Moving your mobile customers from IPv4 to IPv6

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DENOG15

Who am I

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24 years in Telco industry
ATM, WAN, Security, Mobile Networks,
IMS, Fixed Line Access Networks

24 years accompanied by „IPng“ aka
IPv6

State of the network before the introduction of IPv6

Triggers to actually move to IPv6

Mobile networks IP production 101

Introduction milestones for IPv4 and IPv6

Some technical details

Lessons learnt

Question to the auditorium: Why does a mobile provider need to move to IPv6?

1. Fancy new IPv6 features to offer new products?
2. Lack of public IPv4 space?
3. Lack of private IPv4 space?

State of the mobile network before IPv6

- Started with public IPv4 addresses for subscribers
- Switched to production with private IPv4 addresses including NAT44
- 10.0.0.0/8 range insufficient, had to reuse private IPv4, basically split the mobile network in multiple regions
  - Operational, planning headache

Triggers to move to IPv6

- VoLTE in 2014 (moving mobile voice from circuit switched to packet switched) added a bunch of requirements for private IPv4 addresses
- Options:
  - More reuse of private IPv4 (virtualisation)
  - Usage of Squat Space (unannounced public IPv4 addresses assigned to government authorities)
  - Usage of public IPv4 addresses
  - Start VoLTE with IPv6

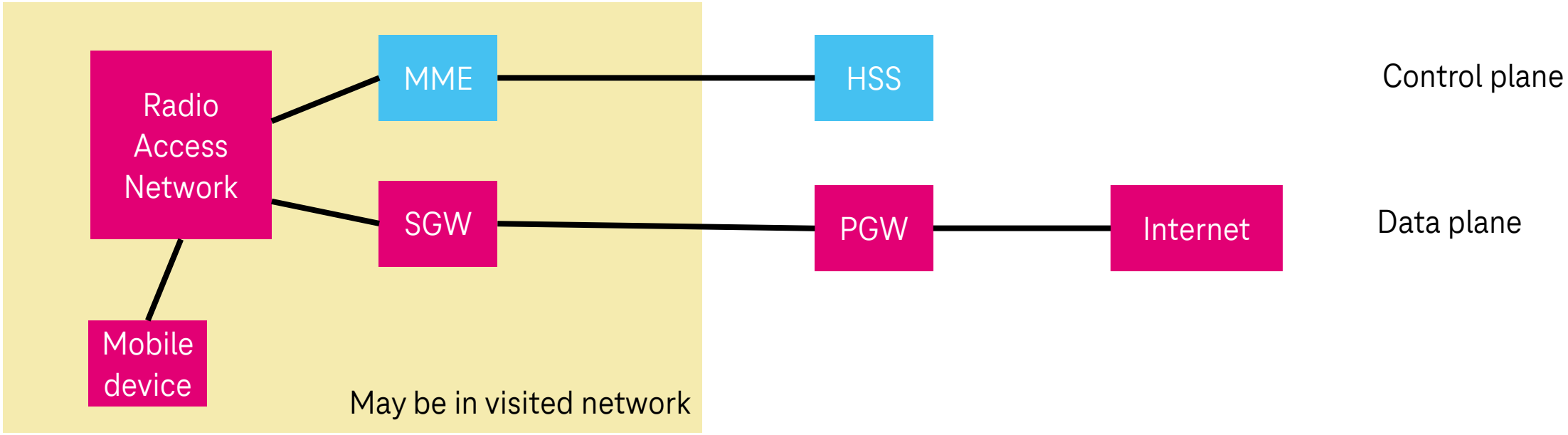
General approach

- IPv6 in VoLTE (Greenfield, most urgent)
- Add IPv6 to IPv4 (Dual Stack) to domestic mobile broadband Internet
- Let everything soak
- remove IPv4 where feasible in omestic mobile broadband Internet

- Leave Roaming at IPv4-only (majority of currently active subscribers is in Germany)
- Leave fallback to public IPv4 and dualstack if selected subscribers require this

Mobile IPv6 101

- 3GPP has standardized IPv6 in mobile networks a long time ago
- In 2G/3G, it was added „piggybagged“ on top of existing IPv4-only standards
- Starting with 4G, IPv6 and the combinations with IPv4 were part of the standards from day 1

