New Testing Paradigm for 5G – IoT Ecosystem

ITU-T QSDG Workshop
Brazil, 27th-29th November
Who we are

InfoVista provides cost-effective network performance orchestration solutions that help our customers provide top-quality user experience while increasing the capital efficiency of their networks.

Best in class solutions for all networks

6 times Gartner Visionary

Enterprises
automatically guarantee business-critical application performance over the secured hybrid-infrastructure, while reducing telecom costs.

#1 in Business Services

Communications Service Providers
maximize the monetization of high-value IT services to business customers at the lowest possible costs.

Over 20 years of leadership

Mobile Operators
reduce costs, boost quality, and prepare for a 5G future with solutions for the entire network and service life-cycle, across the transport, mobile core, and radio network.
Agenda

• 5G – IoT ecosystem at a glance
• Requirements and strategy for 5G quality testing
• A testing approach for IoT QoS/QoE
• Take aways
5G – IoT Ecosystem at a Glance
IoT ecosystem at a glance: Use Cases

Usage scenarios of IMT for 2020 and beyond

Enhanced mobile broadband

Gigabytes in a second

3D video, UHD screens

Work and play in the cloud

Augmented reality

Industry automation

Mission critical application

Self driving car

Future IMT

Massive machine type communications

Ultra-reliable and low latency communications
IoT ecosystem at a glance: Requirements

- **Data rate**
  - 10 X (avg. & peak)
  - 100 X (cell edge)
  - Peak > 10 Gbps

- **Mobility**
  - 1.5 X (walking to 500 km/h)

- **Devices**
  - Programmable/Configurable, Multi-band/mode

- **Battery**
  - Energy savings & cost reductions*

- **Latency**
  - 10 X (avg. & peak) RAN latency < 1 ms

- **Users (eMBB) /devices (IoT)**
  - Context aware, User-centric

- **Massive connectivity**
  - Aggregation of networks, highly flexible and scalable**

- **Networks**
  - Densification, aggregation of networks, highly flexible and scalable**

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*Vs. 3GPP Rel.12; ** no single solution to satisfy all these extreme requirements at the same time
5G – IoT ecosystem relies on its legacy to 4G

5G New RAN (NR) above 6GHz and mmW
(new air interface including some LTE-Pro concepts e.g. Cell Range Expansion, control/user plane split, Coordinated Multipoint CoMP, reduced L2 signaling)

5G capabilities (latency and throughput) with LTE-Pro RAN technology features (e.g. massive MIMO, beamforming, higher order coding, DL/UL CA) (sub 6GHz)

5G New Core (NC) – Rel 2018+
5G Standalone (NR, NC)
5G Non Standalone (5G NR, LTE core) with multiconnectivity
5G capabilities (latency and throughput) with Licensed and Unlicensed spectrum (LTE-U/eLAA; LTE-WiFi interoperability, dual connectivity)

Legacy and 5G Network Slicing
per 5G type of use case and/or vertical:
- eMBB, Massive connectivity IoT
  (legacy: LoRa NB-IoT, LTE-M based, EC-GSM), Mission critical IoT
  (legacy: connected cars, V2X communications)

Legacy and 5G Virtualization; SDN/NFV requiring Mobile edge computing and distributed cloudification
(used in networks as well as testing tools)
- D2D communications

Legacy and 5G
Big Data Analytics; Automation, Machine Learning and Artificial Intelligence
(used in networks as well as testing tools)
Requirements and Strategy for 5G Quality Testing
Requirements and strategy for 5G quality testing

**Quality test use cases to cope with**

<table>
<thead>
<tr>
<th>Test conditions and use cases</th>
<th>Architecture changes</th>
<th>QoE context awareness concept</th>
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<tbody>
<tr>
<td>Enhanced Mobile Broadband</td>
<td></td>
<td>User Context</td>
</tr>
<tr>
<td>Area Traffic Capacity</td>
<td></td>
<td>User’s perception and preferences (quality, location, activity)</td>
</tr>
<tr>
<td>Over the Air Latency</td>
<td></td>
<td>Device context</td>
</tr>
<tr>
<td>Connection Density</td>
<td></td>
<td>CPU load, battery state, device characteristics</td>
</tr>
<tr>
<td>High Mobility</td>
<td></td>
<td>Application context</td>
</tr>
<tr>
<td></td>
<td></td>
<td>QoE metrics, video specific parameters (on demand vs. real time), bit rate, resolution</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Network context</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Load/congestion, air link/backhaul quality, timely available BWD, alternative network/spectrum availability</td>
</tr>
</tbody>
</table>

**Future Architecture**
- Device Centric
- Smarter Devices

**Current Architecture**
- Cell Centric

5G Context Aware QoE
- User
- Device
- Application
- Network

Orchestrating network performance
5G-IoT quality defined by service centric / network sliced quality testing – required pieces

- Statistical sampling and aggregation
- Data mining techniques
- Statistical decision (hypothesis testing)
- Optimization methods

- End user (mobile probes)
- Infrastructure (fixed probes, event logs, counters)
- Traffic (fixed probes)
- Benchmarking (mobile & fixed probes)

- User profile (QoE policies and req.)
- Target SLAs (CAPEX/OPEX req.)
- Competitive awareness (benchmarking)

Network diagnosis flowcharts at air interface, core, and application levels (top-down approach based on end-user to network service mappings)

Healing flowcharts and procedures

Quality profile definition (per network slice)

End-user to network service mappings (per network slice)

Quality Analysis and Processes

Intelligent Algorithms

Needed data sources

NOTE: “per network slices” meaning eMBB services (e.g. TEMS video streaming solutions), IoT critical and/or massive applications (e.g. TEMS use case LoRAWAN)

