VoIP Tutorial

Jim McEachern
jmce@nortelnetworks.com

MPLS 2004

NORTEL NETWORKS™

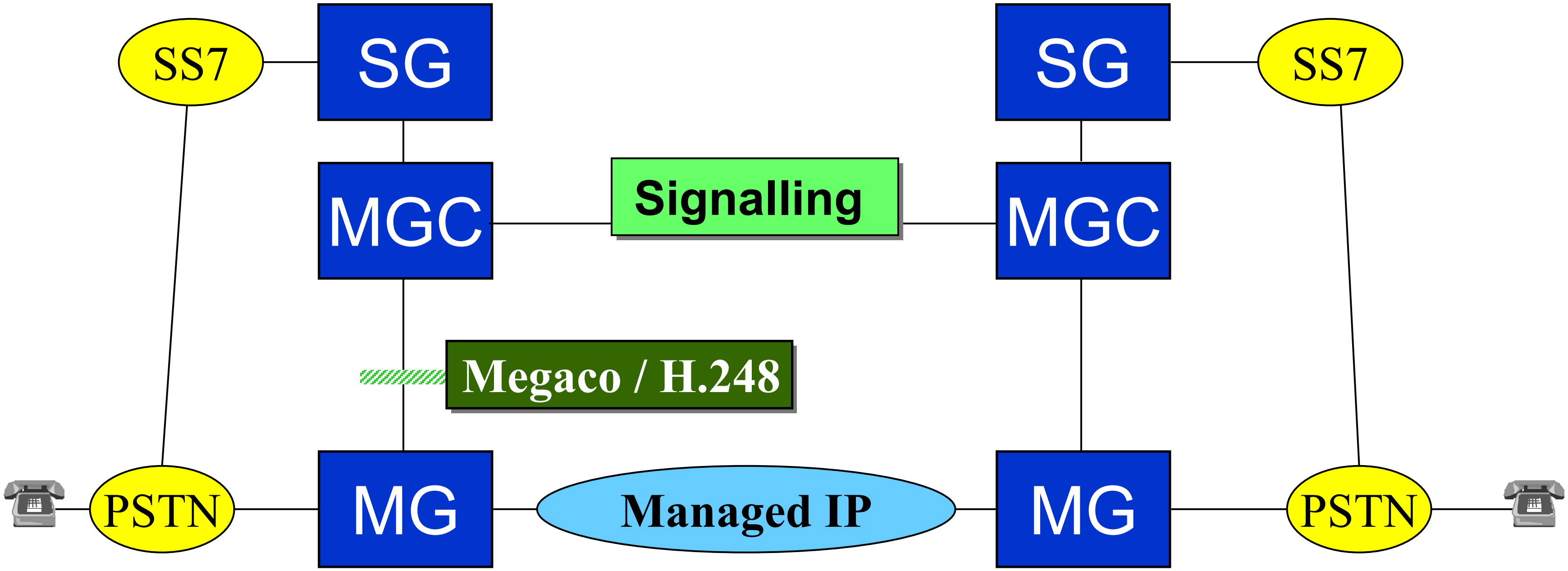
Outline

- VoIP Standards & Architecture
- "NGN": Next Generation Network standards
- QoS
- Carrier VoIP Requirements
- ENUM
- VoIP Interconnection

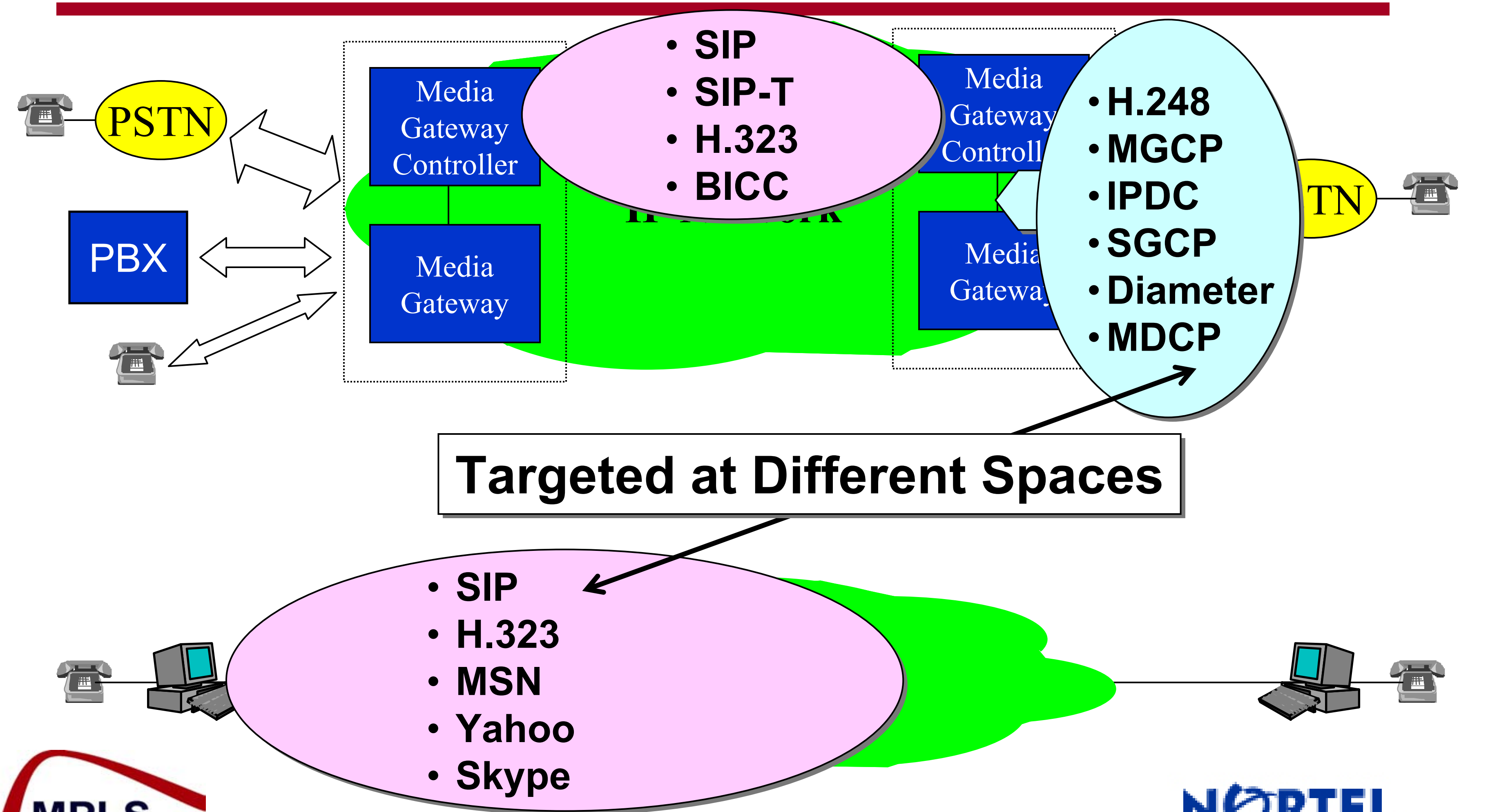
VoIP Standards

- H.248
- H.323
- BICC
- SIP
- SIP-T
- SIP-I
- ...

IETF Megaco Working Group



H.248? or SIP? or H.323? or MGCP?



MPLS 2004

NORTEL NETWORKS

MGCP (RFC 3435) vs. H.248 (RFC 3525)

RFC 3435 is an informational RFC, and contains the following:

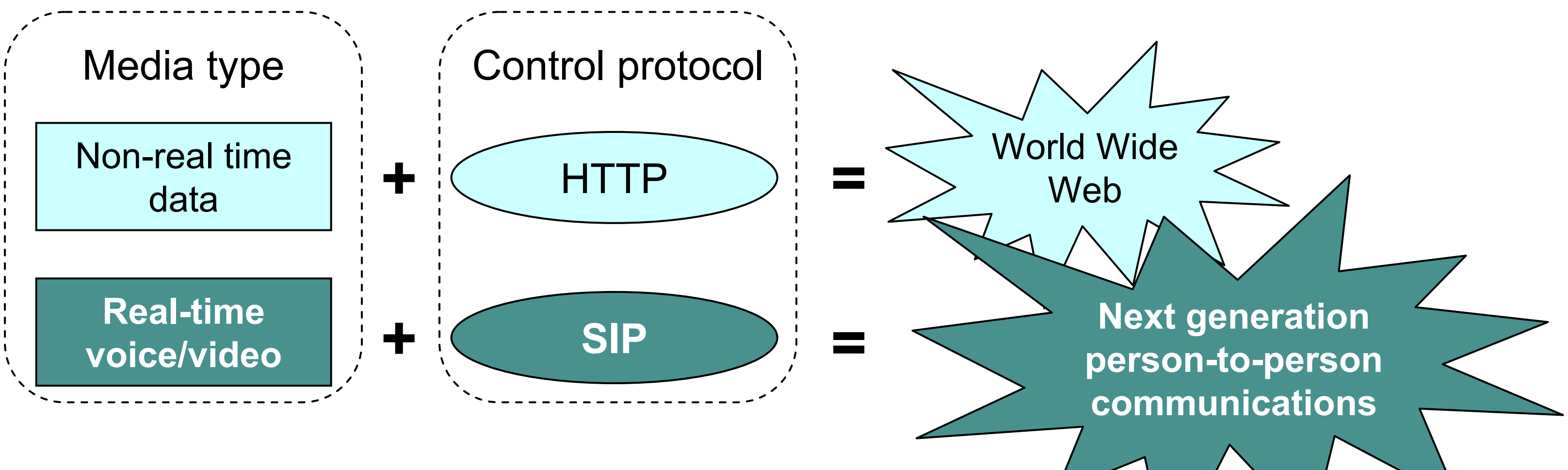
IESG Note

This document is being published for the information of the community. It describes a protocol that is currently being deployed in a number of products. Implementers should be aware of RFC 3015, which was developed in the IETF Megaco Working Group and the ITU-T SG16 and which is considered by the IETF and ITU-T to be the standards-based (including reviewed security considerations) way to meet the needs that MGCP was designed to address.

Note: RFC 3015 has now been updated by RFC 3525

IP Multimedia and Session Initiation Protocol (SIP)

- **SIP – Internet Engineering Task Force (IETF)** defined protocol for session based real-time multimedia
- **IP Multimedia provides a framework** for a wide range of services developed and deployed using Internet techniques
- **Ubiquitous access** (any time, any place, any device, any bearer)
- **SIP allows integration** of voice and video services

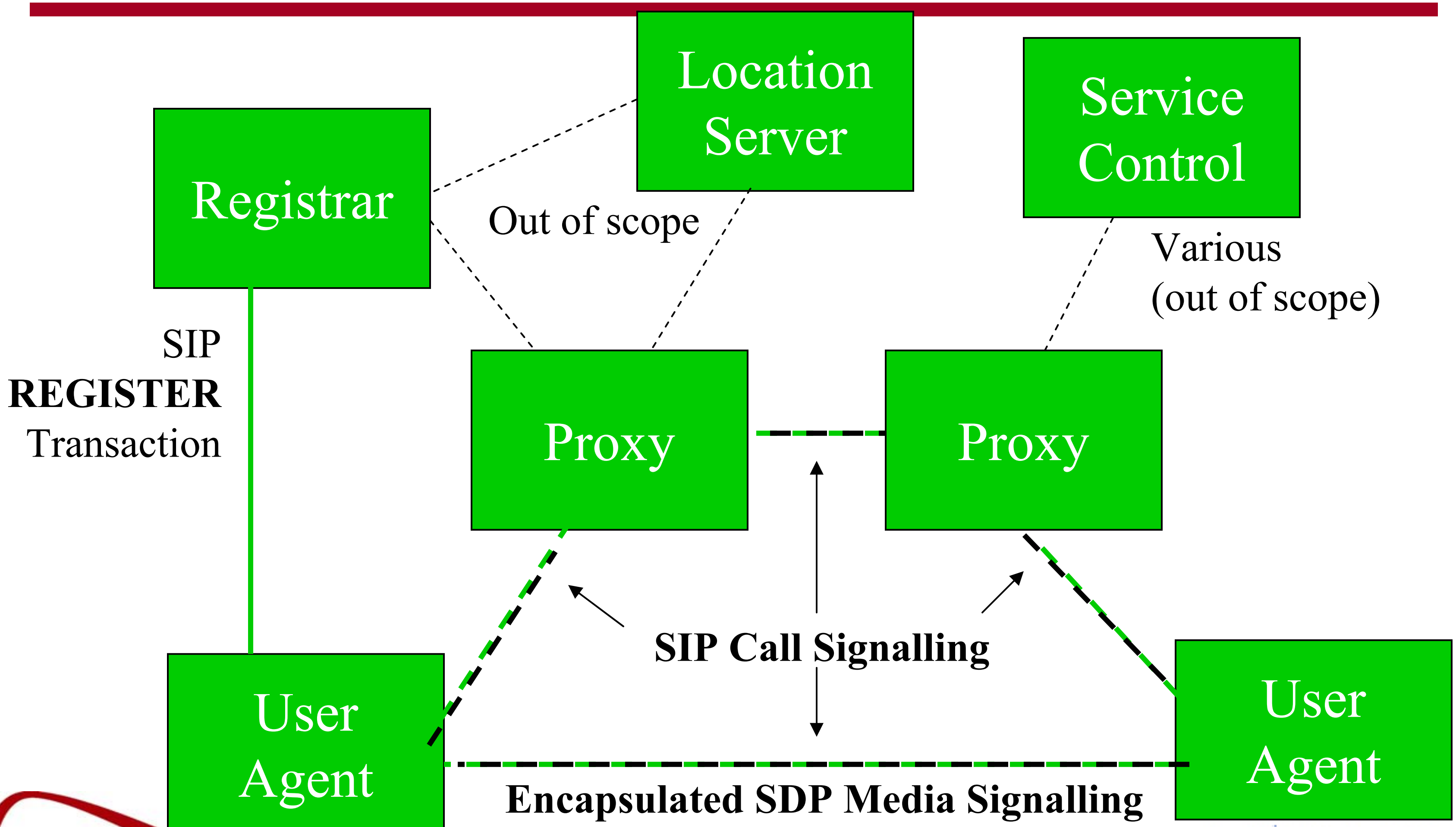


SIP looks like HTTP and SIP addresses look like Web addresses
SIP controls media for all types of service, non real time and real time, and provides a common framework to integrate those

