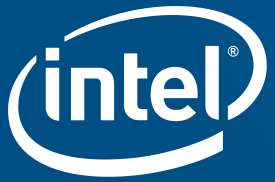

SDN-NFV based Evolved Packet Core

Jacob Cooper
Karla Saur

Acknowledgements:
Intel - Christian Maciocco, Ashok Sunder Rajan, Kannan Babu Ramia
Sprint - Lyle Bertz, Arun Rajagopal, Vivek Vijayan

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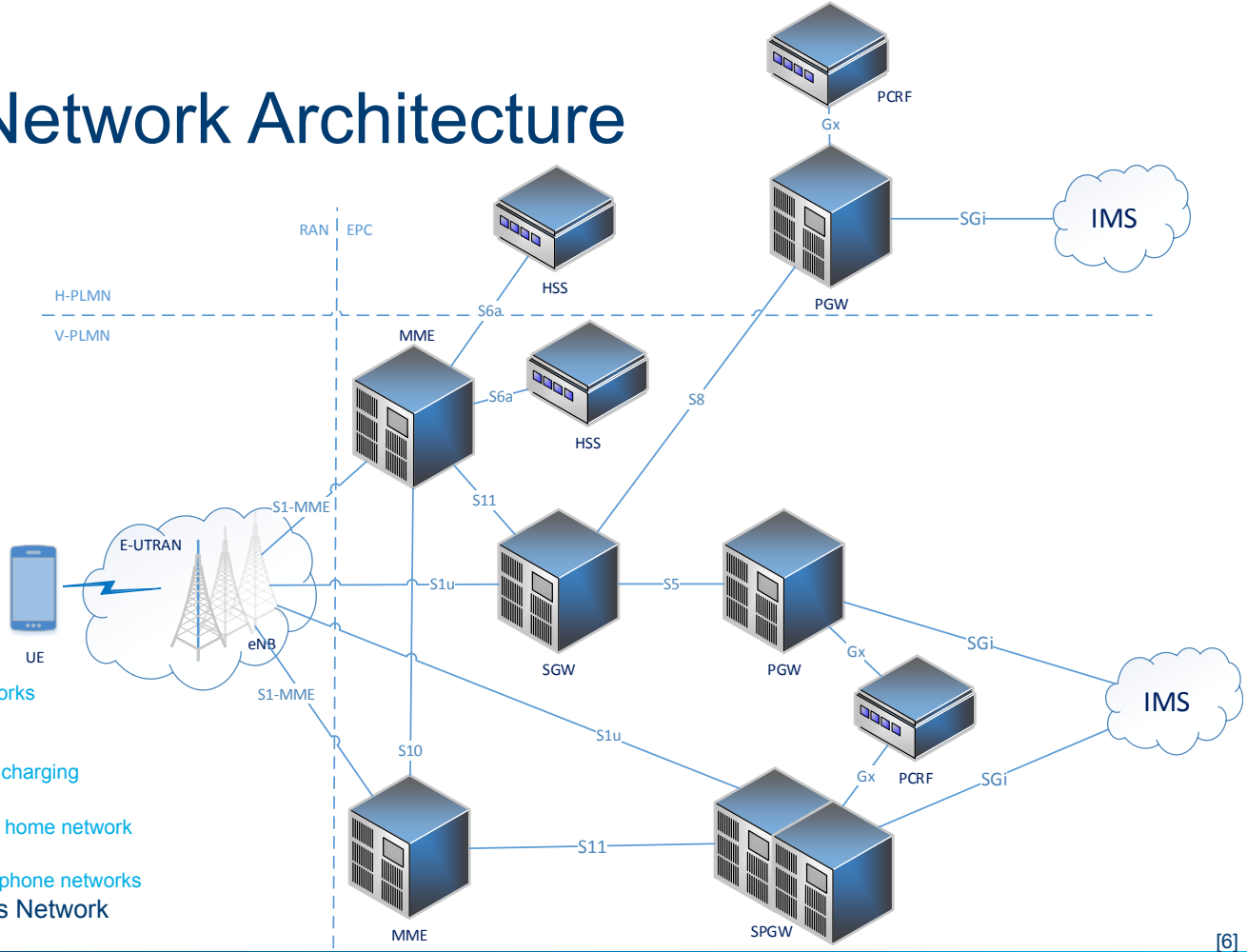
Current Mobile Network Architecture

- EPC: Evolved Packet Core
- RAN: Radio Access Network
- H-PLMN: Home Public Land Mobile Network
  - Subscriber's Carrier Network
- V-PLMN: Visited Public Land Mobile Network
  - Roaming Carrier Network
- MME: Mobility Management Entity
  - Manages mobility events
- UE: User Equipment
  - Cell Phones/Hotspots/Modem
- eNB: evolved Node B
  - Base Station (Cell Towers)
- HSS: Home Subscriber Server
  - User and Subscriber database,
- PCRF: Policy & Charging Rules Function
  - Manages account QoS and Charging
- SGW: Serving Gateway
  - Manages packet flow between Core and Radio Networks
- PGW: PDN Gateway
  - Packet Data Network – or Packet Gateway
  - Maps packets to user accounts, manages policy and charging
- SPGW: Serving & Packet Gateway
  - Combined Serving and Packet Gateway functions on home network
- IMS: IP Multimedia Subsystem
  - Access to IP services, including the Internet and Telephone networks
- E-UTRAN: Evolved Universal Terrestrial Access Network
  - LTE Radio Access Network



[6]

