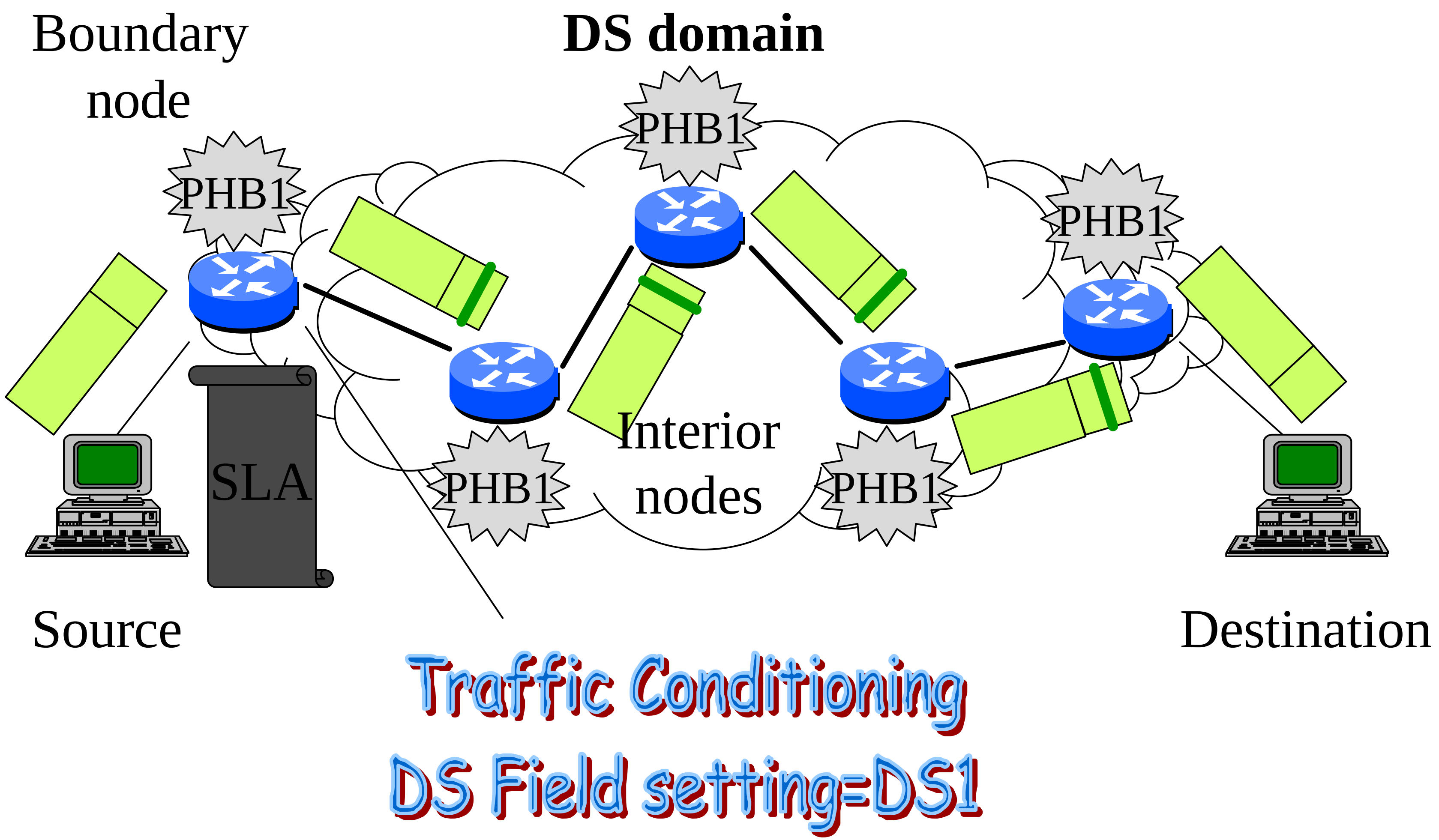
QoS provisioning : functionalities (1)

- **Reservation protocol. To signal the reservation of the necessary amount of resources (CPU, memory, bandwidth) on the data path.**
- **Admission Control. To determine for each new reservation whether it may be accepted or not according to the available resources.**
- **Policing function. To verify whether the reserved amount of resources is not exceeded by the transmitting source.**
- **Scheduling algorithms. To allocate transmission capacity in a packet by packet base in order to reach the QoS objectives of each flow.**
- **Queuing Management. To drop packets, in case of congestion, according to the priority level of the packets.**

Differentiated vs. Guaranteed QoS

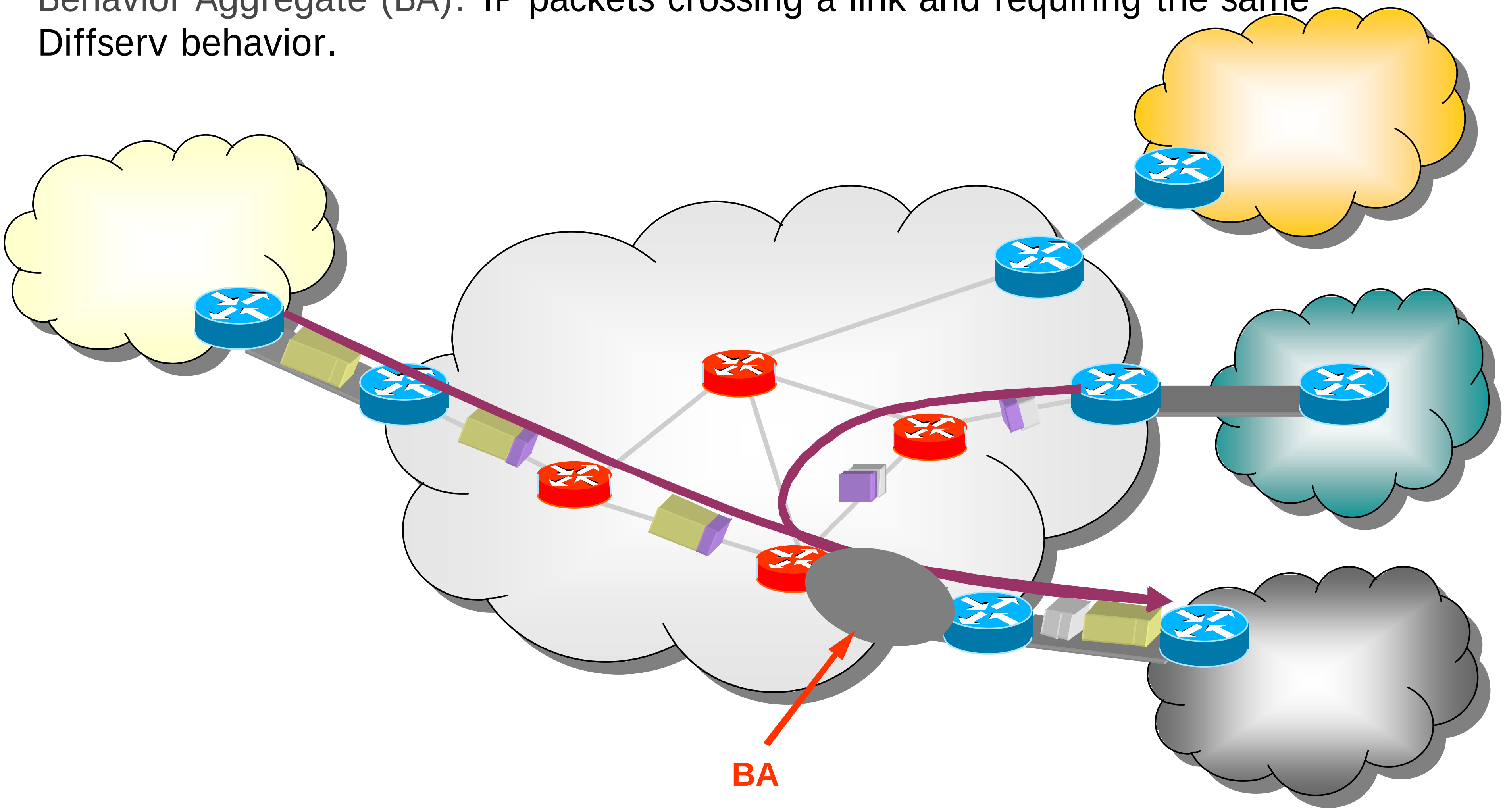
- **Guaranteed QoS needs resource reservation and the associated control functionalities.**
- **Another kind of QoS provisioning exists : Differentiated QoS.**
  - ***The flows are aggregated into traffic classes.***
  - ***No explicit values are given to the end to end QoS parameters, only "relative priorities" between traffic classes are managed in the network nodes.***
  - ***A packet of a traffic class with a higher time priority should be treated "before" a traffic with a lower time priority.***
  - ***Reject election should depend on the class loss priority.***
  - ***Being able to guarantee QoS levels require a sophisticated traffic engineering***

Diff-Serv Architecture Overview



Diff-Serv Architecture Overview

Behavior Aggregate (BA): IP packets crossing a link and requiring the same Diffserv behavior.



Differentiated vs. Guaranteed QoS (2)

- **Differentiated QoS is simpler to implement.**
- **To be supported, it needs basically**
  - ***A way to recognize the priority level of each data packet and***
  - ***Priority-oriented scheduling and queuing algorithms***
- **It is however less efficient than Guaranteed QoS in the case of congestion of higher priority resources.**
- **The amount of higher priority traffic flows should be controlled in each link in order to ensure evolved services models**
  - ***Not easy in a connection-less context***

Two Service Models at the IP level

- **Differentiated Services**
  - ***Superposition of various « Best Effort » networks over the same infrastructure***
  - ***Different QoS in each network***
  - ***No per user flow resources allocation***
  - ***Requires strong traffic engineering to sell QoS guarantees on a Diff-Serv based network***
- **Integrated Services**
  - ***Resources allocation per flow***
  - ***QoS guarantees***
  - ***Requires a signaling protocol: RSVP***
  - ***Optimization requires a QoS sensitive routing approach***

Evaluation (1)

- **The Diff-Serv architecture is relatively** straight forward **with a number of building blocks (PHBs) allowing to construct a wide variety of differentiated services**
- **Some** complexity **remains however concerning**
  - ***The implementation of*** *traffic conditioners* ***at boundary nodes***
  - ***The choice and configuration of*** *scheduling* ***algorithms at interior nodes***
- **The Diff-Serv approach for the provision of QoS for IP traffic could be seen as a** concurrent method **to other approaches such as**
  - ***Int-serv/RSVP***
  - ***MPLS***
  - ***Legacy relative priority marking (IP Precedence Field)***

Evaluation (2)

- **Diff-Serv is**
  - ***More scalable* than Int-Serv/RSVP although less granular**
  - ***Simpler* migration process than MPLS, that is Diff-Serv has less requirements on the hardware of network nodes**
  - ***An enhanced extension to legacy priority/service marking approaches already in use in some parts of the Internet***
- **Diff-Serv may also be complementary with other architectures:**
  - ***Diff-Serv may be used to aggregate Int-Serv/RSVP flows in the core of the network***
  - ***Diff-Serv may use MPLS as an alternative technology where a BA may be mapped to a given label-switched path across the network***

Measurement based Traffic Engineering

Measure and verification of the QoS

- **For the operator**
  - *Network engineering*
    - **To reach a good tradeoff between QoS and resources utilization (e.g. overbooking coefficient).**
    - **Analysis of traffic structure and dimensioning**
  - *Verification that the SLAs are respected*
  - *Evaluation of new technologies, algorithms and equipment.*
  - *Better comprehension of protocols behaviors.*
  - *Billing*
  - *Validate network models used for dimensioning and planing*
  - *Early detection of attacks*
- **For the clients**
  - *Verification of the SLAs*
  - *Benchmark of different operators and service providers*
  - *Dynamic Adaptation of applications*

Types of measures

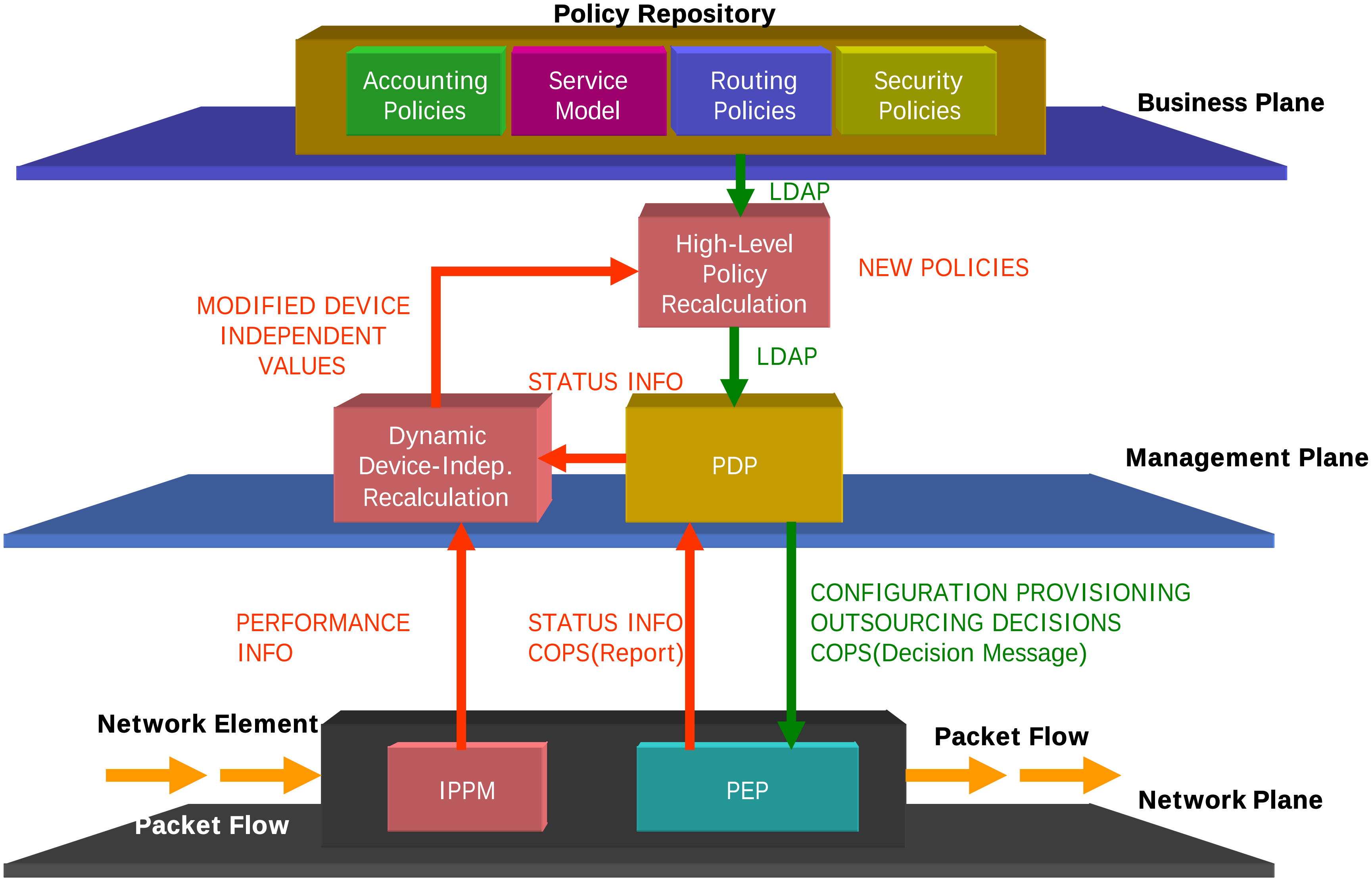
- **Passives**
  - ***Network devices "listen" to packet flows.***
  - ***e.g. "Real Time Flow Measurements" IETF W.G. (RTFM)***

