IPv6 Rapid Deployment (6rd) in broadband networks

Allen Huotari – Technical Leader

ahuotari@cisco.com

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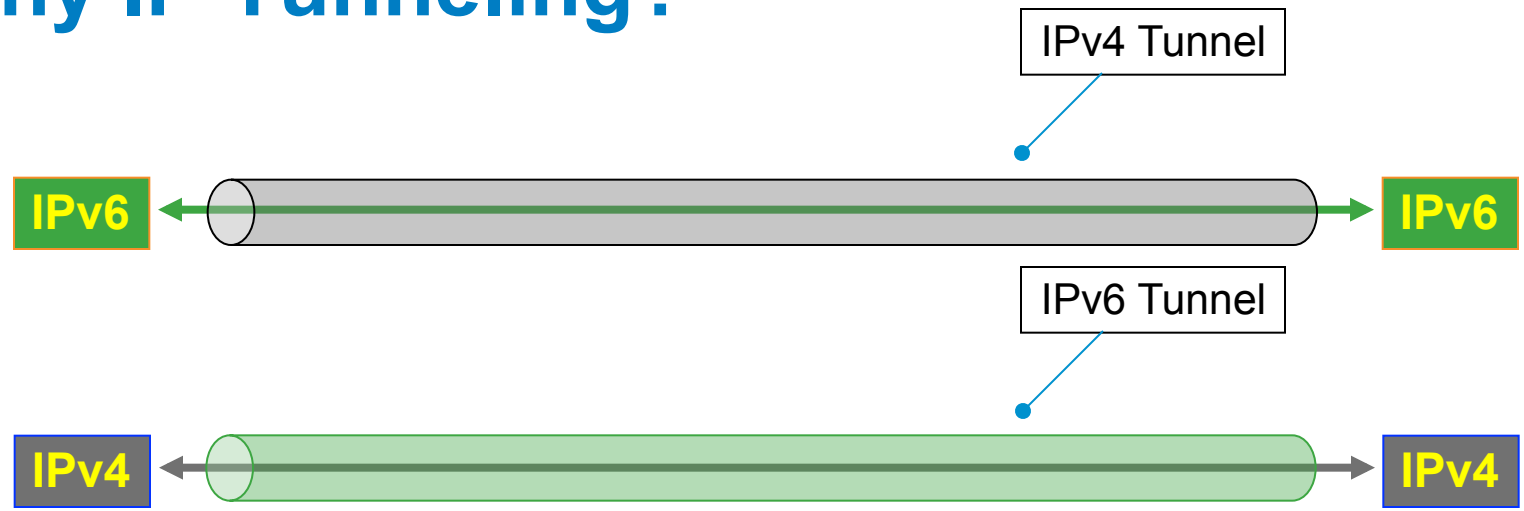
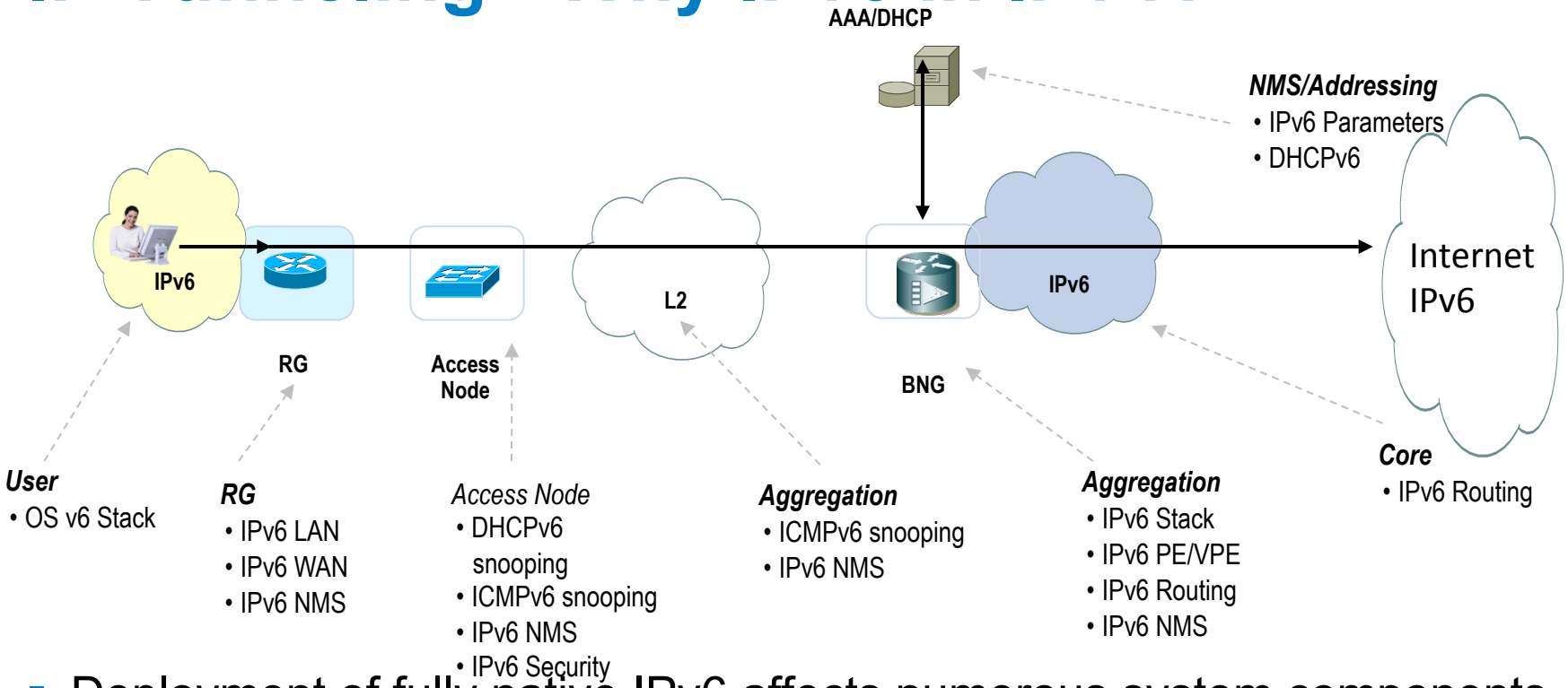
Why IP Tunneling?



