IPv6 deployment issues, analysis and proposals

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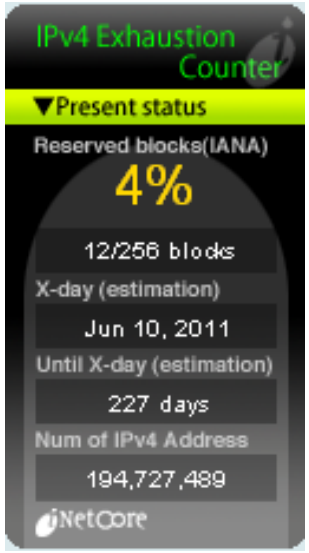
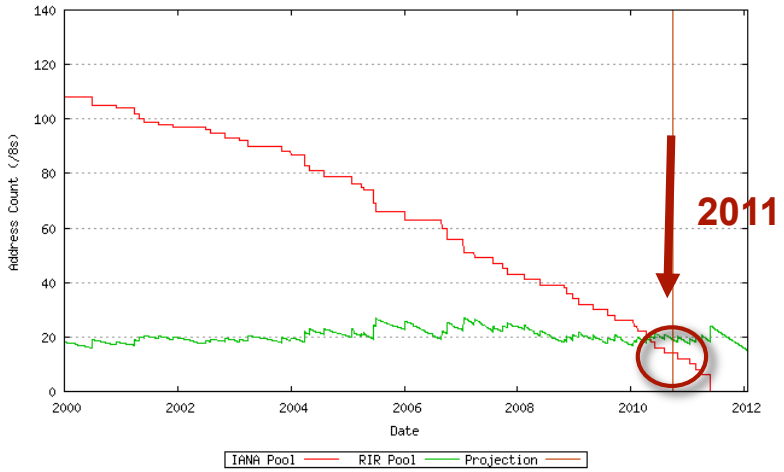
Problem Statements-IPv4 and IPv6 co-exist in the network





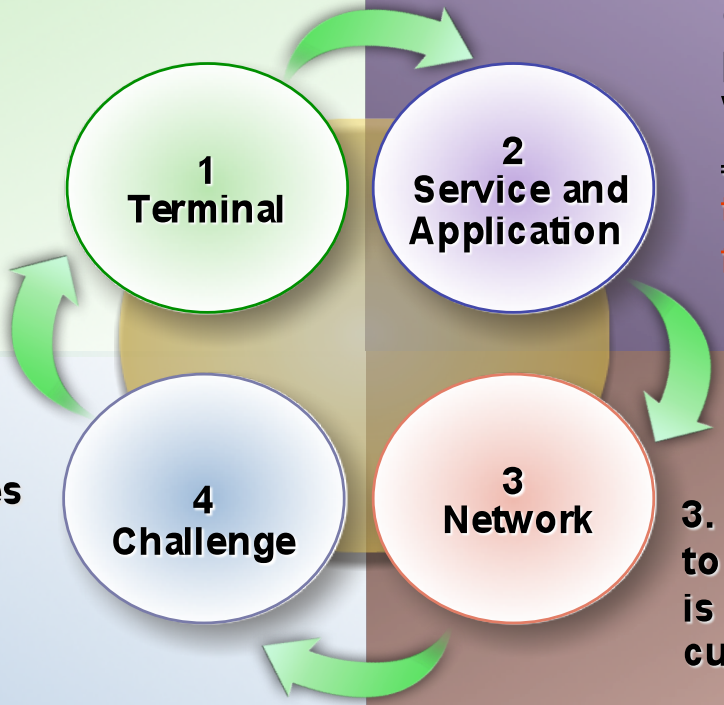
IPv4 address exhaustion is coming

- IPv4 address blocks running out at IANA and the RIRs in the next year or so.
- Different ISPs motivated to provide IPv6 service at different rates. Early providers need to take extra care to retain service levels.
- Content provider support of IPv6 will lag because they are less affected by the address shortage and lack the business case to move.
- IPv4 and IPv6 will co-exist for a long time after IPv6 service is provided by the ISP.

IPv6 Industry Chain: Problems and Challenges

1. ISP may have no control over customer equipment.

⇒ ISP needs to be prepared to support IPv4, dual stack, IPv6 without changes to customer equipment.



2. Business case for most content and application providers to migrate to IPv6 is weak

⇒ ISP will have to support access to IPv4 content and applications for a long time.

4. The challenge: choosing the appropriate transition strategies to:

⇒ protect existing investment

⇒ maintain quality of customer experience

⇒ achieve business objectives without blocking the way to IPv6-only operation in the long run

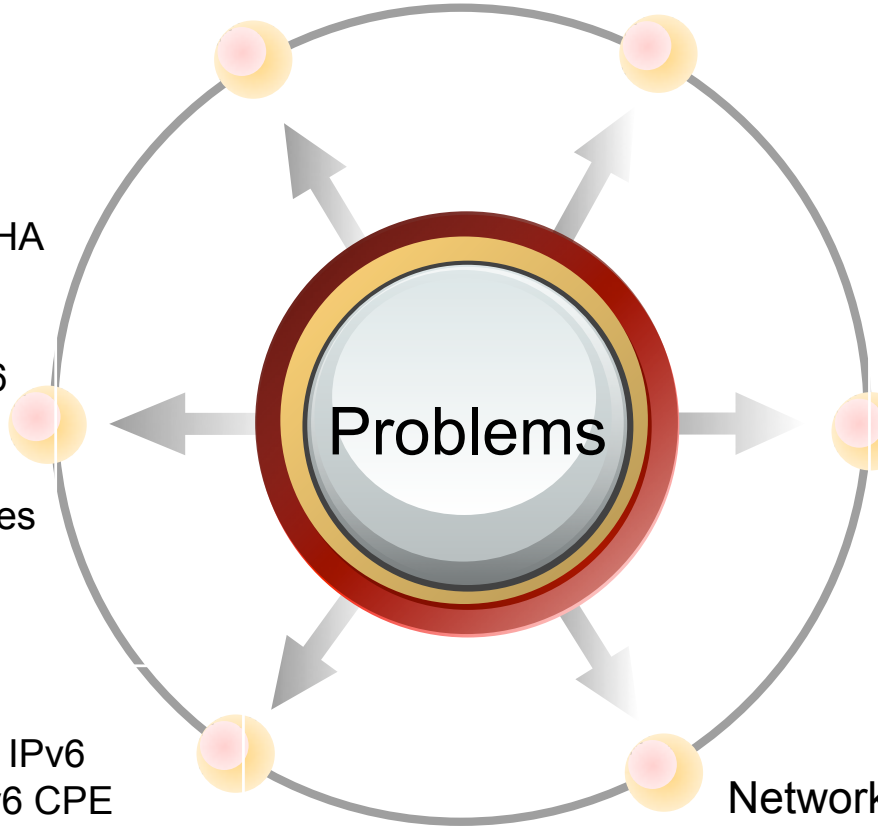
3. ISP with high growth rate relative to available public IPv4 addresses is under pressure to migrate customers to IPv6 for relief.

