IPv6 Migration and Challenges

Huawei Carrier IP

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Key Driver for IPv6: IPv4 Address Exhaustion

We've reached the breaking point

IPv4 Address Space Exhaustion

- IANA free pool has been exhausted (Feb 3, 2011)
- RIR also exhausted : soon after (Apr. 15 2011, the APNIC pool reached the Final /8 IPv4 address block)

Explosive demand for Address

- Growth of broadband deployments (>1 address in ONE home)
- Explosion of smart phones usage
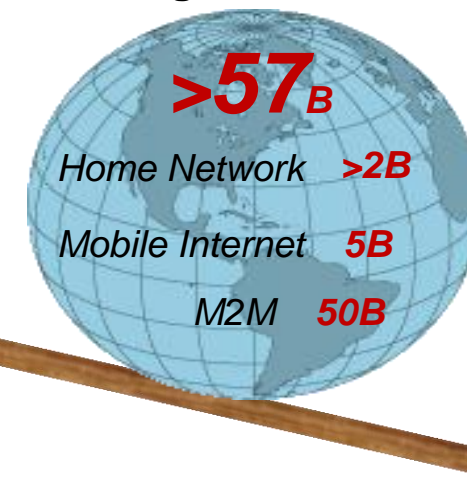- Internet of things

IPv4 Address Space

Hugh Demand

4.3$_B$

>57$_B$

Home Network   **>2B**

Mobile Internet   **5B**

M2M   **50B**

"It's enough to do an experiment, the problem is the experiment never ended."

----*Vint Cerf*

Unbalance

IPv6 Not a Myth, JUST Make the Right Choices

Myth: IPv6 is too complicated for deployment

340,282,366,920,938,463,463,374,607,431,768,211,456

IPv6

Things could be easier

3

- *IPv6 Strategy / time ?*
- *IPv6 migration solution ?*
- *IPv6 migration partner ?*

JUST Make *Choices*

Contents

Two Ways to Solve the Address Issue

Massive work have been done, multiple approaches have been found /tried

Extend IPv4 Address

- Network Address Translation (NAT) , especially **NAT444**
- Collect and reuse the idle IPv4 address
- Stricter Policy on assigning IPv4 address at the RIRs
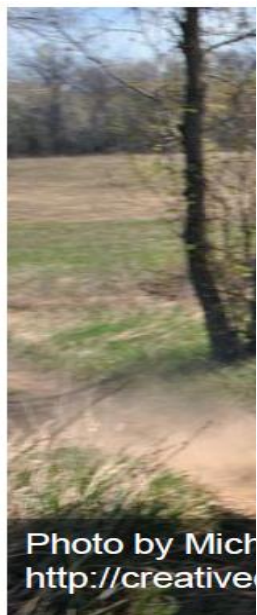
IPv4 Address Space Exhaustion

Migrate to IPv6

Ultimate Solution

$$2^{128} = 2^{96} \text{ times IPv4}$$

Could we JUST use NAT444 to solve the WHOLE address issue ?

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NAT Looks like…

If IPv4 addre

Photo by Carol Mitchell via Flickr
http://creativecommons.org/licenses/by-nd/2.0/deed.en

Source: YAHOO!® *<<Content Delivery Over IPv6: The Yahoo! Experience>>*

NAT444 Still Has Major Impacts to Applications

Dark Side of NAT Story
More complicated network , Hard to maintain, Introduce more delay

App. Category	App.	NAT444 (Private IPv4)	IPv6
Base App. HTTP/JSP/SMTP/POP3/IMAP…	Network News Email Online Shopping	√ **No impact** ✕**NAT hides user information, difficult to be traced back**	Client/Server Architecture √ One address per user,which can be traced back √ Adopt to new service (e.g. M2M) ✕ Need IDC update
Web Multimedia RTP/RTCP/RTSP…	Network Music Online Game Network Video	√ **Basic available** ✕**NAT increases delay and jitter of multimedia and reduces user experience**	
Multi-session App. AJAX/SDP/MAP…	Social Network Electronic map Search engine	√ **Basic available** ✕ **1:N,Session number is limited, slower the user access speed for the App.**	
P2P App. SDP/SIP/H.323…	P2P download IM Video Call	√ **Basic available** ✕ **E2E is broken. Relay or NAT traversal tech. is needed for communication between users behind NAT.**	P2P Architecture √ E2E √ Always Online

Source: CNNIC(2012.01), draft-donley-nat444-impacts-04
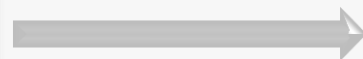
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NAT444 Only is NOT Enough