- **Retains end-end IP semantics**
  - In theory requires “touching” only tunnel end points
- **In practice, given today’s transition *from* IPv4 *to* IPv6 the different tunneling approaches represent different transition strategies:**
  - Fast v6 deployment: IPv6 services and IPv6 end-point enablement (IPv6 over IPv4 using 6rd)
  - Legacy IPv4 support after IPv6 transition: IPv4 services using an IPv6 transport (IPv4 over IPv6 using DS-Lite)

Source: RFC3439

IP Tunneling - Why IPv6 in IPv4?

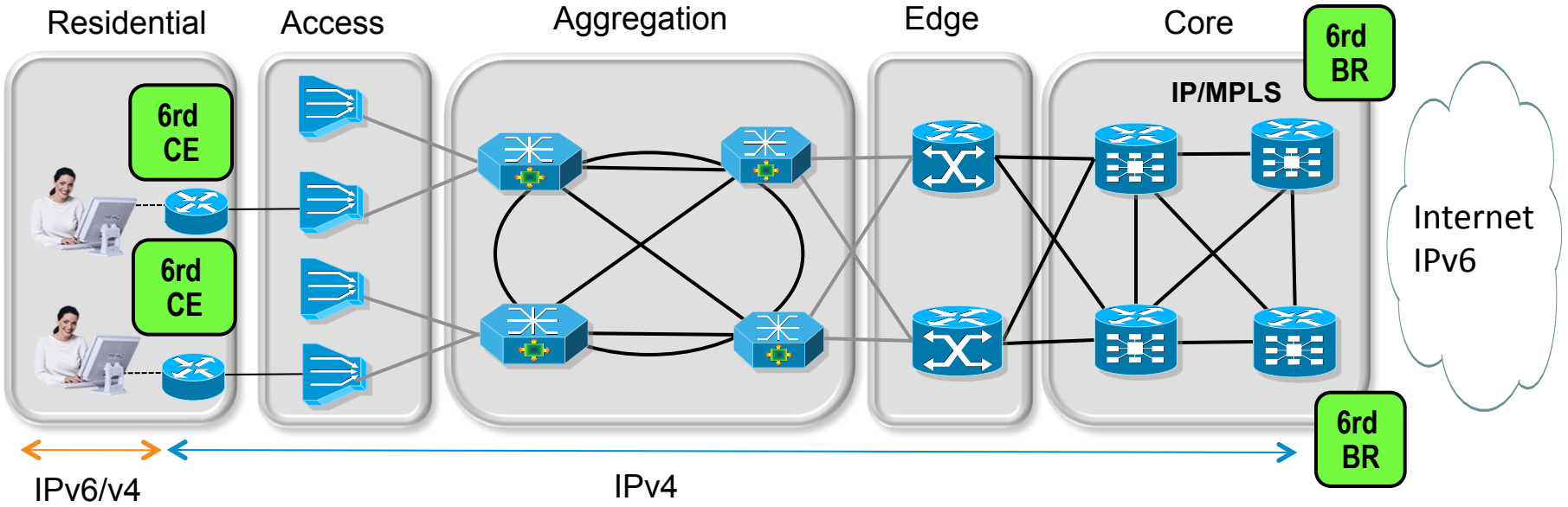


- Deployment of fully native IPv6 affects numerous system components, aka “touch points” - some are more challenging or deferrable than others
  - e.g., IPv6 upgrade of Access Node
- Tunneling IPv6 over existing IPv4 infrastructure provides a transition solution with minimal number of “touch points”

IPv6 via IPv4 SP Networks using “6rd”

- **Method for deploying IPv6 on an IPv4 infrastructure**
- **Not an IPv6 “trial” service**
  - IPv6 to subscriber is production quality, native IPv6 + IPv4 dual-stack
- **Reuses IPv4 infrastructure in the SP**
  - No IPv6 support needed in Access and Aggregation
  - No DHCPv6 server
  - No Neighbor Discovery
- **Similar to 6PE in that it provides a native dual-stack service to a subscriber site by leveraging existing infrastructure and operations**

