WELCOME

IPv6 TRANSITION TECHNOLOGIES

Alastair JOHNSON
alastair.johnson@alcatel-lucent.com

April 2011

AGENDA

1. Introduction
2. Native IPv6 dual-stack
3. DS-Lite
4. NAT64
5. 6rd / 4rd
6. 464XLAT
7. IVI
8. Summary

INTRODUCTION

This presentation covers…

- A look at some of the most common (or popular) IPv6 transition technologies and how they can be deployed
- What technology is appropriate where, and what support looks like
- A brief comparison of the technologies
- Mostly focused on ISPs offering residential or consumer Internet services, however many technologies are applicable in other service environments
- Mostly focusing on the access, aggregation, and edge components of the network – assumes core and other infrastructure is IPv6 ready

INTRODUCTION
LARGE SCALE NAT

- Large Scale NAT (LSNAT), Carrier Grade NAT (CGNAT), or any other type of service provider IPv4-to-IPv4 based NAT platforms and technologies are **not a transition mechanism to IPv6**
- These technologies are IPv4 continuity solutions
- LSNAT is one of several mechanisms that an operator may use to manage IPv4 exhaustion in their network while deploying IPv6 services

- This presentation will not discuss LSNAT beyond this slide

INTRODUCTION

WHAT ARE TRANSITION TECHNOLOGIES

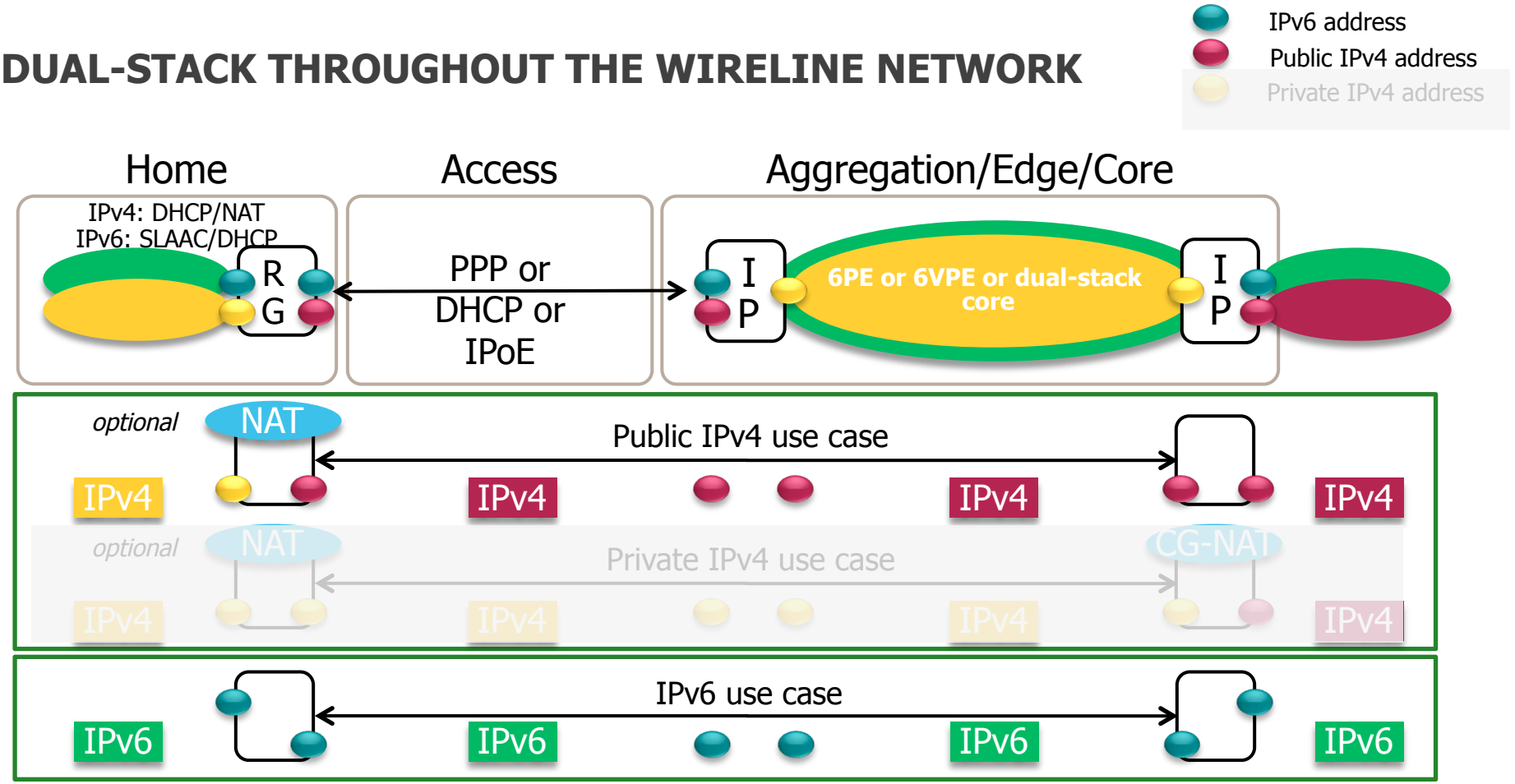
- Transition technologies are mechanisms that allow operators to deploy and migrate their subscriber-base to IPv6
- These transition technologies have been developed by both the IPv6 community and vendors to meet the need of accelerating IPv6 deployment
  - This presentation is not exhaustive – we've done too well in developing options
- There are many different transition technologies that have different pros and cons
- These which should be evaluated carefully to identify which transition technology or technologies are most appropriate for an operator to deploy
- Some transition technologies have a 'long term life', others are seen as interim solutions to deploy IPv6 quickly while investment or technology catches up
- CPE remains one of the most important selections for IPv6 deployment – to support any transition technology and your long term strategy: **Avoid multiple CPE swaps and minimize migrations**