1. NAT444 **only Temporarily** relief IPv4 address problem, but not forever

2. Other **Challenges** arise with Massive Deployment of NAT444

More complicated network
Increase complexity in network management, operation etc.
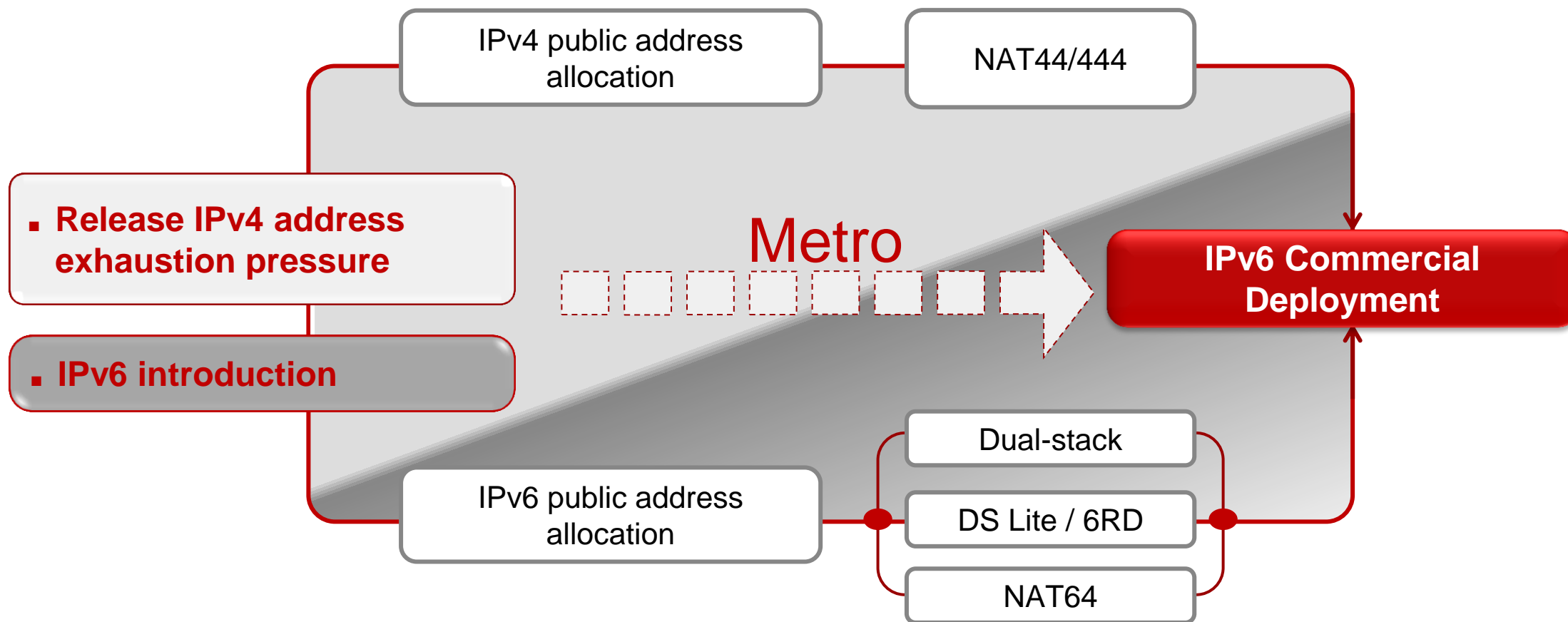
High Cost

Due to Address Sharing

- **Loss of geolocation information**
- **Lawful Intercept/Abuse Response**: hard to determine source
- **Antispoofing**: resulting in loss of connectivity for some users

Migrate to IPv6 is the ULTIMATE Solution for address issue

The Right Way is…

IPv4 public address allocation

NAT44/444

Release IPv4 address exhaustion pressure

IPv6 introduction

Metro

IPv6 Commercial Deployment

Dual-stack

IPv6 public address allocation

DS Lite / 6RD

NAT64

- NAT444 is used in IPv6 introduction period with DS/tunnel solutions to release the IPv4 address pressure

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The Requirement is Beyond Address Exhaustion

IPv6 :Abundant public addresses stimulate the creation of fantastic applications

Windows 7 DirectAccess	**Windows 2008 Cluster**	**Apple Airport**
(transport IPv6 only)	**(**uses IPv6 link-local address)	**(**uses IPv6 Link-local address)

For Enterprise users

- *DirectAccess allows users to remotely connect to corporate network without a traditional VPN client configuration or application, gives users a seamless, secure, anytime remote corporate connection.*

For Residential Users (also SME)

- *Windows 7 HomeGroup: simplifies the sharing within your home network.*
- *Apple Airport makes it easy to connect to the Internet, print, and stream iTunes music to any room in the house — all wirelessly*

IPv6 provides the possibility of having a Better User Experience

Quick Scan of IPv6 Industry Chain: All Ready

Terminal

- **The main Operating Systems are ready**
- Windows 8, Windows 7, Windows Vista, Windows XP, Mac OS, Linux, Solaris
- Android, iOS, Symbian

Standard

- **The core standards are stable**
- Ongoing work will be continued to address the new issues in some deployment-specific scenarios

Content

- **World IPv6 Launch Day: From IPv6 Day to IPv6 Everyday**
- **3000** websites participate world IPV6 Launch Day
- **27%** of pages viewed globally, are reachable over IPv6
- **0.4%** of the total AMS-IX traffic is IPv6 traffic

IPv6 is Ready for Deployment while additional effort is needed

Global Progress: More Join & Faster Developing

Governments are promoting IPv6 to maintain / gain competitiveness

- The US Government set deadline (2012.9.30) for all federal agencies make their public-facing services IPvt6-reachable
- Comcast, AT&T, Verizon, Sprint etc.

- European Commission plan to realize at least 25% of users connecting to the IPv6 Internet.

