DOCTORAL SCHOOL

Stateless Paradigm for Resiliency in Beyond 5G Networks

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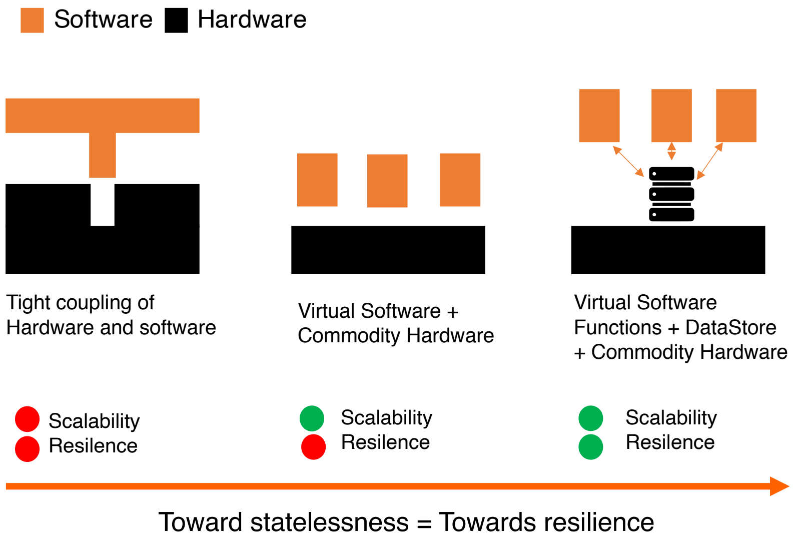
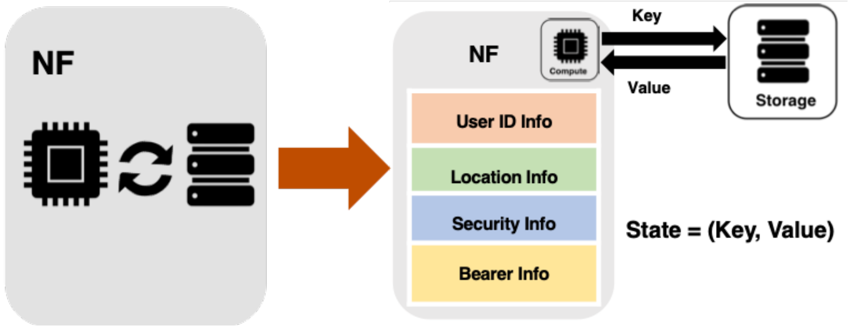
Outline

- Introduction
- State-of-Art
- Network entity resiliency
- Prerequisites for Stateless Implementation – 3Ws
  - What to Store ?
  - When to Store ?
  - Where to Store ?
- Network traffic analysis
- Stateless user-plane
- Conclusion

Introduction

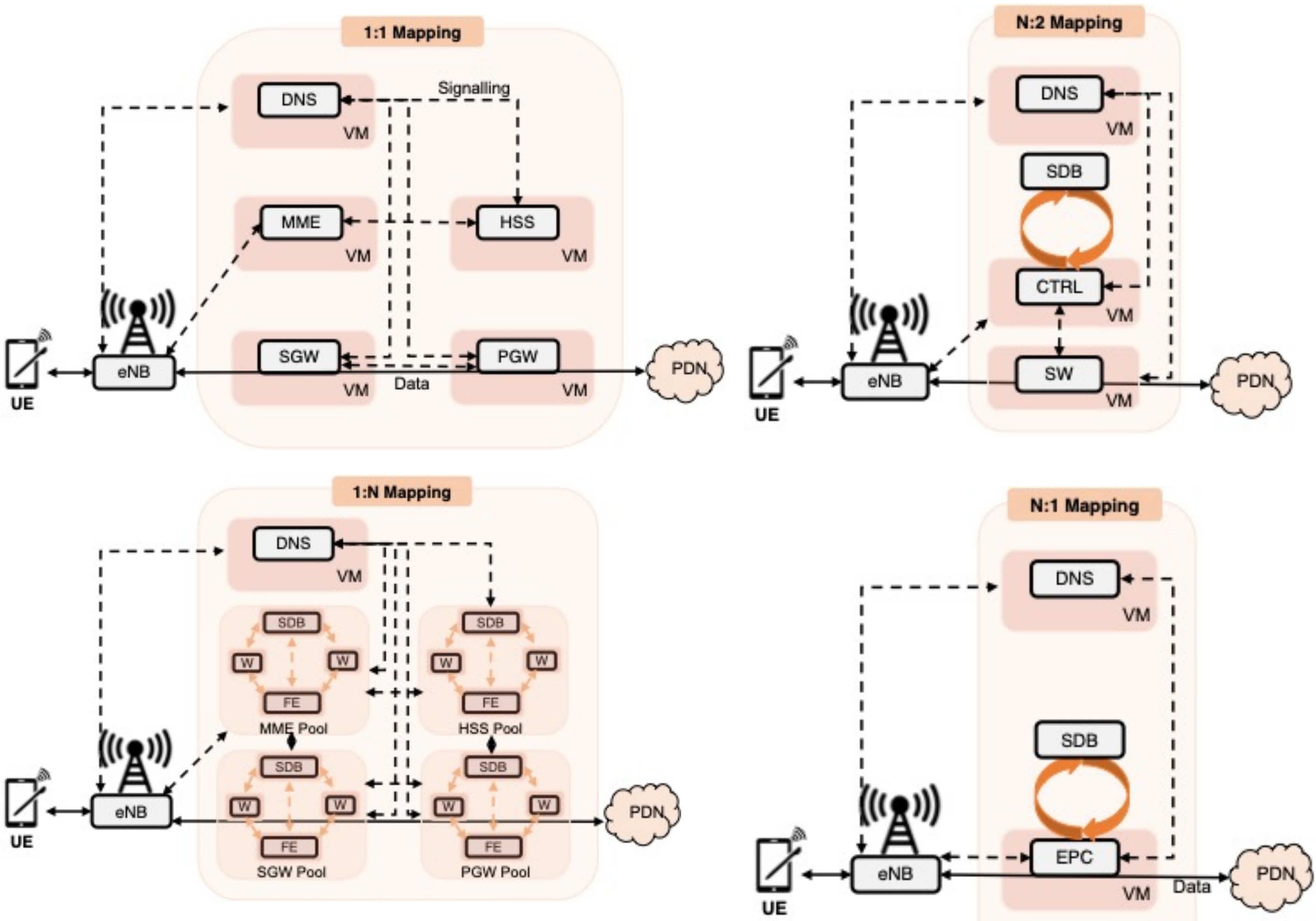
- We moved from hardware centric to software centric and now **data centric architectures**.
- 5G use-cases and its varied traffic distribution have stringent latency, data rate, bandwidth than 4G LTE.
- Availability, Reliability and Scalability properties are expected of 5GS to ensure the above requirements of KPIs.
- Virtualization has helped to achieve scalability
- Stateless Network Functions helps in achieving resiliency and hence reliability.