NATIVE DUAL STACK

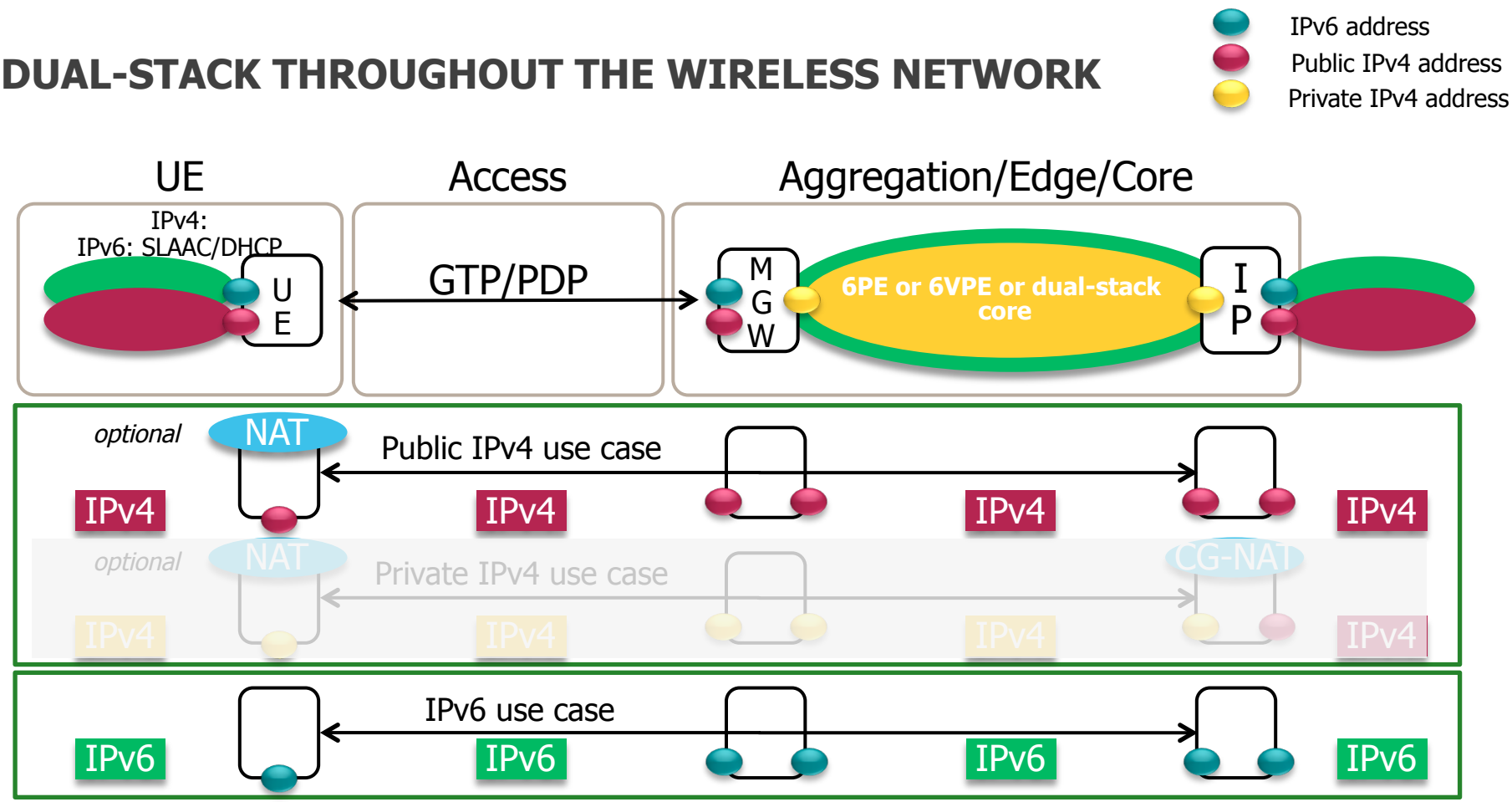
NATIVE DUAL-STACK
INTRODUCTION

- Deploying IPv6 services as native dual-stack is the best case approach for most operators and subscribers
  - But paradoxically it is often the most difficult
- No encapsulation or tunneling is required, and native IPv4 and IPv6 services are offered in parallel in the same subscriber session
  - IPv4 addressing is still provided to the subscriber with a potential for very long term sunsetting
- Deployment complexity levels vary in different environments
  - Some networks where there is minimal or no legacy equipment may find deploying native dual stack services very easy
  - Other networks with older or legacy equipment may find dual stack is not possible due to equipment constraints
  - CPE support is increasing significantly for dual-stack services on PPPoE and IPoE interfaces, including DHCPv6 (with prefix delegation) and SLAAC WAN support
- Ongoing operational considerations
  - What's the impact of running two parallel stacks on the network? Twice the monitoring, reporting, etc…

DUAL-STACK THROUGHOUT THE WIRELINE NETWORK



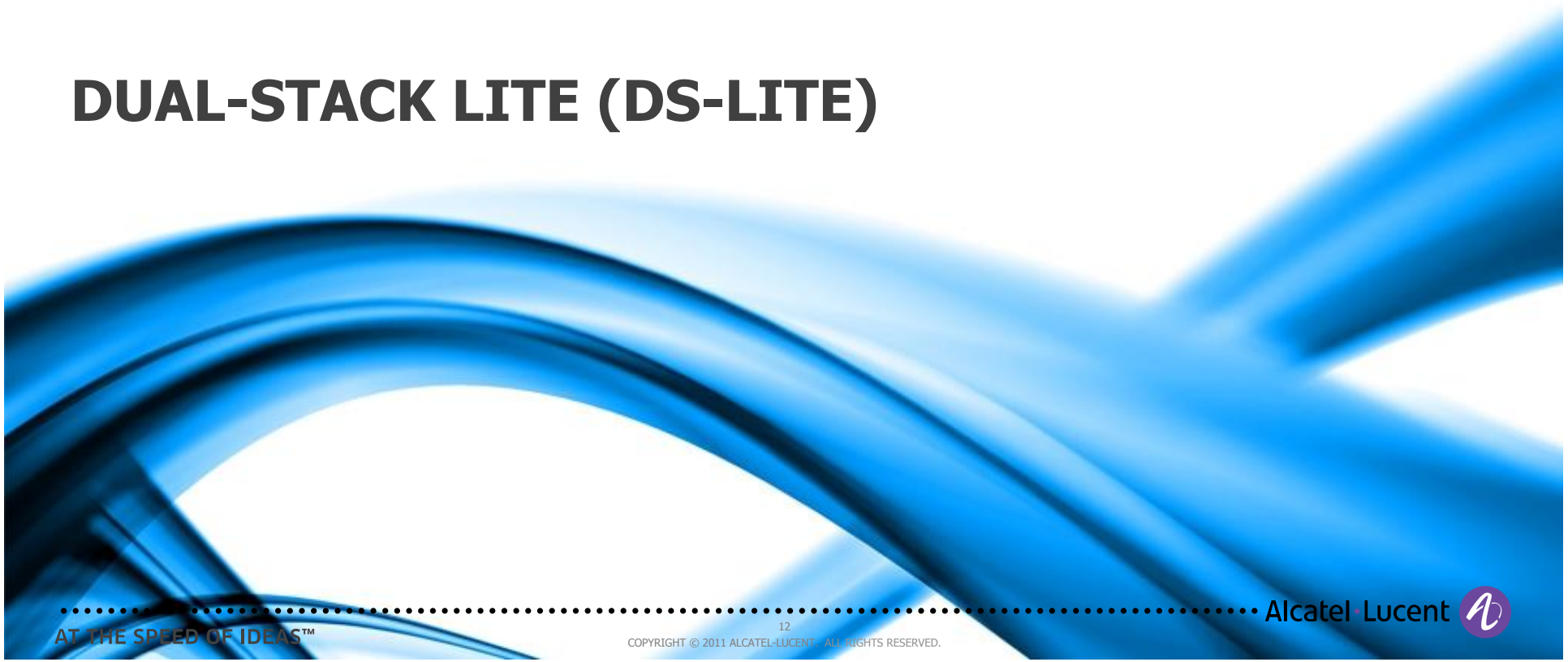
DUAL-STACK THROUGHOUT THE WIRELESS NETWORK



NATIVE DUAL-STACK
DOMAIN IMPACT

ACCESS	• Zero impact in PPPoE environments since PPPoE encapsulates traffic nicely and subscriber RGs will be able to bring up IPv6 when they are ready to support it • Medium to high impact in IPoE environments – depending on topology and access technology. N:1 VLANs may require network rearchitecture to deploy easily, as well as relying on intelligence in the access network
AGGREGATION	• Generally zero impact for IPv6 services if an L2 aggregation network is simply backhauling traffic in VLANs
SUBSCRIBER EDGE	• High impact – need to support IPv6 services, including subscriber management, queuing, accounting, DHCP-PD, SLAAC(*), etc • Scaling may be significantly impacted when enabling IPv6 in BRAS/BNG • * SLAAC for subscriber management is an interesting issue, general industry trend is DHCPv6 based
HOME NETWORK	• Still the most complex domain to manage • Customer Gateway (DSL modem/router, cable modem, etc) most likely needs to be replaced • BBF TR-124i2 specifies the requirements for IPv6 cable residential gateways and vendor support for IPv6 WAN/LAN is increasing significantly, e.g. Technicolor and D-Link • Home network components need to support IPv6 • Internal addressing structure for the home network needs to be considered too

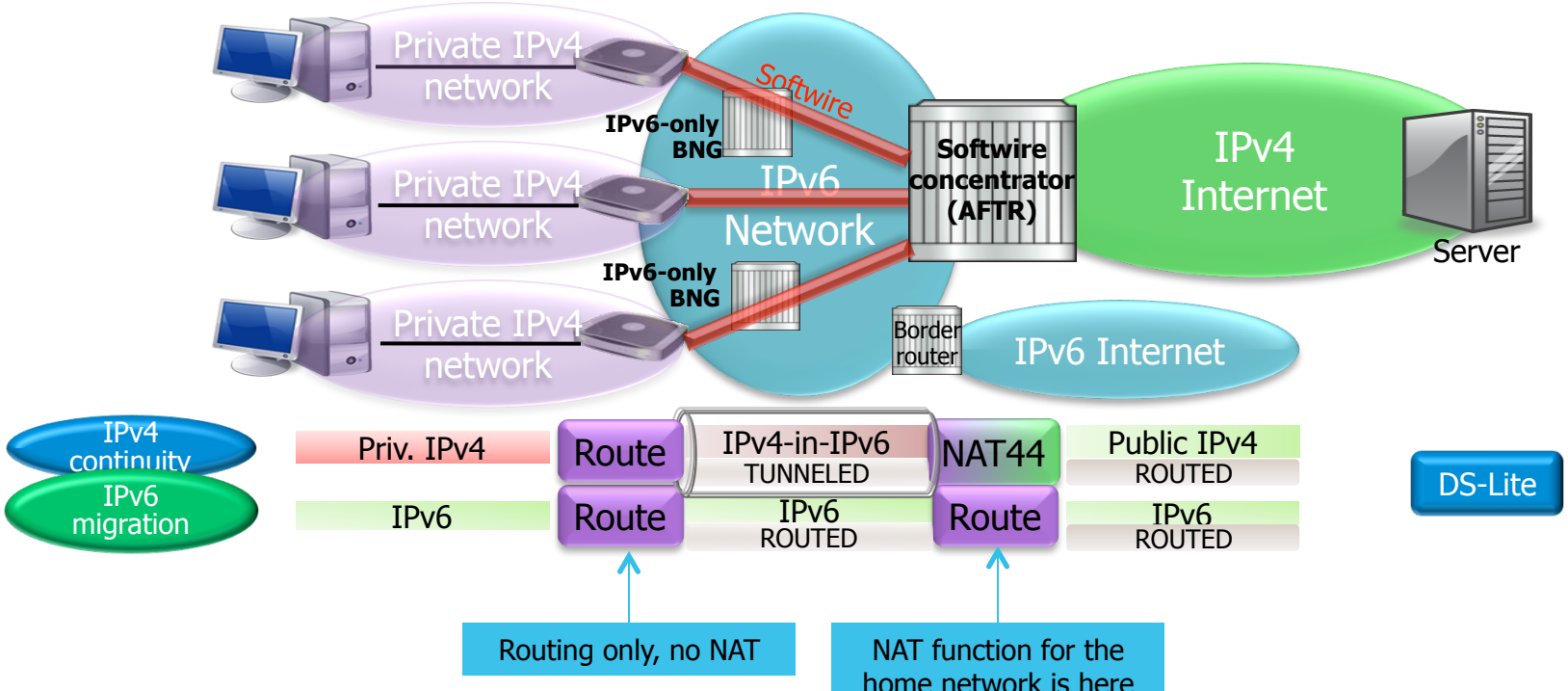
DUAL-STACK LITE (DS-LITE)