⇒ major investment for upgrades to network equipment and support systems.

Issues for IPv4 to IPv6 Transition

CPE:
- Provisioning mechanism
- Recommended length for customer prefix
- Support of legacy CPE while transitioning to IPv6

Service continuity:
- Selection of transition techniques



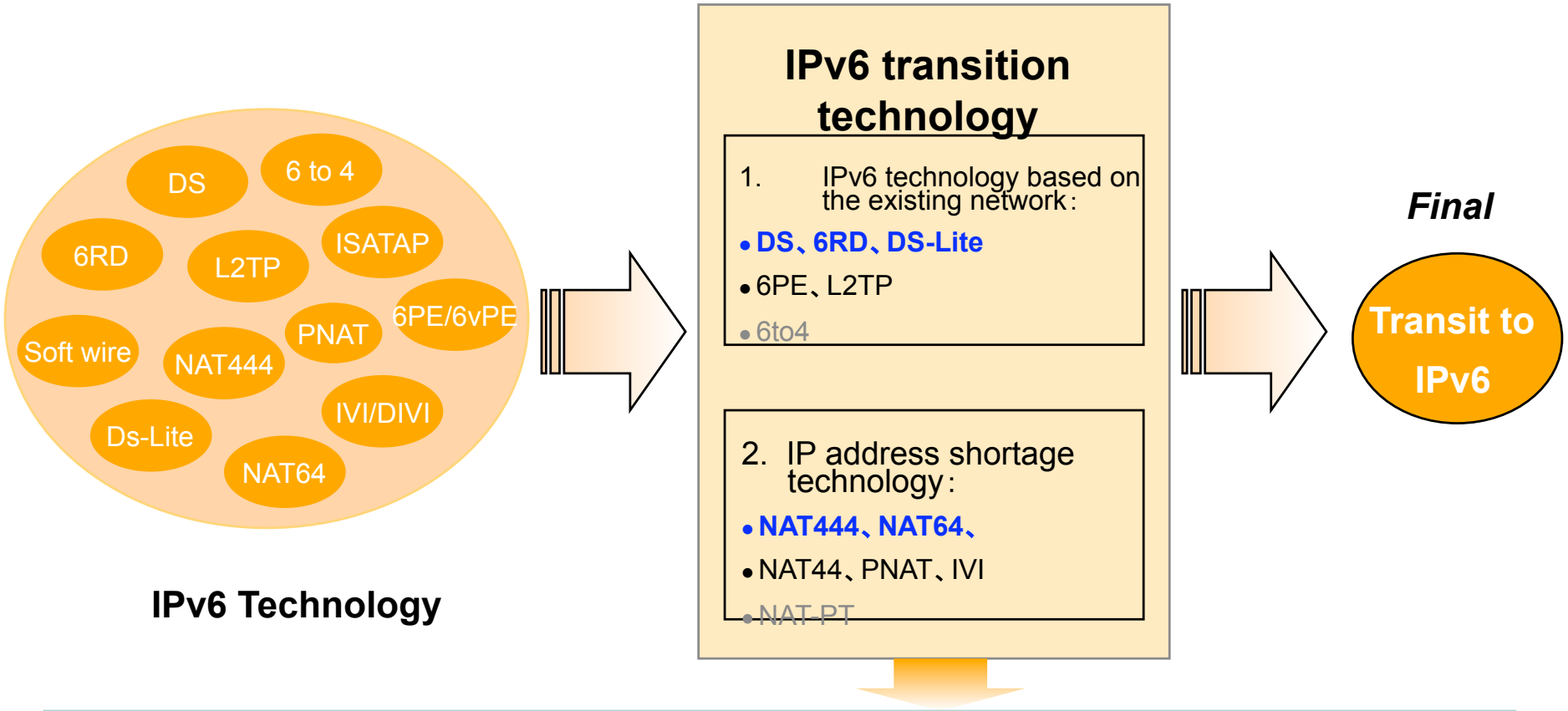
High Availability (HA) :
- Requirements for deploying HA in IPv6
- Available techniques
- Application failover from IPv6 to IPv4;
- HA architecture given the selected transition techniques

Applications :
- Protocol version mismatch between application and network or destination
- Need for ALGs across NATs

DNS:
- Supporting Reverse DNS in IPv6
- Using DDNS to manage IPv6 CPE
- Avoiding unnecessary DNS translation in NAT64 scenario

Network security:
- What IPv4 risks do not apply to IPv6?
- New IPv6 security risks?

How to Transit to IPv6?



Use cases and strategies differ between ISPs during transition to IPv6

- For an ISP with a shortage of IPv4 addresses and a high subscriber growth rate, a combination of multiple technologies is needed
- For an ISP without as much pressure on IPv4 addresses and high penetration of the market already, a solution with minimal modification to the network is preferred. IPv6 transition is step by step.

