Transparent Edge Gateway for Mobile Networks

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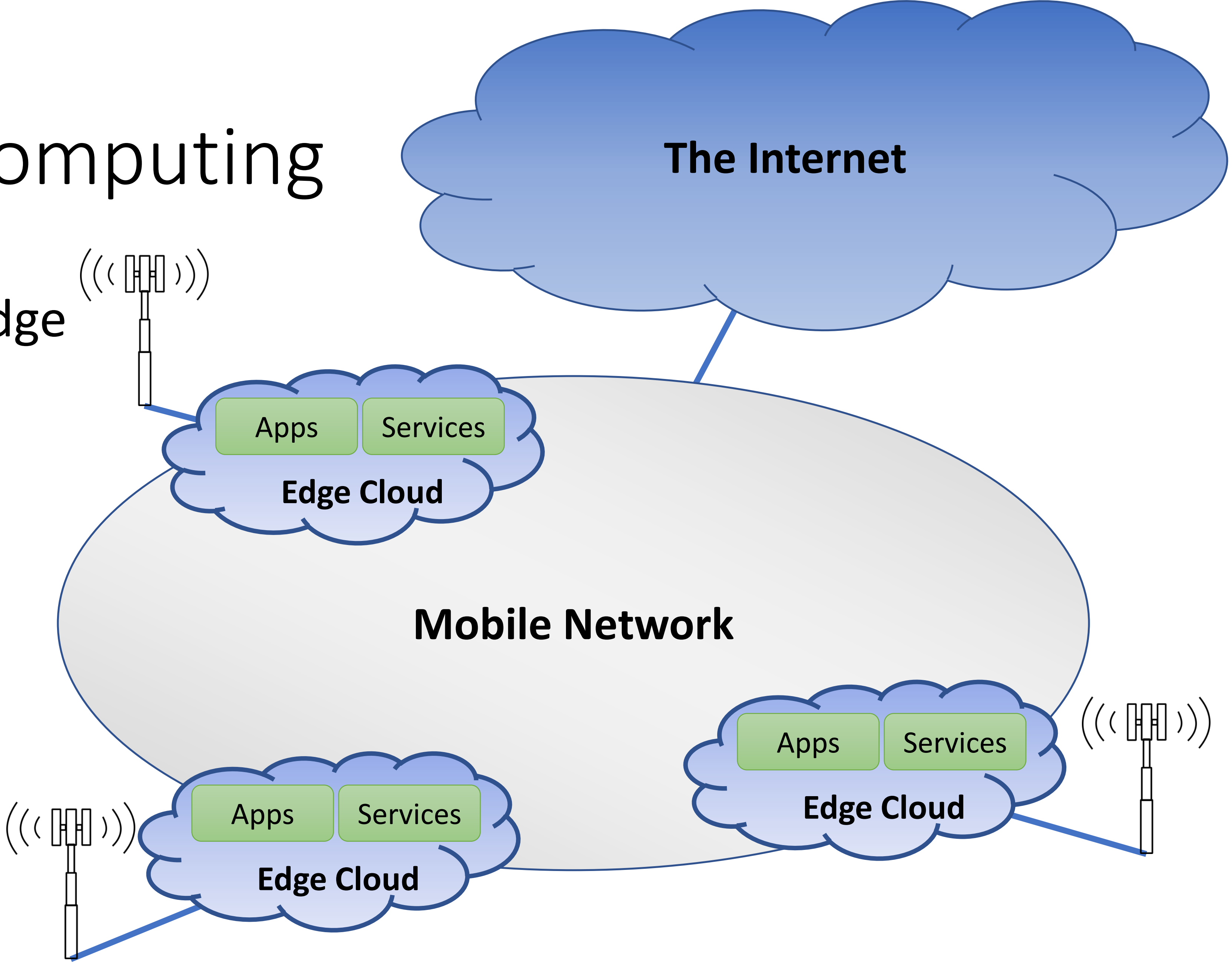
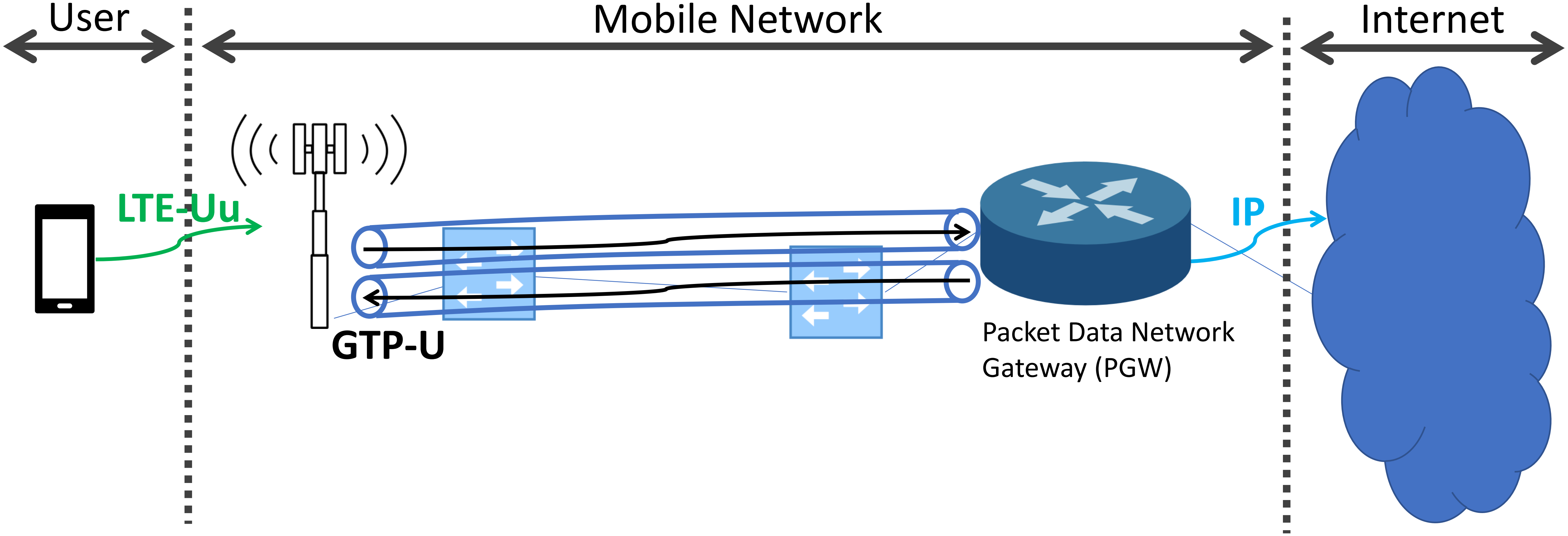
1st P4 European Workshop (P4EU)

