IPv4-Exit Strategy for Mobile Networks

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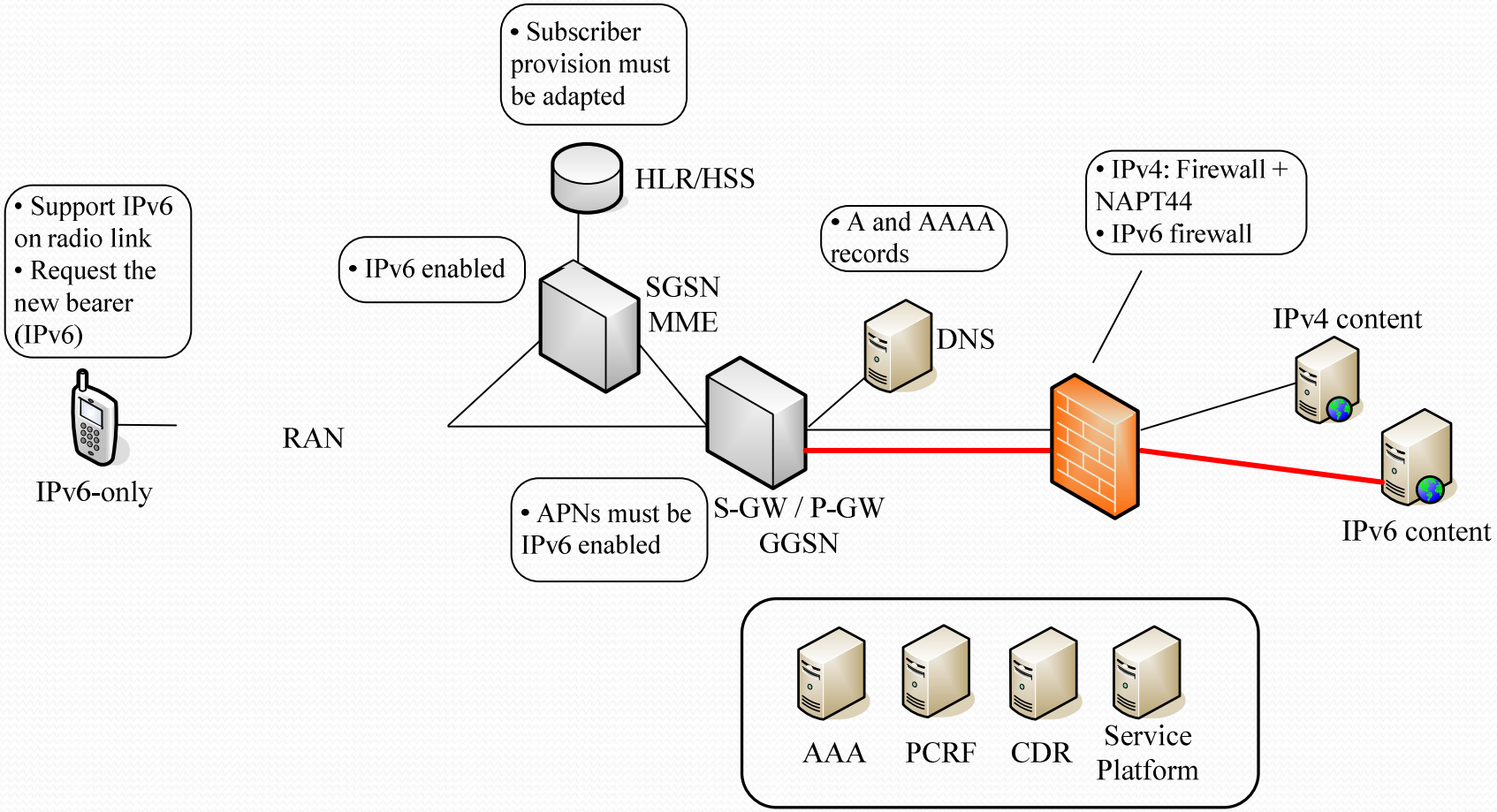
Introduction

