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Towards User-Plane Congestion Management in LTE EPS

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Outline

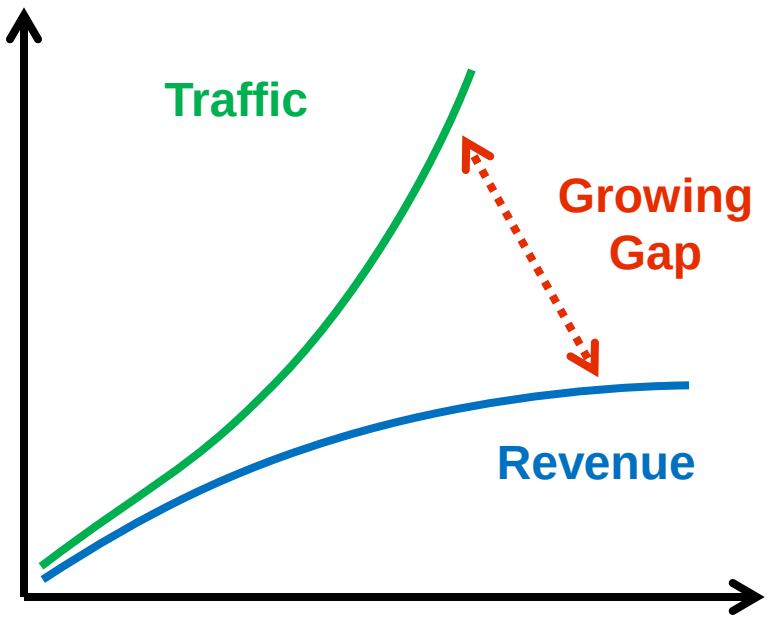
- Motivation and scenarios: Why do we suddenly need user plane congestion management (UPCON)?
- Todays system limitations
- Solution outline in EPC and RAN
  - congestion detection and indication
  - Traffic engineering in evolved packet core
  - LTE eNode B enhancements for UPCON
- Conclusion and outlook

Motivation

- Mobile **traffic grows quickly**
- **What is the problem?**
  - Why can't operators simply upgrade their current networks (i.e. buying more boxes)?

→ **ARPU reached its peak**

- → Not enough cash to simply upgrade the network capacity
- → Optimizations are needed(!!!)



Conclusions:

1. **Congestion caused by data traffic is inevitable**
2. **Mobile network need to minimize QoE degradation as a result of congestion** (→ avoid subscriber churn)

Congestion Scenario: Peak traffic load

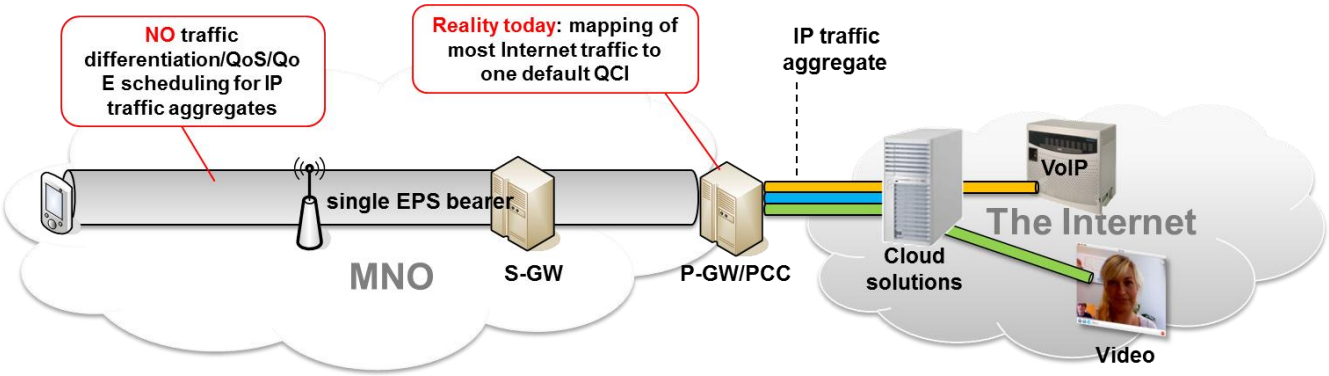
Scenario

- Traffic load increases during peak times at “hot-spot” areas (e.g. train station, new years eve), leading eventually to UP congestion
- This scenario is expected to occur especially at places where many users wait/stay while using their mobile

Note: It is not cost-effective for operators to dimension such “hot-spot” areas for the “worst case” peak, as this would imply very high investments given the rapid increase of mobile data traffic.

Limitations of today's system

- QoS differentiation in the EPS requires signaling for dedicated bearers
  - This works well for special services, such as Voice or Emergency
- However, the majority of data traffic is handled via the default bearer.

