Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)

Submission Title: **Proposed Link Failure Rates for L2R scenarios**

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Re: [TG10 TGD]

Abstract: In the TG10 TGD document, operational scenarios are to be included in Subclause 7.1. For these scenarios, link failure rates will be used to represent signal quality/link quality. This document is prepared to propose more realistic values for these rates.

Purpose: To propose link failure values for the operational scenarios to be used for comparison of proposals for TG10.

INTRODUCTION

- Operational scenarios are to be included in the TG10 TGD, which can be used to evaluate/compare proposals with the common parameters and environments.

- In this document,
  - Currently proposed link failure rates in 15-14-0338-07 were evaluated.
  - Two bit error rates (BERs) were selected for this evaluation: 10^{-6} and 10^{-7}
  - These BERs were used to estimate packet error rates (PERs) for packet size of 100 bytes.
    - For six distinct pairs of nodes
  - These PERs as link failure rates were examined to determine whether these PERs are meaningful in real environments.

- Thorough evaluation of the link failure rates was performed to choose meaningful pairs of nodes (or links to be considered) for data delivery.

SIGNAL QUALITY/LINK QUALITY TO BE SPECIFIED FOR TG10 SCENARIOS

Link failure rate as signal quality/link quality

- **Link failure due to congestion and poor signal quality**: **reflecting** link quality and energy detection information
- The TG10 group reached consensus to have six types of links to be specified for TGD scenarios as shown in 15-14-0338-07.
- A link failure rate assigned for each link in 15-14-0338-07 needs to be evaluated to judge whether it is realistic.
  - In this document, this number is to be evaluated.

Two parameter values considered to propose link failure rates

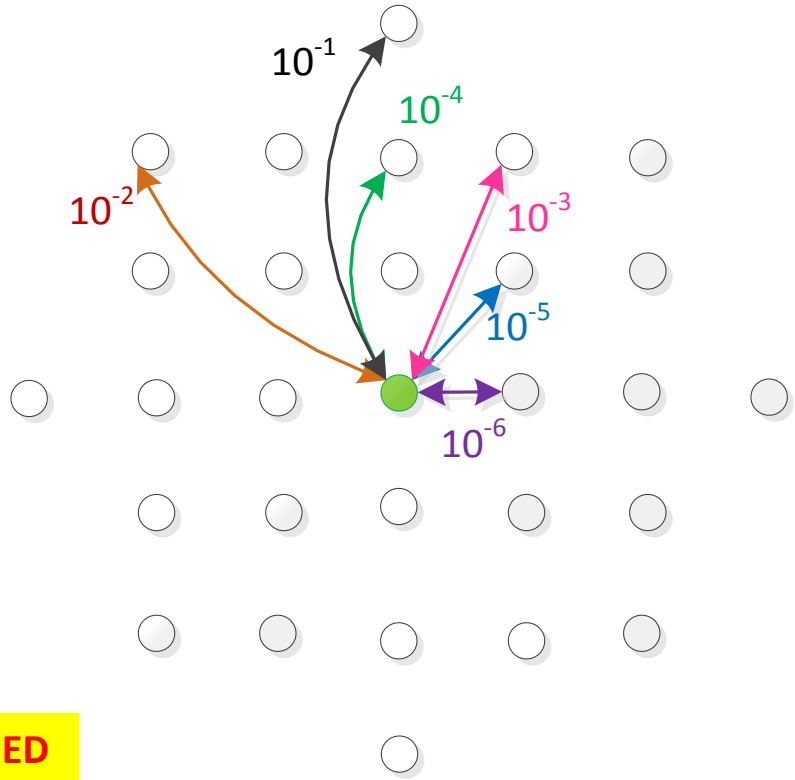
- One packet size is considered from two packet sizes specified in 15-14-0338-07
  - 100 bytes per packet considered although 100 bytes and 255 bytes are specified in 15-14-0338-07
- Two BERs are considered to evaluate link failure rates.
  - 10^{-6} and 10^{-7}

PROPOSED LINK FAILURE RATES IN 15-14-0338-07

Six distances for distinct pairs of nodes in a network specified for TGD scenarios:

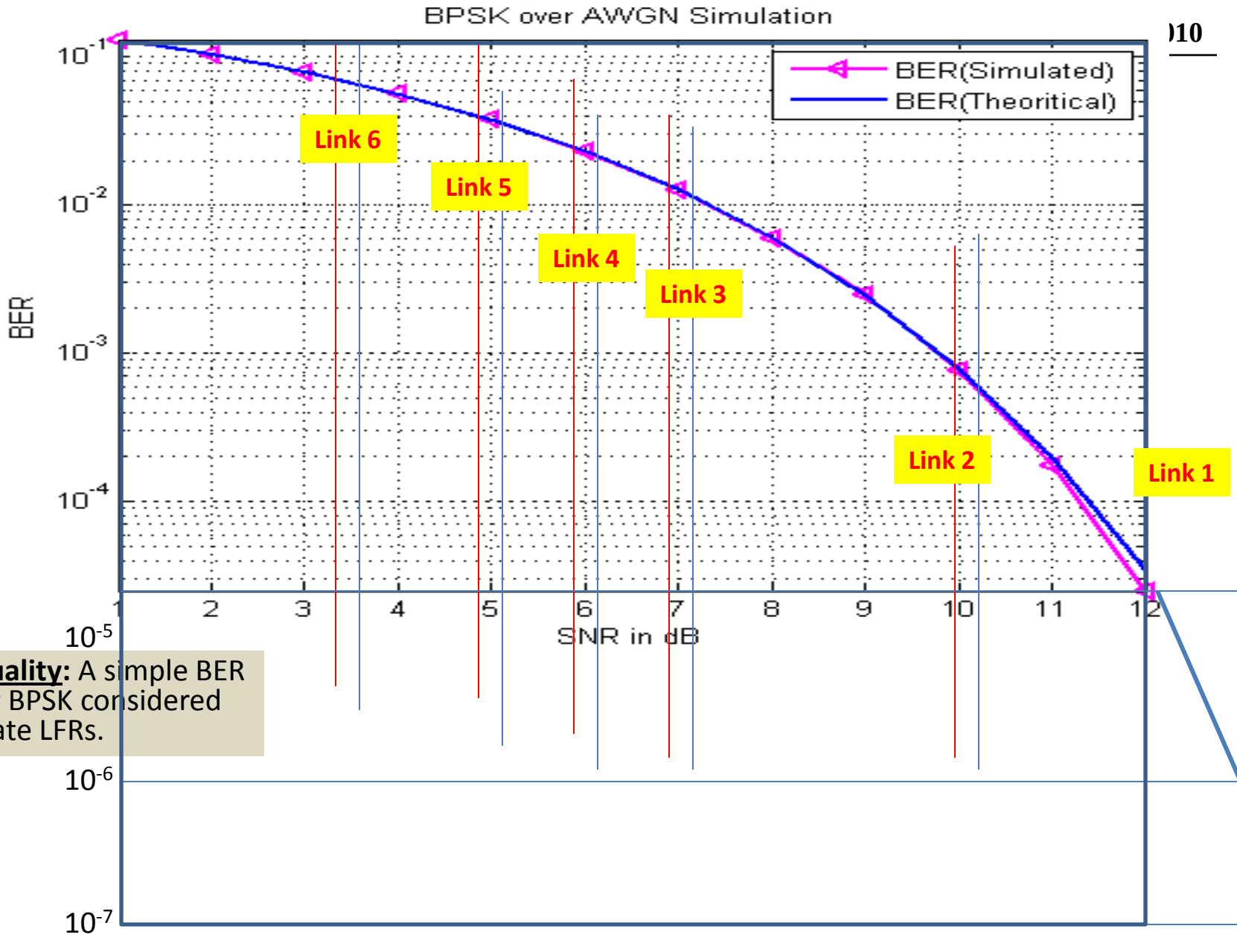
- From 15-14-0338-07

Distances	proposed LFR values
• 1 unit	10^{-1}
• 1.414 unit	10^{-2}
• 2 unit	10^{-3}
• 2.236 unit	10^{-4}
• 2,828 unit	10^{-5}
• 3 unit	10^{-6}



Link failure rates from 15-14-0338-07

LINK FAILURE RATES FOR THESE DISTANCES MAY NEED TO BE ASSIGNED WITH MORE REALISTIC VALUES.
→ THIS IS THE PURPOSE OF THIS DOCUMENT.