Mobile Edge Computing

- Cloud computing at the edge of the mobile network
  - Proximity to users/devices
  - Ultra-low latency
  - High bandwidth
  - Real-time access to radio network information
  - Location awareness

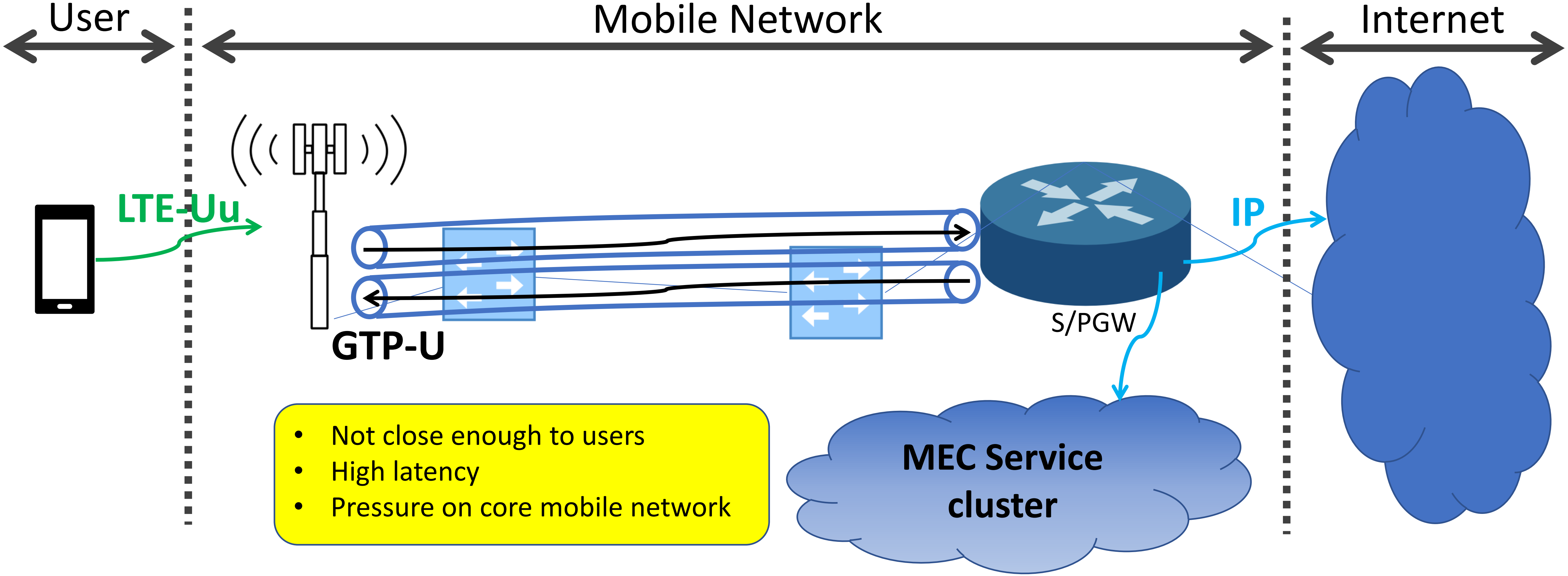


Status Quo of content delivery in mobile networks



Mobile networks use GPRS Tunneling Protocol to connect to the Internet