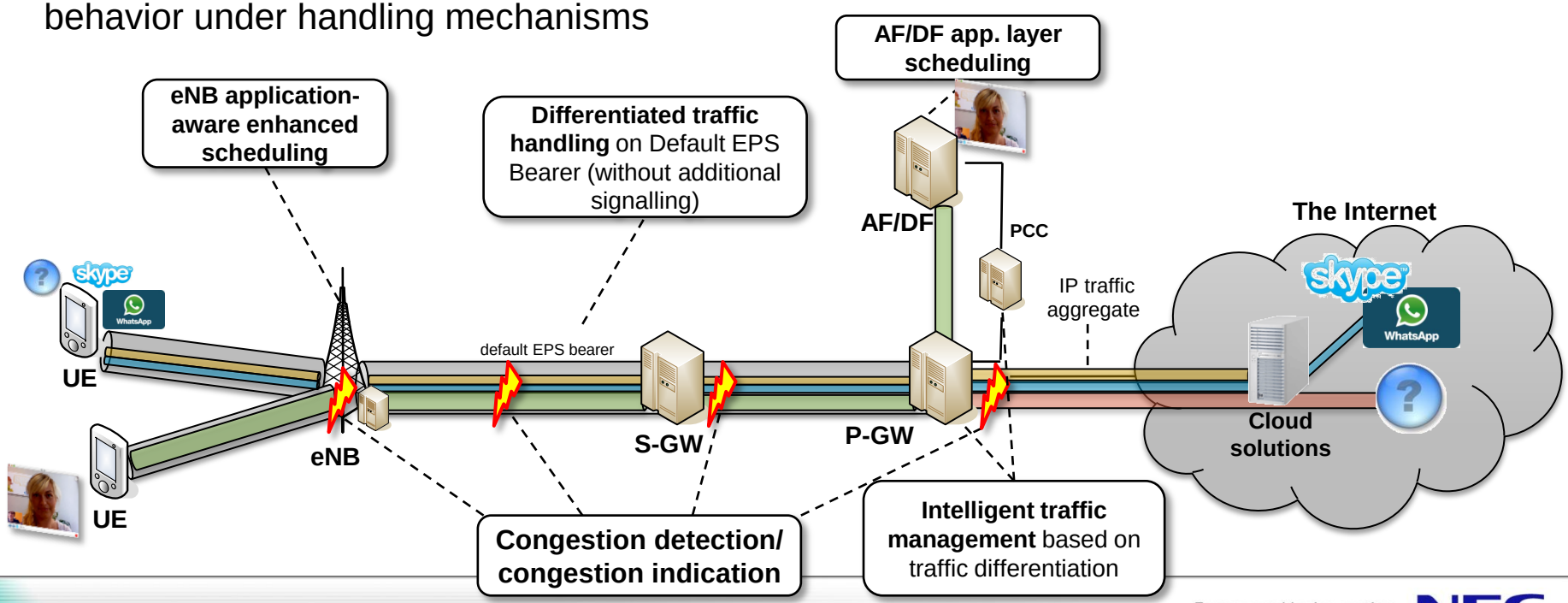


- This means, during user plane congestion all flows get a fair share of the resources
- BUT, QoE during congestion periods is highly service/application dependent

→ **Treating all best-effort flows equally implies that resources are not optimally assigned to the different services from a QoE perspective and will eventually lead to customer dissatisfaction**