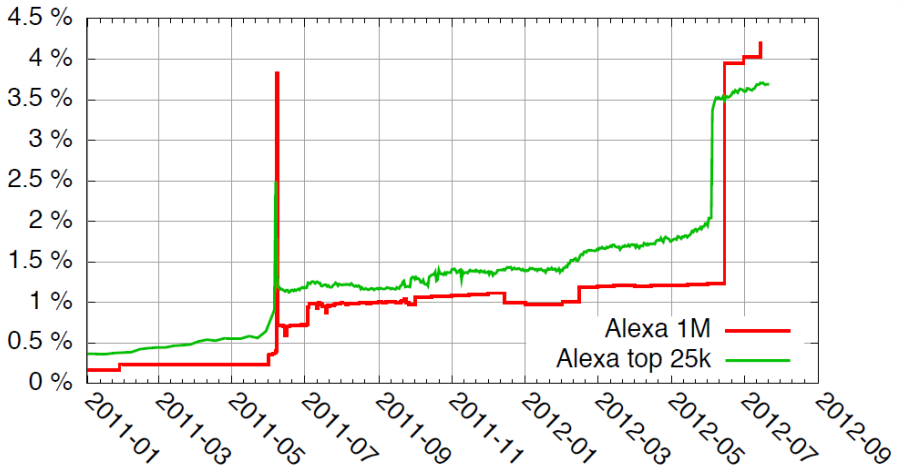
- Increasing demand of IP connectivity
- Limited IPv4 address space (public and private)
  - Expected demand for IP connectivity outpaces the IPv4 address capabilities
  - Delayed by private addressing, stateful NAPT44, virtual address ranges
- IPv6-only addressing to encounter the IPv4 address limitations
  - Dual-Stack does not encounter the private IPv4 address limitations
- Coexistence phase of IPv4 and IPv6
  - Ongoing IPv6 deployment but most services are IPv4-only today
- Incompatibility of IPv4 and IPv6

IPv6 in 3GPP networks



IPv6 distribution

- Most TOP websites enabled IPv6 permanently on World IPv6 day 2012
  - IPv6 enabled: google, facebook, youtube, wikipedia, yahoo…
  - Still IPv4-only: ebay, amazon, spiegel, bild…



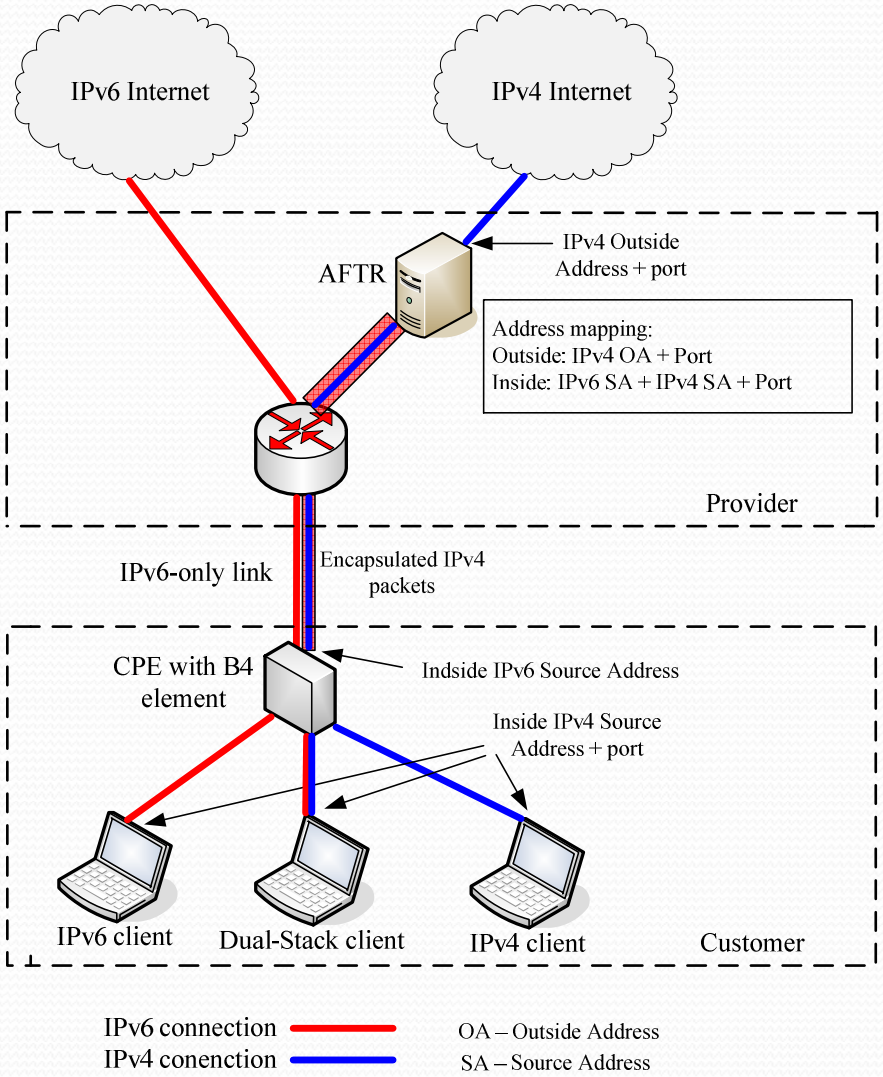
→ Compatibility mechanism required to provide accessibility to IPv4-only services by IPv6-only clients

