



Access Network Technologies



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- > The goal; BroadBand connectivity, the access to your applications
 - Applications
 - End-user expectations
 - Requirements on the network
- > The playground; architecture and technologies
 - Technologies: networks, protocols and forwarding models
 - Life-cycle of a connection
 - Connections seen at L2-L3(L4)
 - Unicast
 - Multicast: IGMP
 - Connections seen from application-specific view (L3-L7)
 - Service connectivity: Voice over IP example
- > There's more than connectivity
 - Control for the data plane, management aspects, accounting and billing
 - Distributed functions
 - Note on standardisation

Applications and requirements

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- > Applications can be classified in multiple ways;
 - ... depending on the customer
 - Business services (SME, utilities): especially specific types of connectivity with very high demands (reliability, synchronisation, ...)
 - Residential services: “triple play” + mobility, and all applications you can think of via internet. Requirements becoming more and more demanding.
 - ... according to their nature
 - Content distribution to users (e.g. VoD)
 - Location-based
 - Multi-media conversations between users (text / voice / image / avatar)
 - Interactivity
 - Media mixing
 - ... depending on their connectivity
 - Data source can be in the network or at end-user's side
 - One source or multiple sources (BitTorrent)
 - One recipient or multiple recipients (conference call)



> End-user expectations

- Accessibility and choice for the user;
 - select a service with associated quality (multi-service),
 - from an appropriate provider (multi-provider),
 - with a specific and affordable subscription (billing),
 - from different places in the network (nomadism)
 - And from its preferred terminal (Fixed Mobile Convergence)
- Quality of experience:
 - Speed (surfing, up- & downloads)
 - interactivity assurance: low delay, low jitter (gaming)
 - Content quality (lack of defects and synchronisation for IPTV, voice quality for VoIP)



> Network requirements

- from user expectations
 - QoS (e.g. network availability, ...)
 - Bandwidth (e.g. minimal bandwidth,...)
 - Support of nomadism
 - Ensure correct connectivity (e.g. NAT traversal,...)
 - Security (e.g. avoid unauthorised reception of information,...)
- from network and service provider perspective
 - technology allowing cost-effective bandwidth upgrades
 - efficient use of resources (eg for multicast flows)
 - accounting & billing
 - provisioning (e.g. addressing scheme)
 - scalable naming and numbering
 - fault & performance monitoring
 - remote configuration of end-user equipment



