Challenges of 5G Ultra Reliability

Li Dehan
HUAWEI RAS Technical Expert

ETR -RT 2018
Contents

1. What is 5G Ultra-high Reliability
2. Challenges of 5G Ultra-high Reliability
3. Solutions for 5G Ultra-high Reliability
4. Q&A
Typical Usage Scenario for 5G

- URLLC scenario will bring big change for telecom network architecture. Ultra-reliable is the basic requirement for entering mission critical vertical industry.

## Vertical Industry Requirements

- Vertical industry like Factory of the future has ultra-high reliability, ultra-high availability, and SIL3 (PFH < 10\(^{-7}\)/h) safety requirement.

<table>
<thead>
<tr>
<th>Use Case</th>
<th>Requirement text</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Factories of the Future</strong></td>
<td></td>
</tr>
<tr>
<td>Motion control</td>
<td>The 5G system shall support communication service availability exceeding at least 99.9999%, ideally even 99.999999%.</td>
</tr>
<tr>
<td></td>
<td>The 5G system shall support UE speeds up to 20 m/s, even for communication services with ultra-low latency and <strong>ultra-high reliability</strong>.</td>
</tr>
<tr>
<td></td>
<td>The cyclic data communication service of the 5G system shall be able to support satisfy the safety requirements according to [* ] for safety integrity level 3 (SIL-3).</td>
</tr>
<tr>
<td>Control-to-control communication (motion subsystems)</td>
<td>The 5G system shall support communication service availability exceeding at least 99.9999%, ideally even 99.999999%.</td>
</tr>
<tr>
<td></td>
<td>The cyclic data communication service of the 5G system shall be able support to satisfy the safety requirements according to [ * ] for safety integrity level 3 (SIL-3).</td>
</tr>
<tr>
<td>Mobile control panels with safety functions</td>
<td>The 5G system shall support a communication service availability exceeding at least 99,9999%, ideally even 99,999999%.</td>
</tr>
<tr>
<td>Process automation – process monitoring</td>
<td>The 5G system shall support a communication service availability of about 99,99 % with a data transmission in intervals between 50 ms up to several seconds.</td>
</tr>
</tbody>
</table>

*Sources:* 3GPP TR 22.804 V1.0.0, Study on Communication for Automation in Vertical Domains

Ultra-reliable of Radio Interface

- Many research target on packet loss rate of radio interface
  - Packet duplication [Popovski] *
  - Multi-connectivity [Fettweis]
  - Diversity-oriented approaches

Sources: Petar Popovski, Research Challenges towards Ultra-Reliable Wireless Communications

* Mehdi Bennis, Building the foundations of Ultra-Reliable and Low Latency wireless communication
Automotive / Factory slicing will have edge cloud in the network, we will have big problem to ultra-reliable requirements.
Challenge of 5G Ultra-high Reliability

For target 5G Ultra reliability, we need to reach telecom grade cloud reliability at first.
DFR in Cloud

- Telecom cloud has same cloud native architecture with public cloud, but all the DFR technology need to be enhanced to meet the telecom grade reliability requirement.

**DFR**

- **Architecture**
  - Stateless VNF
  - Distribute DB
  - LB Pool
  - Redundancy
  - Multi-DC/Region

- **Fault Management**
  - Fault prevention
  - Fault detection
  - Fault localization
  - Fault isolation
  - Self-healing

- **Overload Control**
  - Auto scale in/out
  - Service Degradation
  - Service Rejection

- **Hitless Upgrade**

DFR: Design For Reliability
Fault Detection: DeCentralized HA (DCHA)

- Fast fault detection is the basic feature for guarantee telecom grade reliability.
  - VM Cluster Failure detection time 10+s or even 30+s, will cause service interruption (call drops).
  - COTS & large scale will make failures more frequently, then service interruption (call drops) worsen much more.
  - DCHA supports sub-second VM failure detection.