State of Art : Architectures

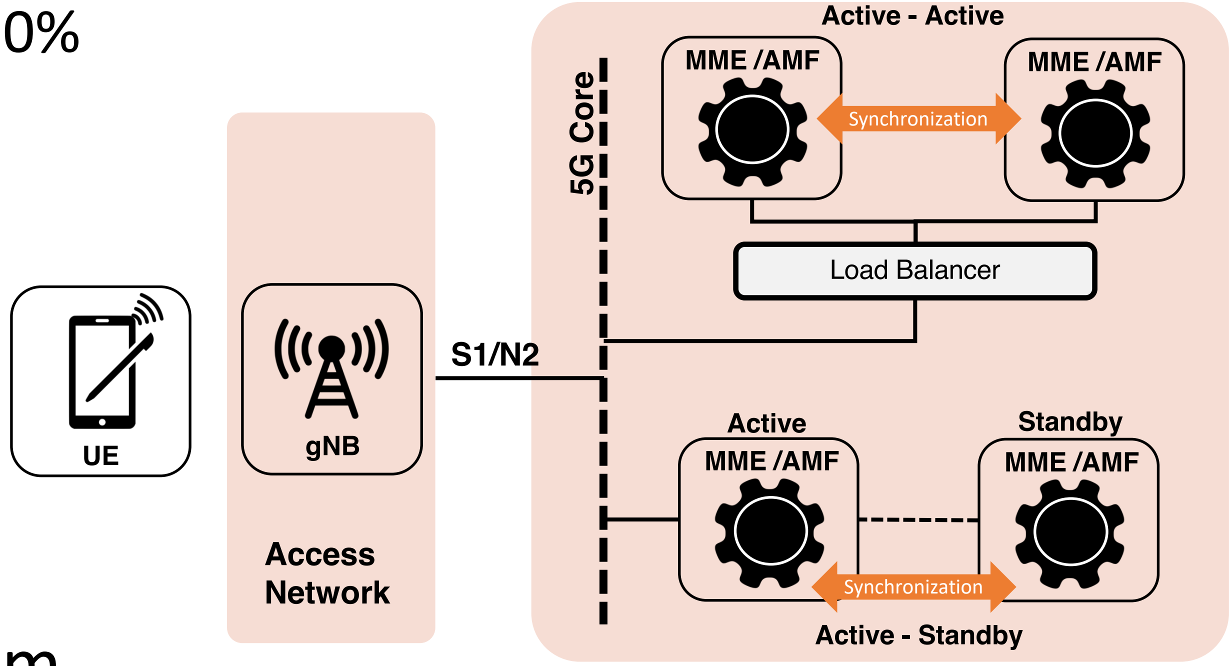
- Various architecture options were proposed to provide resiliency and lower latency.
- Network function vs Instances
  - 1:1 Mapping
  - 1:N Mapping
  - N:2 Mapping
  - N:1 Mapping
- In our experimentation, we consider 1:1 and 1:N



T. Taleb *et al.*, "EASE: EPC as a service to ease mobile core network deployment over cloud," in *IEEE Network*, vol. 29, no. 2, pp. 78-88, March-April 2015.