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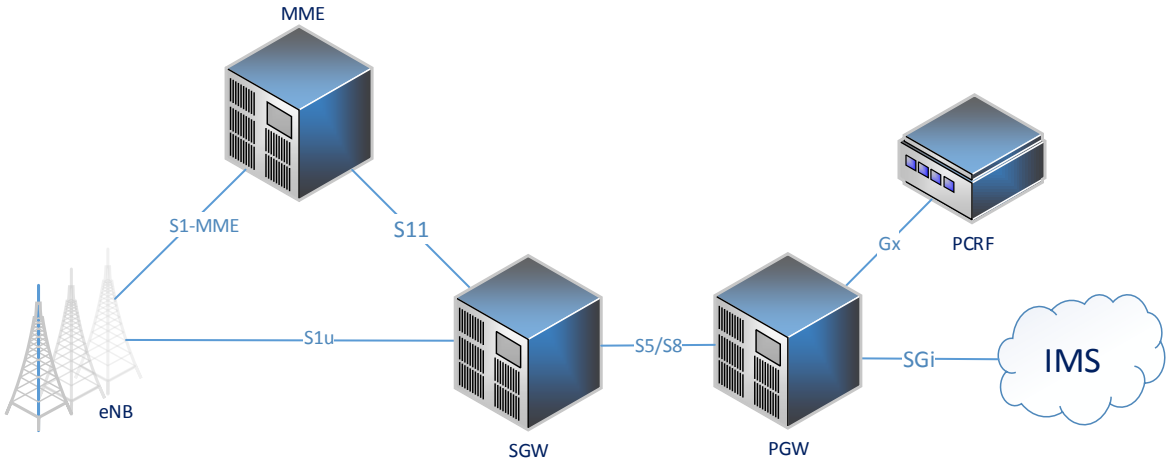

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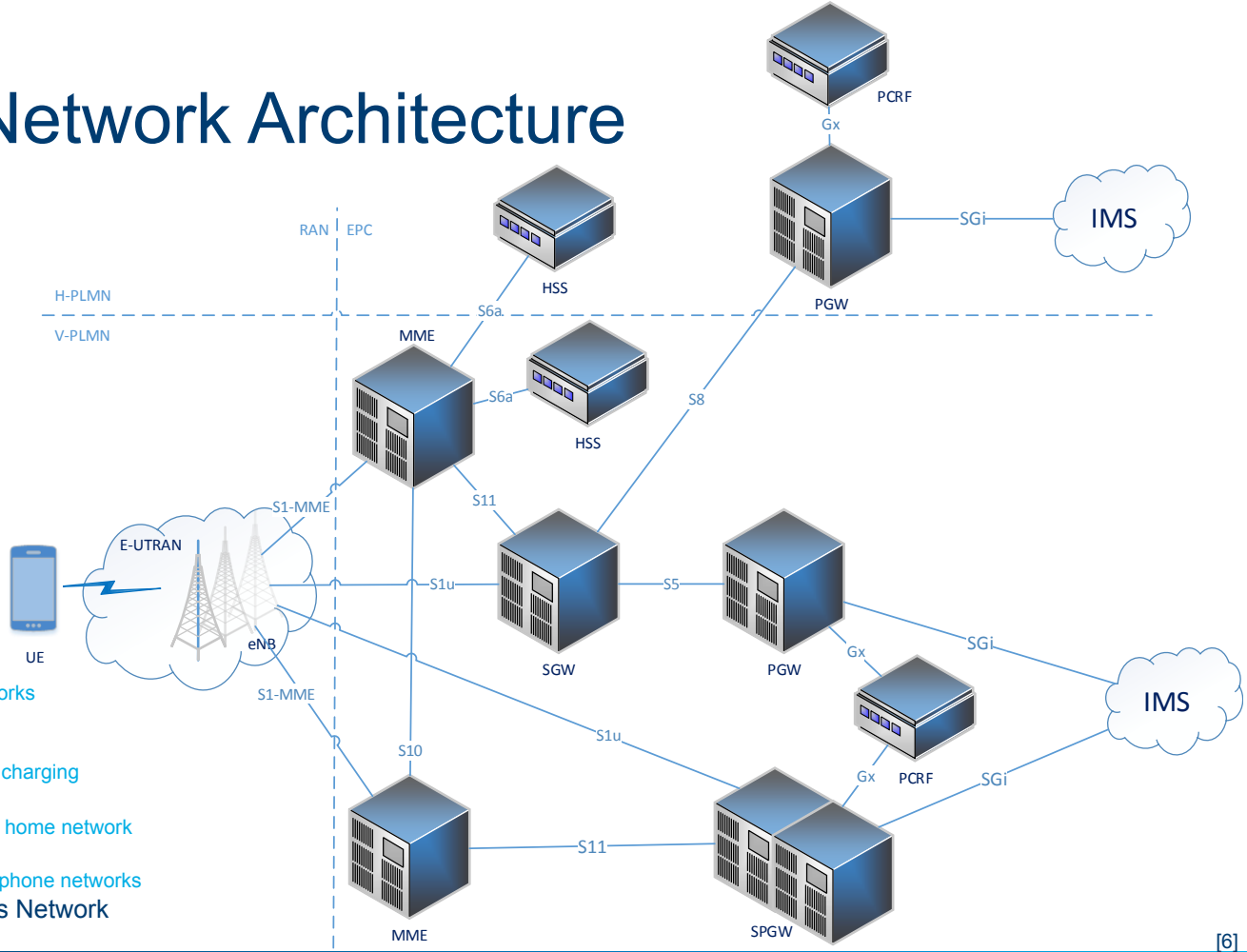