IPv6 Transition Policy

IPv6 technology based on the existing network:

DS、6RD、DS-LITE、

6PE、L2TP、6to4

+

IP address shortage technology:

NAT444、NAT64、

NAT44、PNAT、IVI、NAT-PT

Criteria to select transition technology:

- Protect existing network investment, reasonable transition cost, and moderate network modification difficulty
- Sustainable IPv6 industry chain
- Protect existing service; good user experience
- Push and encourage IPv6 development

IPv6 transition strategy

Backbone network:

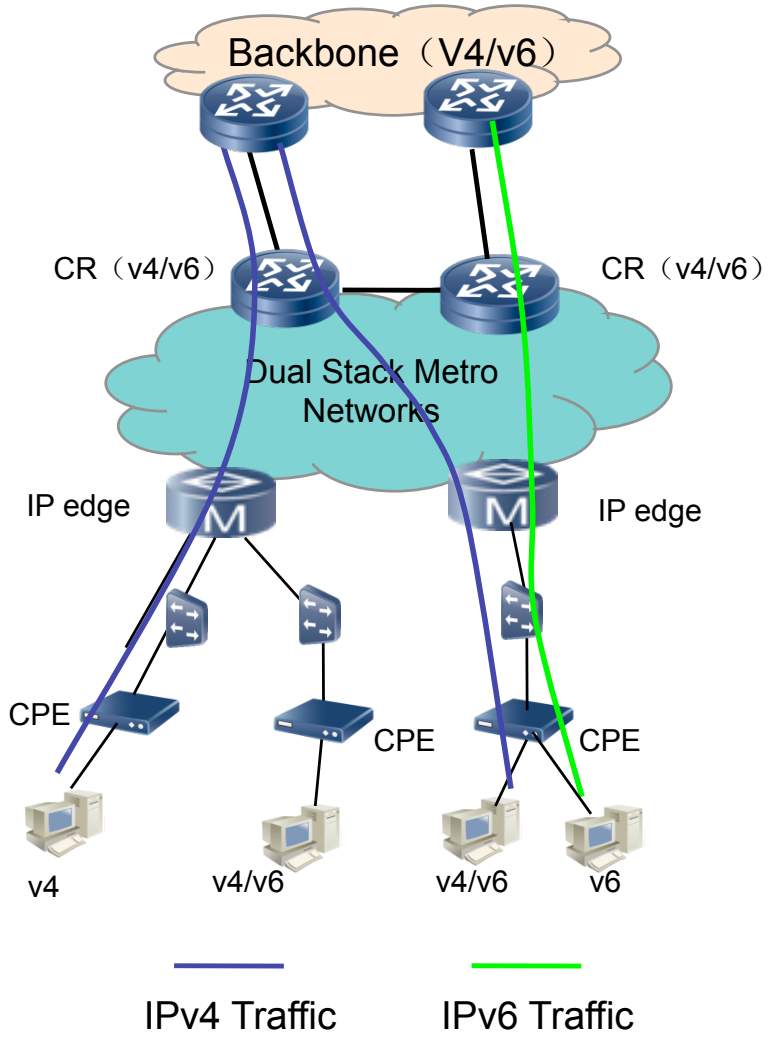
- Provide support for multiple services. Relatively mature IPv6 transition solution: Dual Stack or 6PE/6VPE

Metro network:

- Network scenarios and address pressures vary by ISP. Thus there are multiple valid technologies or combinations of technologies for metro network transition: dual stack、DS-Lite、6rd, and dual stack + NAT444

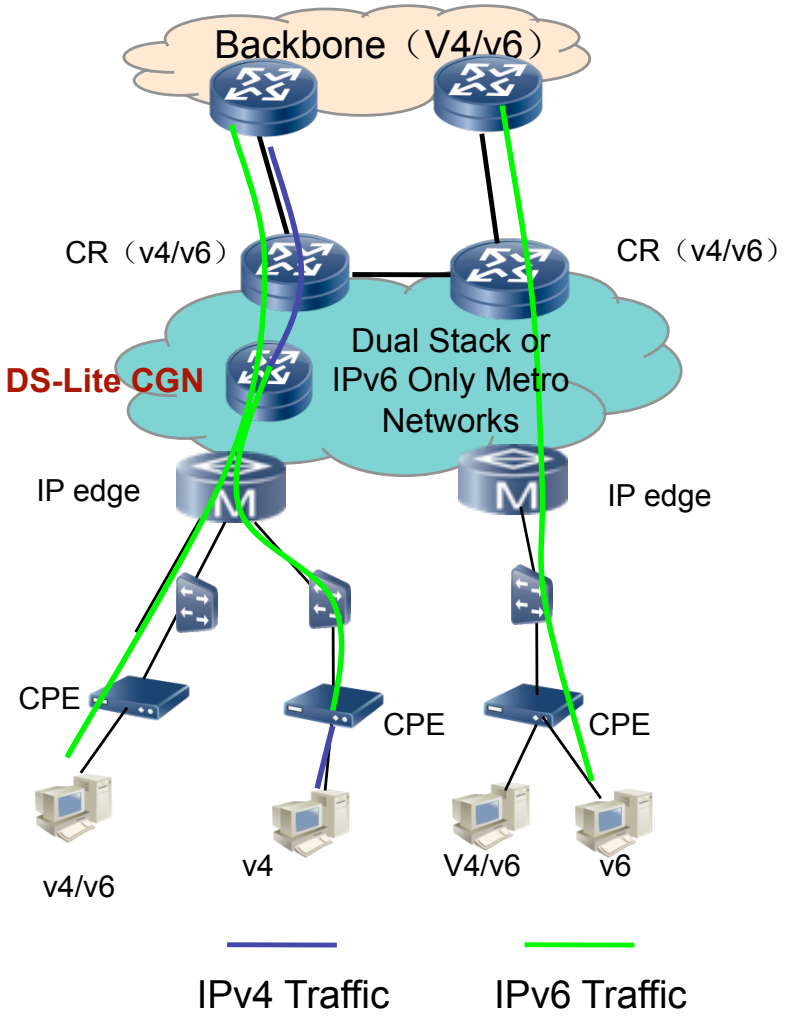
Dual Stack

- Network is upgraded to dual stack to provide IPv6 service. Guarantee existing IPv4 user experience while providing IPv6 service to existing and new users.
- Pros: Simple network modification, guaranteed user experience, accords with future network evolution.
- Cons: dual stack only cannot solve IPv4 address shortage problem. Other technologies need to be considered.
- Co-existence technologies: DS-Lite、NAT444、NAT64、IVI/DIVI
- Requirement to CPE: None