IPv4-Exit techniques

- Different approaches to enable compatibility between IPv4 and IPv6
- Tunneling
  - Encapsulation and transport of IP packets as payload of other IP packets
  - Here: Encapsulation of IPv4 packets in IPv6 packets for transport using a native IPv6 infrastructure
  - Dual-Stack Lite: known from fixed environments
- Translation
  - Address and header conversion between the address families
    - NAT64 + DNS64
    - 464XLAT

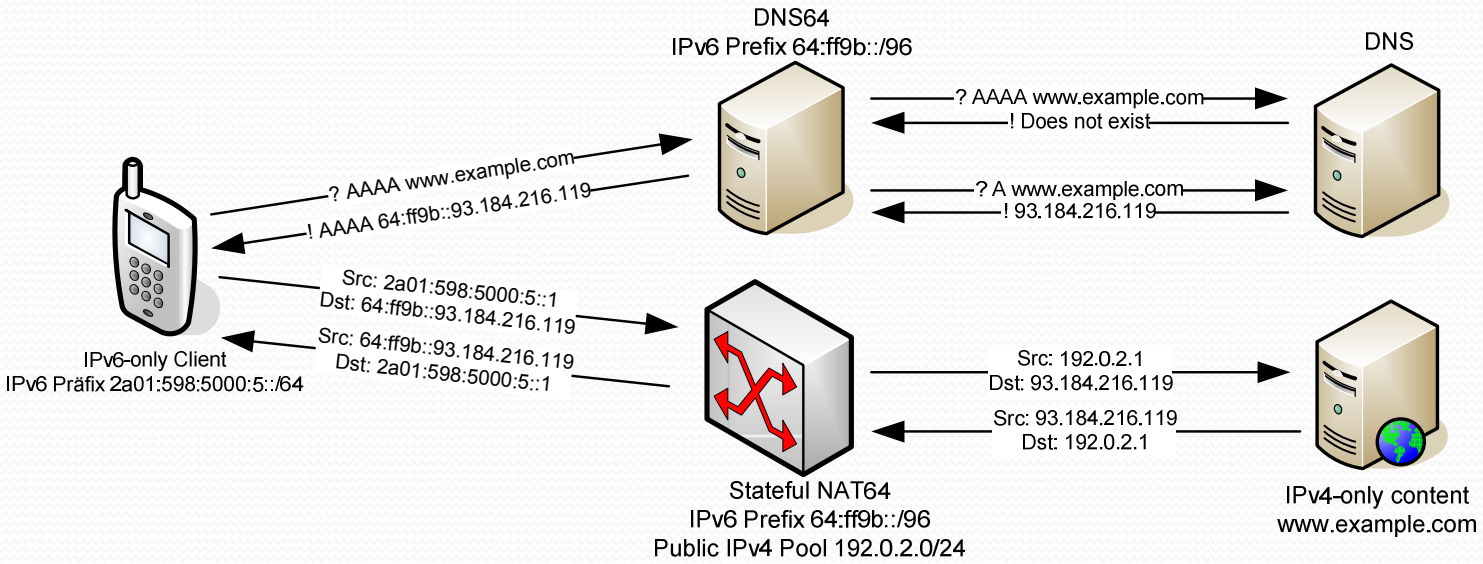
Gateway Initiated Dual-Stack Lite

- Combination of tunneling and NAPT44
- Sharing private IPv4 addresses among customers
- IPv6 address is added as additional element to NAPT44 mapping
- Not supported in current and medium term implementations