Today’s Resiliency Solutions

- Active – Active :
  - Both systems are active
  - Need high degree of synchronization (30% CPU resources)
  - Expensive
- Active – Standby:
  - One stand-by system
  - Expensive
- Both options take few seconds to minutes to resume services apart from being expensive



Stateless Concept – 3Ws

- What to Store ?
  - UE information exchanged between network entities like IMSI, TA etc.
- State storage template design can be,
  - One State
  - Multiple States

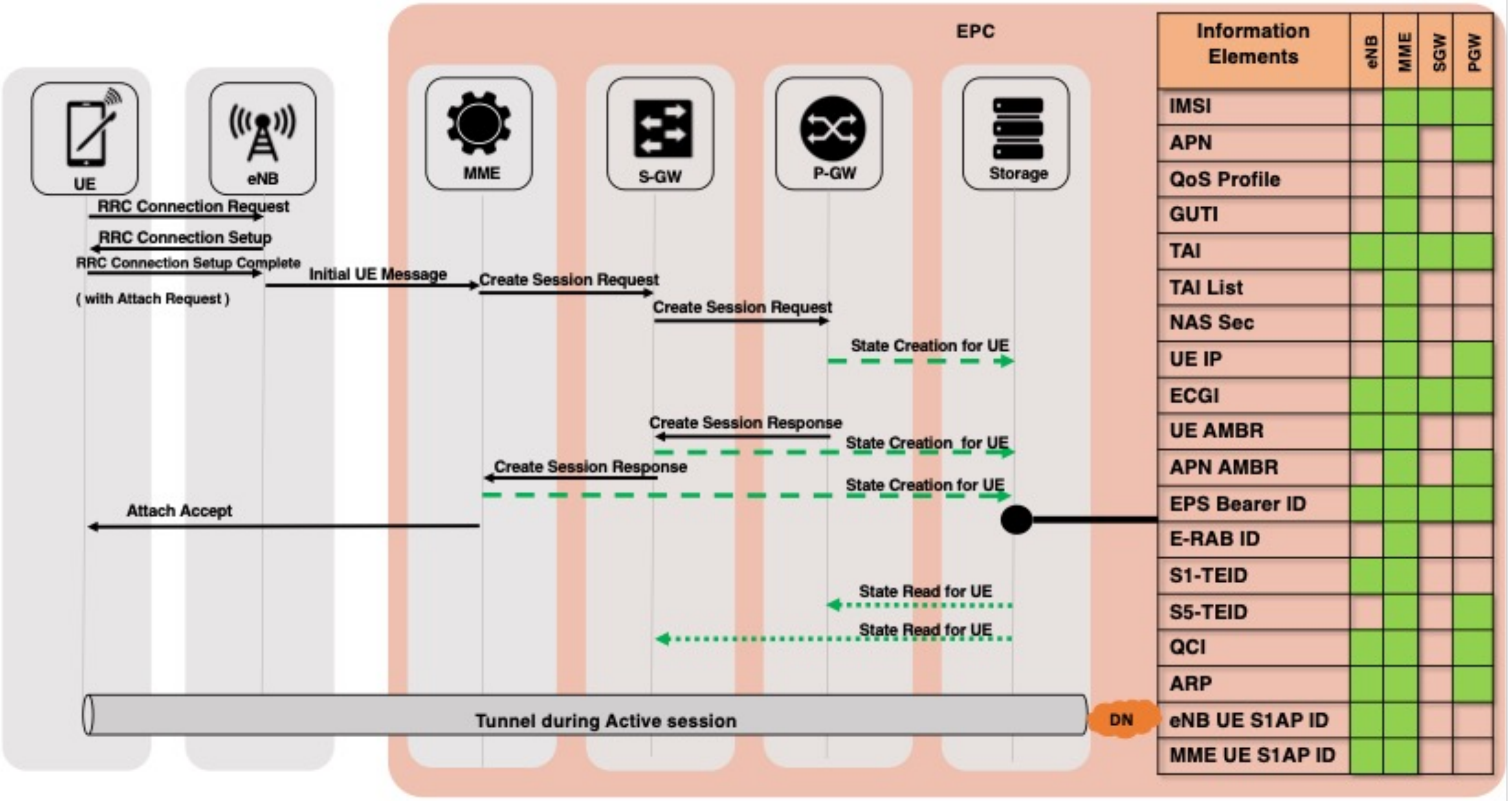
GUTI	UE context

GUTI, Context Type	User Identification
GUTI, Context Type	Location Info
GUTI, Context Type	Security Info
GUTI, Context Type	Bearer Context

UE	eNB	MME	S-GW	P-GW
IMSI GUTI UE IP address C-RNTI - -	- - - C-RNTI eNB S1AP UE ID MME S1AP UE ID	IMSI GUTI UE IP address - eNB S1AP UE ID MME S1AP UE ID	IMSI - - - - -	IMSI - UE IP address - - -
ECGI TAI TAI List -	ECGI TAI - -	ECGI TAI TAI List -	ECGI TAI - -	ECGI TAI - -
LTE K NAS Security Info AS Security Info	- - AS Security Info	- NAS Security Info -	- - -	- - -
APN APN in Use EPS Bearer ID DRB ID - - - QCI - - APN-AMBR (UL) TFT (UL) -	- - EPS Bearer ID DRB ID E-RAB ID S1 TEID (UL/DL) - QCI ARP UE-AMBR (UL/DL) - - -	Default APN APN in Use EPS Bearer ID - E-RAB ID S1 TEID (UL/DL) S5 TEID (UL/DL) QCI ARP UE-AMBR (UL/DL) APN-AMBR (UL/DL) - Subscribed Profile (Subscribed QCI, ARP, UE-AMBR, APN-AMBR)	- APN in Use EPS Bearer ID - - S1 TEID (UL/DL) S5 TEID (UL/DL) QCI ARP - - - -	- APN in Use EPS Bearer ID - - - S5 TEID (UL/DL) QCI ARP - APN-AMBR (UL/DL) TFT (UL/DL) -