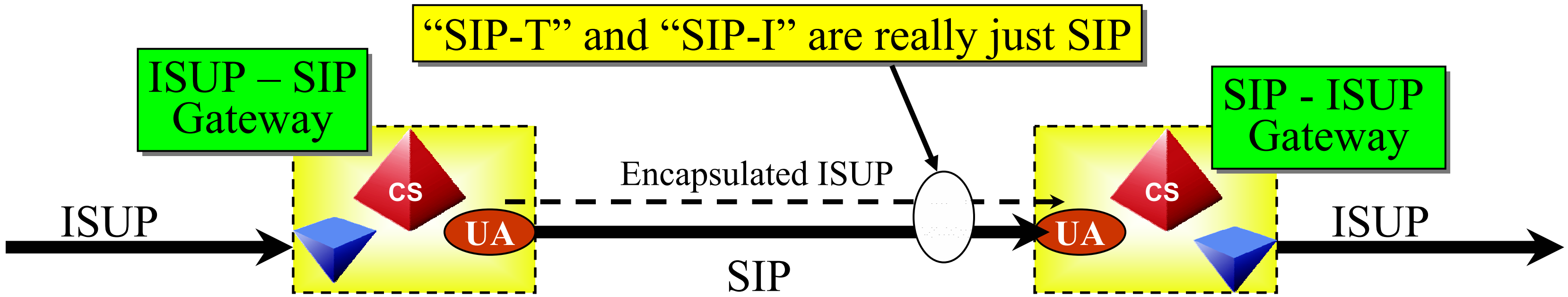
Value of SIP Protocol

- **Abstracts media type**
  - **Value** => common set of services for all media types
- **Utilises Internet-style service creation**
  - SIP and HTTP are part of the same family of protocols
  - **Value** => fast and innovative real-time services
- **Services at the edge**
  - Services can be deployed end-to-end via client (but also supports network based services)
  - **Value** => fast and innovative real-time services
- **Extensible**
  - SIP is text based (like HTTP), very easy to add extensions
  - **Value** => reduced churn in the network to deploy services
- **Flexible**
  - SIP does not define the whole vertical solution (unlike H.323)
  - **Value** => deployed infrastructure can adapt to future service types
- **Scalable**
  - **Value** => network expansion and management is straightforward

SIP Architecture



SIP-T / SIP-I: ISUP – SIP Interworking



ISUP-to-SIP

- terminate ISUP messages
- full ISUP state machine
- translate ISUP into equivalent SIP messages (where an equivalent exists)
- encapsulate original ISUP message and attach to SIP message

SIP-to-ISUP

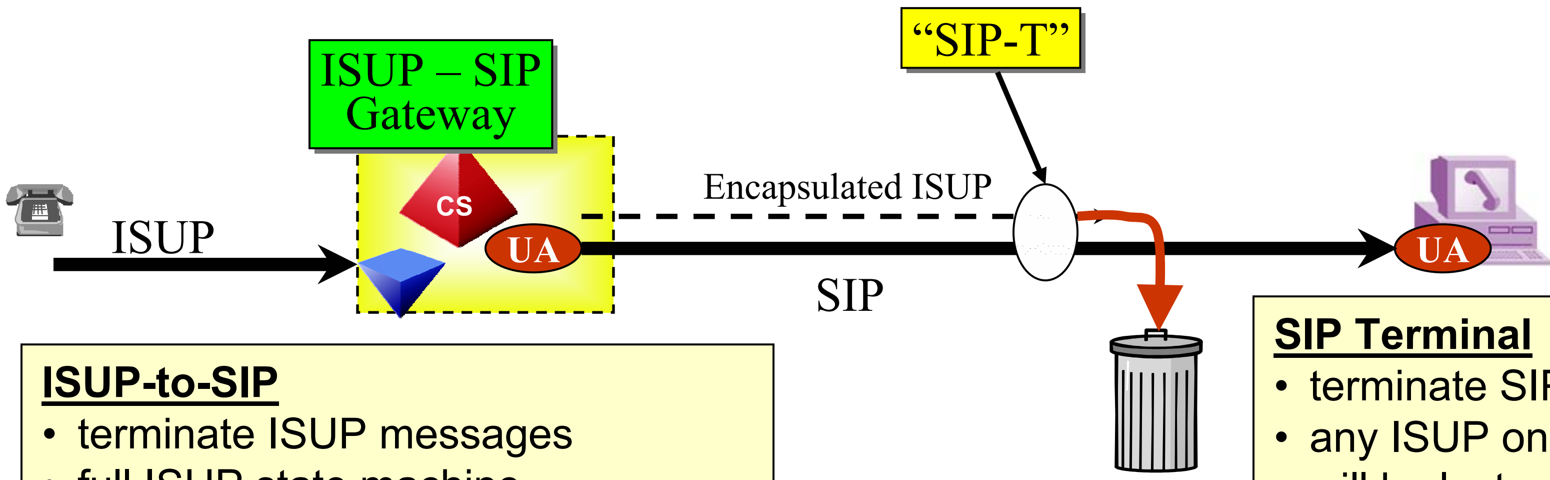
- terminate SIP message
- remove encapsulated ISUP message with partial ISUP state machine
- combine SIP and ISUP info (where there is duplication, SIP takes precedence)
- generate new outgoing ISUP message, with full ISUP state machine

Provides end-to-end Transparency for ISUP Features not Supported by SIP

MPLS 2004

NORTEL NETWORKS

Transition to SIP



ISUP-to-SIP
- terminate ISUP messages
- full ISUP state machine
- translate ISUP into equivalent SIP messages (where an equivalent exists)
- encapsulate original ISUP message and attach to SIP message

SIP Terminal
- terminate SIP message
- any ISUP only features will be lost

Helps Transition from ISUP to an all SIP Network

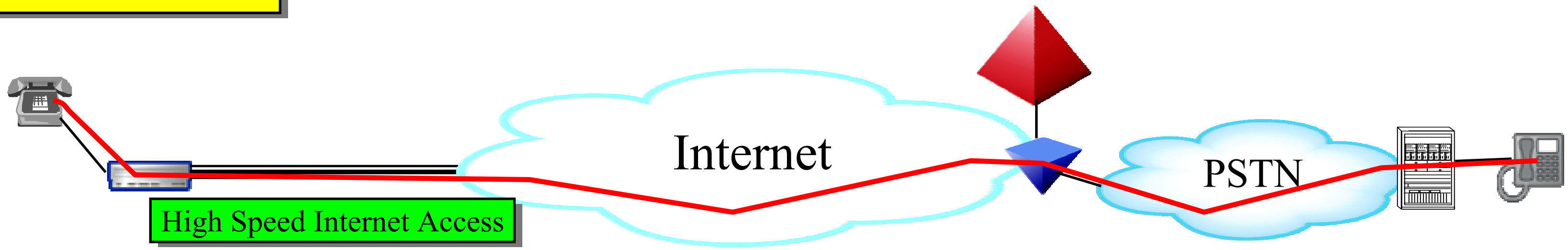
VoIP Architectures

- Toll bypass
  - Peer-to-peer
  - PSTN interconnect
- Circuit-to-packet
  - Long Distance
  - Local (Class 5)
  - Network
- NGN