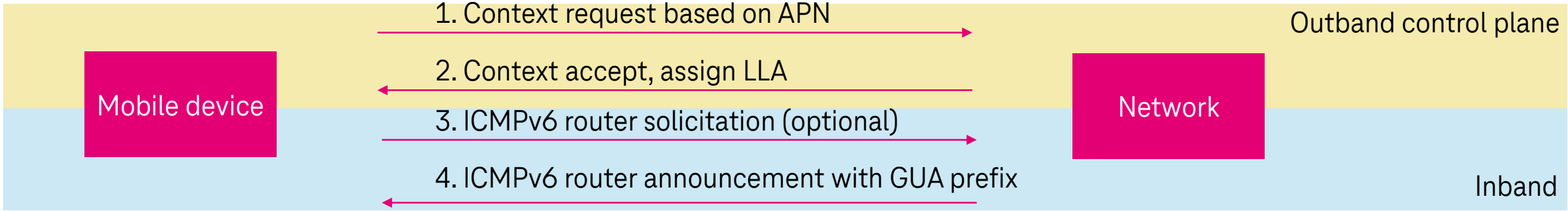


Roaming challenges

- Although roaming agreements exist, there is no control over the network infrastructure of the visited network
- Data traffic is sent from the visited network to the home network tunneled and sent to the Internet there
- Visited network‘s data and control infrastructure needs to support IPv6, although visited network may not offer IPv6 itself at all
- This can become quite challenging
- Better to solve this challenge last – stay IPv4 in roaming scenarios

The 3GPP IPv6 link model

- No ethernet, no MAC, no IPv6 ND, no DAD
  - To conserve network bandwidth and battery resources
  - Effectually a Point-to-Point link.
- LLA of the mobile is assigned by the network via outband mechanisms (PDN context accept)
- A single GUA /64 is assigned to the subscriber, mobile network gateway does not use any address out of this subnet.
- Uses SLAAC for GUA address assignment (ICMPv6 router announcements)



Representation from modem to OS

- Shim is needed
- Linux likes to create LLA on its own
  - LLA translation from „OS LLA“ to „mobile network LLA“
  - Likewise have to translate also other control protocols like ICMPv6, DHCPv6
- Modem is reported to OS as USB-CDC ECM, need to translate from Ethernet to „mobile Point-to-Point“
  - Shim needs to emulate IPv6 ND, respond to host DAD, add/remove Ethernet header

Transition IPv4-only →IPv4v6 Dualstack - Preparation

- Long before, configured mobiles ask the network for IPv4v6 in its APN settings. The network will still downgrade to IPv4 but your subscriber base is prepared.
- Acquired a public IPv6 prefix if not already done so.
- Did a proper IPv6 address planning. Mistakes here will haunt you for the rest of your career.
- Educated everyone about IPv6
- Added IPv6 to backbone network
- Added IPv6 to mobile packet infrastructure between PDN GW and backbone (CE routers, PDN GW, Firewalls, DNS servers, RADIUS server)
- Added IPv6 to control plane, analysis tools, accounting systems
- Optionally: Added IPv6 to Walled Garden Services like Voicemail, Video, Self Service Portals , IMS, RCS
- Migrated subscription database in HLR/HSS, but kept PDN GW at IPv4-only
  - If mobiles ask for Dual Stack, HLR/S-GW will allow IPv4v6 but PDN GW will tell mobile to downgrade to IPv4.

Transition IPv4-only →IPv4v6 Dualstack - Rollout

- Ran all this in a controlled environment by using a dedicated APN
- Tested inhouse in various stages (Lab, separate part of live network) – Operations, colleagues, boss, students
- Used automated tests (e.g. background app running periodically on test mobiles)
- Started a friendly user test – incubation lab (Telekom Hilft Labor)
- Informed the technical press – they will discover anyway what you are doing
- Ran our own blog for the technically versed customers – answers their burning questions, learn doubts, fix issues before they become a problem, steer the public discussion
- Flipped the IPv4v6 switch on all PDN GWs one by one
- Watched the IPv6 usage graphs go up ☺