6rd in One Slide



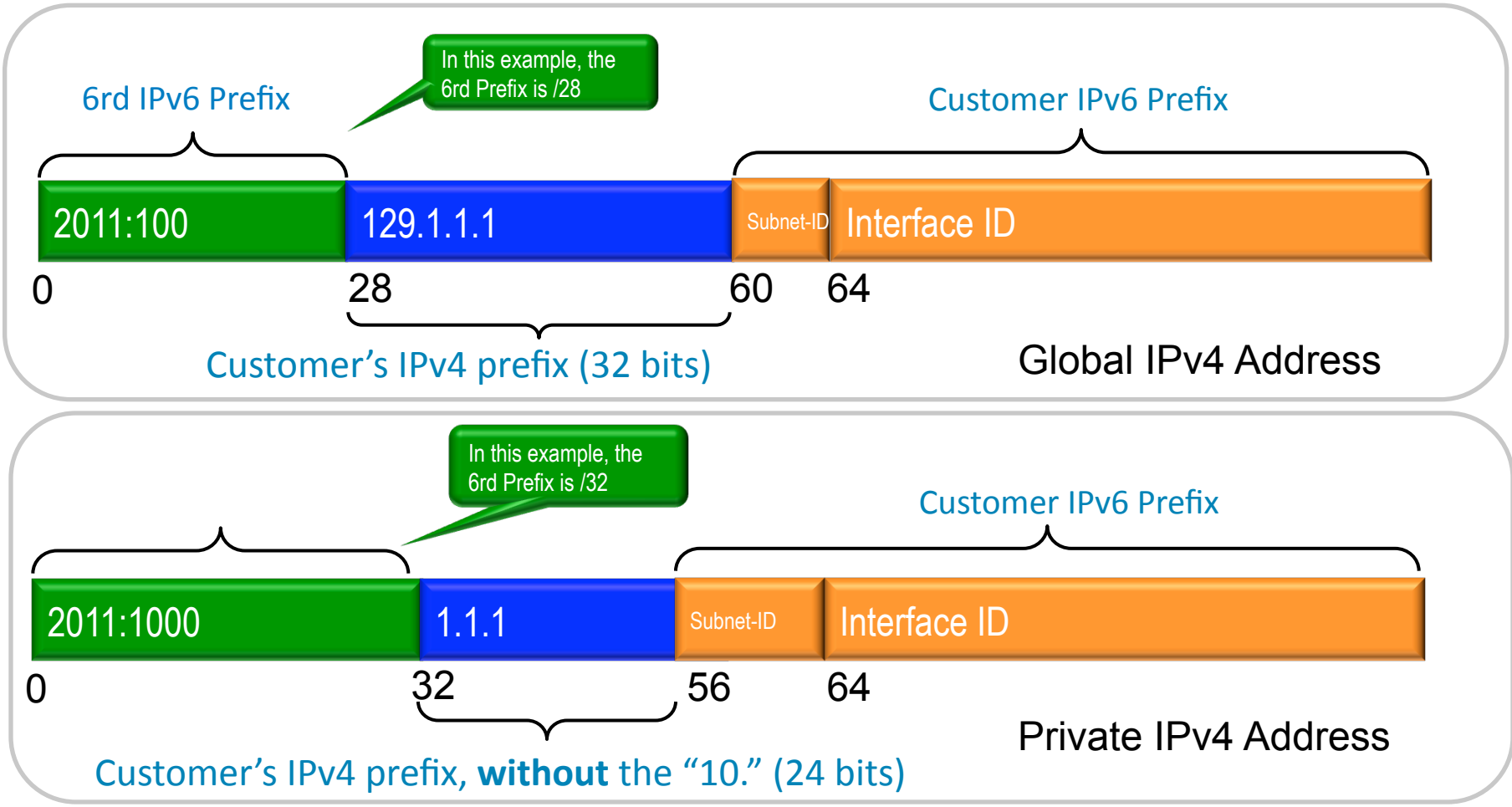
- **Introduction of two components: 6rd CE (Customer Edge) and 6rd BR (Border Relay)**
- **Automatic Prefix Delegation on 6rd CE**
- **Simple, stateless, automatic IPv6-in-IPv4 encap/decap functions on 6rd (CE and BR)**
- **6rd BRs addressed with IPv4 anycast for simplifying BR locations, load balancing, and resiliency**
- **IPv6 traffic automatically follows IPv4 routing**