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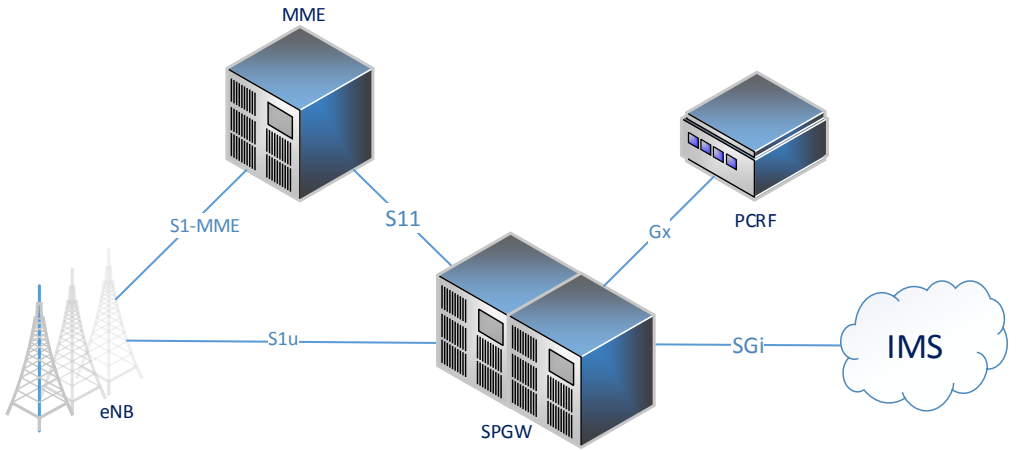
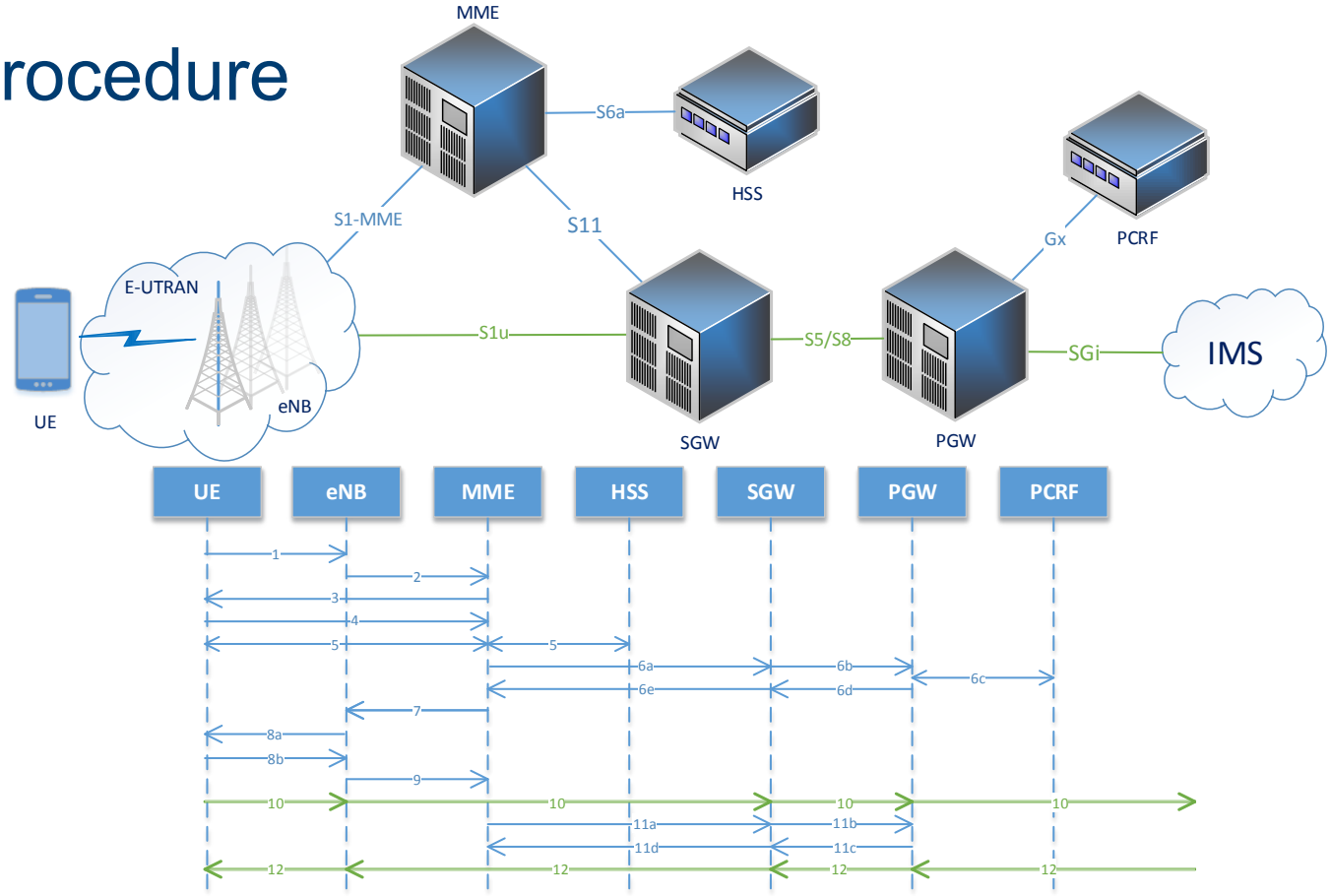


[6]