Characteristics of BB connectivity

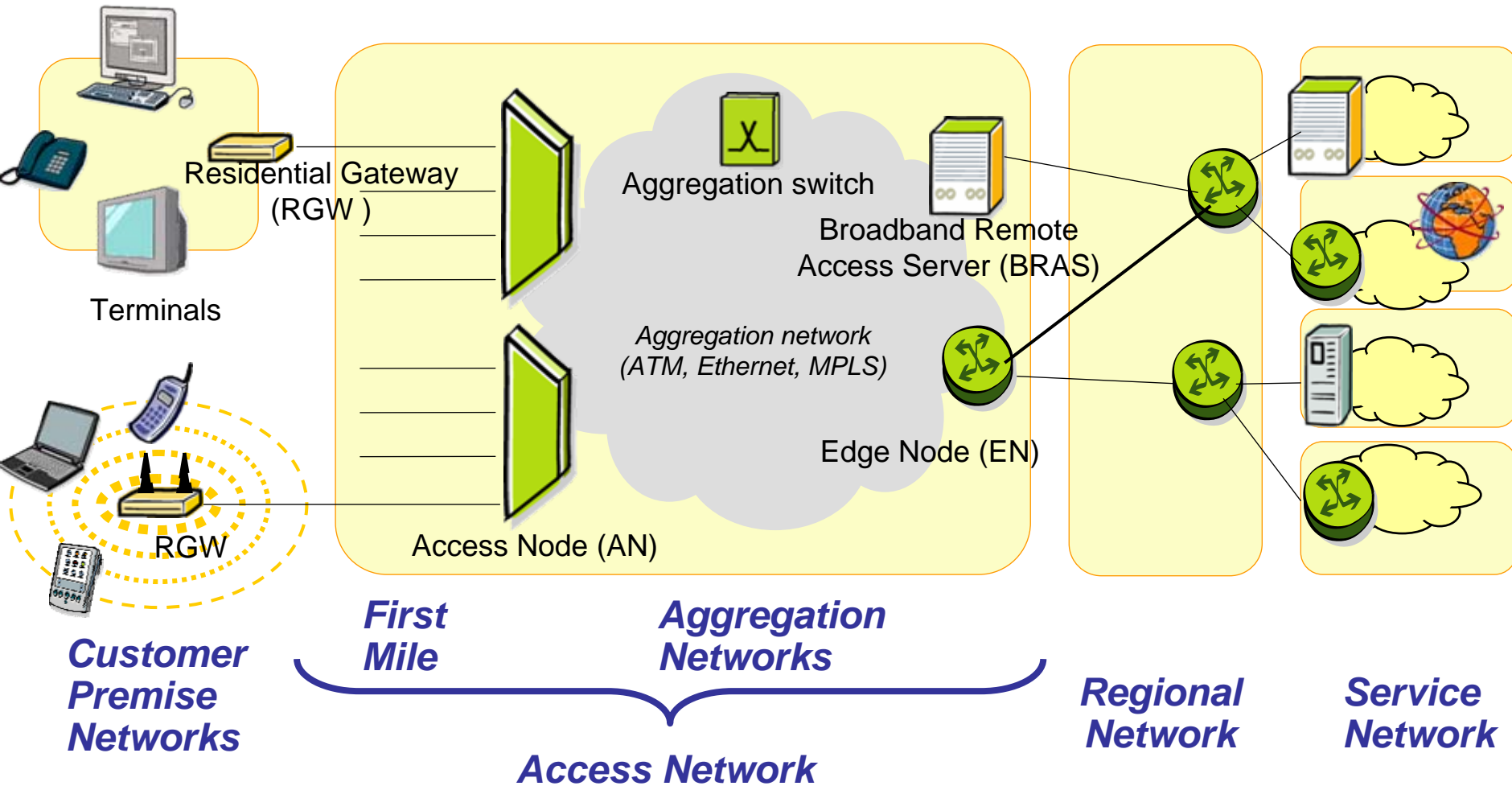


- > Connectivity can be characterised by
 - QoS (delay, jitter, ...) and throughput (minimal and variable bit rate, ...)
 - Location (fixed or nomadic)
 - Nature (static (always-on) or dynamic)
 - Relationship source-destination:

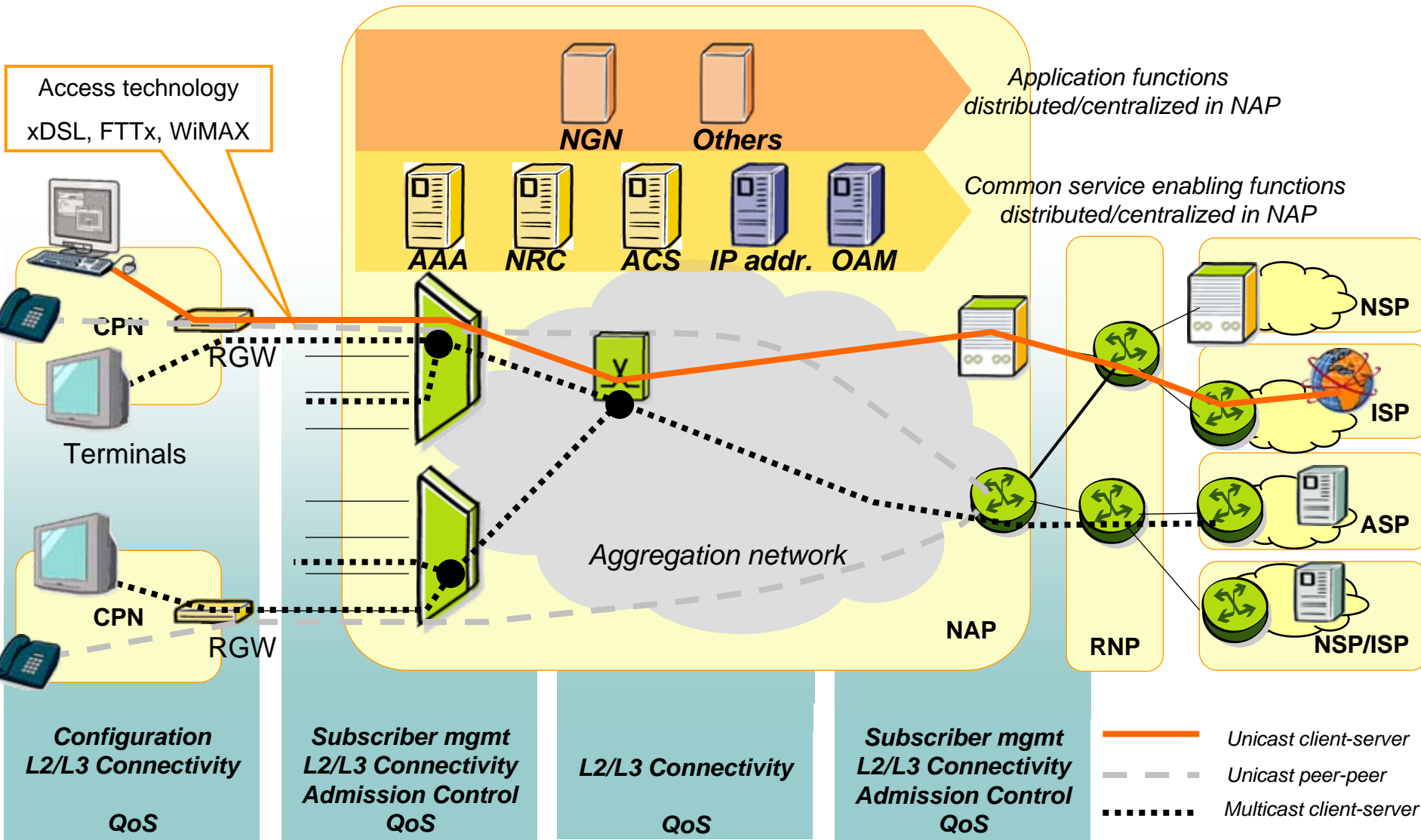
<i># connected parties</i>	Point-point	(Multi-point) Multi-party
<i>Location of the source</i>		
Source in the network	Client / Server unicast	Client / Server multicast - Network-level multicast (Multicast tree in network)
End-user as source	Peer-Peer unicast	Multi-party P2P - application-level multicast - centralized server - network-level multicast

Architectures and technologies

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Connections in BB access networks