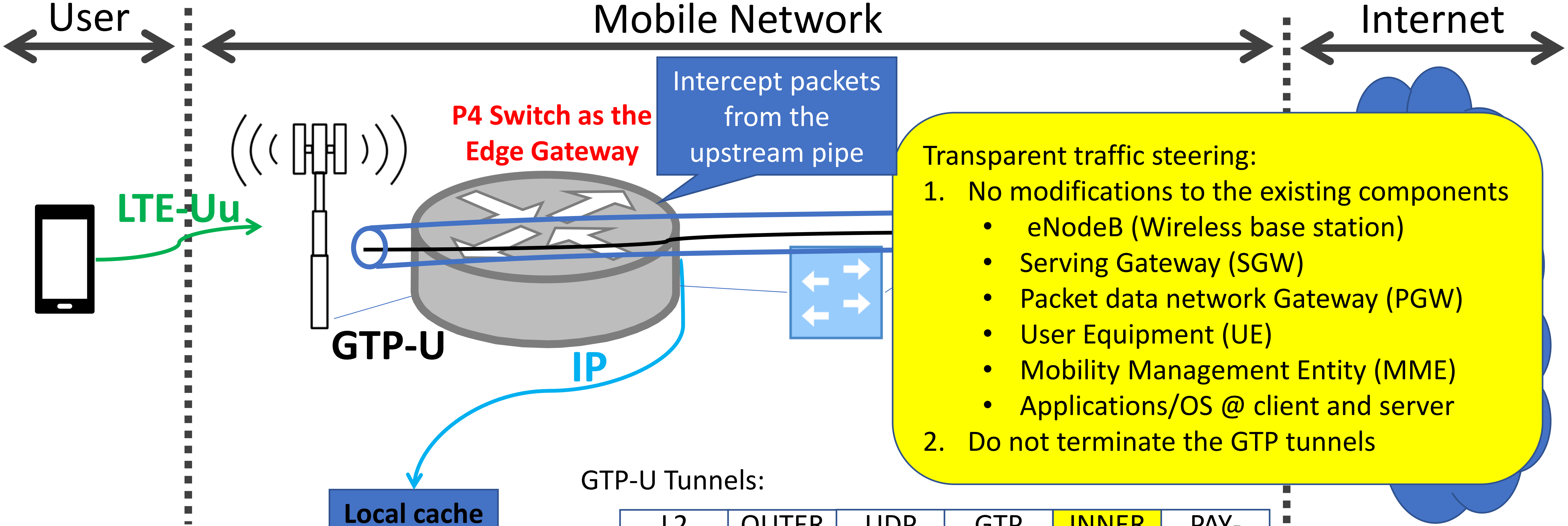
Status Quo of content delivery in mobile networks



- Not close enough to users
- High latency
- Pressure on core mobile network

Intermediate devices cannot terminate GTP tunnels; MEC services have been deployed at PGW or IPX that connects PGW to the Internet

Our proposal: Transparent Traffic Steering at Mobile Networks

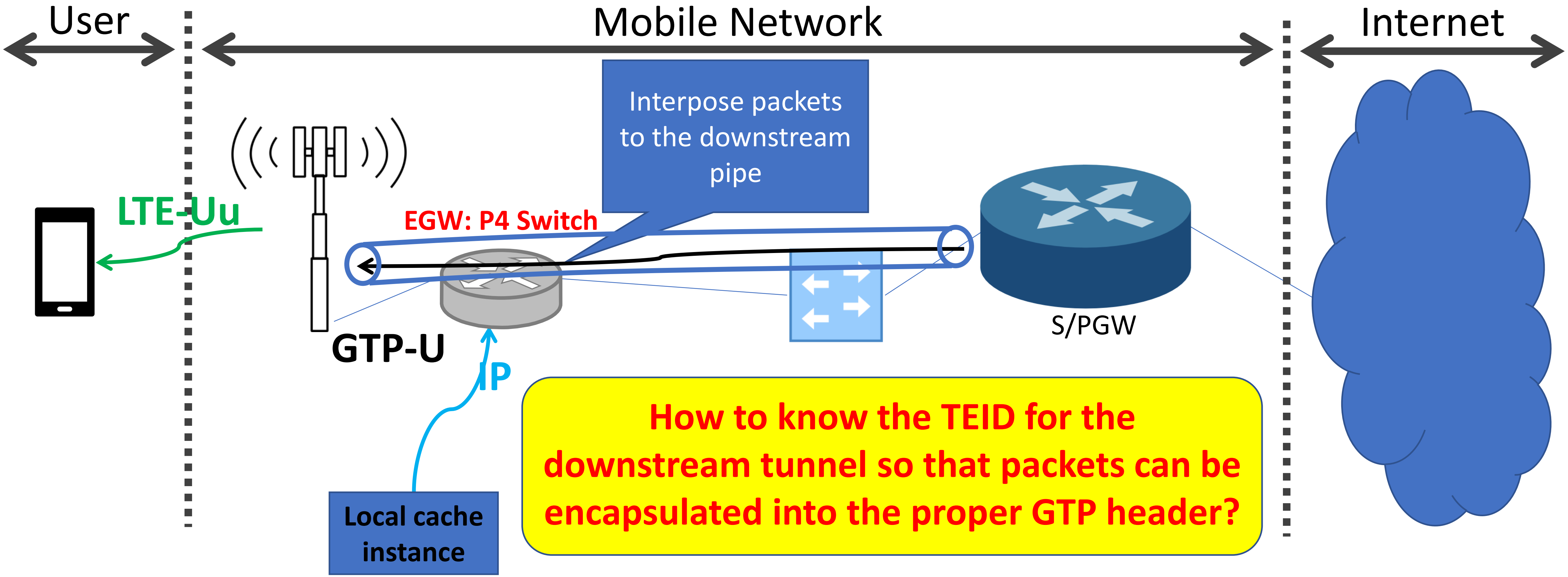


GTP-U Tunnels:

L2 HDR	OUTER IP HDR	UDP HDR	GTP HDR	INNER IP HDR	PAY-LOAD

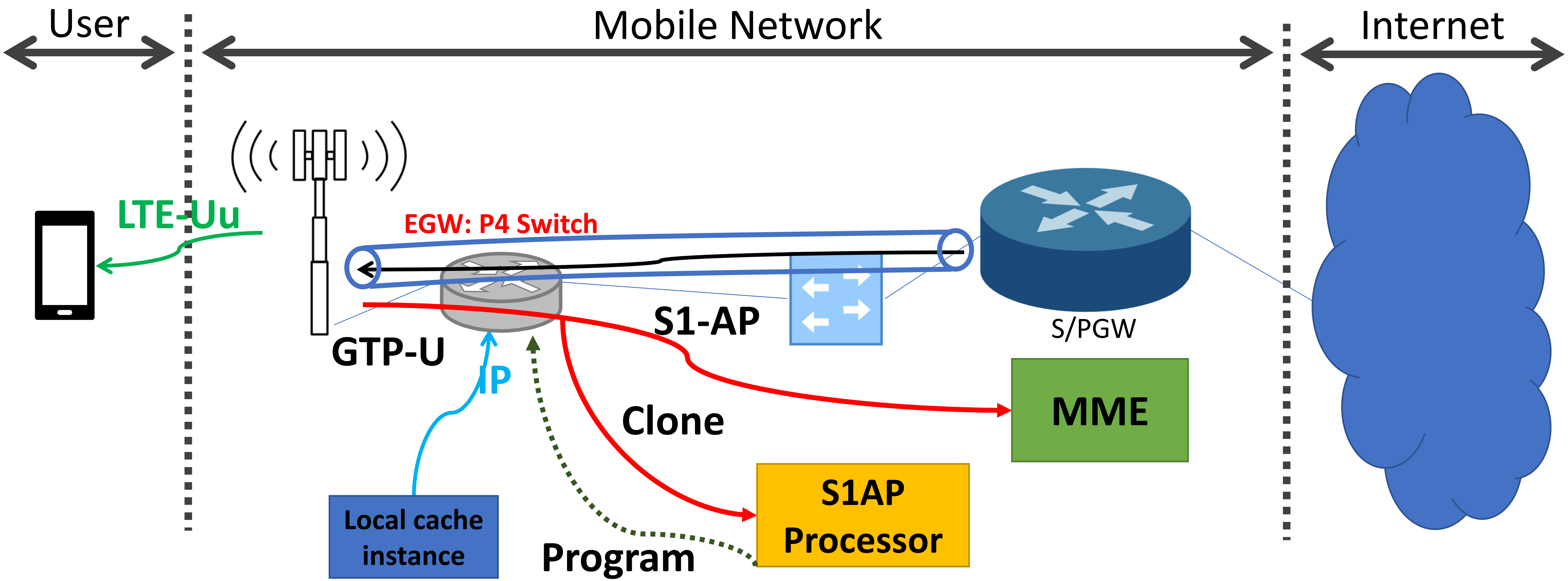
Programmable switches can seamlessly redirect the traffic to MEC

Challenging Issue: Interposing downstream MEC traffic into corresponding GTP tunnels