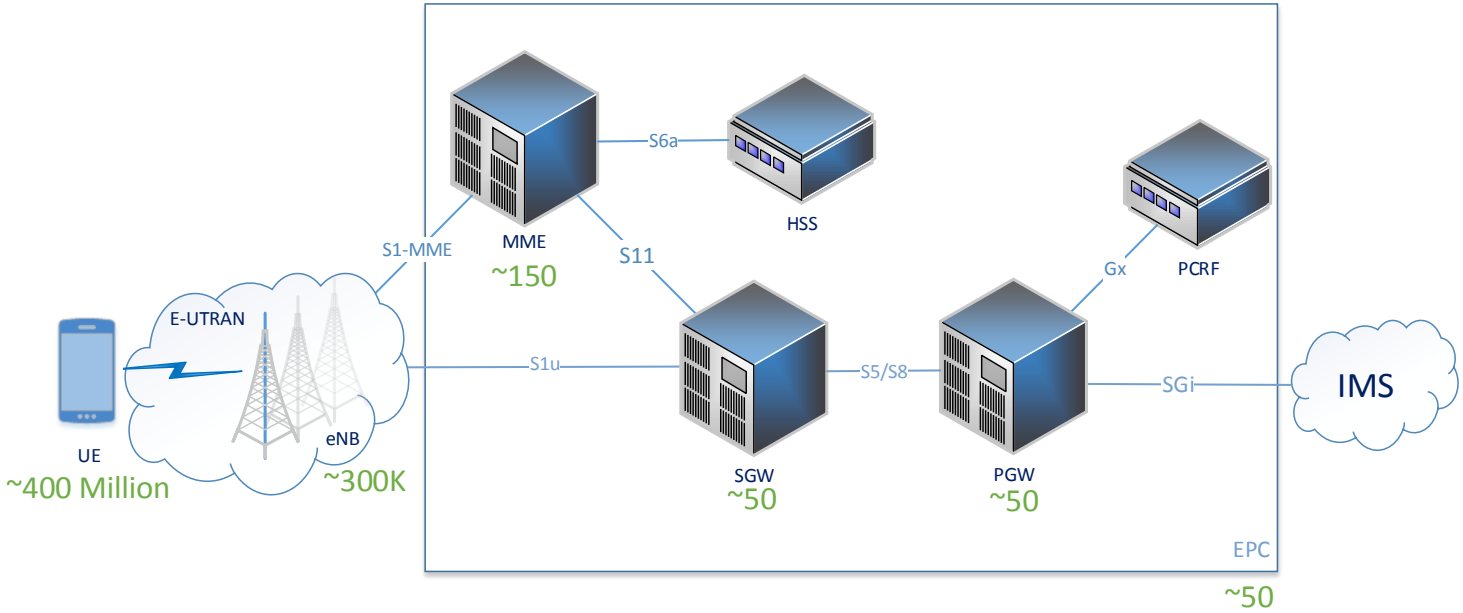
Connection Procedure



[6]

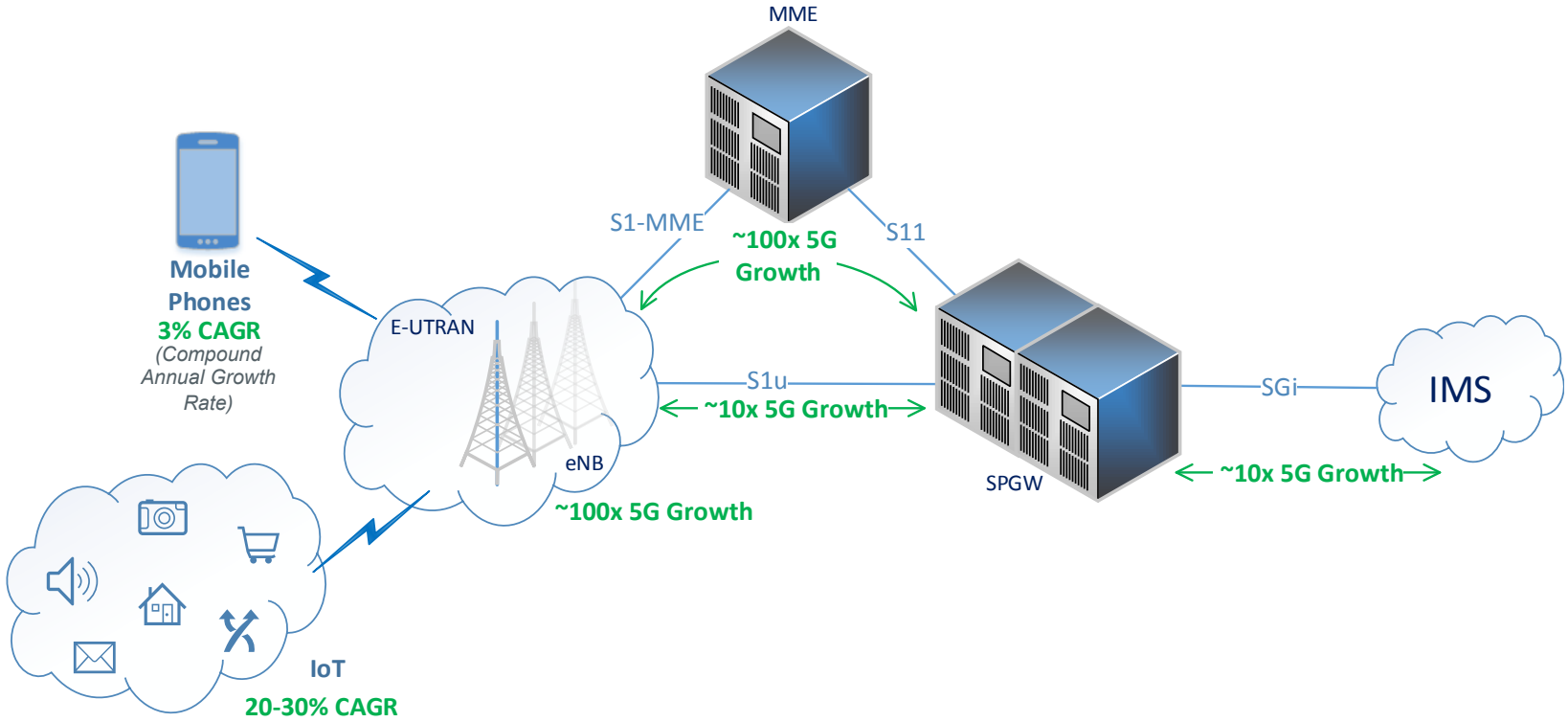
Current Network Deployment & Dimensioning

North America Market



[1,2,3]