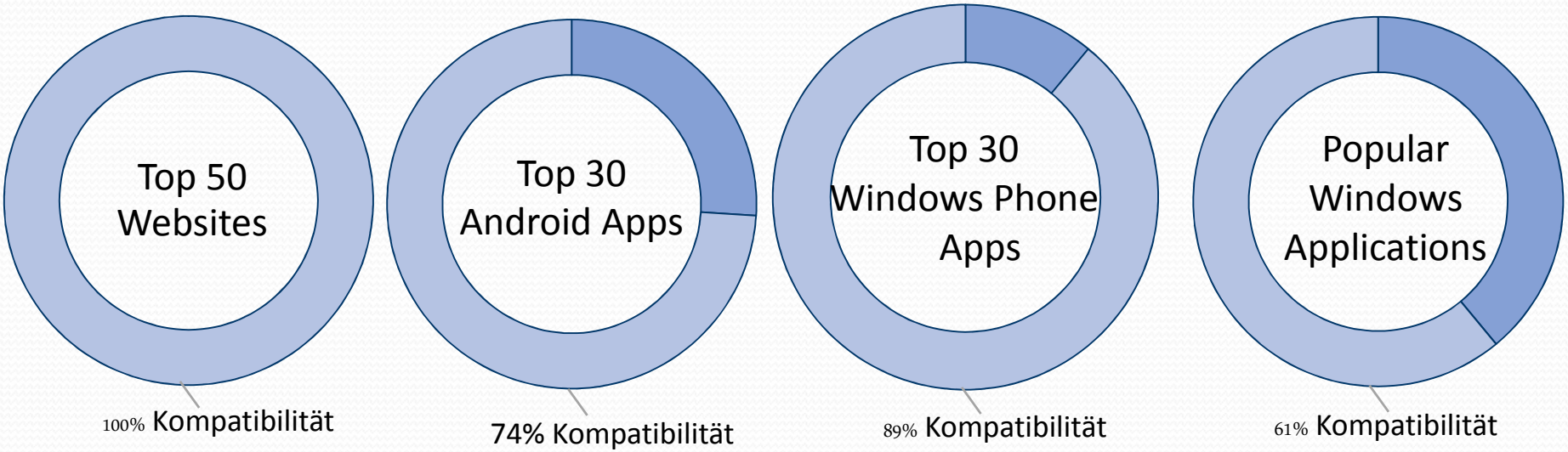


NAT64 + DNS64

- Network-based compatibility mechanism
  - DNS64 (RFC6147)
    - Synthetization of AAAA RR based on A RR
  - Stateful NAT64 (RFC6146)
    - Protocoltranslation
- IPv6 address generation required
  - Broken in case of IPv4-only Applications, APIs and IPv4 literals



NAT64 + DNS64 test results



- Limited applicability due to systematic limitation of address synthesis
  - Referencing IPv4 specific networking APIs , signaling IPv4 literals, no use of FQDN

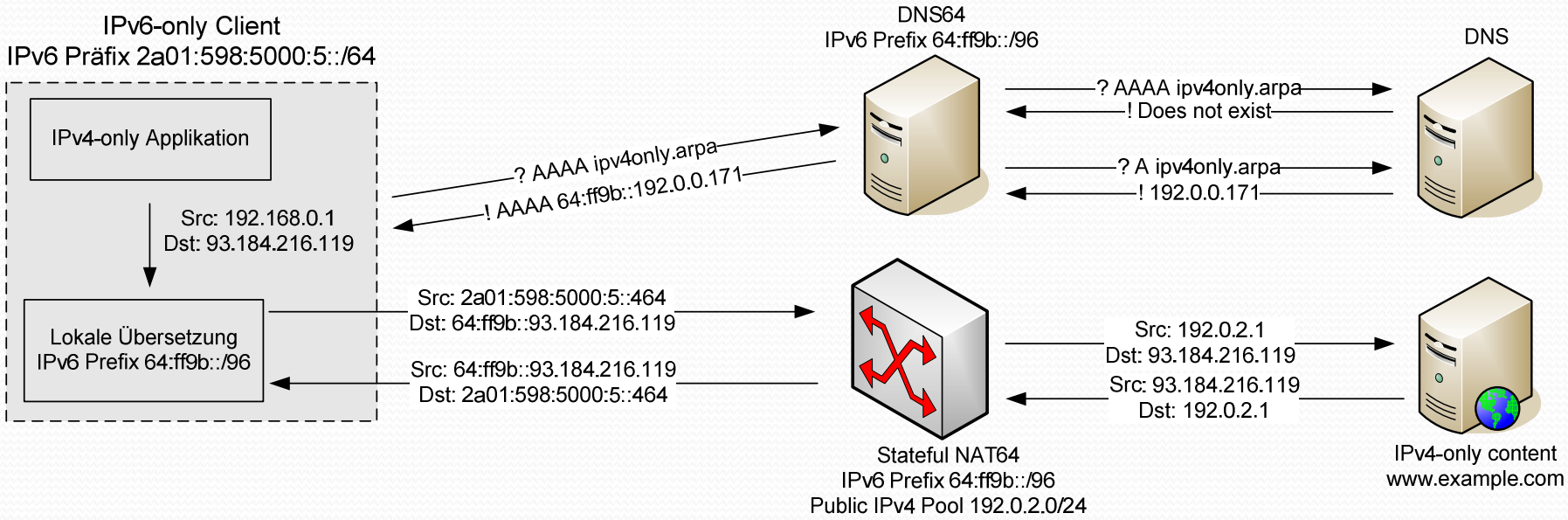
➡ DNS64/NAT64 is good but not good enough to replace IPv4