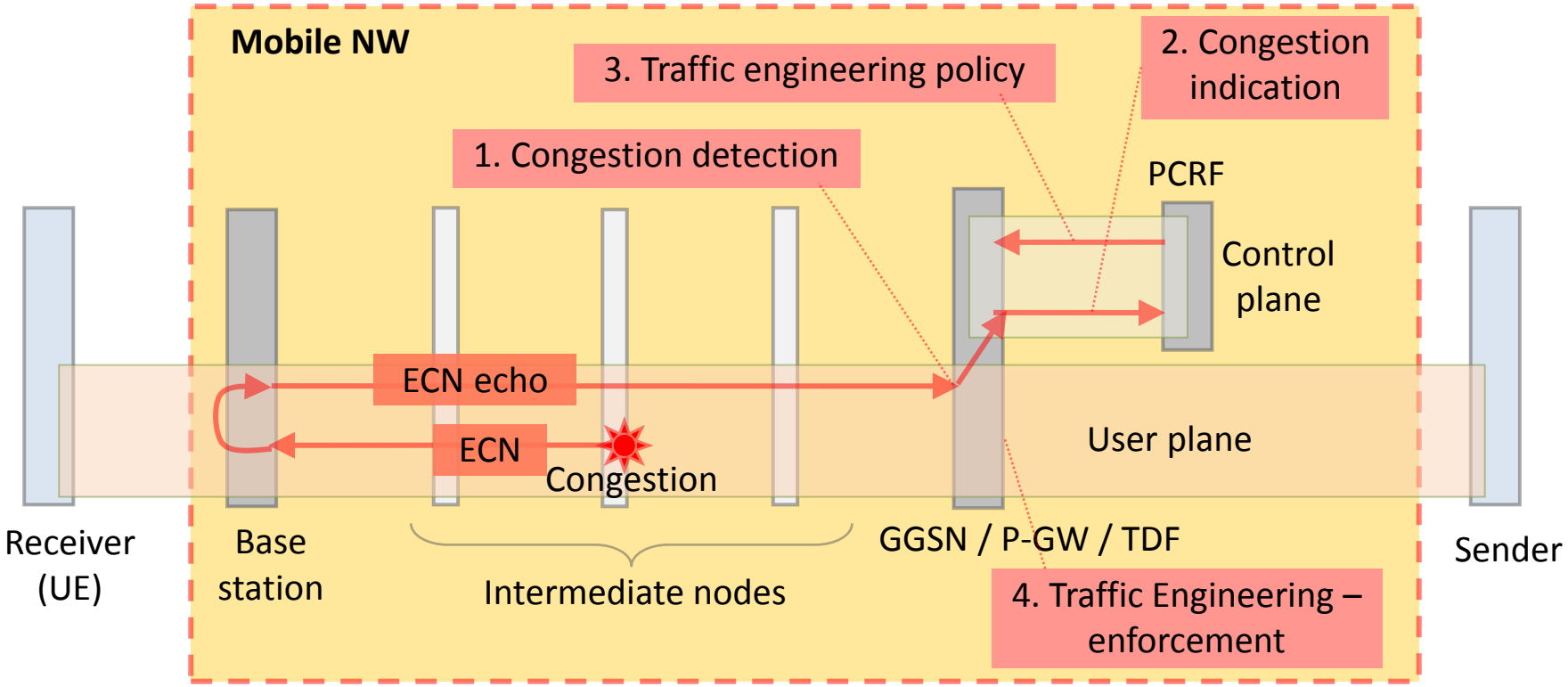
UPCON – Solution outline

1. **Detect user plane congestion** in Radio Access, Backhaul or Core Network entities
2. **Apply different traffic handling / QoS schemes** to user plane traffic, based on Subscriber profile, Application type, Content type
3. **Develop adequate traffic scheduling and traffic engineering mechanisms**, such as per-user or per-flow queuing, application-aware QoE scheduling, flow-based handover, media compression, etc.
4. **Enable policy-based control for operators** to flexibly configure the traffic the network behavior under handling mechanisms