- China CNGI: 5 -year plan for deployment of IPv6
- Japan: Government supportsIPv6 by e-Japan plan (2001)
- India: National IPv6 deployment roadmap (2010)

	2011	2012
RFQ/RFP Commercial trial	france telecom, Telefonica, vodafone, P T, SFR, Bouygues Telecom, O2, belgacom, Kabel Deutschland, swisscom, QSC AG, JAZZTEL, TELE2	TELECOM ITALIA, Deutsche Telekom, BT, TELEKOM AUSTRIA GROUP
Commercial deployment	free	Telefonica, JAZZTEL, france telecom, vodafone, P T

Viewpoint: IPv6 Migration Timing

**For IPv6, the Later (deployment time), the Higher (Cost)**

Comcast: Why start Now
(or Five Years Ago)

comcast

- *Project Timing*

  - IPv6 touches nearly everything in our service delivery network, back office systems, OSS tools, custom tools, IT networks, Security, testing/certification processes, and operations personnel training.

  - Comcast and other major service providers are probably the more complex examples of IPv6 enablement – hence reason to start 5 years ago

  - Comcast needed a controlled approach to IPv6 – begin with infrastructure and provisioning systems, then push technology to customer edge

    - Early start enabled Comcast to drive the IPv6 program as a "low priority" effort, but it received executive support when critical work effort or investment milestones were required

    - Early start made it possible to leverage standard upgrade cycles, incremental budgeting, while maximizing resources and minimizing costs

    - Zero hit to revenue and cost saving programs

Cost: Why start Now

Total Cost of IPv6 Migration

Stay with IPv4

IPv6 Migration – start from Y

IPv6 Migration – start from X

X   Y

IPv6 % in Traffic
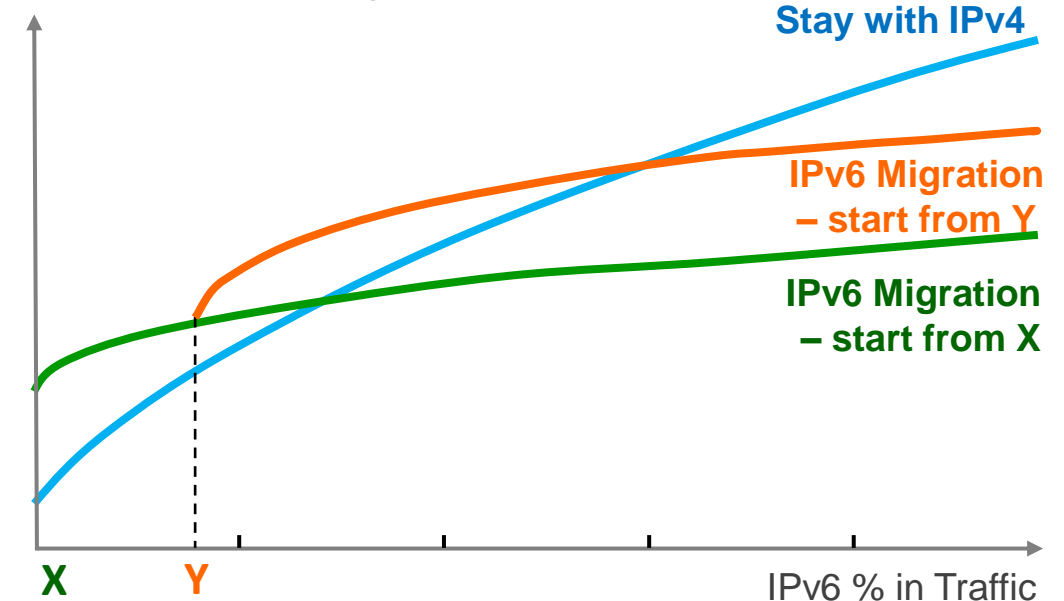
Summary: IPv6, Action Now

Now this is not the end of the work to get IPv6 deployed.
It is not even the beginning of the end.
But it is, perhaps, **the end of the beginning**

-- with apologies to Winston Churchill

Government Initiative

IPv4 Address Exhaustion Issue → **IPV6** ← **IPv6 Service Growing**

Industry Chain is ready for deployment

IPv6: No Longer a Question of Why but How

Contents

The Key Technologies for IPv6 Migration

- Dual Stack for IPv6 introduction
- NAT for IPv4 address extension
- Tunnel technology for isolated IPv4 or IPv6 user accessing
- **Dual Stack is the basis for all migration solutions**

Tunnel Technology	NAT Technology
6PE/6vPE	NAT44
GRE	NAT-PT
L2TP	NAT64/PNAT
6RD (6 in 4)	IVI/DIVI
DS-Lite (4 in 6)	
Dual stack	

Theoretic Migration Method along IPv6 User Growth

Service	IPv4	IPv6	IPv4	IPv6	IPv4	IPv6	IPv4	IPv6

Network	IPv4 Single Stack	IPv4 / IPv6 Dual Stack	IPv6 Single Stack	IPv6 Single Stack

Terminal

HGW(DS) — IPv4 / IPv6

HGW(DS) — IPv4 / IPv6

HGW(DS) — IPv4 / IPv6

HGW(IPv6) — IPv6

Technology	6RD	Dual Stack＋NAT	DS-Lite	NAT64

User	A few IPv6 users	Fast increase of IPv6 users	Massive IPv6 Users	A few IPv4 Users

