RADIO DATA NETWORKS

Application notes

RAy
Link Availability

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Introduction

IEEE definition:

“Availability of the wireless link is the long-term average time when the link performs its intended function”.

In our context:

- **Availability** is usually expressed as a percentage and defines the time a system, link or terminal is meeting its operational requirements, i.e. data is being transmitted through the link at a projected Capacity.
- **Unavailability** is described as “a state of nonservice that occurs due to failure caused by signal drops or other outage”. **Signal drops** are a result of fading, multipath propagation, precipitation attenuation and other atmospheric issues. Together with noise issues this results in **degraded BER** (Bit Error Rate).

Classification of Availability issues:

a. **Link**: Outage or lower Capacity due to signal drops

b. **Equipment**: Hardware failures and Repair Time (expressed by MTBF + MTTR)

c. **External threats**: Human error, superior power, noise from other sources, etc.
These can’t be calculated in advance and thus Availability calculations do not consider them

1. Typical Availability values

- **99 %**
  - Acceptable for ordinary WiFi connection
  - Never used when designing stable radio links
- **99.9 %**
  - Can be used for links where other factors decrease the total Availability significantly e.g. unstable electricity supply
- **99.95 %**
  - Sometime used by ISPs for services with very low Service Level Requirements
  - Unlicensed bands can meet such requirements
- **99.98 %**
  - Standard level of Reliability
  - Often used for less demanding last-mile links
  - Very often combined with ACM function, which allows maintenance of availability during signal drops on the cost of reduced data-speed due to atmospheric or other issues (customer experiences link operation without interruptions; only capacity may fluctuate)
- **99.99 %**
  - The most common used for microwave links design
  - Suitable for last-mile links requiring reasonable quality
  - If applied to backbone links, it is recommended to use ACM function or other mechanism to retain reliability
- **99.995 %**
  - Used for backbone links with guaranteed capacity
  - Licensed bands offer these levels of reliability
- **99.999 %**
  - Typical reliability level for high availability applications
  - Used on backbone links
  - Licensed band is a must
  - Typically used over shorter distances due to cost implications
- **99.9999 %**
  - Used on backbone links
  - Licensed band is a must
  - Typically used over shorter distances due to cost implications

Alternative expressions of Availability:

Availability	99%	99.9%	99.95%	99.98%	99.99%	99.995%	99.998%	99.999%
Amount of “nines”	2	3	-	-	4	-	-	5
Unavailability during a year	88 hours	8.8 hours	4.4 hours	105 mins	53 mins	26 mins	10 mins	5.2 mins

2. Equipment Availability and MTBF Calculations

MTBF calculations are only considered when very high Availability requirements are required (above 99.999%, i.e. 5 “nines”). This would usually only be the case for Back Haul links and for specific corporate last mile connections. The probability of power loss should also be taken into consideration.

Equipment Availability is expressed by the equation:

A = MTBF / (MTBF + MTTR)
where MTBF is mean time between failures and MTTR is mean time to repair. Both are measured in hours.

Example:
RAy units with MTBF of 100 years and expected repair time 10 hours provide Equipment availability = 99.999% (5 nines). If Equipment Availability should be increased to 99.9999% (6 nines), the average repair time must be reduced down to 1 hour. (Repair time is the responsibility of the customer.)

The equation above only treats equipment failure and its repair time; it does not reflect outage due to fading and other atmospheric issues and/or the probability of power outage. By restating the equation, we can cover the general case:

A = uptime / (uptime + downtime)
where downtime is the number of hours of the downtime of the link whether due to equipment outage or power failures or fading and all other atmospheric issues.

Example:
If a system has an uptime of 10 000 hours and a total expected downtime of 10 hours, then
A = 10 000/ (10 000 + 10) = 0.999 or 99.9%

Important

For typical microwave links with Availability requirement below 99.99% the influence of MTBF is negligible (for modern equipment from respected manufacturers) and can be omitted from the calculation.