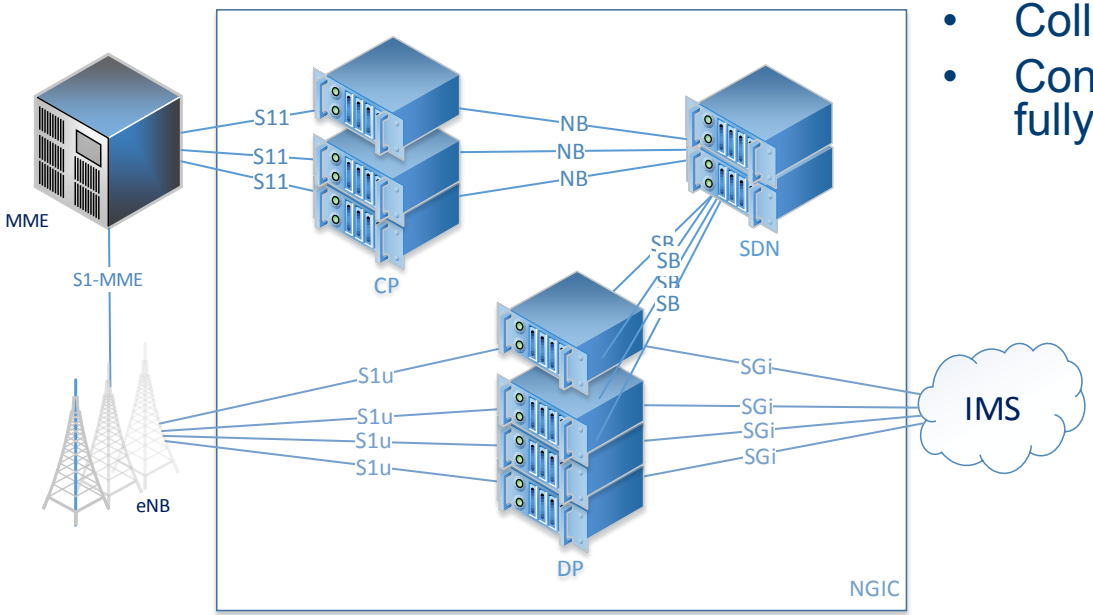
Projected Network Load



[1,3,4,5]

NGIC: Next Generation Infrastructure Core

https://gerrit.opencord.org/#/q/project:ngic



- SDN-based architecture
- Independent control or data scaling
- Collapsed functionalities
- Control Plane (CP), Data Plane (DP) fully virtualized

Features Include:

- GTPv2C Support on S11
- GTP-U Encap/Decap
- CDR: Charge Data Record
- ADC: Application Detection & Control
- Child Protection
- PCC: Policy & Charging Control
- IoT Support: with DDN (Downlink Data Notification
- And many more

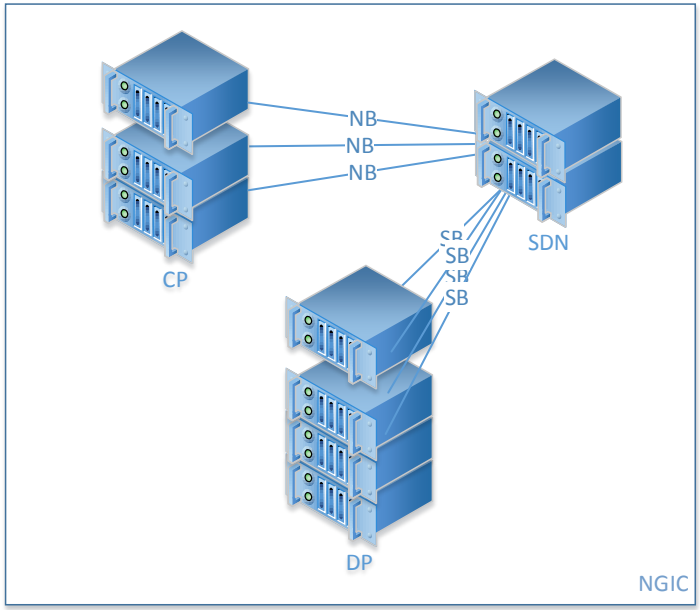
[7,12]

NGIC: Next Generation Infrastructure Core

https://gerrit.opencord.org/#/q/project:ngic

SDN Controller:

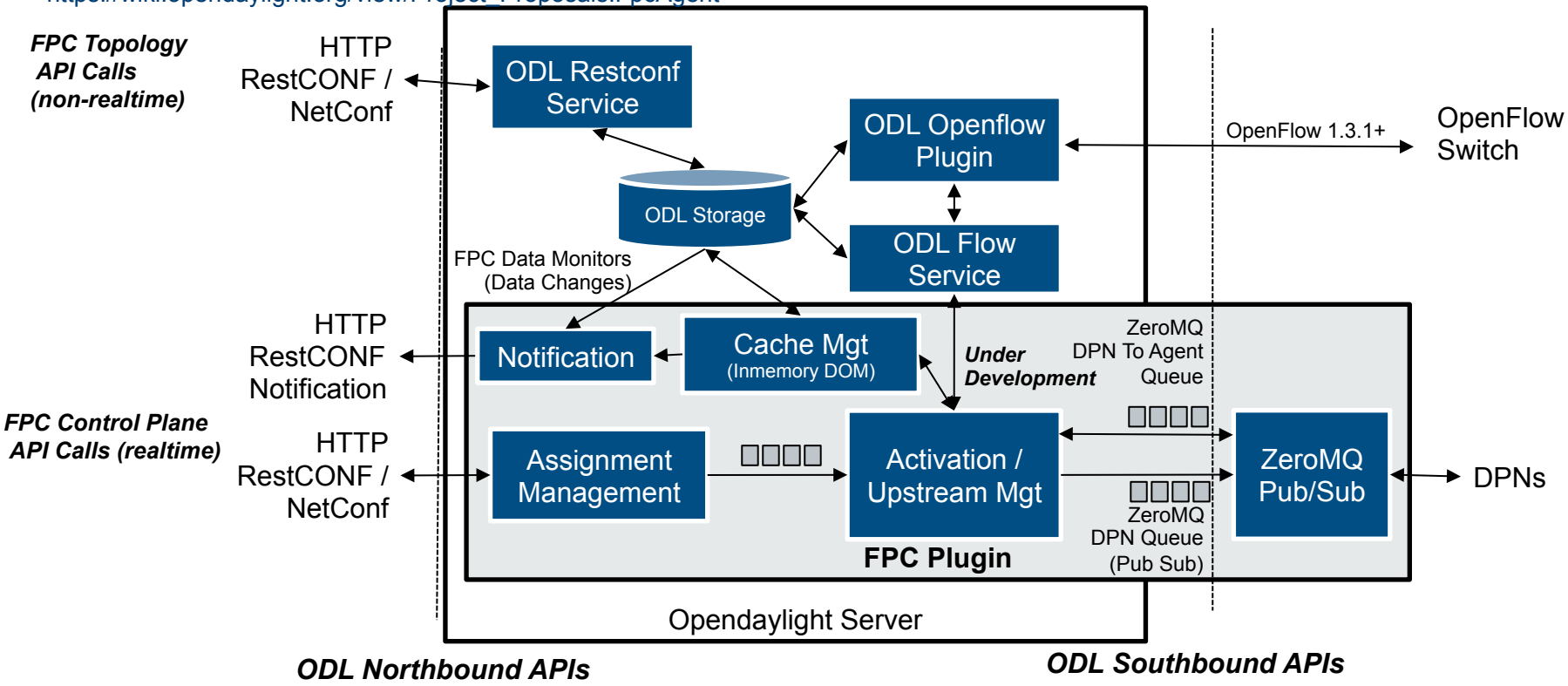
- Implemented as an FPC Agent
  - FPC: Forwarding Policy Configuration
  - Current IETF Draft
- Implemented as OpenDaylight Plugin
  - https://github.com/opendaylight/fpc
- Performs discovery of Clients (Control Planes) and DPNs (Data Plane Nodes)



