Mobile Network QoS Management From Network Centric Operations to Experience & Service Centric Operations

Expresso Senegal
March-2018
Introduction: Quality of Services Challenges for Operators

• Maximize the utilization of offered services.
• Increase the revenues.
• Stay better than competitors.
• Develop and experience new scalable services.
• Optimize the network performance.
• Ensure and improve the Return On Investment (ROI).
Traditional QoS Management: Network centric Operations

Performance Monitoring (OSS KPI)
- Drive Testing and Post Processing
- Analysis and Network data Updating
- Customers Complaints Follow-up

2G
- Radio KPIs analysis and Control
- Coverage and Interference Analysis
- Mobility and Intersystem Interoperability Analysis
- Network Integrity and Capacity Auditing
- Pilot Pollution Control
- Layer 3 analysis for failed events (set-up, Drop…) network or UE based
- Cluster optimization and replanning

3G
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Low Throughput causes analysis
- Functions Upgrade & follow-up

Probe/TEMS
U2000
Cluster optimization and replanning
Performance Monitoring and root cause follow-up: KPI based

Focus of Network Engineer

- Calls: 7500
  - Drop Call Rate: 1.5%
  - Data Drop: 1.3%

- Calls: 8750
  - Drop Call Rate: 0.8%
  - Data Drop: 1.8%

- Calls: 6150
  - Drop Call Rate: 0.75%
  - Data Drop: 1.2%

- Calls: 9720
  - Drop Call Rate: 2.3%
  - Data Drop: 3.6%

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  - Data Drop: 1.2%

- Calls: 9720
  - Drop Call Rate: 2.3%
  - Data Drop: 3.6%

- Calls: 10300
  - Drop Call Rate: 1.2%
  - Data Drop: 0.8%

- Calls: 11200
  - Drop Call Rate: 1.6%
  - Data Drop: 0.3%

- Calls: 5400
  - Drop Call Rate: 3.5%
  - Data Drop: 4.1%

- Calls: 8500
  - Drop Call Rate: 0.5%
  - Data Drop: 1.1%

- Calls: 6700
  - Drop Call Rate: 3.3%
  - Data Drop: 2.8%

- Calls: 8500
  - Drop Call Rate: 1.7%
  - Data Drop: 1.4%

- Calls: 10800
  - Drop Call Rate: 1.2%
  - Data Drop: 1.33%

- Calls: 7350
  - Drop Call Rate: 1.3%
  - Data Drop: 1.5%

- Calls: 9500
  - Drop Call Rate: 1.2%
  - Data Drop: 1.6%

> 2% Drop Threshold Set by SLA
PM and root cause follow-up: Enhanced KPI based, TopN

<table>
<thead>
<tr>
<th>Calls</th>
<th>Drop Call Rate</th>
<th>Data Drop</th>
<th>Focus of Network Engineer</th>
</tr>
</thead>
<tbody>
<tr>
<td>7500</td>
<td>1.5%</td>
<td>1.3%</td>
<td>TopN Cells/sites with Highest CDR</td>
</tr>
<tr>
<td>8750</td>
<td>0.8%</td>
<td>1.8%</td>
<td></td>
</tr>
<tr>
<td>6150</td>
<td>0.75%</td>
<td>1.2%</td>
<td></td>
</tr>
<tr>
<td>9720</td>
<td>2.3%</td>
<td>3.6%</td>
<td></td>
</tr>
<tr>
<td>10300</td>
<td>1.2%</td>
<td>0.8%</td>
<td></td>
</tr>
<tr>
<td>1200</td>
<td>1.6%</td>
<td>0.3%</td>
<td></td>
</tr>
<tr>
<td>5400</td>
<td>3.5%</td>
<td>4.1%</td>
<td></td>
</tr>
<tr>
<td>8500</td>
<td>0.5%</td>
<td>1.1%</td>
<td></td>
</tr>
<tr>
<td>8500</td>
<td>1.7%</td>
<td>1.4%</td>
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<td>1.6%</td>
<td></td>
</tr>
<tr>
<td>8500</td>
<td>1.7%</td>
<td>1.4%</td>
<td></td>
</tr>
</tbody>
</table>
Performance Monitoring and root cause follow-up: Alarm based

Start

Fault happens

Fault Detection & Confirmation: NSM or FM

Escalation Analysis by Front Office

Front Office

TT assigned to FO

Solved

Yes

No

Confirmation from FO

End

No

Yes

Back Office

TT assigned to BO

Solved

Yes

No

Escalade to third Level

FO / BO / FM

TT assigned to FM

Solved

Yes

No

Close Trouble Ticket

Field maintenance
Drive Testing and Post Processing: Coverage Issue in 3G

- **Dive Test Measurement**
  - **Best Server’s CPICH > -90 dBm**
    - **Yes**
      - **Coverage Area Optimization**
    - **No**
      - **Coverage Problem Area**
        - Antenna Tilting/ High change
        - Pilot Power increase
        - Hardware Change
        - Missing Neighbors analysis
        - Pilot power of Neighbors analysis