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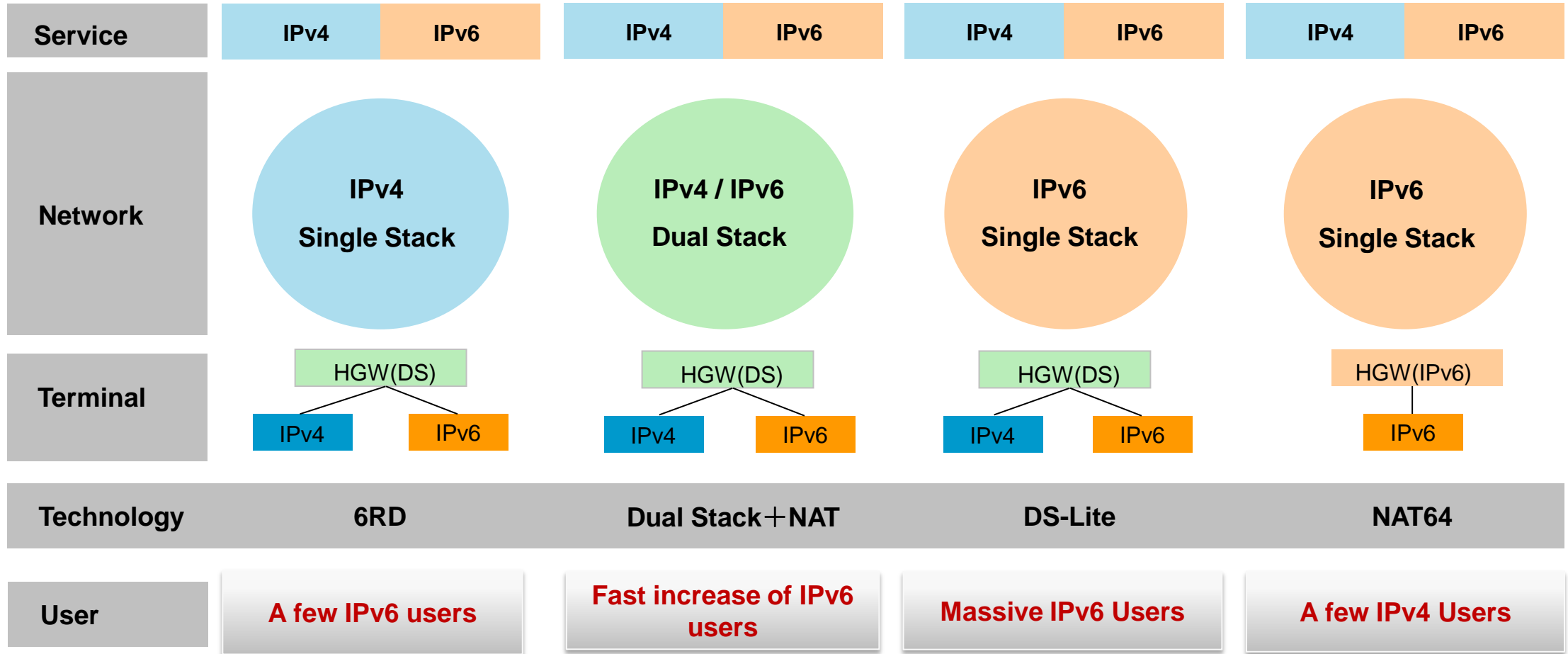
How to Choose: the Overall Considerations

Impacts on Subscriber and service

- Existing subscriber experience not influenced
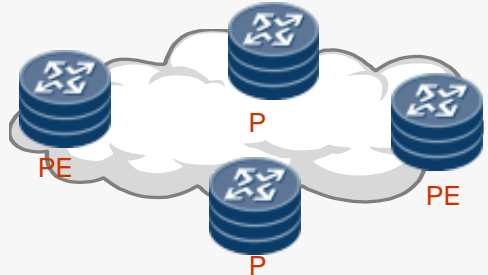
Migration Cost
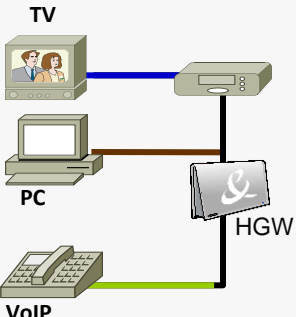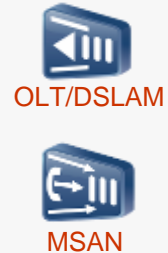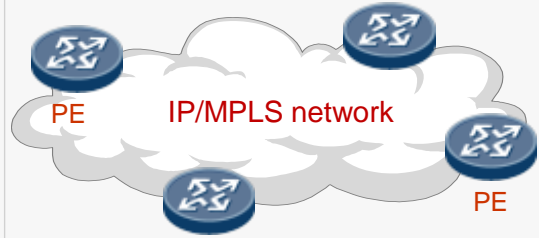
- Less cost while ensure the technology introduction
- Less cost with lower complexity

Technology Maturity

- More mature in standardization
- More vendor support

IPv4 → IPv6
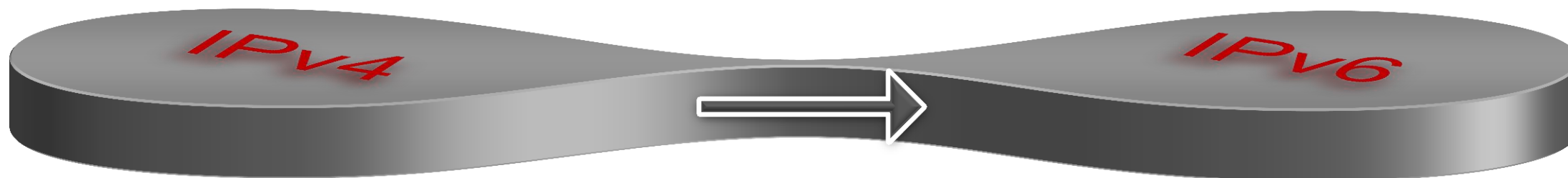
The Impacts on Network : What Changes