• KPI to QoS (network), to respective QoE (end-user), per service
• KPI, QoS, and QoE profiles per time and space scale
TEMS 5G testing approach – performance orchestration platform

Aligned with draft recommendation E.FINAD “Framework for Intelligent Network Analytics and Diagnostics”, TD 307 (TEMS contributors)

- Operations (FM, resources, licensing etc.)
- Storage of raw data,
- Real-time dashboards,
- Real-time analytics
- Monitoring statistics reports/views
- Alarms
- RCA on Real-time data

TEMS Discovery
Insightful Post Processing & Analysis of TEMS & 3rd party results

TEMS Post Processing Product
- Powerful off-line analytics
- Multi data format
- Desktop and Enterprise versions

Data Collection

Mobile Device  TEMS Case  TEMS Panel  Laptop  TEMS Remote  TEMS Backpack
Demo case for NR: Foreseen RAN centric primary testing use cases

**Test scenarios:** scanners and devices (when available)

1. Walking test probes within the desired mmW access coverage (indoor, outdoor) - various conditions.
2. Drive test probes within the desired mmW access coverage (outdoor) performed in various conditions.
3. Dedicated drive test probes crossing 5G NR – LTE coverage areas – various conditions
4. Dedicated drive tests for multiRAT and eLAA integration evaluation, troubleshooting

**Test conditions**

- See 5G TF for mmw case
- Highway, trains, urban/suburban/rural
- Different configurations (for AAS gain evaluation vs. traditional antennas) – if possible
- Sub6GHz case won’t require weather and/or season dependency testing

**General scope:** ensure min. req. performance per 5G use cases (eMBB/Rel15 focused)

1. Radio ubiquity/presence and efficiency (scanners/devices based coverage)
2. Radio continuity (mobility), Dual connectivity / LTE-NR coexistence
3. Interference control and optimization (!)
4. RAN performance / efficiency (in terms of min. requirement to meet all services’ demands of bandwidth/throughput, latency
5. MultiRAT inter-working / continuity (!)
A View on IoT QoS/QoE
### Connected devices forecast

**Ericsson Mobility Report**  
*June 2016*

<table>
<thead>
<tr>
<th></th>
<th>2015</th>
<th>2021</th>
<th>CAGR 2015-2021</th>
</tr>
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<tbody>
<tr>
<td>Cellular IoT</td>
<td>0.4</td>
<td>1.5</td>
<td>27%</td>
</tr>
<tr>
<td>Non-cellular IoT</td>
<td>4.2</td>
<td>14.2</td>
<td>22%</td>
</tr>
<tr>
<td>PC/Laptop/Tablet</td>
<td>1.7</td>
<td>1.8</td>
<td>1%</td>
</tr>
<tr>
<td>Mobile Phones</td>
<td>7.1</td>
<td>8.6</td>
<td>3%</td>
</tr>
<tr>
<td>Fixed Phones</td>
<td>1.3</td>
<td>1.4</td>
<td>0%</td>
</tr>
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15 billion → 28 billion
IoT at a glance

A range of technologies for a range of applications within mission critical and massive communications context

<table>
<thead>
<tr>
<th>Use Cases</th>
<th>Surveillance</th>
<th>Connected cars, connected homes</th>
<th>Smart meters, agriculture, transportation, environment, health care, industry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Requirements &amp; Constraints</td>
<td>THROUGHPUT</td>
<td>LATENCY</td>
<td>COST</td>
</tr>
<tr>
<td>Technology</td>
<td>Lte Cat-1</td>
<td>Lte Cat-M</td>
<td>Lora</td>
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</tbody>
</table>
An IoT quality testing strategy

- **STEP 1.** IoT verticals: trace based coverage, connectivity and availability monitoring and user directed troubleshooting
- **STEP 2.** IoT verticals (SLAs and QoE centric) use case solutions for automated root cause analysis
  - Performance (throughput, latency within QoS aware scheduler’s context), availability and consistency
  - RAN resources and performance stress (cellular IoT)
IoT testing questions and InfoVista/TEMS preliminary answers

- Is the (NB/LTE-M)-IoT cell configured as planned?
- Does the network perform as expected?
  - What is the coverage?
    - Enough to receive NPSS and NSSS and use received signal power and quality…
    - …or to test a traffic transfer and measure BLER…
    - …or is something else required?
  - Are all procedures executed as expected?
    - Perform tests (containing the different procedures) and verify signaling
  - Performance in regards to throughput and latency?
    - Run the services and verify the results
- Is legacy LTE performance affected?
IoT testing enhancement in our products

- Support for more NB-IoT devices
- Support for NB-IoT scanner
- Predefined monitors and workspaces
- NB-IoT technology enhancements (IEs, events, …)
- Control functionality
  - RAT, band and EARFCN/PCI lock.
IoT QoS/QoE testing

**NB-IoT**
- Connectivity (indoor, outdoor) based on L3 decoding of NB-IoT/LTE-M signaling
- Coverage validation and performance (indoor, outdoor)
- Latency, UL/DL peak rate
- Battery life (PowerSavingMode, eDRX activity %)
- Unique QoE model (under research)

**LTE-M**
- Mobility performance (indoor, outdoor)
- LTE-M voice service support (call control and performance MOS)
Take Away
Take away

1. 5G – IoT ecosystem’s use cases variety, technologies complexity and interdependencies require testing paradigms which regard not only the technology (r)evolution but also radical shift in testing procedures and methodologies.

2. Automation, analytics, user/device centric and context aware become crucial for the 5G–IoT ecosystem quality.

3. TEMS proves once again thoughtful leadership with foreseen 5G preliminary test use cases and novel modeling of QoE IoT testing.