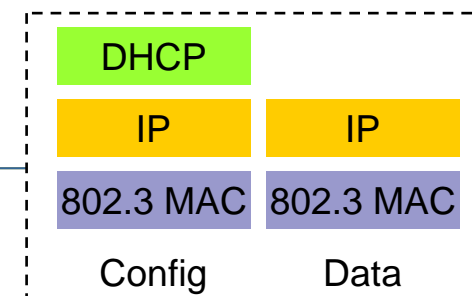
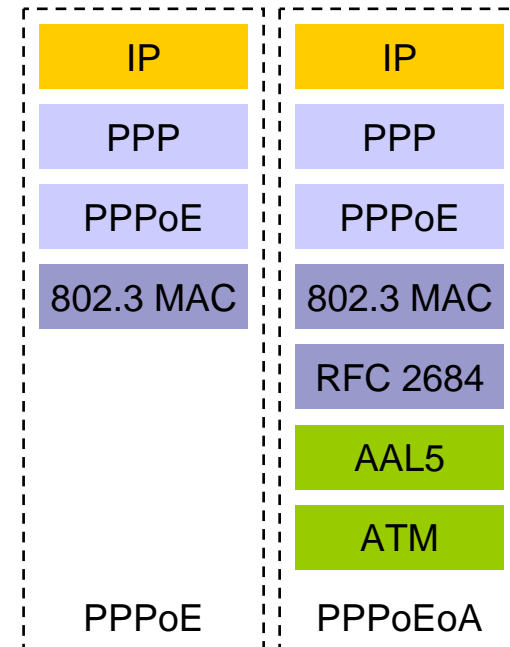


Technologies for Broadband access: protocols



> Layered model and corresponding protocols

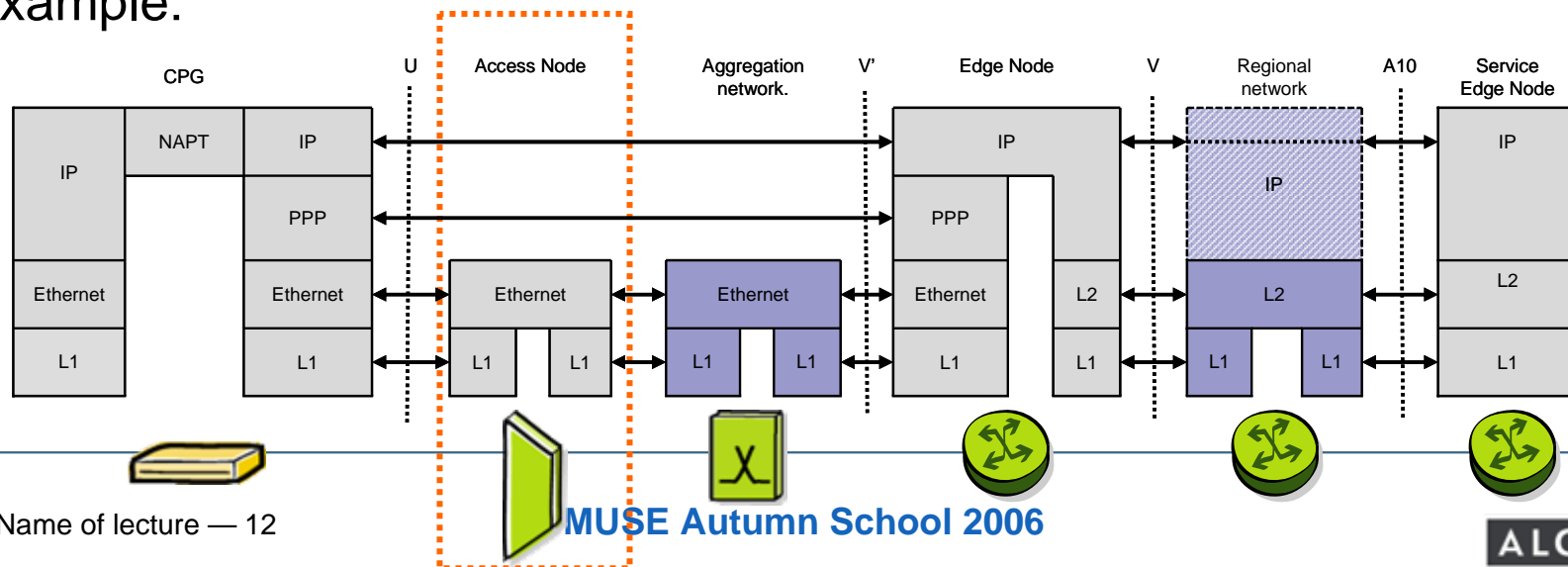
- Layer 2 (Link)
 - ATM: fixed cells, connection-oriented
 - Ethernet: variable frames, connectionless
- Layer “2.5”
 - MPLS: encapsulation, connection-oriented
- Layer 3 (network)
 - IP: packets, connectionless
- Layer 4 (transport)
 - TCP (connection-oriented) or UDP (connectionless)
- Autoconfiguration
 - **PPP** suite : data plane + control plane
 - Link establishment + authentication + IP configuration
 - **DHCP**: control plane only
 - IP configuration + other parameters