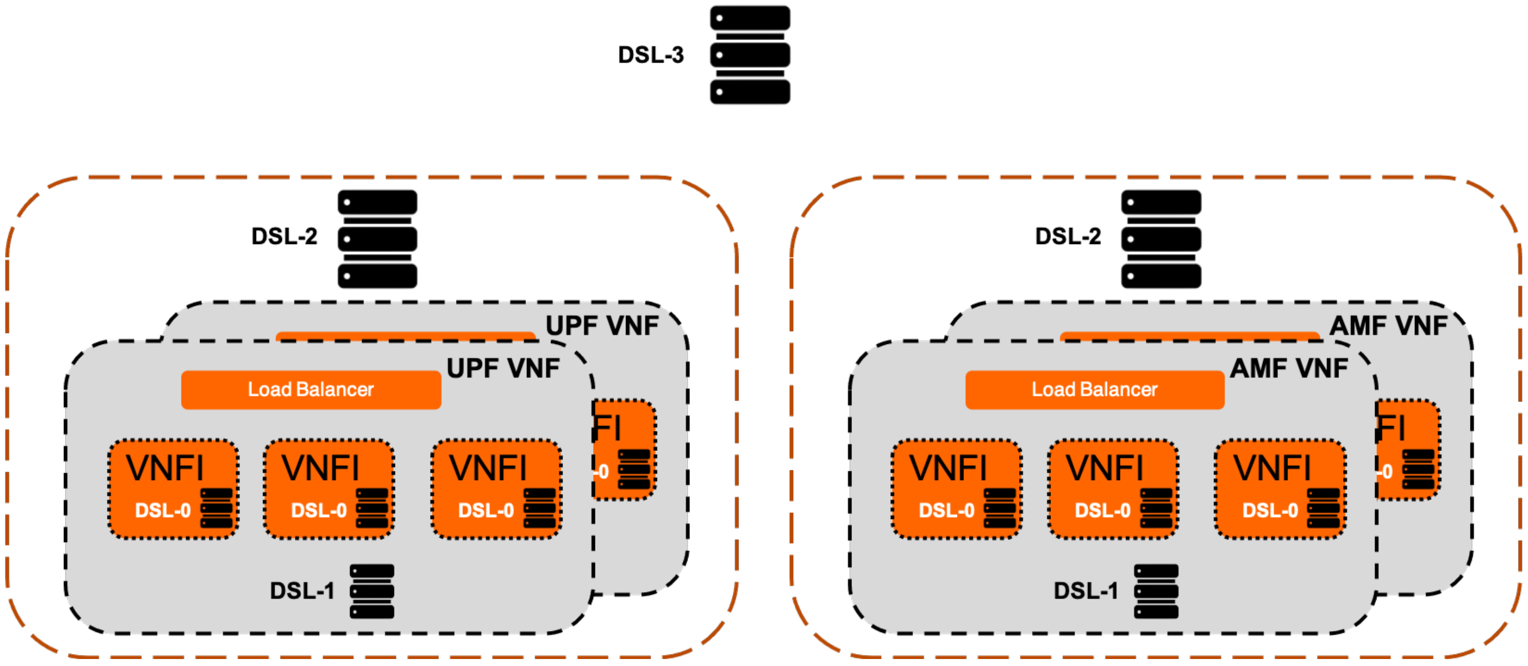
Stateless Concept – 3Ws

- When to Store ?
  - Message-level
  - Transaction-level
  - Procedure-level
- Challenges
  - Number of DB trasactions
  - Bottle neck issues
  - Consistency issues



