Access Network Technologies

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Overview

- 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

Please note: strong focus on fixed access networks

Applications and requirements

Consumer's perspective

- 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)

Consumer's perspective

- End-user expectations
  - Accessability 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)

Impact on the telecom networks

- 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

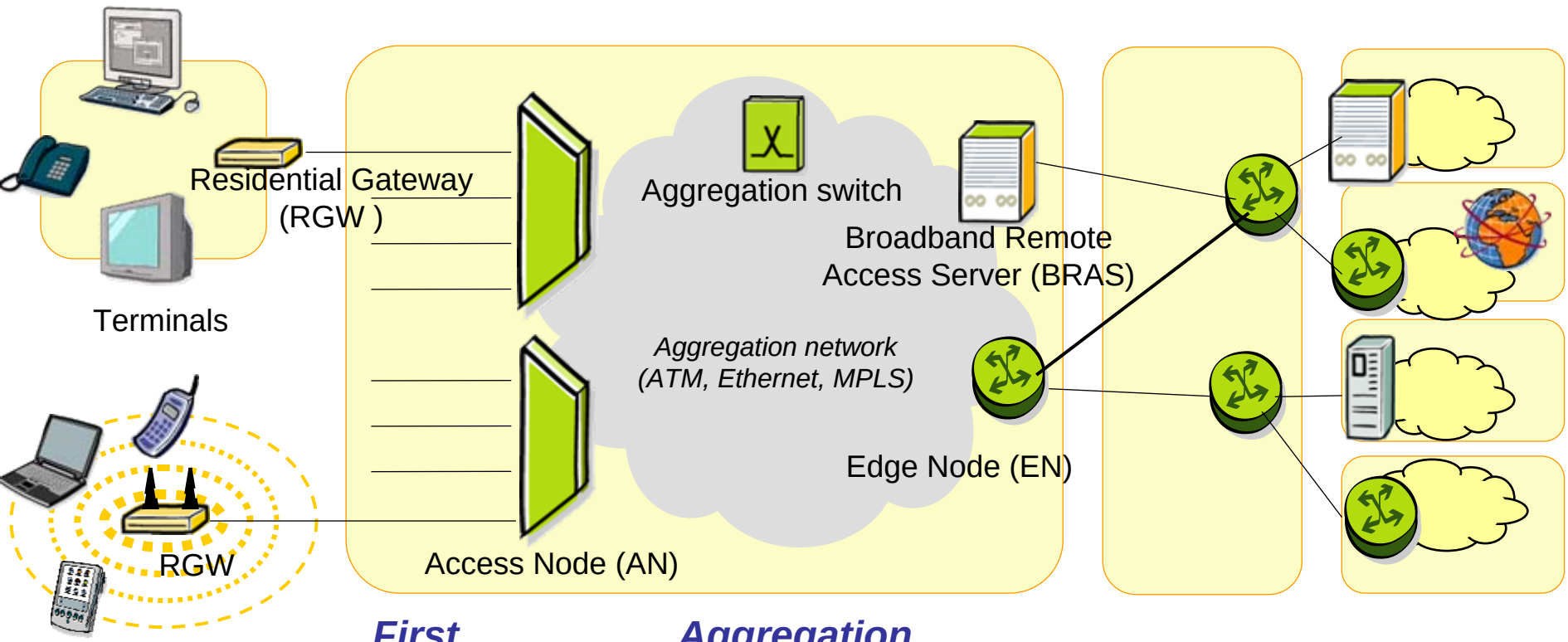
Characteristics of BB connectivity

- 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:

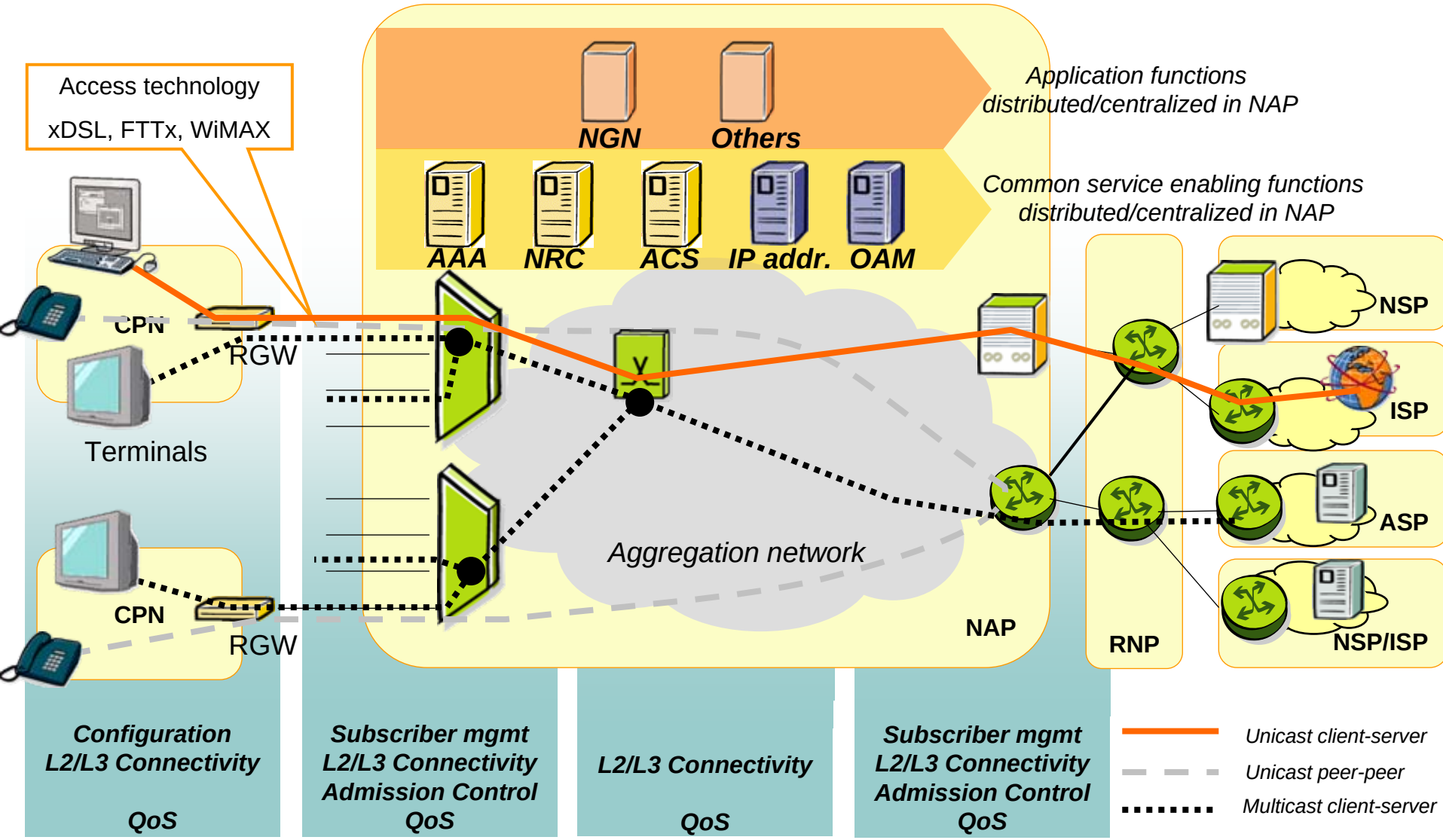
# connected parties / *Location of the source*	***Point-point***	***(Multi-point) Multi-party***
Source in the network	**Client / Server unicast**	**Client / Server multicast** **- Network-level multicast (Multicast tree in network)**
End-user as source	**Peer-Peer unicast**	**Multi-party P2P** **- application-level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