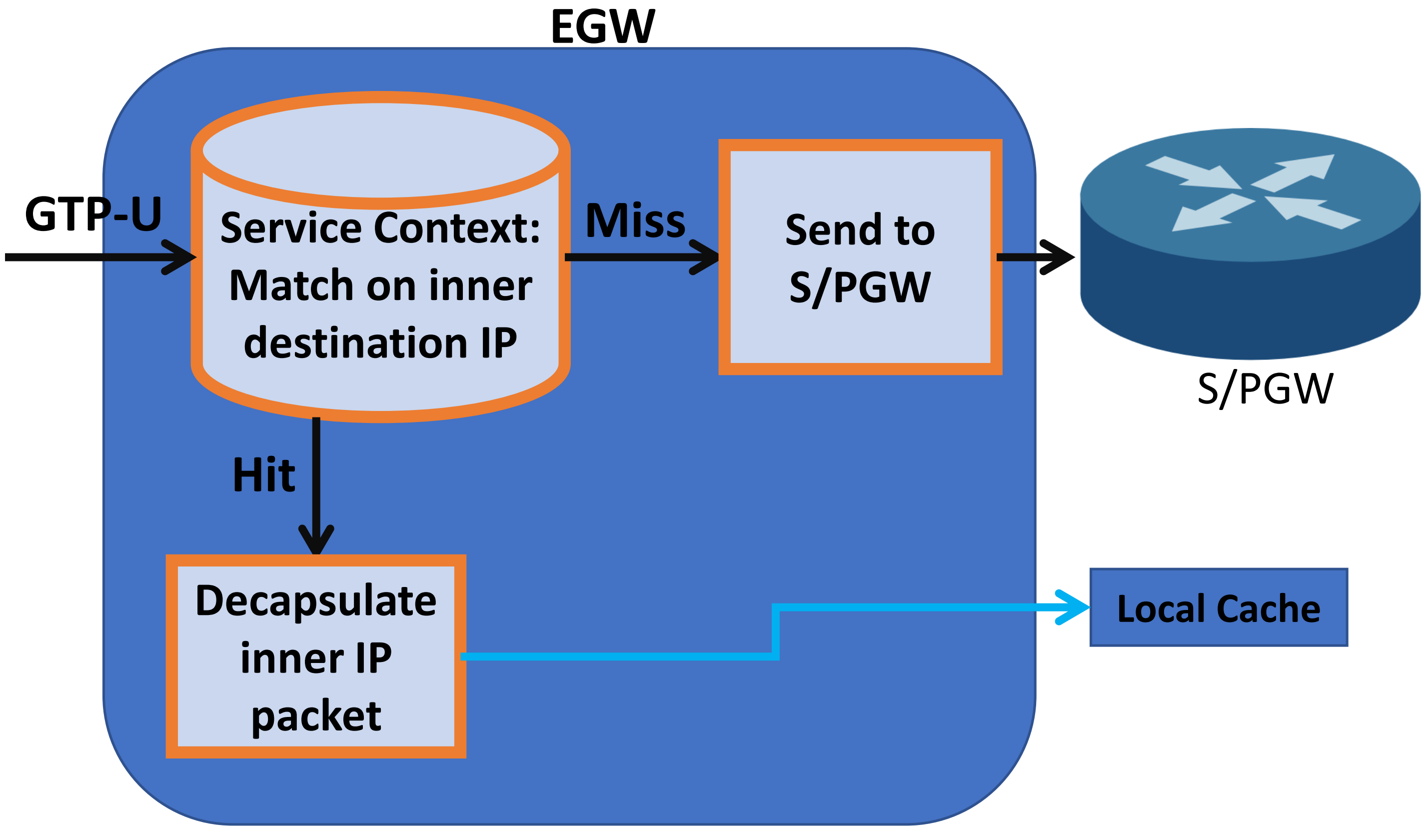
How to know the TEID for the downstream tunnel so that packets can be encapsulated into the proper GTP header?

Challenging Issue: Interposing downstream MEC traffic into corresponding GTP tunnels



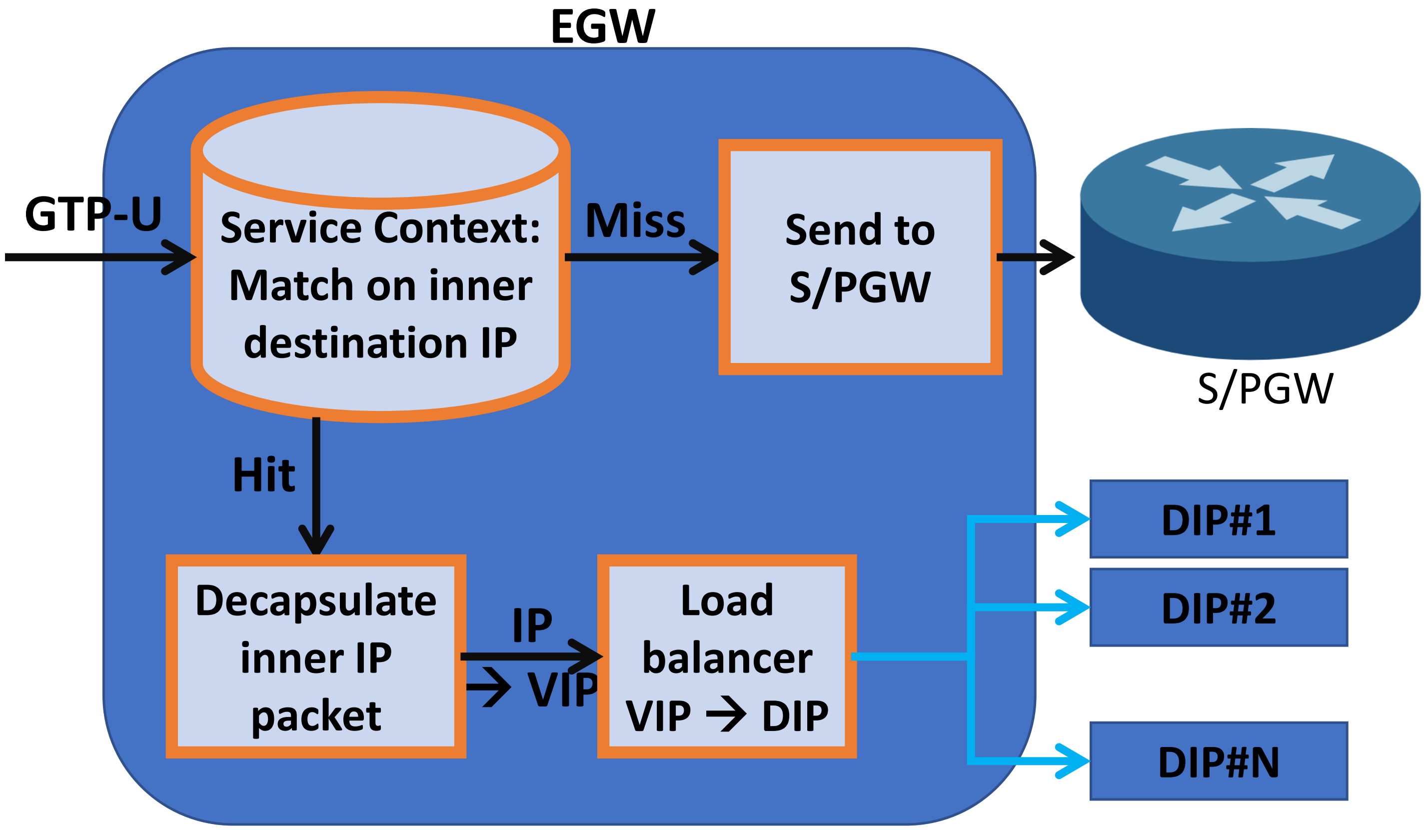
Extract downstream TEID from S1AP control messages during UE attach/handover