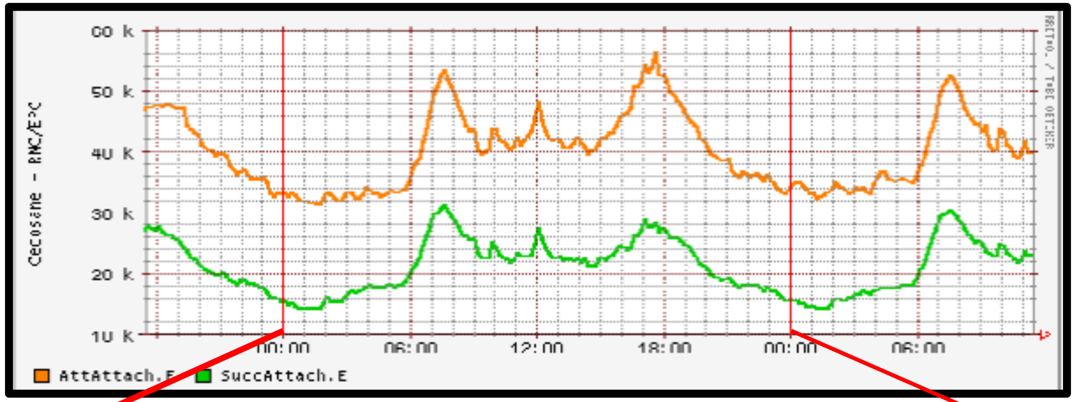
Stateless Concept – 3Ws

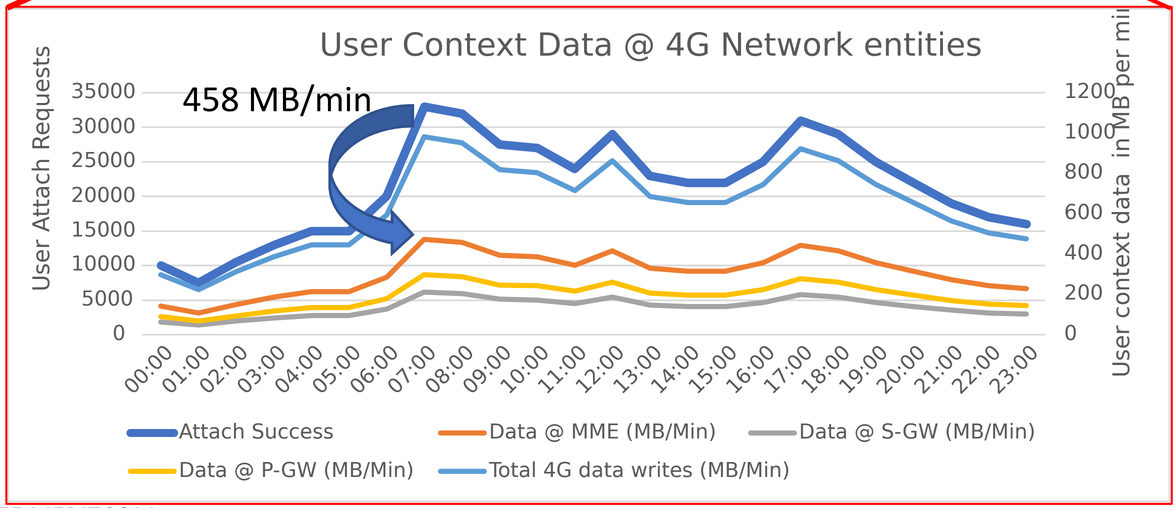
- Where to Store ?
  - Hierachical storage is benificial
    - We define Data Storage Levels (DSLs)
  - Central storage
- Challenges ?
  - Strong consistency
  - Network latency
  - Bottle neck issues



Network Traffic Analysis

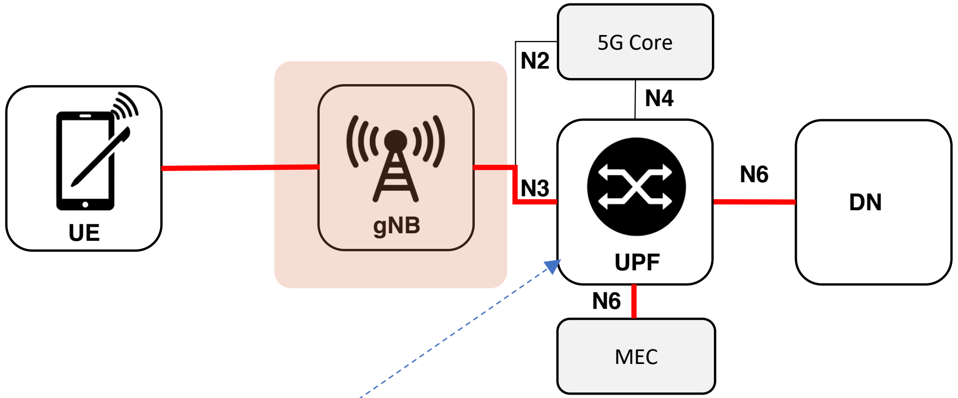
- LTE initial-attach traffic : objective is to understand the traffic at network entities.
  - Volume
    - Number of requests made by UE
    - Number of requests/queries made by NF to datastore
  - Size
    - Bytes of signalling messages
    - Bytes of state to/from datastore
  - Frequency
    - Influenced by both volume and size per unit time
- Only 60% of requests are accepted, 40% requests consume some network entity resources.