Native, Dual-Stack IPv4/IPv6 service from subscriber perspective

Three key parts in 6rd

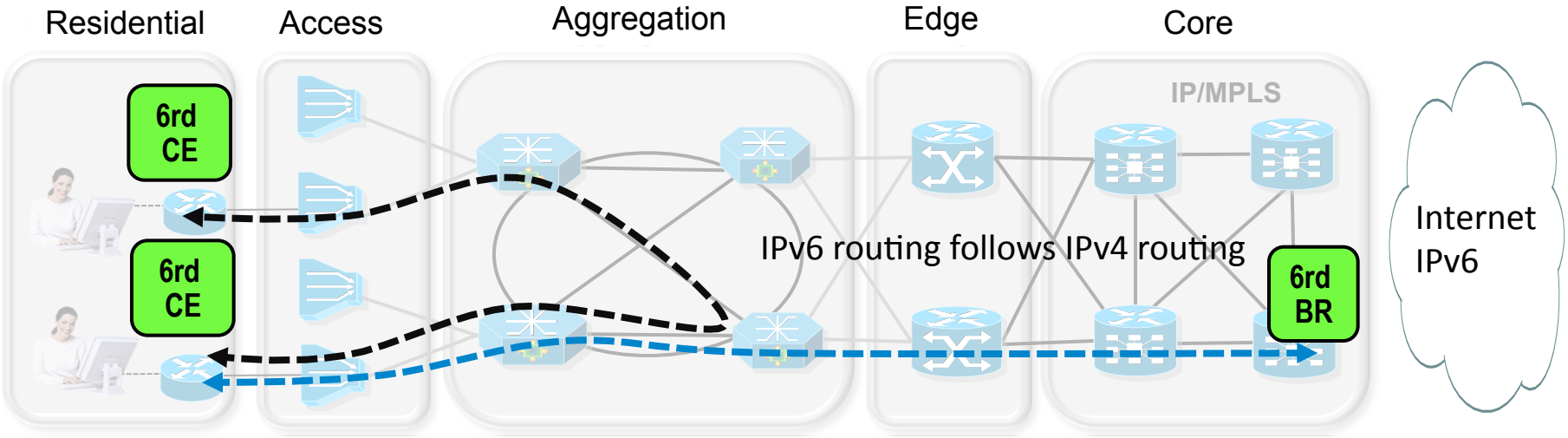
- **IPv6 Prefix Delegation derived from IPv4**
  - No need for DHCPv6 on 6rd CE WAN interface
  - No need for DHCPv6 server in the network
  - Supports Global IPv4 or NATted IPv4 in same deployment
- **Stateless mapping and encapsulation of IPv6 over IPv4 (RFC 4213)**
  - IPv4 encapsulation automatically determined from IPv6 destination of each packet
  - No per-subscriber tunnel state or provisioning, hence single dimension scaling (dataplane) on 6rd BR
- **IPv4 Anycast to reach Border Relay**
  - Simplify network 6rd BR placement, load balancing and/or redundancy across multiple 6rd BRs

6rd Automatic Prefix Delegation



- **In practice, any number of bits may be masked off, as long as they are common for the entire 6rd domain (applicable to aggregated global IPv4 space as well)**