Architectures and technologies

Networks

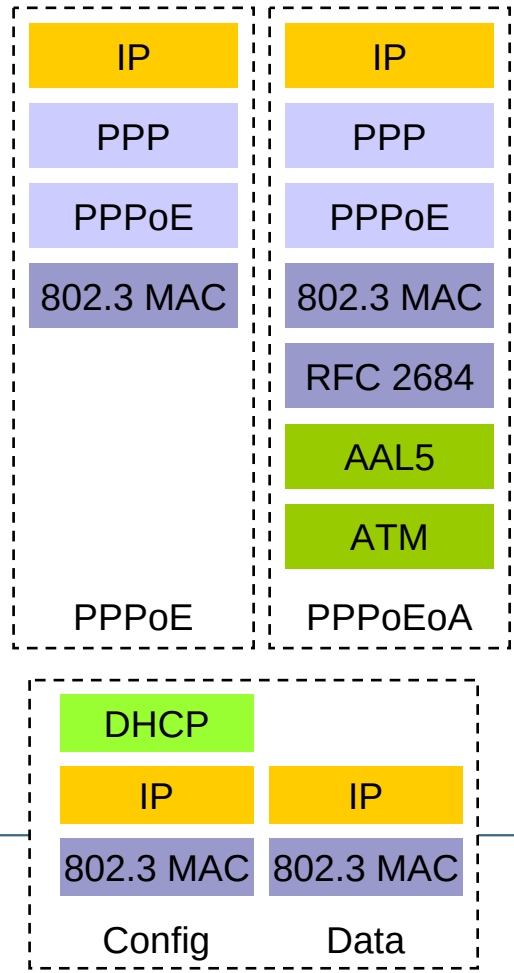

Residential Gateway
(RGW)
Terminals
RGW
Aggregation switch
Broadband Remote
Access Server (BRAS)
Aggregation network
(ATM, Ethernet, MPLS)
Edge Node (EN)
Access Node (AN)
Customer
Premise
Networks
First
Mile
Aggregation
Networks
Regional
Network
Service
Network
Access Network

Connections in BB access networks



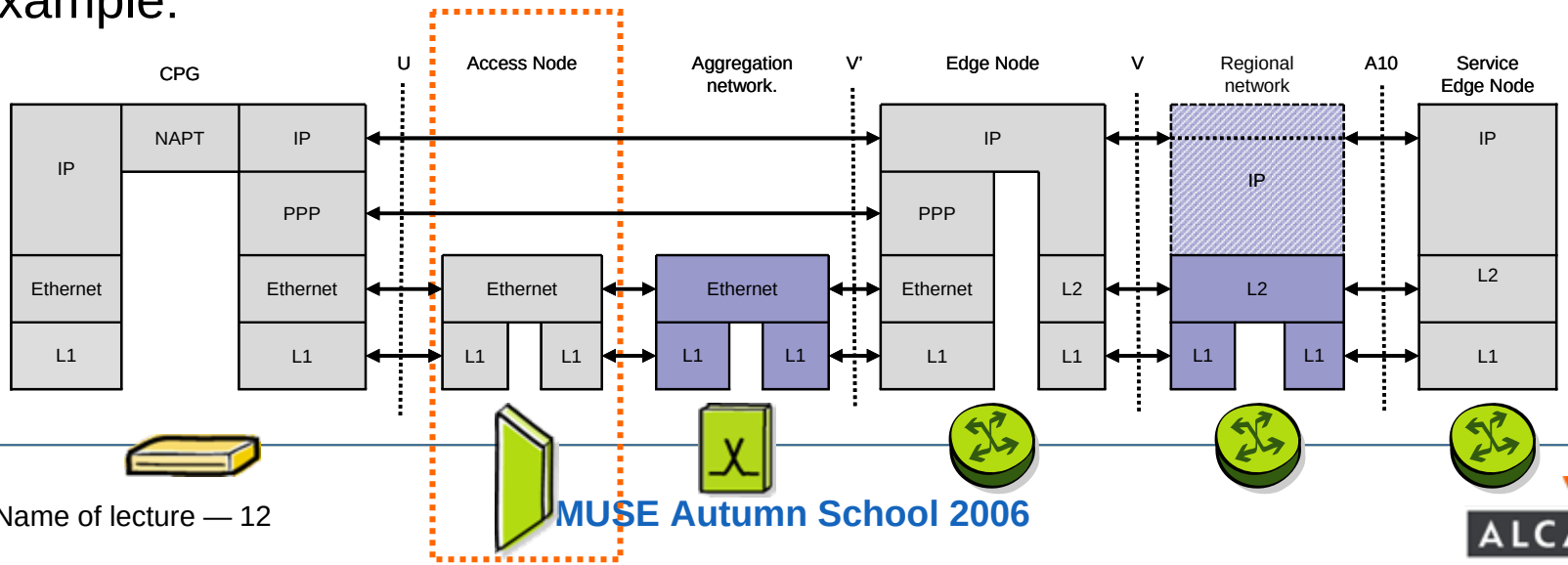
Technologies for Broadband access: protocols

