We help ideas meet the real world

IoT: Rethinking the reliability

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Outline

- IoT Definition
- IoT Differentiation
- Reliability
- Throughput
- Latency
- Accuracy
- Performance criteria
The Internet of Things (IoT) is a framework in which all things have a representation and a presence in the Internet. More specifically, the Internet of Things aims at offering new applications and services bridging the physical and virtual worlds, in which Machine-to-Machine (M2M) communications represents the baseline communication that enables the interactions between Things and applications in the cloud. – IEEE Communication society

The Internet of Things (IoT) is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction. - TechTarget
Evolution of IoT

HOW STANDARDS PROLIFERATE:
(SEE: A/C CHARGERS, CHARACTER ENCODINGS, INSTANT MESSAGING, ETC)

SITUATION:
THERE ARE 14 COMPETING STANDARDS.

14?! RIDICULOUS!
WE NEED TO DEVELOP
ONE UNIVERSAL STANDARD
THAT COVERS EVERYONE'S
USE CASES. YEAH!

SITUATION:
THERE ARE 15 COMPETING STANDARDS.

https://xkcd.com/927/
IoT differentiation - 5G

Broadband++
high throughput, consistent QoE

50+ MBPS EVERYWHERE

M2M
low cost, low battery consumption

Critical communications
low latency, high reliability

Source: IEEE communication society: Realizing 5G - ofcom
### LPWAN

<table>
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<tr>
<th></th>
<th>SIGFOX</th>
<th>LoRa</th>
<th>LTE-M Rel. 12/13</th>
<th>EC-GSM Rel. 13</th>
<th>5G (targets)</th>
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<td>&lt;13km 160 dB</td>
<td>&lt;11km 157 dB</td>
<td>&lt;15km 164 dB</td>
<td>&lt;15km 156 dB</td>
<td>&lt;15km 164 dB</td>
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<tr>
<td>MCL</td>
<td>Unlicensed 900MHz 100Hz</td>
<td>Unlicensed 900MHz &lt;500kHz</td>
<td>Licensed 7-900MHz 200kHz or shared</td>
<td>Licensed 7-900MHz 1.4 MHz or shared</td>
<td>Licensed 7-900MHz shared</td>
</tr>
<tr>
<td>Spectrum Bandwidth</td>
<td>Data rate</td>
<td>Battery life</td>
<td>Availability</td>
<td></td>
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<tr>
<td></td>
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<td>&gt;10 years</td>
<td>Today</td>
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<tr>
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<td>&lt;10 kbps</td>
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<td>Today</td>
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<td>&gt;10 years</td>
<td>2016</td>
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<td>&gt;10 years</td>
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**Source:** Nokia: “LTE-M – Optimizing LTE for the Internet of Things”
Definition of Reliability

A useful source of definitions in the reliability area is:

IEC 60050-192
International Electrotechnical Vocabulary
Chapter 192: Dependability

Current edition is ed1.0 from 2015-02
(replacing IEC 60050-191)

Reliability = Ability to perform as required, without failure, for a given time interval, under given conditions

Dependability = Ability to perform as and when required
The Load – Strength model (from IEC 62506)

Figure 2 – Relationship of PDFs of the product strength vs. load in use
“Robustness”

“Robustness” is another important term, f.inst. used in the SW area. One definition from IEEE std. 610.12.1991 is:

“Robustness is defined as the degree to which a system operates correctly in the presence of exceptional inputs or stressful environmental conditions”

A more pragmatic definition is:

“if it does not crash or hang, then it is robust”

Robustness is thus not so well-defined as Reliability, but it may be closer to the end-users perception of the product.

“Ruggedness” is more or less another word for Robustness.

“Robustness” is not defined in IEC 60050-192 !!!
Caution

ราว - Type A: Qualitative accelerated test

- **Probability analysis** to evaluate the risk of failures if we know the use stress distribution and the strength distribution. But we can **not say when** its going to happen!

รวด - Type B/C: Quantitative accelerated/time+event comp test

- **statistical tools** (like Weibull analysis etc.) to analyse the **confidence** on the obtained time-to-failure results for a given use stress level, i.e. **when** the failure is going to happen.
IoT Differentiation

5G wireless will not be only “4G but faster”. New wireless modes: high reliability, low latency, and many devices.

"Slide from MassM2M group, Department of Electronic Systems, Aalborg University - http://massm2m.es.aau.dk/"
Vestas - Risø
Reliability impairments for wireless networks

- Decreased received power
- Uncontrollable received interference
- Resource depletion
- Protocol reliability
- Equipment failure

"Source from MassM2M group, Department of Electronic Systems, Aalborg University - [http://massm2m.es.aau.dk/](http://massm2m.es.aau.dk/)"
Traffic generation

- Asynchronous
  - Periodic and on-demand reporting
  - Stable (stationary) behavior
  - Uniform/Poisson arrivals

- Synchronous
  - Alarm reporting
  - Non-stationary
  - Beta arrivals

"Slide from MassM2M group, Department of Electronic Systems, Aalborg University - http://massm2m.es.aau.dk/"
Periodic reporting

"Slide from MassM2M group, Department of Electronic Systems, Aalborg University - http://massm2m.es.aau.dk/"
Alarm reporting $T = t$

"Slide from MassM2M group, Department of Electronic Systems, Aalborg University - [http://massm2m.es.aau.dk/](http://massm2m.es.aau.dk/)"
Alarm reporting $T=t+1$

"Slide from MassM2M group, Department of Electronic Systems, Aalborg University - http://massm2m.es.aau.dk/"
Signalling a change

Slide from MassM2M group, Department of Electronic Systems, Aalborg University - http://massm2m.es.aau.dk/
Reliability and latency

"Slide from MassM2M group, Department of Electronic Systems, Aalborg University - [http://massm2m.es.aau.dk/]"
Performance criterion – EMC - IEC 61000-4-3

A) Normal performance within limits specified by the manufacturer, requestor or purchaser

B) Temporary loss of function or degradation of performance which ceases after the disturbance ceases, and from which the equipment under test recovers its normal performance, without operator intervention

C) Temporary loss of function or degradation of performance, the correction of which requires operator intervention

D) Loss of function or degradation of performance which is not recoverable, owing to damage to hardware or software, or loss of data
4.3 Exclusion bands

The frequencies on which Short Range Devices (SRD) are intended to operate, shall be excluded from the conducted and radiated RF immunity tests.

The frequencies on which the SRD transmitters are intended to operate shall be excluded from conducted and radiated emission measurements when performed in transmit mode of operation.

There shall be no frequency exclusion band applied to emission measurements of SRD receivers, and/or associated ancillary equipment.

The emission measurement and immunity test exclusions are referred to as "exclusion bands" and are defined in clauses 4.3.1 and 4.3.2 of the present document.

ETSI EN 300 328 V1.9.1 (2015-02)
Standards verticals and horizontals

IoT SDOs and Alliances Landscape
(Vertical and Horizontal Domains)

Source: AIOTI WG3 (IoT Standardisation) – Release 2.0
Real world example

![Real world example image](image-url)
Summary

- The IoT will provide two different solutions to reliability
  - Massive machine to machine communication
  - Ultra reliable wireless communication

- Depends on traffic generation models
- Signalling constraints
- Latency considerations
- Performance criterion
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