Take a break…

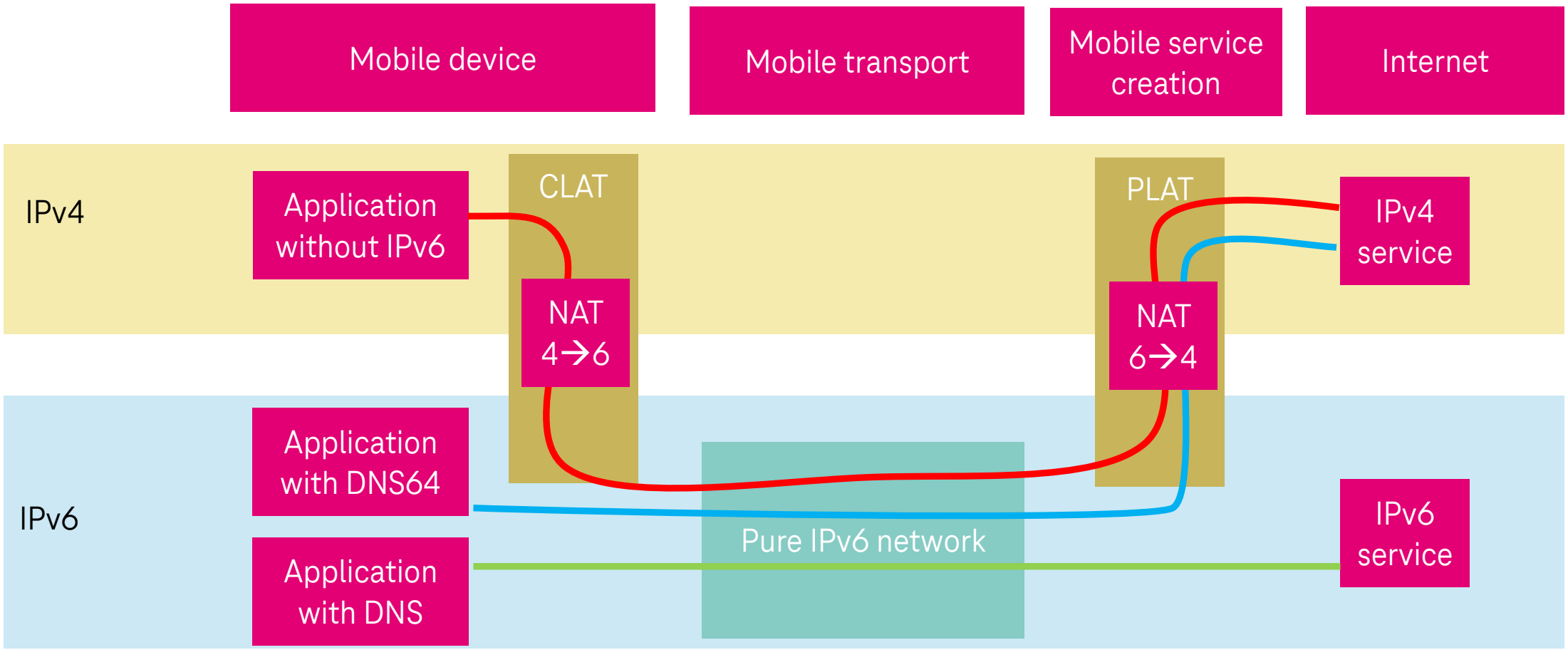
- Now your subscribers use IPv6 but you still have the IPv4 safety net.
- If anything breaks, subscribers will use IPv4 as fallback
  - Mostly not noticable due to Happy Eyeballs (RFC 6555)
- Fix any IPv6 issues now (e.g. missing IPv6 routes in backbone)
- No single IPv4 spared so far!

The tricky part: Removing IPv4 from the mobile

- Legacy IPv4 connectivity will still be required for years
- Luckily, the mobile ecosystem has developed a good toolset to maintain access to IPv4 resources with an IPv6-only address
- 464XLAT (RFC 6877) as a combination of
  - RFC 6145 (→RFC7915) – IP/ICMP translation algorithm
  - RFC 6146 – NAT64
  - RFC 6147 – DNS64
  - CLAT (part of RFC 6877)

  Plus we need
  - RFC 6052 – Addressing of IPv4/IPv6 translators
  - RFC 7050 – Disovery of the prefix used for IPv6 address synthesis