- **Actives**
  - ***Network devices send "packet probes"***
  - ***e.g. "Internet Protocol Performance Metrics" W.G. - IPPM)***

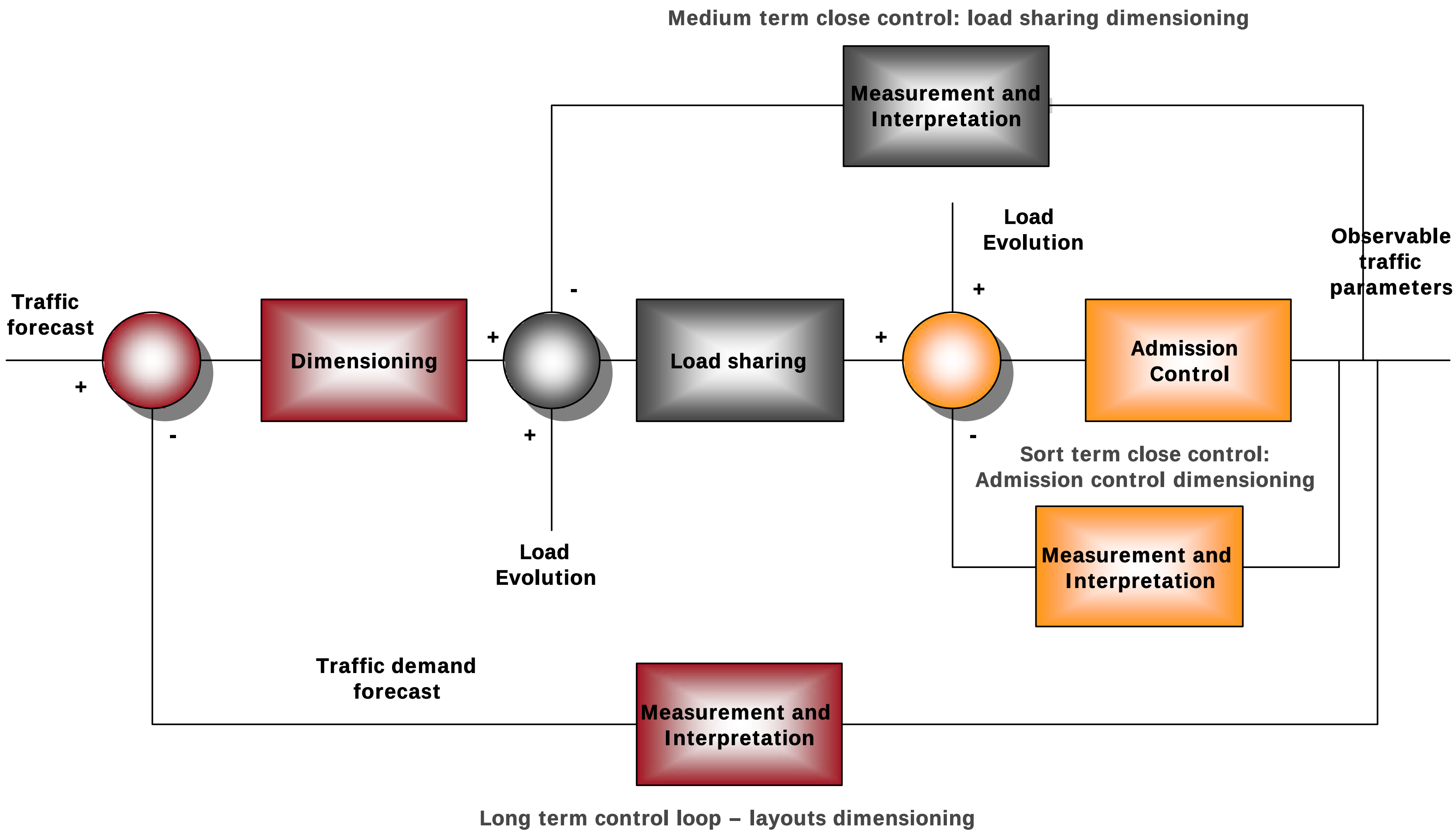
Some open problems

- **Flow classification**
  - ***Per application protocol, per transport protocol, etc.***
  - ***Identification trunks***
- **Sampling**
  - ***Spatial***
  - ***Temporal (Deterministic, Poisson, other ?)***
  - ***Packet Based / Flow Based / Class Based?***
  - ***Tradeoff between the preciseness of the measure and the resources consumed to do it.***
  - ***Minimize the impact on the user traffic***
- **Modeling**
  - ***Reference to interpret the measures***

Closed Loop Network Operation



Close Loop Control for Traffic Engineering



New results and ongoing research on:

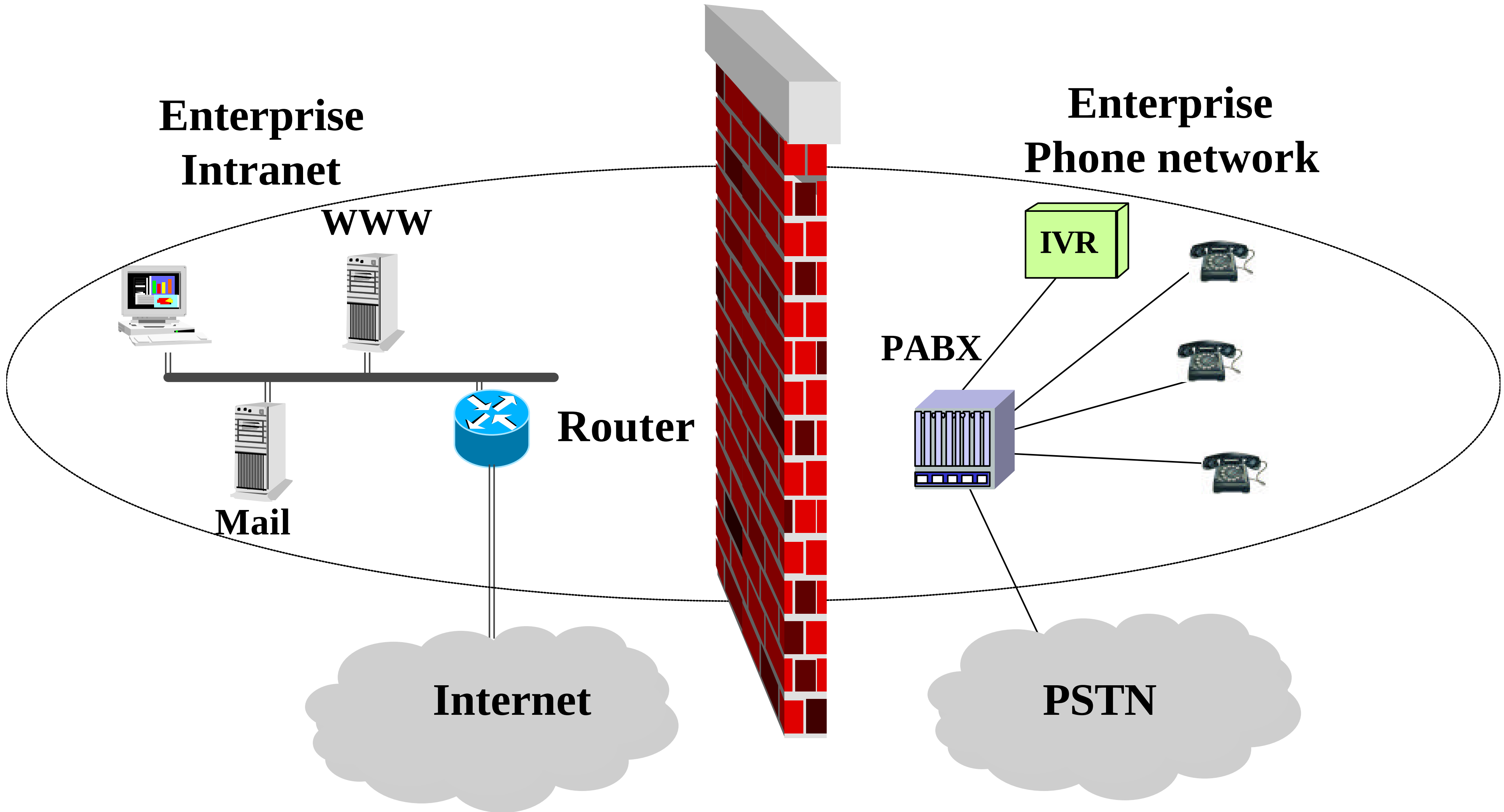
- **Admission control for TCP flows**
  - ***Delaying TCP flows transmission enhance the overall performances***
  - ***Admission control for UDP flows will become mandatory as the percentage of UDP flows increase***
- **Load sharing**
  - ***MPLS allows for resources optimization by means of flexible load sharing***
  - ***Avoidance of well known QoS sensitive routing and load sharing in legacy IP networks***
- **Layout optimizations based on realistic cost functions considering network's OPEX**

Voice and Telephony over IP

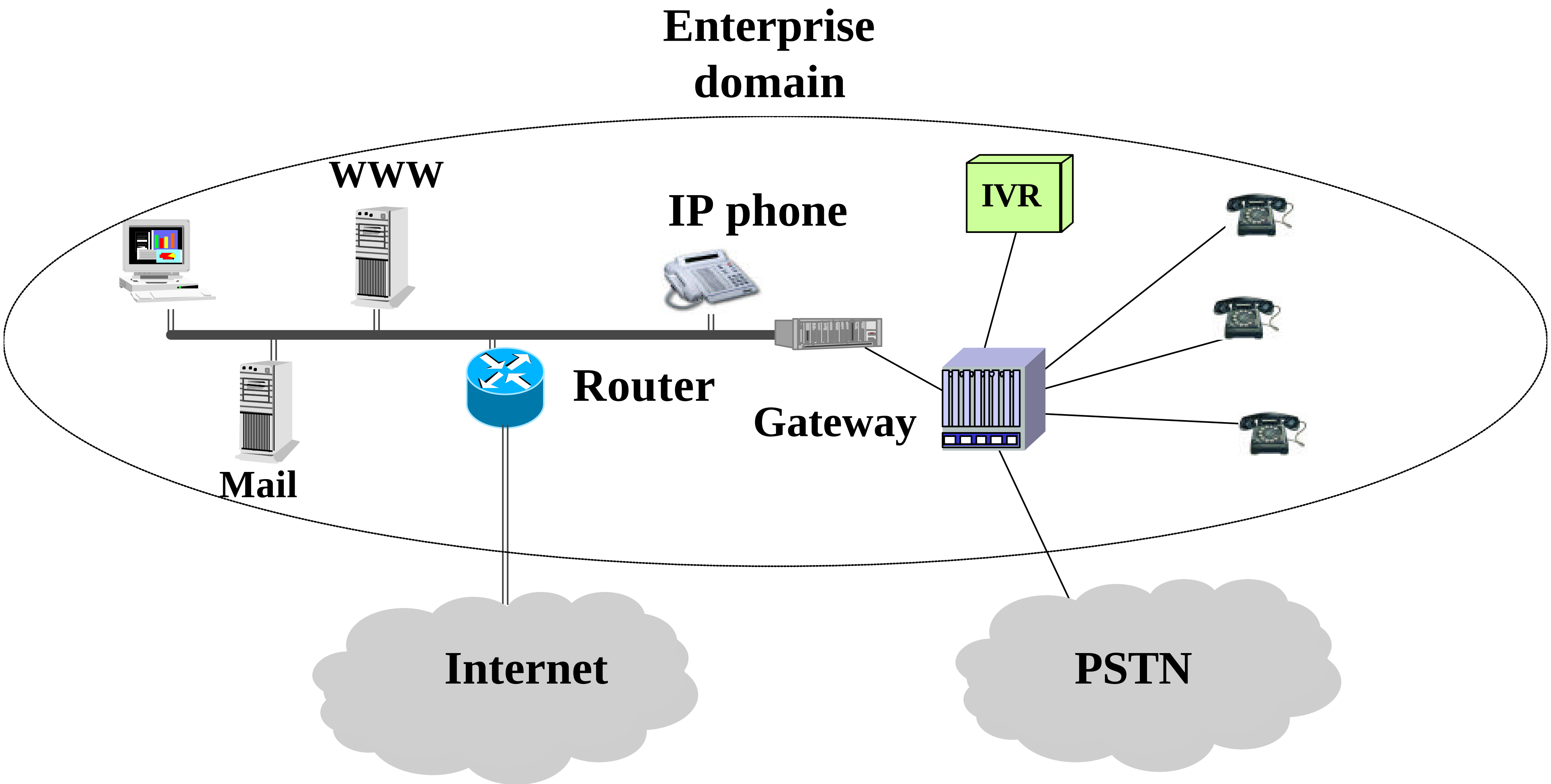
Markets and applications examples

- **Telephony to the terminal:**
  - ***Voice and data teleworking***
  - ***Home services simultaneity***
  - ***CTI***
  - ***Multimedia***
  - ***Web Call Centers***
  - ***PBX-IP, IPBX, IP Centrex***
- **Telephony in the Intranet and extranet:**
  - ***PABX interconnection***
- **Telephony in the backbone**
  - ***International Telephony***
  - ***Evolution of PSTN backbone***
  - ***Service integration in the access***
  - ***New operators***