Terminal	Access	Metro / Aggregation	S-PoP	Core	Internet

Terminal	Access	Metro / Aggregation	S-PoP	Core	Internet
Existing CPE	PPPoE- No change	No Change	NAT444	For MPLS: • P: No Change • PE: 6PE, 6vPE	Dual Stack
IPv4 CPE, no NAT			L2-Aware NAT		
6-in-4 tunnel			6RD		
IPv6 Only	IPoE – Support for DHCPv6	L2 Metro – No Change L3 Metro – 6PE & 6vPE	NAT64	For Native IP: Dual Stack	
4-in-6 tunnel			DS-Lite		
Dual Stack			Dual Stack		

The Impacts on Terminal

Terminal Type	Dual Stack	DS-Lite	6RD	NAT64
Routing mode (L3)	Need to be upgrade to support DS and NAT if choosing NAT444	Need to be upgraded to support DS & DS-Lite GW (4 in 6)	Need to be upgraded to support DS & 6RD GW (6 in 4)	Need to be upgraded to support IPv6 protocol stack
Bridge mode (L2)	**No change** (transparent)	**Need to be replaced** (to support DS & DS-Lite GW)	**Need to be replaced** (to support DS & 6RD GW)	**No change** (transparent)

■ For 6RD and DS-Lite, the GW function which is to start 4 in 6 tunnel or 6 in 4 tunnel can be moved down to device to support, in this way, the network terminal only needs to support DS

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The Impacts on Multi-play Service

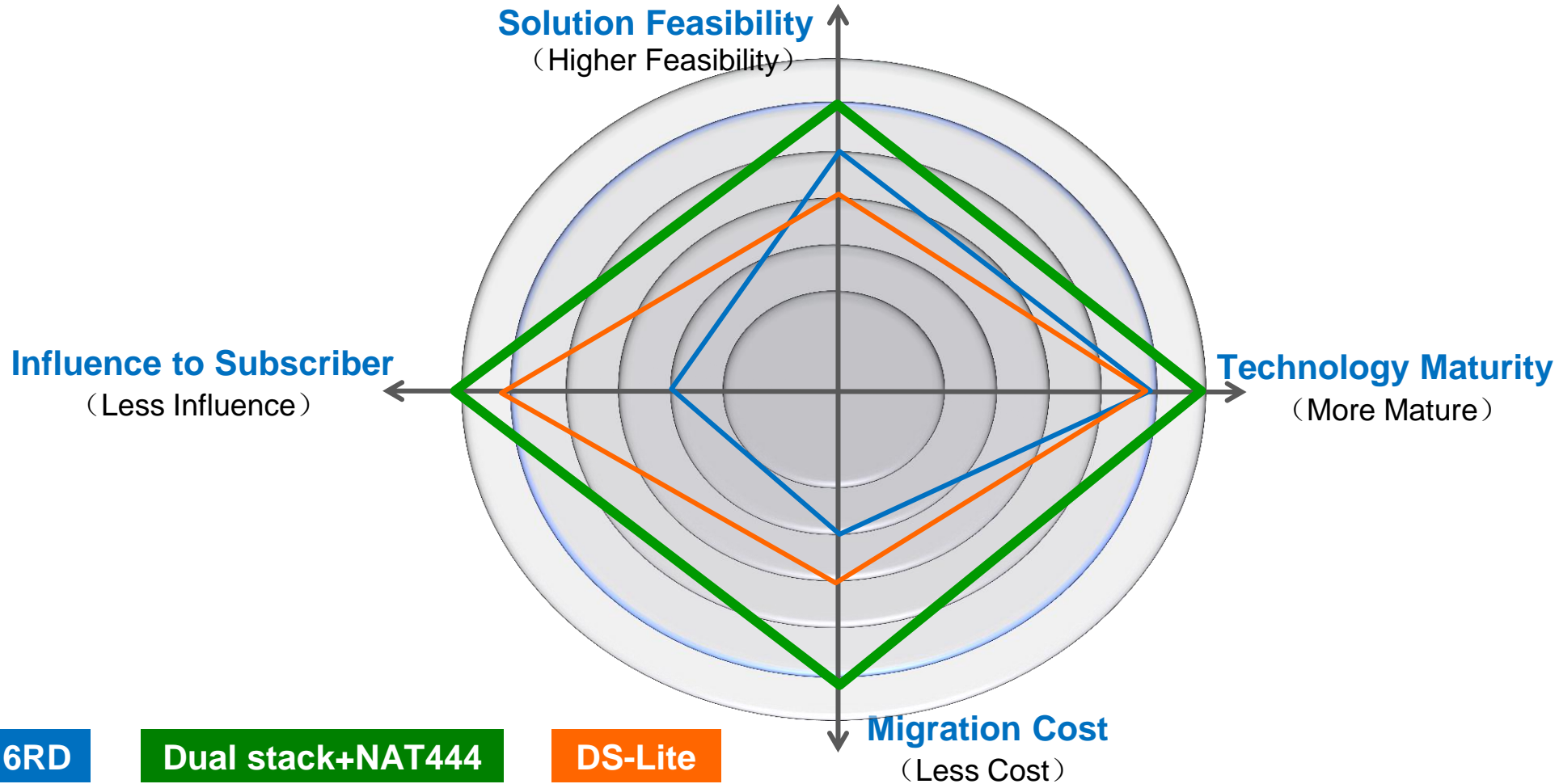| Service	Dual Stack	DS-Lite	6RD	NAT64
HSI	- Network forwarding performance will be affected by NAT44 probably - The technologies for P2P application crossing double NAT network is not totally mature	NAT and 4 in 6 tunnel will affect network forwarding efficiency and performance probably	NAT and 6 in 4 tunnel will affect network forwarding efficiency and performance probably	- NAT64 will affect network forwarding performance probably - The impact of applications crossing NAT64 still need to be evaluated later
IPTV	Need NAT added if using private IPv4 address	Transport efficiency is lower , multicast replication point can't move down as DS-Lite tunnel is P2P	Transport efficiency is lower , multicast replication point can't move down as DS-Lite tunnel is P2P	Only for IPv6 device
VPN	No significant impact	No significant impact	No significant impact	No significant impact