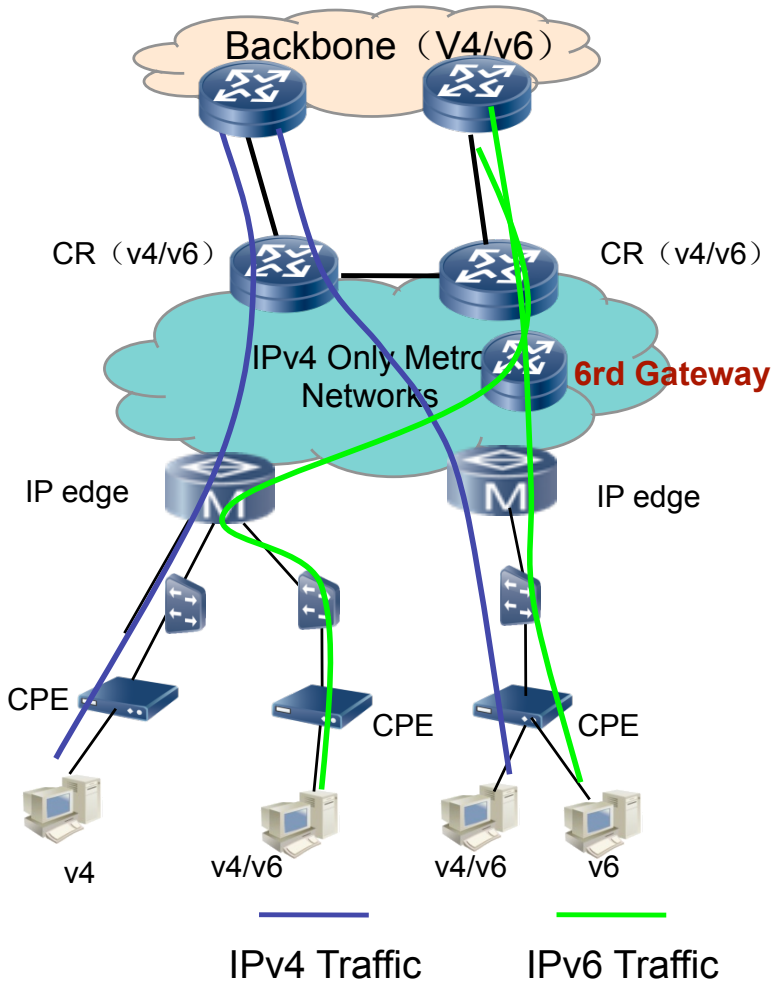
DS-Lite

- For ISP with IPv4 address shortage.
- Allocate IPv6 address only to the host to solve the problem of IPv4 address shortage.
- Pros: Solve the problem of IPv4 address shortage
- Cons: NAT is needed for all IPv4 service. High load on the CGN. High cost to modify the existing network and CPE.
- Co-existence technologies: network is dual stack or native IPv6 network
- Requirement to CPE: Need to upgrade to support DS-Lite; can avoid by using Gateway Initiated DS-Lite.



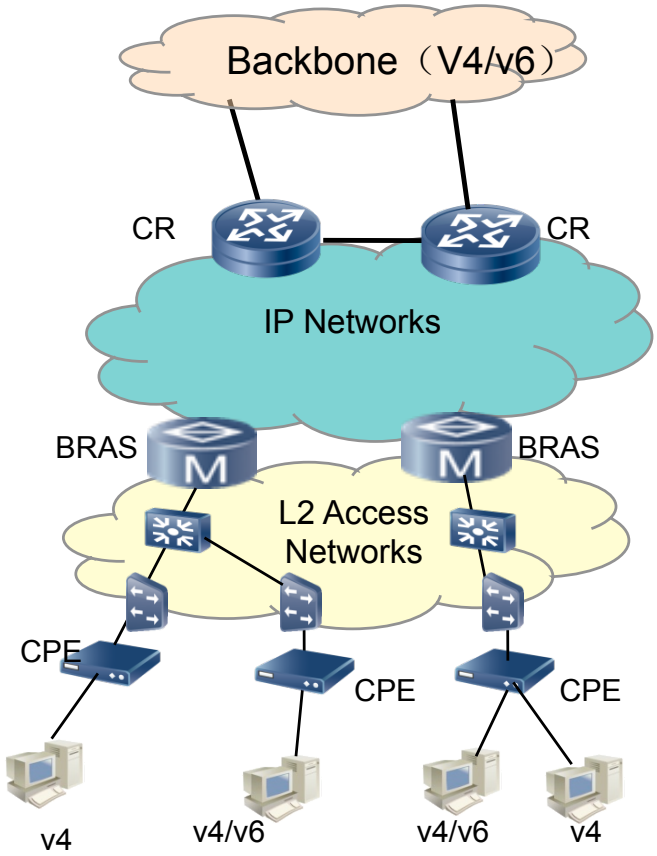
6rd

- For ISP with sufficient IPv4 addresses.
- 6rd Gateway is added into the existing metro network. CPE or individual hosts are upgraded to support 6rd.
- Pros: Simple network modification; guaranteed user experience
- Cons: Other technologies need to be considered to solve IPv4 address shortage. Network needs to be rebuilt when it migrates to IPv6 in the future.
- Co-existence technologies: NAT44 (for IPv4 address shortage)、NAT64 (if IPv6 only terminal visits IPv4 application)
- Requirement to CPE: IPv6-only user site needs to upgrade CPE or hosts to support 6rd.



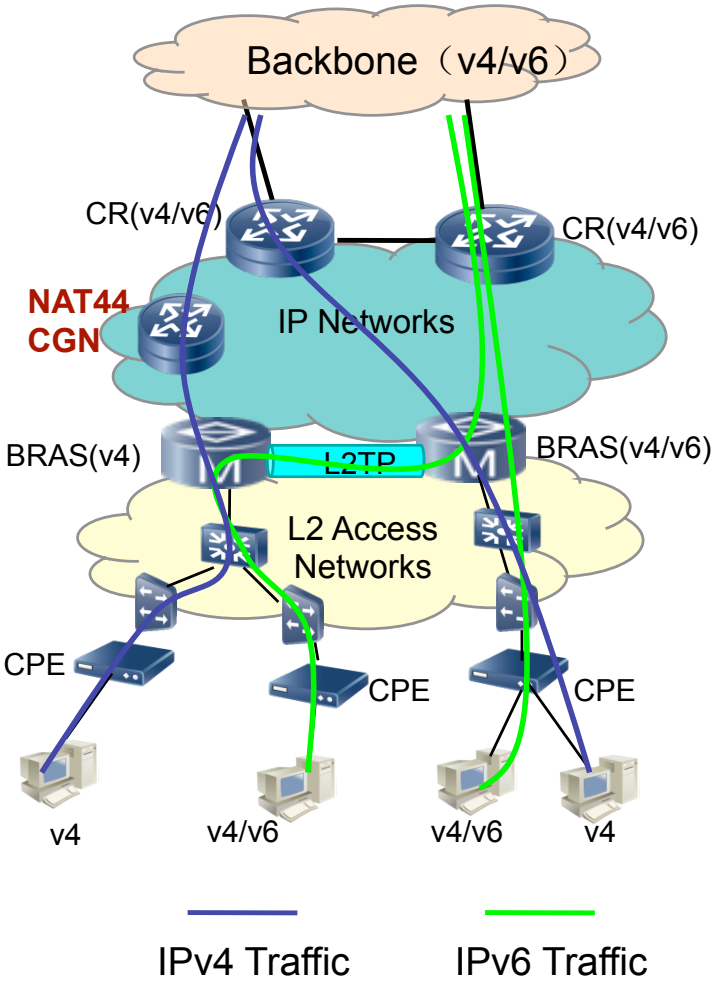
Proposal for IPv6 Transition- L2 Access Network and Lack of IPv4 Address Scenarios(1)