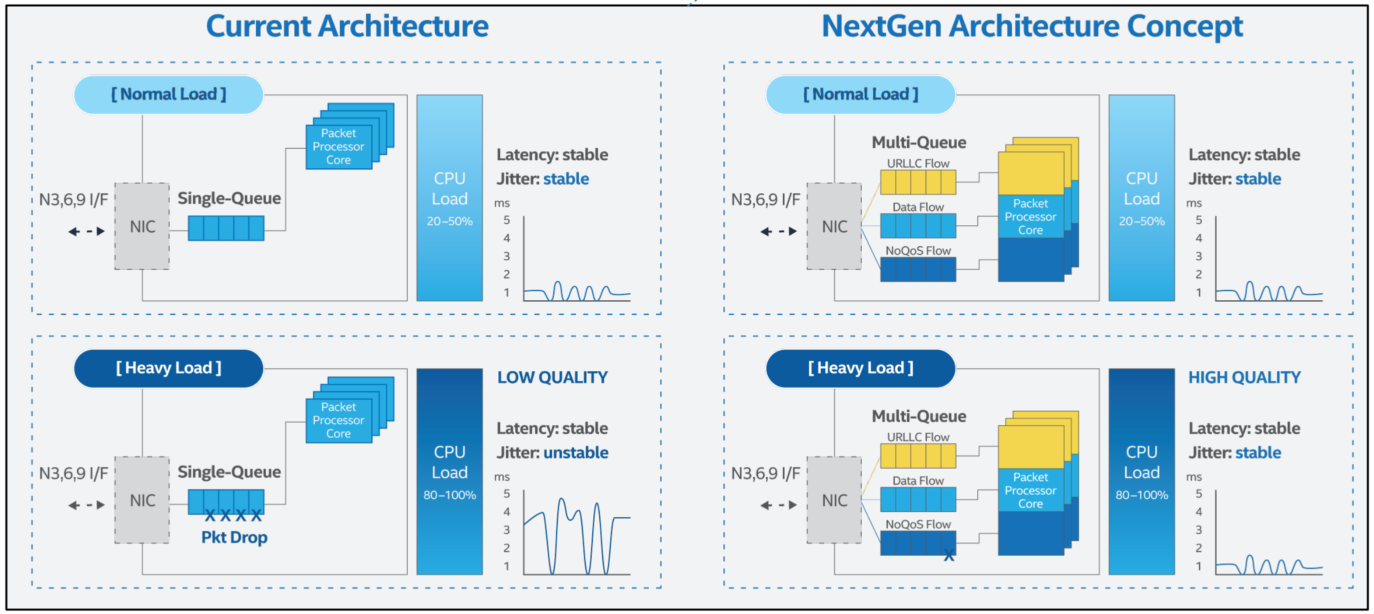




User/Data-Plane Stateless ?

- High throughput is expected of an User-Plane function.
- Next-Generation User-Plane Fuction
  - Data Plane Development Kit (DPDK)
  - Vector Packet Processing (VPP)
- Intel Experiment
  - 50K users
  - 295 packets/sec (per UE)
  - 32 - 40 microseconds PPL

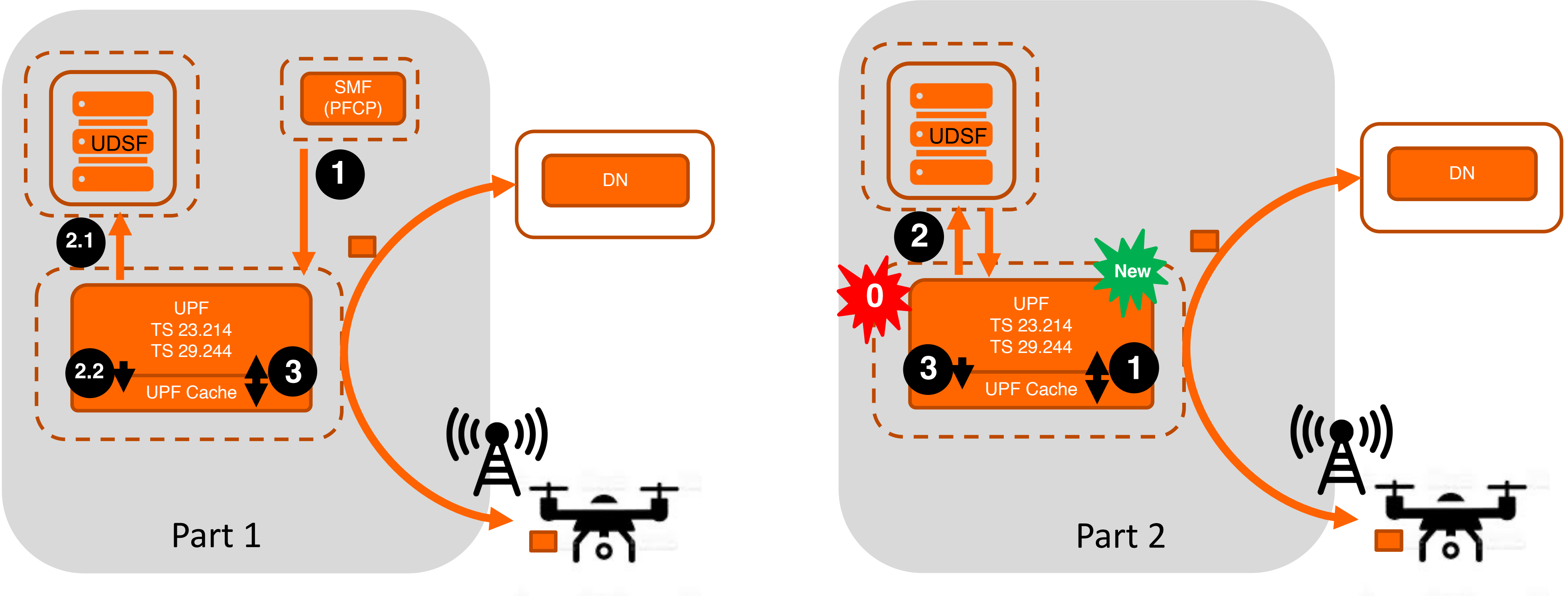




White Paper, Intel and SK Telecom, **Low Latency 5G UPF Using Priority Based 5G Packet Classification**