- **Dominance Area Optimization**
  - **Yes**
    - 4th Best Server’s Ec/Io < 6 dB
      - **Yes**
        - **Complete Measurement Analysis**
      - **No**
        - **Dominance Area Optimization**
  - **No**
    - **Dominance Problem area (Low best server Ec/No)**
    - **Dominance Problem area (High best server Ec/No)**
Analysis and Change Implementations

Collection of Users Complaints

Radio Performance audit

RF Parameters Audit

Traffic Analysis

Physical Sites Parameters Audit

Competitive Benchmark Audit

End to End Audit Report

Core

Transport

RAN

Mutual Optimization Plan

Cluster Network Optimization

Post Optimization Drive Test

Is the Cluster Optimized

Yes

No

• Cell
• cluster
• Complain
• Voice call
• Throughput

Ranking

Worst Cluster

Traffic Analysis

Physical Sites Parameters Audit

Competitive Benchmark Audit

End to End Audit Report

Transport

RAN

Is the Cluster Optimized

No
Enhanced QoS Management: Experience & Service Centric Operations

With the development of mobile networks, customer needs and behaviors have changed. Mobile communications means so much more than simple voice communication; there is now mobile Internet with web surfing, video phone, streaming media, and microblogging. Focusing on traditional KPIs only are no longer adequate for measuring the quality of mobile services. The objective of network optimization has gradually shifted from enhancing network performance to improving quality of experience (QoE). Therefore, assessing and optimizing QoE is the trend for optimizing today mobile networks.
Traditional Evaluation Method KPI ≠ End-users’ Experience

- Individual user experience is flooded in average KPI
  - Drop Call Rate 0.0846% (excellent)
  - The real situation (cell 129)
    - 4 people dropped call >= 2 times in 3 hours
    - 2 people dropped all the calls

- Lack of subjective service quality monitoring
  - e.g. MOS(DT test) can evaluate end user's accurate experience directly, but just sample measurement. Many user’s may have bad experience, such as noise, echo...still out of monitoring.

- Element KPI ≠ E2E service success rate
  - Every domain is excellent
  - 40%: End-user service successful rate

<table>
<thead>
<tr>
<th>KPI</th>
<th>Value</th>
<th>Compliants</th>
<th>Example Times (GSM /a month)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MOS (DT test)</td>
<td>3.6</td>
<td>Vague audio</td>
<td>288</td>
</tr>
<tr>
<td></td>
<td>(Excellent)</td>
<td>One-way audio/noise/echo/...</td>
<td>412</td>
</tr>
</tbody>
</table>

How can we define and manage the end-users’ experience?
Experience & Service Operations View

Operational Use Cases

Calls – 7500
Drop Call Rate – 1.5%
Data Drop – 1.8%

Product Planning & Campaign

Who are impacted by: Call Drop/Call Failure/Data Access Failure/Data Drop/Low Throughput

Has anyone experienced failure?

Hot Spots & HVC Focus Operations

Customer Centric View & Proactive Action

How many individual subscribers made the calls

How many are Corporate/Mass, what is their CEI

Service Mix & OTT Service Management

Device Performance

Which are devices that are being used

Data & Voice

Iphone

Ipod

Ipad

Samsung galaxy S3

Network Investment & Optimization

Which are services that are failing

Data & Voice

Voice

Video Call

Experience & Service Operations View

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Which are services that are failing

Data & Voice

Voice

Video Call
Assessment of a set of QoE KPIs (Technical)

- Excellent/Good/Fair/Poor/bad
- Coverage/ Accessibility/ Retainability/ Integrity
- Streaming Service Setup Success Rate
- Streaming Service Setup Delay
- Streaming Service Download Completion Rate
- RRC Connection Setup Success Rate
- TBF Setup Success Rate
- Attach Success Rate
- PDP context Activation Success Rate
- Streaming Server Connection Success Rate
- ...
What is the correlation between QoS and QoE?