DS-LITE
INTRODUCTION

- Addresses operators who want IPv6-only access networks while providing support for IPv4-only nodes
- CPE encapsulates IPv4 traffic into IPv4-over-IPv6 tunnel using RFC2473
- Softwire concentrator decapsulates IPv4 packet and performs NAT44 using unique IPv6 transport address for NAT mapping (LSGN)
- IPv4 traffic is routed by CPE to IPv4-over-IPv6 tunnel and is subject to a single NAT operation at the softwire concentrator (or Address Family Transition Router [AFTR])
- IPv6 traffic is routed natively by CPE and BNG

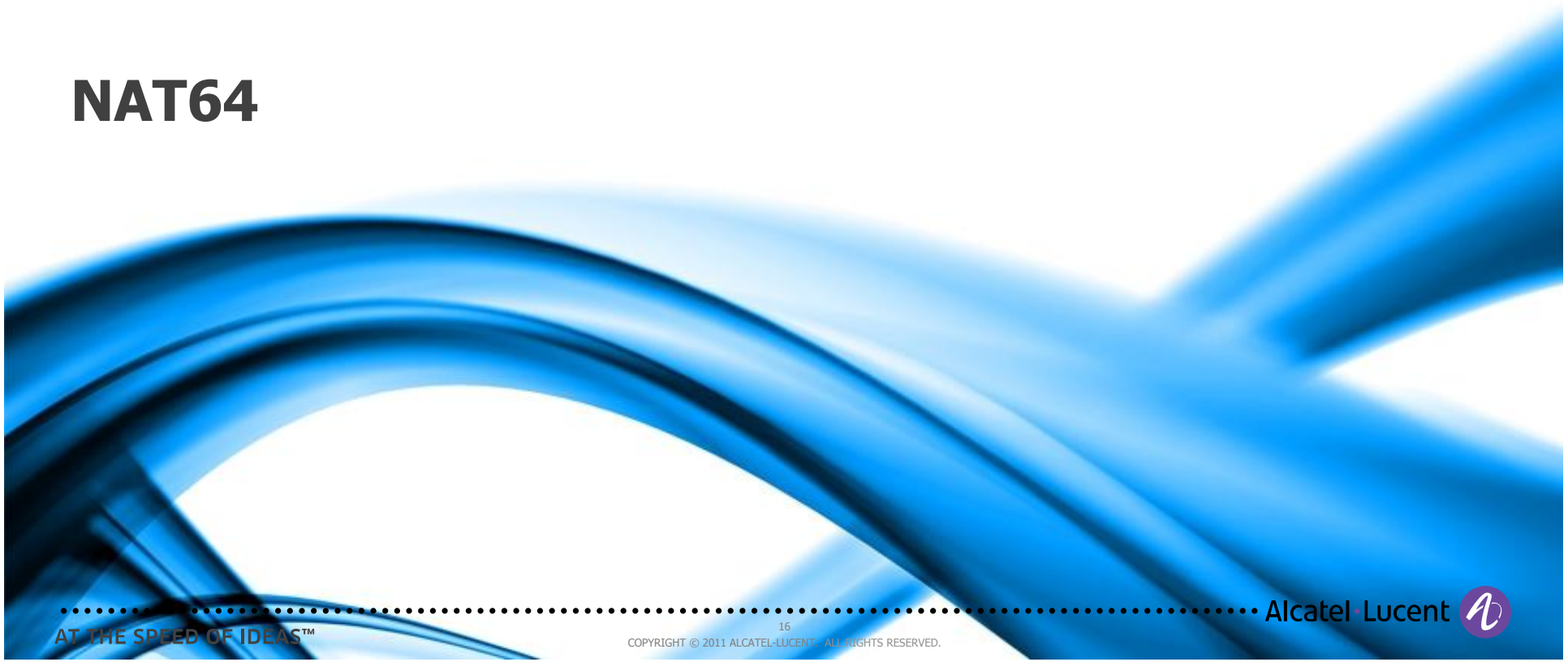
DUAL-STACK LITE



DS-LITE
DOMAIN IMPACT

ACCESS	• Medium to high impact depending on topology and technology • Access network becomes **single stack IPv6 only** so all upgrades that a native dual-stack scenario requires are also required for DS-Lite
AGGREGATION	• Generally zero impact for IPv6 services if an L2 aggregation network
SUBSCRIBER EDGE	• High impact: AFTR is needed in the network – may be colocated in the BNG or a dedicated element • BNG must support all requisites for implementing IPv6 subscriber management
HOME NETWORK	• Still the most complex domain to manage • Customer Gateway (DSL modem/router, cable modem, etc) most likely needs to be replaced – must support IPv6-only WAN and DS-Lite – vendor support increasing • Home network components need to support IPv6 • Internal addressing structure for the home network needs to be considered too • IPv4 NAT at the customer gateway is removed