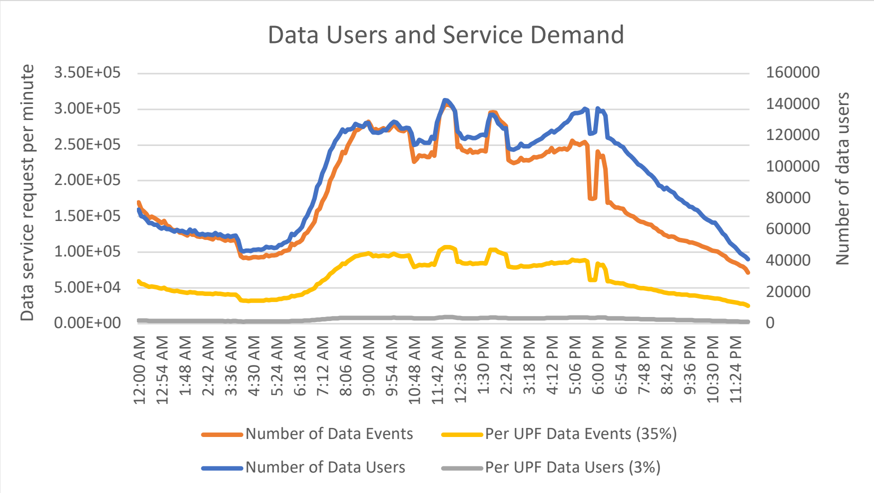
Quasi-Local Stateless Model

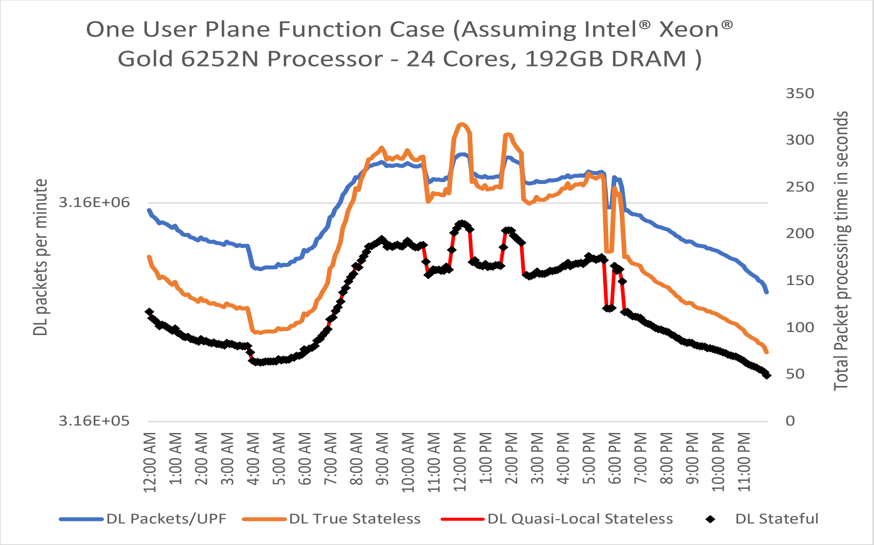
- Part 1 – UPF caches the UE context to external datastore like 3GPP UDSF (TS 29.598).
- Part 2 – Upon failure, a new instance fetches the UE context to process packets and caches it for future purpose.



One User-Plane Function case

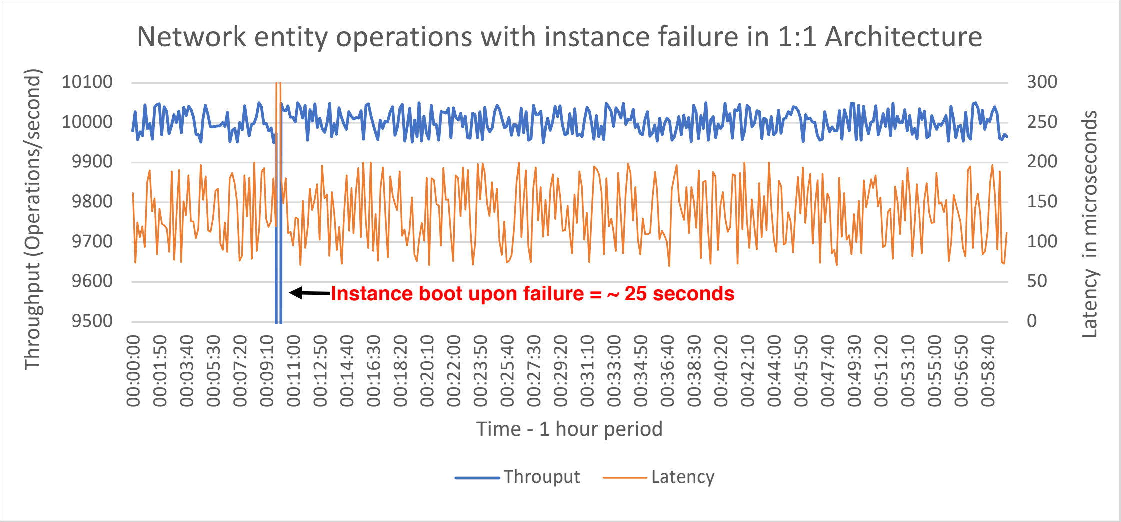
- Traffic following data service request
  - Over a period of 24h
  - Data service request (non voice)
- Assumptions (based on Intel experiment)
  - Number of UPFs = peak users/50K = 3 UPFs
  - Data service requests @ one UPF = ~ 34% of total requests
  - One data request = 295 packets
- Applying Stateless Schemes
  - **True Stateless** – every packet needs context fetch
  - **Quasi-Local Stateless** – first packet of UE needs context fetch
  - **Stateful** – no fetch, context always in local cache.
- **E2E latency is maintained with Stateless UPF**

