An SDN QoE-Service for Dynamically Enhancing the Performance of OTT Applications

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Outline

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• SDN-based supporting architecture
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  ▫ QoE monitoring
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Motivation

For mobile network operators (MNO)

- MNOs face a tremendous increase of data traffic
- Much of the traffic is originating from OTT Apps
- MNOs lose money: profits are unaffected while cost is higher

For Over-The-Top players (OTT)

- Increased App types with large QoS diversity “compete” for the same pool of resources
- OTT Apps are served without QoS guarantees, over the default best-effort bearer

Then, why not go for a win-win paradigm of MNO-OTT “interfacing”, where:
- OTT Apps are served with better QoE (introducing some OTT control)
- QoS differentiation per App type
  - App prioritization possible
- Resources shared more efficiently
- MNOs get into the revenue loop
Enabler: The SDN architecture

Software Defined Networking offers:
- Decoupling of Control & Data Plane
- Abstraction of lower level functionality
- Directly programmable network control

Main benefits:
- Centralized management enables optimal, global decision-making
- Dynamic, manageable, adaptable, agile control (SW-based policies)
- Infrastructure / Vendor neutral
- Cost-effective, fast time-to-market

Faster innovation towards QoE-centric policy enforcement and network management, on a per-flow basis

* https://www.opennetworking.org/sdn-resources/sdn-definition
SDN based QoE-Service: Idea

The QoE-Service requests some KPIs

The SDN controller translates these requests into monitoring commands

The MNO collects the requested data from appropriate nodes and reports back to the SDN controller

The collected data are modelled into QoE by the QoE-Service

QoE policies are triggered by the QoE service and applied by the SDN controller
## SDN based QoE-Service: Challenges

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<th>Step</th>
<th>Challenges</th>
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| The QoE-Service requests some KPIs                                    | ✓ What KPIs to monitor  
                                                                           ✓ Where to monitor those KPIs |
| The SDN controller translates these requests into monitoring commands | ✓ MNO-specific requests  
                                                                           ✓ Monitoring periodicity  
                                                                           ✓ Signaling overhead       |
| The MNO collects the requested data from appropriate nodes and reports back to the SDN controller | ✓ QoE modeling problem  
                                                                           ✓ Appropriate thresholds   |
| The collected data are modelled into QoE by the QoE-Service           | ✓ Network management problem  
                                                                           ✓ Resource constraints      |
| QoE policies are triggered by the QoE service and applied by the SDN controller |                                                                          |
The QoE management cycle
1 - QoE monitoring: The “what”

**Monitoring options:**
- Real-time + user-level
  - Monitor KPIs per user e.g. buffer status
- Longer-term + cell-level
  - Monitor over a longer period of time
  - Average QoS values e.g. congestion level per cell, average throughput
  - Load forecasting techniques

**Reporting alternatives:**
- QoE-based reporting
  - Per user and per application QoE reporting
- QoS-to-QoE-based reporting
  - Reporting of critical KPIs
  - Max/Min acceptable bounds per application

➤ Collection of statistics per cell and per application!
1 - QoE monitoring: The “where”

- Monitored KPIs depend on the QoE models
  - Agents at the users
  - Probes at network nodes
  - Statistics at base stations or gateways, etc.
  - User feedback
2 - QoE modeling

- **VoIP**: \( R = 94.2 - [0.024d + 0.11(d - 177.3)H(d - 177.3)] - [11 + 40\ln(1 + 10p)] \)

- **YouTube (TCP)**: \( QoE = 3.5 \times e^{-(0.15L + 0.19)N} + 1.5 \)

- **HTTP Adaptive Streaming (TCP)**: \( QoE = 0.003 \times e^{0.064t} + 2.498 \)

- **Real-time video (UDP)**: \( V_q = 1 + I_{coding} \times I_{transmission} \)

- **FTP**: \( QoE = a \log_{10}(\beta R), \quad 10\text{kbps} < R < 300\text{kbps} \)

- **Or**: QoS-related metrics such as delay, bandwidth, handover failure, etc.
3 - QoE steering

Traffic management alternatives:

1. At the Access Network:
   - Admission control
   - Mobility management
   - Application prioritization
     ▫ (e.g. cross-layer scheduling)
   - etc.

2. At the Core Network (LTE):
   - PCRF: can provide a policy for particular flows to enhance / deliberately degrade the performance
   - MME: able to shift certain flows or select S/P-GW for particular flows in order to enhance the QoE performance
   - Packet marking
   - etc.

3. SDN-NFV solution:
   - Virtual EPC concept
   - Relocate the S/P-GW:
     • Migrate/Shift the network functions to different hardware devices
Exploitation

**Different business models can be defined:**

- **Token-based models:** charge users according to the QoS/QoE
  - Tokens may accompany the purchase of a particular application

- **Contract-based models:** charge following a tiered approach with different bandwidths and quota limits
  - E.g. gold, silver, platinum subscribers

- **Service-based models:** allow access with a certain QoS/QoE in relation with a particular service (pay as you go)
  - E.g. online gaming, where a group of users is playing an interactive game on a social website or at some host gaming server
Conclusions

- An SDN-based QoE-Service can:
  - Guarantee the required QoE level for on-demand services
  - Offer advanced treatment to premium users
  - Limit the “just-a-pipe” role of a communication network
- A plethora of elastic traffic management decisions can be proposed

Challenges:
- Net Neutrality issues
- The willingness of OTTs and/or MNOs to share information about their assets or about their customers
- Realization issues of the SDN Controller

Our goal:
- Show the potential of this OTT-MNO collaborating paradigm
- Introduce this QoE-Service into the 3GPP architecture
Thank you!

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