Technologies for Broadband access: data plane

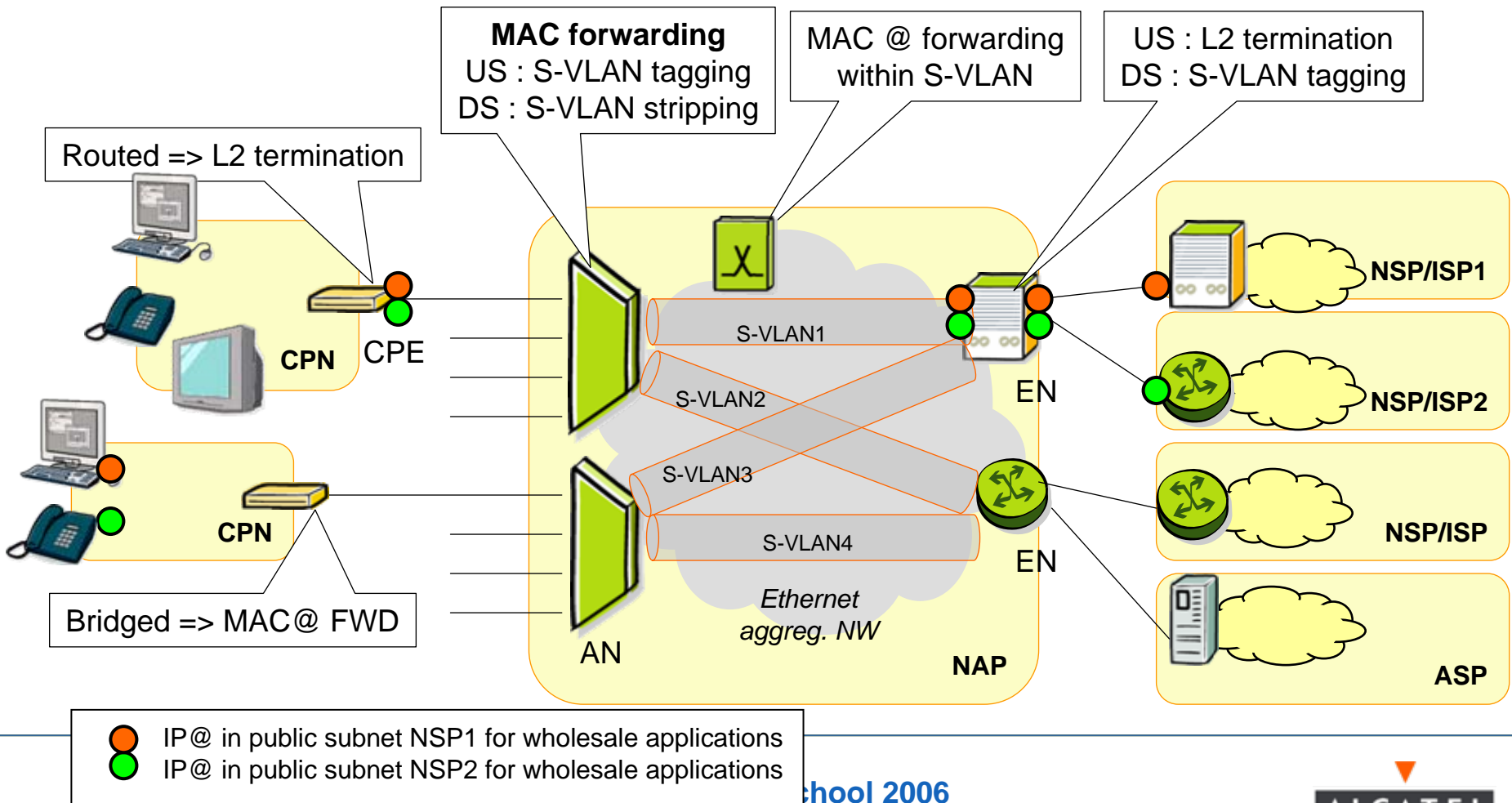
- > Layered model and corresponding protocols
 - Every node, depending on its nature, will interpret and terminate layers L1 – L(N)
- > Types of nodes
 - L2 switch: ATM (VP/VC connection) or Ethernet (flooding and learning, VLANs)
 - L3 router: IP (routing table and routing protocol)
 - Mixture of L2 and L3 (L2 termination without routing protocols nor IP address)
 - Optionally MPLS enabled (LSP connection)

> Example:



Data plane: packet forwarding

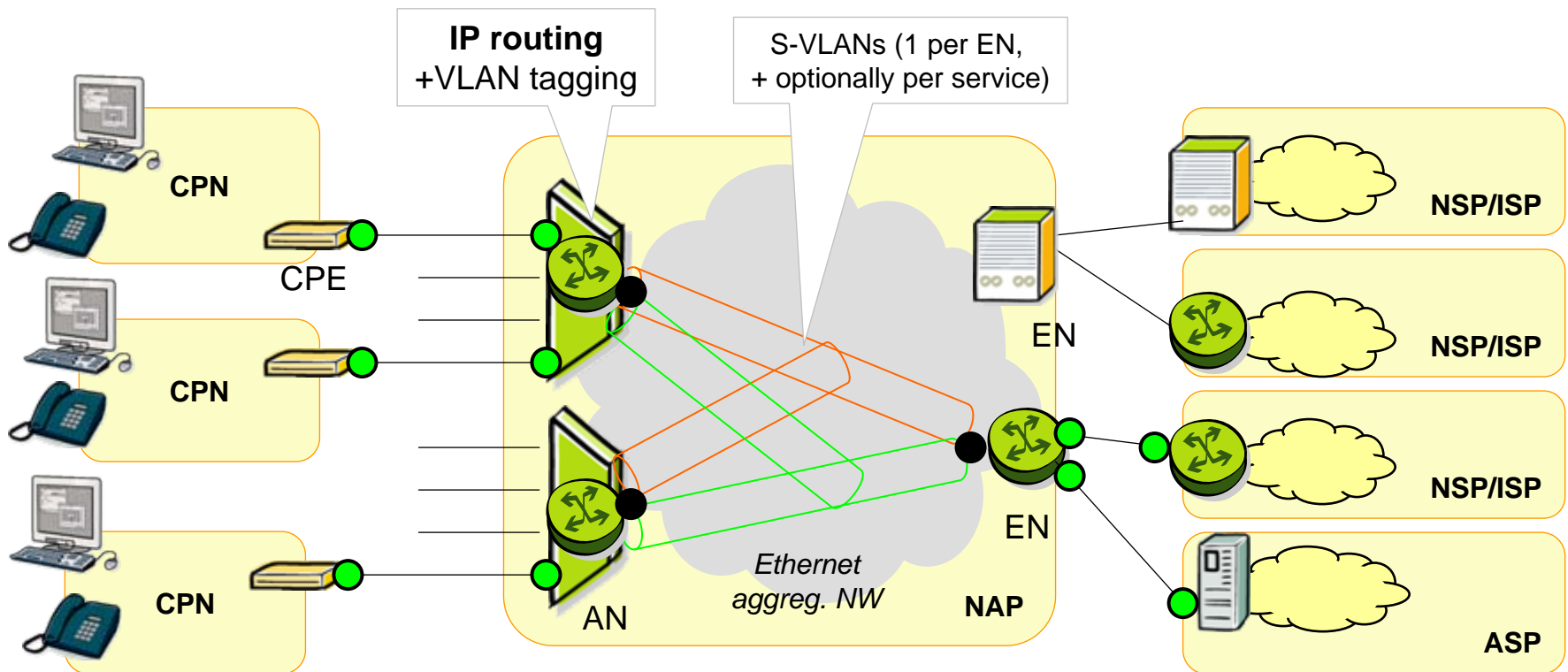
> Forwarding models in the access network: L2 oriented



Data plane: packet forwarding



> Forwarding models in the access network: L3 oriented



- IP@ in public subnet NAP for retail applications
- IP@ in private subnet (not globally accessible)

> Connection

- Job of the network at Layer 2 – Layer 3: deliver frames
 - Assign L3 parameters and learn L2 and L3 parameters
 - Put up tunnels if needed (e.g. PPP)
 - Apply forwarding rules to guide the frames from source to destination

> Application session awareness

- Job of the network at Layer 3 and above:
 - Help user to map the destination to the right IP address (e.g. DNS, SIP lookup)
 - For conversational services, allow proper application signaling interaction
 - Improve user's experience by applying "tricks" on the media
 - Improve security for the network (and for the users)
 - Instrumental to applications (NAT traversal etc...)

> Confusing note:

- Generic "IP sessions" concept;
 - Limited to the creation, management and tear-down of IP address allocations, to handle each subscriber according to his/her service contract.
 - No insight into the application involved.

Connection life-cycle seen at L2-L3



- 0 Network configuration: getting the network up and running
 - L2: RSTP, VLAN configuration
 - L3: routing table population in EN (and AN depending on NW model)

- 1 Autoconfiguration: CPE getting ready
 - Network configures CPE (Residential GW + end-user terminal)
 - Basic configuration
 - Authentication by NAP and/or by NSP, using either PPP or DHCP
 - IP address assignments in multi-provider environment
 - Correlation of user records (AAA architecture)
 - Further application- or profile-dependent configuration
 - RGW maintenance, config of services on top of network layer; by ACS via TR-69

- 2 Admission control: for user gaining access to a resource or service
 - User requests service via signaling (e.g. IGMP for IPTV) or just generates/demands traffic
 - Network checks for permission (based on profile), for associated capacity and for its availability in the network

Connection life-cycle seen at L2-L3



- 3 End-end connectivity: configuration of connectivity parameters in network for end-end transport between the parties
 - L2 parameters; MAC learning, VLAN (un)tagging, ARP
 - L3 parameters; routing table updates by configuration or routing protocols
 - Multicast; IGMP proxy/snooping and PIM translation
 - Peer-peer; route depends on network model

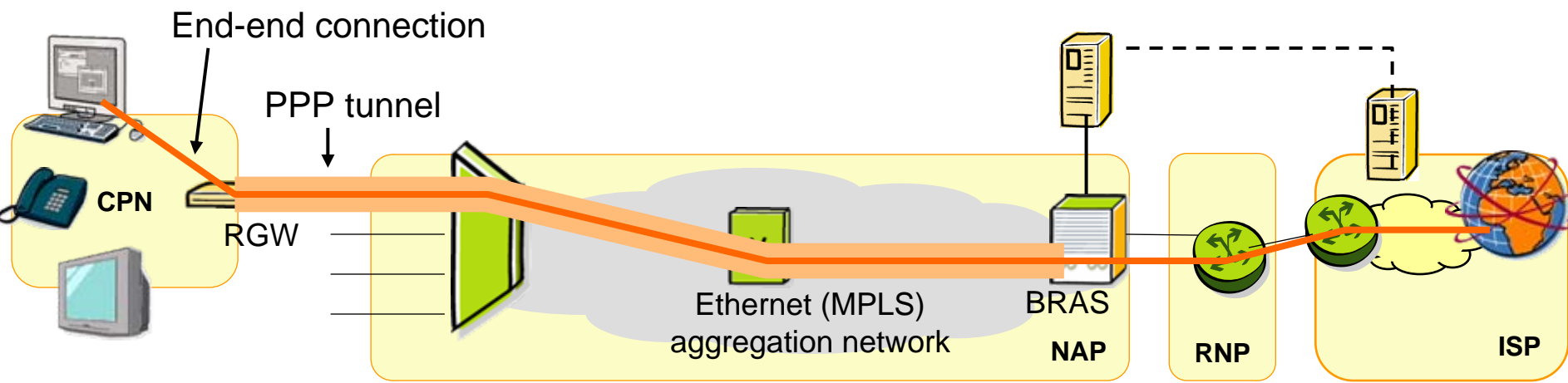
- 4 QoS handling: guarantee of a certain quality
 - Marking – scheduling – policing at ingress
 - Scheduling according to p-bits or ToS in intermediate nodes
 - Scheduling (and possibly policing) at egress