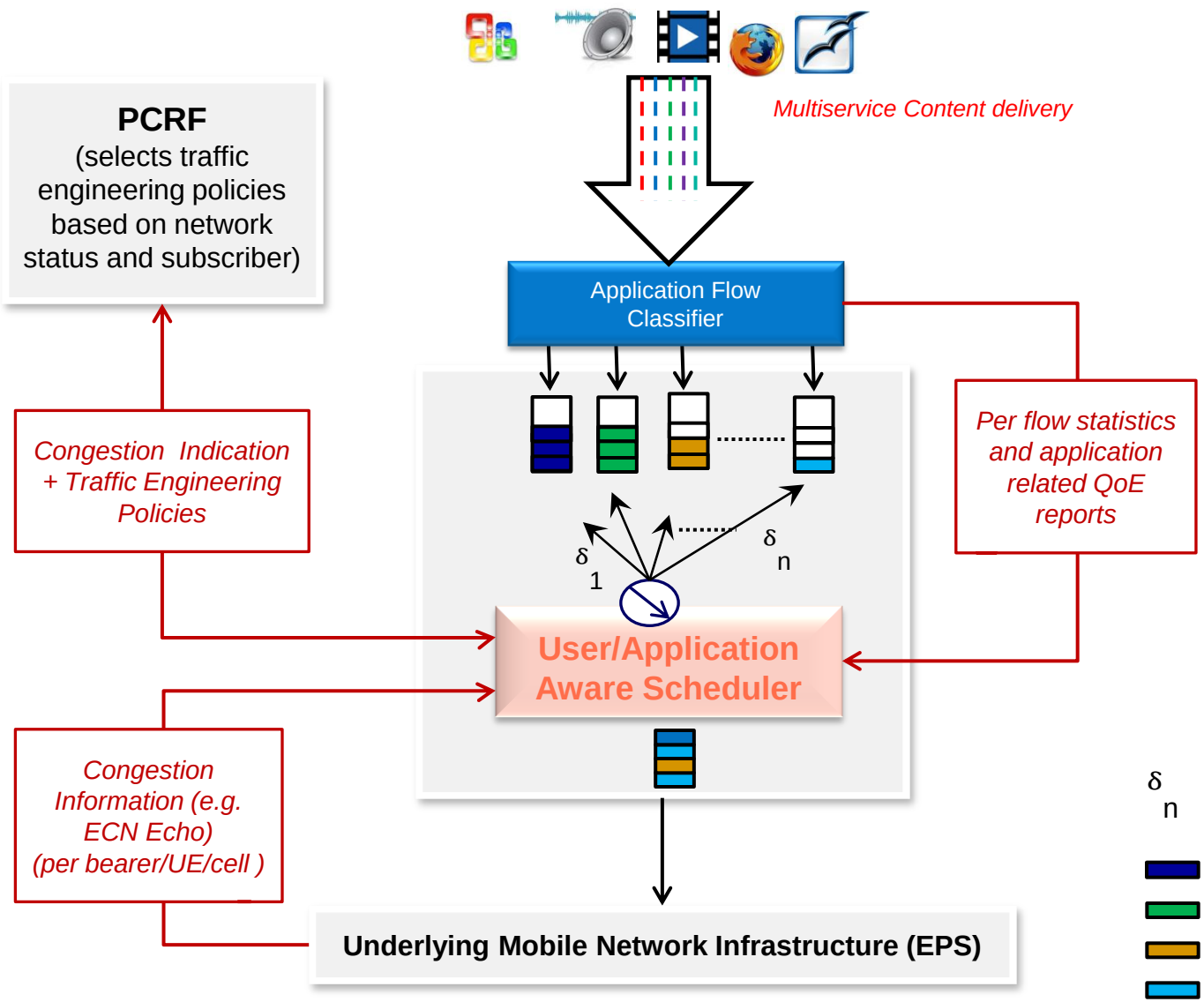


Congestion detection and indication

- Solutions covers all aspects of congestion management:
  1. lightweight congestion detection/signalling,
  2. congestion indication to PCRF in the GTP tunnel
  3. selection of traffic engineering policies and provisioning, and
  4. enforcement of traffic engineering policies



Traffic Engineering: User/Application-aware Scheduling



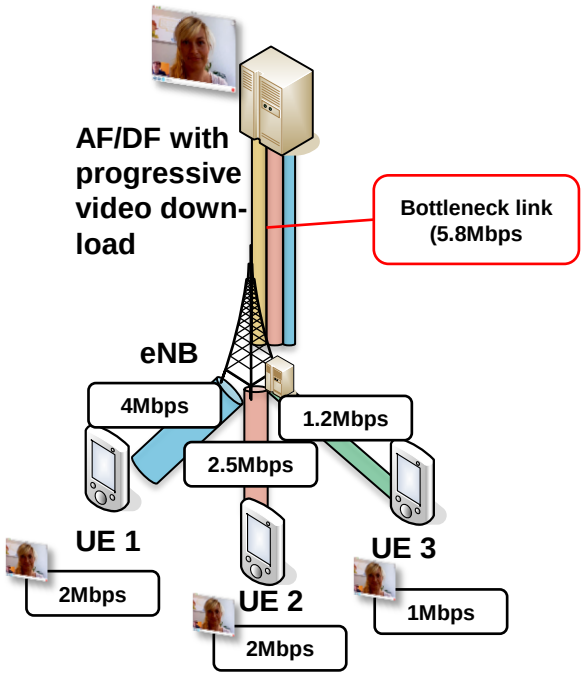
Key Selling Points:

- Minimizes user plane congestion
- Improves QoE for subscribers by taking subscription and application/ content type into account
- Enables fast data access for paying customers – even during congestion

δ_n Transmit-time slice based on flow priority

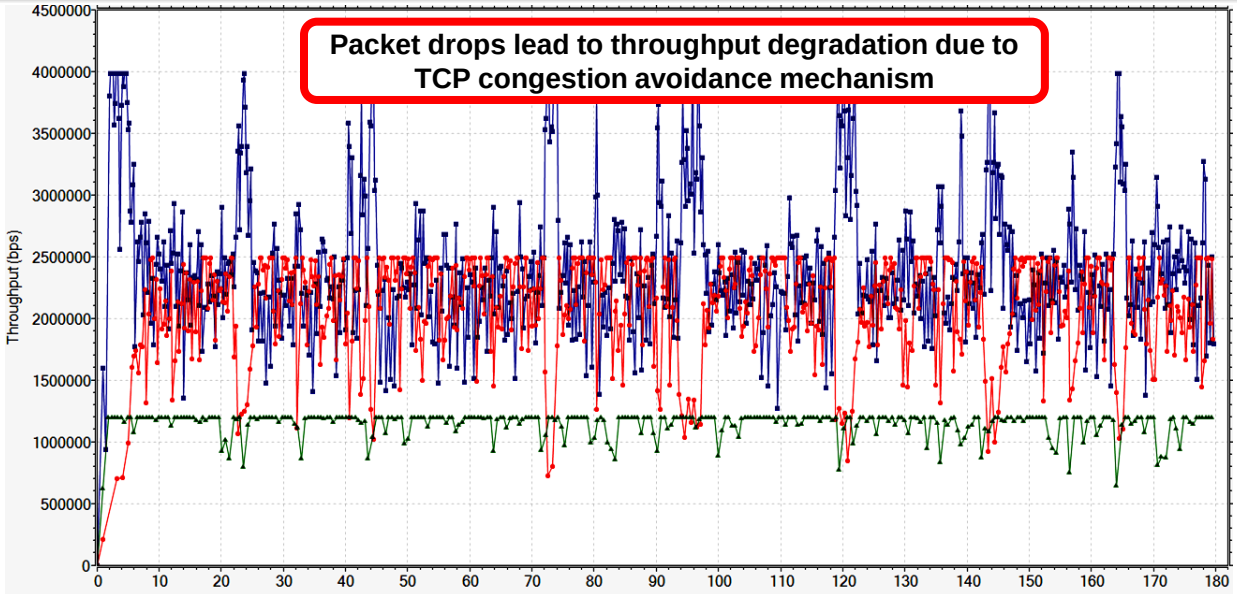
- Application/Content Type 1
- Application/Content Type 2
- Application/Content Type 3
- Application/Content Type n