Design of EGW: Upstream Direction



Design of EGW: Upstream Direction
Consistent load balancing

- When there are multiple instances in the MEC, EGW will perform load balance function to balance the load among instances.
- Load balancing is a well-studied problem and a wide range of solutions are available for consistent translation of VIP to DIP
  - Silkroad (Sigcomm'17)
  - Faild/Beamer (NSDI'18)



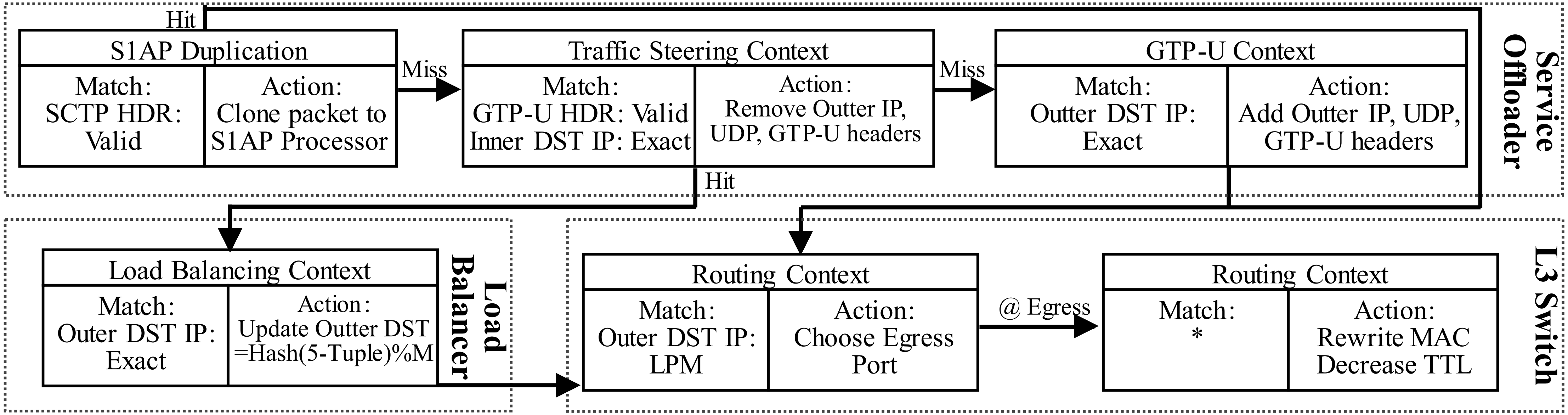
Design of EGW: Downstream Direction

- Interpose packets from MEC to UE’s GTP tunnel
  - When a packet from MEC is received, the original IP header of the packet is copied to the inner IP header, while an outer IP header with eNB and SGW IP addresses, an UDP header with GTP-U port designator, and a GTP-U header with UE’s corresponding downstream TEID are added.