- 5 Release of resources: user ending the application, or DHCP release

> Example of High Speed Internet by means of PPP

- Assumptions: L2 AN, routed modem, IP wholesale (PPP terminated in BRAS)
- DSL modem and PC powered on
 - modem establishes PPP connection to BRAS, and gives PC a private IP address
- Network learns about L2/L3 parameters during PPP establishment
 - L2 AN and Ethernet switches perform MAC learning for modem and BRAS
 - BRAS remembers assigned IP address and notifies core network by means of routing protocol
- Data transfer
 - User sends IP packets to a server far far away in the internet
 - In RGW (or PC) packets encapsulated into PPP session
 - In the L2 Access Node and intermediate Ethernet switches; packets sent to BRAS based on Ethernet destination within the VLAN
 - In the Edge Node, forwarded based on IP destination into core network
 - Server responds to the user
 - Crosses the internet and core network to the Edge Node
 - BRAS forwards packet into PPP session/tunnel
 - Network brings packet through tunnel up to RGW

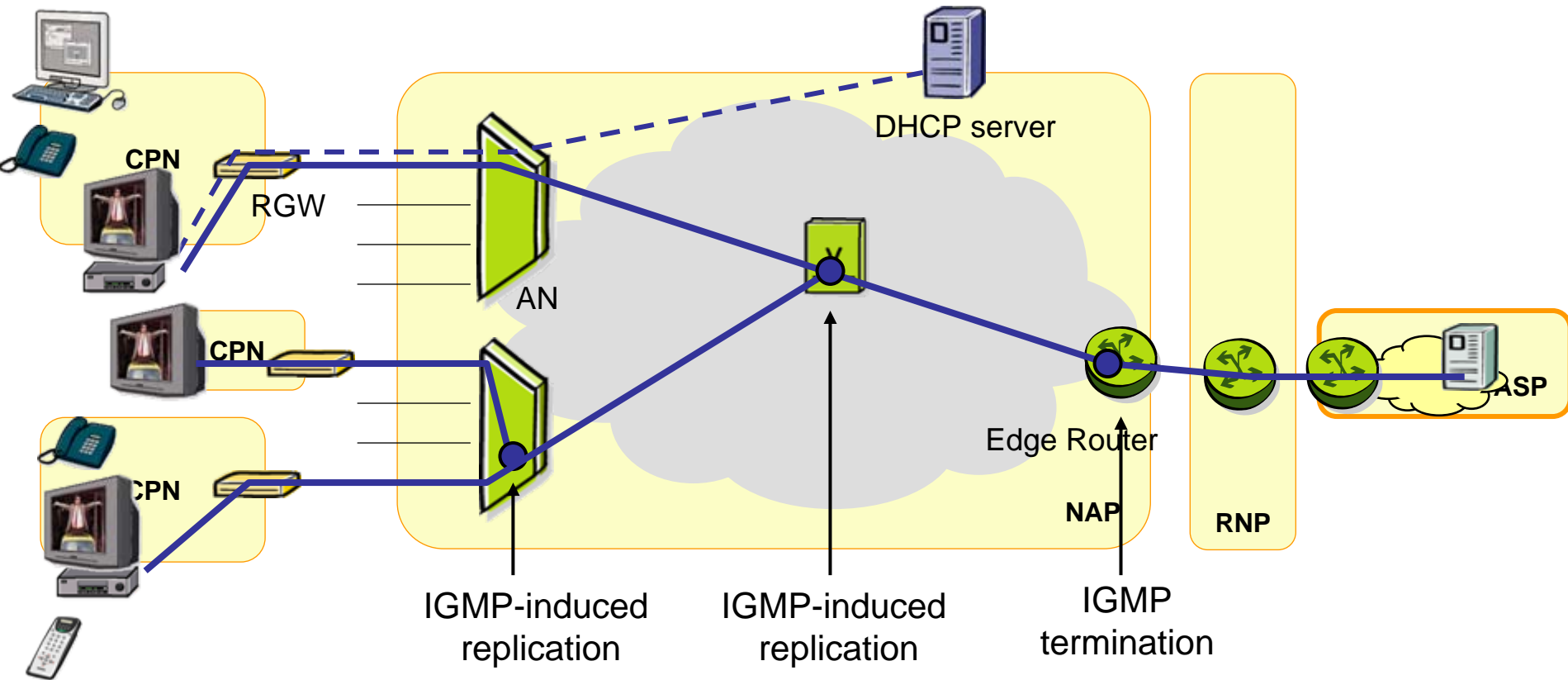
Unicast connection



> Example of IPTV

- Assumptions: L3 AN, bridged modem, IPTV service offered by ASP (retail user)
- User switches on his TV and STB
 - STB autoconfigures by means of DHCP to DHCP server in the access network
- The network learns about L2/L3 parameters
 - (depends on type of AN (L2 or L3))
- STB downloads Electronic Program Guide
 - Gives correlation between channel and multicast IP address to be asked for
- User zaps to a channel
 - STB sends IGMP leave for the old channel and IGMP join for the new channel
 - Depending on place where the channel was already present, new leaf/branch in the multicast tree is built by IGMP snooping.