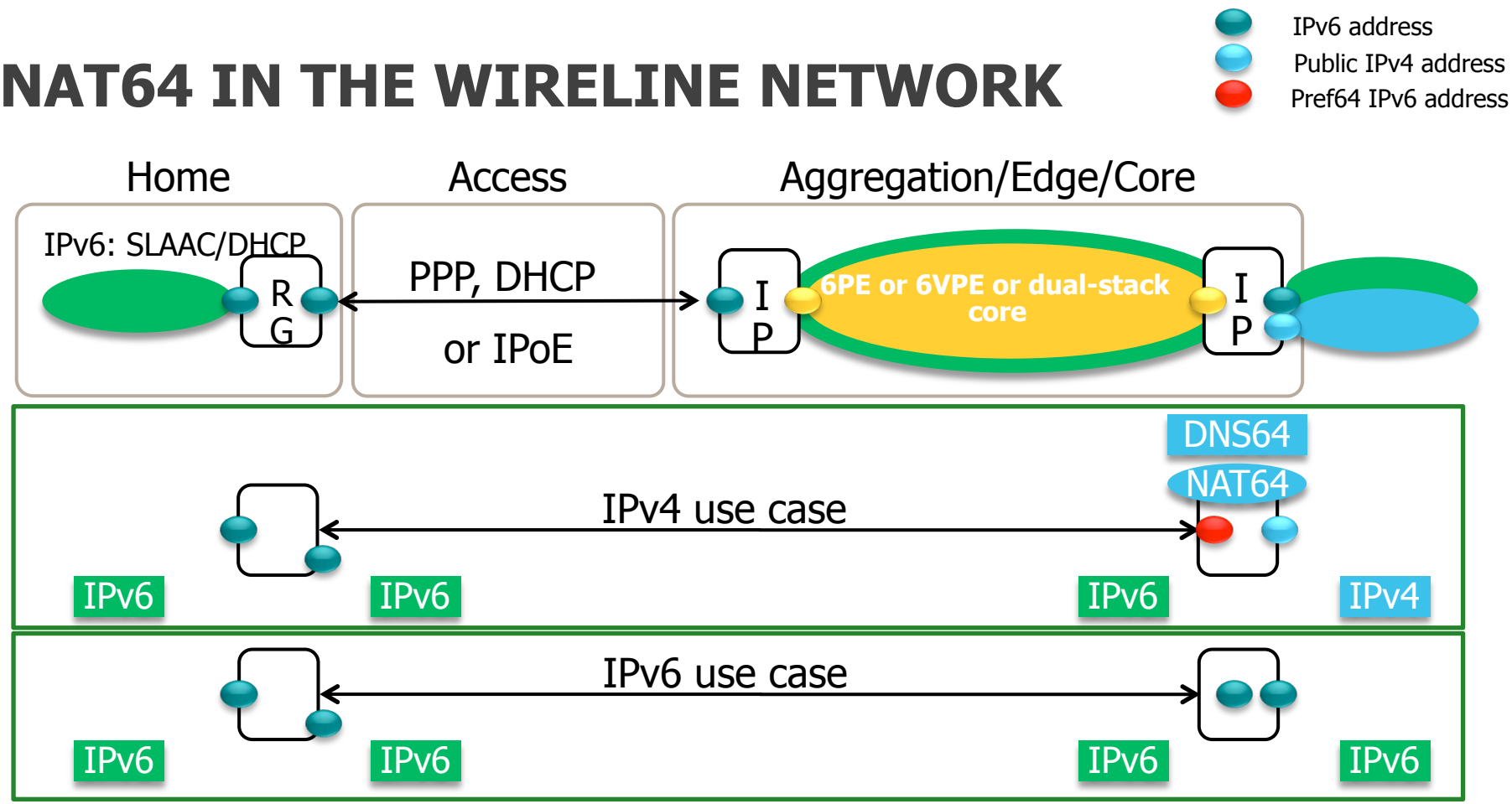
NAT64



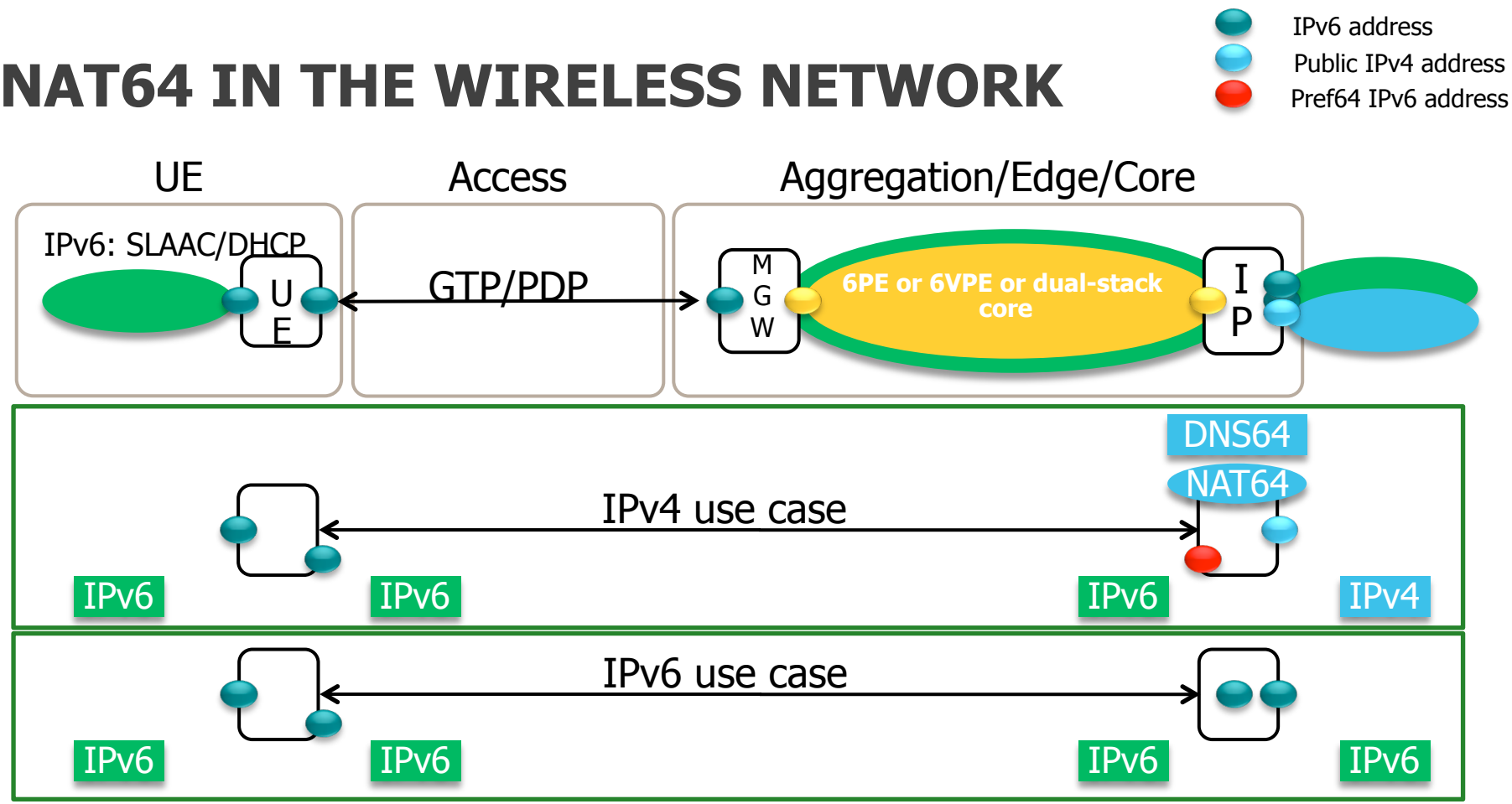
NAT64
INTRODUCTION

- Addresses operators who want IPv6-only access networks, but providing support for IPv4-only servers or content
  - Implies a well behaved, well understood CPE/UE – and ideally a minimal set of applications
- CPE/UE connects to IPv4 hosts through a synthesized IPv6 address, provided by a DNS64 engine
  - Well known prefix 64:ff9b::/96 is used to map IPv4 server addresses
  - Any client that cannot use a DNS64 server or provide local DNS64 resolution will not be able to connect to the IPv4 server, e.g. no more connecting by IP address
- IPv6 traffic is routed natively by CPE and BNG

NAT64 IN THE WIRELINE NETWORK



NAT64 IN THE WIRELESS NETWORK

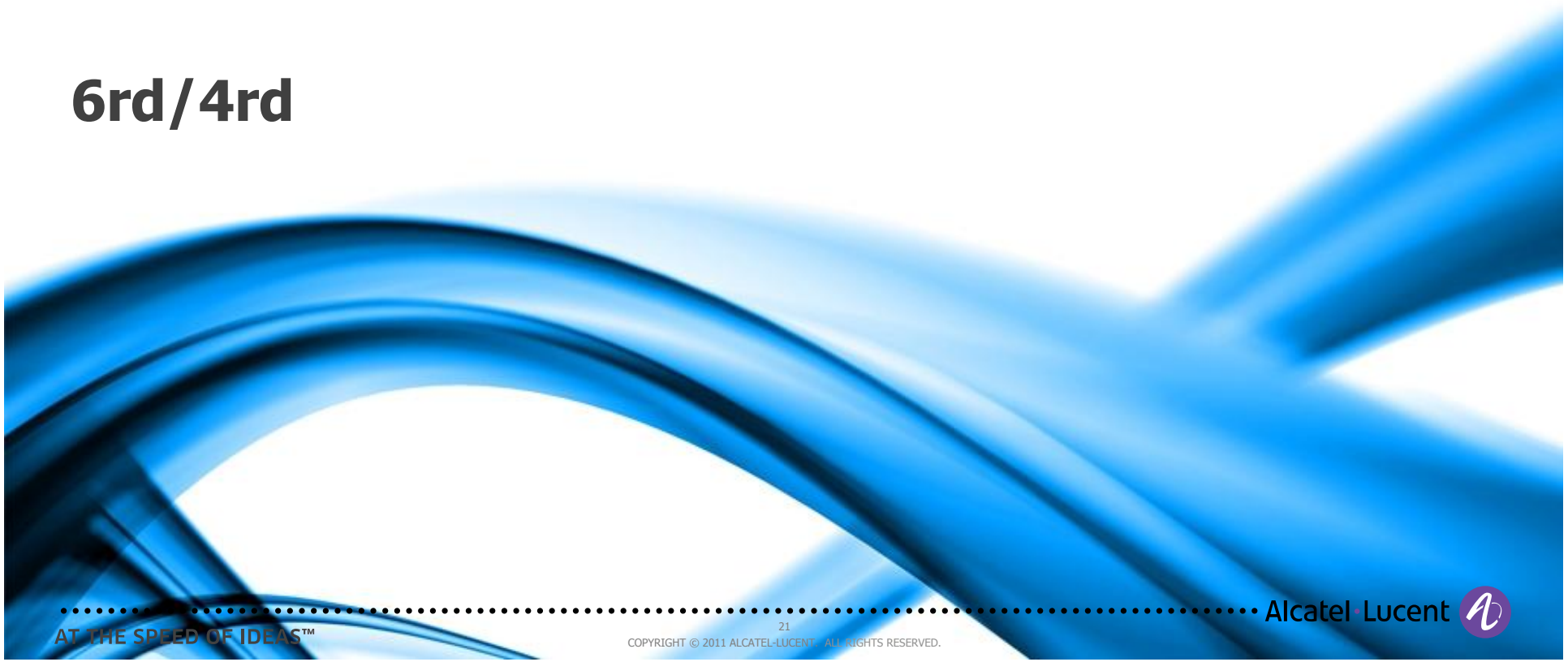


NAT64

DOMAIN IMPACT

ACCESS	• Medium to high impact depending on topology and technology • Access network becomes **single stack IPv6 only** so all upgrades that a native dual-stack scenario requires are also required for NAT64
AGGREGATION	• Generally zero impact for IPv6 services if an L2 aggregation network
SUBSCRIBER EDGE	• High impact: NAT64 is needed in the network – may be colocated in the BNG or a dedicated element • DNS64 node must also be deployed • BNG must support all requisites for implementing IPv6 subscriber management
HOME NETWORK	• Still the most complex domain to manage • Customer Gateway (DSL modem/router, cellphone, cable modem, etc) most likely needs to be replaced – must support IPv6-only WAN • Home network components need to support IPv6 • Internal addressing structure for the home network needs to be considered too • IPv4 NAT at the customer gateway is removed – and direct IPv4 support may be removed • DNSSEC support will break with a DNS64 in the middle of the DNS chain • Typically only useful or talked about for wireless environments at the moment