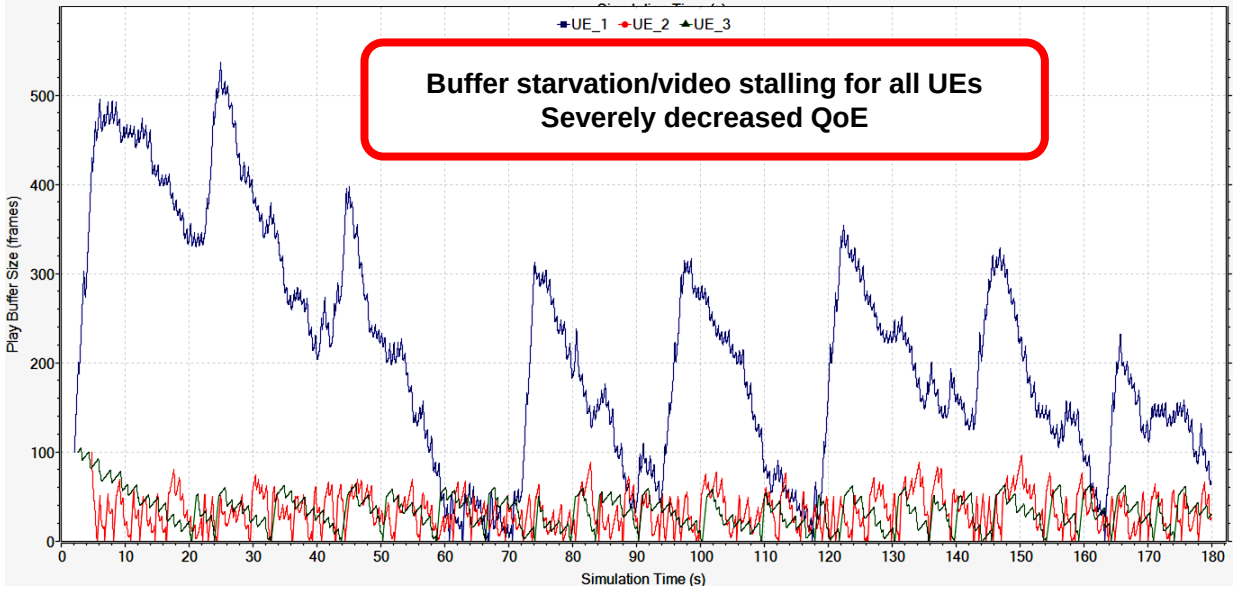
Application-Aware Scheduling in AF/DF: Preliminary results



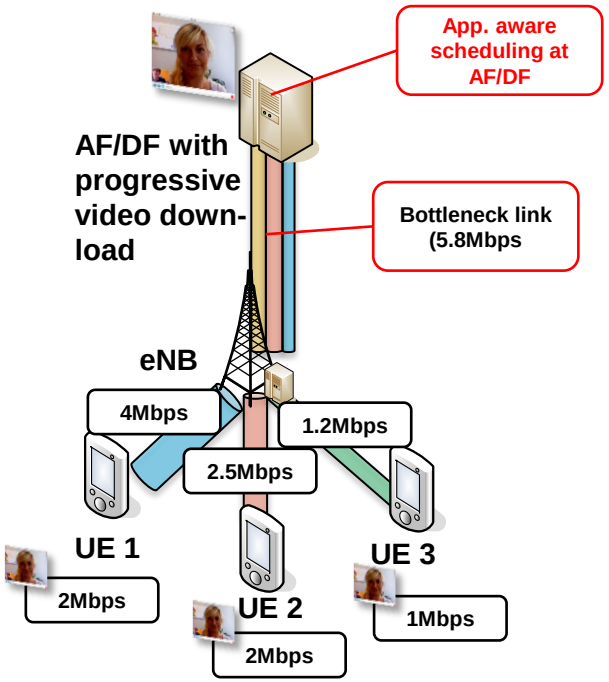
Without application-aware scheduling:

- **Packet drops** at bottleneck link lead to decreased throughput due to TCP congestion avoidance mechanism
- **Note that overall link capacity would be sufficient to carry demand!**



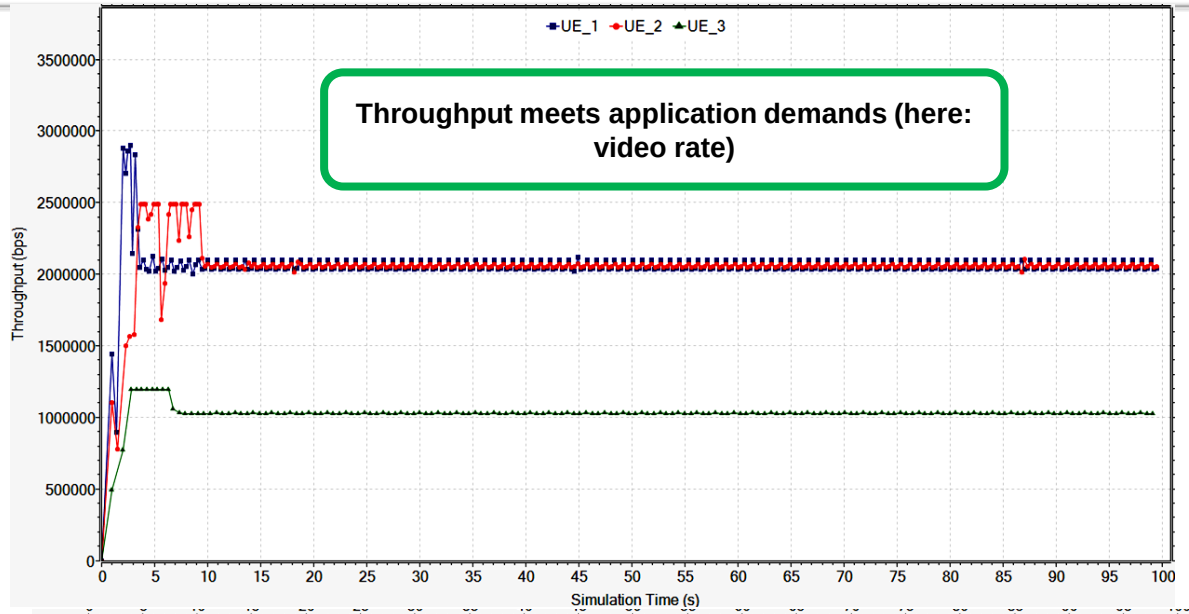


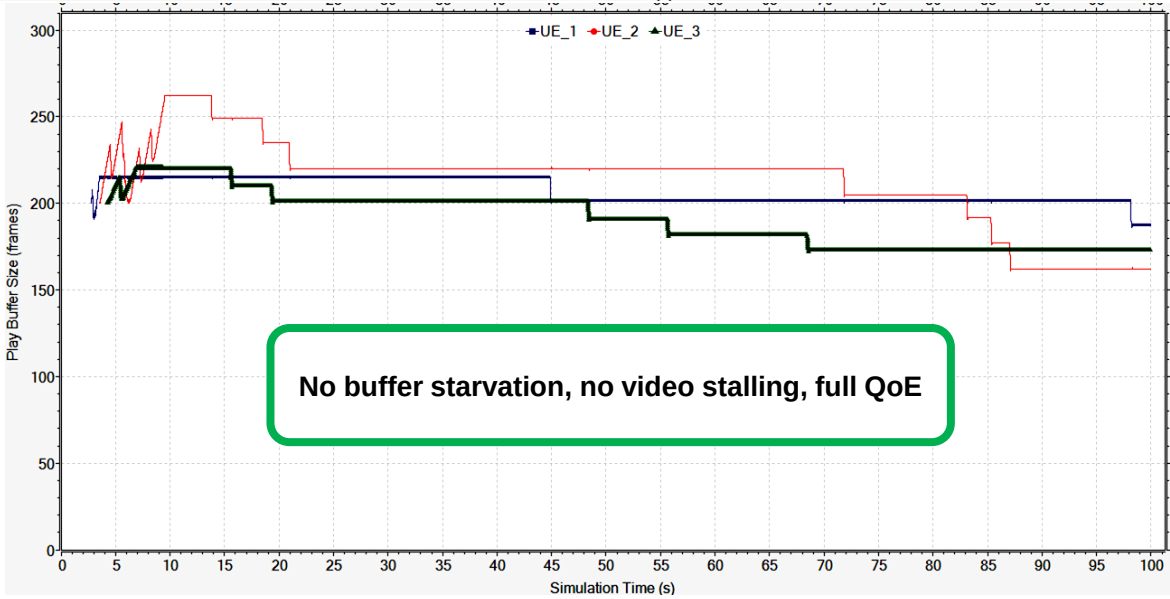
Application-Aware Scheduling in AF/DF: Preliminary results



