## **Belgian IPv6 Council**

# IPv6 in 5G

April 2022 <u>thierry.van\_de\_velde@nokia.com</u> Global Core Networks Presales Leader



## Introduction

### the role of IPv6 in 5G

- NAT44 and NAT64 costs 50% of processing power in User Plane
- User Plane is up to 50% of the footprint of a Cloud Core Network
- Mandatory Data Retention systems are needlessly complex due to NAT
- XLAT464 and Dual Stack are widely supported by 4G/5G UEs
- We will show that IPv6 unlocks lower latency communications in 5G
- IPv6 will unlock a Flat 5G Advanced and 6G network



## IPv6 is mainstream in Tier 1 MNOs

#### https://www.worldipv6launch.org/measurements/ (ranked by volume)

Rank 🔺	Participating Network 🗘	ASN(s)	IPv6 deployment
1	RELIANCE JIO INFOCOMM LTD	55836, 64049	93.63%
2	Comcast	7015, 7016, 7725, 7922, 11025, 13367, 13385, 20214, 21508, 22258, 22909, 33287, 33489, 33490, 33491, 33650, 33651, 33652, 33653, 33654, 33655, 33656, 33657, 33659, 33660, 33661, 33662, 33664, 33665, 33666, 33667, 33668, 36732, 36733	70.92%
3	Combined US Mobile Carriers	3651, 6167, 10507, 20057, 21928, 22394	87.44%
4	Charter Communications	7843, 10796, 11351, 11426, 11427, 12271, 20001, 20115, 33363	53.56%
5	ATT	6389, 7018, 7132	73.48%
6	T-Mobile USA	21928	92.42%
7	Deutsche Telekom AG	3320	72.69%
8	Orange Business Services	3215	71.28%
9	<u>Claro Brasil</u>	4230, 28573	72.87%
10	Verizon Wireless	6167, 22394	83.10%



## Mobile packet-switched core networking Evolution of 3GPP standards 1998 - 2020



#### eLTE is however unlikely to ever happen

leading 5GC for 5G SA coexisting forever with EPC to 5G NSA ?





### Interworking between Evolved Packet System and 5G System

Interconnection requirements for 5G Option 2

- S5/S8 pre-anchoring
  - convincing the MMEs in HPLMN and foreign
    VPLMN to select a combined PGW-C/SMF
  - using UE Network Characteristics (UENC) or PGW address in HSS for Data APN (as for IMS)
- N26 for handovers with single registration
  - passing MM/SM context between AMF & MME
  - AN, AS and NAS rekeying occurs
- S5/S8-U temporary tunnel for Packet-Switched Handover (PSHO) via PGW-U/UPF
  - indirect forwarding from old RAT to new RAT

5G Option 2 is not really Stand Alone... until national & international NR/eLTE coverage will be achieved



#### UE IPv6 address allocation

#### in Evolved Packet System (EPS) and in 5G System (5GS)



#### UE IPv6 address allocation in EPS and in 5GS

when Managed Address Configuration & Other Stateful Config flags are set





HIGHLY CONFIDENTIAL - CONTROLLED DISTRIBUTION SUBJECT TO EXPLICIT PERMISSION FROM THE AUTJHOR. COPYRIGHT © 2015 ALCATEL-LUCENT. ALL RIGHTS RESERVED.



### Our vision : unlocking multicast thanks to 5G LANs

while keeping Broadcast, Unknown unicast & Multicast (BUM) under control





## 2022 : The added value of mobile networks is...

Lossless active mode handover besides idle mode mobility





![](_page_10_Figure_4.jpeg)

#### Problem statement #1

5GS Session & Service Continuity (SSC Mode 3) has limitations

#### For the End User

- when the IPv6 address changes in SSC mode 3, new IPv6 flows have to be established by the app or by QUIC, leading to packet loss & latency
- International roaming traffic is home routed in practice today, to the PGW/UPF-PSA in the HLPMN : high latency, high cost, low throughput
- Selective local break-out (LIPA, UPF-ULCL, Nokia SGW-SLBO) does not work for pure IPv6 traffic : in the absence of NAT66 the downstream traffic is attracted to the UPF-PSA/PGW

#### For the Operator

- SSC mode 3 does not work for IPv4 (a.o. in private DNNs...)
- SSC mode 3 does not work for EPS UE or for 5GS with EPS interworking
- (Re)subnetting IPv4/IPv6 address space when adding a new UPF/PGW instance, to avoid host route announcements
- Adding a VM/Pod to a UPF/PGW instance also requires IP address (re)subnetting
- BGP sessions announcing UE subnets between UPF/PGW VM/Pods and DC switch fabric are hard to automate (when Pods move to other compute nodes)