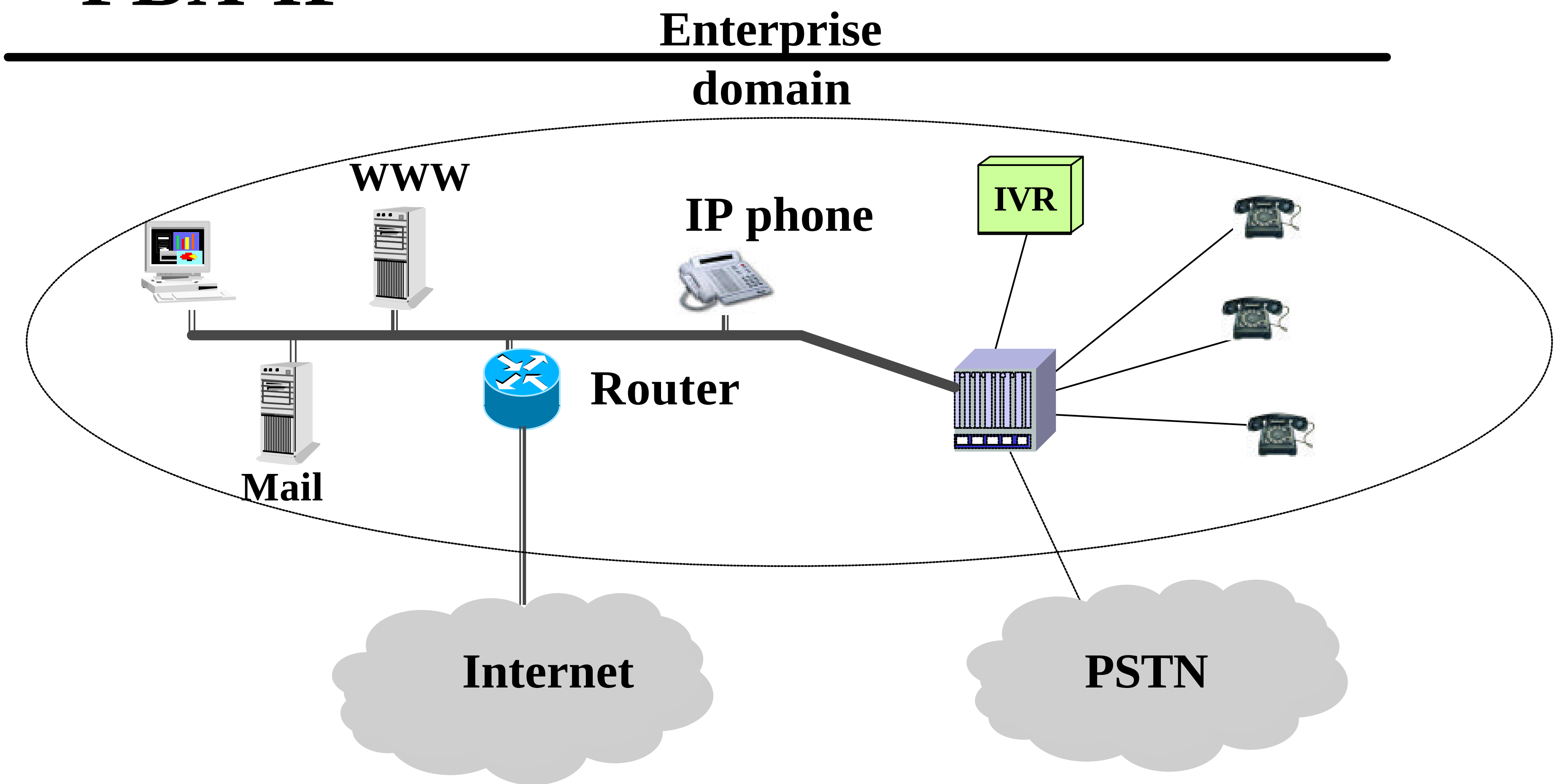
Telecom/ Datacom separation



Telephony service interworking: gateway



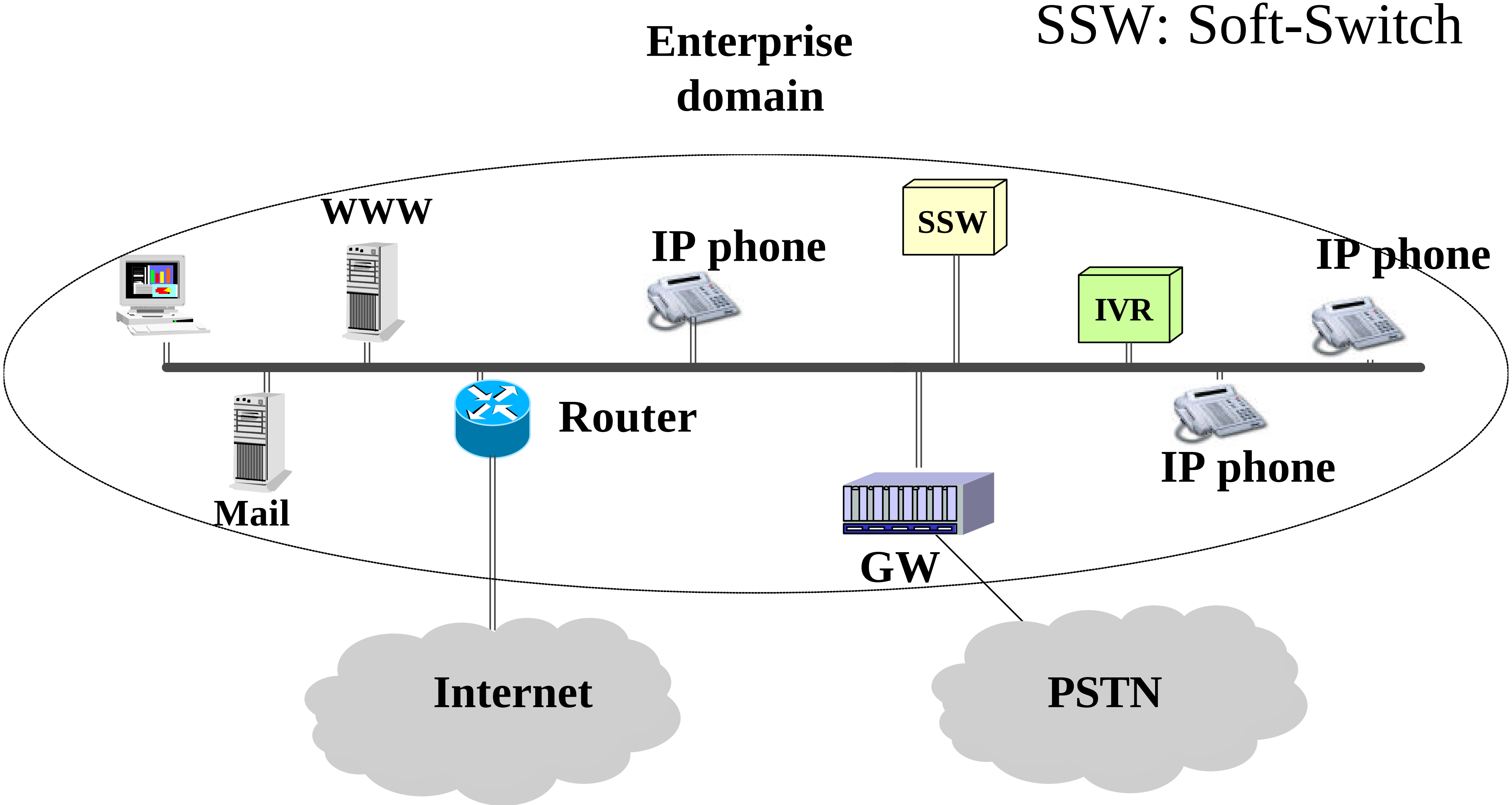
Telephony service interworking : PBX-IP



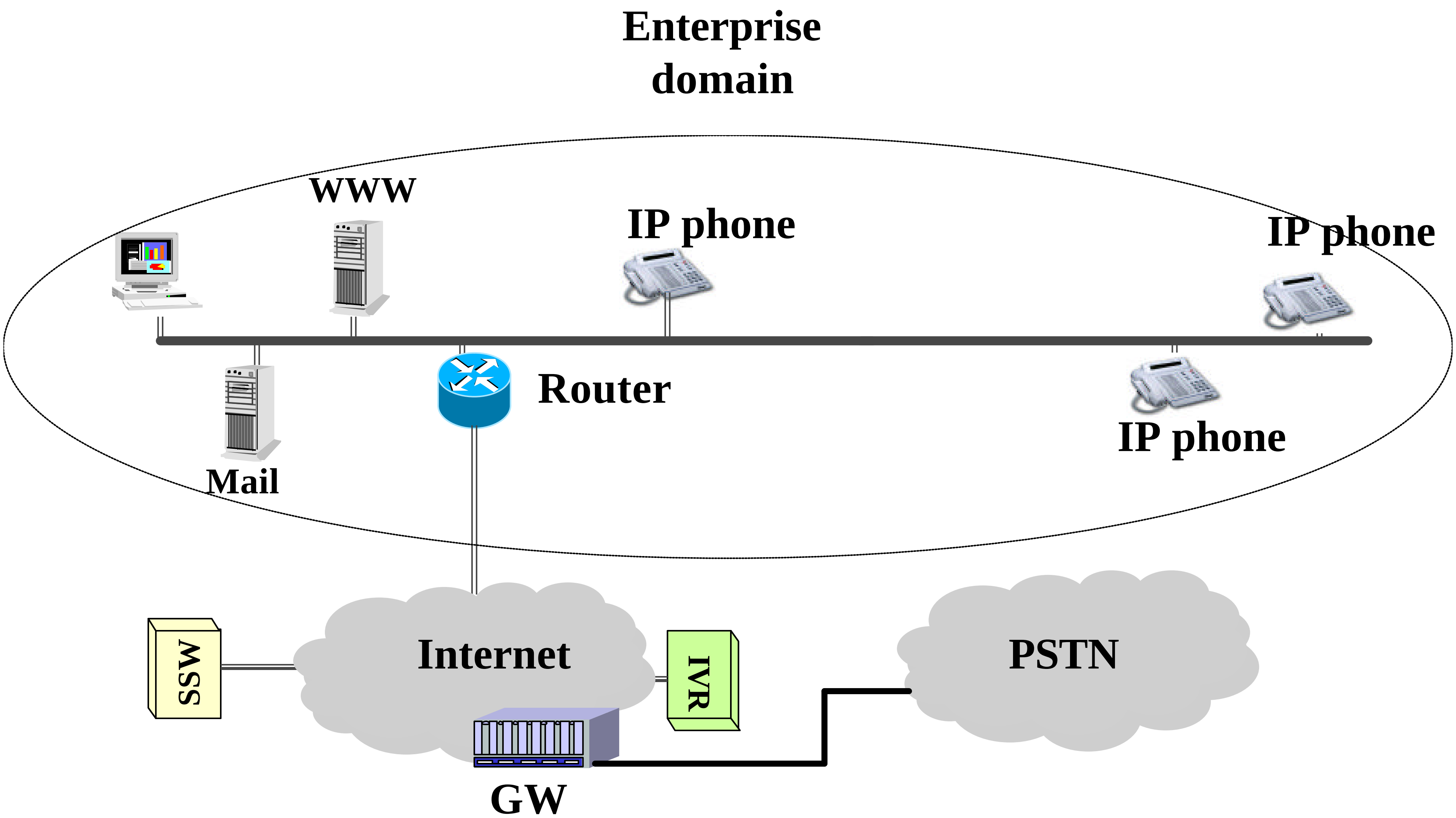
- IP telephony and legacy telephony interworking
- Web based control of PABX functionalities
- Control of telephony services: PINT

The IPBX concept

SSW: Soft-Switch



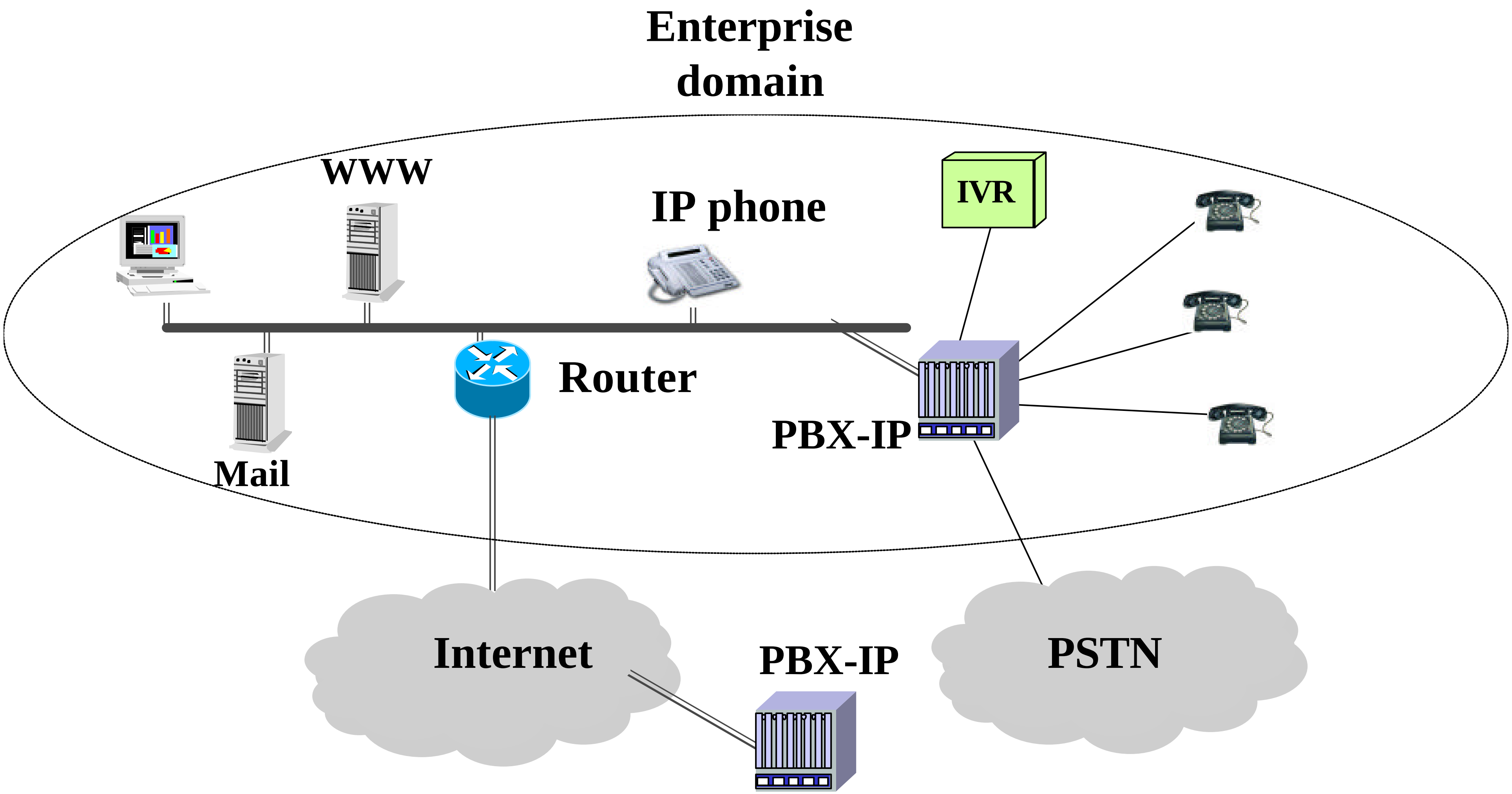
The IP Centrex concept: ASP approach



Markets and applications examples

- **Telephony to the terminal:**
  - *Voice and data teleworking*
  - *Home services simultaneity*
  - *PBX-IP, IPBX, IP Centrex*
  - *CTI*
  - *Multimedia*
  - *Web Call Centers*
- **Telephony in the Intranet and extranet:**
  - *PABX interconnection*
- **Telephony in the backbone**
  - *International Telephony*
  - *Evolution of PSTN backbone*
  - *Service integration in the access*
  - *New operators*