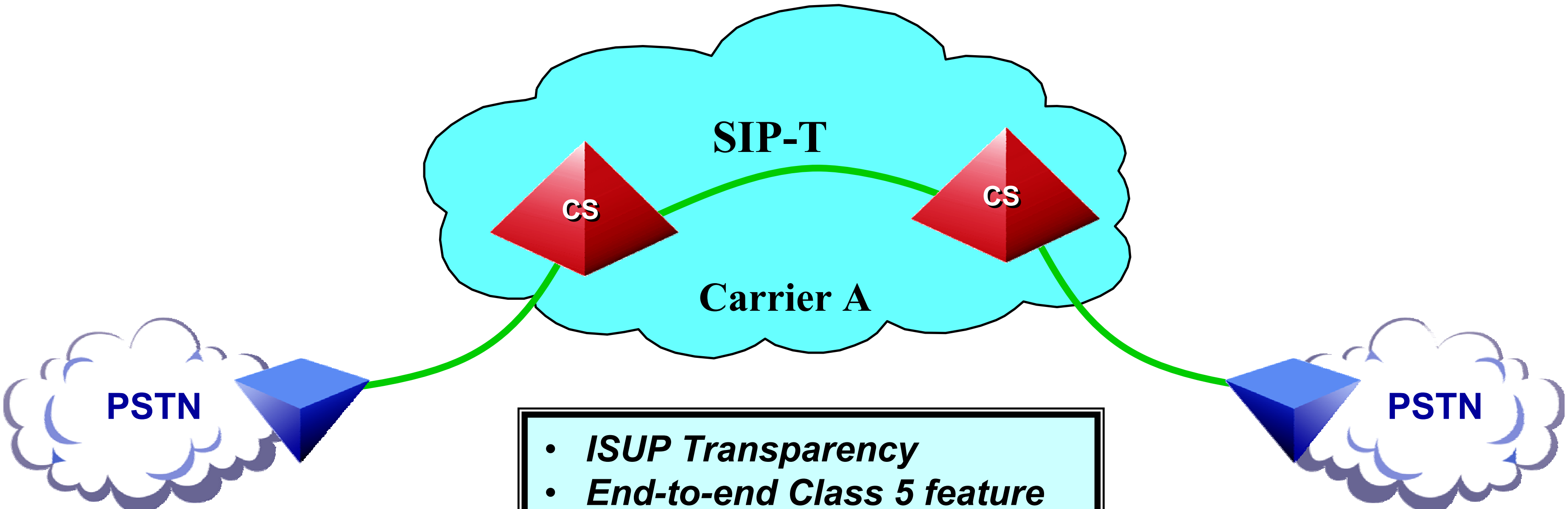
VoIP Architectures: Toll Bypass

Peer-to-peer

PSTN Interconnect



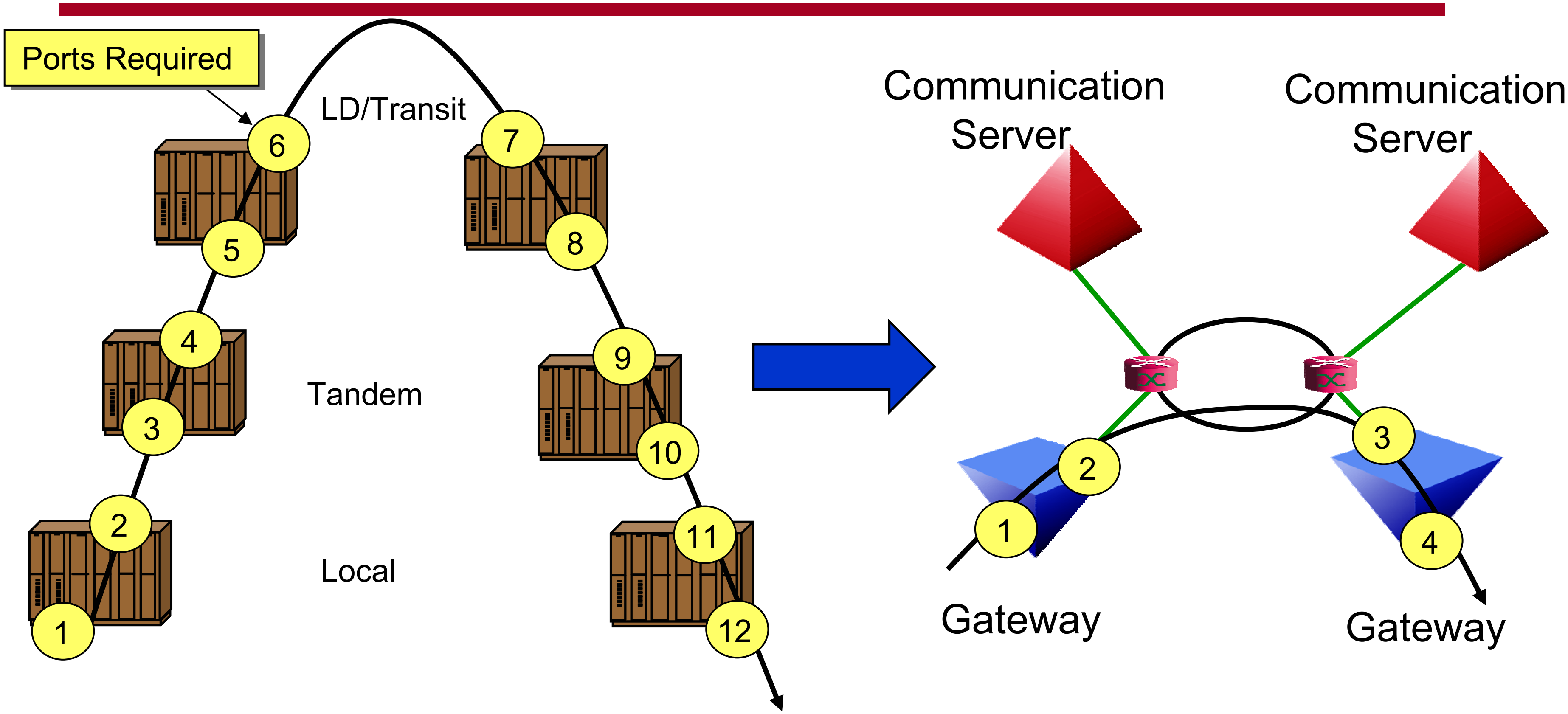
Circuit to Packet: Long Distance



- *ISUP Transparency*
- *End-to-end Class 5 feature transparency*

…Ensuring Seamless PSTN Interworking

Circuit to Packet: Long Distance

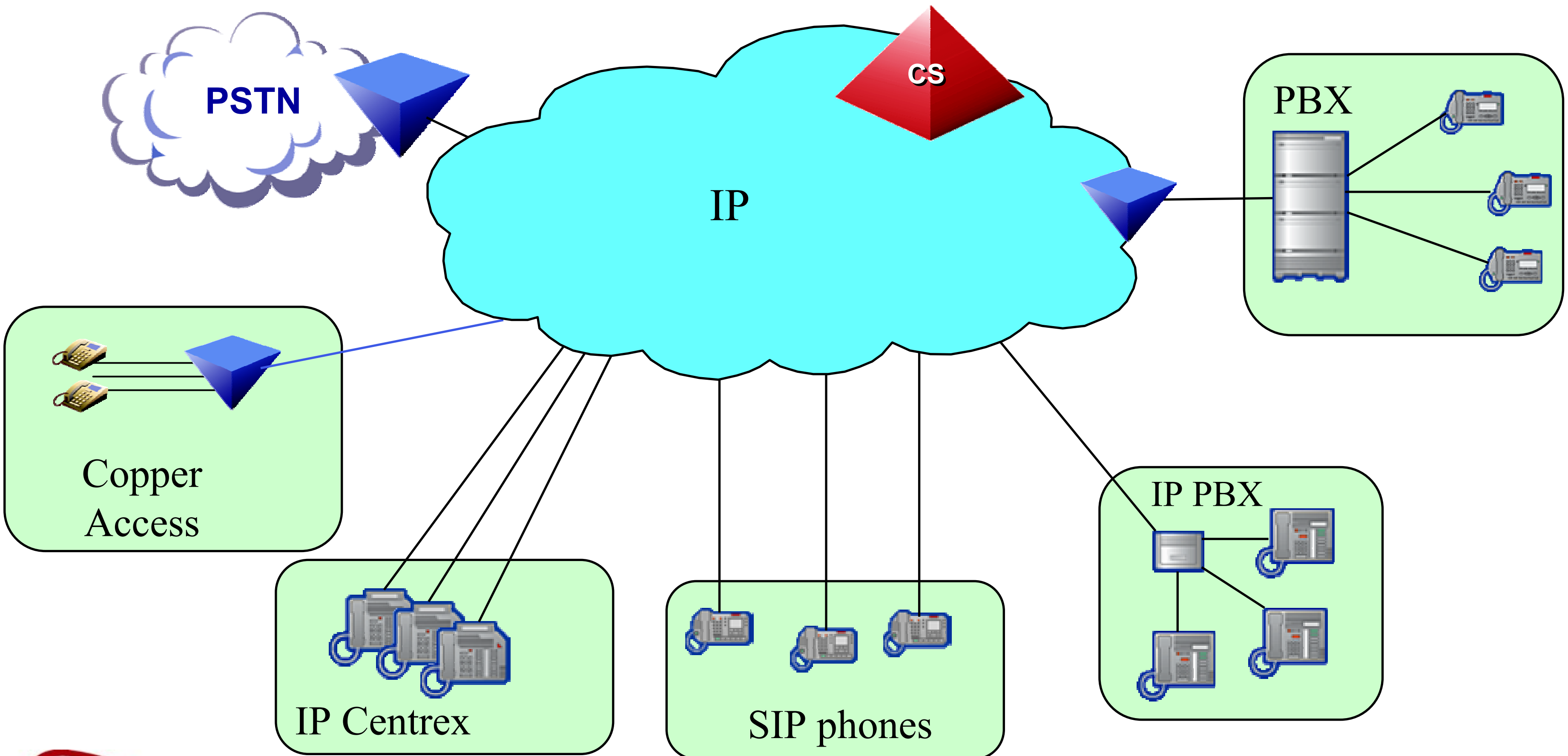


Packet Trunking greatly reduces the number of TDM trunks required

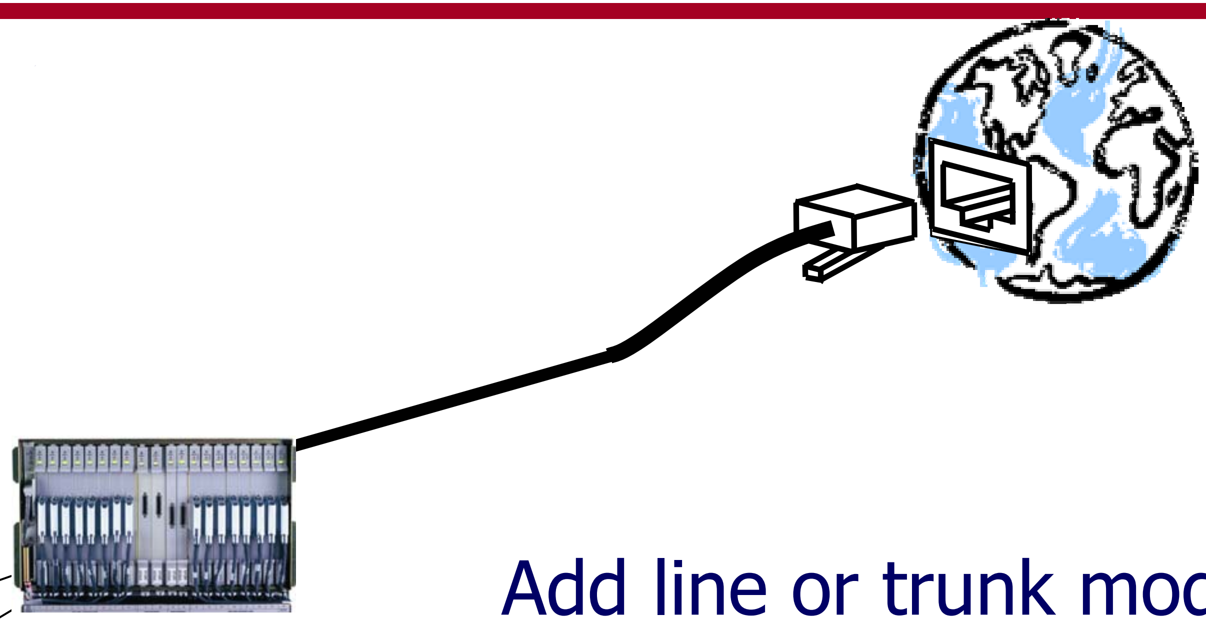
MPLS 2004

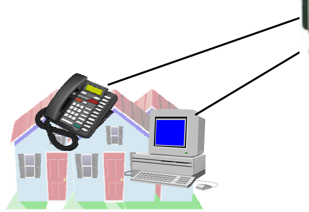
NORTEL NETWORKS

Circuit to Packet: Local (Class 5)



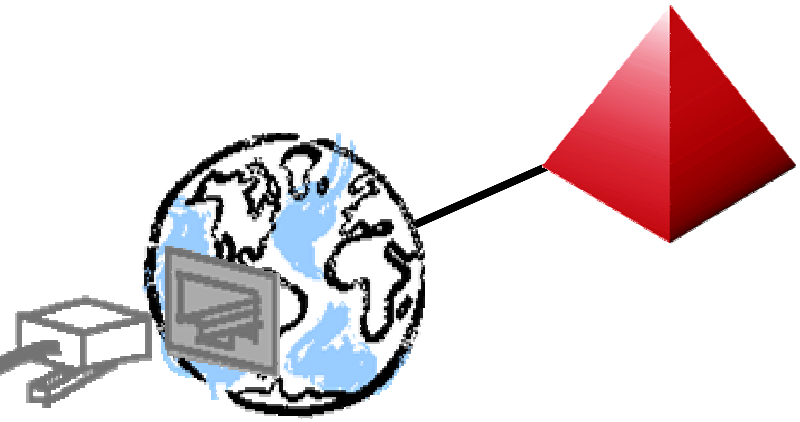
Circuit to Packet: Network Evolution

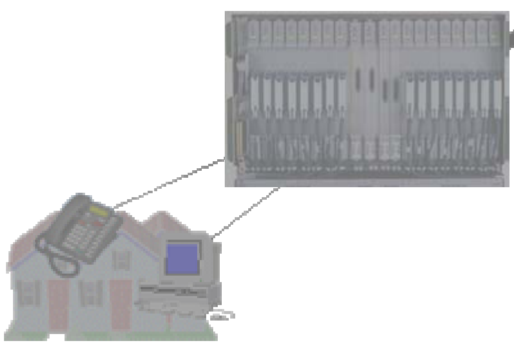




Add line or trunk module to the network at the point where access is needed

Circuit to Packet: Network Evolution





Network-based for access anywhere

Servers control access devices

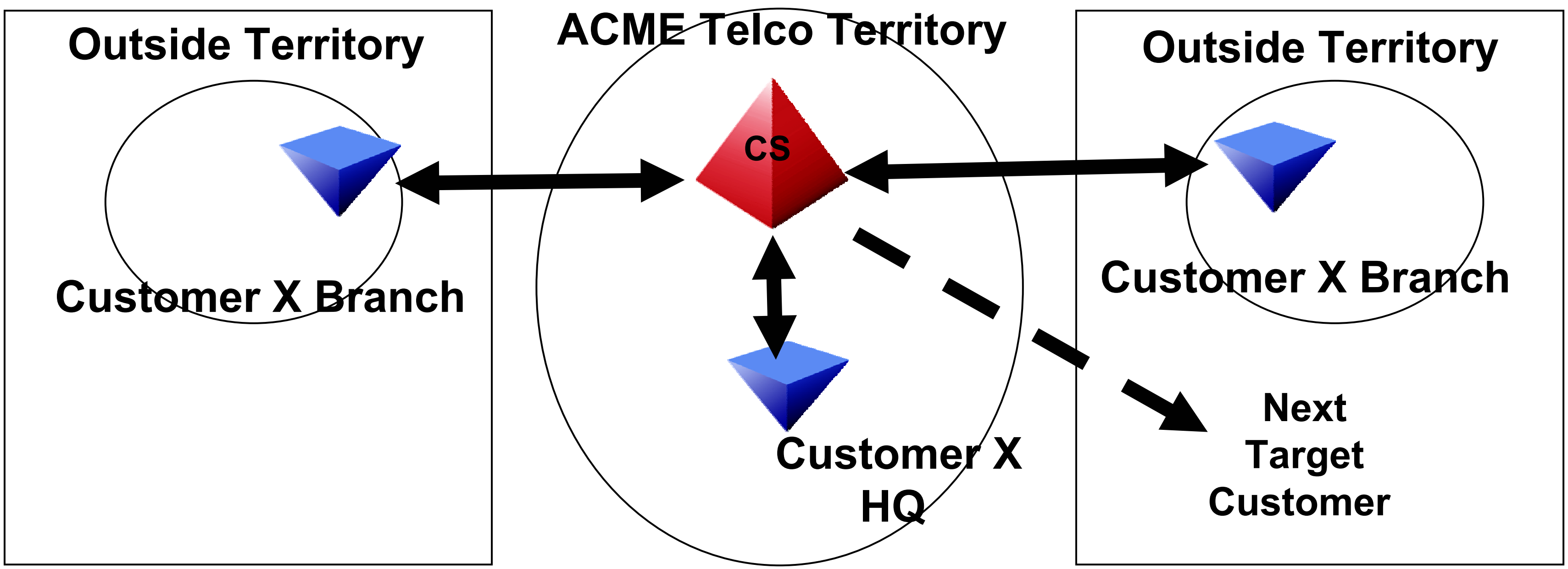
Modular!

Network growth → Add a server

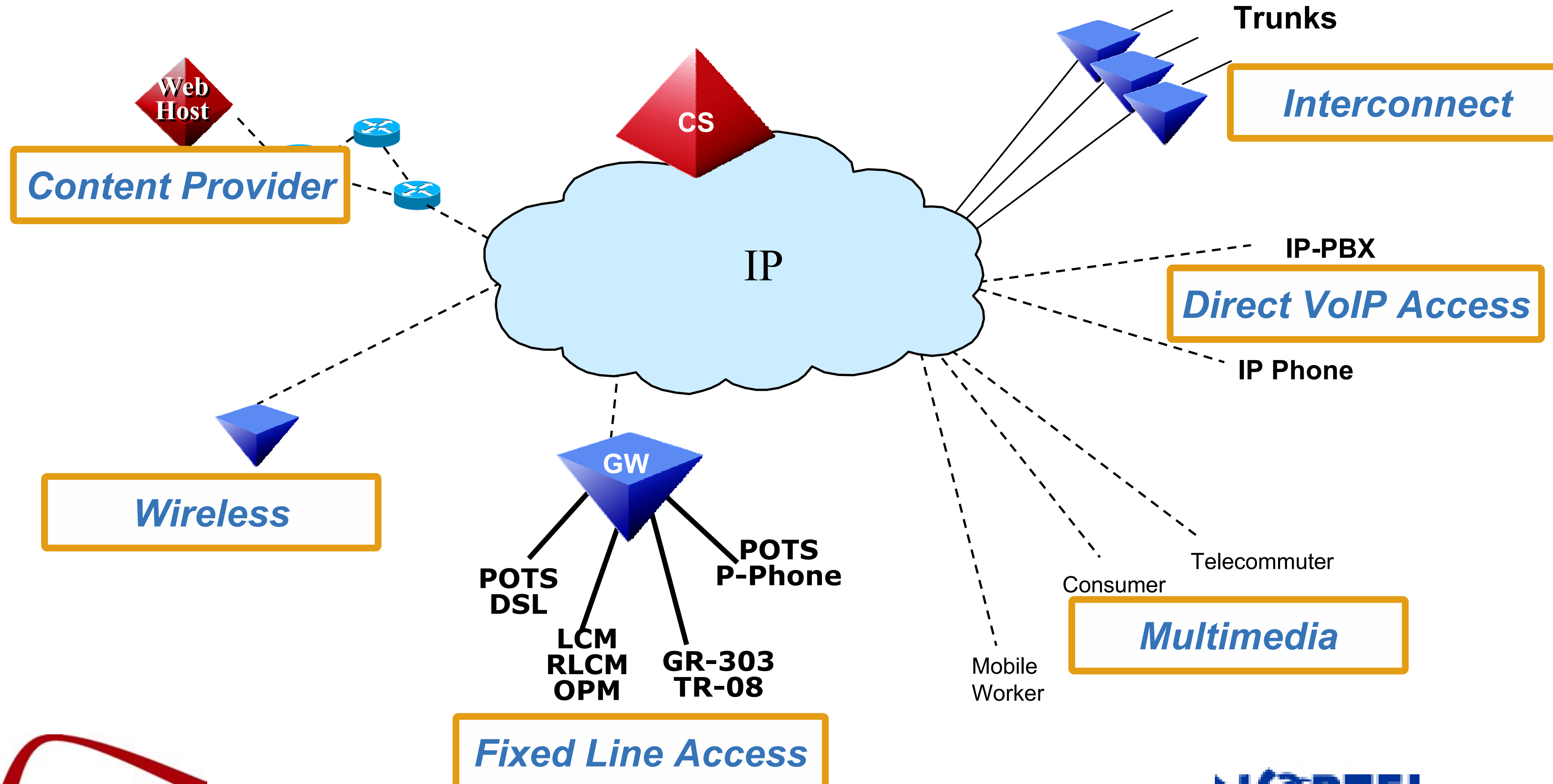
MPLS 2004

NORTEL NETWORKS™

Circuit to Packet: Network Evolution



VoIP Architectures: NGN



MPLS 2004

NORTEL NETWORKS

Outline

- VoIP Standards & Architecture
- "NGN": Next Generation Network standards
- QoS
- Carrier VoIP Requirements
- ENUM
- VoIP Interconnection

MPLS 2004

NORTEL NETWORKS™

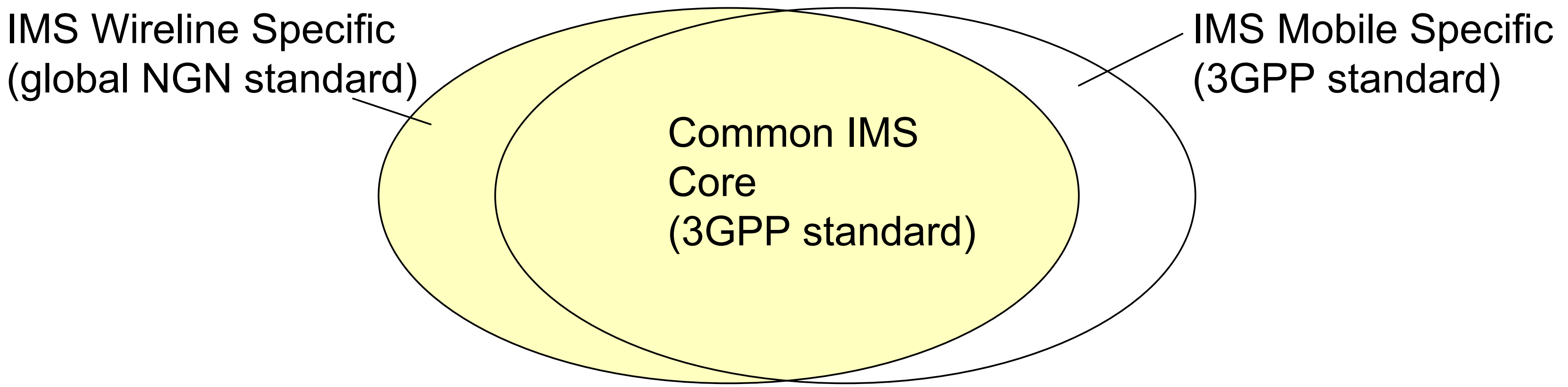
NGN Standards

- ITU-T FGNGN
- ETSI TISPAN
- ATIS NGN-FG

> **Emerging consensus to base core NGN architecture on 3GPP IMS**

3GPP IMS in Next Generation Networks

- IMS is agreed as a key component of the “Release 1” global NGN standard
- Cooperation required with 3GPP
- Goal : a common IMS core with access-specific extensions