Key points

- There is a way to make P2P application run in NAT444 network, but standardization not finish yet
- Still need to find a way to make it possible that using DS-Lite tunnel to carry IPv4 based multicast service
- NAT64 and NAT44 added in network to effect network forwarding performance

Technology Maturity: Dual Stack is Best

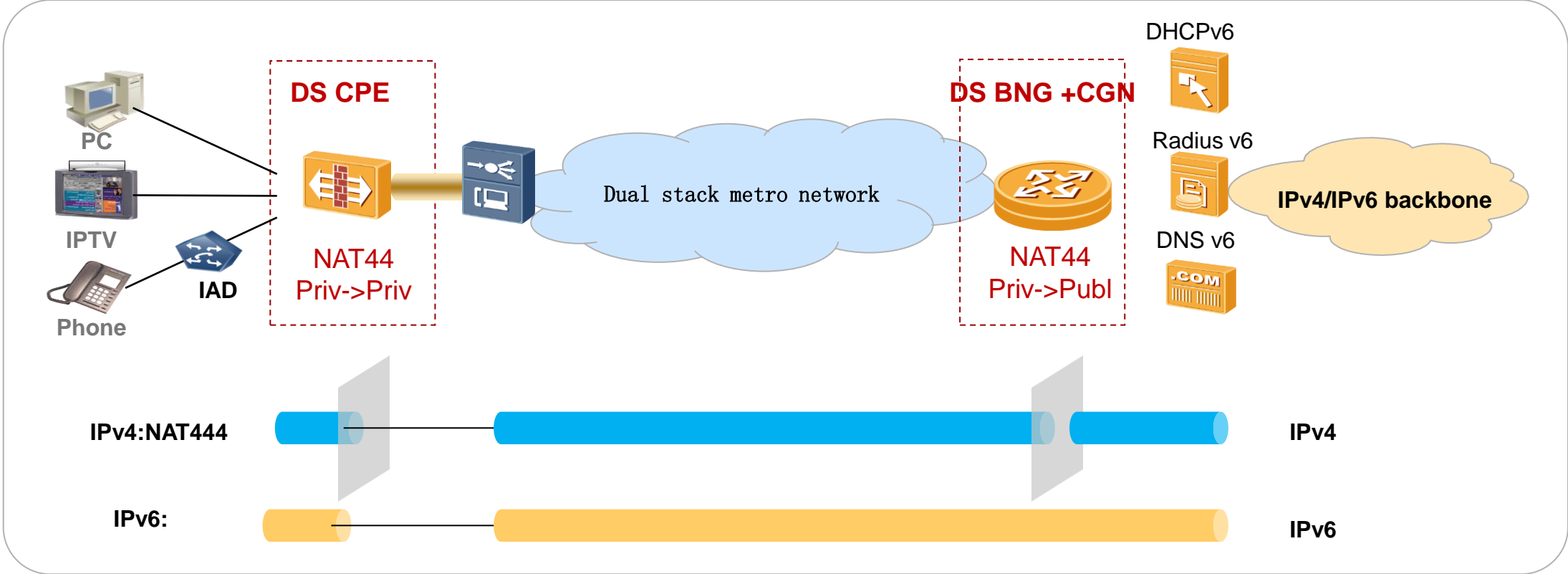| Maturity	Dual Stack	DS-Lite	6RD
Standard	■ Acknowledged and most accepted ■ Very close to formal standardization	■ WGLC Phase（work group last call), ust finished one RFC (RFC6634) in Aug. 2011	■ Near to formal standardization
Equipment	■ Mainstream vendors support ■ Most existing equipments can support DS by software upgrade	■ Ready for trial, not ready for massive deployment ■ For routing type CPE，can be upgraded to support DS-Lite	■ Very few vendor support (6RD GW) ■ CPE has to be replaced
Network Deployment	■ Can be used for commercial deployment ■ Currently be in massive test by Telcos	■ Test and evaluation	■ Very few trial networks for 6RD