[13]

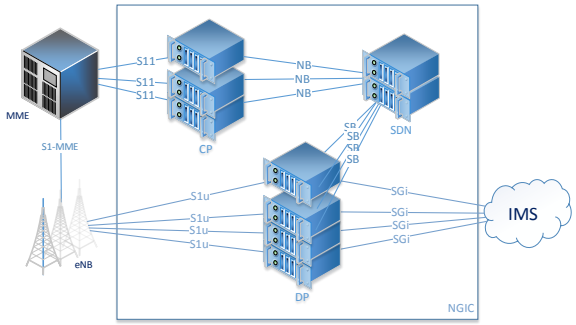
FPC Agent in OpenDaylight – Sprint

https://wiki.opendaylight.org/view/Project_Proposals:FpcAgent

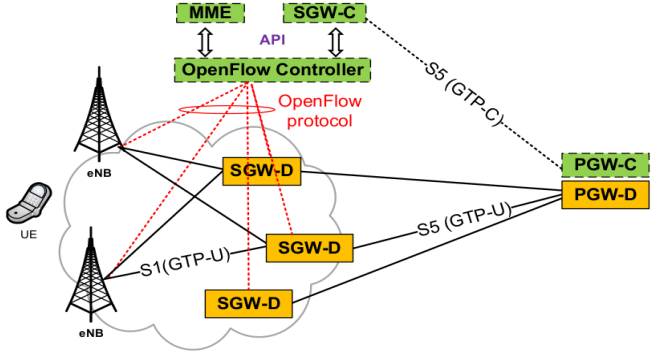


[19]

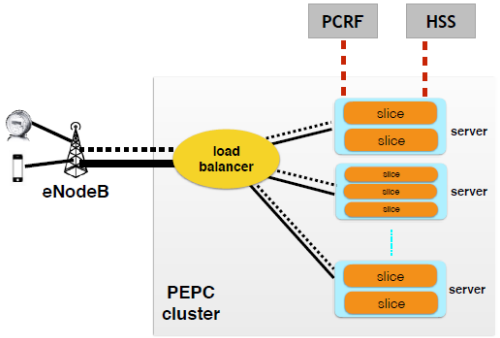
Existing EPC SDN Architectures



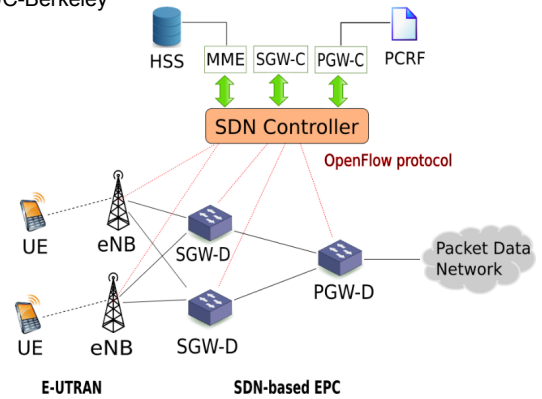
NGIC



New Control Plane in 3GPP LTE/EPC Architecture for On-Demand Connectivity Service IEEE CloudNet 2013, Orange Labs



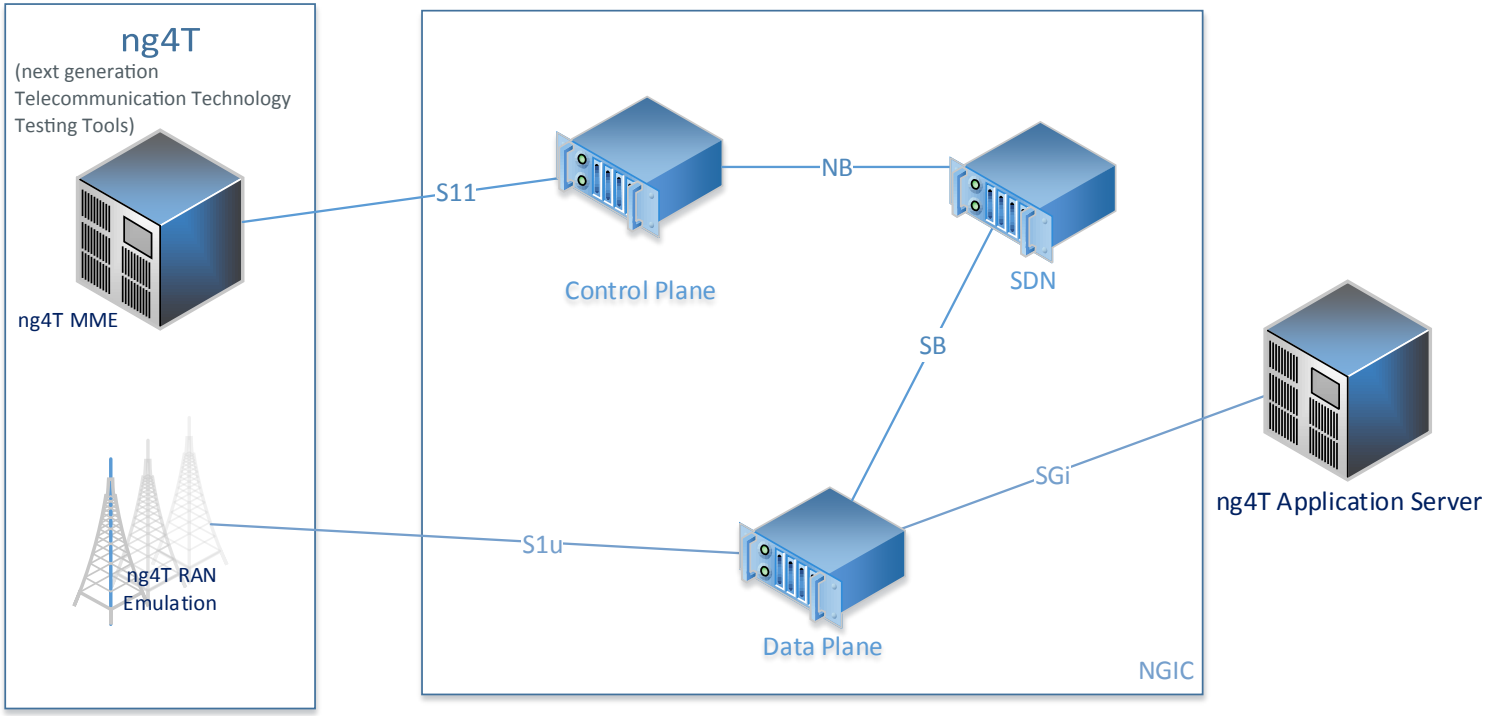
A High Performance Packet Core for Next Generation Cellular Networks
SIGCOMM '17 , UC-Berkeley