Interest to achieve maximum commonality

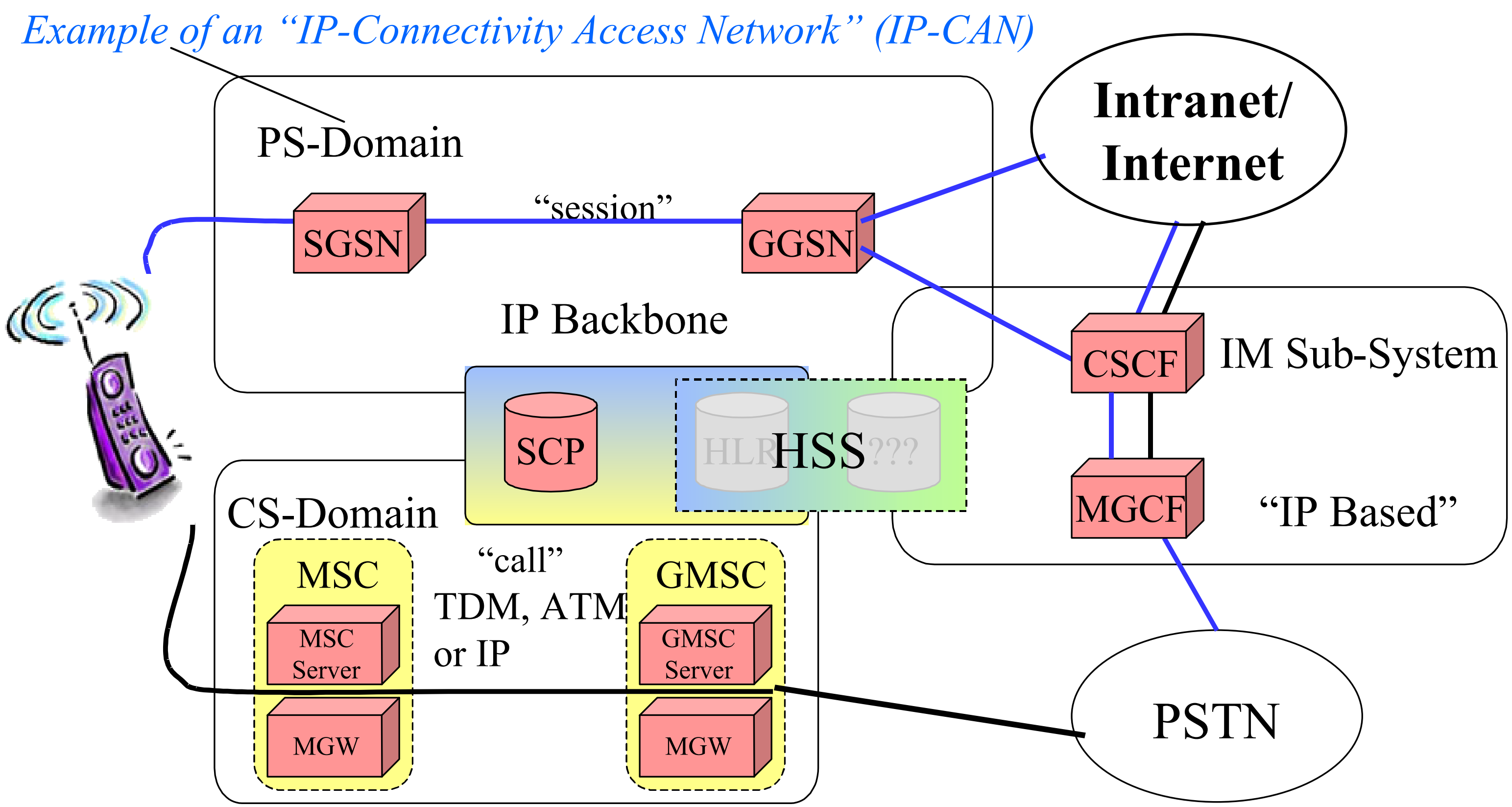
MPLS 2004 NORTEL NETWORKS

What is IMS?

- IMS: IP Multimedia Subsystem
- Provides multimedia solution for UMTS operators
  - Reflects "carrier" requirements for IP multimedia
- Uses IETF protocols with 3GPP extensions and profiling
- Introduced in 3GPP Release 5 (approved June 2002) specifications. Enhanced in Release 6 (target approval Sept-Dec 2004)
- Originally developed for UMTS/GPRS access but system design enabled evolution towards access independence in Release 6
- Support for inter-operator and international roaming
- Supports deployment of multivendor systems through well defined open interfaces
- Support for IPv6 is mandated within the IM Subsystem
- Does not provide service equivalence to the Circuit Core
  - based on SIP service model

Advanced multimedia for UMTS and GPRS

IMS position in 3GPP system



New Terminology

CSCF – Call State Control Function

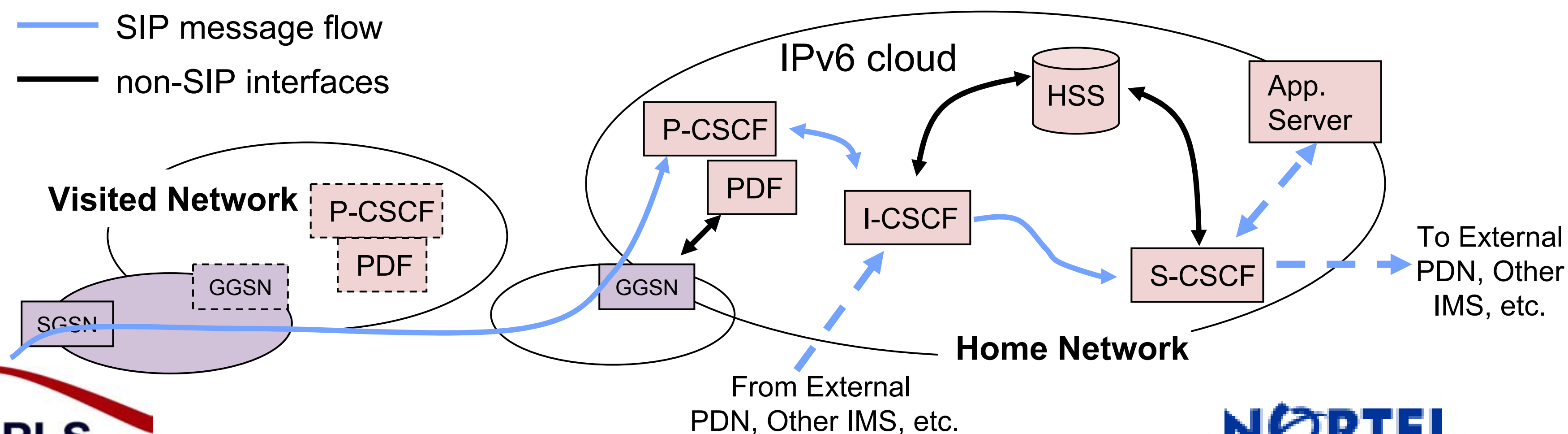
HSS – Home Subscriber Server

MGCF – Media Gateway Control Function

IMS is an overlay to an IP-enabled access network

IMS – Key Elements

- CSCFs ("Call State Control Functions") provide handling of SIP signalling in network
  Three flavours of CSCF
  - "Proxy-CSCF" – manages access to IMS local to the IP anchor point
  - "Interrogating-CSCF" – finds the right Serving-CSCF
  - "Serving-CSCF" – provides user services
- HSS ("Home Subscriber Server") provides centralised database of subscription and service information
- PDFs ("Policy Decision Function") manages policy for handling IP flows in network
  - Release 5: PDF is in P-CSCF, Release 6: PDF can be separated
- Application Server – Provides value added applications on top of IMS framework



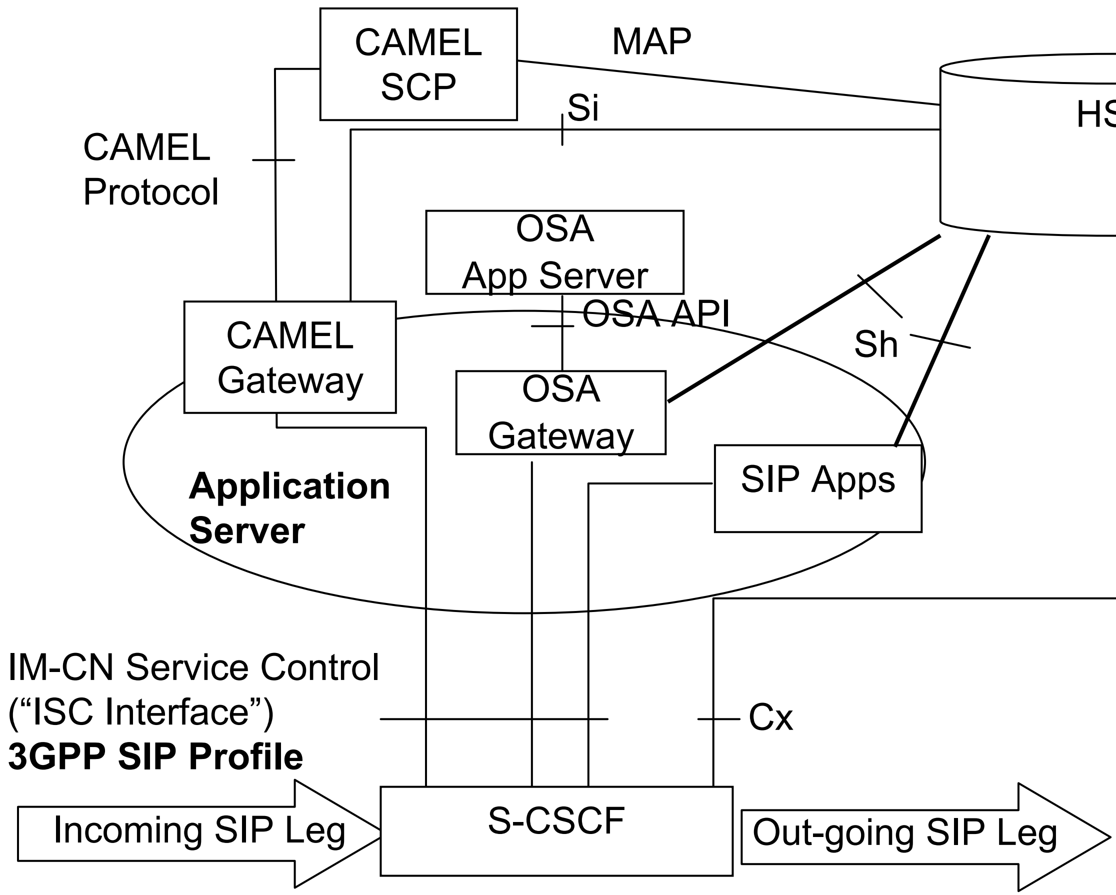
IMS services

3GPP standardizes IMS Service Capabilities NOT Services

- 3GPP defines mechanisms for services based on Presence, MMS, Streaming, but the services that would use these are not defined
- Services are implemented in Home Network
  - Service knowledge not required in visited network but may exist
- Examples of Services that can be built on IMS
  - Point to point and conferenced multimedia
  - Presence
  - Instant Messaging
  - Streaming
  - Combinations and integration of these
- Services may be included in the S-CSCF or in to an application server
- Three IMS Service Platforms (Application Servers)
  - CAMEL (IMS-SSF) – provides transition for legacy services
  - OSA – Open Service Access (OSA-SCS) – provides “web services” like API
  - SIP (SIP-AS) – provides service creation for SIP infrastructure
- S-CSCF communicates with the three types of Application Servers via the IP multimedia service control (ISC) interface. The ISC interface is SIP-based.

Open architecture for services

Services Architecture



IMS access independence

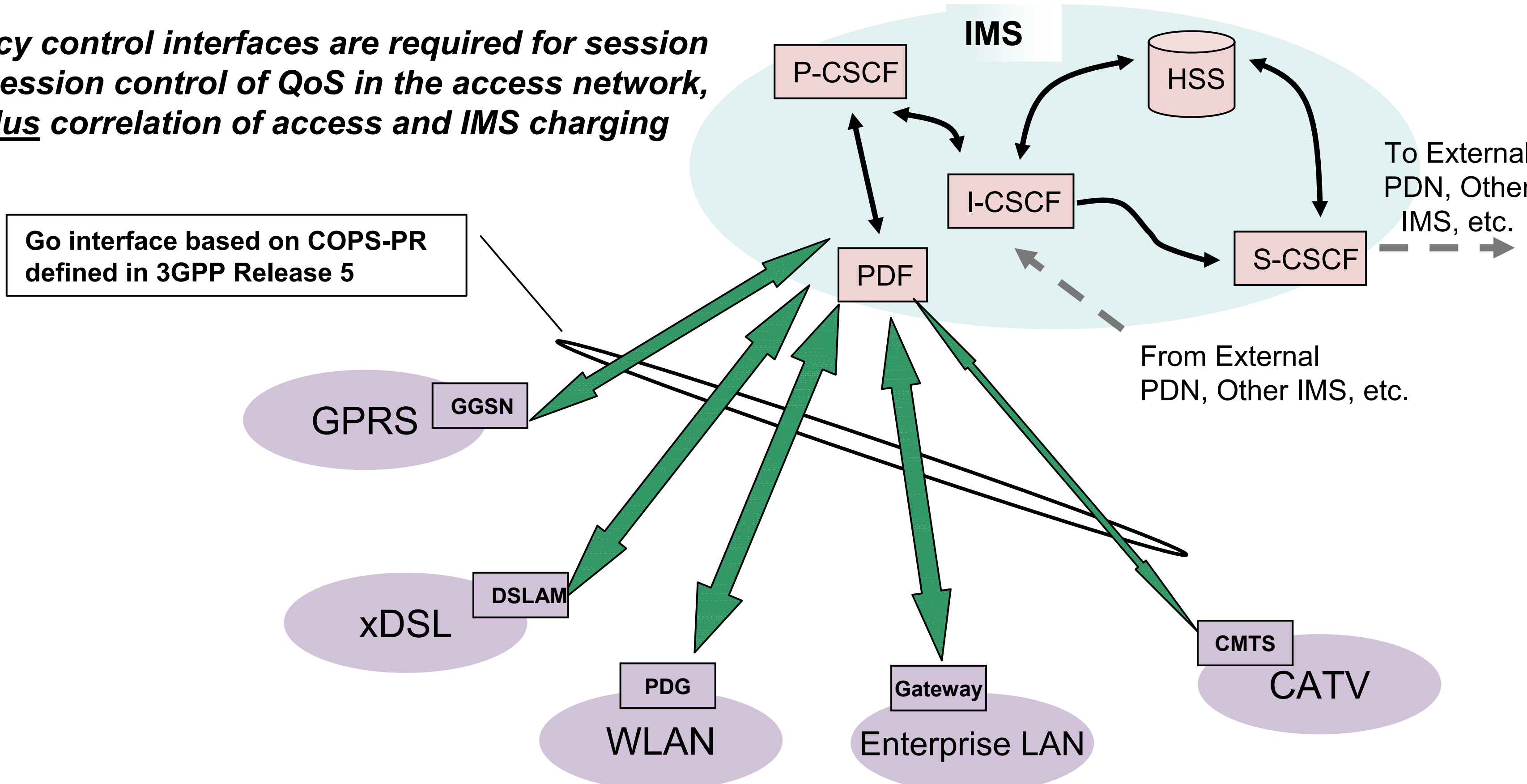
- The Core IP Multimedia Subsystem is intended in principle to be able to offer service to terminals on any kind of access that supports IP
  - UMTS/GSM using GPRS
  - CDMA
  - Wireless LAN
  - Ethernet/xDSL
  - Etc.