464XLAT

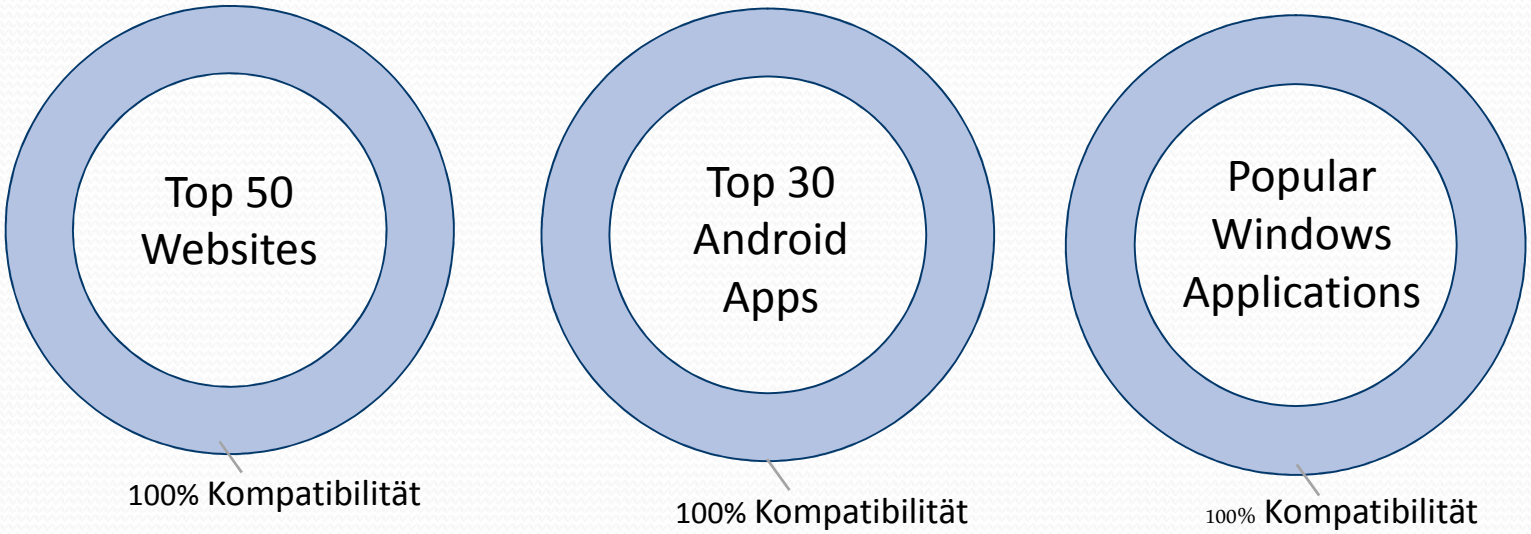
- Stateful NAT64 (RFC6146)
- DNS64 (RFC6147)

} 464XLAT is based on NAT64 + DNS64

- Stateless NAT64 (RFC6145)
  - Performing a client-side translation
- Prefix64 discovery (RFC7050)
  - Performs detection if NAT64/DNS64 is available in the network.



464XLAT test results



- Service parity with IPv4/Dual-Stack operation

Comparative assessment

	Dual-Stack	DS-Lite	GI-DS Lite	Stateful NAT64	464XLAT
Functionality	good	good	good	**limited**	**good**
Technical resources	high	**high**	**high**	**limited**	**limited**
Operational costs	high	**high**	**high**	**limited**	**limited**
Overhead	medium (signaling)	**high (access/core)**	**medium (core)**	**none**	**none**
Planning costs	high	**high**	**high**	**limited**	**limited**
Engineering costs	limited	**high**	**high**	**limited**	**limited**
Applicable in mobile networks	yes	**hard**	yes	yes	**medium**
IPv6-only access	**no**	yes	yes	yes	yes
Saves IPv4 addresses	**no (priv.)** yes (pub.)	yes (priv. and pub.)	yes (priv. and pub.)	yes (priv. and pub.)	yes (priv. and pub.)