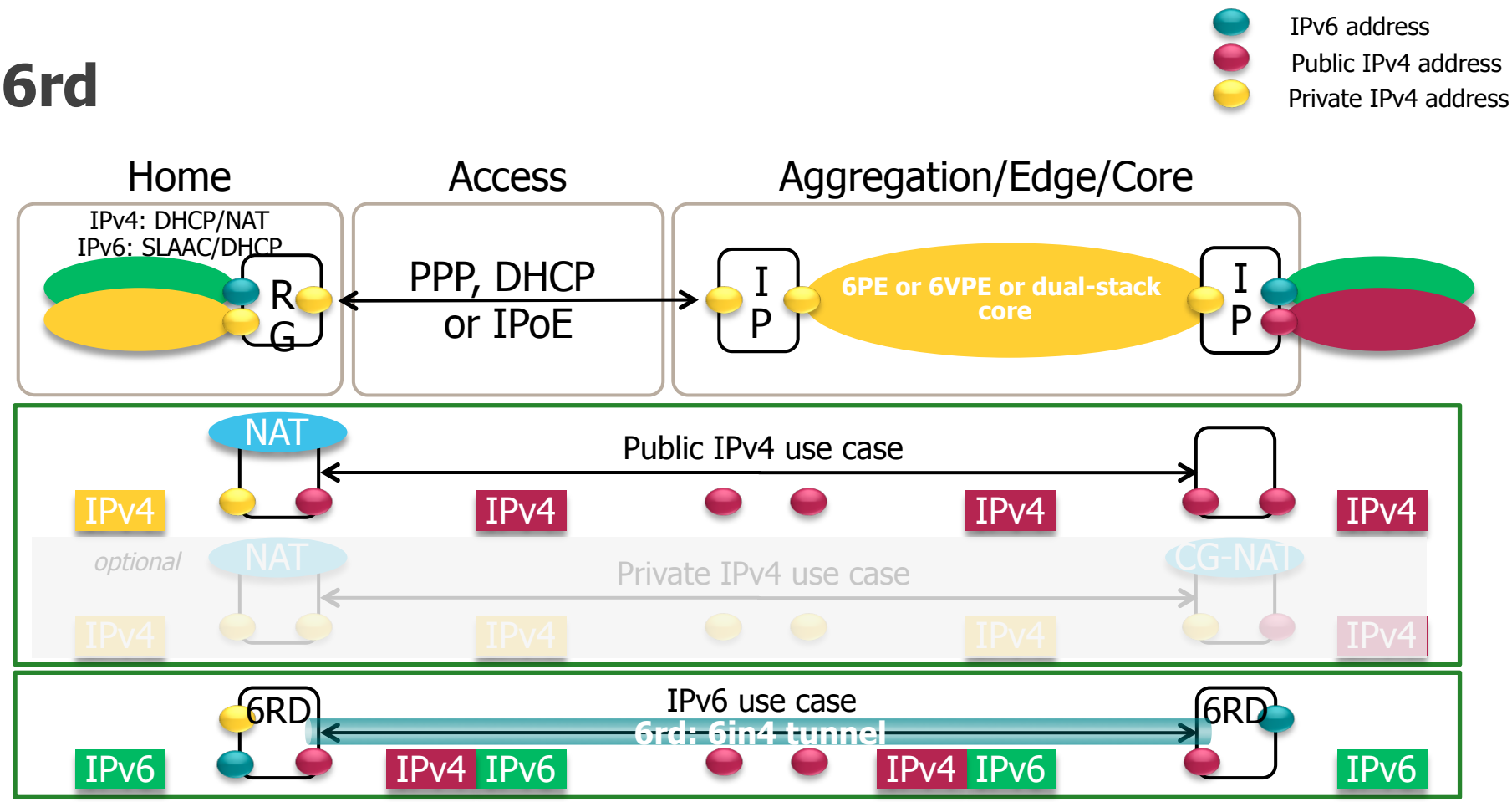
6rd/4rd



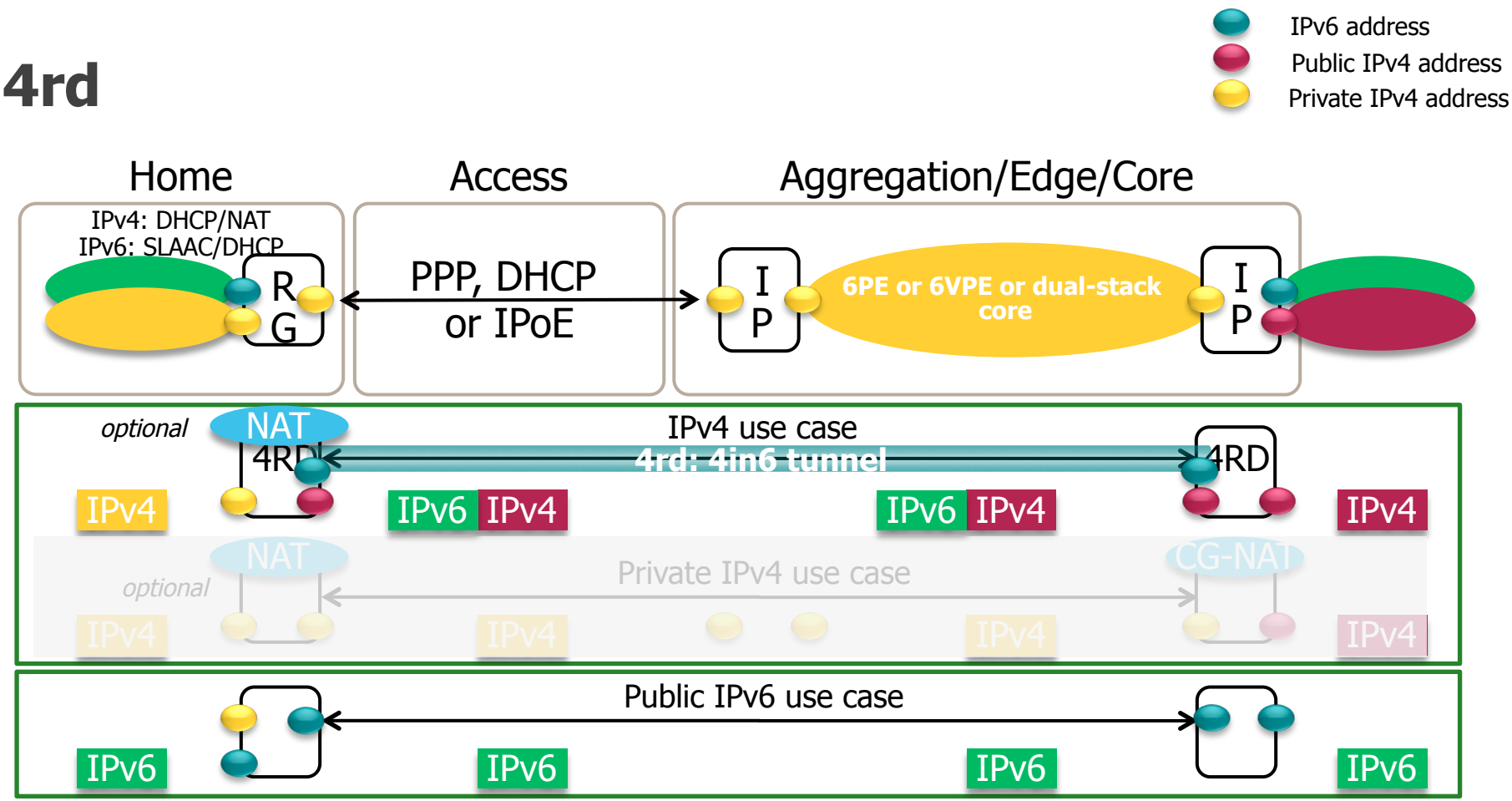
6rd/4rd
INTRODUCTION

- 6 **R**apid **D**eployment and 4 **R**esidual **D**eployment
- A tunneling technology based loosely on 6to4
- **6rd** allows IPv6 to be deployed over existing IPv4-only access networks, without any forklift upgrades to the access, aggregation, or subscriber management networks
- **4rd** allows IPv4 to be deployed over IPv6-only access networks, to provide legacy support for IPv4 services
- All addresses are automatically discovered by the CPE, while the BR address may be statically configured or discovered via a variety of mechanisms (e.g. dhcp option)
- Fits well for wireline network environments where a CPE swap or upgrade is easy, but access networks are complex or expensive to modify (or are third party)
- Device-to-device traffic may be routed directly, and not through the BR when staying within a 6rd domain
- 6rd has plans under discussion for eventual sunsetting in favor of native IPv6 (dual or single stack)