Signal quality: A simple BER curve for BPSK considered to estimate LFRs.

PER VALUES FOR BER OF 10^{-6}

Signal to noise ratio applying inverse square law for signal propagation

For BERs = 10^{-6} and for packet size = 100 bytes = 1kbits = 10^{3} bits

Distance = 1 unit	SNR = 0 dB	BER = 10^{-6}	PER = 10^{-3}
Distance = 1.4 unit	SNR = -3 dB	BER = 10^{-3}	PER = 0.63
Distance = 2 unit	SNR = -6 dB	BER = 1.5×10^{-2}	PER = $1-2.73\times10^{-7}$
Distance = 2.236 unit	SNR = -7 dB	BER = 2.5×10^{-2}	PER = $1-1.01\times10^{-11}$
Distance = 2.83 unit	SNR = -8 dB	BER = 4×10^{-2}	PER = $1-1.87\times10^{-18}$
Distance = 3 unit	SNR = -9.5 dB	BER = 7×10^{-2}	PER = $1-3\times10^{-32}$

← PER = $1 - (1 - 10^{-6})^{1000} = 1 - (1 - 10^{-3}) = 10^{-3}$ for BER of 10^{-6}

PER VALUES FOR BERS OF 10^{-6} AND 10^{-7}

Signal to noise ratio applying square law for signal propagation

Two sets of BERs: 10-6 and 10-7 with PER size = 100 bytes = 1kbits = 10^3 bits

Distance = 1 unit	SNR = 0 dB	BER = 10^{-6}	PER = 10^{-3}
Distance = 1.4 unit	SNR = -3 dB	BER = 10^{-3}	PER = 0.63
Distance = 2 unit	SNR = -6 dB	BER = 1.5×10^{-2}	PER = $1-2.73\times10^{-7}$
Distance = 2.236 unit	SNR = -7 dB	BER = 2.5×10^{-2}	PER = $1-1.01\times10^{-11}$
Distance = 2.83 unit	SNR = -8 dB	BER = 4×10^{-2}	PER = $1-1.87\times10^{-18}$
Distance = 3 unit	SNR = -9.5 dB	BER = 7×10^{-2}	PER = $1-3\times10^{-32}$

Distance = 1 unit	SNR = 0 dB	BER = 10^{-7}	PER = 10^{-4}
Distance = 1.4 unit	SNR = -3 dB	BER = 5×10^{-4}	PER = 0.606
Distance = 2 unit	SNR = -6 dB	BER = 10^{-2}	PER = $1-4.32\times10^{-5}$
Distance = 2.236 unit	SNR = -7 dB	BER = 2×10^{-2}	PER = $1-1.68\times10^{-9}$
Distance = 2.83 unit	SNR = -8 dB	BER = 3.5×10^{-2}	PER = $1-3.37\times10^{-16}$
Distance = 3 unit	SNR = -9.5 dB	BER = 6×10^{-2}	PER = $1-1.34\times10^{-27}$

CONCLUSIONS AND PROPOSED VALUES FOR LINK FAILURE RATES

- Link failure due to congestion and poor signal quality: reflecting link quality and energy detection information
- Link failure rates for six pairs of nodes are evaluated
  - With BERs of 10^{-6} and 10^{-7}
- Link failure rates for only two pairs of nodes are practically meaningful.
  - Other rates approach to one, which means no successful data delivery between two nodes of each of these pairs.
- **Only two link failure rates are proposed.**
  - **Link failure rates (LFRs) between adjacent nodes and between diagonally adjacent nodes respectively : (10^{-3} and 0.63) and (10^{-4} and 0.6).**
  - **Link failure rates (LFR) between other pairs of nodes: 1**