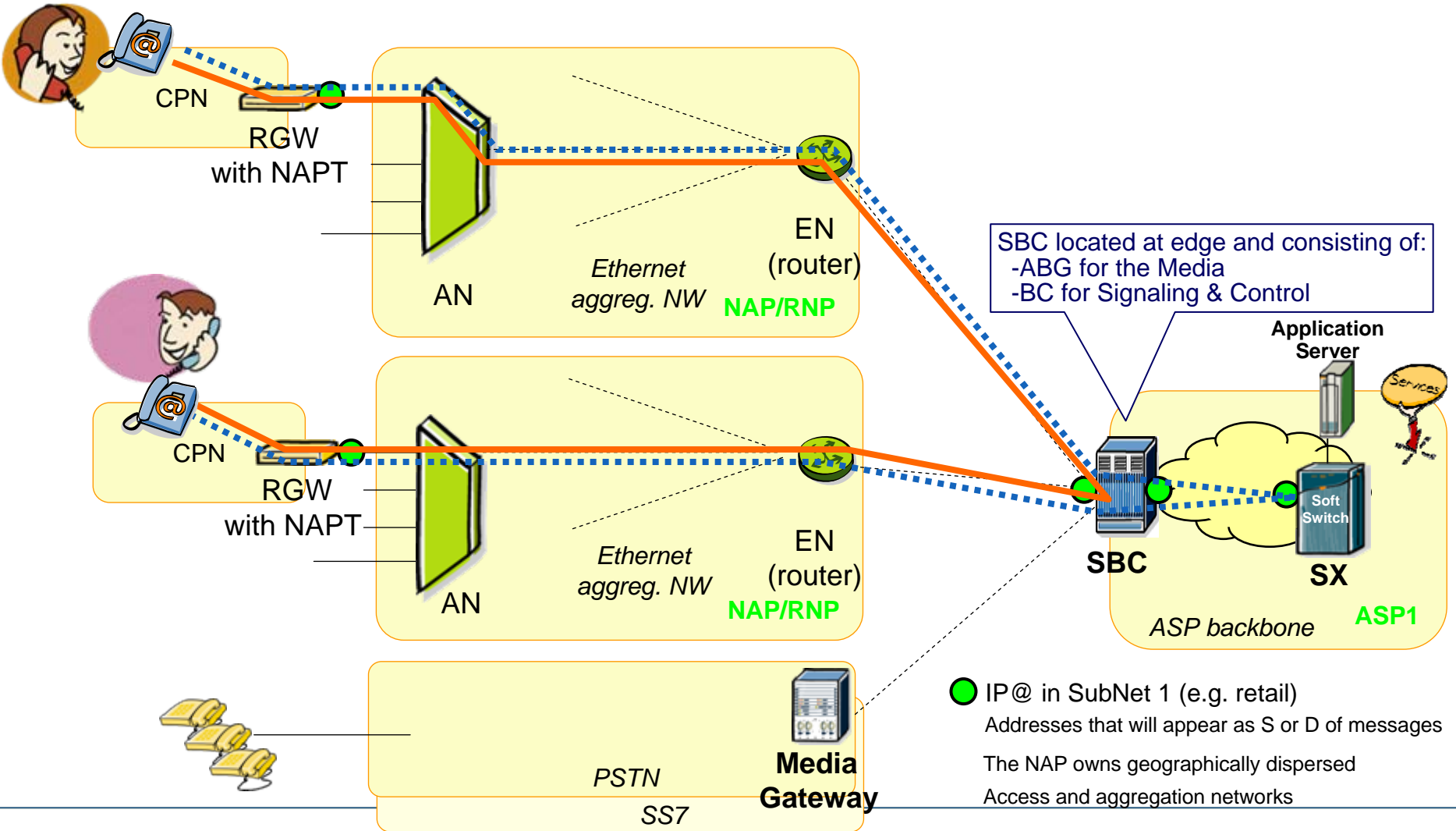
Multicast connection



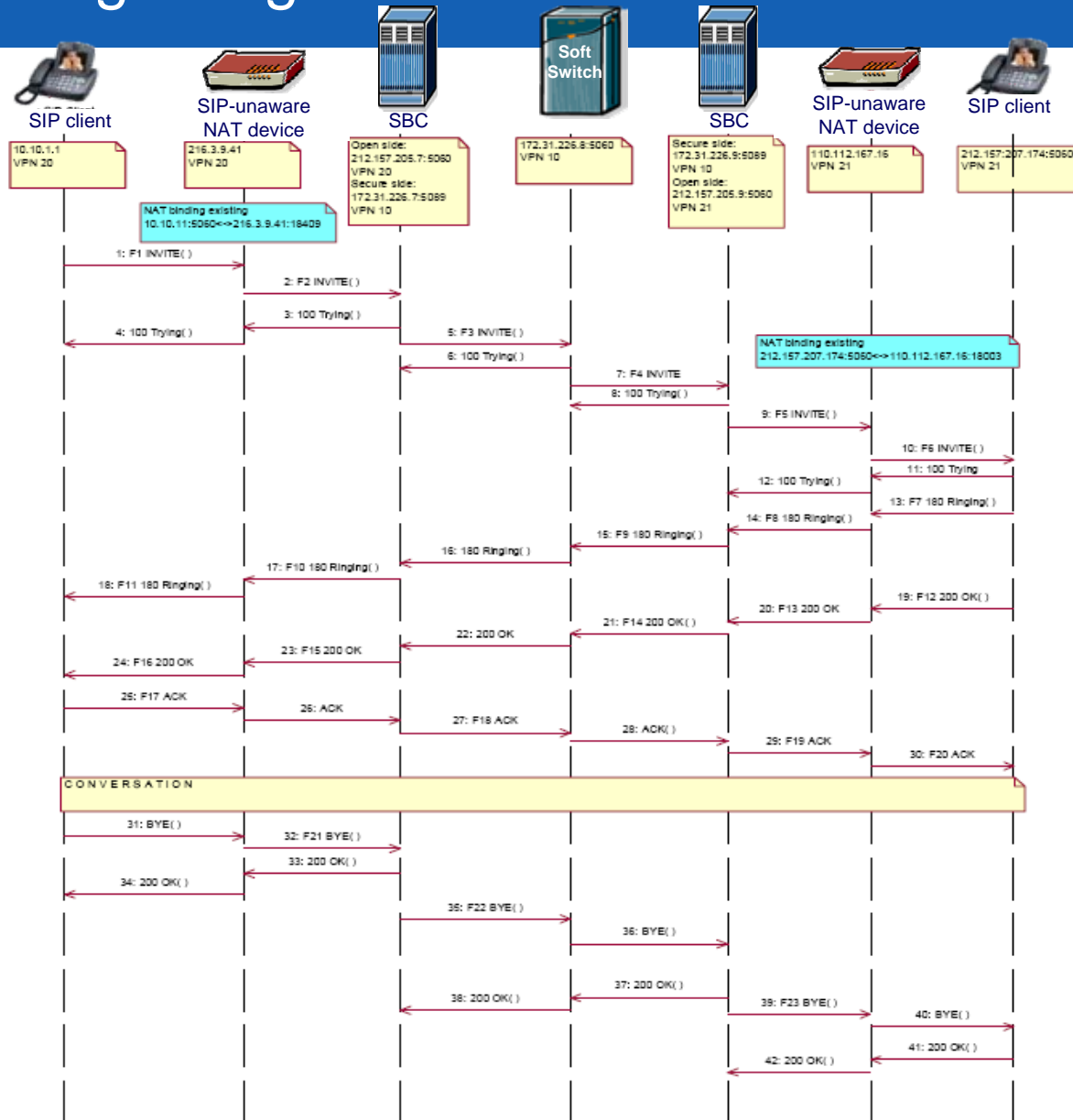
> Example of conversational service (VoIP)

- Application-specific elements
 - Softswitch (SX)
 - Registrar and location server
 - Session Border Controller (SBC)
 - Media Gateway
- Starting point
 - L2 and L3 connectivity is established
 - Some extra application-specific parameters have been configured at end-user
- Following actions, based on SIP signaling
 - User registers to the network (user, IP address, location)
 - Calling party invites Called Party
 - Called party answers request
 - Parameter negotiation between parties (e.g. type of codec)
 - Throughout, network (SBC) keeps track of IP addr and ports to perform NAT traversal
 - <<< **CONVERSATION** >>>
 - One party ends the call, releasing the mappings in the network (SBC)

VoIP call



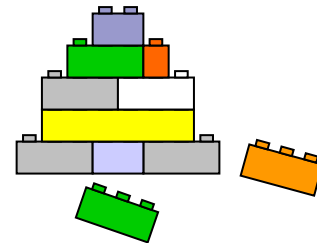
VoIP call: signaling flow



More than connectivity...

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- > Several additional dedicated architecture parts, going beyond pure connectivity (data plane).
 - Configuration and update of data sets for data plane (Control plane)
 - Authentication and authorization of end-users
 - IP address allocations
 - Resilience: doubling of nodes and links for protection, switch-over mechanisms
 - QoS: Admission Control (possible architecture: IMS)
 - OAM (management plane)
 - Network management system (performance and fault monitoring, provisioning)