6rd stateless mapping and encap/decap



IF 6rd IPv6 Prefix Positive Match

THEN encap in IPv4 with embedded address

Dest = **Inside** 6rd Domain

2001:100 | 8101:0101 | Interface ID

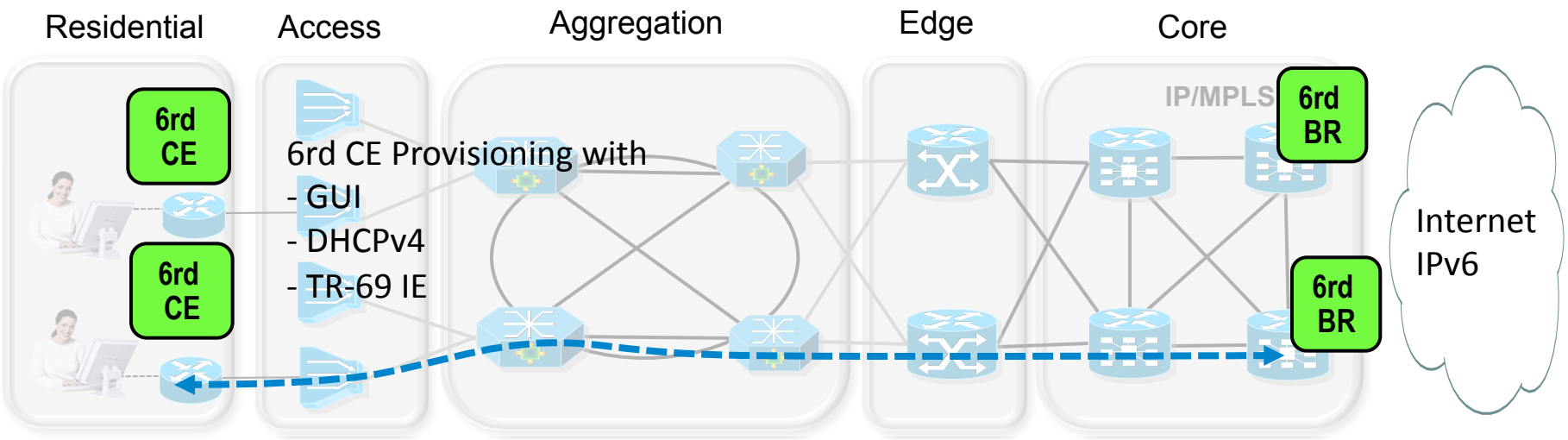
ELSE 6rd IPv6 Prefix Negative Match

THEN encap with BR IPv4 Anycast Address

Dest = **Outside** 6rd Domain

"Not 2001:100…" | Interface ID

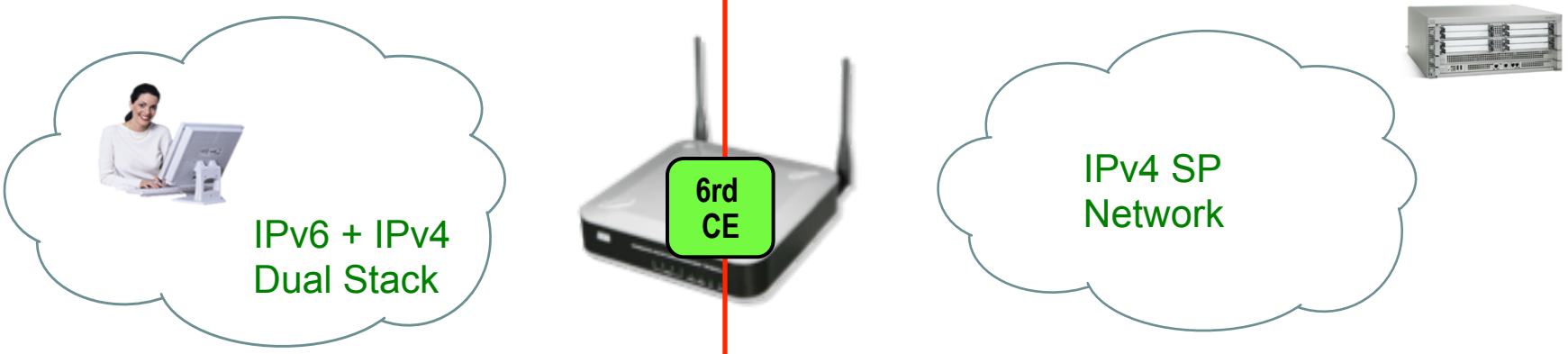
6rd CE Overview



- **RG 6rd CE configuration, same for all subscribers (via TR-69, DHCP …) across 6rd Domain**
  - ISP 6rd IPv6 prefix and length
  - Common IPv4 bits suffix length
  - 6rd Relay IPv4 address (likely anycast)
- **NAT44 (for IPv4) and 6rd CE (for IPv6) can nicely coexist**
- **RG LAN side configured as for "native IPv6"**

