Um mecanismo baseado em SDN para flexibilizar o controle de tráfego em redes LTE

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Outline

❖ Introduction
❖ Software-Defined Networking
❖ Long-Term Evolution networks
❖ SDN and LTE integration
❖ Proposed traffic control mechanisms
❖ Literature review
❖ Conclusions and future work
Introduction

- Mobile data traffic is growing at a compound annual growth rate of 57%.
- Increasing number of higher-generation connectivity.
- Multimedia streaming represents more than 50% of mobile data traffic.

Future networks

- 5G networks for people and things
- Lower latency and higher data rates
- Heterogeneous Networks (HetNets)
- High-connectivity backhaul and core networks for more base stations

Software-Defined Networking will be a key differentiator of 5G systems
Contributions

❖ **This work contributes with…**

❖ OpenFlow protocol integrated into LTE backhaul networks
❖ Specialized OpenFlow EPC controller for LTE traffic control
  ❖ Network traffic routing
❖ Bearer admission control
❖ Literature review on SDN and LTE integration
Software-Defined Networking

- Decouples the control plane from the data plane
- Network intelligence is centralized in software
- Simplified distributed forwarding hardware
- More agile and cost-effective networks
OpenFlow protocol

- SDN southbound interface
- Basic primitives to program the forwarding plane of OpenFlow switches
- Concepts of flows to identify network traffic
- **Switch datapath specification**
Long-Term Evolution networks

- 4G standard for high-speed wireless communication
- Maintained by the 3rd Generation Partnership Project
- Evolved Packet System (EPS)
  - Evolved Universal Terrestrial Radio Access Network (E-UTRAN)
  - Evolved Packet Core (EPC)
EPS architecture

Packet domain only
Standardized interfaces
GPRS Tunneling Protocol (GTP)
LTE QoS and EPS bearers

- EPS bearers identify packet flows with common QoS treatment
- Bearers are associated with a QoS Class Identifier (QCI)
  - Minimum Guaranteed Bit Rate (GBR)
  - Non-Guaranteed Bit Rate (Non-GBR)
SDN and LTE integration

- **Proposed integration**
  - OpenFlow switches in the backhaul network (S1 interfaces)
  - New OpenFlow match fields for GTP TEID routing
  - No changes in EPC elements for tunnel handling
SDN and LTE integration

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Software-Defined Mobile Networking (SDMN)
Network topology

- **Wired backhaul topology**
  - Ring with arbitrary number of OpenFlow switches
  - Unified S-GW/P-GW gateway element
  - Ethernet full-duplex links

- **Wireless access topology**
  - Hexagonal grid with inter-site distance of 500 m
  - UEs scattered closed to the eNBs
OpenFlow EPC controller

- LTE traffic control mechanisms
  - Backhaul traffic routing
  - Bearer admission control
OpenFlow EPC controller

Controller communicates with the MME element for bearer management procedures
Network traffic routing

- Look for routing paths and install GTP TEID match rules
- For the ring topology, the routing options are reduced to clockwise or counter-clockwise paths
- Different routing policies
  - Shortest Path Only
  - Shortest Path First
Bearer admission control

- Reserve the requested bandwidth for accepted GBR bearers
  - Shortest path only routing policy blocks GBR requests when there is no available bandwidth in the shortest routing path
  - Shortest path first routing policy checks on the other routing path for the required bandwidth before blocking the GBR request
Performance evaluation

- **Network Simulator 3 + OFSwitch13 module**

- **Backhaul ring size**: 4/10 OpenFlow switches connected to eNBs

- **UE load distributions**: balanced or unbalanced (30% of UEs in one half of the ring, 70% on the other half)

- **Admission control**: up to 40% of link bandwidth for GBR traffic

<table>
<thead>
<tr>
<th>Traffic applications</th>
<th>Traffic type</th>
<th>Bearer QCI</th>
</tr>
</thead>
<tbody>
<tr>
<td>VoIP</td>
<td>UDP</td>
<td>GBR (1)</td>
</tr>
<tr>
<td>Live Video Streaming</td>
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<td>GBR (2)</td>
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</table>
**Block ratio analysis**

Improved block ratio for the *shortest path only* routing policy

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10 OpenFlow switches in the ring
Routing path analysis

Improved block ratio for the shortest path only routing policy

4 OpenFlow switches in the ring
Literature contributions for SDMN
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- Mobile backhaul network
- Use cases
- Congestion control
  - Venmani et al. 2012
- Mobility Management
  - Gurusanthosh et al. 2013
Literature contributions for SDMN

Mobile backhaul network

Use cases

Congestion control

Mobility Management

Pentikousis et al. 2013

Tunnel-based

Kempf et al. 2012

Tag-based

Hampel et al. 2013

Flow-based

Li et al. 2012

Jin et al. 2013

Mobile core network

Traffic routing

Venmani et al. 2012

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- **Mobile core network**
  - Traffic routing:
    - Traffic offloading
  - Traffic management:
    - Load balancing

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Mobile core network
- Traffic routing
- Traffic management
- Use cases

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Conclusions and future work

❖ **This paper shows…**

❖ How the OpenFlow protocol can be used to assist LTE traffic control management
  ❖ *Backhaul traffic routing*
  ❖ *Bearer admission control*
❖ SDMN literature review, focusing on backhaul and core networks

❖ **As future work…**

❖ Explore traffic control in heterogeneous networks
❖ Improve the proposed mechanisms to support UE mobility