- 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



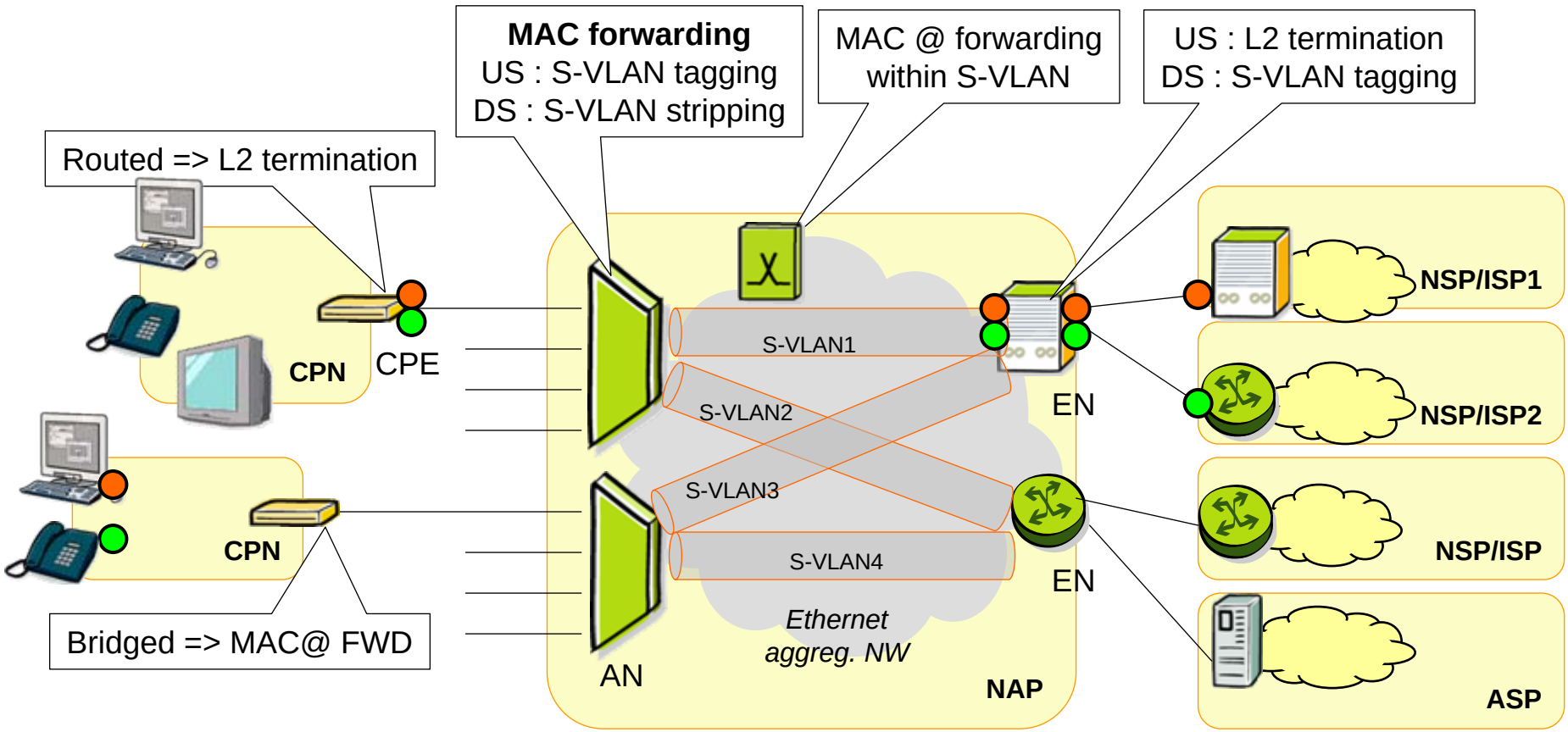
Technologies for Broadband access: data plane

- 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:



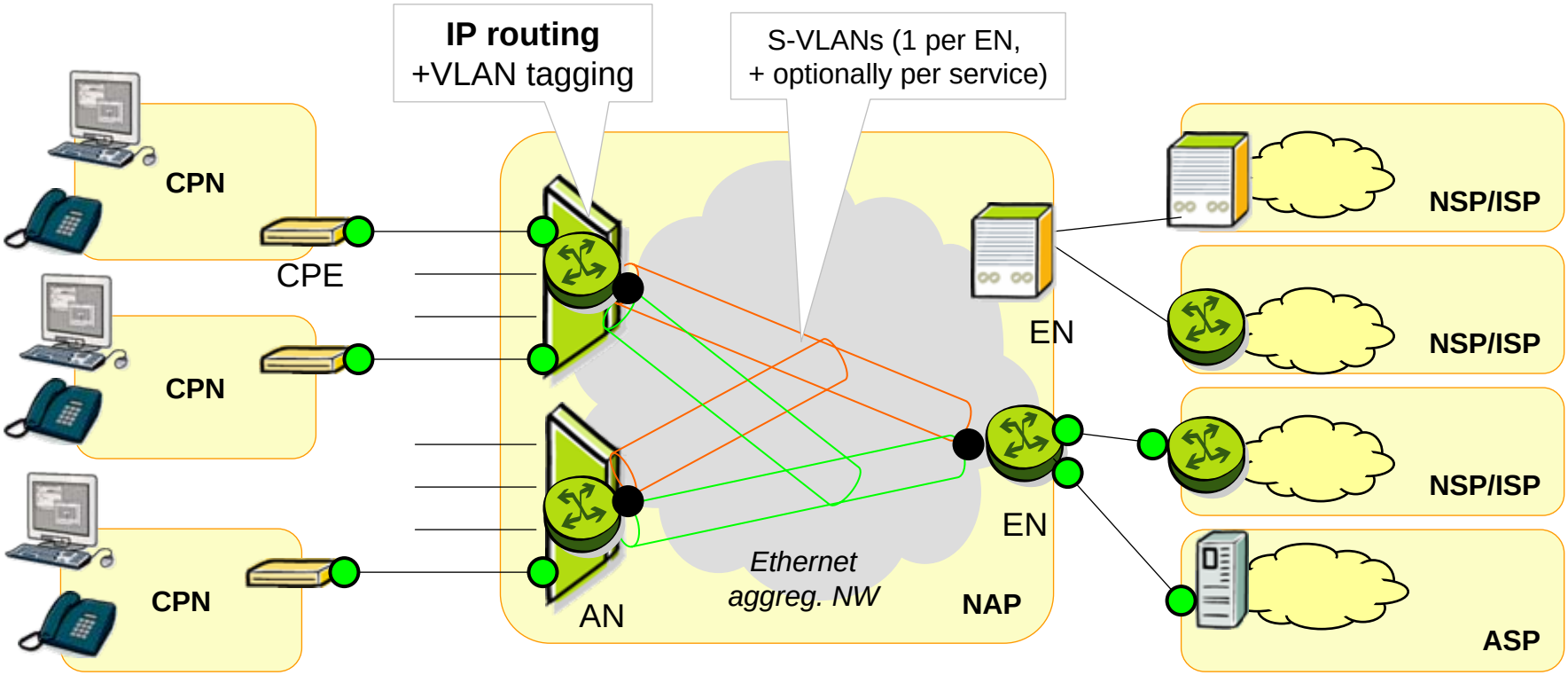
Data plane: packet forwarding

> Forwarding models in the access network: L2 oriented



Data plane: packet forwarding

> Forwarding models in the access network: L3 oriented



Connections and sessions

- 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

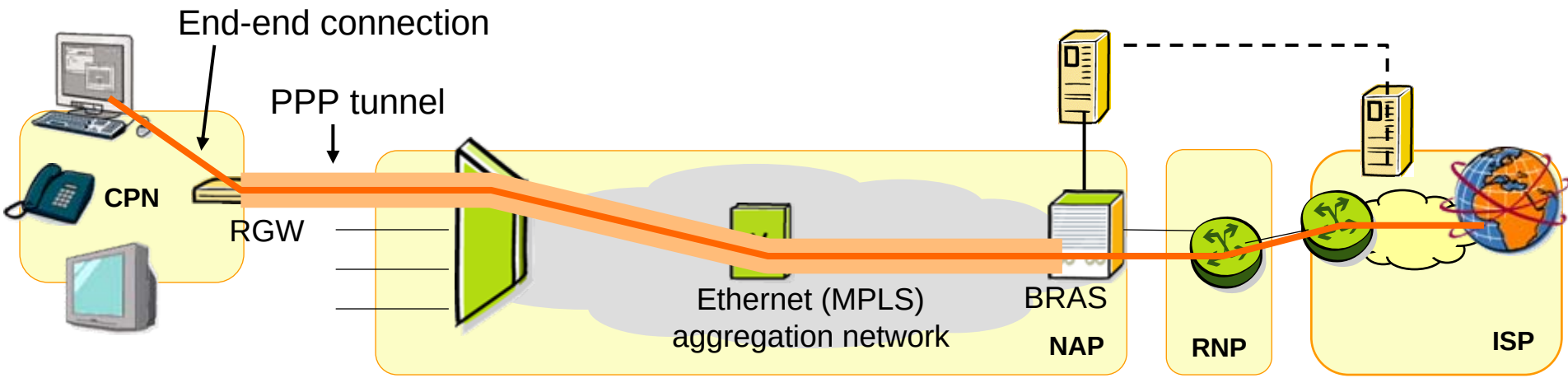
- Marking – scheduling – policing at ingress
- Scheduling according to p-bits or ToS in intermediate nodes
- Scheduling (and possibly policing) at egress