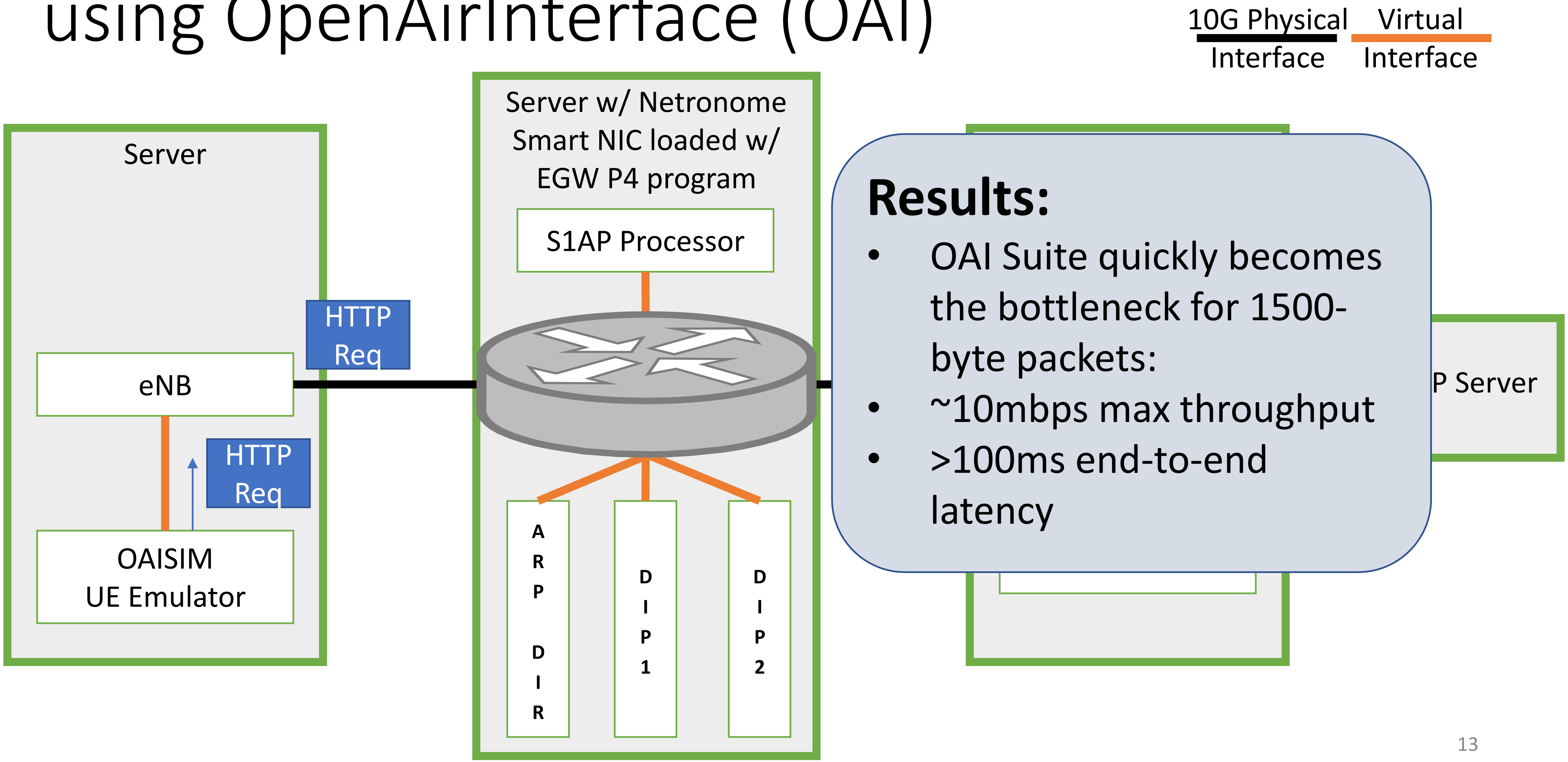
Summary: Basic functions of EGW

- Intercept packets from upstream GTP tunnel if they are destined to IP addresses within the MEC
- Send intercepted packets to MEC instances using load balancing
- Interpose packets from MEC to the proper downstream GTP tunnel
- Clone S1AP protocol message to an out-of-the-band S1AP processor

