ISAAR
a SDN enabled QoE Framework

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Motivation

• Experienced quality of Internet services is crucial for customer satisfaction
• QoE monitoring and enforcement is thus required for business success
• Aim: application specific differentiated handling of traffic flows for major Internet services
• 3GPP standard based procedures using dedicated bearers are hardly used today
• Default bearer differentiated flow handling is missing

→ Improved QoE measurement and enforcement framework required

→ ISAAR Framework (ISAAR = Internet Service quality Assessment and Automatic Reaction)

ISAAR augments existing QoS functions by flow based network centric QoE monitoring and enforcement functions
Architecture Overview

• Modular service specific QoE management architecture

• 3 functional components:
  • QoE Monitoring (QMON) – flow detection and assessment,
  • QoE Rules (QRULE) – policy rules and permission checking and
  • QoE Enforcement (QEN) – respective flow manipulation

• Interworking with existing QoS mechanisms
  • 3GPP PCC
  • Priority marking (DiffServ, Ethernet prio, MPLS prio)
  • Proprietary router QoS support (queueing, scheduling, shaping)
  • SDN based QoS support (e.g. through OpenFlow Action Sets)
Architecture Overview

ISAAR Framework Logical Architecture

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Architecture Components – QMON

QMON operation
- Flow classification
  - With and without DPI
  - Centralized / distributed
  - With SDN match and action rules
- Flow capturing
  - SDN support to tee out flows
- Flow Monitoring
  - Application specific KPI calculation

QMON output
- Flow Information and QoE estimation
  - currently implemented: “Video QoE estimation”
Architecture Components – QRULE

QRULE input
- Flow information and corresponding QoE estimation from QMON

QRULE operation
- Mapping input flow to service flow classes
- Check whether QoE enhancement is allowed by general operator policy
- Check whether QoE enhancement is allowed for this user and this flow class
- Determine Per Flow Behaviour (PFB) based on the Enforcement Database of QEN

QRULE output
- PFB specific commands for QEN for 3GPP PCC triggering and/or marking, shaping, dropping and even (SDN/LSP) path selection
Example: PFB commands for marking rules and SDN flow based path selection in high contention situations

<table>
<thead>
<tr>
<th>Media Type</th>
<th>Key Performance Indicator</th>
<th>IP DSCP</th>
<th>OpenFlow Actions</th>
<th>Ethernet Prio</th>
<th>MPLS Traffic Class</th>
<th>3GPP QCI</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Video</td>
<td>Buffer Level in Sec. Th1 &lt; t &lt; Th2</td>
<td>CS5 101 000</td>
<td>set normal priority</td>
<td>101</td>
<td>101</td>
<td>6 (or 4)</td>
<td>Mark in S/P-GW and eNodeB with high priority</td>
</tr>
<tr>
<td></td>
<td>Buffer Level in Sec. t &lt; Th1</td>
<td>“Expedited Forwarding (EF)” 101 110</td>
<td>Change path + set high priority</td>
<td>111</td>
<td>111</td>
<td>1</td>
<td>Mark in S/P-GW and eNodeB with highest priority</td>
</tr>
<tr>
<td></td>
<td>Buffer Level in Sec. Th2 &lt; t</td>
<td>“Best Effort (BE)”</td>
<td>set low priority</td>
<td>000</td>
<td>000</td>
<td>9</td>
<td>Mark in S/P-GW and eNodeB with default priority or even start dropping packets</td>
</tr>
<tr>
<td>Voice</td>
<td>Delay in ms</td>
<td>EF 101 110</td>
<td>Choose best path + set high priority</td>
<td>111</td>
<td>111</td>
<td>1 or 2</td>
<td>Mark in S/P-GW and eNodeB with highest priority or even Create dedicated bearer with QCI 1 or 2</td>
</tr>
<tr>
<td>Facebook</td>
<td>Page load time</td>
<td>CS5 101 000</td>
<td>Choose best effort path + set normal priority</td>
<td>101</td>
<td>101</td>
<td>6</td>
<td>Mark in S/P-GW and eNodeB with high priority</td>
</tr>
</tbody>
</table>
Architecture Components – QRULE / PFB Example

LTE Test 720p

buffered video time in s

packet time in s

LTE Test 720p

Buffer Level

Threshold 1

Threshold 2

normal priority

high priority

low priority

BE/LE marking

CS5 marking

EF or equivalent class marking

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Architecture Components – QEN

QEN input
- Flow information and QRULE action command set

QEN operation
- Register enforcement capabilities
- Execute flow manipulation via:
  - 3GPP – PCC (PCRF / PCEF)
  - IETF & IEEE priority marking
  - Automated router configuration with vendor specific QoS capabilities and settings
  - SDN capabilities for marking and Traffic Engineering (TE)
- Granularity: per-flow or per-class
  - PFB & class PHB / flow & class TE
Architecture Components – QEN

QEN flow manipulation options

- 3GPP – PCC (PCRF / PCEF)
  - QCI marking and/or dedicated bearer setup
- IETF & IEEE priority marking
  - IP Diffserv, Ethernet priority, MPLS traffic class priority without the need to change the configuration of network elements
  - Synchronized inside/outside GTP tunnel & IPSec tunnel marking
- Automated router configuration with vendor specific capabilities and settings
  - Cisco / Juniper specific router configuration with flow-specific rules for scheduling, shaping, dropping as well as path (LSP) selection
- SDN capabilities for marking and TE
  - marking via OpenFlow switch action list configuration
  - flow-specific traffic engineering (LSP selection or flow-specific forwarding paths)
Architecture Components – Placement of Components

QMON – depends on processing power and route pinning
QRULE – at core site with distributed copies
QEN – full path to

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Signalling and Interfaces

- ISAAR can be deployed in a distributed fashion - therefore signalling is needed
- ISAAR internal signalling
  - Information exchange between functional components
  - Coordination of probes and enforcement
  - Change of flow specific router/switch configuration
- ISAAR external signalling
  - Interworking with 3GPP (Gx, Gxx, Rx, Sd etc.)
  - Interworking with SDN – (OpenFlow API)
  - Interworking with MME for location aware monitoring
    - monitored flows <-> actual flows → probe selection and assumption that neighbouring flows experience similar QoE
    - location awareness for correlation of bad QoE with geographic location and/or network topology location
Summary

- ISAAR addresses QoE management for Internet based services
- 3 components (QMON, QRULE, QEN) to monitor and manipulate flows
- Location aware service flow observation and steering
- Interworking with 3GPP PCRF/PCEF (but ISAAR is also able to work independently of 3GPP QoS functionality)

- SDN enhances ISAAR in multiple ways:
  - Ease of flow detection by detailed matching capabilities
  - Ease of flow separation for monitoring
  - Ease of enforcement by priority marking and/or flow specific path selection