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

Unicast connection

- 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

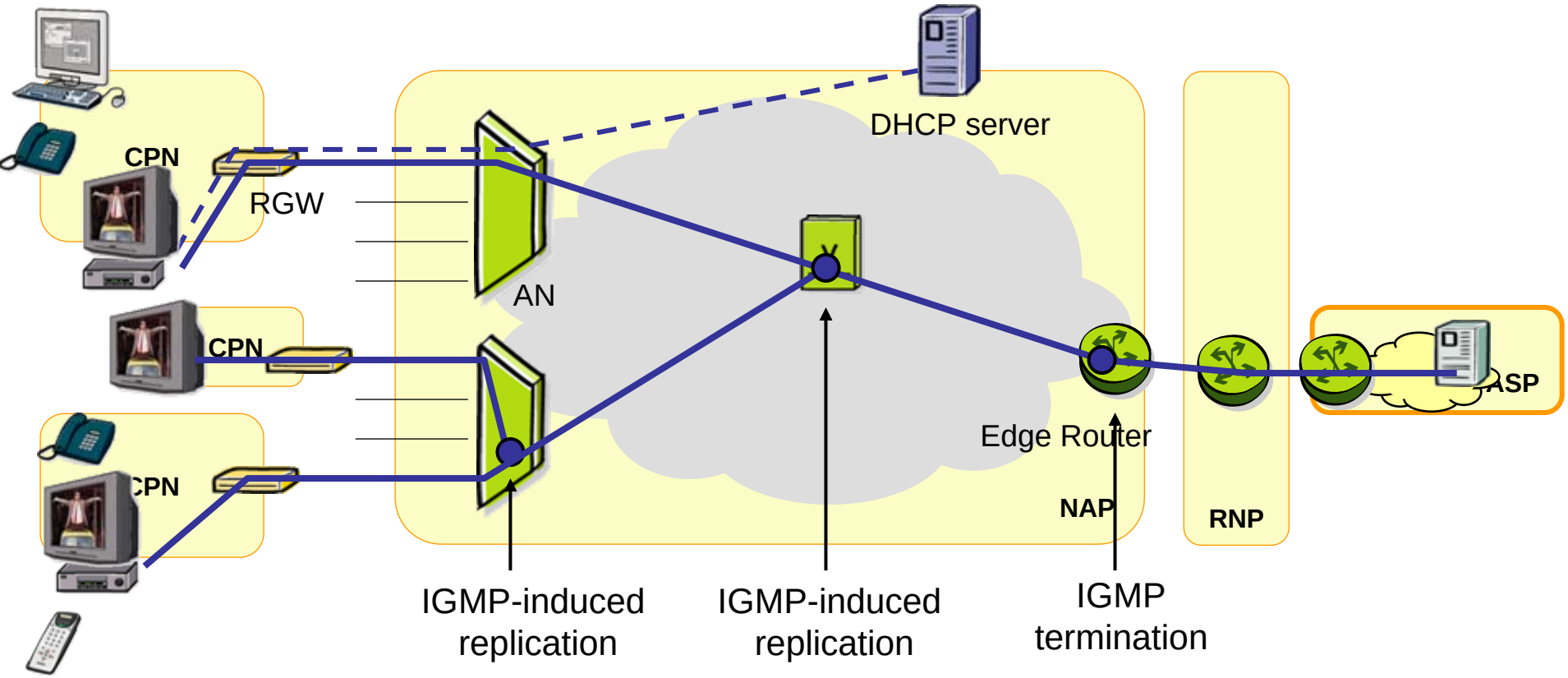


Multicast connection

> 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 Progam 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