Dual Stack > 6RD > DS Lite

The Best Choice is Dual stack + NAT444

Solution Feasibility （Higher Feasibility）

Technology Maturity （More Mature）

Migration Cost （Less Cost）

Influence to Subscriber （Less Influence）

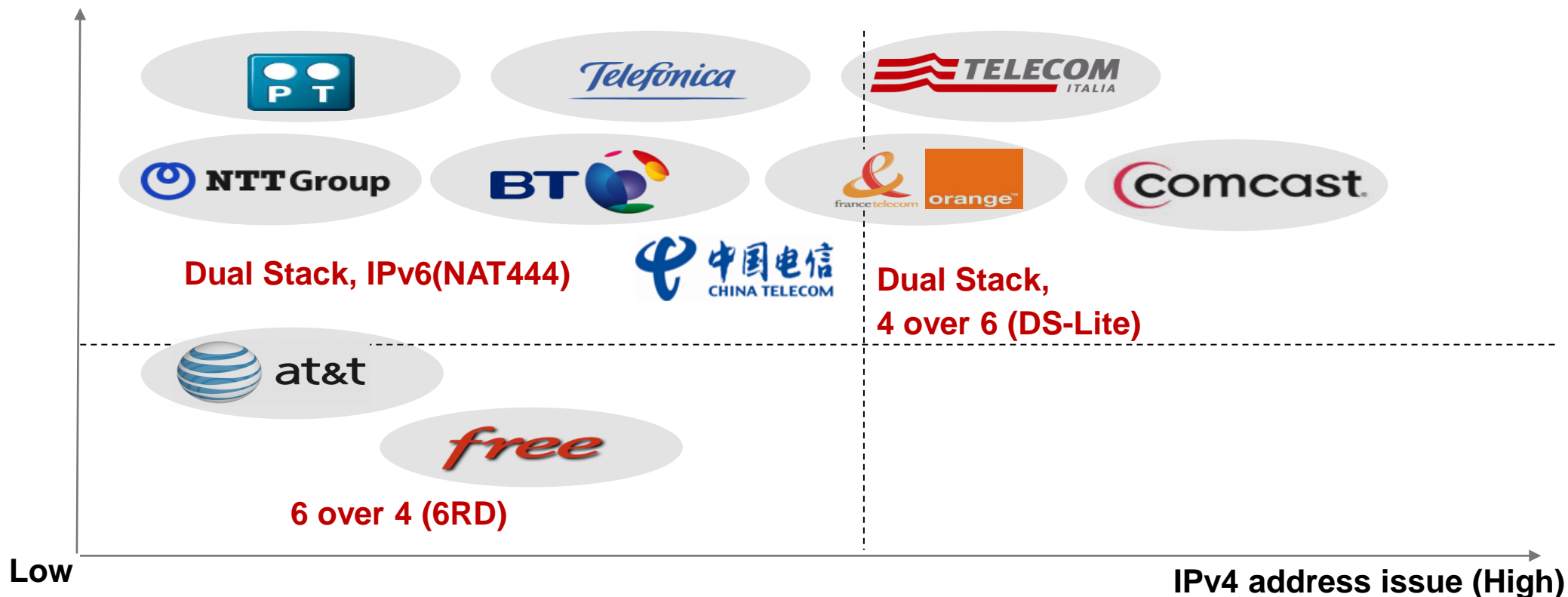6RD | Dual stack+NAT444 | DS-Lite

Dual Stack + NAT444 Technology

- Two layer NAT44, one @ HGW, one @ BNG GW
- Dual stack BNG and metro network

The Global Operators' Choice to IPv6 Migration

IPv6 Strategy (High)

Dual Stack, IPv6(NAT444)

**Dual Stack,
4 over 6 (DS-Lite)**

6 over 4 (6RD)

Low

IPv4 address issue (High)

Contents

IPv6 Evolution: Main Contributor for Standard

- **20 RFC ＋ 29 WG drafts (RFC-to be) + 35 individual drafts**
- Huawei leads IETF v4 to v6 transition, multicast transition, and renumbering work, is the top 3 contributor for each mainstream

  RFC 4925, RFC 5121, RFC 5790, RFC 5949, RFC 6036, RFC 6264, RFC 6273, RFC 6279, RFC 6422, RFC 6431, RFC 6436, RFC 6437, RFC 6440, RFC 6463, RFC 6563, RFC 6572, RFC 6636, RFC 6644, RFC 6654, RFC 6653