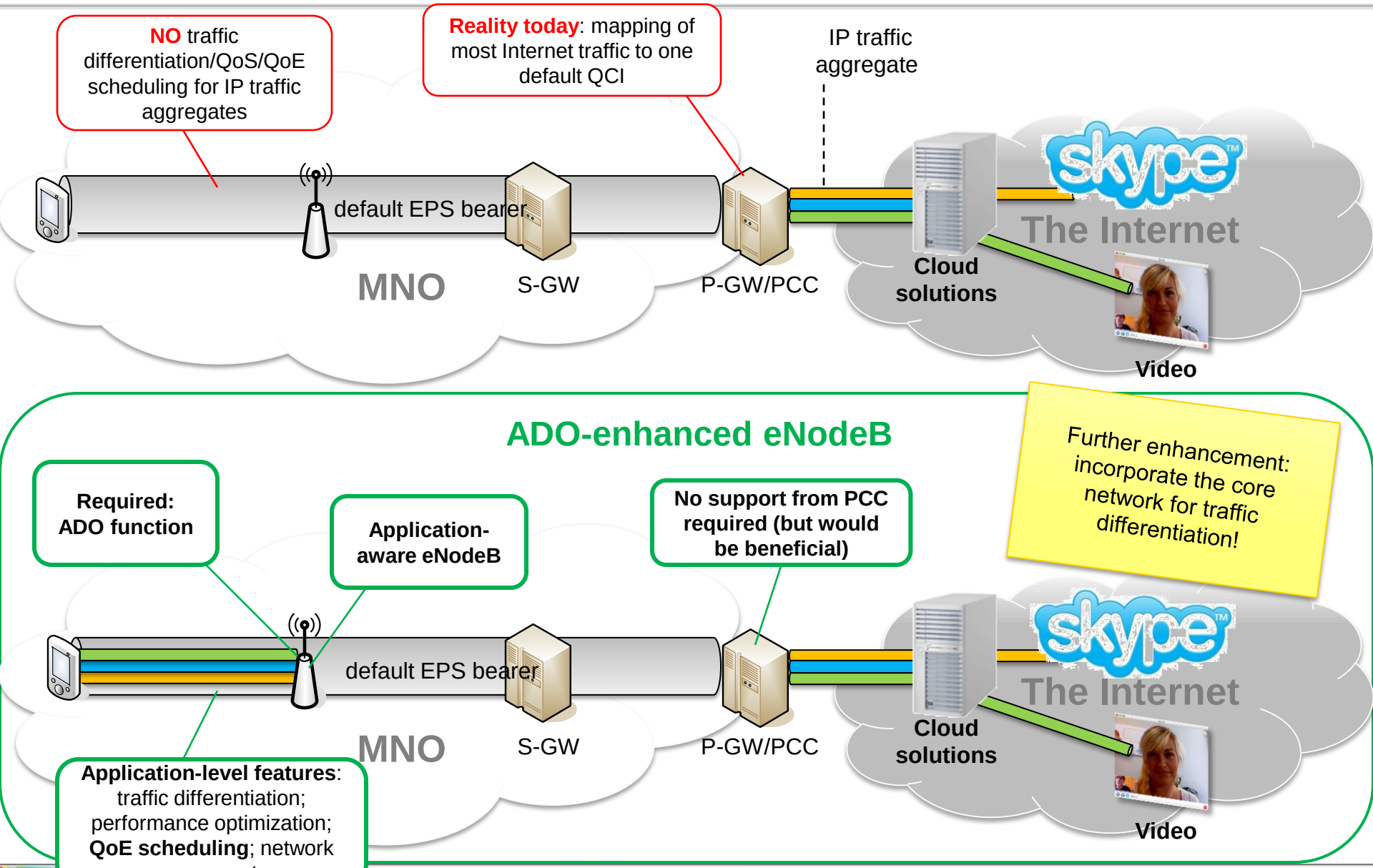
With application-aware scheduling:

- Scheduler uses app. information to meet required data rate
- No packet drops at bottleneck link
- Solution is independent of packet drop policies
- Solution does not require any signaling towards UEs





LTE eNodeB Application-Driven Optimization (ADO)



LTE-ADO: Approach

Low impact on existing base station architecture

- **Minimize impact** of integration in existing system architecture
- But **maximize benefits** for operator and subscriber

Solution can be stand-alone for eNodeBs

- Because of missing standardization, solution should be operating autonomously in the eNodeB
- No support from EPC and especially from UE side required
- No signaling required
- But: integration with other UPCON elements would be beneficial

If available, use QoE information to improve functionality / performance in eNodeB

- **Avoid over-** and **under-provisioning** of resources
- **Meet customer expectations** on quality of experience

