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

Submission Title : Multiple Retransmission Spreading Scheme for NG-SUN FSK PHY

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Re : TG4ad Next Generation SUN PHYs

Abstract : This contribution describes the multiple retransmission spreading scheme for NG-SUN FSK PHY.

Purpose: Discussion

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Introduction

- **A2UICT proposed a NG-SUN FSK PHY**
  - Position based FSK(P-FSK) Modulation to achieve higer performance than 2FSK
    - ☞ BER performance of P-FSK : – 2.7dB gain @ BER 10^{-5} compared with FSK
  - Spreading to achieve high sensitivity under harsh environment
    - ☞ A simple spreading scheme in the form of repeating duplicated symbols was proposed for NG-SUN FSK PHY in initial proposal
    - ☞ Since this simple spreading scheme cannot achieve diversity gains, it degrade the performance in multi-path channel environments
    - ☞ A different scheme of spreading is required than one that repeats duplicated symbols.
- **This contribution describes the Multiple Retransmission Spreading as a new spreading scheme for NG-SUN FSK PHY**
  - Show the simulation results of P-FSK PHY with multiple retransmission spreading
    - ☞ BER/PER simulation under AWGN, COST207, and IEEE802.22 channel model

Proposed Spreading(1)

- **NG-SUN channel:** RF link with high path loss (>120dB)
  - Require better signal reception in harsh environments
  - A simple spreading scheme in the form of repeating duplicated symbols was proposed to achieve high sensitivity in the initial proposal.
- **A simple spreading scheme in the form of repeating duplicated symbols**
  - A => repetition of "A$\bar{A}$" where A is a symbol

    e.g.) 0 => repetition of "01" , 1 => repetition of "10"

    e.g.) 01 => repetition of "0110", "11" => repetition of "1100"
  - Repetition of "A$\bar{A}$": useful for FSK based system
    - ☞ Repetition rate depends on spreading factor(SF)

      SF 1(0 dB), 2(3dB), 4(6dB), 8(9dB),16(12dB), 32(15dB)
    - ☞ Can be selected according to channel condition

Proposed Spreading(2)

- **This simple spreading scheme can only obtain SNR gain according to the spreading factor, but not diversity gain.**
  - Achieve SNR gain only according to the spreading factor
    - ☞ 3 dB gain @ SF=2, 12 dB gain @ SF=16
  - Only SNR gain can be obtained, no diversity gain can be obtained.
    - ☞ Degraded performance under multipath channel conditions
- **This simple spreading scheme causes extended packet transmission time due to repeatation of duplicated symbols**
  - doubled transmission time @ SF=2, 16 times @SF=16
  - This could not be applicable due to limited chance of transmission
- **Different scheme of Spreading other than duplicated code symbols is required**
  - SNR gain, Diversity gain should be achieved simultaneously
  - Easily applicable to the limited chance of transmission according to the regional regulations

A New Proposal of Spreading Scheme(1)

- **Multiple Retransmission Spreading(1/2)**
  - Transmitter send packet until the reception of ACK from the receiver
    - ☞ Maximum # of re-transmission : defined by SF
    - ☞ Transmitter set the retrial counter @ new PHR
  - Receiver combines the received packets up to current packet before decoding
    - ☞ When successful decoding is performed, the receiver send back ACK to the transmitter
    - ☞ If the receiver does not combine the received but decoding failed packet, it is performing just STOP-and-WAIT ARQ operation

A New Proposal for Spreading Scheme(2)

- **Multiple Retransmission Spreading(2/2)**
  - Retransmission of the packets by the transmitter can be applicable to the limited chance of transmission situation by the regional regulations
  - Time interval between the retransmission of the packets can guarantee the independence of the multipath channels
    - ☞ Time diversity effect can be achieved
    - ☞ According to the receiver operation (combining or not of the decoding failed packets)
      - ➢ Combining applied : SNR and combining diversity gain can be obtained
      - ➢ Combining not applied : selection diversity gain can be obtained

Performance Simulation

- **Simulation Environment for P-FSK PHY**
  - Channel model : COST207 GSM in urban area / IEEE802.22 in rural area
  - Data rate : 12.5 Kbps/50 Kbps
  - 1/2, K=7 convolution code
  - Hard decision Viterbi decoding
  - Interleaver-Deinterleaver
  - Total data : 200Kbits(25,000 bytes)
  - 1,000 packets of 25 byte(200 bits)/packet
  - # of multiple transmission : 1 / 4 / 16
- **Performance Simulation Results**
  - Uncoded/Coded BER vs. Eb/No
  - PER vs. Eb/No