Recommendation

- Short-term architecture
  - Dual-Stack for production network
  - Parallel testing of 464XLAT
  - Distribution of IPv6 and 464XLAT capable devices
- Middle-term architecture
  - IPv6-only step by step for well-tested devices
  - Dual-Stack for legacy devices
  - Distribution of IPv6 and 464XLAT capable devices
- Long-term architecture
  - IPv6-only access without any compatibility mechanism
  - 464XLAT just in case

Current problem areas

- IPv4-Exit activities are coupled to capabilities of end user devices
  - Limited availability of 464Xlat
- Local translation not fully compliant to the standard yet
  - Support of fragmented packets, ICMP messages…
- Systematic limitations
  - Restricted support for IPv4 Options, IPv6 EH, Layer 4 protocols
- Ongoing discussions/standardization activities on tethering (Prefix Delegation, 64share…)
- NAT64 inherits the well known limitations of NAT
  - ALGs, NAT-T…

Conclusion

- IPv4 does not meet the business need any more
- IPv6-only access network encounters the IPv4 address limitations
- The theoretical and practical assessments reveal that IPv6 in 3GPP networks can be realized as a smooth and careful process
  - Protocol translation as feasible compatibility mechanism provide compatibility between IPv4 and IPv6
- IPv6 deployment will be two-folded in the next years

Thanks for your attention

Backup slides

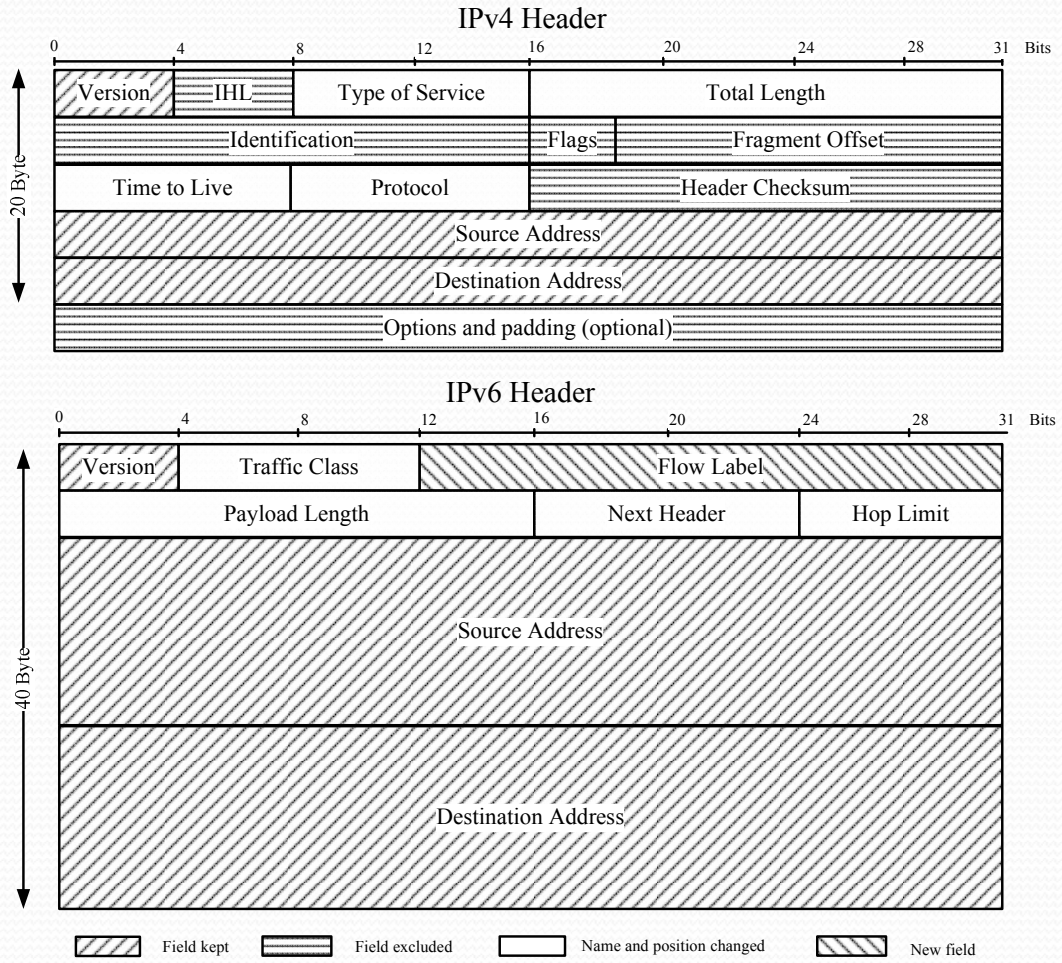
Drivers and goals

- IPv6 deployment is network driven (no marketing intentions)
  - Save private IPv4 addresses and virtualization instances
  - Save public IPv4 addresses and NAPT44 sessions
  - Dual-Stack networks require twice the engineering, planning operational effort than single-stacked network
- 100% compatibility with IPv4-only services and applications must be ensured
  - Maintain user experience, broken services will not be accepted