The PBX-IP concept and telephony VPNs



Telephony VPN over IP (From level 2 to level 3 VPNs)

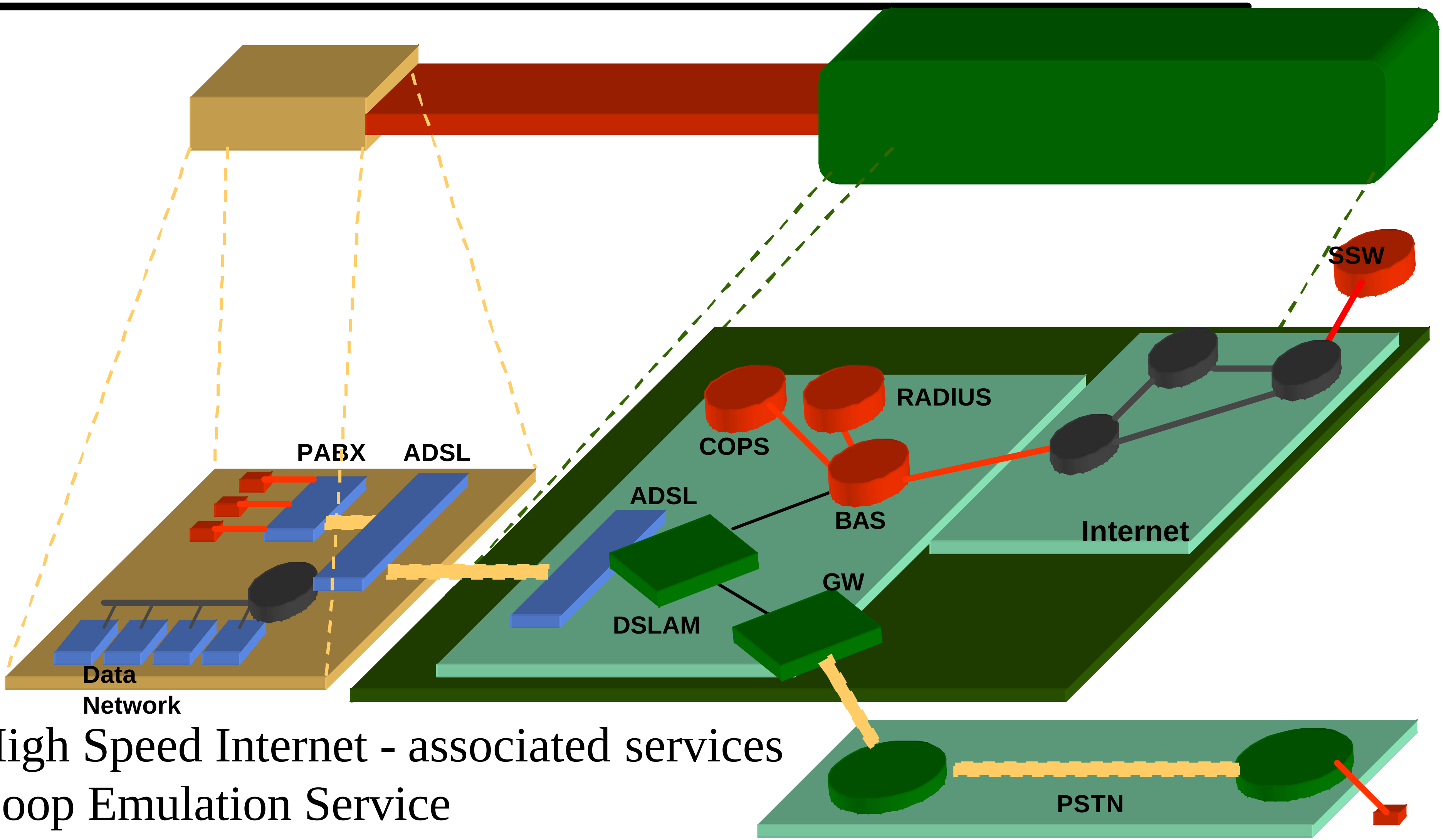
Markets and applications examples

- **Telephony to the terminal:**
  - ***Voice and data teleworking***
  - ***Home services simultaneity***
  - ***PBX-IP, IPBX, IP Centrex***
  - ***CTI***
  - ***Multimedia***
  - ***Web Call Centers***
- **Telephony in the Intranet and extranet**
  - ***PABX interconnection***
- **Telephony in the Telecom Operator**
  - ***International Telephony***
  - ***Evolution of PSTN backbone***
  - ***Service integration in the access***
  - ***New operators***

Telecom operators

- **International traffic**
  - ***Reduce the cost of terminating calls***
- **National traffic**
  - ***Opportunity for CLECs***
  - ***Could reduce the cost of dealing with traffic growing, the market is not clear today***
- **Access networks**
  - ***IP based VoDSL, VoWLL, VoHFC (cable networks), etc.***
- **Others**

ADSL Access



High Speed Internet - associated services

Loop Emulation Service

Leased Lines, TLS

VToIP genesis: Historical perspective

- **197x: first audio transmission over packet networks**
- **1992: Release of LBNL « vat » tool (IP based)**
- **1995: RTP standardized**
- **Dec. 1995: presentation of Vocaltec's Internet Phone**
- **Mid 1996: more than 30 PC-to-PC telephony products available**
- **May 1996: H323.1 ratification by the ITU-T**
- **June 1996: Release of free software by Microsoft (Netmeeting), Intel (Internet Phone) and Netscape (CoolTalk)**

A lot has happened since then…

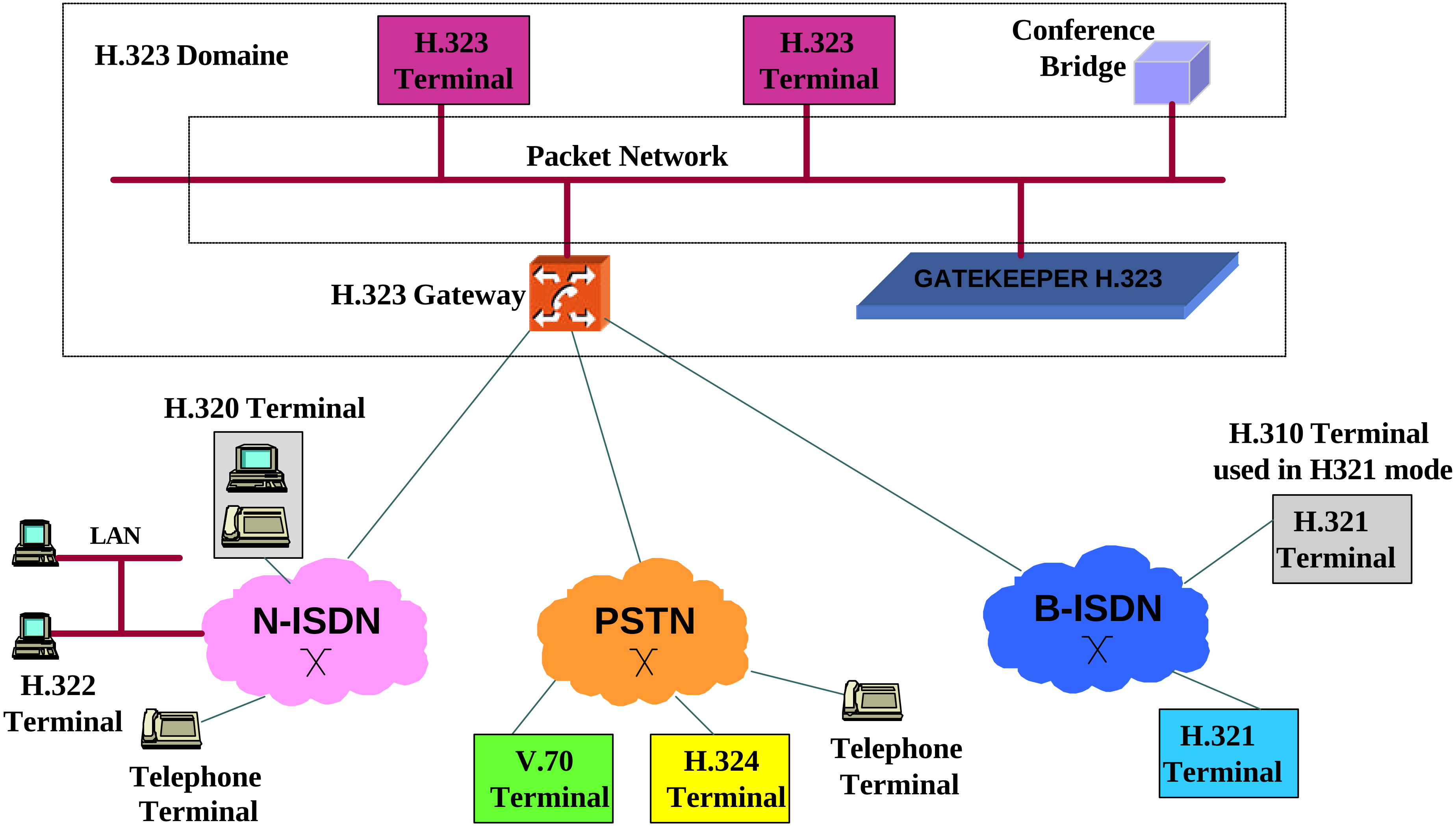
ITU-T H.32x history

- 1990: multimedia over N-ISDN (H.320)
- 1995: multimedia over B-ISDN and ATM (H.321)
- June 1996: H.323v1 approved by ITU-T Study Group 15 for packet-based multimedia communications systems
- February 1998: H.323v2 approved
- February 1999: H.323v3 approved
- November 2000: H.323v4 approved

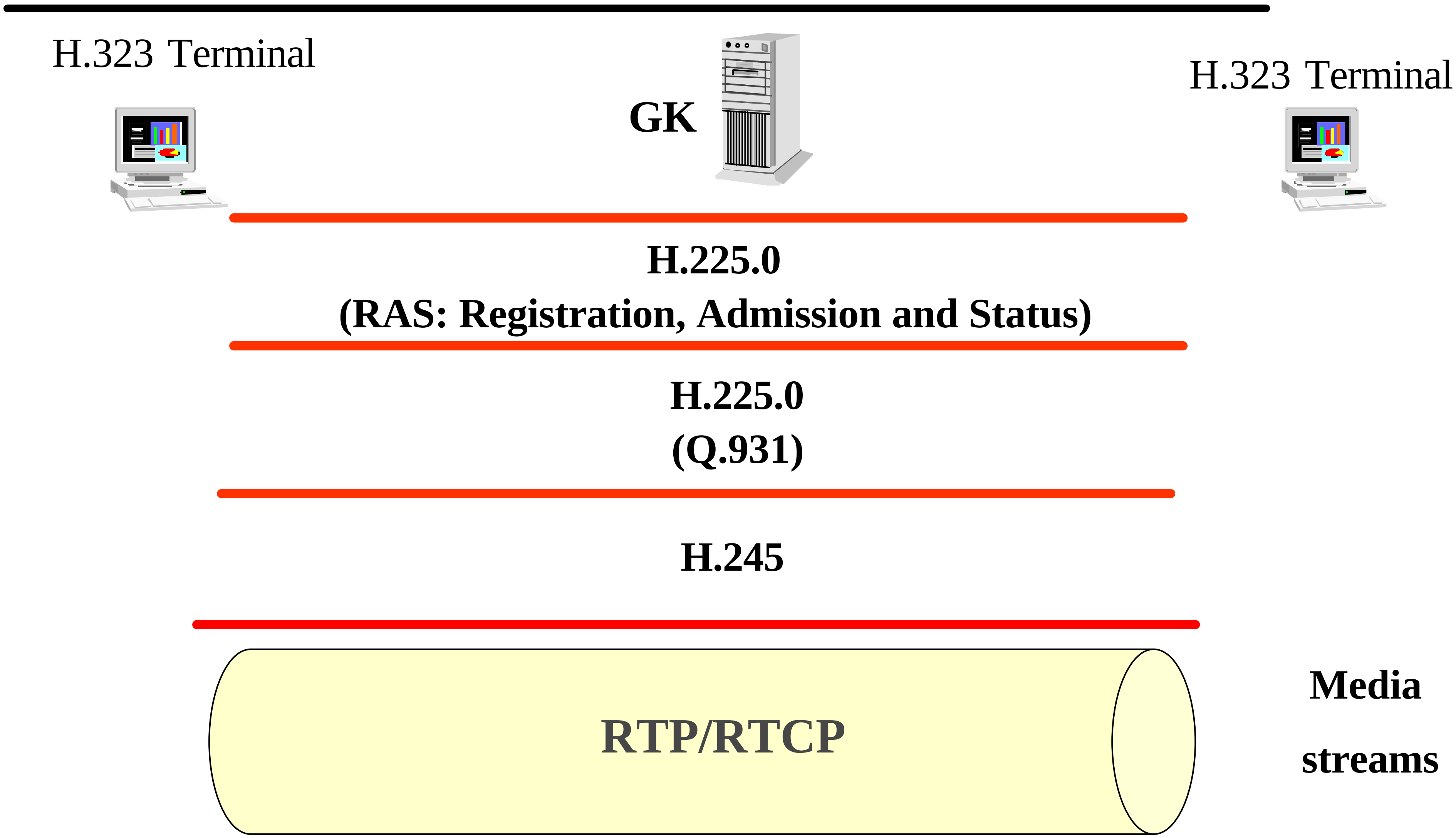
The H.323 architecture and its components

Standard ITU-T « Packet Based Multimedia Communications »	
H.323	Global architecture Defines H.323 “entities”: Terminal, Gatekeeper, Gateway, MCU
H.225.0	Call signalling Packetization (RTP/RTCP)
H.245	Call Control Signalling
H.235	Security, cryptography
H.450.X	Optional Services
G.711 GSM G.729 ...	Audio Video Coding