- **Scenario**: L2 access network; PPPoE dial in; End point of PPP link is BRAS； CPEs are in routing or bridged mode; BRASs are connected to CR directly or via aggregation routing。
- **Requirement for IPv6 transition**: Core Routers (CR) should be dual stack to support v4/v6 services; BRAS should be dual stack to support v4/v6 broadband users (A BRAS which cannot upgrade to IPv6 sets up L2TP tunnel to a dual stack BRAS and terminates the PPPoEv6 link in the dual stack BRAS via the tunnel); L2 access networks do not change.
- **Transition proposal for network**: **dual stack+NAT44 CGN**; When IPv4 addresses are exhausted, NAT44 CGN is deployed, IPv6 and private IPv4 addresses are allocated to new broadband users.
- **Requirement for equipment**: UE: any version; CPE: IPv4 only or dual stack, for IPv4 only user, dual stack, for dual stack user; L2 AN: no change; BRAS and CR: dual stack
- **Related standard**s: RFC4213 (Basic Transition Mechanisms for IPv6 Hosts and Routers), other specifications about NAT.
- **Involved ISP**: China Telecom



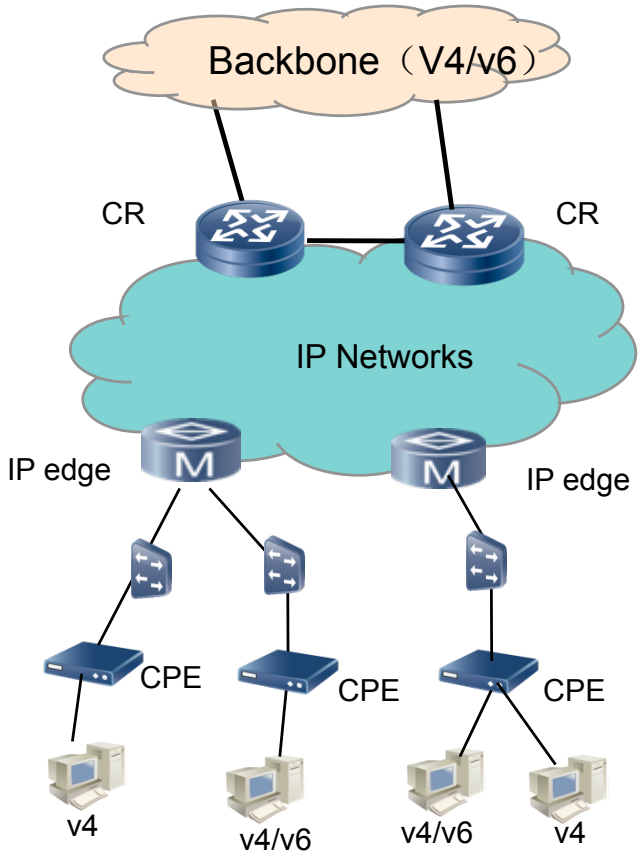
Proposal for IPv6 Transition- L2 Access Network and Lack of IPv4 Address Scenarios(2)

- Pros:
  - In these scenarios, only a small portion of network devices in the metro networks need to be upgraded during transition to IPv6. Dual stack will not lead to too much cost of management. Dual stack network can well guarantee existing IPv4 user experience.
  - NAT44 is more mature, and many applications have supported NAT44.
  - Small traffic for NAT, only a part of IPv4 traffic needs NAT.
  - The degraded quality of experience caused by NAT CGN is limited to theset of new broadband users which have been assigned private IPv4 addresses.
  - ISPs who do not manage the customer's home gateway cannot oblige the customer to upgrade their home gateway to support a certain technology (e.g., DS-Lite, 6rd, etc.). Dual stack network requires nothing of the home gateway.
- Cons:
  - NAT will lead to degraded quality of experience in some applications (e.g. P2P).



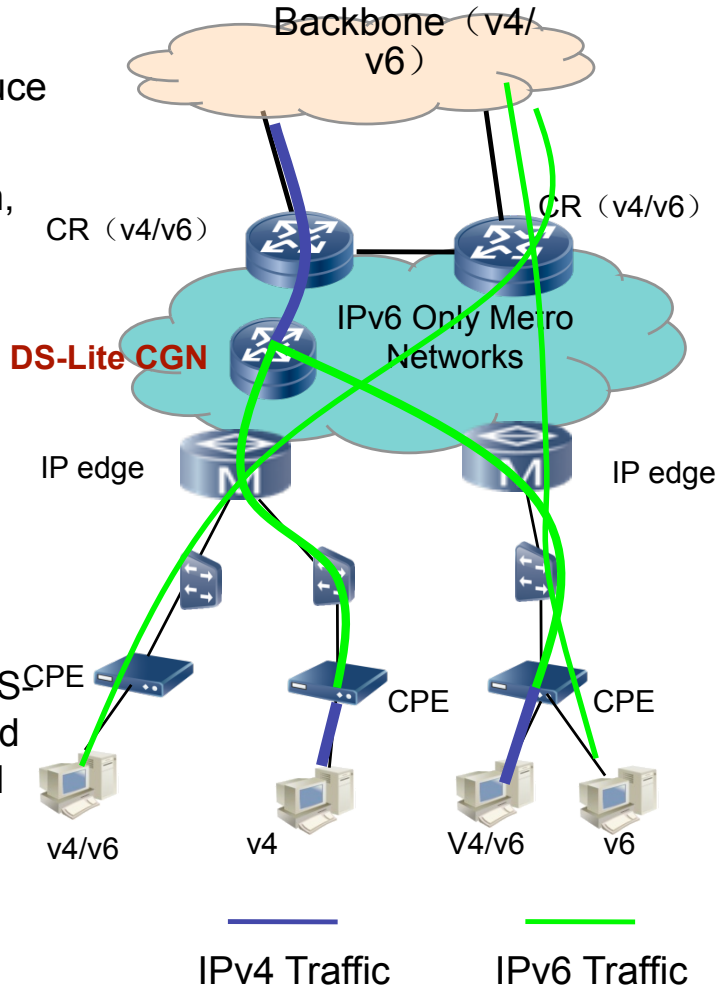
Proposal for IPv6 Transition- L3 Access Network and Lack of IPv4 Address Scenarios(1)