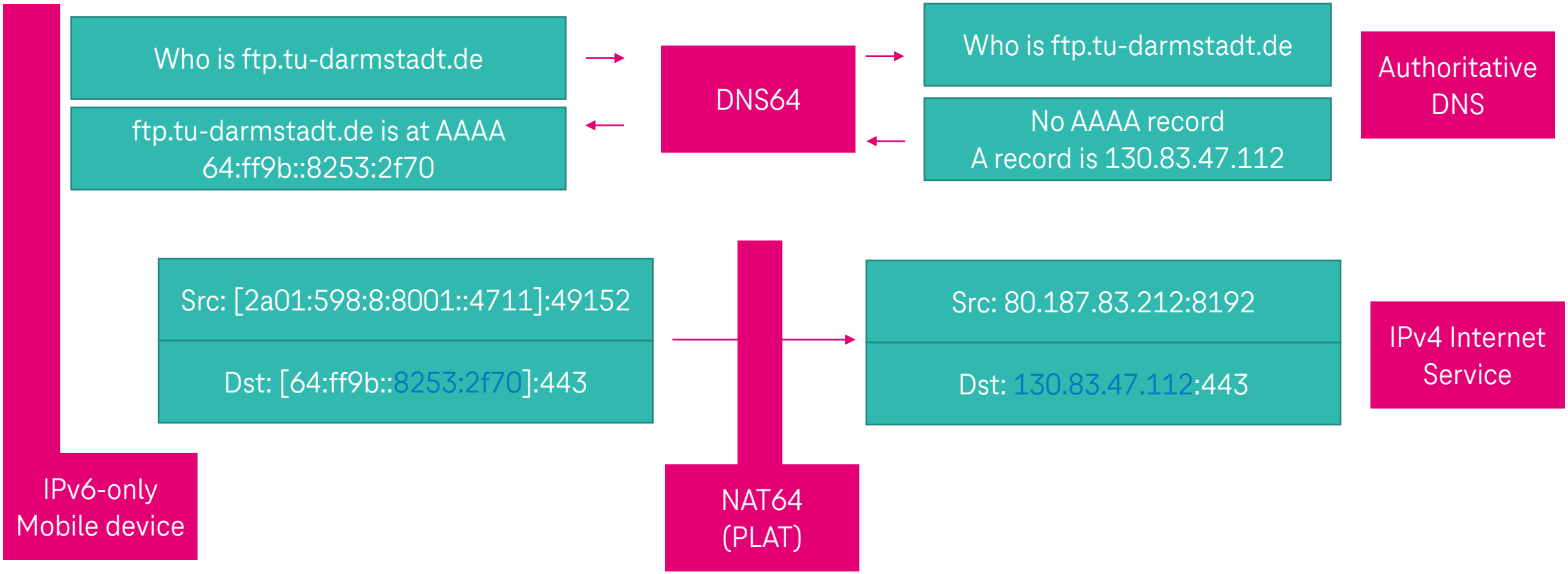
464XLAT at a glance



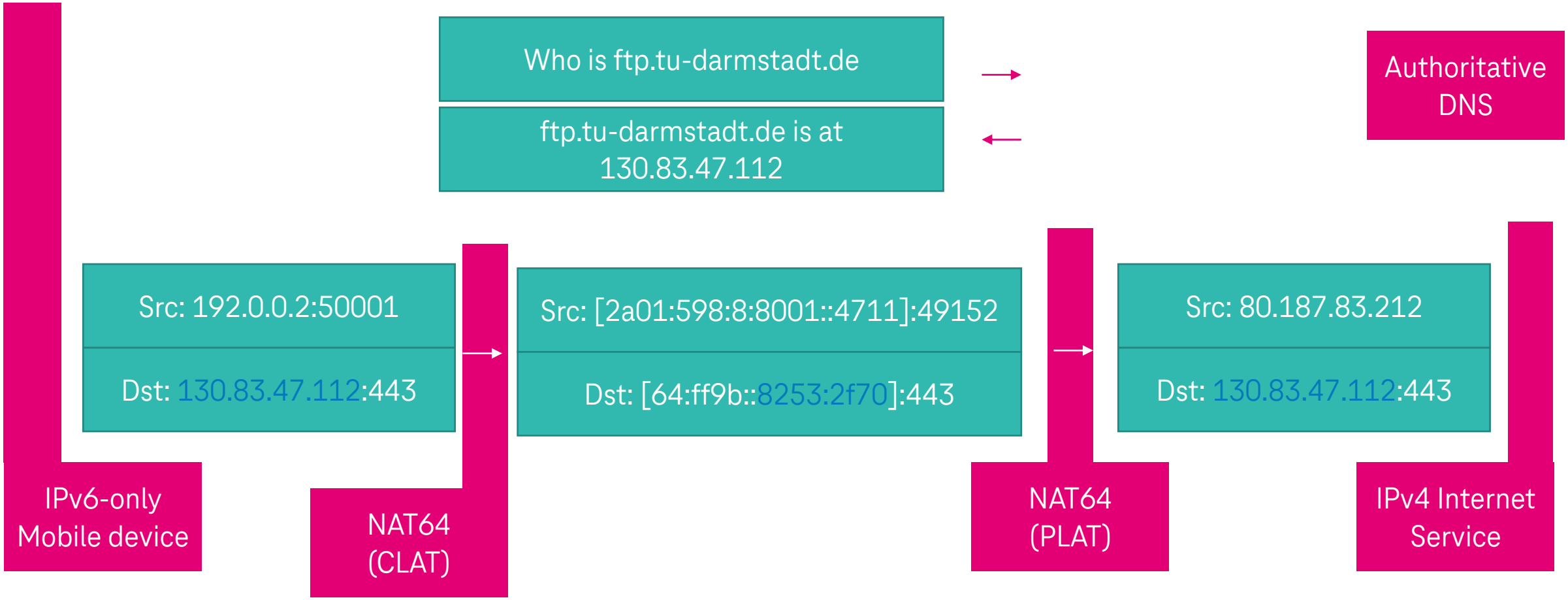
Red: 464XLAT, Blue: NAT64/DNS64, Green: direct