H.323 functional architecture

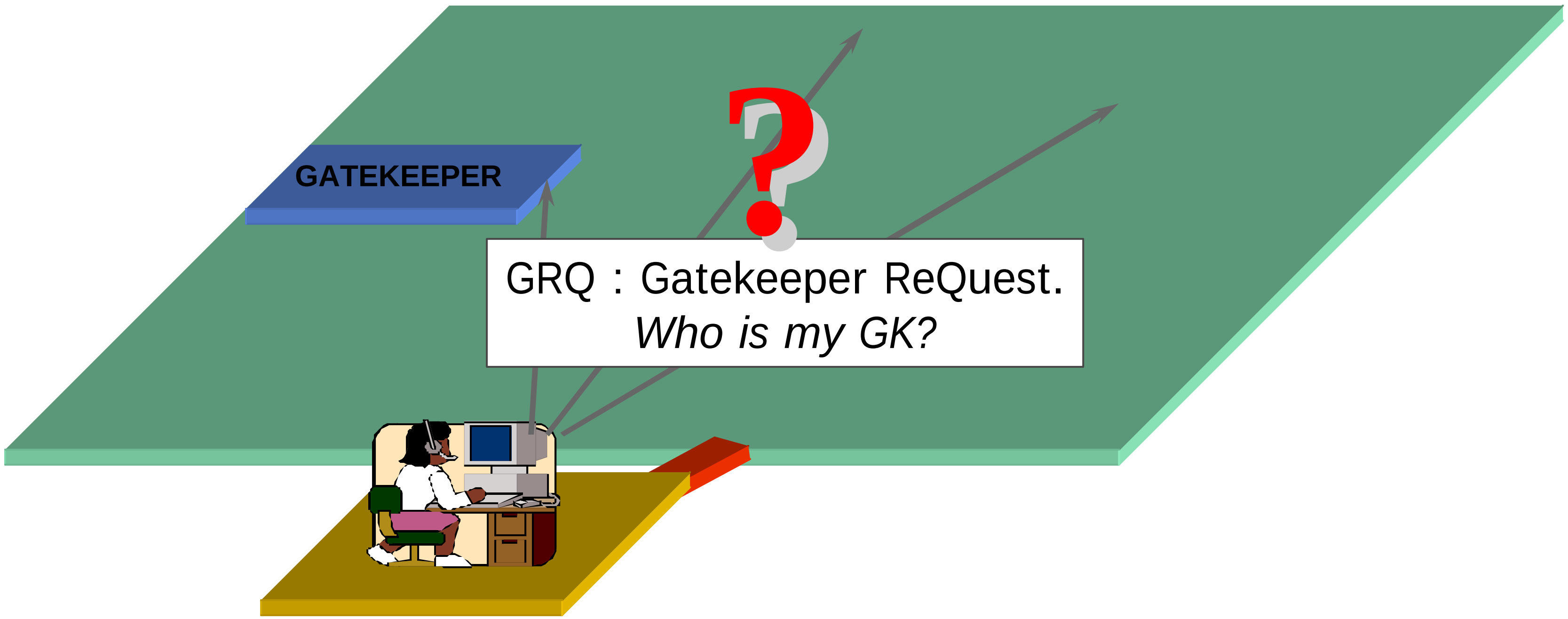


H.323 Basic Call Overview



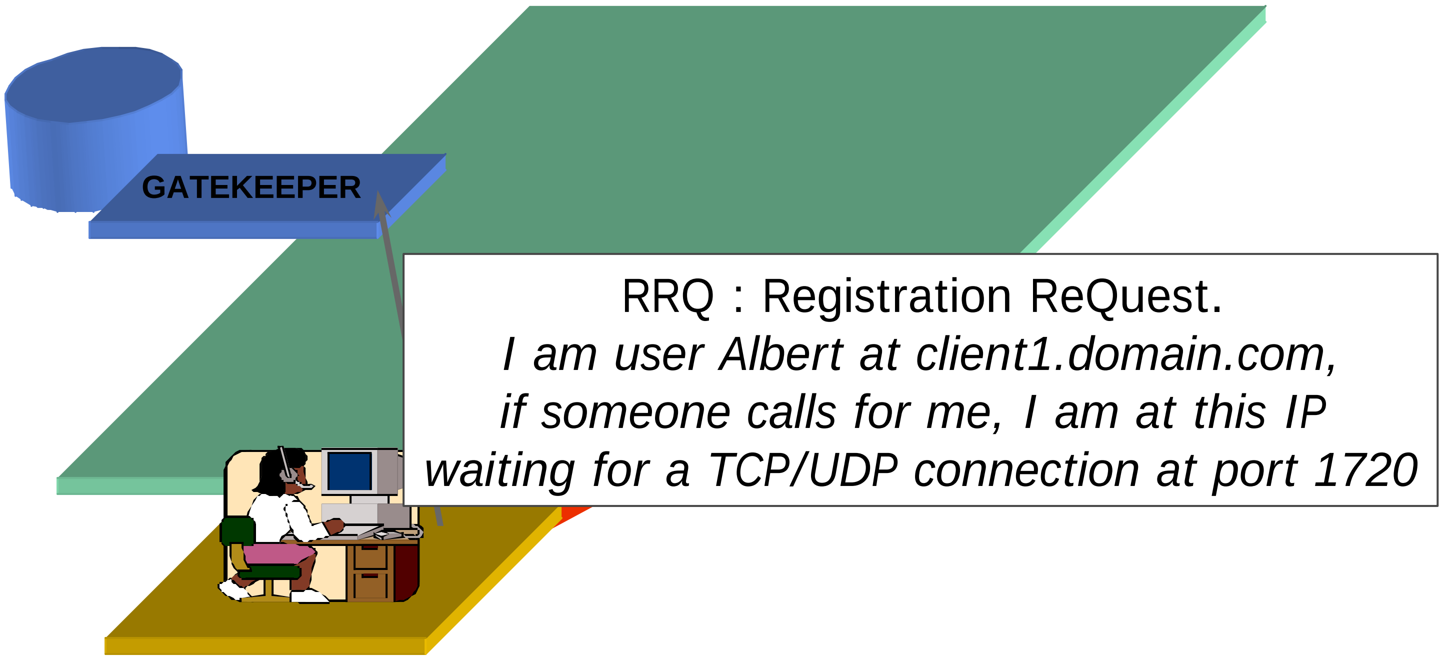
RAS Signaling : Getting the GK IP address

- Method 1: Manually configured.
- Method 2: Get the GK IP address using DNS extensions (Ressource Record)
- Method 3: Gatekeeper Discovery: GRQ/GCF/GRJ



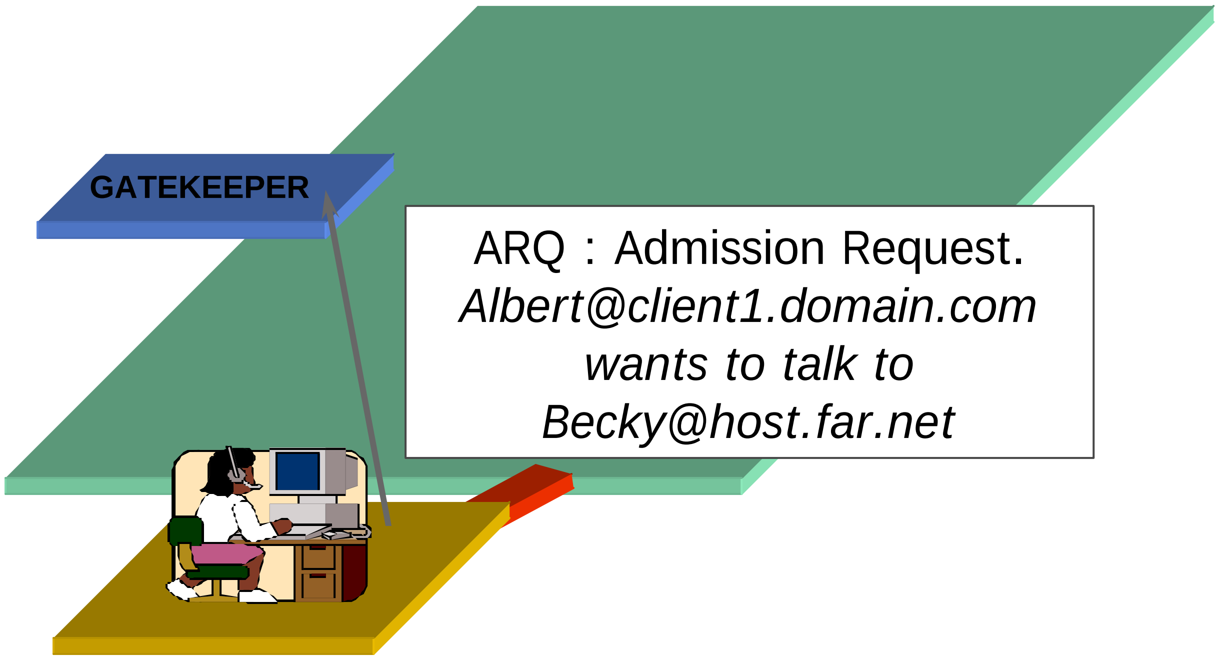
RAS Signaling: Registering into the GK

- Registering allows an endpoint to inform the gatekeeper about the mappings alias/TSAP transport address (IP/TCP/UDP) of the Call Signaling channel (Messages RegReQuest / RegConFirm / RegReJect)



RAS Signaling: Asking for Permission

- Call admission control uses (Messages AdmReQuest / AdmConFirm / AdmReJect) and is used to translate addresses.



Main RAS functionalities

- <u>Gatekeeper Discovery</u> **(GK ReQuest/ GCF/ GRJ) (can also be done through DNS)**
- <u>Registration</u> **(RRQ: Registration Request/ RCF: Registration Confirm/ RRJ: Registration Reject,)**
- <u>Admission Control</u> **(AdmReQuest/ AdmConFirm/ AdmReJect)**
- <u>Bandwidth Control</u> **(Bandwidth ReQuest/ BCF/ BRJ)**
- <u>Endpoints location</u> **(LRQ/LCF/ LRJ)**

H.225 Annex G: Inter-Domain Communication

- A new functional entity: the Border Element (BE)
- One or more per administrative domain
- In charge of routing information exchange

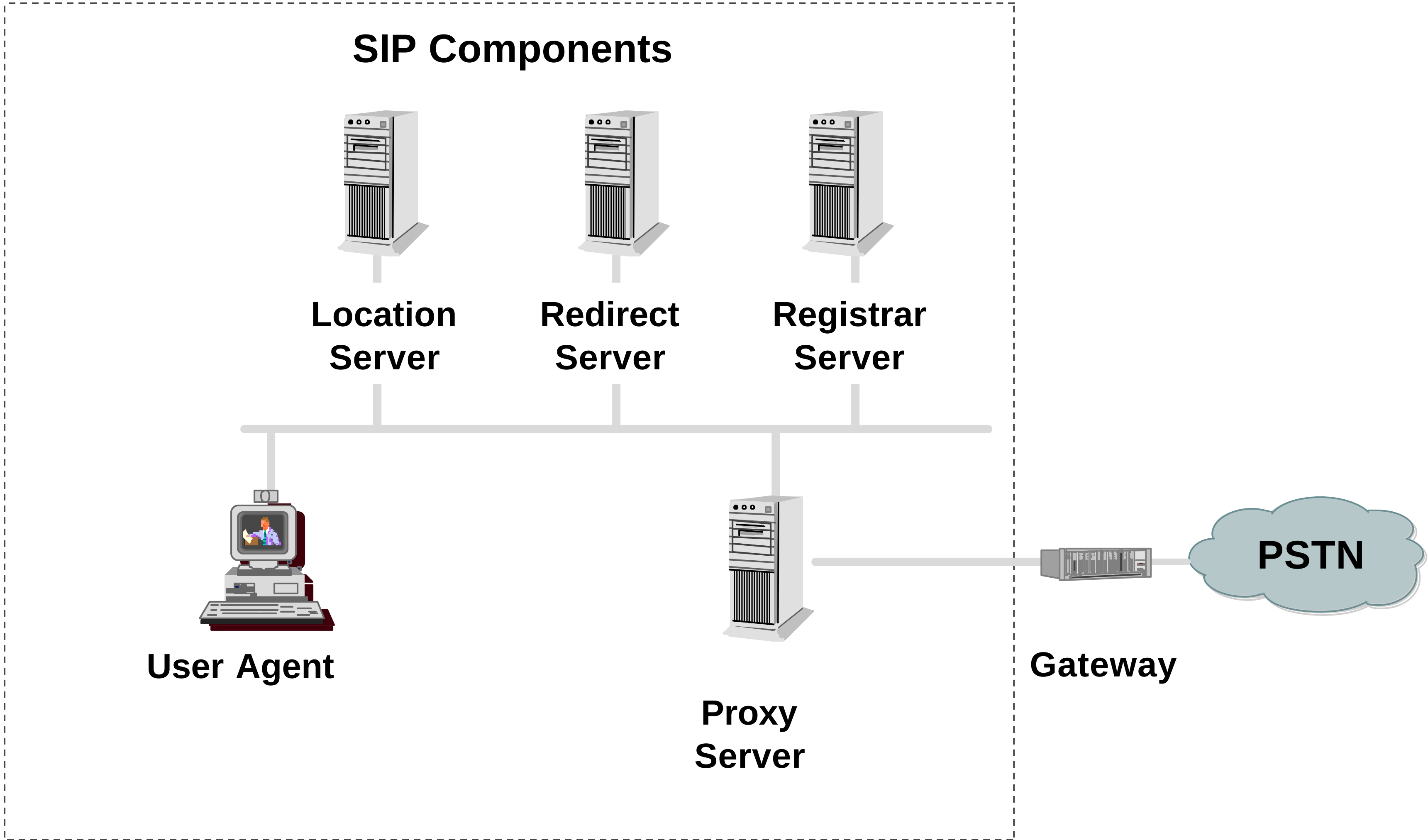
SIP (Session initiation Protocol)

- **SIP (Session initiation Protocol) is an application-level signaling protocol designed by the MMUSIC Working Group of the IETF (RFC 2543)**
- **Designed to be simple and evolutionary**
  - ***Portable on "light" terminals***
  - ***Independent of the lower-layer transport protocol***
  - ***Flexible to be extended with additional capabilities***
- **Client-Server protocol derived from HTTP:**
  - ***Reuses syntax and semantics of HTTP (code architecture, message headers, overall operation)***
  - ***In particular, uses text-based encoding***