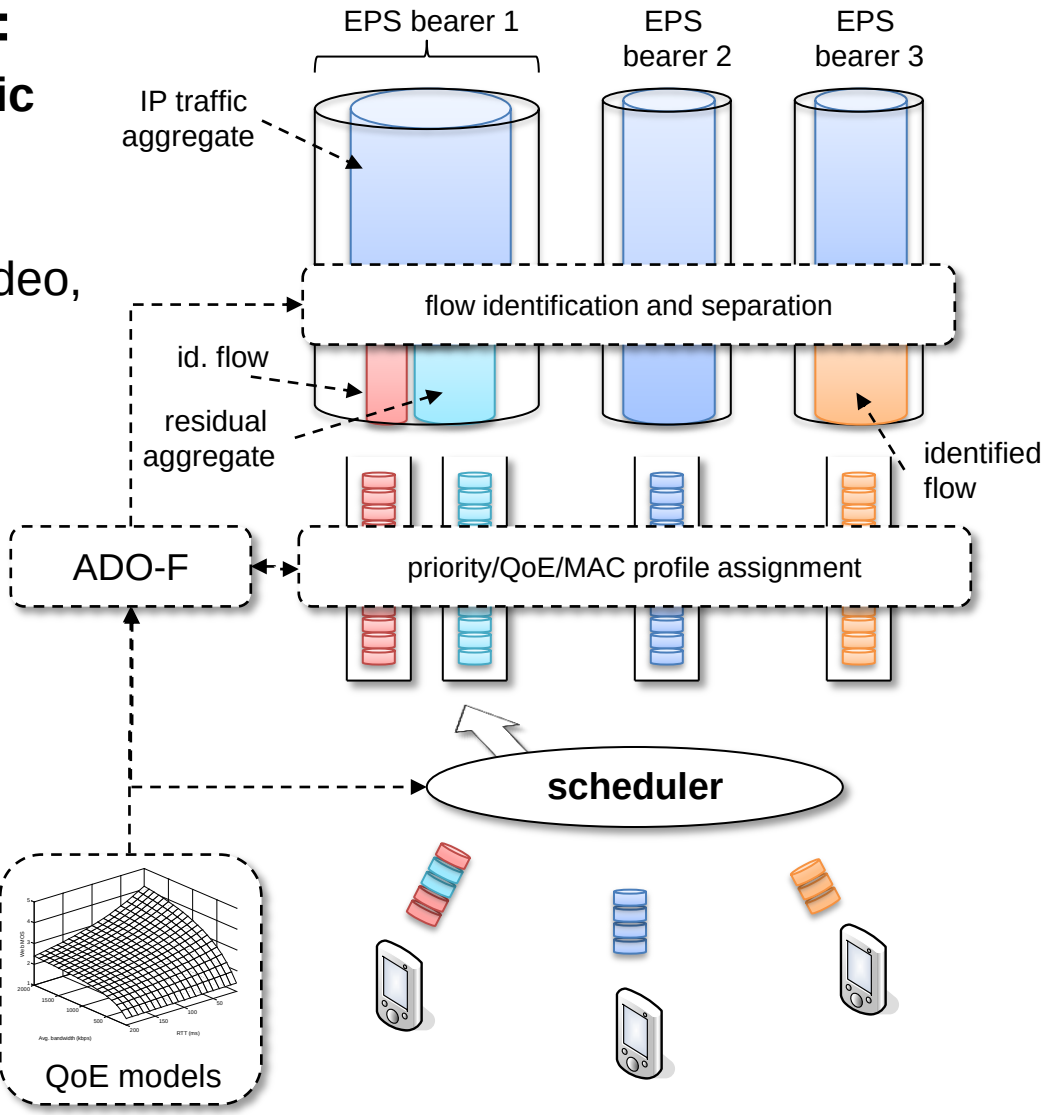
LTE-ADO: Application-aware scheduling in eNodeB

Utilize application information:

- Inter and intra EPS bearer **traffic differentiation**
- **QoE scheduling** for important applications (e.g. progressive video, gaming, ThinClients, Cloud applications)

Benefits:

- **To-the-point provisioning** of radio resources
- Efficient **isolation** of traffic classes/traffic flows
- **Protection** of high priority traffic
- Enables handling of **premium services**



Work in progress

Conclusion and Outlook

UPCON is of key importance for mobile networks

- Tackle the mobile traffic explosion
- Meet growing user expectations
- Avoid cost explosion for network capacity enhancements

NECs vision on UPCON:

- **Complete and light-weight solutions** in EPC and RAN
  - Congestion detection and congestion indication
  - Traffic engineering in P-GW/PCRF
  - Application-aware scheduling on application/distribution function
  - Application-driven optimization of eNodeB functions in RAN
- **Modular approaches** to allow progressive implementation and integration
- **Standardization** for future-proof solutions

User perception decides on service acceptance!

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