COST 207/IEEE 802.22 channel models

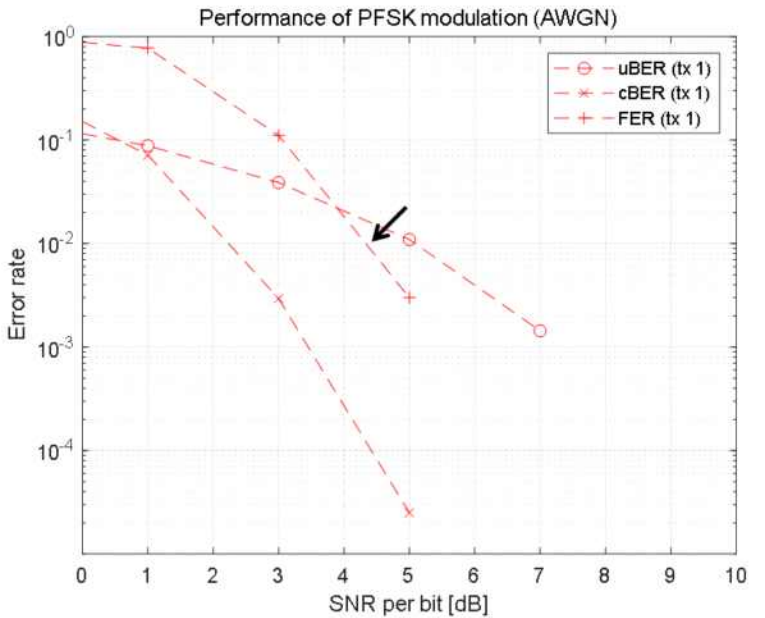
- **# of paths : 6 for each model**
  - Max. delay of IEEE802 model is larger than COST207
  - Each path contributes to performance degradation due to ISI if any kinds of counter measures are not used
    - ☞ Performance degradation would be getting worse with increasing transmission rate
    - ☞ IEEE802 channel will be more serious than COST207 channel
- **Quasi-static Rayleigh channel**
  - Due to small value of Doppler spread
    - ☞ The coefficient of each multipath remains constant over a packet transmission
    - ☞ Re-generation of channel coefficients per each packet transmission

Performance Simulation(3)

- **Expectation of the performance**
  - Error rate performance:
    - ☞ For low rate transmission : Performance would be similar to that of single path fading channel
    - ☞ For higher rate transmission : Error floor would be added to the single path fading performance due to Inter-Symbol Interference (ISI)
  - Approach to enhance the performance
    - ☞ Need to achieve some form of diversity gain
    - ☞ NG-SUN FSK PHY tries to incorporate spreading to get enhanced sensitivity performance
    - ☞ If we implement the spreading in the form of multiple transmission of a packet and receiver tries to combine the demodulated symbol, we can get time diversity gain over the SNR gain

BER/PER Simulation Results(1)

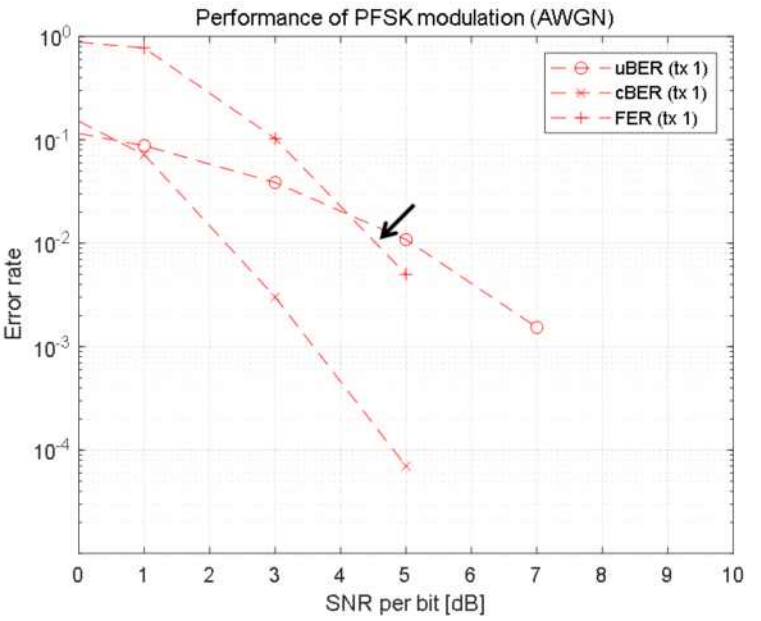
☐ Performance of P-FSK modulation over AWGN @ 12.5Kbps



- 1% PER @ Eb/N0 of 4.4 dB

BER/PER Simulation Results(2)