• Technical Correlation
  ➢ Possible through convergent indicators

• Perception Correlation
  ➢ Difficult but possible

• Methodology
  ➢ Identify QoS indicators/parameters, technically measurable and influencing the QoE
  ➢ Use intrusive measures (with a reference)
  ➢ Evaluate both indicators and quality perceived by the user (QoE)
  ➢ Establish formulas for calculating QoE through QoS indicators
  ➢ Apply methods to non-intrusive measures

• Advantages
  ➢ Estimate the QoE based on network indicators without the need for intrusive measures

• Limits
  ➢ Requires adaptation to the effects external to the user (regulator)
Factors (aspects) Affecting the QoE

• Technical
  - The specific expectation of the user in terms of quality indicators
  - Technologies’ trend
  - Users’ equipment

• Users perception
  - The present particular context of the user (need, mood, physical state ...)
  - Living standard (price)
  - The social environment (culture, intellectual level, customs, ...)
  - User experience in the network or other networks
  - Fashion and trends
  - Advertising offers/products (including those of competitors)
Exemple of Parameters

**Voice quality**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Causes</th>
<th>Impact on QoE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Call Establishment Failure</td>
<td>Various causes (Radio or core network)</td>
<td>customer dissatisfaction</td>
</tr>
<tr>
<td>Echo</td>
<td>Transmission issue</td>
<td>Poor listening</td>
</tr>
<tr>
<td>Distortion</td>
<td>Interferences</td>
<td>Hearing difficulties</td>
</tr>
<tr>
<td>Background noise</td>
<td>Wrong network configuration</td>
<td>Hearing difficulties</td>
</tr>
<tr>
<td></td>
<td>Equipment out of date (EOM, EOS)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bad interconnection of network elements</td>
<td></td>
</tr>
<tr>
<td>Call drops</td>
<td>Various causes (Radio or core network)</td>
<td>customer dissatisfaction</td>
</tr>
</tbody>
</table>
### Exemple of Parameters

#### Data quality

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Cause</th>
<th>Effect</th>
<th>Impact on QoE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Packets loss</td>
<td>Transmission error</td>
<td>Packets retransmission</td>
<td>Navigation delay</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Low download speed</td>
</tr>
<tr>
<td>Latency (end-to-end delay)</td>
<td>Queuing Congestion</td>
<td>Delay on real time application</td>
<td>Impossibility for online gaming</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lag of image for video surveillance</td>
</tr>
<tr>
<td>Jig</td>
<td>Different root Algorithm different from network nodes</td>
<td>Packets arrive on wrong order Waiting reordering</td>
<td>Navigation delay</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Low download speed</td>
</tr>
</tbody>
</table>
## Exemple of Parameters

**Video quality**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Cause</th>
<th>Effect</th>
<th>Impact on QoE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time of first slow image appearance</td>
<td>Bad Buffer Sizing</td>
<td>Wide waiting before the image starting</td>
<td>Wide waiting before the image starting</td>
</tr>
<tr>
<td>Availability of the video</td>
<td>Server congestion</td>
<td>Flow of video non continuous</td>
<td>Video stop</td>
</tr>
<tr>
<td></td>
<td>Slow transmission link</td>
<td></td>
<td>Video shift</td>
</tr>
<tr>
<td>Resolution and Frame rate (Image per second)</td>
<td>Bad dimensioning of the resolution vs user bit rate</td>
<td>inadequate transmission channel to route video</td>
<td>Delays, stopping video</td>
</tr>
<tr>
<td>Codec used</td>
<td>Bad compression, so more data</td>
<td>inadequate transmission channel to route video</td>
<td>Delays, stopping video</td>
</tr>
<tr>
<td>Poor delivery of video</td>
<td>Wrong sizing/configuration of application reader</td>
<td>Poor flow synchronization</td>
<td>Cut-off/ stopping the video</td>
</tr>
</tbody>
</table>
Converting from KPI to QOE

**QoE**

- Defined by Service type:
  - Voice quality: accessibility, call drop, speech quality
  - WEB quality: accessibility, web delay, download speed
  - SMS quality: accessibility, access delay
  - ...

- Defined by Network domain:
  - Wireless network performance
  - Core network performance
  - IP network performance
  - Transmission network performance
  - Service system performance
  - ...

**Experience on Marketing**

**Experience on Management**

**Experience on KQI**

**Network KPI**

- User Perception

- User QoE

- Experience on KQI

- Experience on Network Performance

**Core network / VAS KPIs**

**Bearer network KPIs**

**Radio KPIs**

- Voice services KQIs

- Data services KQIs

**KQIn=f (KPI1, KPI2, ..., KPIn)**

- KQEn=g (KQI1, KQI2, ..., KQIn)

- QoEn=g (KQI1, KQI2, ..., KQIn)=gf (KPI1, KPI2, ..., KPIn)

**Core network / VAS KPIs**

- MSC/MGW

- Node B

- RNC

**Foundation**

**Additional Data**

- Establish QoE Evaluation System

- Set up QOE, KQI, KPI mapping relationships

- Focus more on KQI than KPI

- Transformate from Objective KPIs to Subjective QoE
initialized with default weight value & benchmark for KQIs, yet need to get agreement with operator.