A Comparison of SDN and NFV for Re-designing the LTE Packet Core IEEE NFV/SDN 2016, IIT Bombay

[16,17,18, 20]

Demo / Test Setup



[14]

Presented by Sprint at NFV World Congress May 2017

Linear Scaling Characteristics

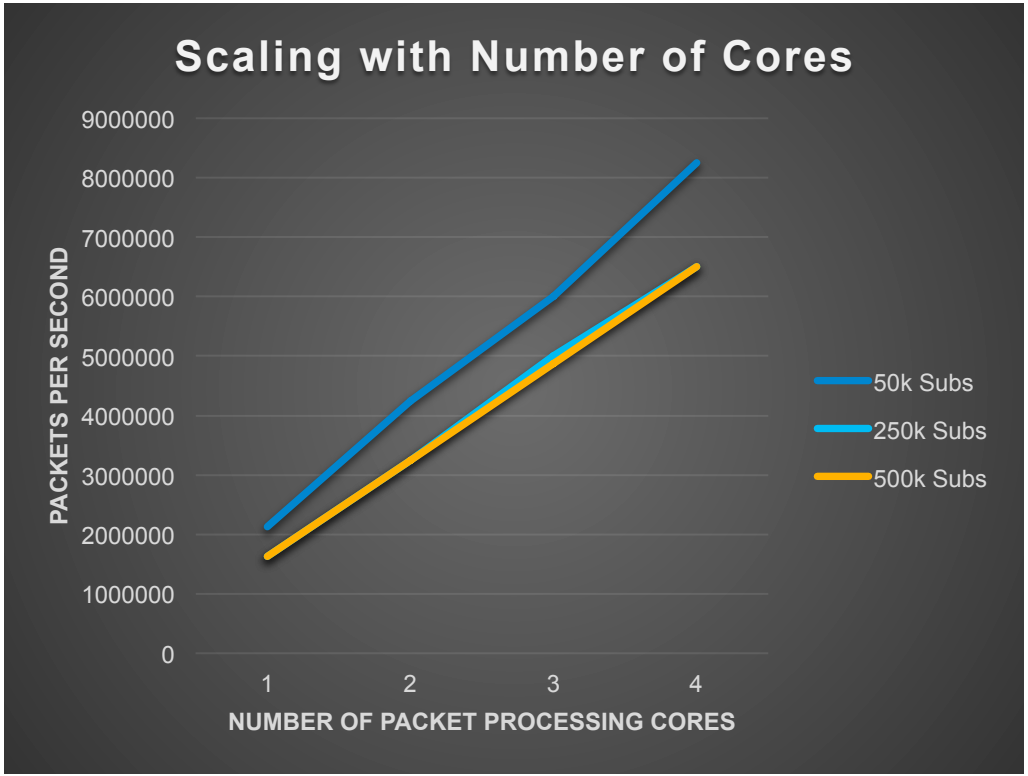
All packet processing cores implement all network functions (PGW, SGW, etc)

- 1 packet processing core
  - 2.125 Million pps (50k subs)
  - 1.625 Million pps (500k subs)
- 4 packet processing cores
  - 8.2 Million pps (50k subs)
  - 6.5 Million pps (500k subs)