- **Scenario**: access networks are L3. Compared to L2 access network scenario, there are more IP devices in the metro networks.
- **Requirement for IPv6 transition**: Core Routers (CR) should be dual stack to support v4/v6 services. The requirement for other IP devices depends on the transition technology.
- **Transition proposal for the network**:
  - **Solution 1: Native IPv6 + DS-Lite (or GI DS-Lite)**
  - **Solution 2: Dual stack+NAT44 CGN**
  - The problem of IPv4 address exhaustion is solved via DS-Lite (or GI DS-Lite) or NAT44
- **Requirement for equipment** :
  - **Solution 1**: UE: dual stack or v4/v6 only; CPE: dual stack with support for DS-Lite (GI DS-Lite scenario, CPE doesn't need to support DS-Lite); L3 network: IPv6 only
  - **Solution 2**:UE: any version; CPE: IPv4 only or dual stack, for IPv4 only user, dual stack, for dual stack user; L3 network: dual stack
- **Related standards**: RFC4213 (Basic Transition Mechanisms for IPv6 Hosts and Routers) , DS-lite to be RFC, GI DS-lite stable WG draft, other NAT specifications.
- **Involved ISP**: FT and Comcast are interested in DS-Lite.



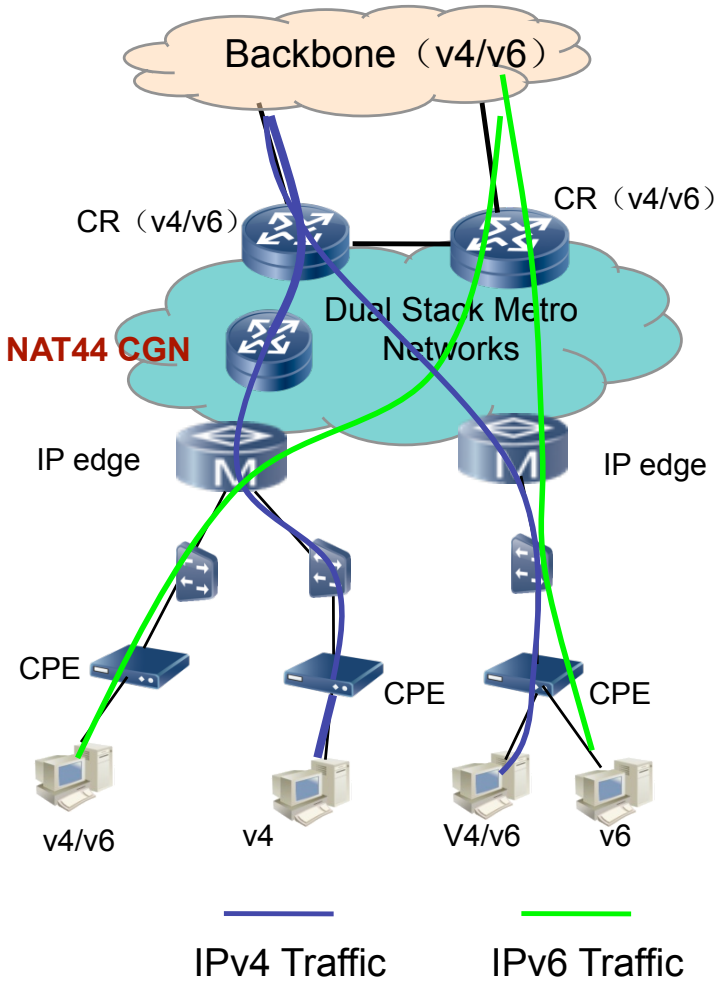
Proposal for IPv6 Transition- L3 Access Network and Lack of IPv4 Address Scenarios(2)

- Pros (Native IPv6 + DS-Lite) :
  - Compared with dual stack networks, IPv6 only network will reduce the cost of management and maintenance.
  - The NAT actions in DS-Lite CGN are actually NAT44 translation, so DS-Lite inherits the pros of NAT44 when compared with other transition technologies.
- Cons (Native IPv6 + DS-Lite) :
  - An ISP who does not manage the customer's home gateway, needs to provide a DS-Lite home gateway to the customer.
  - All the IPv4 traffic needs NAT, increasing the cost for CGN. The degraded experience caused by NAT CGN will impact all broadband users who use IPv4 service.
  - The existing home gateway needs to be upgraded to support DS-Lite. (If GI DS-Lite is deployed, the home gateways don't need to be upgraded, but the IP edge devices need to support dual stack and support GI DS-Lite).
  - NAT will lead to degraded quality of experience in some applications (e.g. P2P).