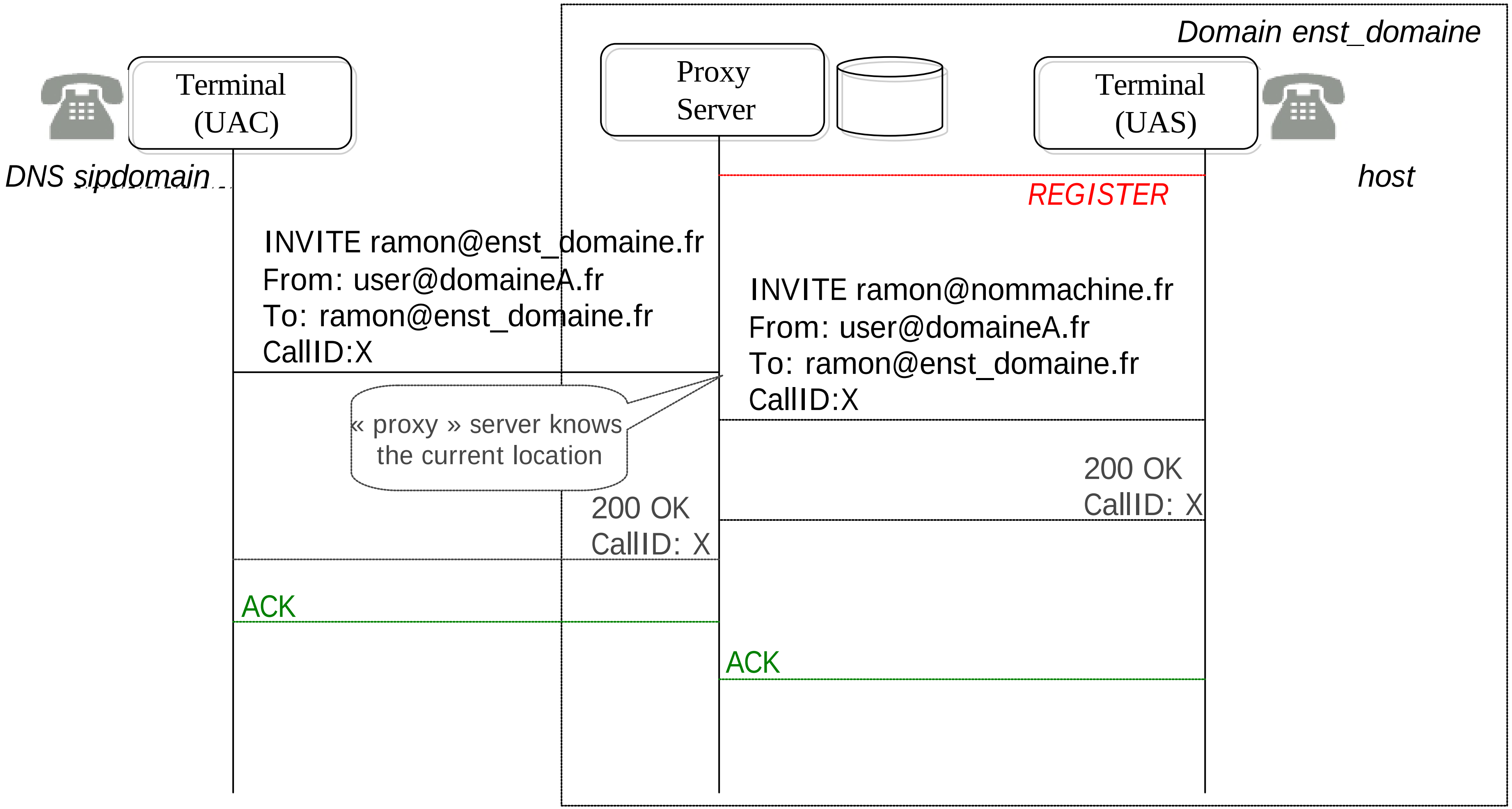
Additional components required

IETF, « Session Initiation Protocol »	
SIP (Session Initiation Protocol)	**Call set-up protocol**
SDP (Session Description Protocol)	**Session description: codecs supported, etc**
SAP (Session Announcement Protocol)	**Use of multicast**
RTP/RTCP	**Packetization and audio/video transmission**
G.711, GSM, G.729 ...	**Audio/ Video Codecs**

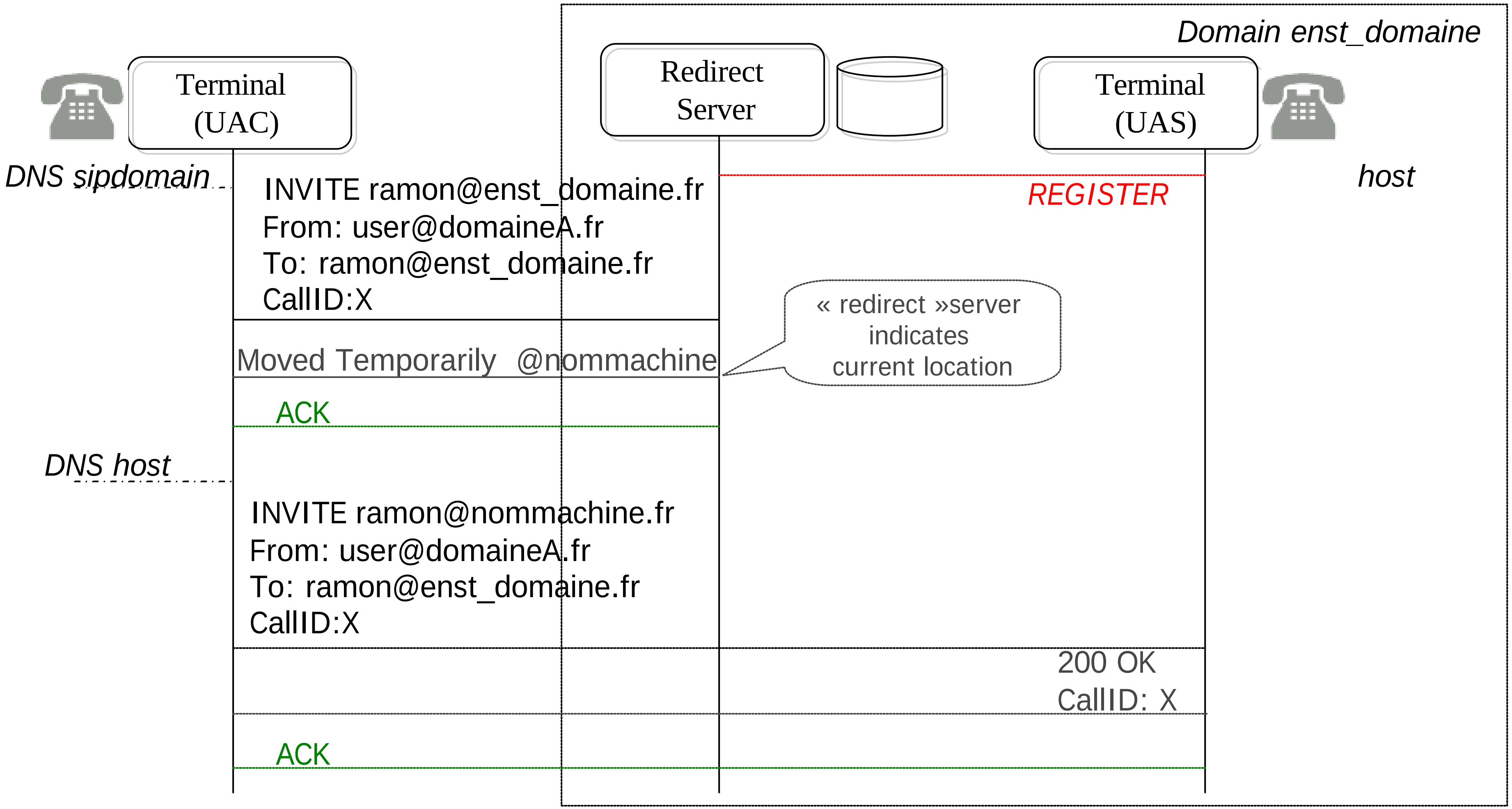
SIP “Architecture”



Call Setup using a Proxy Server



Call Setup using a Redirect Server



SIP Messages: Requests

SIP Requests:

- *INVITE – Initiates a call by inviting user to participate in session.*
- *ACK - Confirms that the client has received a final response to an INVITE request.*
- *BYE - Indicates termination of the call.*
- *CANCEL - Cancels a pending request.*
- *REGISTER – Registers the user agent.*
- *OPTIONS – Used to query the capabilities of a server.*
- *INFO – Used to carry out-of-bound information, such as DTMF digits.*

Table 1 - SIP and H.323

	SIP	H.323
Standards Body	IETF.	ITU.
Relationship	Client-Server	Peer-to-Peer.
Origins	Internet based and web centric. Borrows syntax and messages from HTTP.	Telephony based. Borrows call signaling protocol from ISDN,Q.SIG.
Client	Intelligent user agents.	Intelligent H.323 terminals.
Core servers	SIP proxy, redirect, location, and registration servers.	H.323 Gatekeeper.
Current Deployment	Interoperability testing between various vendor's products is ongoing at SIP bakeoffs. SIP is gaining interest.	Widespread.
Interoperability	IMTC sponsors interoperability events among SIP, H.323, and MGCP. For more information, visit: http://www.imtc.org/	

Table 2 - SIP and H.323

	SIP	H.323
Capabilities Exchange	SIP uses SDP protocol for capabilities exchange. SIP does not provide as extensive capabilities exchange as H.323.	Supported by H.245 protocol. H.245 provides structure for detailed and precise information on terminal capabilities.
Control Channel Encoding Type	Text based UTF-8 encoding.	Binary ASN.1 PER encoding.
Server Processing	Stateless or stateful.	Version 1 or 2 – Stateful. Version 3 or 4 – Stateless or stateful.
Quality of Service	SIP relies on other protocols such as RSVP, COPS, OSP to implement or enforce quality of service.	H.323 gatekeeper contributes to Bandwidth management/control and admission control. The H323 specification « recommends » using RSVP for resource reservation.

Table 3 - SIP and H.323

	SIP	H.323
Security	**Registration -** User agent registers with a proxy server. **Authentication -** User agent authentication uses HTTP digest or basic authentication. **Encryption -** The SIP RFC defines three methods of encryption for data privacy.	**Registration -** If a gatekeeper is present, endpoints register and request admission with the gatekeeper. **Authentication and Encryption -** H.235 provides recommendations for authentication and encryption in H.323 systems.
Endpoint Location and Call Routing	Uses SIP URL for addressing. Location servers provide routing information.	Uses E.164 or H323ID alias including URLs and a address mapping mechanism if gatekeepers are present in the H.323 system.Gatekeepers provides routing information. Annex G for inter-domain

Table 4 – SIP and H.323

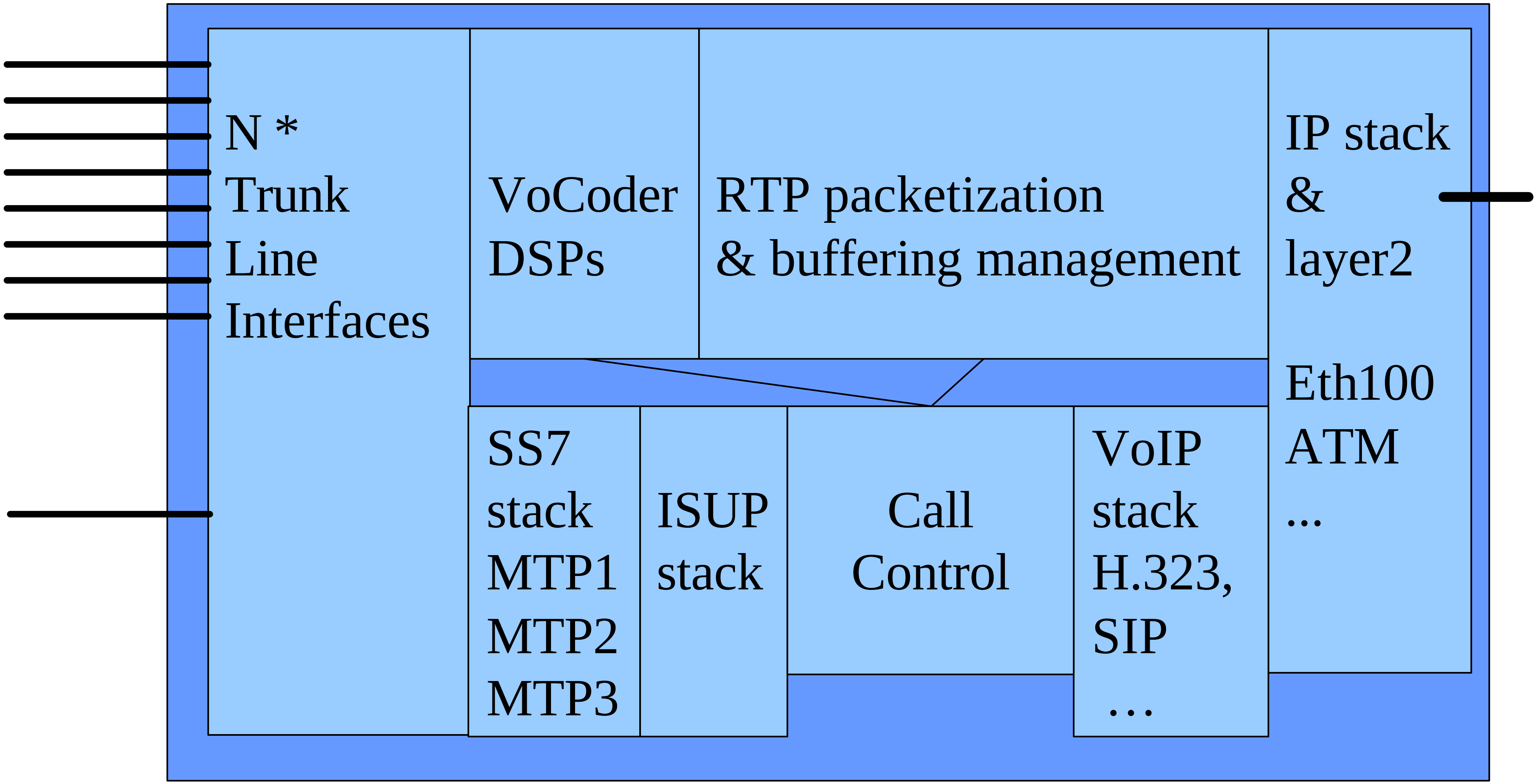
	SIP	H.323
Features	Basic call features.	Basic call features.
Conferencing	Basic conferencing without conference or floor control.	Comprehensive audiovisual conferencing support. Data conferencing or collaboration defined by T.120 specification.
Service or Feature Creation	Supports flexible and intuitive feature creation with SIP using SIP-CGI and CPL. Some example features include presence, unified messaging, or find me/follow me.	H.450.1 defines a framework for supplementary service creation.

Note: Basic call features include: call hold, call waiting, call transfer, call forwarding, caller identification, and call park.