- **Huawei leads the harmonization between IETF and ITU-T standardization on IPv6**
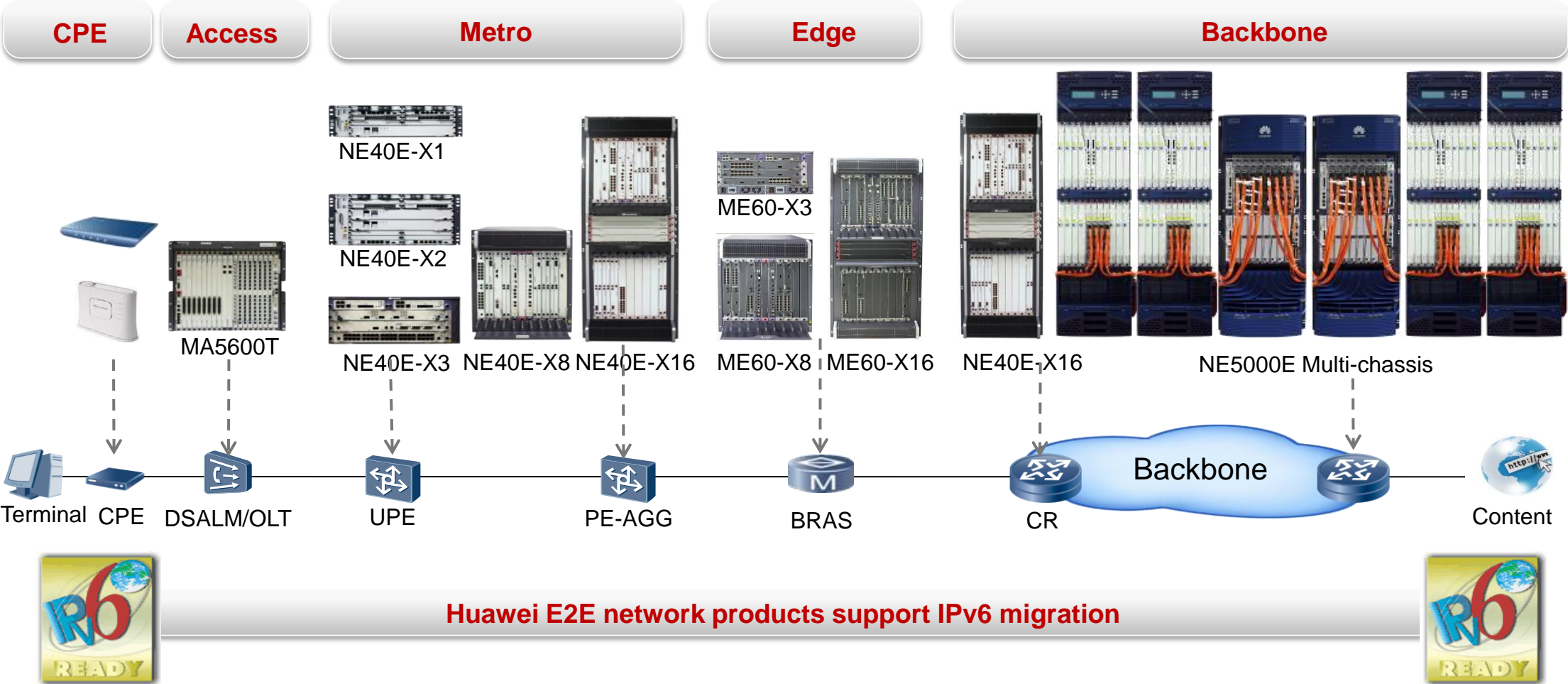
Y.2057 (ipv6split)	Y.2059 (ipv6na)	Y.2058 (ipv6migration)

- **Huawei is the co-editor of WT-242 "Migration Strategies to IPv4/v6 Dual Stack " and WT-296 " IPv6 Transition Mechanisms Test Plan"**

  A. Contributions in all these working groups
  B. Several editors positions held by Huawei

E2E IPv6 Products Overview

| CPE | Access | Metro | Edge | Backbone |

NE40E-X1

NE40E-X2

ME60-X3

NE40E-X3   NE40E-X8   NE40E-X16   ME60-X8   ME60-X16   NE40E-X16   NE5000E Multi-chassis

MA5600T

Terminal   CPE   DSALM/OLT   UPE   PE-AGG   BRAS   CR   Backbone   Content

Huawei E2E network products support IPv6 migration

Professional Service Ensure Smooth IPv6 Migration

Customized service ensure SMOOTH IPv6 migration of networks & services

Consulting	Design	Testing	Migration	Service verification	Network Optimization
IPv6 network consulting	**Network integration design**	**Network integration testing**	**Service and data migration**	**Service integration verification and acceptance**	**Day 2 Care**
▪ Information collection and demand research ▪ IPv6 service evolution consulting ▪ Network architecture evolution consulting ▪ Network IPv6 capability assessment ▪ IPv6 evolution solution TCO analysis	▪ IPv4 address extension ▪ IPv4 to IPv6 network evolution	▪ IPv6 lab test (IOT) ▪ IPv6 pilot test	▪ IPv6 feature enabling (Software, hardware, and configuration) ▪ IPv4 to IPv6 service and data migration	▪ Basic network acceptance ▪ Expanded network acceptance ▪ IPv6 service verification	▪ Assistance in troubleshooting ▪ Aid in releasing IPv6 services ▪ Solution change and verification ▪ Skill transfer

Dedicated Team (Center of Innovation)   +   Specialized Tools   +   Knowledge Center

Dedicated Team (Center of Innovation)	Specialized Tools	Knowledge Center
▪ Dedicated Team with rich experience	▪ Assessment tool (Device, network, service) ▪ Integration test tool ▪ Monitoring tool (Network, service) ▪ Fault locating tool	▪ IPv6 network design database ▪ Network design tool ▪ Typical IPv6 case database

Practical Deployment Experience

Practical Experience for IPv6 Deployments

| Universidad Shenzhen 2011 | CTC Hunan Metro network | CTC Jiangsu Metro network | EXPO Shanghai | China CNGI Backbone network | CMCC Guangdong Metro network | CMCC Jiangsu Metro network | CMCC Beijing MDCN |

Tests & Trails with Global operators

Thank you

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