☐ Performance of P-FSK modulation over AWGN @ 50Kbps

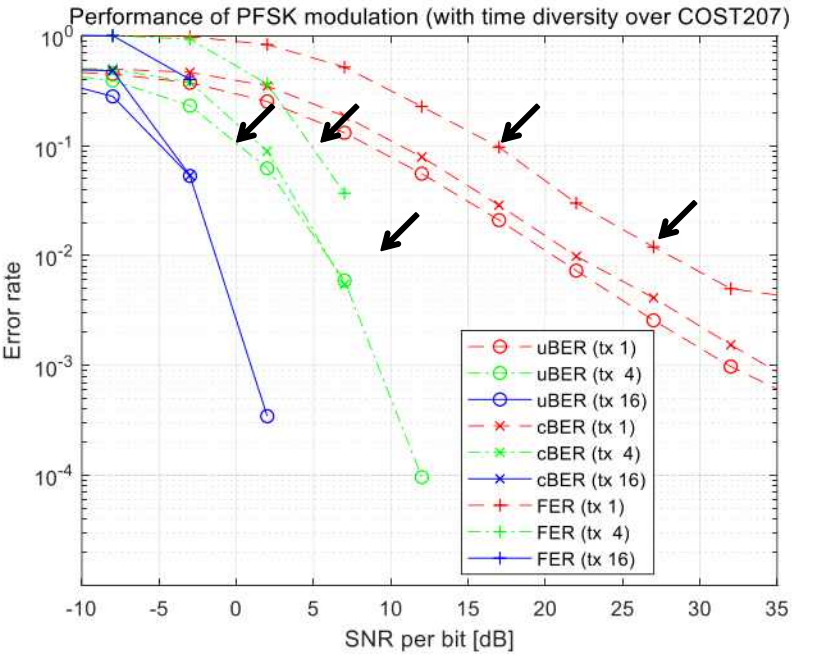


- 1% PER @ Eb/N0 of 4.5 dB

BER/PER Simulation Results(3)

☐ Performance of P-FSK modulation over COST207@12.5Kbps

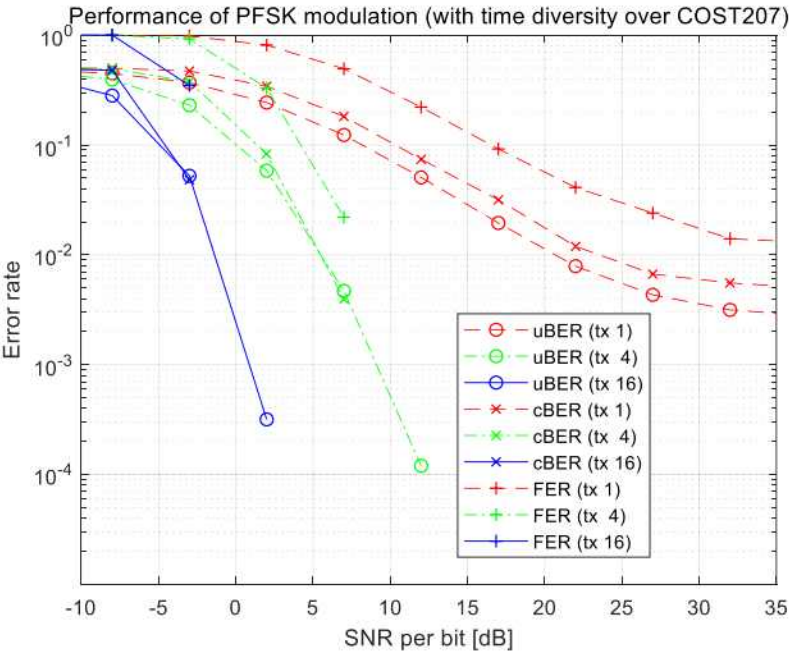
- **1%/10% PER @**
  - Eb/No of 28/17 dB for single transmission
  - Eb/No of 9/5 dB for 4 times retransmission
    - ☞ 9/12 dB gain (6 dB SNR gain + 13/6 dB diversity gain)
  - Eb/No of 2/0 dB for 16 times retransmission
    - ☞ 26/17 dB gain (12 dB SNR gain + 14/5 dB diversity gain)



BER/PER Simulation Results(4)