IPv6 in contrast to IPv4

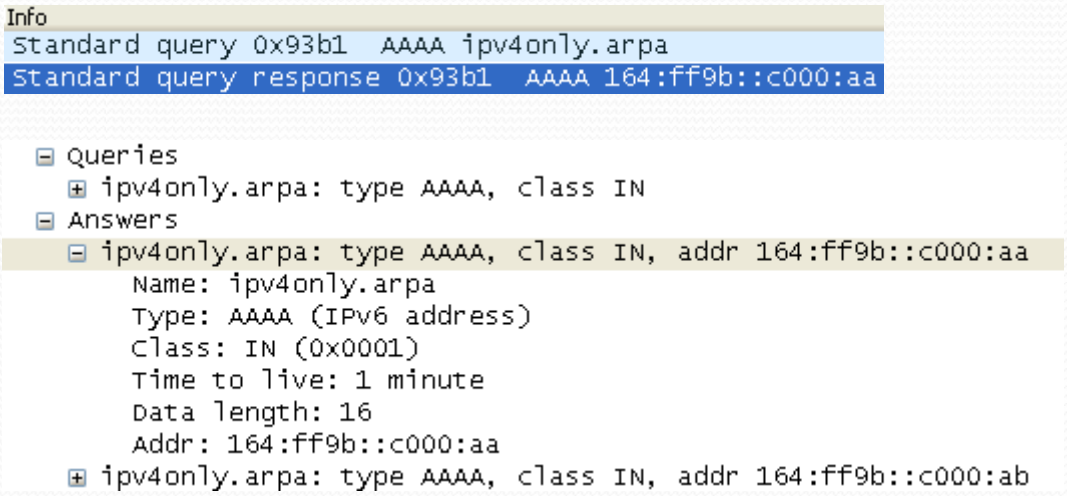
- Addressing architecture
- IPv6 address configuration
- Header structure
- DNS
- Fragmentation and PMTUD
- ICMP
- ….

Enlarged address space is the major benefit of IPv6



464XLAT technical details

- Prefix discovery (RFC7050)
  - The client will lookup the well-known FQDN ipv4only.arpa. If a AAAA record is presented for this well-know IPv4-only FQDN, the client can parse the response to find the Pref64 used within this network
- Wireshark



464XLAT technical details

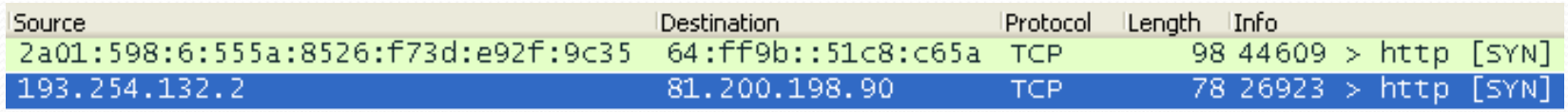
- Stateless NAT64 (RFC6145)
  - Algorithmically map IPv4 addresses to IPv6 addresses
  - Maps 32 bits IPv4 address into an IPv6 address
- Wireshark

Source	Destination	Protocol	Length	Info
192.0.0.4	157.55.56.171	TCP	76	39809 > 40031 [SYN] Seq=0
157.55.56.171	192.0.0.4	TCP	76	40031 > 39809 [SYN, ACK]
192.0.0.4	157.55.56.171	TCP	68	39809 > 40031 [ACK] Seq=1

Source	Destination	Protocol	Length	Info
2a01:598:6:55be::464	164:ff9b::9d37:38ab	TCP	96	39813 > 40031 [SYN] Seq=0
2a01:598:6:55be::464	164:ff9b::9d37:38ab	TCP	96	39813 > 40031 [SYN] Seq=0
164:ff9b::9d37:38ab	2a01:598:6:55be::464	TCP	96	40031 > 39813 [SYN, ACK]