Implementation of EGW using P4 language



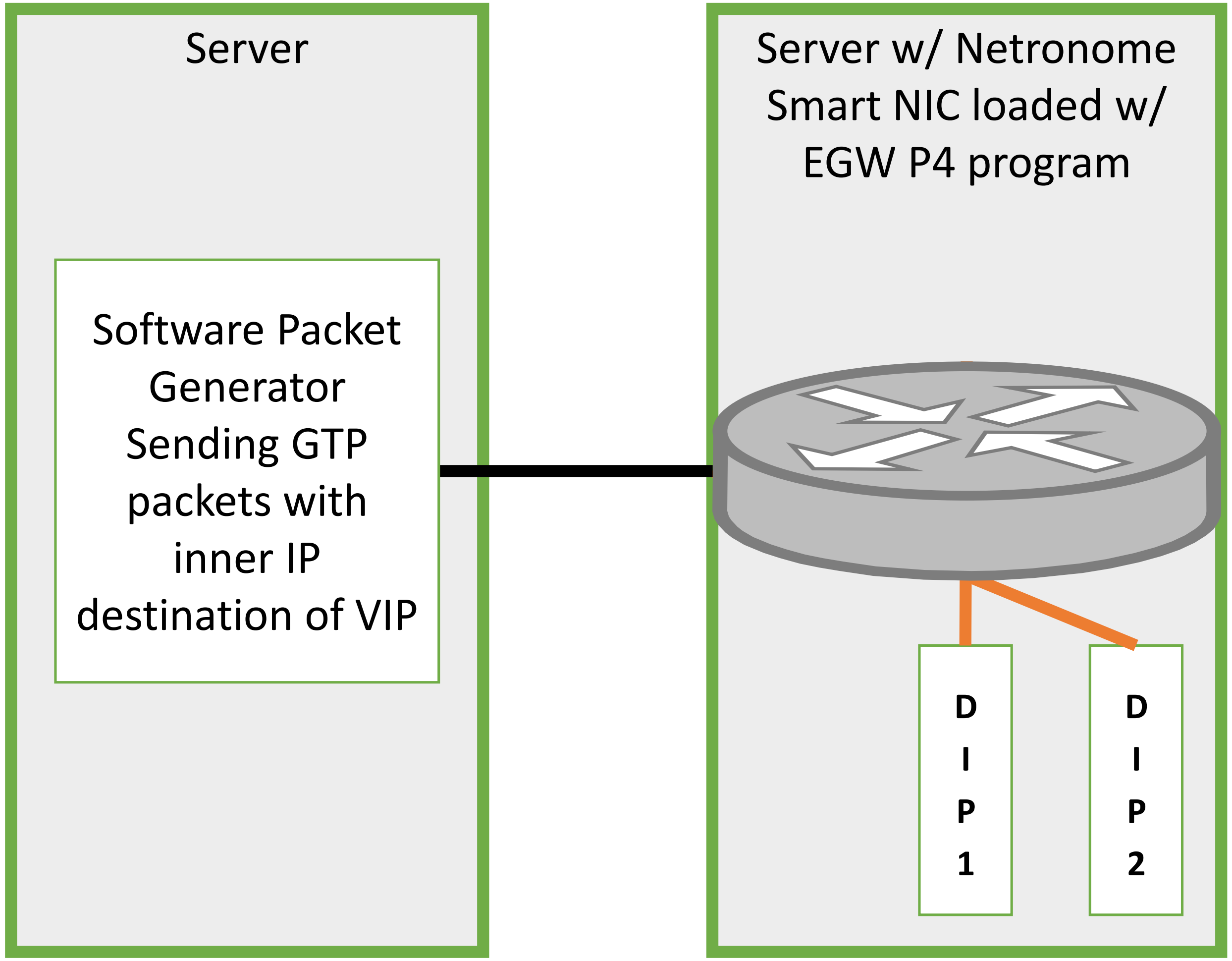
Verification on reference 5G protocol stack using OpenAirInterface (OAI)



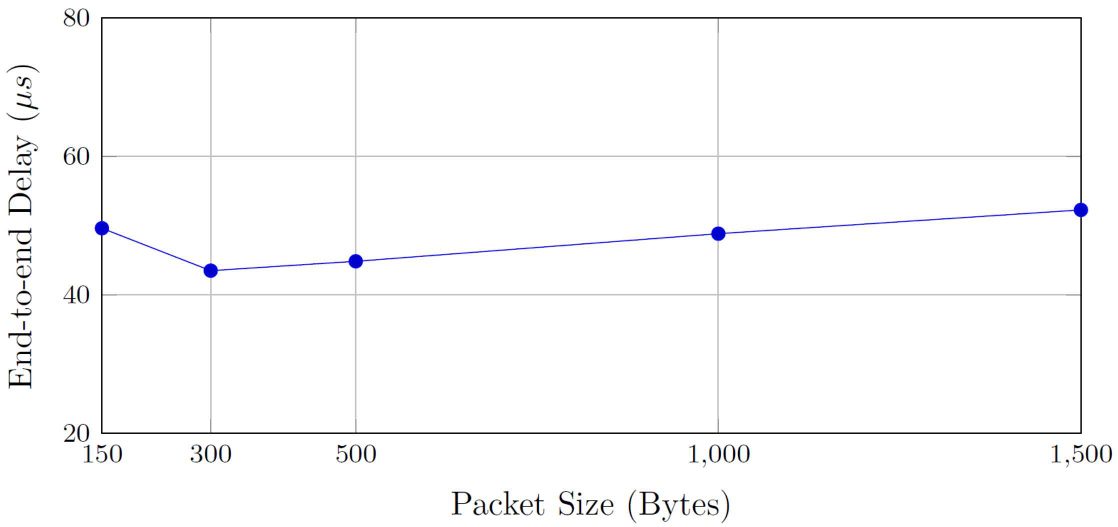
Results:

- OAI Suite quickly becomes the bottleneck for 1500-byte packets:
- ~10mbps max throughput
- >100ms end-to-end latency

Pressure testing on Netronome P4 target



EGW works at 10G line rate w/ packets of size 150 Bytes and above



Contributions and Summary

- Proposed EGW enables transparent traffic steering to/from mobile edge cloud on LTE and next generation 5G
- New applications of P4 language and programmable switches for Mobile networks
- Proof-of-concept using reference LTE protocol stack (Open AirInterface) and Netronome P4-compatible smart NIC

Thank You!