Automatically generate optimization report and send out alarm information immediately for poor QoE status.

\[
QoE = 4 \times 40\% + 3 \times 10\% + 4 \times 10\% + 3 \times 25\% + 4 \times 15\% = 3.65, \text{Good}
\]
Estimate the global QoE

**Example of weighting by Indicator**

- Identify consumer preferences (surveys):

<table>
<thead>
<tr>
<th>Coverage</th>
<th>Voice</th>
<th>QoS</th>
<th>QoE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30%</td>
<td>80%</td>
<td>24.00%</td>
</tr>
<tr>
<td>Accessibility</td>
<td>25%</td>
<td><strong>97.18%</strong></td>
<td>24.30%</td>
</tr>
<tr>
<td>Retainability</td>
<td>25%</td>
<td>98.58%</td>
<td>24.65%</td>
</tr>
<tr>
<td>speech quality</td>
<td>20%</td>
<td>90.87%</td>
<td>18.17%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>91.11%</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Voice (streaming)</th>
<th>Video QoS (DT)</th>
<th>QoE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time of video starting</td>
<td>40%</td>
<td>85%</td>
</tr>
<tr>
<td>Intermittent Stop of Video</td>
<td>30%</td>
<td>90%</td>
</tr>
<tr>
<td>Video image quality</td>
<td>20%</td>
<td><strong>96%</strong></td>
</tr>
<tr>
<td>Voice quality of the video</td>
<td>10%</td>
<td>98%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SMS</th>
<th>QoS</th>
<th>QoE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Originating Successful</td>
<td>40%</td>
<td><strong>97%</strong></td>
</tr>
<tr>
<td>Terminating Successful</td>
<td>40%</td>
<td>95%</td>
</tr>
<tr>
<td>Reception duration</td>
<td>20%</td>
<td>90%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Data (DT)</th>
<th>QoS</th>
<th>QoE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Connection establishment</td>
<td>30%</td>
<td>95%</td>
</tr>
<tr>
<td>email reception successful</td>
<td>20%</td>
<td>98%</td>
</tr>
<tr>
<td>email sending successful</td>
<td>20%</td>
<td>93%</td>
</tr>
<tr>
<td>continuous http navigation</td>
<td>15%</td>
<td>95%</td>
</tr>
<tr>
<td>download speed</td>
<td>15%</td>
<td><strong>85%</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Establish a weighting grid by service to obtain an assessment of the client's feel (QoE)
Each level has around 3 KQIs, and each of the KQIs will be evaluated subjectively with the attached template.
QoE Monitoring Tools

- **Application layer tools**
  - E.g. Ping, FTP, HTTP browsing, MMS, SIP, WAP, etc...

- **Field measurement tools**
  - Radio measurements + application layer performance

- **Protocols analyzers**
  - Protocol stack performance analysis at any interface

- **Mobile QoS Agents**
  - L1-L7 measurements, position and location
  - Active and passive measurements
Mobile Quality Agent (MQA)

- **Measuring** mobile multimedia service quality, radio parameters, and producing **and reporting performance** statistics to central management servers.

- **Active probing** and/or **passive monitoring**, which turns thousands of commercial mobile phones into (secure and non intrusive) service quality probing stations.

- A **central management server** derives KPIs out of the reports from QoS agents, and manages QoS agents, i.e. dynamically dispatches, installs, and activates or deactivates them.
Mobile Quality Agent: Nemo CEM

**Radio Conditions**
- No Coverage detection
- WIFI Connectivity

**Localisation**
- GPS or Network
- Indoor/outdoor

**Device Information**
- Brand/Model
- OS
- SIM information and status
- Battery, Storage, RAM, CPU

**Cross Operators**
- Benchmark
- Roaming

**Data**
- Performances from device
- Volume per application

**User Interaction**
- Ticketing
- Surveys
Mobile Quality Agent: Nemo CEM

Privacy protection

- **User opt-in required to install agent**
- **No content and personal data collection**
- **Option to activate full anonymous mode**
- **User can uninstall agent anytime**
- **User can deactivate data collection**
- **User can deactivate geolocation**

Nemo CEM is under full user's control
Device Performance Analysis

This document presents results of the Nemo Customer Experience Monitor trial performed by Expresso Senegal between January 1\textsuperscript{st} 2018 and February 20\textsuperscript{th} 2018.

During that period, the following number of samples have been collected:
Device Performance Analysis

Call Setup Success Rate (%)

Averaged Web Page Loading Time per Device

Call Success rate per day

SMS Time to Network (s)
Device Performance Analysis

Best Technology available

Voice Call Success

Failure
Think, work and act as one team to meet our customers’ dreams