464XLAT technical details

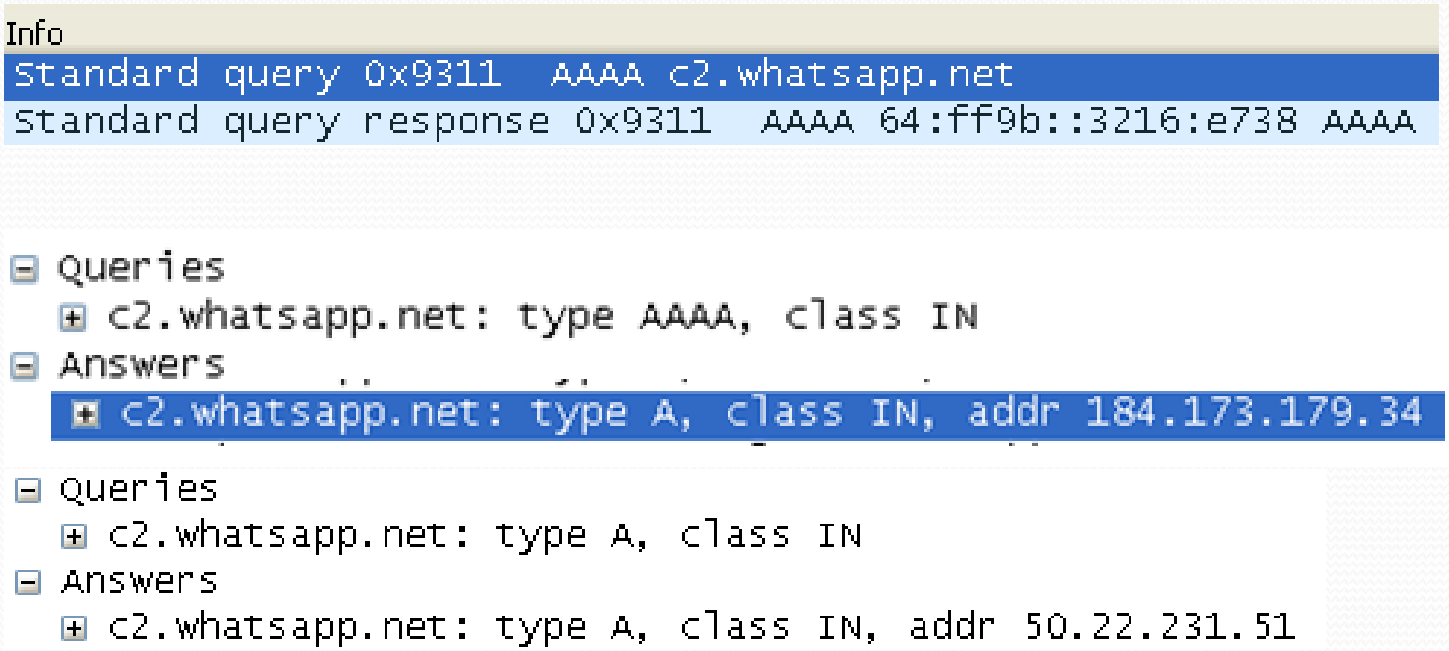
- Stateful NAT64 (RFC6146)
  - Dynamic translation of IPv4 packets to IPv6 packets and vice versa
  - Based on an IPv4 address pool, not deterministic
  - Translation based on session state
- Wireshark



Source	Destination	Protocol	Length	Info
2a01:598:6:555a:8526:f73d:e92f:9c35	64:ff9b::51c8:c65a	TCP	98	44609 > http [SYN]
193.254.132.2	81.200.198.90	TCP	78	26923 > http [SYN]

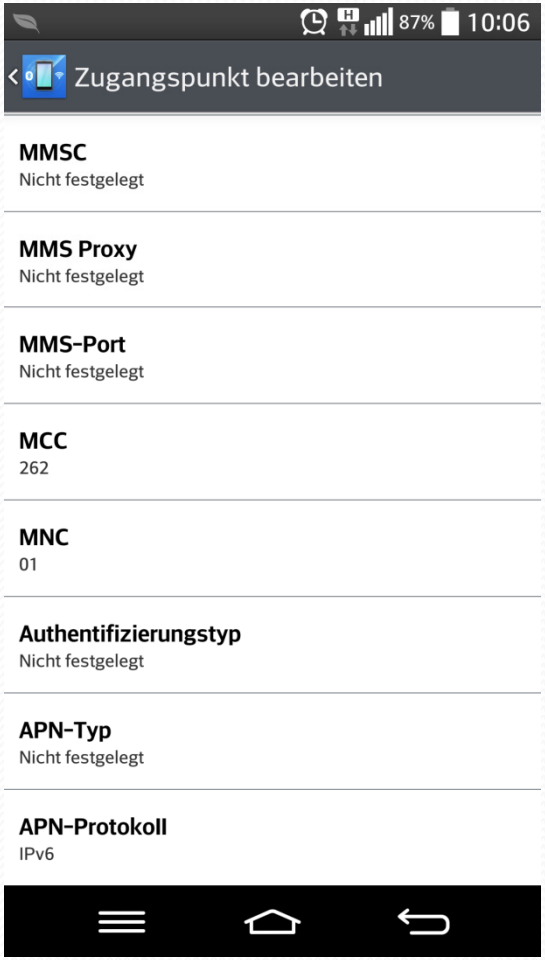
464XLAT technical details

- DNS64 (RFC6147)
  - When an FQDN does not have a AAAA record, the DNS64 will synthetically create one based on a network defined Pref64
  - The pref64 is a prefix hosted on the NAT64 for translation
- Wireshark



464XLAT technical details

- Android APN settings



- Android interfaces