- Work is not yet complete:
  - Release 5 IMS documentation focuses on UMTS/GSM
  - Release 6 IMS split out the 'access independent' parts, but does not explicitly address other access systems
  - Some work in 3GPP Release 6 on WLAN access to IMS - incomplete
  - 3GPP2 MMD (Multimedia Domain) uses IMS core subsystem over CDMA

IMS architecture fits with access independence concepts

Multiple access architecture

Policy control interfaces are required for session by session control of QoS in the access network, <u>plus</u> correlation of access and IMS charging

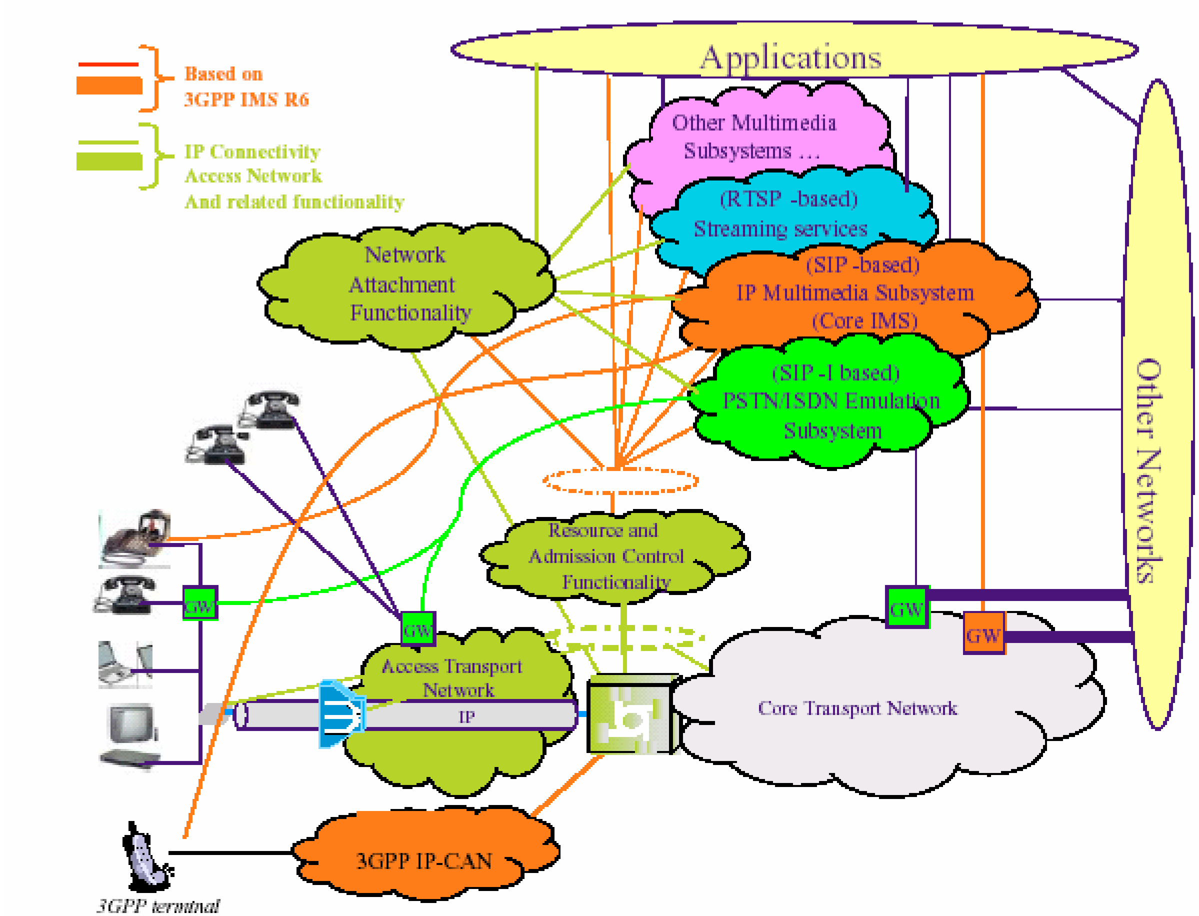


IMS for carrier applications

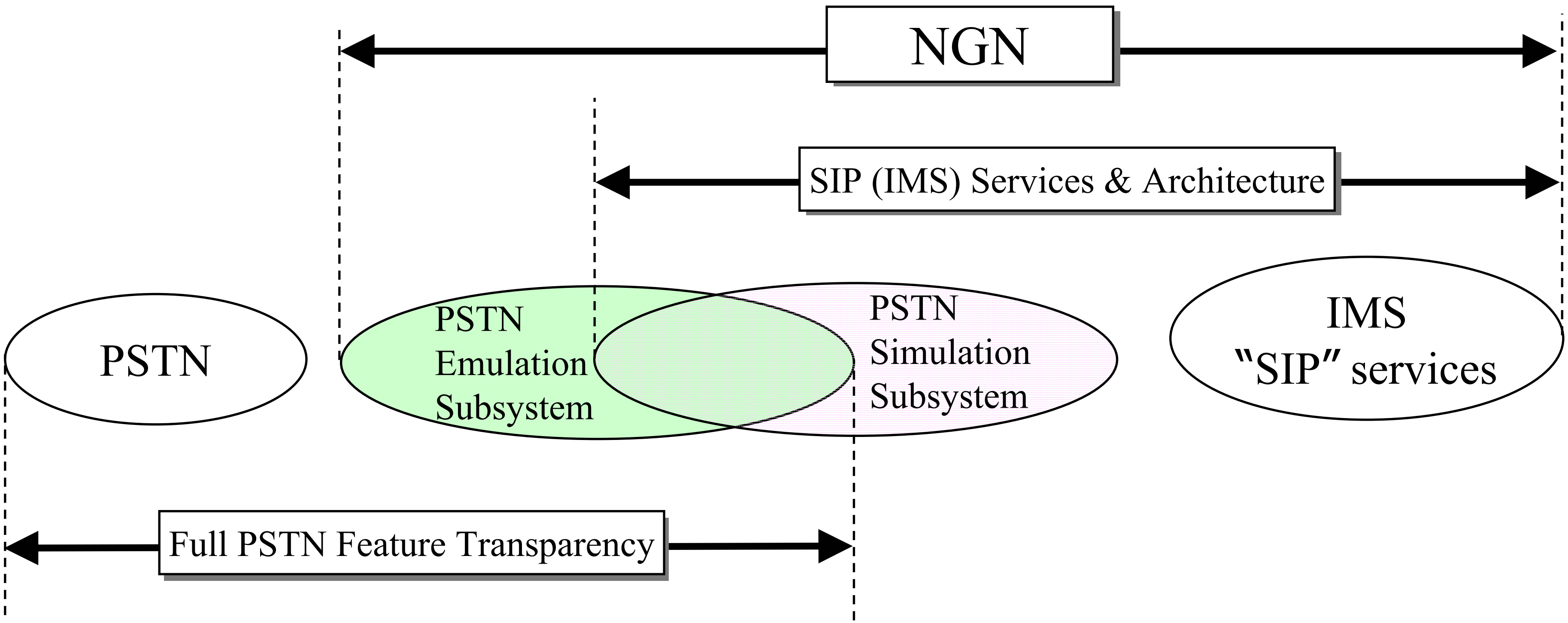
Some areas where IMS deltas may be needed (based on recent TISPAN/3GPP discussions) :

- **Security requirements (3GPP IMS only supports smart-card based security)**
- **Requirements for support of IPv4**
- **SIP Profile requirements for xDSL access to IMS**
- **Gq extensions for NGN (e.g. for NAT control)**
- **QoS classes and end to end QoS interworking**
- **Emergency call and regulatory service support**
- **Default codec support**

ETSI TISPAN View



PSTN Emulation vs. Simulation

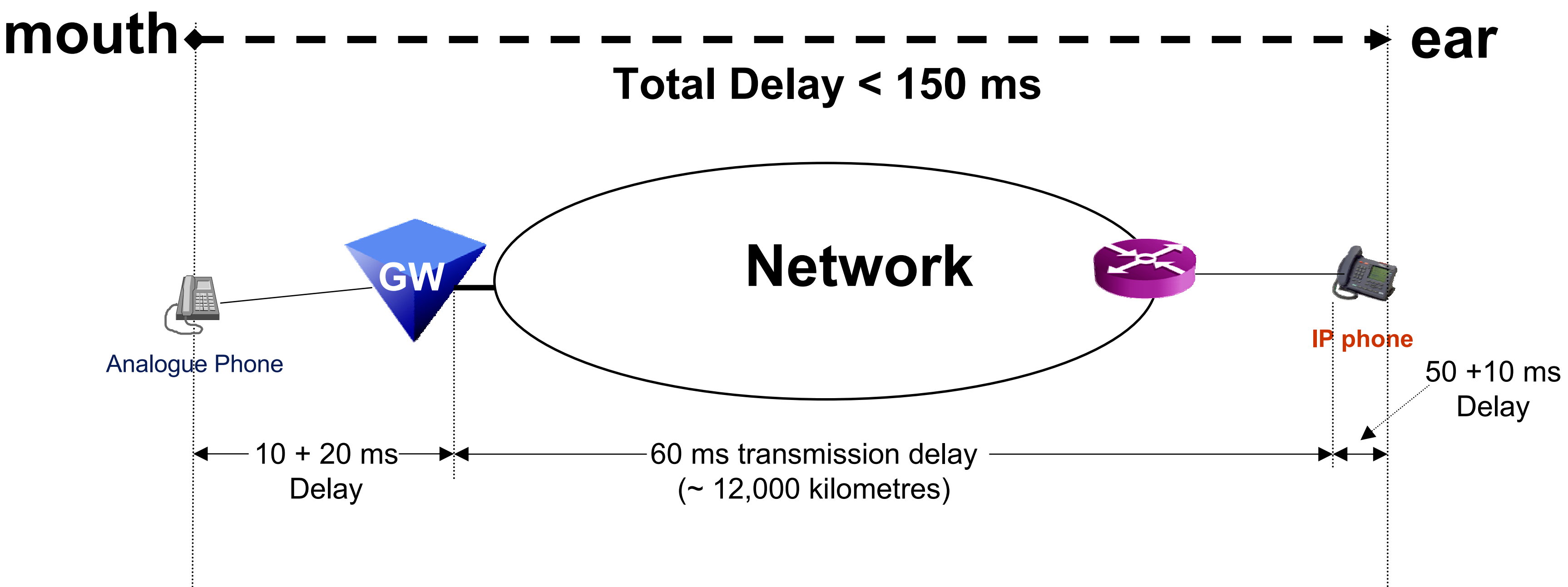


Outline

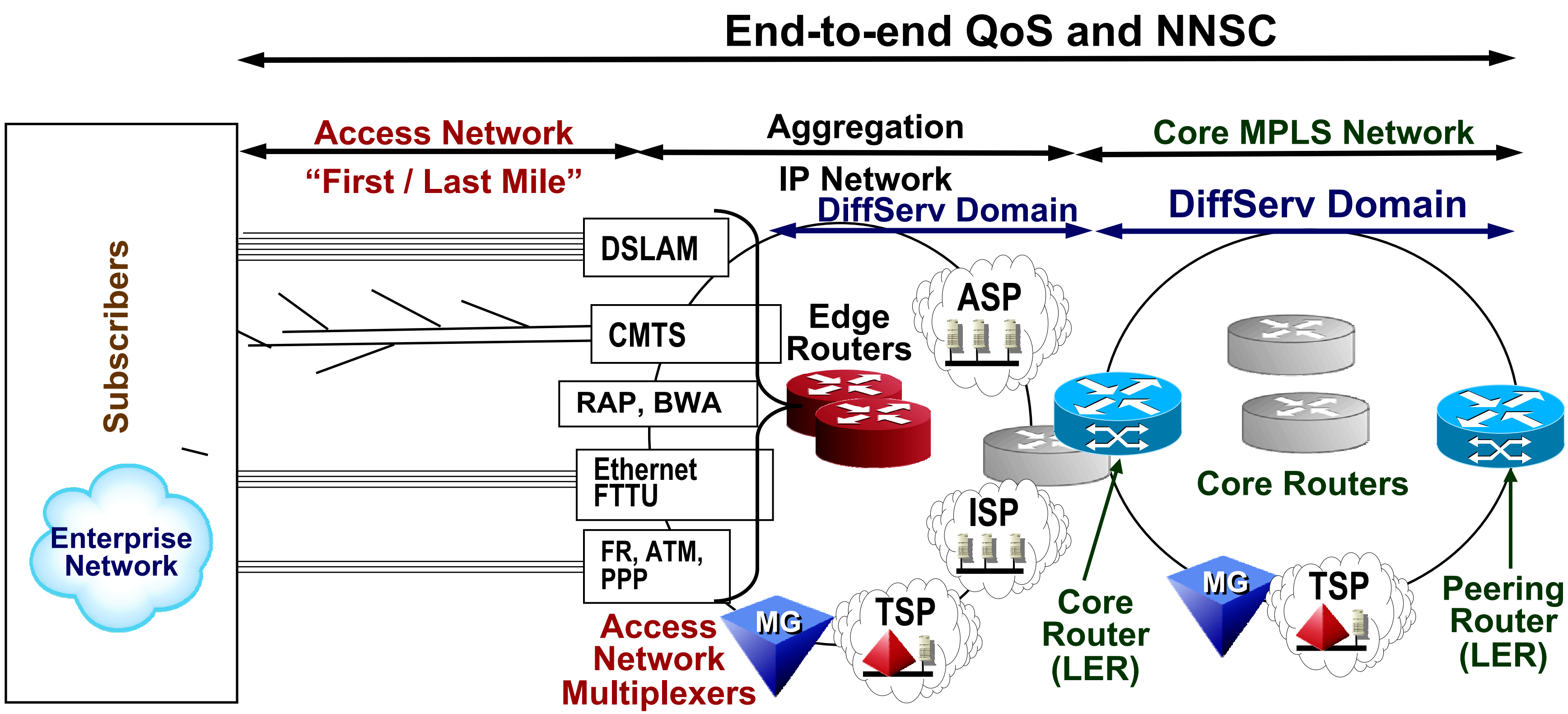
- VoIP Standards & Architecture
- "NGN": Next Generation Network standards
- QoS
- Carrier VoIP Requirements
- ENUM
- VoIP Interconnection