 - Element management (e.g. a DSLAM)
 - Important special case; CPE management (Auto-Configuration Server)
 - Subscriber management (e.g. authorizations)
 - Service and policies management
 - Accounting and billing
 - Generating and processing CDRs and statistics
 - Used for billing generation and SLA control with customer and other providers



- > Also, some functions don't necessarily have to be centralized and can be embedded into existing nodes (distributed architectures)
 - Generic
 - QoS: admission control at ingress points of the network
 - Performance monitoring to estimate Quality of Experience
 - TCP accelerator
 - Application specific
 - SBC: NAT traversal, pinholing etc... can be done in the Access Node
 - Caching for popular multimedia content



Shaping the scene; standardisation



- > Standards are crucial for telecoms
 - Mission:
 - Define requirements and capabilities of a technology, subsystem or architecture
 - Promote interoperability of equipment : open interfaces, standard protocols
 - Realistic footnote:
 - it is also a playground for company-centric lobbywork, competitive positioning and strategy promotion
 - But beyond the quibbles standardisation has proven benefits
 - for users: compatibility of equipment and services (e.g. GSM roaming)
 - for providers: choose equipment from competing vendors (avoid lock-in)
 - for vendors: reduce amount of customer-specific developments
- > Important SDOs (Standard Developing Organisations);