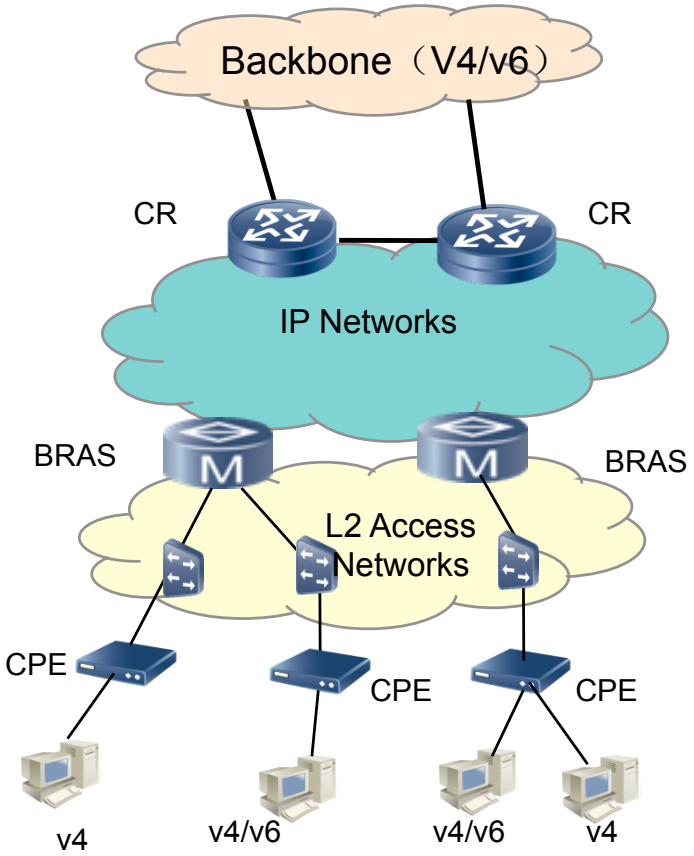
Proposal for IPv6 Transition- L3 Access Network and Lack of IPv4 Address Scenarios(3)

- Pros (Dual Stack+NAT44 CGN) :
  - No change to the existing HGW and terminals when using Dual Stack. Reduces cost in the Home Network.
  - NAT44 technology is mature. Most mainstream applications have considered NAT44, without many ALGs.
  - NAT traffic is relatively small; only new users' IPv4 traffic has to pass through the NAT.
  - Impacts to the applications (e.g., P2P) when deploying NAT CGN are limited to the new users using private IPv4 addresses.
  - For the scenario when the HGW is not provided or managed by the ISP or there is no HGW, this deployment does not involve the modification of the existing HGW. The v4 only HGW does not need to be replaced.
- Cons (Dual Stack+NAT44 CGN) :
  - User experience of some applications (e.g.,P2P) may degrade after deploying NAT CGN.
  - The cost of management and maintenance is higher than the IPv4 only case due to the large number of dual stack devices in the metro network.



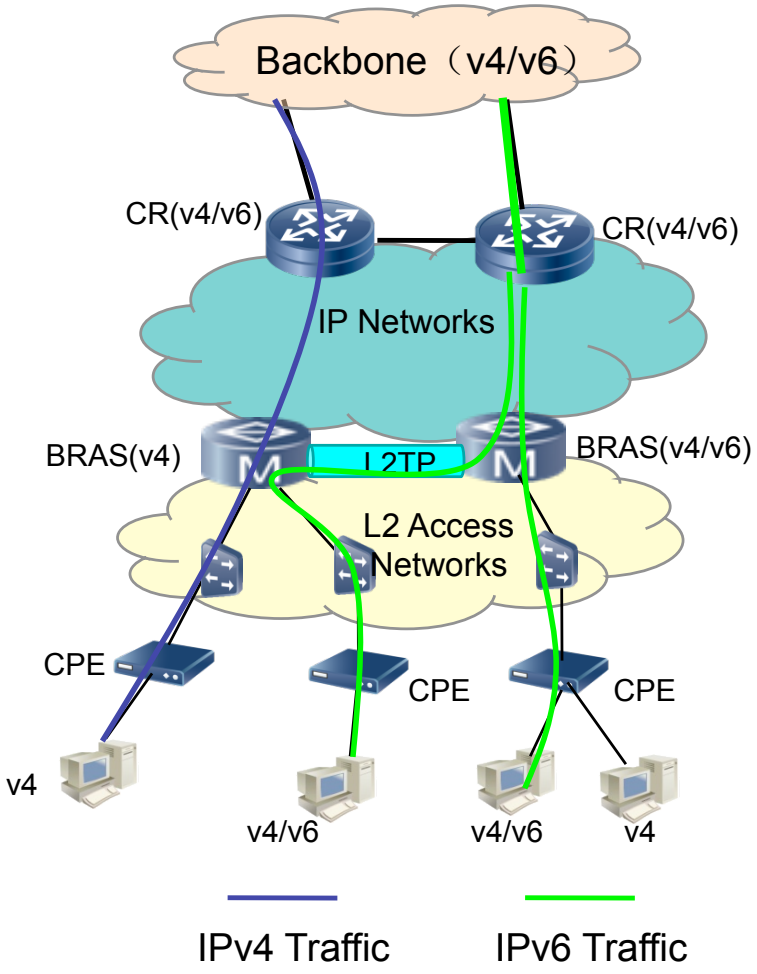
Proposal for IPv6 Transition- L2 Access Network and Not Lack of IPv4 Address Scenarios(1)

- **Scenario**: Access networks are L2. PPPoE dial in. End point of PPP link is BRAS. CPEs are in routing or bridged mode. BRASs are connected to CR directly or via aggregation routing.
- **Transition requirement**: CR needs to be dual stack to support v4/v6 service. BRAS needs to be dual stack to support access of IPv4 and IPv6 user. (BRAS which cannot be upgraded to dual stack needs an L2TP tunnel to terminate the PPPoE link to a dual stack BRAS). No change to the layer 2 access network.
- **Network transition proposal**: **Dual Stack**
- **Equipment requirements**: UE: any version. CPE: IPv4 only or dual stack, for IPv4 only user, dual stack, for dual stack user. L2 AN: no change. BRAS and CR: dual stack
- **Related IETF specification**: RFC4213 (Transition Mechanisms about dual stack and tunneling)
- **Involved ISP**: NTT has deployed dual stack.