Mouth to Ear Delay

Example is for G.711 codec using 20 ms packet time



Reference Network Diagram



Points to note

- Some QoS technologies are End-to-End**:
  - DiffServ
- Some QoS technologies only have significance on/between devices or within a network region:
  - MPLS
  - Ethernet 802.1p / Q (VLANs)
  - Port Prioritization
  - DOCSIS
  - PPP
  - ATM
  - Frame Relay
  - xDSL
  - Wireless link-layer technologies (e.g., 802.11e)
  - Traffic separation using λs, Frequencies or Time Slots

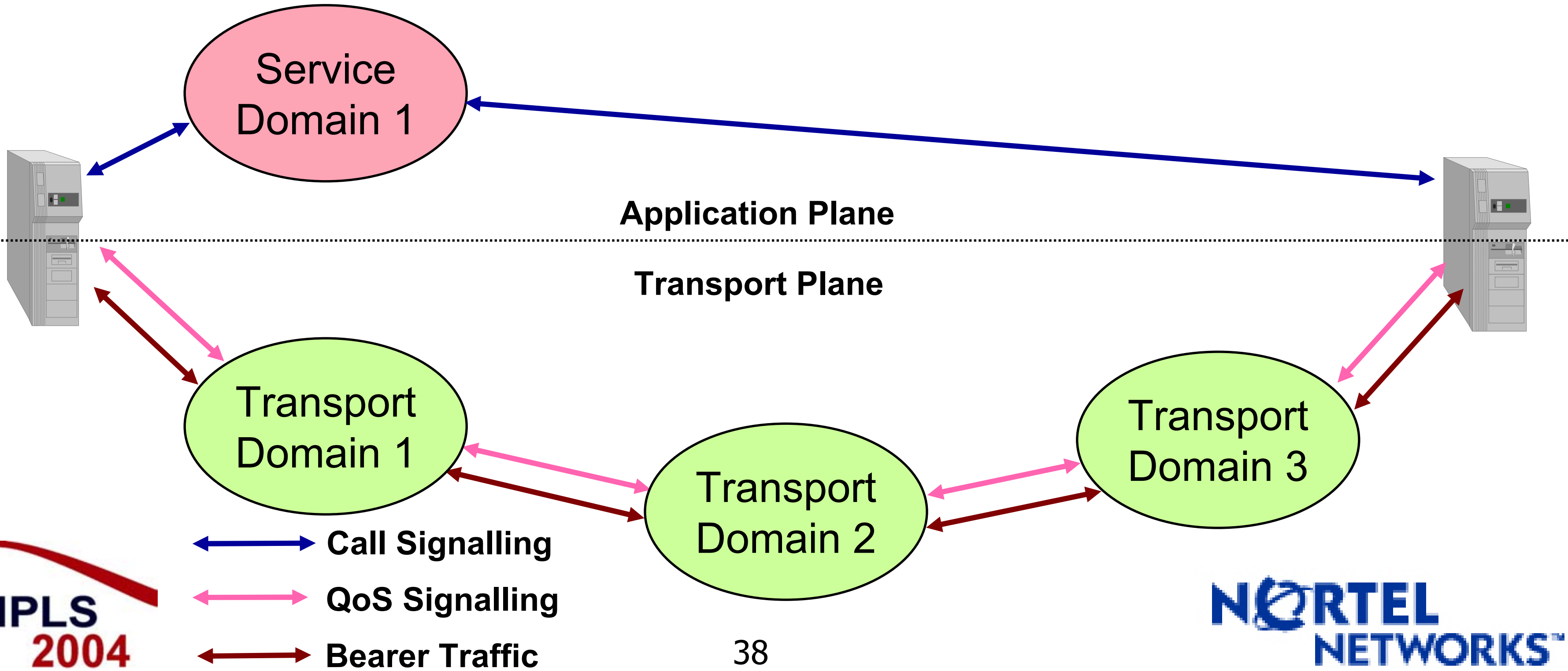
** End-to-End defined as User-User, User-Host or Host-Host

MPLS 2004

NORTEL NETWORKS™

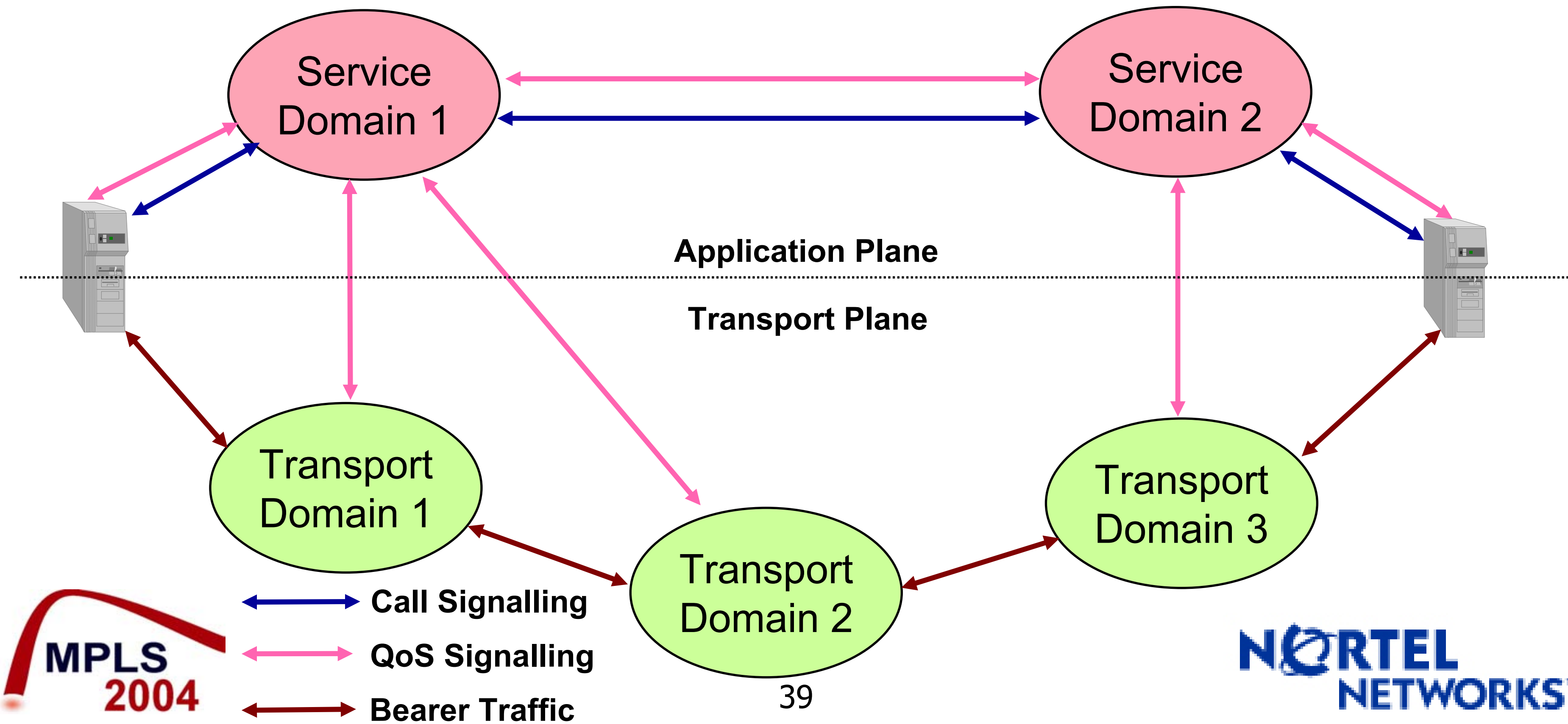
Internet model

- inter-connected networks mainly serve to provide end to end connectivity
- intelligence remains at network edge
- stimulates new services
- but who is responsible for end to end QoS ?



Managed-Network model

- service provider able to control end to end QoS
- … but end-point tied to specific service provider
- less opportunity for end-points to create new services



MPLS 2004

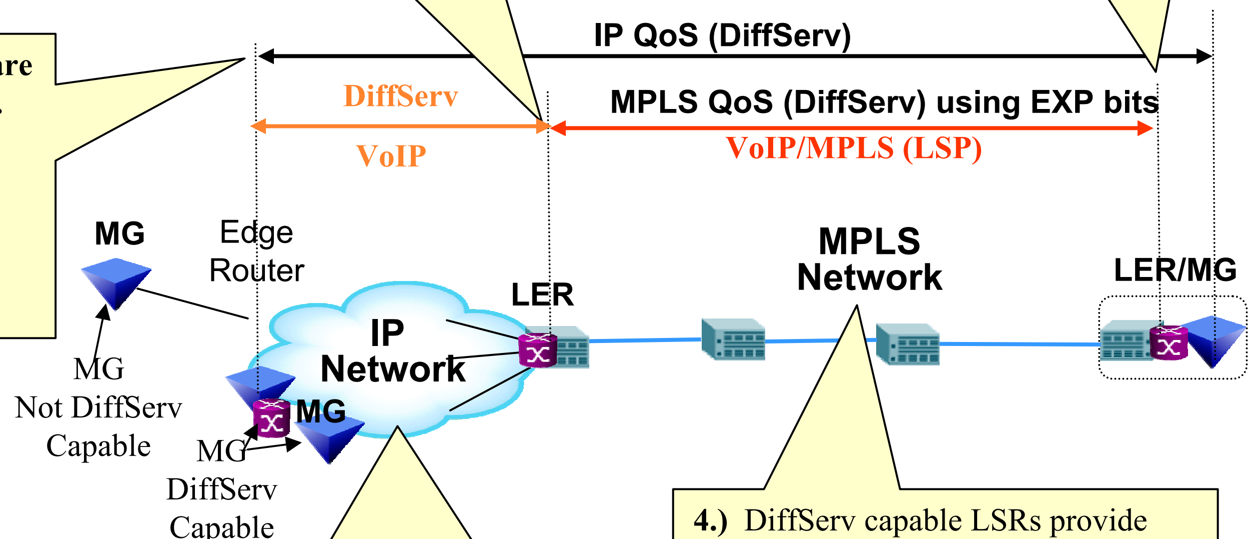
NORTEL NETWORKS

QoS with MPLS Core Network

3.) Mapping between DSCP and MPLS Shim Header and/or EXP bits is performed.

5.) MPLS Shim header is terminated. IP packet with DSCP values are exposed. DSCP is used to provide differentiation (QoS).

1.) At the edges, packets are marked with DSCP values.
CS5 = Telephony signaling
EF = PCM streams (voice)
EF = T.38 fax
CS2 = OAM&P
CS6 = Routing, IP control



2.) DiffServ mechanisms are used in IP access and aggregation networks. At least 4 different service classes are supported using EF, AF, CS and DF PHBs.

4.) DiffServ capable LSRs provide differentiation (QoS) for the supported service classes. EXP bits in the MPLS Shim header are used for indication for differentiation (QoS).

MPLS 2004

NORTEL NETWORKS™

Nortel Networks Service Classes (NNSC)

Traffic Category	Nortel Networks Service Class	Assigned DSCP	Example Application
Network Control	Critical	**CS7**	Critical Alarms, heartbeats
	Network	**CS6**	Routing, Critical OAM, Signaling between Call Servers (SIP-T)
Interactive	Premium	**EF, CS5**	IP Telephony (VoIP, FoIP)
	Platinum	**AF41, AF42, AF43, CS4**	Video Conferencing, Interactive Gaming
Responsive	Gold	**AF31, AF32, AF33, CS3**	Streaming audio/video, Video on Demand
	Silver	**AF21, AF22, AF23, CS2**	Client/Server Transactions, OAM&P
Timely	Bronze	**AF 11, AF12, AF13**	Priority data, email, billing
	Standard	**DF (=CS0)**	Best effort

MPLS 2004

NORTEL NETWORKS

QoS Mapping: Example 1

- **In this example, the E-LSP PSC supports 4 Ordered Aggregate and one of the OAs have three Behavior Aggregates.**
  - This example requires that flow admission control for inelastic traffic and flow conditioning for elastic traffic is performed before flow is admitted into the MPLS network.
  - LSRs support 4 queues

Application/Service Type	DSCP name	MPLS EXP	Comments	Queuing	PHB
Administrative	CS7	110	The OA behavior is same as Network Control service class	Rate	CS
Network Control	CS6				
Telephony	EF	101	The OA behavior is same as Telephony service class. Admission control per service class ensures conformance	Priority	EF
Signaling	CS5				
Real-time Interactive	CS4				
Broadcast Video	CS3				
Low Latency Data, High Throughput Data, OAM	AF21, AF11, CS2	011	BA provides low drop probability	Rate	AF
	AF22, AF12	010	Traffic in this BA is drop eligible		
	AF23, AF13	001	Traffic in this BA is drop eligible		
Standard	DF	000	Traffic in this BA is drop eligible	Rate	DF

Note: PSC = EXP-Inferred-PHB Scheduled Class
OA = Ordered Aggregate
BA = Behavior Aggregate within a OA

MPLS 2004

NORTEL NETWORKS™

QoS Mapping: Example 2

- **In this example, the E-LSP PSC supports 6 Ordered Aggregate and two of the OAs have two Behavior Aggregates each.**
  - LSRs support 6 queues