6rd



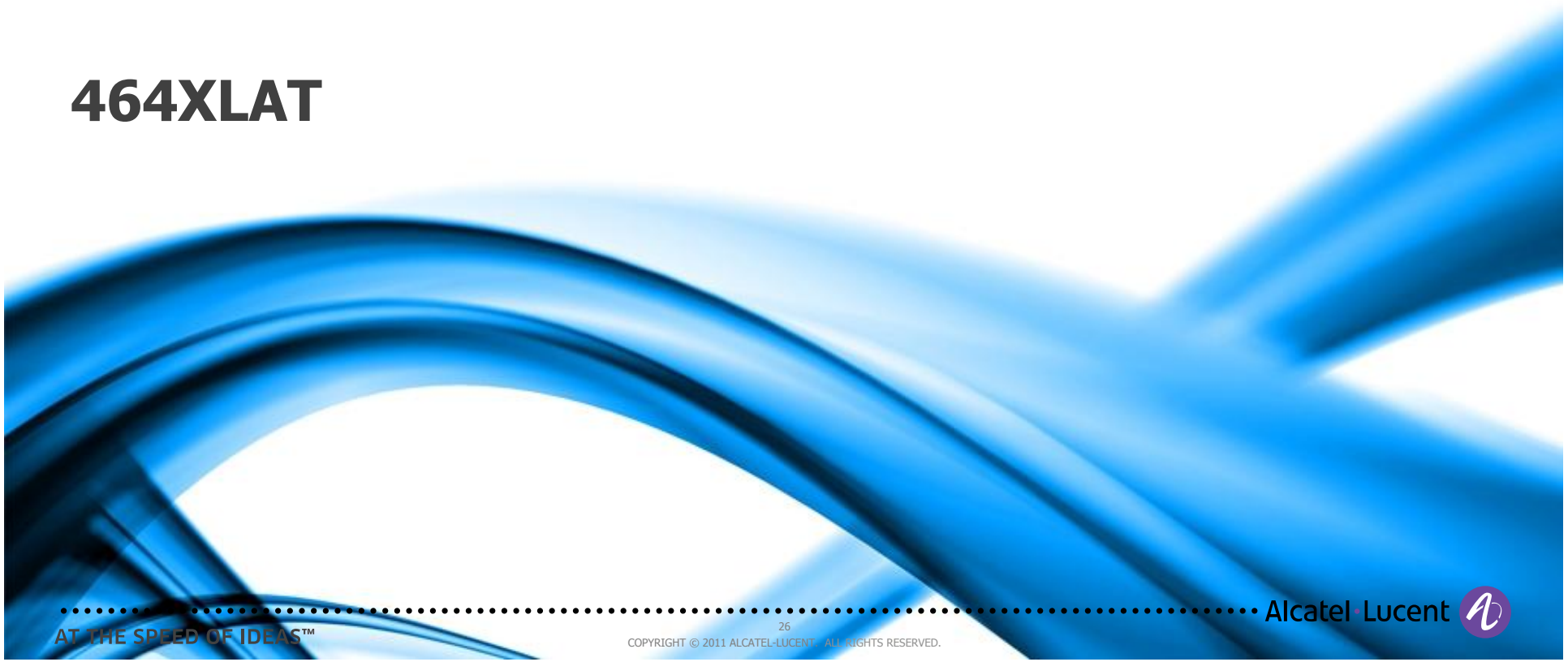
4rd



6rd/4rd
DOMAIN IMPACT

ACCESS	• No impact for 6rd – access network remains **exactly the same** • Medium-to-high impact for 4rd as the access network becomes **single stack IPv6 only** so all upgrades that a native dual-stack scenario requires are also required for 4rd
AGGREGATION	• Generally zero impact for IPv6 services if an L2 aggregation network
SUBSCRIBER EDGE	• High impact: BR is needed in the network – may be colocated in the BNG or a dedicated element • BNG must support all requisites for implementing IPv6 subscriber management for 4rd • Potential loss of visibility of tunneled traffic at BNG
HOME NETWORK	• Still the most complex domain to manage • Customer Gateway (DSL modem/router, cable modem, etc) most likely needs to be replaced or upgraded – must support 6rd/4rd, and IPv6-only WAN for 4rd. Many RGs are shipping 6rd support today • Home network components need to support IPv6 for native services • IPv4 NAT at the customer gateway is still present • Potential MTU impact for tunnels – potentially higher WAN MTU or frag-support • Useful for environments where the access network can't be touched (wholesale..)

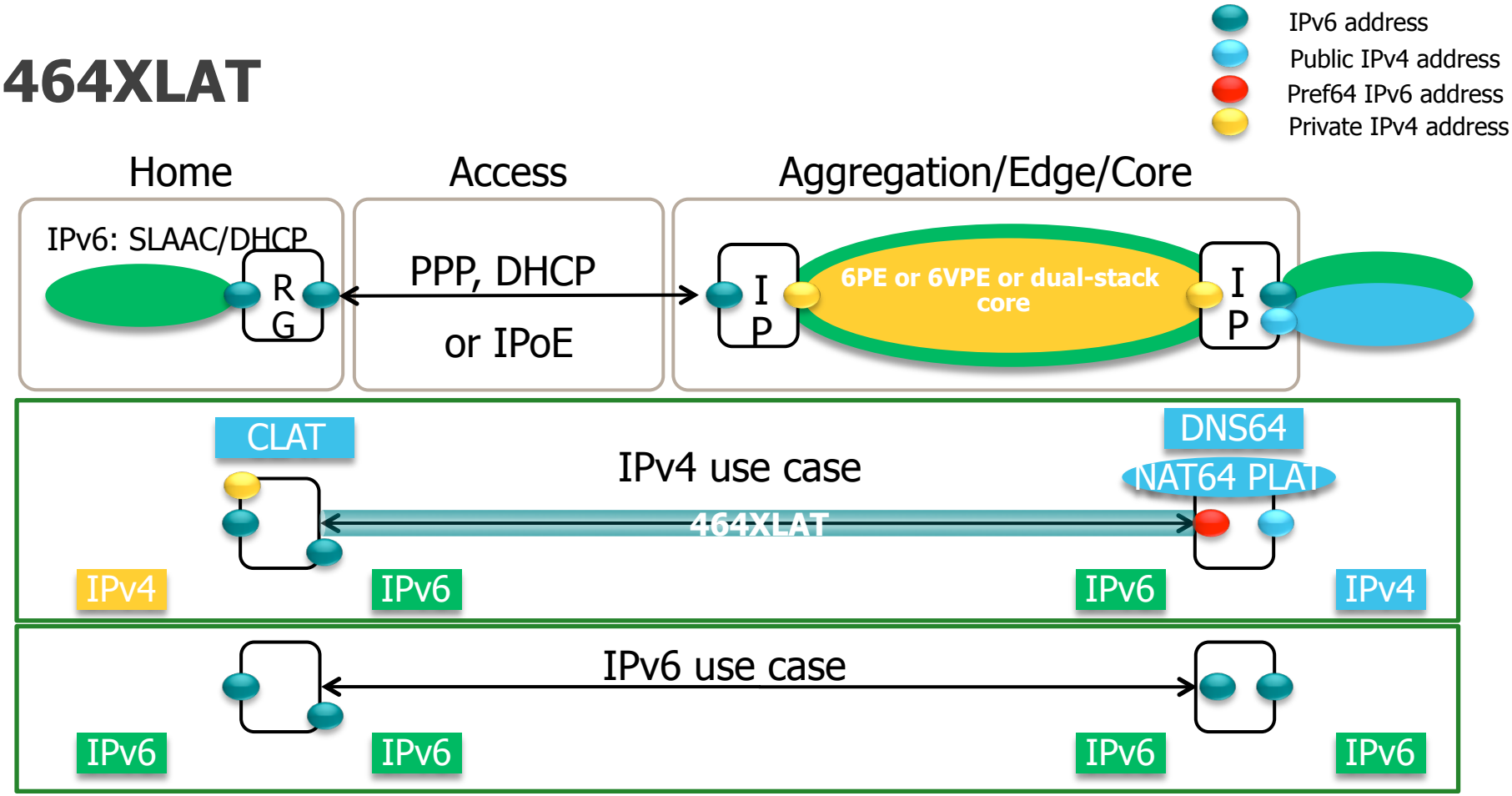
464XLAT



464XLAT
INTRODUCTION

- A distributed variant of NAT64/DNS64 whereby the 'CLAT' (stateless IPv4-map-to-IPv6) device is located in the home network, and the 'PLAT' (stateful NAT64) device is located in an operator network
  - The PLAT does not have to be located in the ISP network, it could be outsourced
- Home clients may continue to be IPv4-only single stack as the CLAT will provide home-network address family translation – potentially double-translating (NAT44 + NAT64)
- All of the previous considerations for NAT64 continue to apply