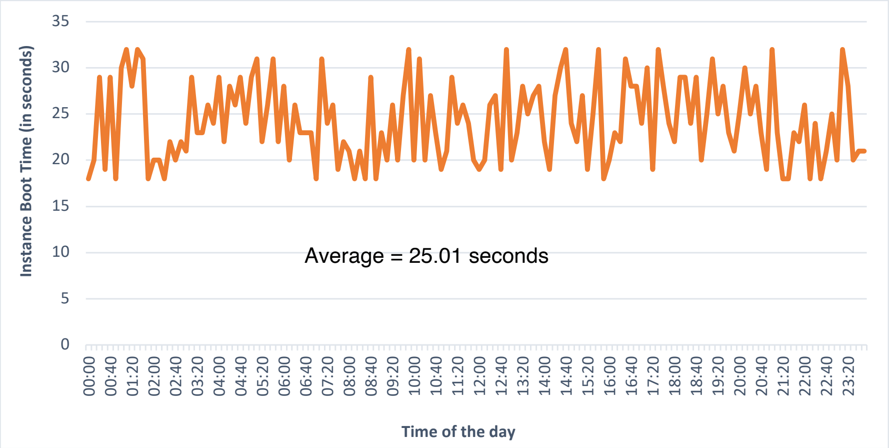




Failure Scenario

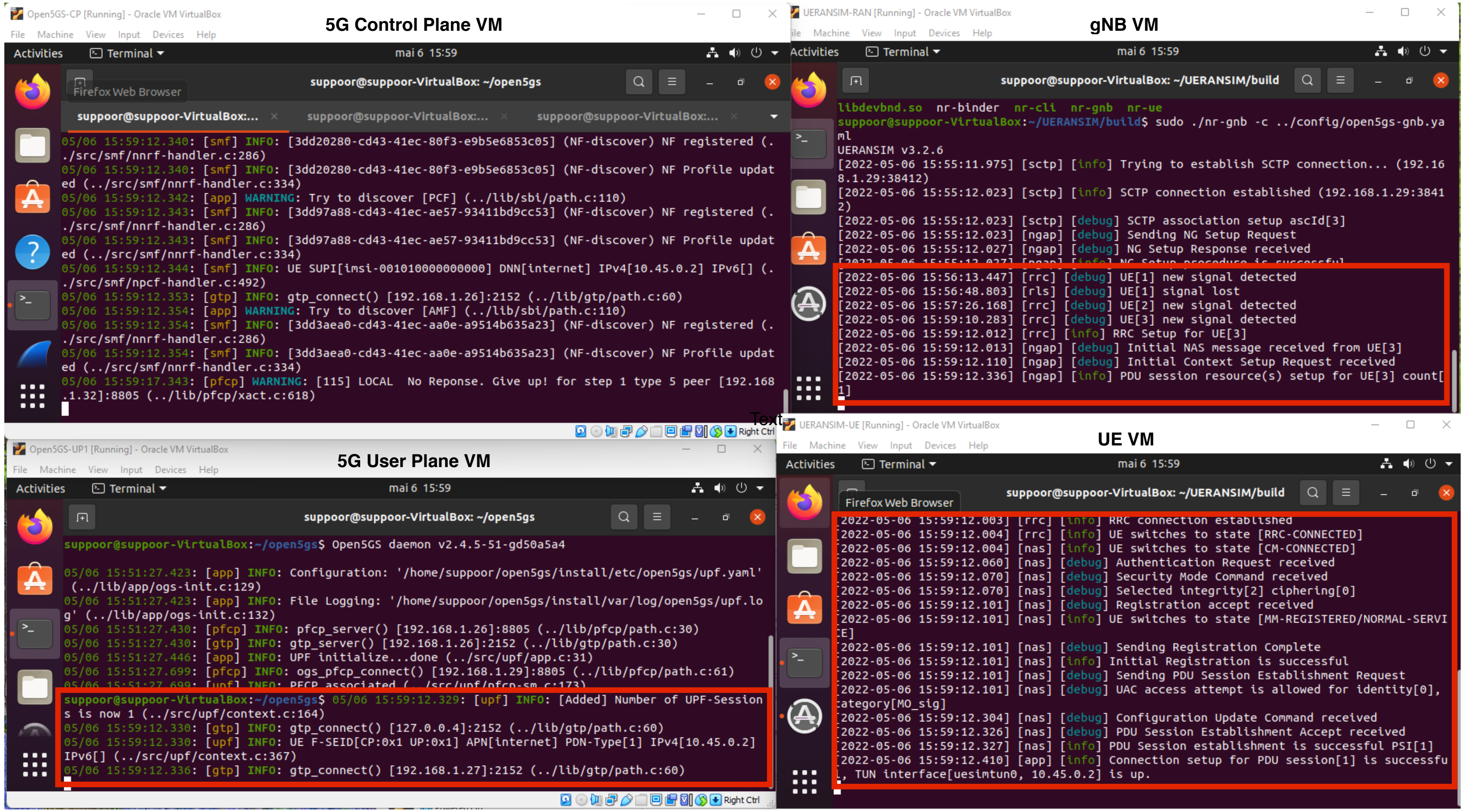
- Failure recovery
  - Non-telecom service with Quasi-Local Scheme
  - Service downtime approximates system unavailability.
- Instance boot time
  - Simulation on Google Cloud Platform
  - Average time of 25 seconds





Future Work

- Use Quasi-Local Stateless in real telecom system.
  - Open 5GS – 5G SA core
  - UERANSIM – UE, eNB
- Challenges
  - Resource with 32+ GB of RAM



Conclusion

- Quasi-Local Model is well suited for User-Plane traffic
  - Packet processing latency is close to current stateful systems.
  - Indeed less expensive than that of dedicated redundant back-up systems.