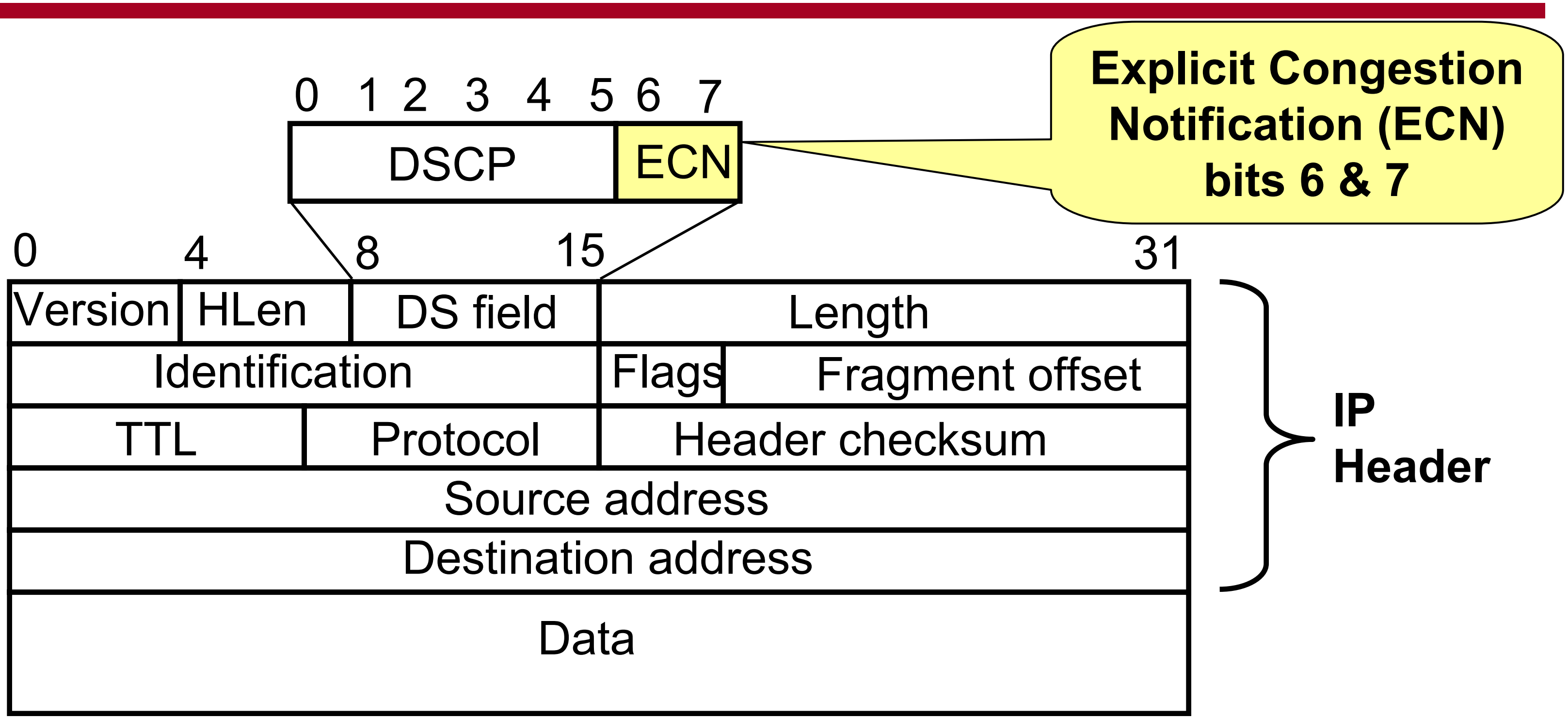
<table>
<tr><th>Application/Service Type</th><th>DSCP name</th><th>MPLS EXP</th><th>Comments</th><th>Queuing</th><th>PHB</th></tr>
<tr><td>Administrative</td><td>CS7</td><td rowspan="2">111</td><td rowspan="2">The OA behavior is same as Network Control service class</td><td rowspan="2">Rate</td><td rowspan="2">CS</td></tr>
<tr><td>Network Control</td><td>CS6</td></tr>
<tr><td>Telephony</td><td>EF</td><td rowspan="3">110</td><td rowspan="3">The OA behavior is same as Telephony service class</td><td rowspan="3">Priority</td><td rowspan="3">EF</td></tr>
<tr><td>Signaling</td><td>CS5</td></tr>
<tr><td>Real-time Interactive</td><td>CS4</td></tr>
<tr><td>Broadcast Video</td><td>CS3</td><td rowspan="2">101</td><td rowspan="2">The OA behavior is same as Broadcast Video</td><td rowspan="2">Rate</td><td rowspan="2">2nd EF</td></tr>
<tr><td>Multimedia Conferencing</td><td>AF41, AF42, AF43</td></tr>
<tr><td rowspan="2">Low Latency Data, OAM</td><td>AF21, CS2</td><td>100</td><td>BA provides low drop probability</td><td rowspan="2">Rate</td><td rowspan="2">AF</td></tr>
<tr><td>AF22, AF23</td><td>011</td><td>Traffic in this BA is drop eligible</td></tr>
<tr><td rowspan="2">High Throughput Data, Multimedia Streaming</td><td>AF11, AF31</td><td>010</td><td>BA provides low drop probability</td><td rowspan="2">Rate</td><td rowspan="2">AF</td></tr>
<tr><td>AF12, AF13, AF32, AF33</td><td>001</td><td>Traffic in this BA is drop eligible</td></tr>
<tr><td>Standard</td><td>DF</td><td>000</td><td>OA behavior = Standard SC</td><td>Rate</td><td>DF</td></tr>
</table>

Note: PSC = EXP-Inferred-PHB Scheduled Class
OA = Ordered Aggregate
BA = Behavior Aggregate within a OA

What is ECN CAC

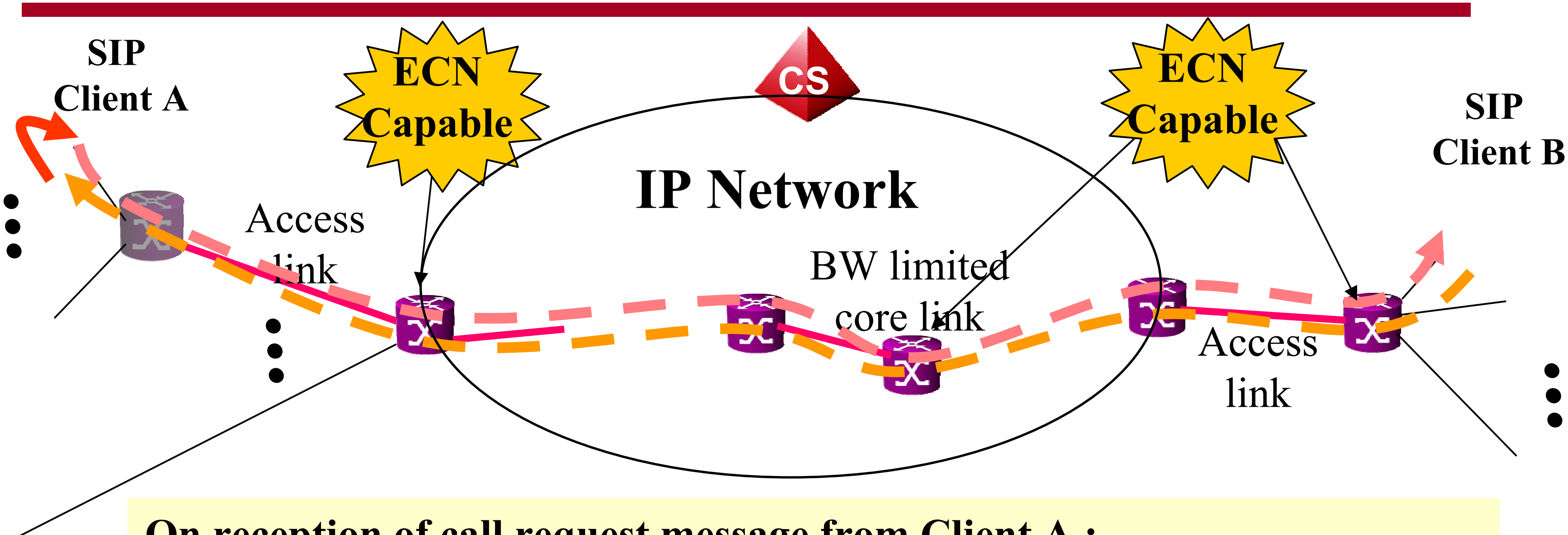
- Call admission control (or IP session admission) is a mechanism to block new real-time inelastic flows like voice and videoconference when the network resources are at capacity and additional flows will degrade the service quality to established users.
- ECN CAC is a probe based approach during session (call) setup to determine if there is sufficed bandwidth for a new session to be admitted.
- Better scalability than some alternative mechanisms
  - VAC solution uses simple call counting and requires that the switch is topology aware. It has issues of scalability
  - Bandwidth reservation (RSVP) plus book keeping is an alternative approach but it requires that the routers maintain state information, has issues of scalability and may not have sufficient flexibility to address different applications.

DiffServ Field & Explicit Congestion Notification



- DiffServ (DS) Field
  - The first six bits contain the DiffServ Code Points (DSCP).
  - Bits 6 & 7 of the DS Field are used for Explicit Congestion Notifications (ECN). RFC 3168 defines the use of ECN for TCP flows.

CAC Procedure



On reception of call request message from Client A :

- •Client B, generates and sends **Request probe** packets to Client A
- •If EF rate > than "a", ECN bit 7 set to '1'
- •Upon receiving Request probe packets, Client A replies with **Response probe** packets to Client B, echoing the received ECN bits
- •If EF rate > than "a", ECN bit 7 set to '1'
- •If Response probe packets ECN='00' Client B will start alerting the user (Ring phone)

Outline

- VoIP Standards & Architecture
- "NGN": Next Generation Network standards
- QoS
- Carrier VoIP Requirements
- ENUM
- VoIP Interconnection

Regulatory

Service Providers require a number of complex regulatory capabilities to effectively migrate to packet.

Lawful Intercept
- CALEA, German LI Certification

Number Portability
- LNP, wireless NP

Emergency Services
- E911, GETS

Operator Services
- TOPS, Global TOPS for tandem and Class 5 related features

Outline

- VoIP Standards & Architecture
- "NGN": Next Generation Network standards
- QoS
- Carrier VoIP Requirements
- ➢ ENUM
- VoIP Interconnection

ENUM in a nutshell RFC 2916

- take phone number

+1 613 555 1234

↓

- turn it into a FQDN

4.3.2.1.5.5.5.3.1.6.1.e164.arpa.

↓

- ask the DNS
- return list of URI's

sip:jim@nortelnetworks.com

MPLS 2004

NORTEL NETWORKS™

Public ENUM vs. Operator ENUM

- **Public ENUM** is the administrative policies and procedures surrounding the administration of e164.arpa as defined in RFC 2916
  - mapping of E.164 number to URI's
  - Nation State Control
  - Generally speaking Consumer Opt In (Consumer Control of the NAPTR records)
- **Operator (Private) ENUM** is the use of DNS technology *described* in RFC 2916 in other domains.
  - Service Provider or Enterprise Controlled
  - Non Visible to the the general Internet user
    - Access Control to the Data
    - May or may not have linkages to a public ENUM service

Lessons learnt in the ENUM Trials

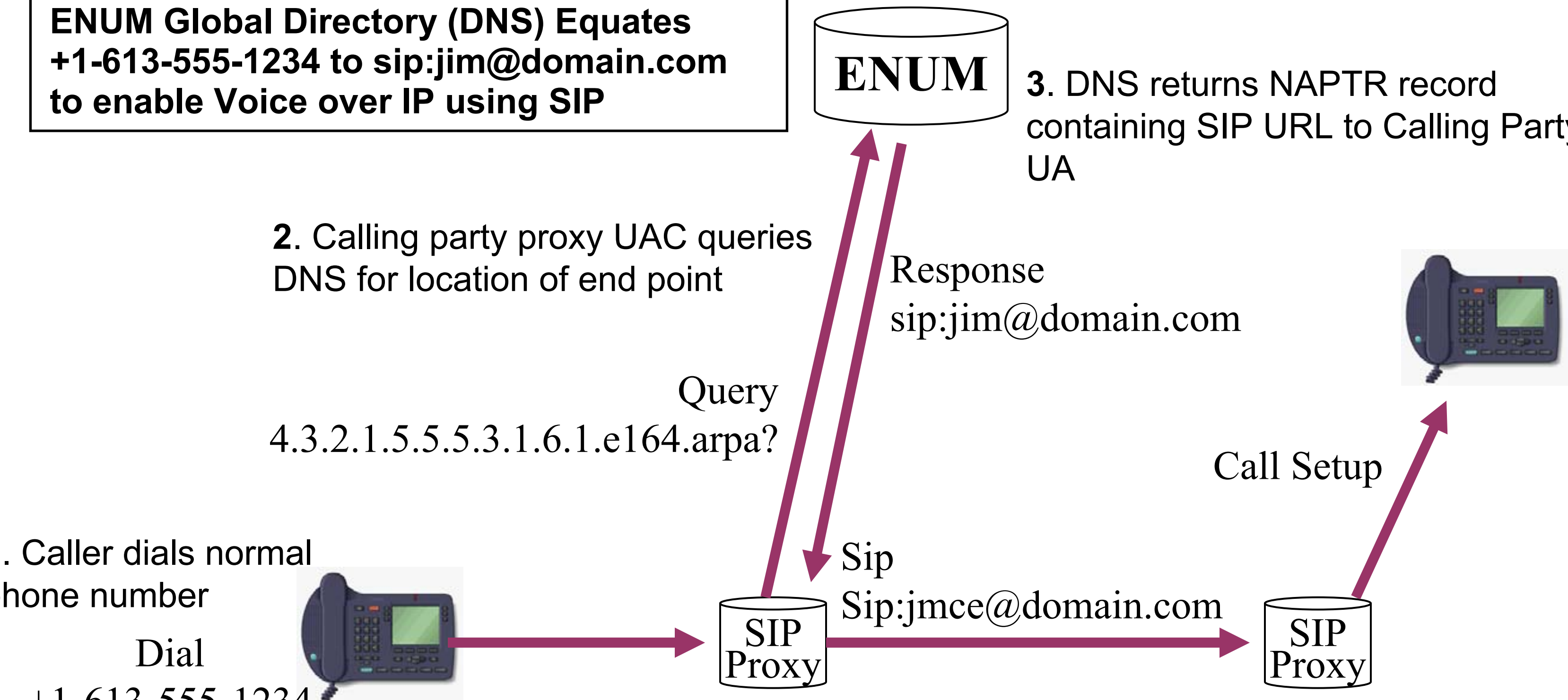
ENUM technology works,

- **Most problems solved, but shift in focus for the business models.**
- **The original business model of ENUM for residential subscribers with opt-in for existing numbers has problems:**
  - **privacy problems with multiple services (e-mail spam)**
  - **Validation and re-validation of the number holder problem**
- **But the major problem is how to overcome Metcalfe's Law!**
  - ***The usefulness, or utility, of a network equals the square of the number of users***

Simple Carrier ENUM/SIP Call Flow

ENUM Global Directory (DNS) Equates +1-613-555-1234 to sip:jim@domain.com to enable Voice over IP using SIP