464XLAT

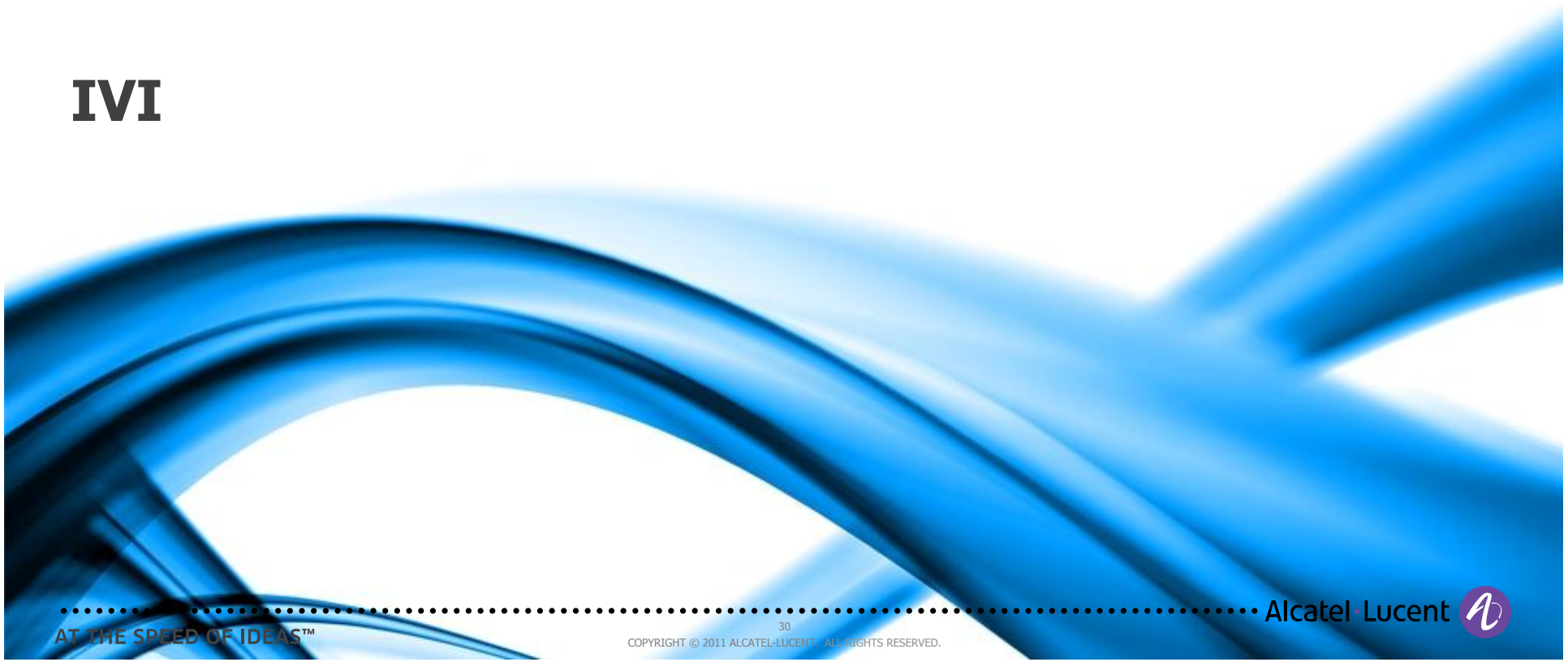


464XLAT

DOMAIN IMPACT

ACCESS	• Medium to high impact depending on topology and technology • Access network becomes **single stack IPv6 only** so all upgrades that a native dual-stack scenario requires are also required for 464XLAT
AGGREGATION	• Generally zero impact for IPv6 services if an L2 aggregation network
SUBSCRIBER EDGE/ISP	• BNG must support all requisites for implementing IPv6 subscriber management • NAT64 node (PLAT) may be deployed in the operator network, or elsewhere • DNS64 node may also be deployed
HOME NETWORK	• Still the most complex domain to manage • Customer Gateway (DSL modem/router, cellphone, cable modem, etc) most likely needs to be replaced – must support IPv6-only WAN • Home network components need to support IPv6 • Internal addressing structure for the home network needs to be considered too • CLAT provides translation from IPv4 to IPv6 locally (in the CLAT UE or CLAT element) and forwards IPv4 traffic towards PLAT • DNSSEC support will break with a DNS64 in the middle of the DNS chain

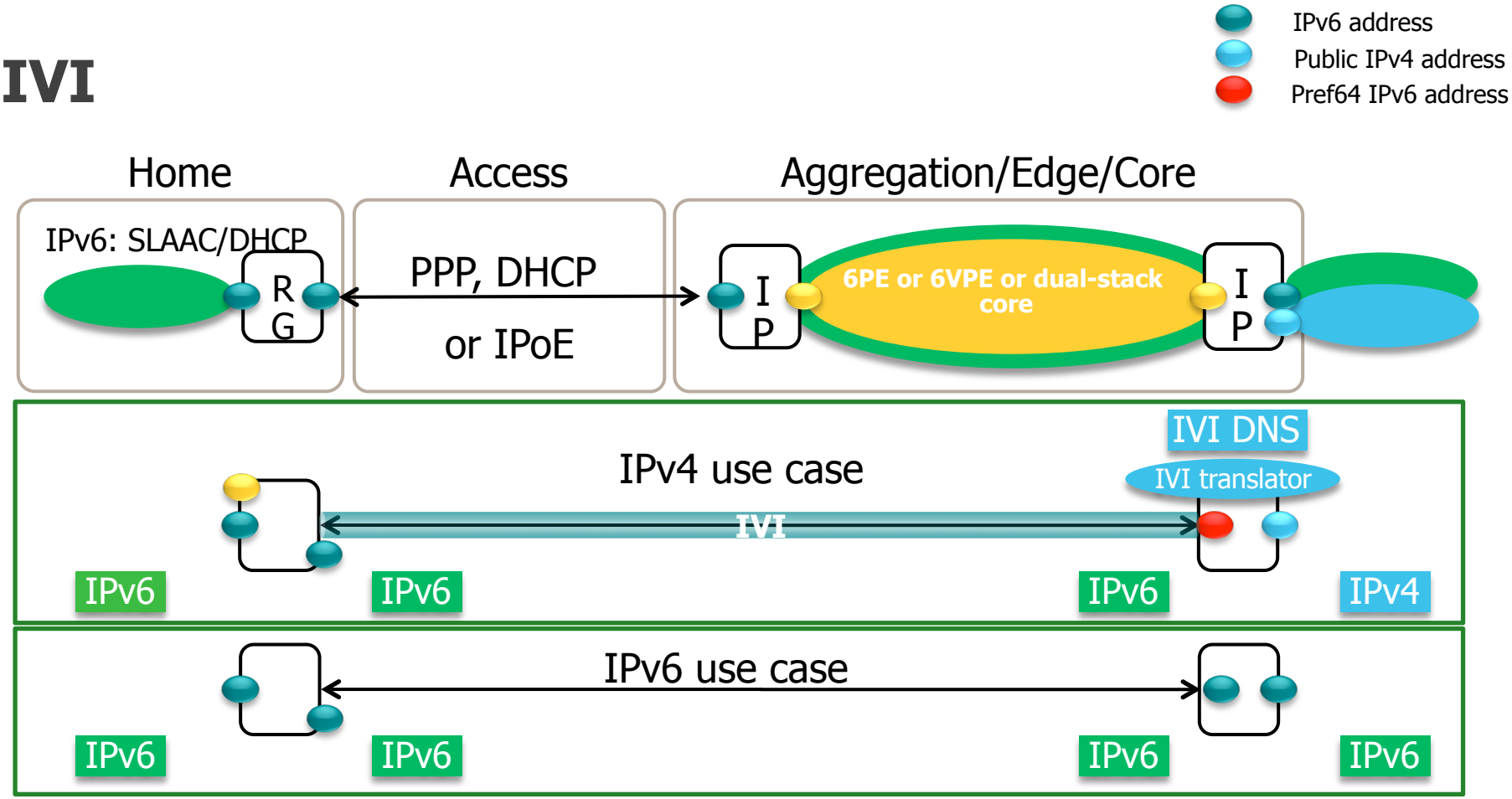
IVI



IVI
INTRODUCTION

- IV is 4, and VI is 6… so IVI is 4 and 6
- A stateless address family translation approach where a one-to-one mapping is made between IPv4 and IPv6 addresses
- Fixed mapping negates the need for translation logging
- Stateless behavior means the IPv4 address can be used for inbound connections (unlike NAT64 without presignalling)
- Will use an IPv4 address for every IVI IPv6 host in the network
- Still requires state in the form of ALGs for IPv4 applications which embed addresses in the protocol payload
- Useful for environments where an IPv6-only network is being planned, but connectivity to IPv4 environments is also desirable through a high-speed but state-free translator