Additional (overhead) cores for Data Plane Node

- Rx Core
- Tx Core
- Load-balancing Core
- Master Core
- Statistics Core

Packet processing cores are in addition to the overhead cores



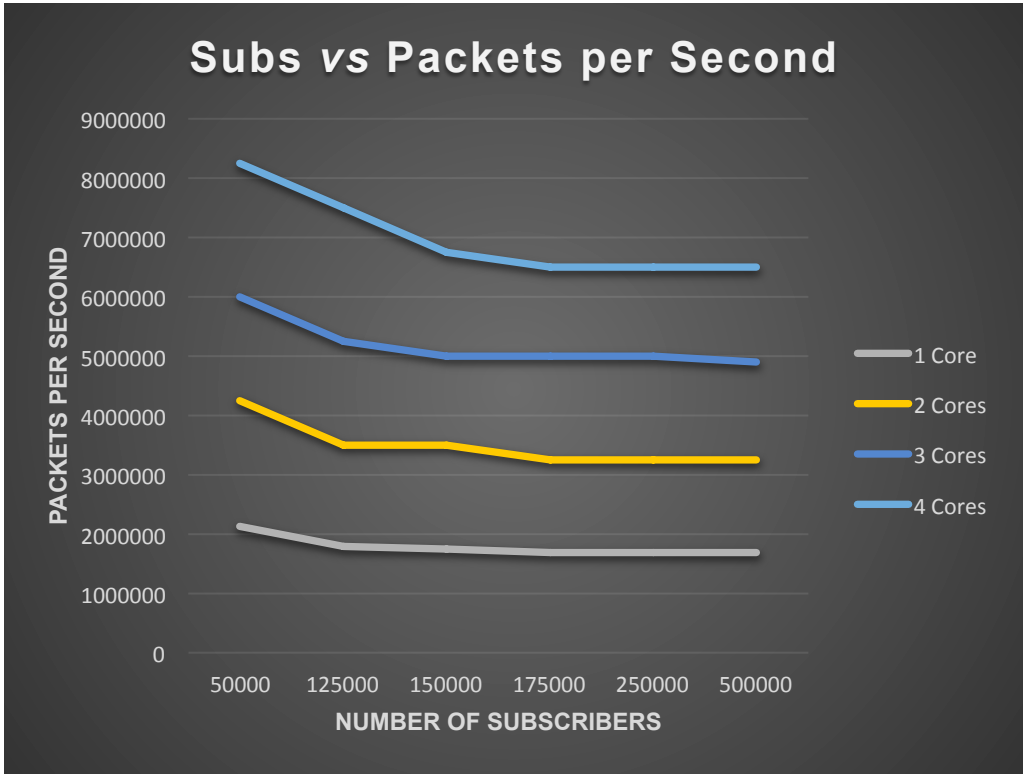
[8,15]

Presented by Sprint at NFV World Congress May 2017

Impact of Subscriber Load

- Increasing subscriber load (number of subs) reduces pps numbers from 50k-175k subs
- Minimal to no impact to pps after 200k subs

- https://www.layer123.com/nfv-webcast-mle123-live/



[8,15]


cp
root@ilepc6:/home/jacooper/ngic/cp#
dp
root@ilepc6:/home/jacooper/ngic/dp#
forwarder_subscriber
root@ilepc6:/home/jacooper/scripts#
topology
root@ilepc6:/home/jacooper/scripts#
forwarder_device
root@ilepc6:/home/jacooper/scripts#
ranc
lte1@ranc:~/nfv-ran-sprint/test$
karaf
root@ilepc6:/home/jacooper/scripts#

Press http://newsroom.sprint.com/sprint-launches-c3po-open-source-nfvsdnbased-mobile-core-reference-solution.htm

Sprint Launches C3PO – Open Source NFV/SDN–Based Mobile Core Reference Solution

Streamlined, high-performance data plane significantly improves network core performance

SAN JOSE, Calif. (BUSINESS WIRE), May 15, 2017 - Sprint (NYSE: S) today announced the availability of C3PO (Clean CUPS Core for Packet Optimization – CUPS: Control & User Plane Separation), an open source NFV/SDN-based mobile core reference solution designed to significantly improve performance of the network core by providing a clean, streamlined, high-performance data plane for the packet core.

“C3PO revolutionizes the network core and it’s part of our expanded toolbox of solutions to meet the coming wave of data in the years ahead,” said Günther Ottendorfer, Chief Operating Officer – Technology, Sprint. “C3PO is an important part of our NFV and SDN initiative, enabling Sprint to adapt more quickly to market demands and scale new services more efficiently and cost-effectively.”

C3PO uses standard high-volume server hardware and streamlines mobile core architecture by collapsing multiple components into as few network nodes as possible. In lab tests conducted on Dell EMC DSS 9000 rack scale infrastructure with compute sleds running dual socket 14 core Intel® Xeon® processors E5-2680 v4, Sprint achieved 1.63 Mpps (million packets per second) throughput. This C3PO configuration demonstrated high efficiency by utilizing as few as seven processor cores - with one packet processing core and six processor cores supporting other tasks such as Control Plane, statistics, load balancer, operating system and other operations, for 500,000 subscribers using a typical Sprint traffic model. A similar C3PO configuration achieved 2.2 Mpps with a similar traffic model for 50,000 subscribers.

[8]

Press http://newsroom.sprint.com/sprint-launches-c3po-open-source-nfvsdnbased-mobile-core-reference-solution.htm

Sprint and Intel Labs Collaboration

The availability of the solution is the result of four years of collaboration between Intel Labs and Sprint on a joint research effort to develop optimal DPDK-based data plane nodes and disaggregated evolved packet core architectures, as well as a platform for further 5G core infrastructure research.

“C3PO makes traditional mobility architectures and software designs more streamlined, efficient and scalable,” said Dr. Ron Marquardt, Vice President of Technology at Sprint. “By combining Sprint’s real-world operator knowledge with Intel’s research on optimizing software for standard high-volume servers, we’ve developed a single solution that provides seven functions previously located within separate physical elements.”

C3PO addresses bottlenecks in mobile core packet performance by separating and independently scaling the data plane and control plane. The C3PO architecture collapses multiple evolved packet core and SGi LAN elements in a single data plane instance. A serving gateway, packet gateway, deep packet inspection, child protection, carrier grade NAT, static firewall, and service function chaining, or any combination of these functions, can be collapsed into one data plane instance.

C3PO is designed to be used by global operators and other third-parties as a reference for commercial applications. Intel Labs technologists built the next generation core control plane and data plane virtualized EPC applications, and Sprint developed the SDN controller enhancements. The EPC application code from Intel is available via the CORD project in ON.Lab, and the SDN plug-ins from Sprint are available via OpenDaylight.

For more information, please visit:

https://builders.intel.com/blog/opening-the-way-to-a-more-efficient-core-network/ [8]

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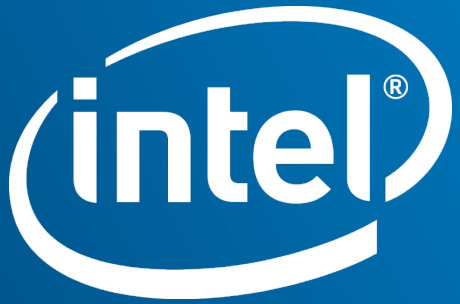
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