**Centralized Failure Detection**

**Decentralized Failure Detection**

COTS failure is normal, DON’T let it make service interruption become normal.
Self-healing: Fault Intelligent Self-Healing (xFISH)

- Intelligent self-healing service provides best self-healing strategy, can support Zero Touch fault management in Cloud.
Fast prevention: DM Failure Analysis for gray failure prediction (DMFA)

- The fault of hardware which has life limitation (hard disk) can be predicted. System degradation also can be predicted.

- 20% failures → 80% business impact
- Hard to detect, diagnose and recovery

COTS/Decoupling/Virtualization of NFV will make it worse and more challenging

“Gray Failure: The Achilles’ Heel of Cloud-Scale Systems”
Peng Huang, Chuanxiong Guo, Lidong Zhou, etc. HotOS ‘17
Fault Localization: Converged Localization Flow-based ML (CLFM)

- Cross layer fault localization is one of the biggest challenge in the NFV.
- CLFM uses Hierarchical unsupervised machine learning to localize typical fault in the NFV cloud in one second.
Overload Control: Intelligence OverLoad Control in cloud (IOLC)

- Predict the service change, automatic scale out to avoid overload in the cloud
  - OLC inside VNF must guarantee the VNF can survive before automatic scale out.
  - If the resources in the pool is limited, IOLC can borrow resources for overload VNF from other VNF which is not busy.

![Diagram of Overload Control in a Resources Limited Cloud](image)
From “5 9s “to “6 9s” and SIL 3

- But how to reach ultra high availability and SIL 3? We still need to borrow some ideas from safety critical industry.

<table>
<thead>
<tr>
<th>Software HA Architecture and Technology</th>
<th>Telecom Cloud</th>
<th>Safety Critical *</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Stateless VNF</td>
<td>• Fault Detection &amp; Diagnosis</td>
</tr>
<tr>
<td></td>
<td>• Distributed Database</td>
<td>• Error Detecting Codes</td>
</tr>
<tr>
<td></td>
<td>• LB Pool</td>
<td>• Diverse Monitor</td>
</tr>
<tr>
<td></td>
<td>• All Active Disaster Recovery</td>
<td>• Functionally Diverse Redundancy</td>
</tr>
<tr>
<td></td>
<td>• DCHA</td>
<td>• Stateless Software</td>
</tr>
<tr>
<td></td>
<td>• XFISH</td>
<td>• Graceful Degradation</td>
</tr>
<tr>
<td></td>
<td>• DMFA</td>
<td>• Static Resources Allocation</td>
</tr>
<tr>
<td></td>
<td>• IOLC</td>
<td>• Semi-formal Methods</td>
</tr>
<tr>
<td></td>
<td>• CLFM</td>
<td>• Formal design and refinement Methods</td>
</tr>
<tr>
<td></td>
<td>• VM/Container Fault Isolation</td>
<td>• Event tree analysis</td>
</tr>
<tr>
<td></td>
<td>• Grey Upgrade</td>
<td>• Fault tree analysis</td>
</tr>
<tr>
<td></td>
<td>• FMEA/FTA</td>
<td>• Software functional failure analysis</td>
</tr>
</tbody>
</table>

*IEC 61508-3 Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 3: Software requirements*
E2E Channel Redundancy

- Borrow ideas from safety critical industry (TMR/NVP/Voting)
- E2E channel redundancy is one choice to guarantee E2E service high availability, ms level switchover is the first step.

E2E Channel redundancy in 5G network

Cost VS Reliability
Service Defined Availability (SDA) for 5G slicing

- Different reliability and availability for different slicing, Not Built to Peak
  - Different slicing has different network resources allocation strategy.
  - Different slicing has different HA service in cloud.

SDA (Service Defined Availability) for different slicing
Conclusions

- Ultra high reliability/availability and SIL 3 safety requirements bring challenges for telecom industry.
- “5 9s” reliability of telecom cloud is the foundation of 5G ultra high reliability/availability.
- Ideas form safety critical industry can be borrowed for 5G, but cost is the big problem.
- AI is the interesting direction for increasing the 5G ultra high reliability/availability.
Thank you

www.huawei.com