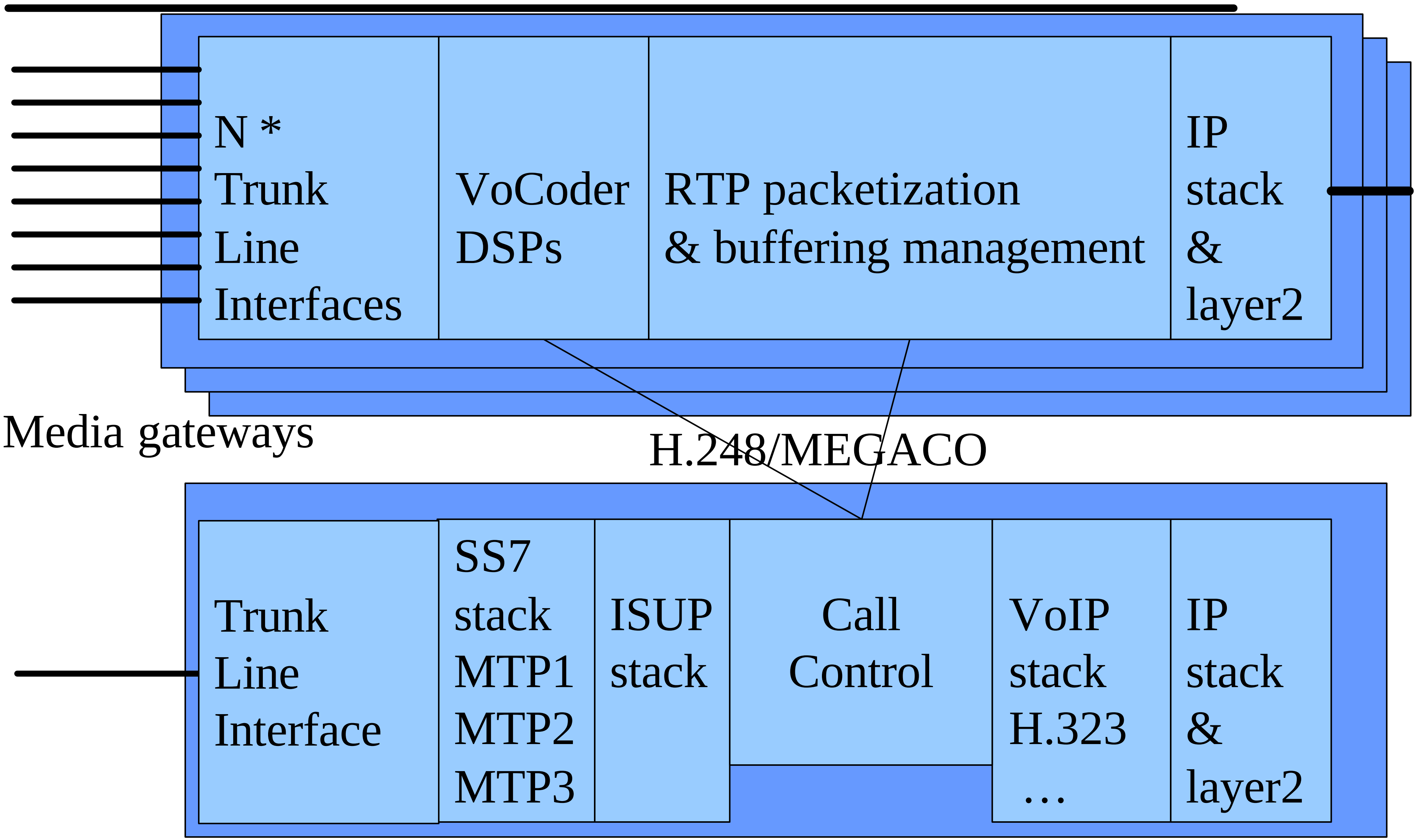
An alternative architecture

- **The principles of decomposed gateways**
- **The protocol architectures**
  - ***The H.248/MEGACO protocol***
  - ***Signaling transport over IP networks: SIGTRAN***

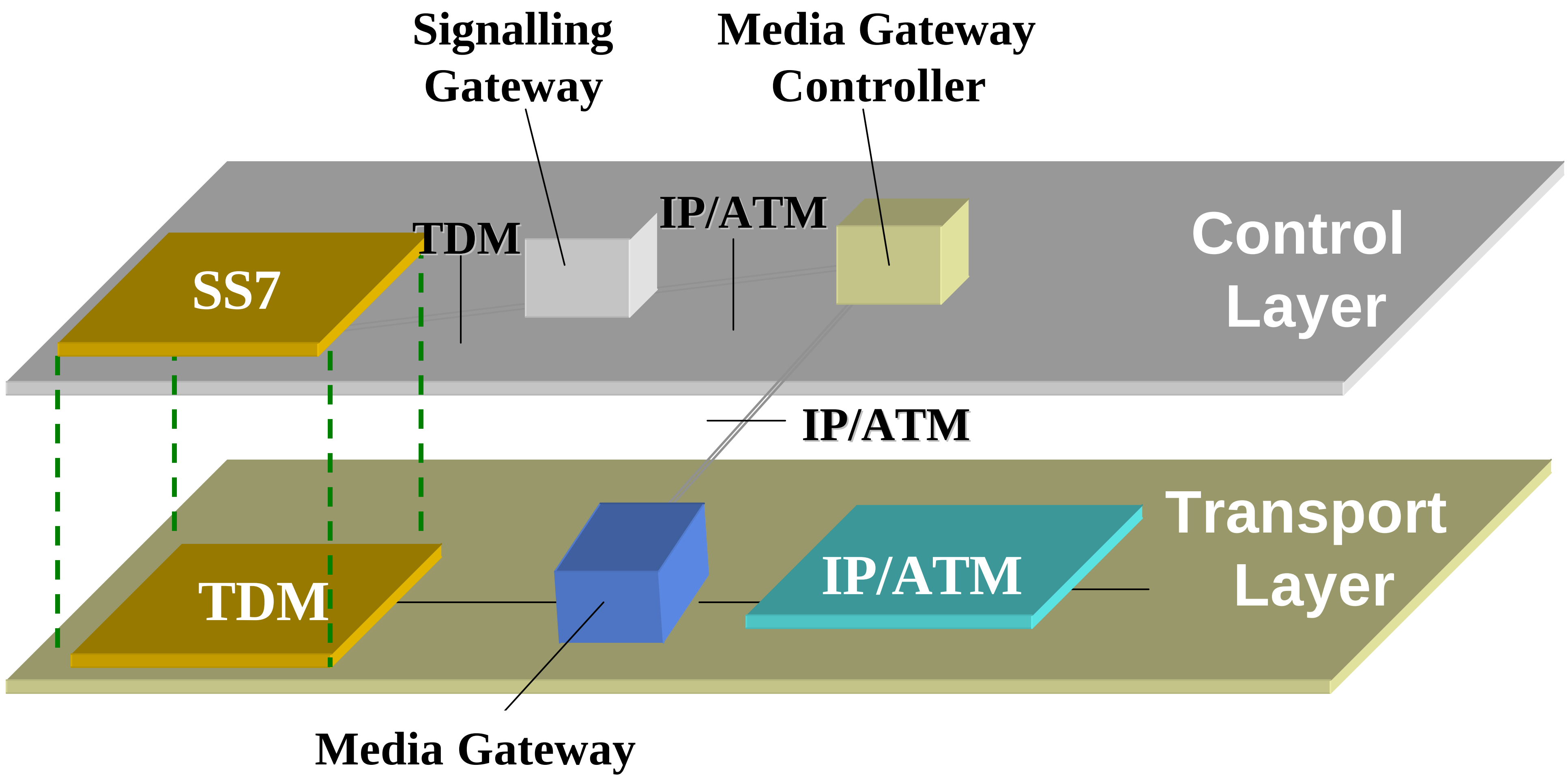
From centralized gateway design…



… to distributed gateway design



Architecture Overview



1. Control and transport independence

Media Gateways and stimuli IP phones

- **Examples of media gateways:**
  - ***IP phone.***
  - ***Several legacy telephony ports: residential gateway (could be included in some IADs)***
  - ***Interconnection the PABX with the LAN***
  - ***User of the PSTN***
  - ***Interconnected with the PSTN***
- **IP phone case**
  - ***Stimuli telephones***
  - ***Simpler service evolution***
  - ***Lower prices***
  - ***More control (e.g. for billing)***

Summary on IP telephony

- **The technology is mature**
  - *Not the case for SIP yet*
- **The market is taking up**
  - *The companies are now confident in the technology*
    - **Less warning about QoS and reliability**
  - *But the migration process is just starting*
- **Following unbundling for Internet Access provision, low price telephony offer is growing**
- **PABX integrators would like to open new business opportunities**
  - *How to become a Telephony Service Provider with a minimum investment?*
- **Which billing approach?**
  - *IP phone to IP phone: which meaning for « telephony minutes »*
- **Telephony remain the main source of revenues, for how long ?**

A Word on Multicast

Multicast

- **Network Multicast**
  - ***Multicast routing***
    - **Multipoint to Multipoint**
      - ***Hierarchical CBT trees, source base trees***
      - ***Scalability issues***
    - **Point to multipoint**
      - ***SSM-Source Specific Multicast***
      - ***a solution for flow distribution***
  - ***Reliable Transport Multicast***
    - **An open issue**
- **Application multicast**
  - ***Content delivery networks***
  - ***Peer-to-peer based solutions***
  - ***Which complementarities ?***

From IPv4 to IPv6

Overview of protocol and architectural evolutions

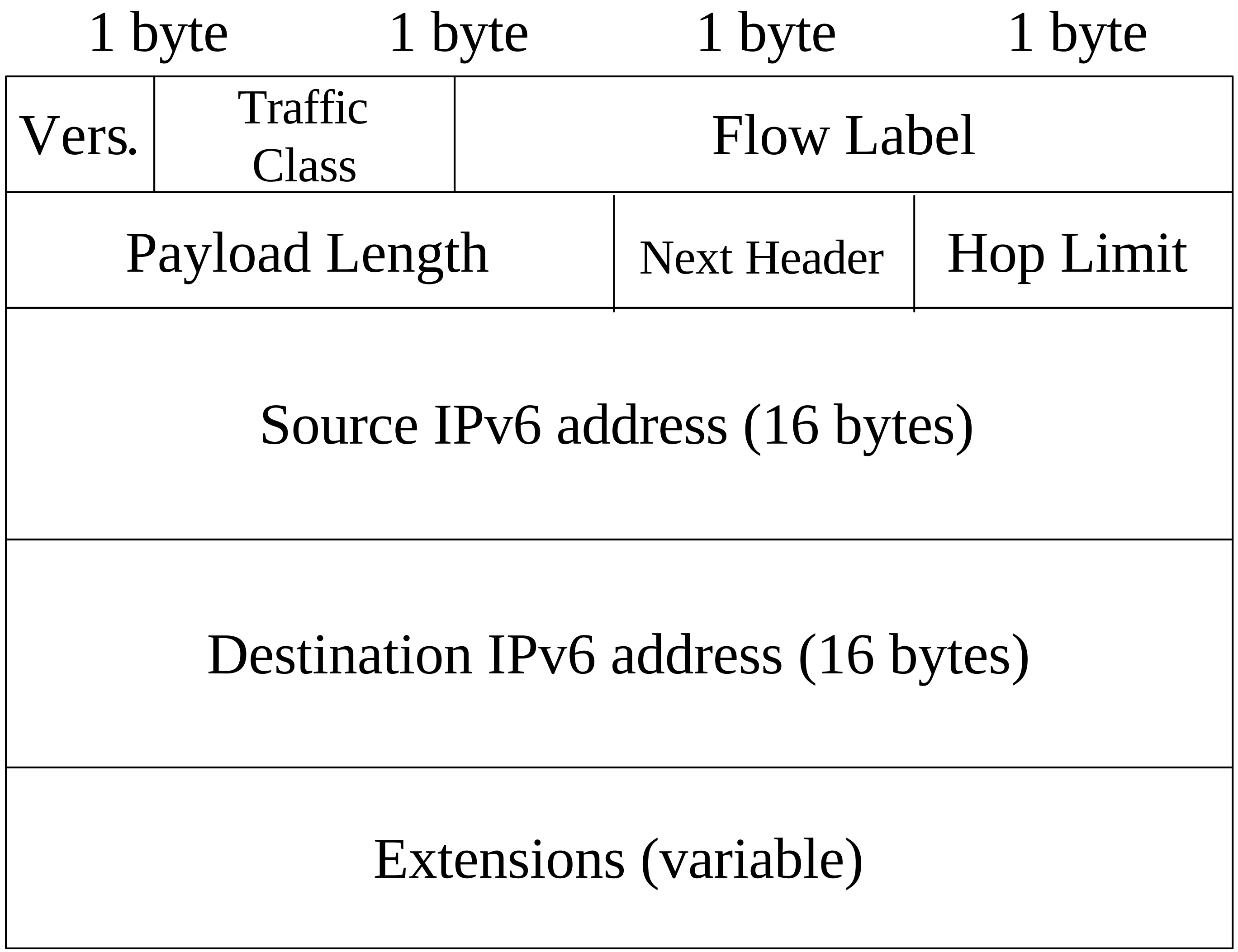
Why IPv6?