![](_page_11_Picture_13.jpeg)

#### Problem statement #2

#### No Selective Local Break Out (SLBO) for IPv6 UEs

#### Nokia Selective Local Break-Out (SLBO) at CMG 12.0r1 Serving Gateway (2Q2020)

Preserving seamless mobility

- Static/dynamic PCC rules in Serving Gateway for low-latency access to
  - MEC
  - Enterprise LAN
  - Internet in Visited PLMN
- Configure>mobile>pdn>dnai-map>
  - ENTRY-ID {[PLMN-LIST...] [MVNO] [INCOMING-APN-LIST ...]} MAPPED-APN ....
- Configure>mobile>pdn>apn>
  - Name ...
  - Aa-group
  - Accounting
  - Charging
  - Pcrf-selection
  - Pdn-type
  - Redirect
  - Router <vprn>
    static-local-pcc
  - Static-predefined-pcc
  - Steering
  - Svc-steering
  - ...

![](_page_12_Figure_23.jpeg)

![](_page_13_Figure_0.jpeg)

## PFCP PDN Type Ethernet for non-Ethernet EPS PDN Type and 5GS PDU Type Representing the UE by a MAC address at the UPF or UPF Component instance

![](_page_14_Figure_2.jpeg)

## UPF-dependent MAC Range or Segment Routing Label? Ultra Reliable Segment Routing (URSR)

![](_page_15_Figure_1.jpeg)

filed in 2020 Patent Pending

## Generalizing the invention

## Traffic replication across diverse Segment Routed paths

![](_page_16_Figure_2.jpeg)

filed in 2020 Patent Pending

•

•

٠

![](_page_17_Figure_0.jpeg)

![](_page_18_Figure_0.jpeg)

#### Conclusion

a long journey

- In 3GPP R15 a regrettable schism appeared in 4G/5G Core Network standards
- Both the EPS and 5GS standards permit Ethernet services today
- However 3GPP specified URLLC, TSC and 5G LAN further only in the 5GS
- IPv6-based 3GPP SSC Mode 3 is not achieving lossless handovers
- When IPv6 grows, Selective Local Break Out (SLBO) in Enterprise and Visited PLMNs will become impossible; also 3GPP UPF-ULCL becomes useless
- Flat, Low-Latency and Ultra Reliable 5.5G/6G networks will require either real/virtual UE MAC Addresses or a UE MPLS Segment Routing Label (SRoMPLS or SRv6)

![](_page_20_Picture_0.jpeg)

#### Copyright and confidentiality

The contents of this document are proprietary and confidential property of Nokia. This document is provided subject to confidentiality obligations of the applicable agreement(s).

This document is intended for use of Nokia's customers and collaborators only for the purpose for which this document is submitted by Nokia. No part of this document may be reproduced or made available to the public or to any third party in any form or means without the prior written permission of Nokia. This document is to be used by properly trained professional personnel. Any use of the contents in this document isimited strictly to the use(s) specifically created in the applicable agreement(s) under which the document is submitted. The user of this document may voluntarily provide suggestions, comments or other feedback to Nokia in respect of the contents of this document ("Feedback"). Such Feedback may be used in Nokia products and related specifications or other documentation. Accordingly, if the user of this document gives Nokia Feedback on the contents of this document, Nokia may freely use, disclose, reproduce, icense, distribute and otherwise commercialize the feedback in any Nokia product, technology, service, specification or other documentation.

Nokia operates a policy of ongoing development. Nokia reserves the right to make changes and improvements to any of the products and/or services described in this document or withdraw this document at any time without prior notice.

The contents of this document are provided "as is". Except as required by applicableaw, no warranties of any kind, either express or implied, including, but notimited to, the implied warranties of merchantability and fitness for a particular purpose, are made in relation to the accuracy, reliability or contents of this document. NOKIA SHALL NOT BE RESPONSIBLE IN ANY EVENT FOR ERRORS IN THIS DOCUMENT or for

anyoss of data or income or any special, incidental, consequential, indirect or direct damages howsoever caused, that might arise from the use of this document or any contents of this document.

This document and the product(s) it describes are protected by copyright according to the applicableaws.

Nokia is a registered trademark of Nokia Corporation. Other product and company names mentioned herein may be trademarks or trade names of their respective owners.

#### < Confidential >

![](_page_21_Picture_12.jpeg)