6rd CE Component on RG

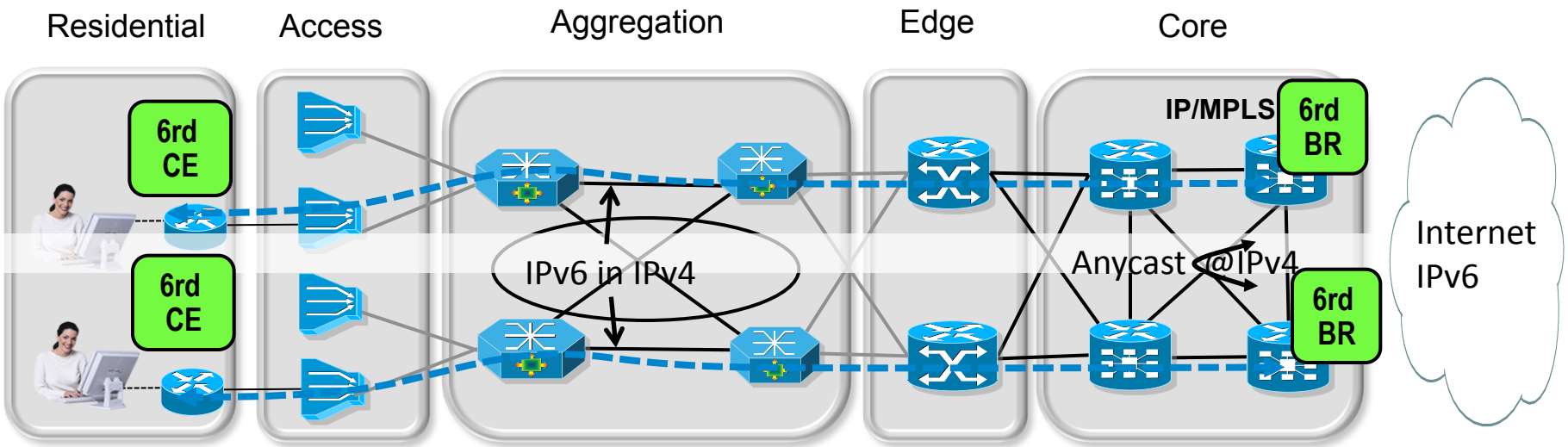
- **LAN-Side:**
  - Production Native IPv6 Service +
  - Global or NATted IPv4
- **WAN-Side:**
  - IPv6 via Global IPv4
  - or NATted IPv4



6rd lives here

- **IPv6 Internet Access delivered to home, allowing IPv6 enabled applications and content to remain unaffected by IPv4 exhaustion**
- **IPv6 in SP Network evolves at its own pace, with its own balance of costs and incentives**

6rd Border Relay Overview



- **Single multipoint tunnel interface in 6rd BR**
- **No per-user state, serves ALL users in 6rd domain**
- **6rd BRs must have IPv6 reachability (Native, 6PE, GRE Tunnel, etc) and know/have configured**
  - ISP 6rd IPv6 prefix and length
  - Common IPv4 bits suffix length
  - 6rd Relay IPv4 address (likely anycast)
- **Stateless encapsulation: BR positioned anywhere relevant, flows can be asymmetric**

Standardization Status

- **draft-ietf-softwire-ipv6-6rd-10.txt is now an IETF Standards Track WG document (RFC Soon)**
  - Idea has been circulating in the IETF since 2007 when Free Telecom first deployed it based on the invention of Remi Despres (RFC 5569 to be published shortly describing this)

Summary:
IPv6 Rapid Deployment (6rd) - IPv6 in IPv4

- **Pros**
  - Enables a v6 service to a routed CPE user
  - IPv6 can traverse existing IPv4 infrastructure. No new access CAPEX to enable v6
  - Derives IPv6 from IPv4 addresses, eliminating need for much of IPv6 OSS
  - Efficient local routing of subscriber-subscriber traffic
  - Stateless = easier to scale & operate
  - Easily combined with NAT44 to mitigate IPv4 exhaustion
  - Makes operational models of v4 and v6 similar
- **Cons**
  - Continuing to use public IPv4 doesn't solve IPv4 exhaustion. Solution may need to be combined with NAT44
  - Extra overhead from encapsulation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