- **Mainly for Avoiding address starvation**
- **Also**
  - ***Simplifying network management, automatic discovery***
  - ***Integrated protocol architecture***
  - ***Native IPSec implementation***
  - ***Enhancing the mobile architecture***
  - ***Facilitating QoS provisioning? WRONG!***
- **Main problem**
  - ***Migration process***

IPv4 Header

<table>
<tr><th colspan="2">1 byte</th><th colspan="2">1 byte</th><th colspan="2">1 byte</th><th colspan="2">1 byte</th></tr>
<tr><td>Vers.</td><td>IHL</td><td colspan="2">TOS</td><td colspan="4">Total Length</td></tr>
<tr><td colspan="4">Identification</td><td colspan="2">Flags</td><td colspan="2">FO</td></tr>
<tr><td colspan="2">TTL</td><td colspan="2">Protocol</td><td colspan="4">Header Checksum</td></tr>
<tr><td colspan="8">Source IPv4 address (4 bytes)</td></tr>
<tr><td colspan="8">Destination IPv4 address (4 bytes)</td></tr>
<tr><td colspan="3">Options</td><td colspan="5">Padding</td></tr>
</table>

IPv6 Header



1 byte
1 byte
1 byte
1 byte
Vers.
Traffic Class
Flow Label
Payload Length
Next Header
Hop Limit
Source IPv6 address (16 bytes)
Destination IPv6 address (16 bytes)
Extensions (variable)

Header Evolutions

- **The new header is**
  - ***simpler: to allow high speed implementations***
  - ***longer: because of the longer addressing***
- **Simpler**
  - ***The checksum has be eliminated***
    - **it had to be recomputed at every hop because of changes in the header (e.g. TTL)**
    - **UDP checksum becomes mandatory**
  - ***No options (fixed length): the extensions are treated as new headers and in most of the cases in an end to end approach***

Header Evolutions

Simpler

- ***The flow label:***
  - **The flow concept is introduce. Help in processing the packets of a flow (for example when dealing with RSVP flows).**
  - **Could help the forwarding**
- ***No fragmentation in most cases (treated by the extensions when necessary***
  - **Minimal MTU: 1280bytes (to take into account the tunneling when crossing Ethernet interfaces)**
- ***Conceived for optimal processing by 64 bits hardware***

Addressing

- **The unicast address have been conceived to**
  - ***avoid future starvations***
  - ***simplify the routing (prefix structure)***
  - ***allow automatic configuration***
  - ***simplify the mobile architecture***
- **Anycast address has been defined**
- **Local address allow to deal with automatic configuration processes**

Addressing

- **Encapsulation of IPv4 addresses facilitates a smooth migration**
  - ***IPv4 tunnels***
  - ***Applications that deal booth with IPv4 and IPv6 stacks in order to communicate with booth types of distant hosts***

Other evolutions

- **IPSec is mandatory**
  - ***Then, for example, no ad-hoc security is needed for the routing protocols***
- **ICMPv6 integers IGMP and ARP.**
  - ***Unification of different protocols to simplify the implementation (e.g. common format)***
- **Automatic discovery of routers and prefixes**
  - ***For example, it simplifies the mobility architecture***

Challenges

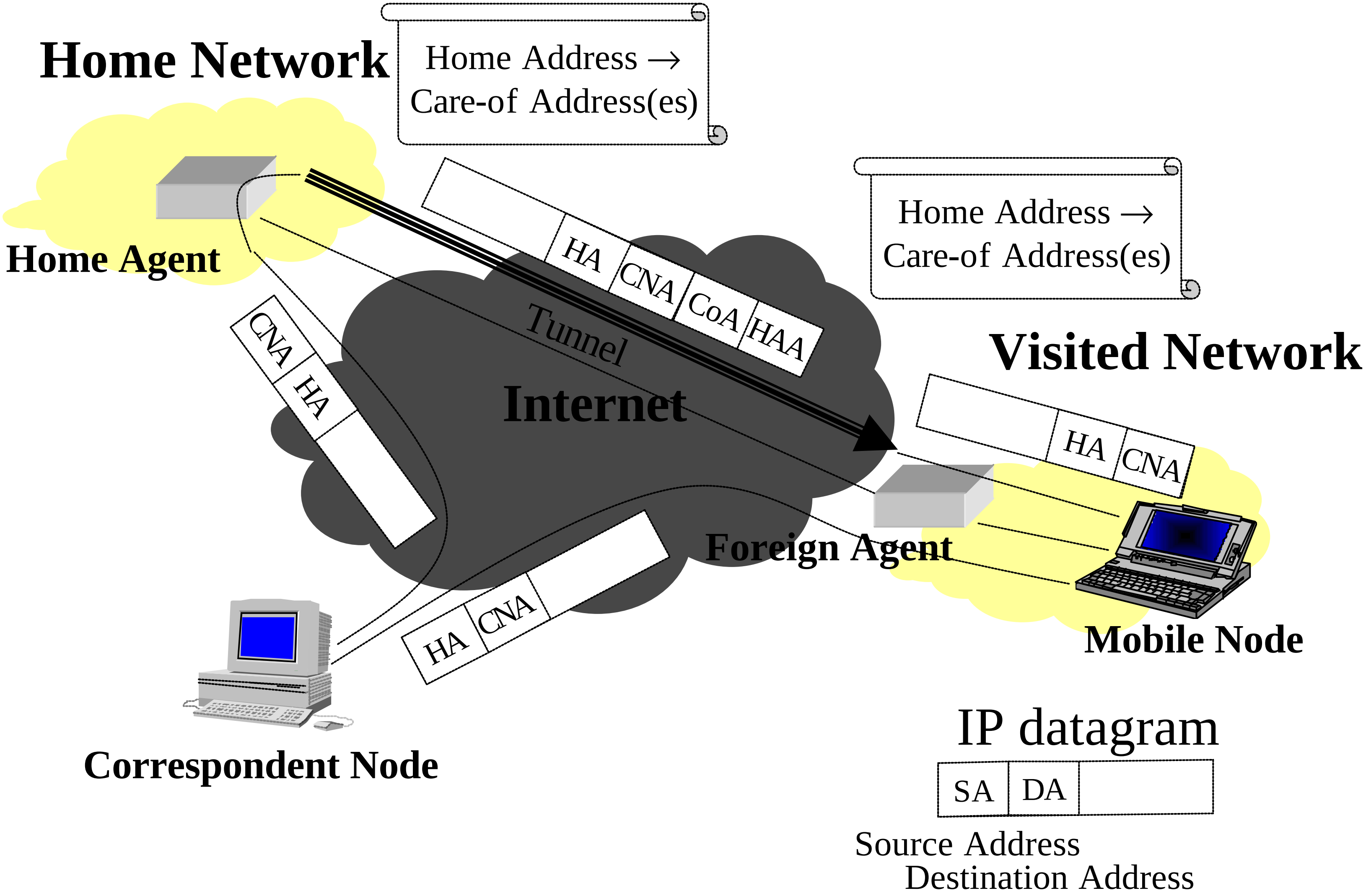
- **Which needs to migrate?**
  - ***The USA are not in a hurry***
  - ***Japan and other Asian countries are facing addresses starvation problems***
  - ***Impact of new applications (e.g. telephony) and mobility***
- **Which migration process?**
  - ***Overlay approach (6Bone)***
    - **Not a migration!**
  - ***Gateways***
    - **Same problems as NATs**
  - ***Double stacks***
    - **DNS issues**
  - ***Others?***

Mobile IP

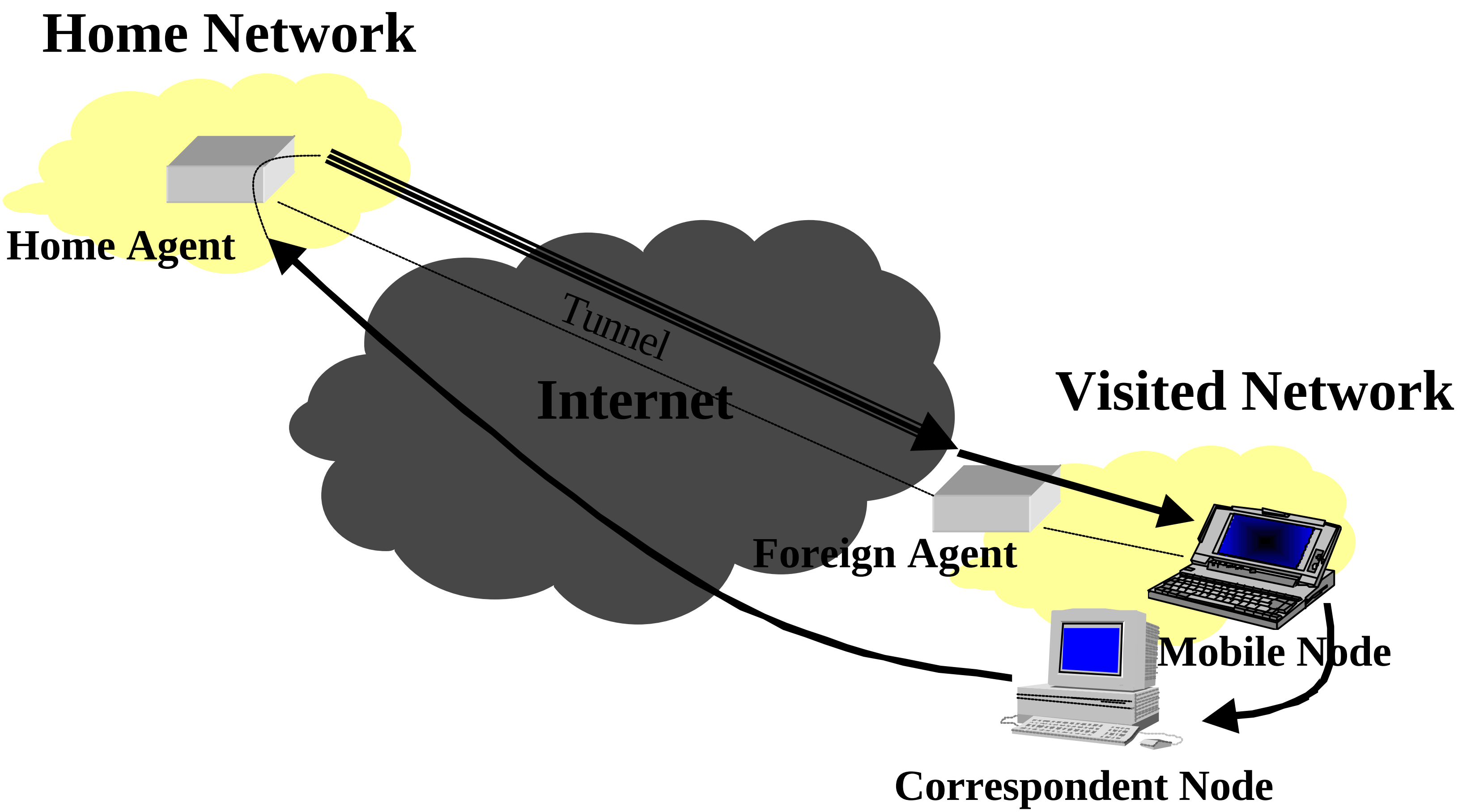
Requirements of the IP mobility architecture

- **Two major requirements arise when considering IP mobility:**
  - *Application transparency*
  - *Seamless roaming*
- **Difficulty: addresses are used both for flow identification and routing purposes**

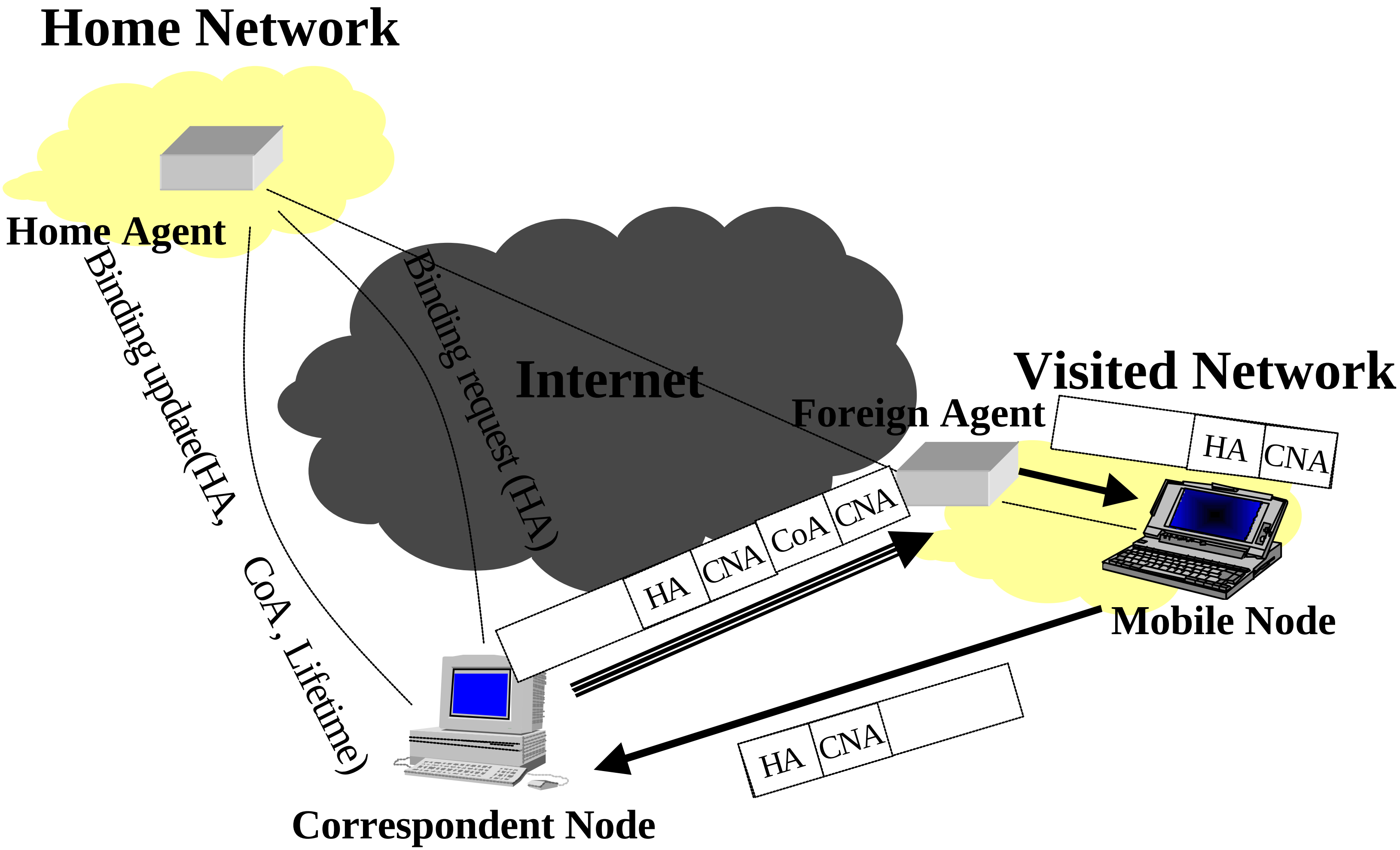
Architecture Overview



Example of Drawbacks: Triangle Routing



Route optimization



Other issues

- **Smooth handover**
- **Micro-mobility (Cellular IP)**
- **Security**
- **Which synergy with GPRS/UMTS**
- **IPv6 and mobility**
  - ***Simpler architecture***

General conclusion

- **The telecommunication world is moving towards « all IP »**
- **The Internet/Telecom/Media convergence, usually called the triple play, is becoming a reality**
- **Technology diversity will continue to increase in the short term but will probably be reduced in the long term**
  - ***Fix networks will be based on FTTO, FTTH***
  - ***Ethernet will conquer the MAN and probably the WAN***
  - ***A unified control plane will be deployed, in particularly for service provisioning, traffic engineering and protection in multilayer networks***
    - **Optical switching has been delayed**
  - ***A new technology is required for high speed mobile access, UMTS has several technological limitations***
- **New equipment is being designed and developed to cope with the transition towards the « all IP »**
  - ***Hybrid packet/TDM switching fabrics***
  - ***Heterogeneous SDH, ATM, Ethernet, interfaces***

General conclusion

- **A clear separation between the network plane and the user plane is being implemented**
- **The NGN architectures will become the norm**
- **Standardize middlewares will allow different companies to deploy heterogeneous service planes over the same network**
- **Network services become a commodity**
  - ***Already today, telecom services start to be sold as water or electricity, no more tailored offers***
- **The market moves towards a new organization of the chain of value**
  - ***What will be the role of the telecom operators tomorrow ?***