3. Link Availability versus Distance and Capacity

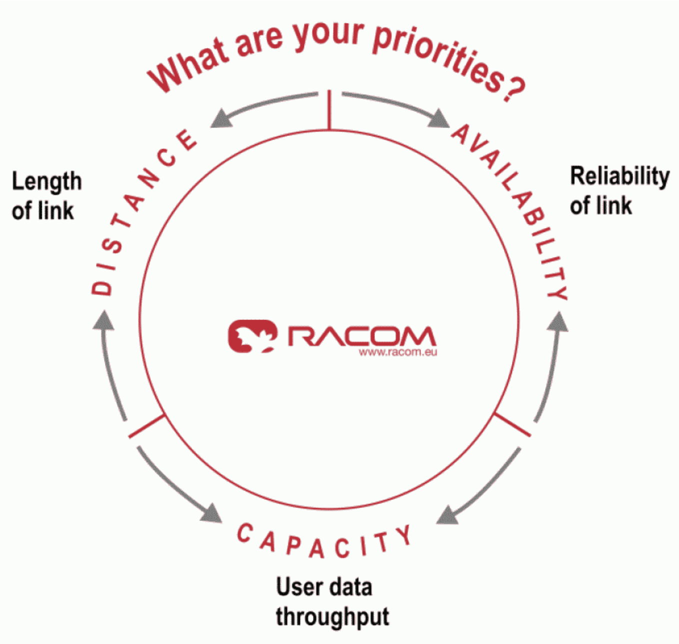

Fig. 3.1: Priorities

Length and Reliability of a link combined with required Capacity are the three main considerations when designing a link. Changing the value of one parameter has an impact on the possible values of the other two.

The combined values of Distance, Availability and Capacity as shown in the figure, define the minimum system gain of the chosen equipment, calculated as: 2x antenna gain + available Tx power – Rx sensitivity (actual values for the chosen channel, channel width, modulation and other parameters of the wireless connection).

Reduction in Link Availability can be offset using ACM (Automatic Control of Modulation) available in modern microwave units. This automatically decreases link Capacity (reducing modulation) during periods of lower signal. Use of ACM is an ideal solution for last-mile links (optimum is higher standard capacity + few moments of lower capacity) but not for backbone links (decreased capacity may cause issues for the whole network).

4. The cost of Availability

Link Unavailability is caused by atmospheric factors related to weather. The typical behavior is few very short (few seconds) to short (tens of seconds) signal attenuations or signal drops. Those issues culminate with storms, rain and snow – for more details see ITU recommendations (ITU-R P.530 and related).

Higher Availability (with constant Distance and Capacity) is always more costly (both CAPEX + OPEX). Typical relationships are expressed in the following chart:

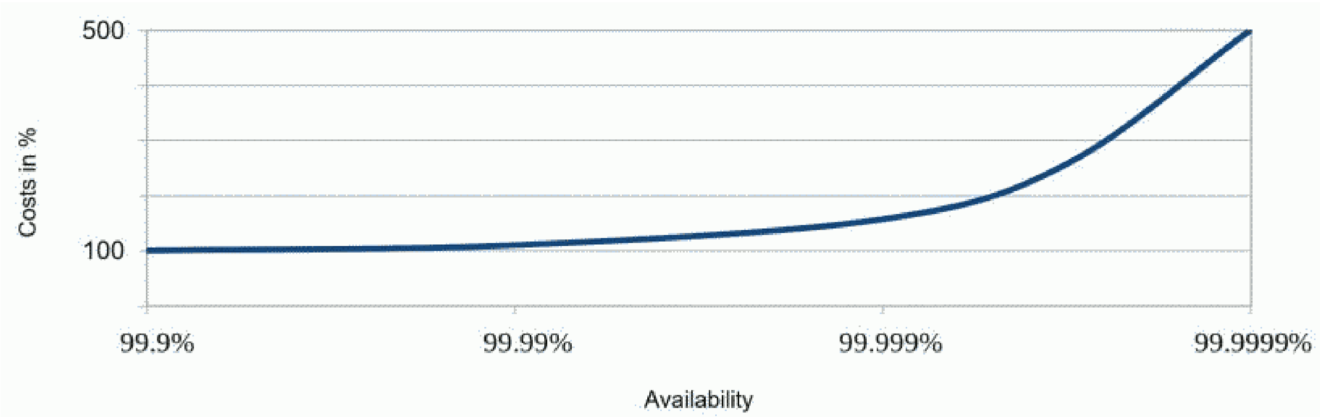

Fig. 4.1: Availability costs

Typically, an increase of Availability from three to four nines (from 99.9% to 99.99%) is not very costly, while increasing to five nines (to 99.999%) is 1.5x - 2x more costly and then increases exponentially.

Note

In practice, an increase in Availability by one nine (for example from 99.99% to 99.999%) requires an increase of system gain by 10 dBm (to increase fade margin). Each additional +10dBm can be realized by a number of technical solutions (up to the limits of physics):

- Higher specification equipment e.g. units with:
  - Higher output power of the transmitter
  - More sensitive receiver
  - Larger and/or higher quality antennas, etc.
- License for higher output power (typical steps in price table for licensed bands are +10dBm)
- License to get wider channel, XPIC, etc. (only licensed bands)
- Higher elevation of antenna, better place, etc.

Each technical or license improvement means additional cost (CAPEX or OPEX or both).

Appendix A. Revision History

Revision 1.0 2017-11-24

First issue