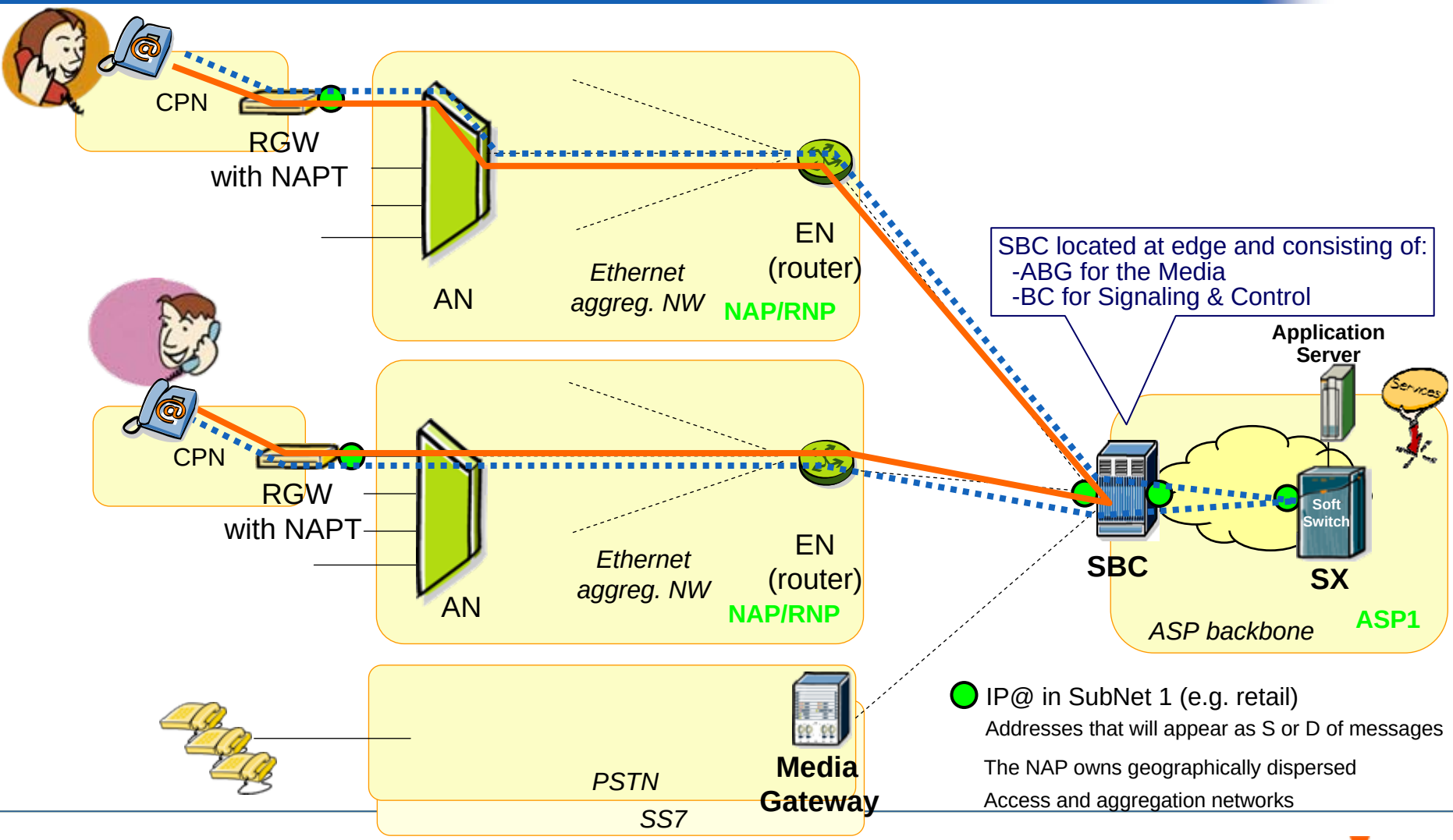


Application session awareness at L3-L7

> 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 negociation 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