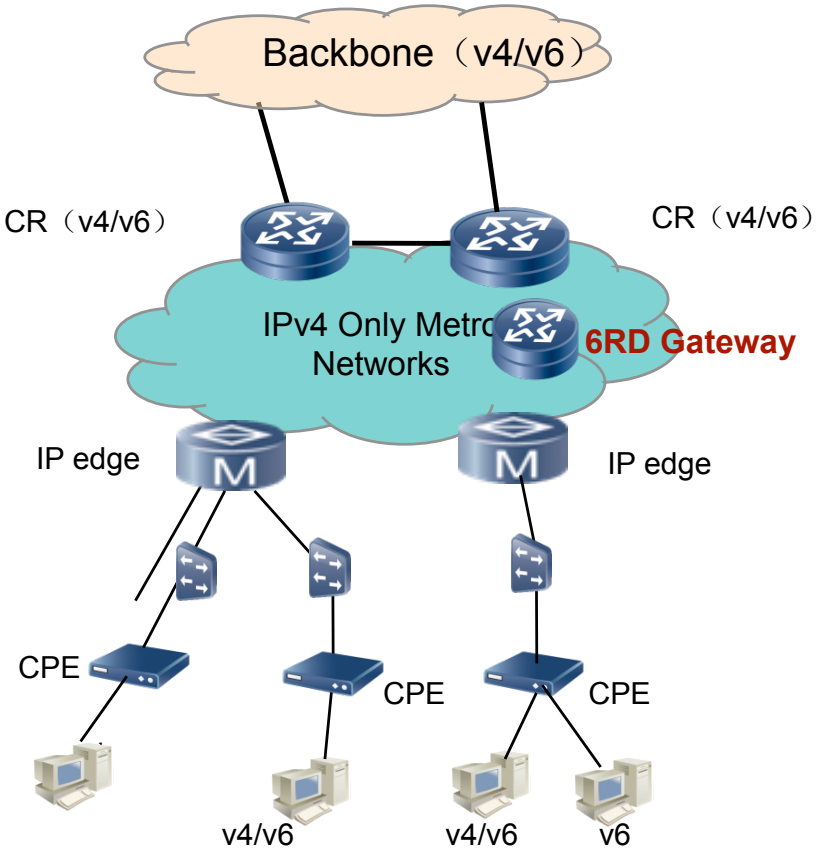
Proposal for IPv6 Transition- L2 Access Network and Not Lack of IPv4 Address Scenarios(2)

- Pros:
  - A small number of IP devices needs to be upgraded. Easy for the network to upgrade to dual stack and be compatible with existing services.
  - No change to the network after IPv4 disappears gradually, according with future network evolution.
  - HGW needs to support IPv6 only for the users who have the IPv6 service requirement in the initial stage of IPv6 transition. No change to the HGW of IPv4 only users, reducing the cost of HGW modification.
- Cons：
  - Layer 3 devices need to be upgraded to support dual stack. The cost of management and maintenance is relatively higher than v4 only network.



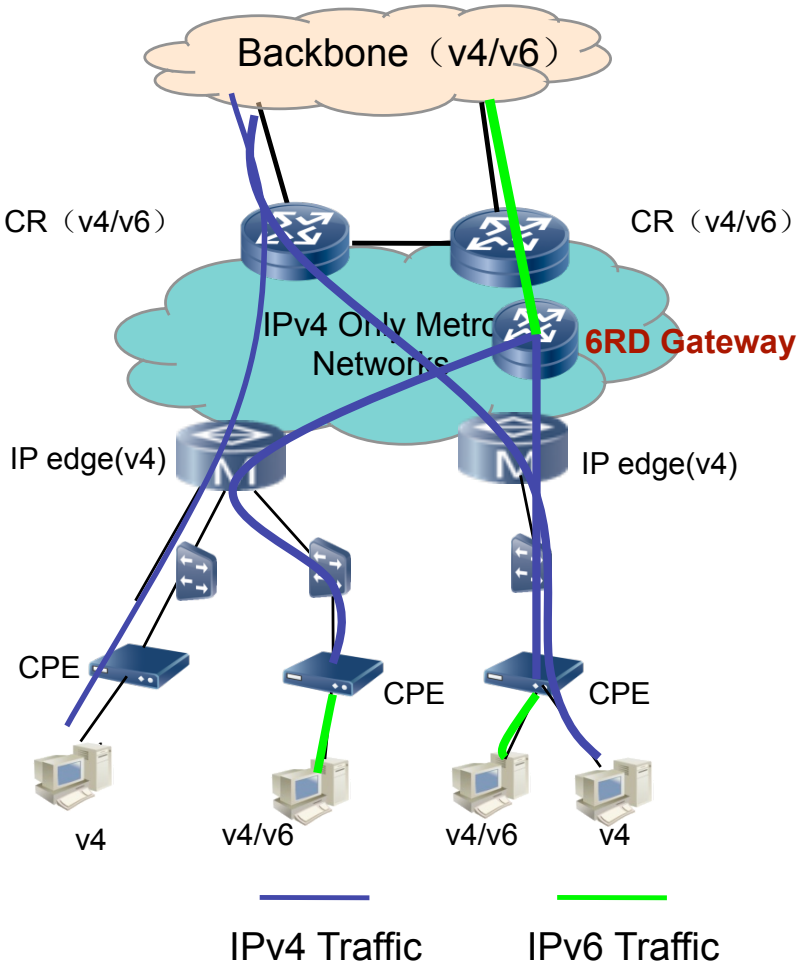
Proposal for IPv6 Transition- L3 Access Network and Not Lack of IPv4 Address Scenarios (1)

- **Scenario**: Access network is layer 3. DHCP is used to configure Broadband access. IP edge device is connected to CR via multi-level aggregation. Many L3 devices in the metro network.
- **Transition requirement**: CR needs to support dual stack. Other IP devices have various requirements based on the technology selection.
- **Transition proposal**: 6rd
- **Equipment requirements**: UE: any version. CPE: IPv4 only or dual stack, for IPv4 only user, dual stack with 6rd support, for dual stack user or IPv6 only user. CR: dual stack. Other L3 network device: no change.
- **Related IETF specification**: RFC5969
- **Involved ISP**: Free has deployed 6rd



Proposal for IPv6 Transition- L3 Access Network and Not Lack of IPv4 Address Scenarios(2)

- Pros:
  - No change to other devices in the metro network except CR.
  - IPv4 only metro network. Management and maintenance cost is relatively lower than dual stack network.
- Cons：
  - Network needs to be upgraded to IPv6 in the future.
  - CPE or user terminals need to support 6rd tunnel initiation.



Summary

Network scenarios and address pressures vary by ISP, So:

- Factors to be considered when transition to IPv6:
  - Whether to protect existing investment
  - Whether to guarantee existing user's experience
  - Whether to push the development of existing service
  - Whether to push and encourage IPv6 development
- During transition to IPv6, ISPs should select proper transition solution and technology.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Thank you