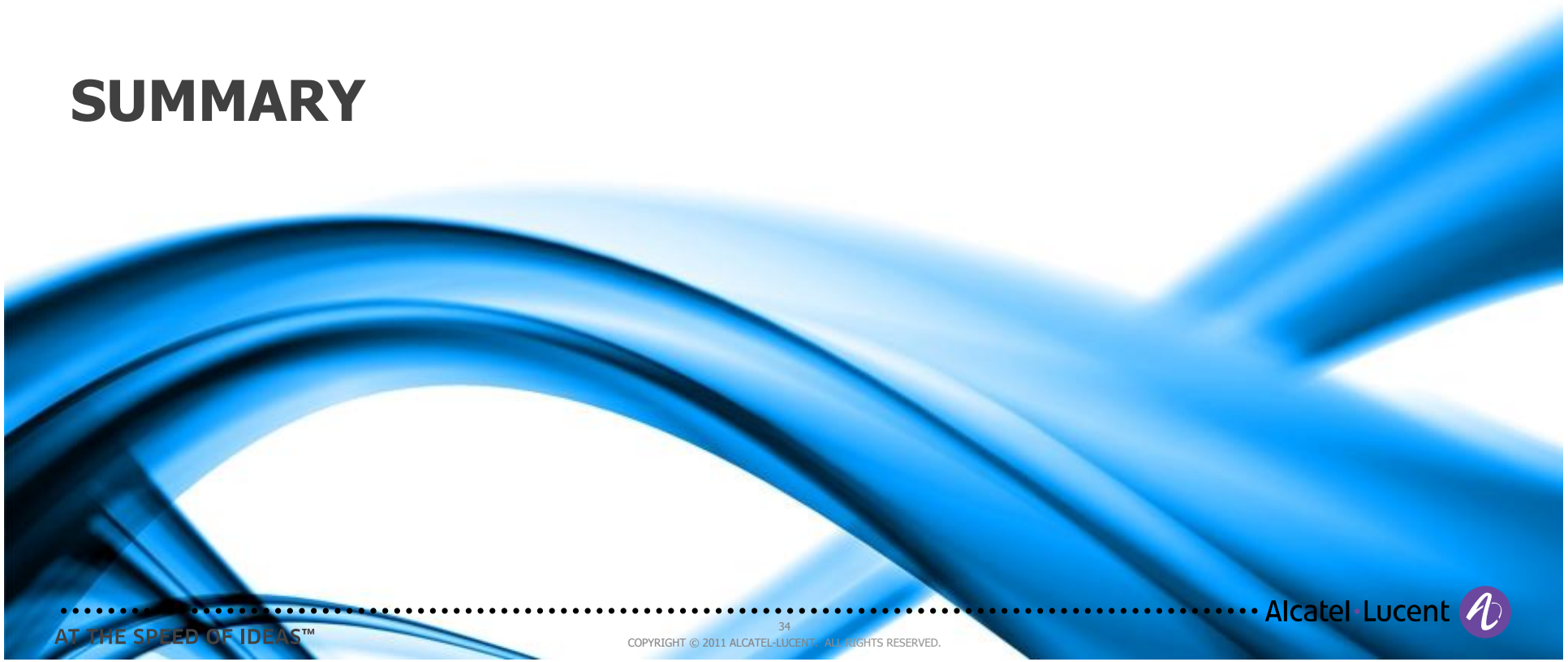
IVI



IVI
DOMAIN IMPACT

ACCESS	• Medium to high impact depending on topology and technology • Access network becomes **single stack IPv6 only** so all upgrades that a native dual-stack scenario requires are also required for IVI
AGGREGATION	• Generally zero impact for IPv6 services if an L2 aggregation network
SUBSCRIBER EDGE	• High impact: IVI translator is needed in the network – may be colocated in the BNG or a dedicated element • IVI DNS node must also be deployed • BNG must support all requisites for implementing IPv6 subscriber management • Subscribers still receive a public IPv4 address that is unique to them on the outside of the translator
HOME NETWORK	• Still the most complex domain to manage • Customer Gateway (DSL modem/router, cellphone, cable modem, etc) most likely needs to be replaced – must support IPv6-only WAN • Home network components need to support IPv6 • Internal addressing structure for the home network needs to be considered too • IPv4 NAT at the customer gateway is removed – and direct IPv4 support may be removed • DNSSEC support may break with a IVI DNS in the middle of the DNS chain

SUMMARY



METHODS OF TRANSITION

Home device	Access network	Destination	Solutions
IPv4	IPv4	IPv4 Internet	Dual-Stack
IPv6	IPv6	IPv6 Internet	
IPv4	IPv6	IPv4 Internet	DS-Lite
IPv6	IPv6	IPv4 Internet	NAT64 Stateful
IPv6	IPv4	IPv6 Internet	6RD
IPv4	IPv6	IPv4 Internet	4RD
IPv4	IPv6	IPv4 Internet	464XLAT
IPv6	IPv6	IPv4 Internet	IVI

SUMMARIES AND COMPARISON

	Native Dual Stack	DS-Lite	NAT64	6rd/4rd	464XLAT	IVI
CPE	Almost always CPE change	CPE change and support for DS-Lite	CPE change (IPv6 only)	CPE change	CPE change	CPE change (IPv6 only)
Pro	'Simple' technology with no transition or tunneling involved	Single address family in the access network	Single address family in the access network	Single address family in the access network Quick to deploy	Single address family in the access network Translation can be outsourced	Single address family in the network One-to-one mapping removes translation logging
Con	Cost of supporting dual-stack networks Device support Deployment time	All the effort of deploying dual-stack + extra Extra DS-Lite AFTR needed Traffic obfuscation in the network Device support	Application brokenness with IPv4-literals NAT logging required Will only work for IPv6-supporting hosts	Traffic obfuscation in the network Device support Not necessarily a 'long term' solution	Application brokenness with IPv4-literals Traffic obfuscation in the network Device support Translation logging required	Stateless one-to-one mapping can be expensive on IPv4 resources Device support Will only work for IPv6-supporting hosts

Every transition technology employs translation – applications **will** be affected

CONCLUSION

- There are a lot of transition technologies available with varying levels of support
- Operators should carefully evaluate which technology is most appropriate to meet their needs
- The transition technology should align with the long term vision of the operator – generally this should look towards native IPv6 support
- It might take multiple iterations to get to a long term view of native IPv6 (with transitional support for IPv4) – but it is important to try minimizing this from an investment and complication perspective

REFERENCES

Document	Location
Broadband Forum TR-177 IPv6 in Context of TR-101	http://www.broadband-forum.org/technical/download/TR-177.pdf
Broadband Forum TR-187 IPv6 for PPP Broadband Access	http://www.broadband-forum.org/technical/download/TR-187.pdf
Broadband Forum TR-124i2 Functional Requirements for Residential Gateway Devices	http://www.broadband-forum.org/technical/download/TR-124_Issue-2.pdf
RFC6333 Dual-Stack Lite Broadband Deployments	http://tools.ietf.org/html/rfc6333
RFC6052 IPv6 Addressing of IPv4/IPv6 Translators	http://tools.ietf.org/html/rfc6052
RFC6146 Stateful NAT64	http://tools.ietf.org/html/rfc6146
RFC6147 DNS64 DNS Extensions	http://tools.ietf.org/html/rfc6147
RFC5969 IPv6 Rapid Deployment on IPv4 Infrastructures	http://tools.ietf.org/html/rfc5969
draft-despres-softwire-4rd-u IPv4 Residual Deployment	http://tools.ietf.org/html/draft-despres-softwire-4rd-u-06
RFC6204 Basic Requirements for IPv6 Customer Edge Routers	http://tools.ietf.org/html/rfc6204 https://datatracker.ietf.org/doc/draft-ietf-v6ops-6204bis/
RFC6586 Experiences from an IPv6 Only Network	http://tools.ietf.org/html/rfc6586
464XLAT Experiences from T-Mobile USA	https://sites.google.com/site/tmoipv6/464xlat
RFC6219 CERNET IVI Translation Design and Deployment	http://tools.ietf.org/html/rfc6219
RFC6145 IP/ICMP Translation Algorithm	http://tools.ietf.org/html/rfc6145
RFC6144 Framework for IPv4/IPv6 Translation	http://tools.ietf.org/html/rfc6144
draft-townsley-v6ops-6rd-sunsetting Sunsetting for 6rd	http://tools.ietf.org/html/draft-townsley-v6ops-6rd-sunsetting-00
IPv6 CPE at the ARIN GetIPv6 Wiki	http://getipv6.info/index.php/Broadband_CPE

AT THE SPEED OF IDEAS™

Alcatel·Lucent

AT
THE
SPEED
OF
IDEAS™

Alcatel·Lucent

www.alcatel-lucent.com