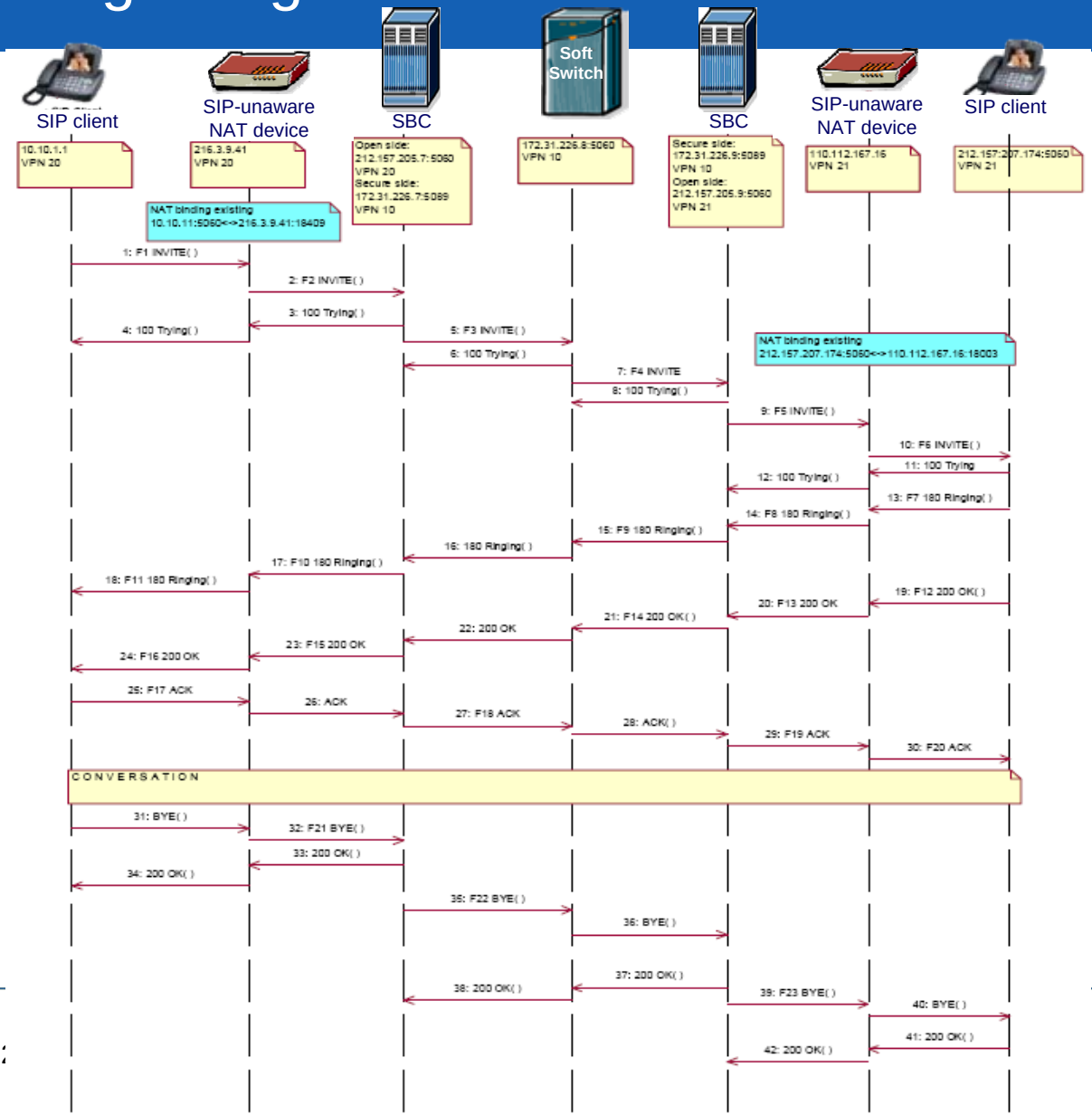
IP@ in SubNet 1 (e.g. retail)

Addresses that will appear as S or D of messages

The NAP owns geographically dispersed

Access and aggregation networks

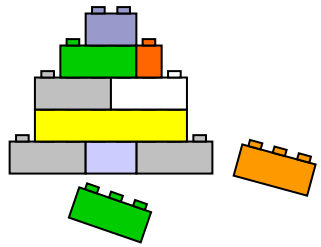
VoIP call: signaling flow



More than connectivity…

Behind the scenes

- 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



Behind the scenes

- 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 requirememements 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);

DSL FORUM, ETSI, HGI Home Gateway Initiative, IETF, ITU International Telecommunication Union, IEEE

Thank you …

Question Time