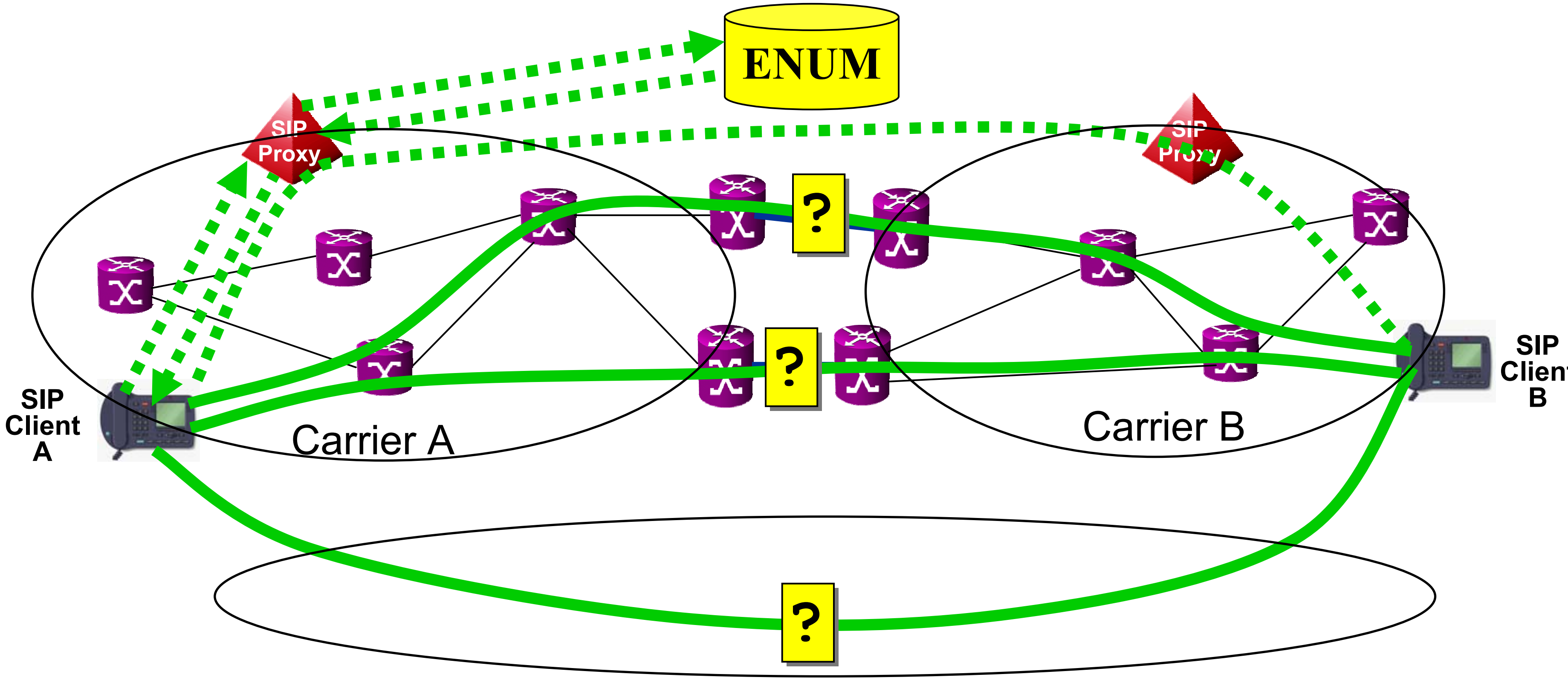
1. Caller dials normal phone number



4. Calling party UA connects the call

ENUM can provide central translations

A More Complex Carrier ENUM Example



Not clear if ENUM can provide routing

MPLS 2004

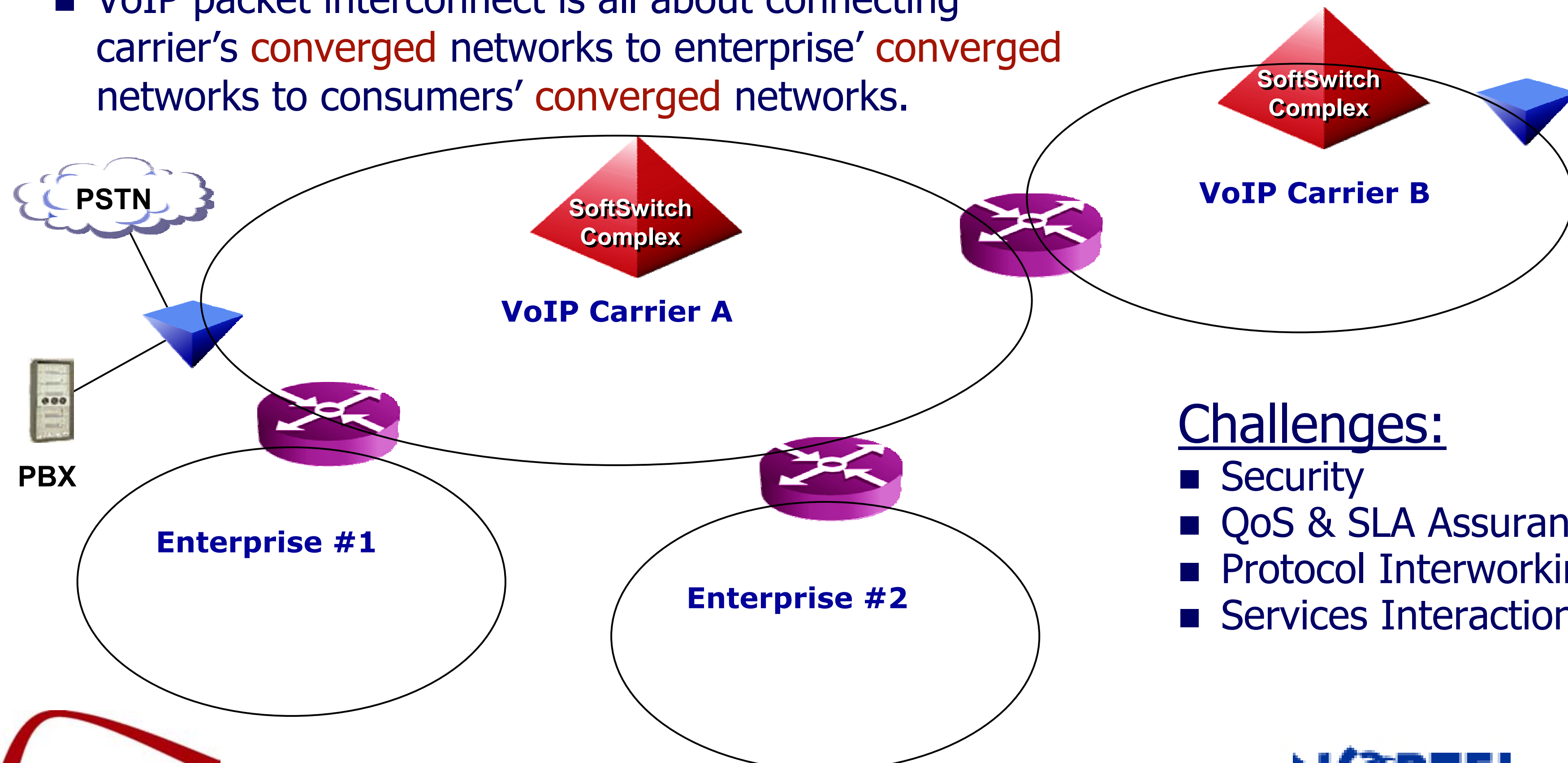
NORTEL NETWORKS

Outline

- VoIP Standards & Architecture
- "NGN": Next Generation Network standards
- QoS
- Carrier VoIP Requirements
- ENUM
- ➢ VoIP Interconnection

VoIP Packet Interconnect: Challenges

- Voice over IP is all about network convergence.
- VoIP packet interconnect is all about connecting carrier's converged networks to enterprise' converged networks to consumers' converged networks.



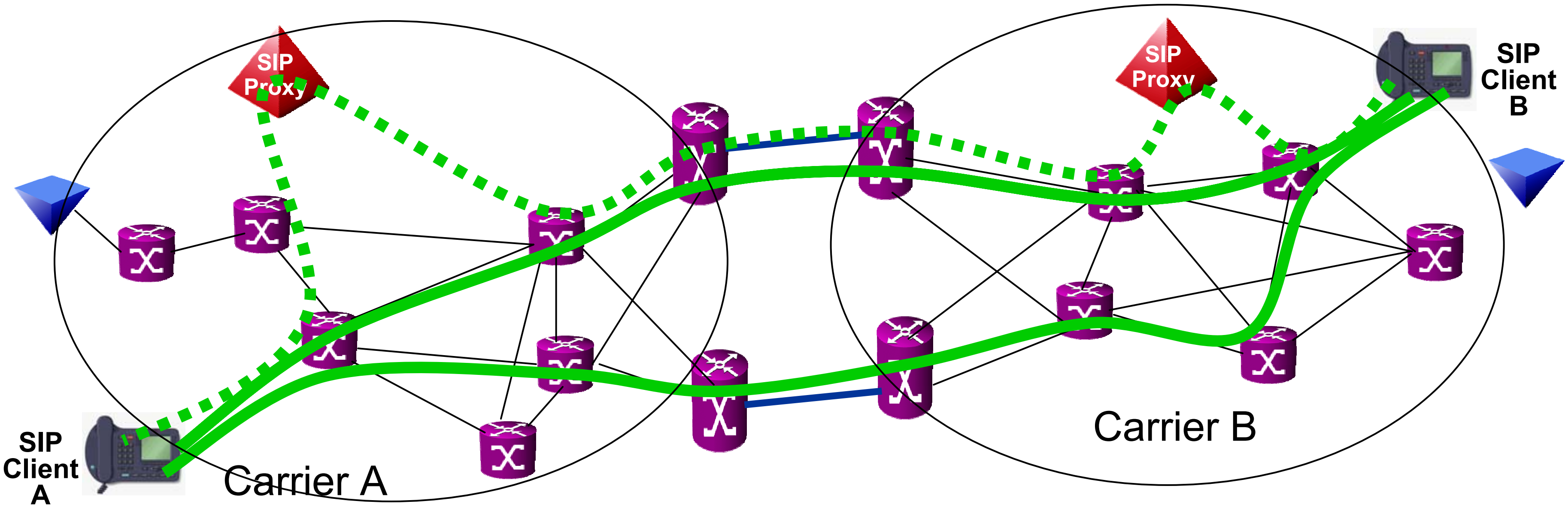
Challenges:

- Security
- QoS & SLA Assurance
- Protocol Interworking
- Services Interaction

VoIP Packet Interconnect Considerations

- Architectural Alignment
- Protocol Alignment
- Encoding & transcoding
- Voice Band Data & DTMF
- Service Interactions
- Security
- Quality of Service
- Trouble handling
- Accounting & Reporting
- …

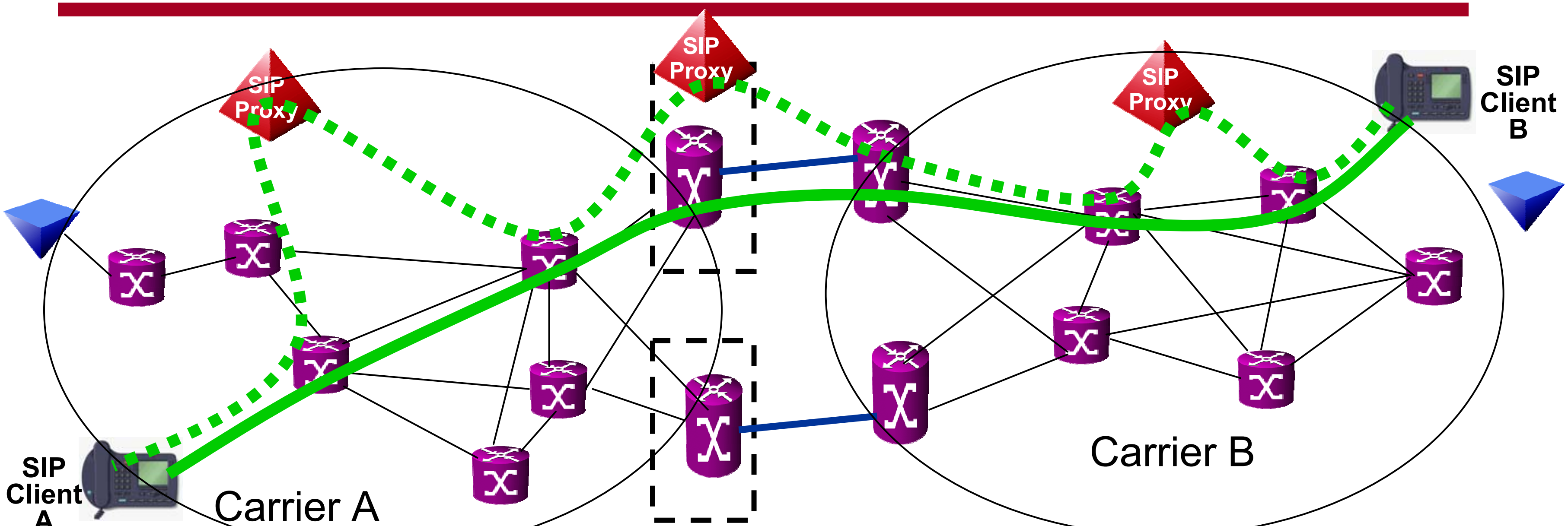
End-to-End Model



Challenges

- NAT / FW
- QoS
- Security

Border Control Model



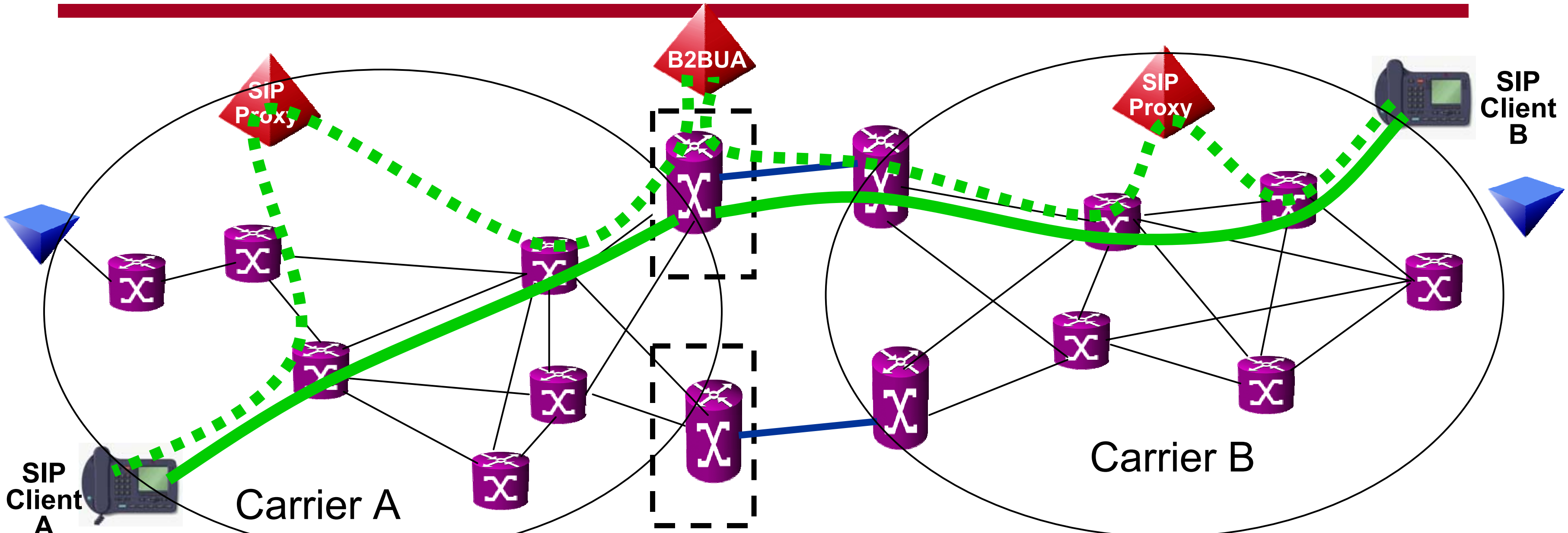
- Border Proxy?
- Application Level Gateway (ALG)?
- B2BUA?
- B2BUA with media anchor?

No Industry Consensus on Border Control Functions

MPLS 2004

NORTEL NETWORKS

Trusted Network Model



- Unique carrier capabilities
- Network security
- Media anchor point at edge
- Controlled interworking

Used by 3GPP, PacketCable, ITU-T

Conclusions

- VoIP is ready for volume deployment now
- Ongoing work will further enhance “quality of experience”
- Regulatory requirements still being considered
- Initial deployment for voice will enable future capabilities as market matures
  - Multimedia
  - Converged core for NGN