□ Performance of P-FSK modulation over COST207@50Kbps

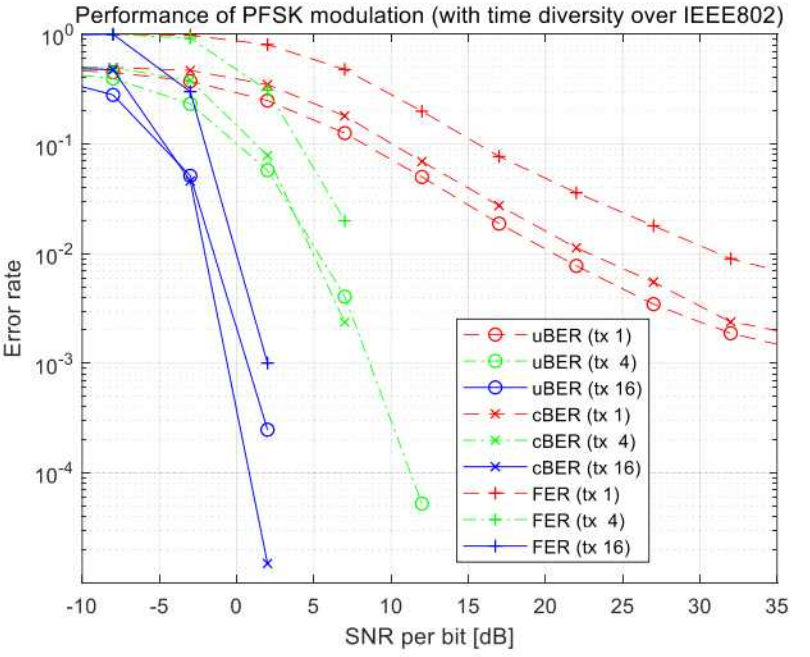
- **1%/10% PER @**
  - Eb/No of ??/17 dB for single transmission
  - Eb/No of 9/4.5 dB for 4 times transmission
    - ☞ ??/12.5 dB gain (6 dB SNR gain + ??/6.5 dB diversity gain)
  - Eb/No of 1/-1 dB for 16 times transmission
    - ☞ ??/18 dB gain (12 dB SNR gain + ??/6 dB diversity gain)



BER Simulation Results(5)

☐ Performance of P-FSK modulation over IEEE802@12.5Kbps

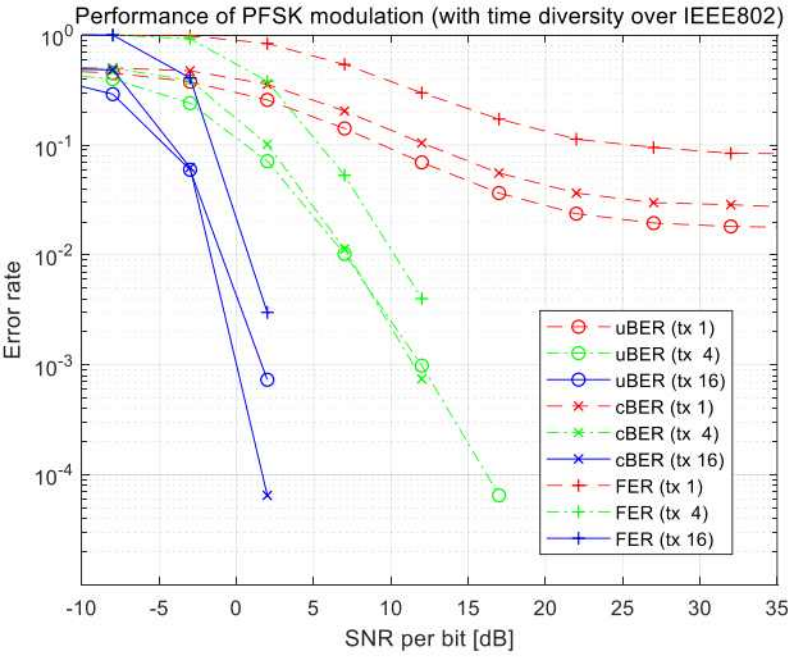
- **1%/10% PER @**
  - Eb/No of 31/15 dB for single transmission
  - Eb/No of 8/4.5 dB for 4 times transmission
    - ☞ 23/10.5 dB gain (6 dB SNR gain + 17/4.5 dB diversity gain)
  - Eb/No of 0/-2 dB for 16 times transmission
    - ☞ 31/17 dB gain (12 dB SNR gain + 19/5 dB diversity gain)



BER Simulation Results(5)

☐ Performance of P-FSK modulation over IEEE802@50Kbps

- **1%/10% PER @**
  - Eb/No of ??/25 dB for single transmission
  - Eb/No of 10/5 dB for 4 times transmission
    - ☞ ??/20 dB gain (6 dB SNR gain + ??/14 dB diversity gain)
  - Eb/No of 0.5/-2 dB for 16 times transmission
    - ☞ ??/27 dB gain (12 dB SNR gain + ??/15 dB diversity gain)



Conclusion of Simulation

- With single transmission for a packet, the error rate performance follows the single path fading and error floor as expected.
- With multiple retransmissions and receiver combining (noncoherent) of the demodulated symbols, the error rate performances show huge improvement including the SNR gain and diversity gain
  - ☞ 1% of PER can be achieved even at higher transmission rates
- Therefore, we propose the multiple retransmission spreading scheme to improve the performance of NG-SUN PHY in multipath channels.

Thanks for Listening !
Q&A