https://de.wikipedia.org/wiki/464XLAT

464XLAT at work – with DNS provided by network operator



464XLAT at work – with DNS on mobile or without DNS



Transition IPv4v6 Dualstack →IPv6 only - Preparation

- Builds on top of your IPv4v6 Dualstack work
- If not done before, now highly recommended: Add IPv6 to Walled Garden Services like Voicemail, Video, Self Service Portals, IMS, RCS
  - Mandatory if subscriber identification by subscriber IP is necessary
- Check your control plane, analysis tools, accounting service whether they can cope with an empty/non-existant IPv4 field
- Reserve IPv6 addresses for IPv6-only APN
- Enable DNS64 for the IPv6-only APN address range, or have dedicated DNS performing DNS64 for the IPv6-only APN address range
  - DNS64 only for IPv6-only subscribers, not for Dualstack subscribers
- Enable NAT64 on existing NAT44 device

Transition IPv4v6 Dualstack →IPv6 only - Rollout

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- Informed the technical press – they will discover anyway what you are doing
- Ran your own blog for the technically versed customers – answers their burning questions, learn doubts, fix issues before they become a problem, steer the public discussion
- Changed the APN from Dualstack APN to IPv6-only APN on all devices
  - IPv6-only APN will only hand out IPv6 addresses
- Watch the IPv4 usage graphs go down ☺

Change the APN from Dualstack APN to IPv6-only APN on all devices

- Deutsche Telekom APNs for public mobile broadband
  - Dualstack APNs: internet.telekom, internet.t-mobile
  - IPv6-only APN: internet.v6.telekom
- Can‘t send a broadcast mail to all customers to go into the mobile‘s settings and change APN there
- Can‘t send all your customers to Telekom Shops to have their settings changed
- There is no really usable over the air provisioning standard
- Worked with smartphone manufacturers to have the new APN settings as default for new devices, and modify old default Dualstack APN as part of regular device software upgrades.
- Changed default settings in Android Source Code (operator settings table)

Connection attemps from the Internet

- With native IPv6 communication, no NAT is in place, we have IPv6 without address translation – the mobile has a globally unique address
- So clients on the Internet could attempt to reach service on the mobile
  - Drains battery quickly since all these unsolicited packets must be received and processed before eventually being dropped on the device
  - Count against included volume, data volume limits may be reached quicker - „bill shock“
- IPv6 firewall in the mobile network filters out all IP connection attempts from Internet to mobile

Bonus…

- IPv6 addressing
  - IPv6 GUAs are assigned randomly to mobile devices
  - Tariff option available to have static IPv6 prefixes assigned
  - Firewall is not in place when using this option
- Mobile device can act as a router (e.g. „Tethering“/“Mobile Hotspot“/“Connection Sharing“)
  - DHCPv6 prefix delegation (PD) could be used to get more GUA prefixes to assign another GUA to Tethering WiFi Hotspot – not available in mobiles and not supported by the network currently
  - Instead, mobile phone OS uses RFC7278 technology to extend the /64 GUA from the 3GPP uplink to an attached WiFi hotspot network by means similar to bridging.

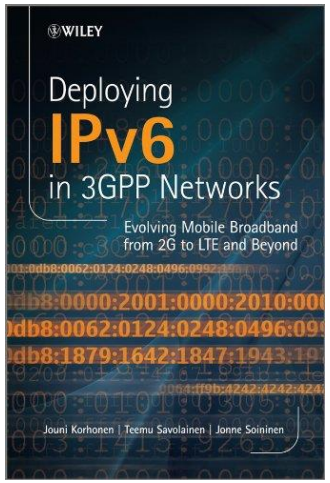
Goal reached?

- Significant reduction of private IPv4 address usage
- No need to extend reuse factor of IPv4 addresses
- No major incidents during and after transition period
- The long tail of „old“ devices still requiring IPv4 will be there for years

Thank you very much!

Deploying IPv6 in 3GPP Networks: Evolving Mobile Broadband ...

Jouni Korhonen, Teemu Savolainen, Jonne Soininen · 2013



Any questions?

Poll

In your opinion, what needs to be done in order to push IPv6 deployment further?

925016

https://vote.telekom.net/925016