

## GOALS

Study the effect of OTT encryption VPN on:

- i) throughput (overhead due to encryption),
- ii) UE CPU utilization,
- iii) UE power consumption

Compare different encryption protocols

## CHALLENGES

Lack of real-life data of VPN measurements over 5G

VPNs mostly designed for fixed connections, however, mobile networks have different characteristics

Some popular VPN protocols might not be suitable for mobile use

## DEMO SETUP

**Network:** LTE (B7) and 5G NSA (n78) R15

**Core:** ATHONET, **RAN:** Nokia Airscale Micro

**UE:** Samsung S10 5G

**VPN protocols:**

1. IPSEC/IKEv2
2. WireGuard
3. OpenVPN
4. MS-SSTP (Microsoft Secure Socket Tunneling Protocol)
5. IPSEC/L2TP (IKEv1)

## RESULTS

**Throughput:** additional throughput in the range of 5% - 10% depending on the encryption protocol.

**CPU utilization:** increase around 5% for the specific CPU capabilities of the terminal in use and the specific throughput (10Mbps).

**LTE vs 5G:** 5G is more demanding than LTE in terms of CPU & power consumption.

**WireGuard** protocol seems more lightweight related to the other protocols.

## MORE RESULTS

LTE measurements for 10Mbps UL user traffic

	Idle	no VPN	IPSEC-IKEv2	IPSEC-L2TP	WireGuard	OpenVPN	MS-STP
<b>L2</b>							
PDCP throughput (Mbps)		10,201	11,187	11,554	11,277	10,821	10,703
RLC throughput (Mbps)		10,209	11,208	11,570	11,298	10,844	10,725
MAC throughput (Mbps)		10,727	11,678	11,900	11,954	11,503	11,148
<b>PHY</b>							
PUSCH throughput (UL) (Mbps)		11,782	12,627	12,848	12,882	12,369	11,559
<b>UE</b>							
CPU Usage (%)	8,68	12,95	17,08	15,46	14,63	15,88	18,98
Device battery current (A)	-0,0646	0,0058	0,0992	0,0847	0,0626	0,0896	0,1632

5G measurements for 10Mbps UL user traffic

	Idle	no VPN	IPSEC-IKEv2	IPSEC-L2TP	WireGuard	OpenVPN	MS-STP
<b>L2</b>							
PDCP throughput (Mbps)		10,196	11,162	11,526	11,244	10,804	10,750
RLC throughput (Mbps)		10,263	11,288	11,654	11,377	10,932	10,826
MAC throughput (Mbps)		10,747	11,746	12,082	11,843	11,470	11,163
<b>PHY</b>							
PUSCH throughput (UL) (Mbps)		11,128	11,851	12,258	12,055	11,467	11,165
<b>UE</b>							
CPU Usage (%)	10,77	14,88	20,04	21,61	18,57	19,82	20,99
Device battery current (A)	0,2174	0,2831	0,4106	0,4280	0,3730	0,4686	0,5198

## CONCLUSIONS

Encryption penalty in throughput, CPU utilization and power consumption seems manageable

Additional throughput (5 – 10%) should be factored-in in the radio planning if widespread encryption use

## POST MORTEM

Additional issues to be studied in the future:

- Comparing setup time of various encryption VPNs
- Connection resilience in various conditions: loss of connection, inter-RAT handover, IP change
- Nested VPNs (VPN within a VPN)
- VPN remote management & statistics