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Project: IEEE P802.15 Working Group for Wireless Specialty Networks

Submission Title: Simulation results of performance evaluation for MAC of UWB-BAN draft of IEEE802.15,6ma in cases of random geographical distribution of multiple coexisting BANs

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Email:[1: kohno@ynu.ac.jp, 2: kohno@yrp-iai.jp] Re: []

Re: for revision of draft D03 of IEEE802.15.6ma

Abstract: This document contains some results of performance evolution for MAC of IEEE802.15.6ma to revise the draft in MAC layer.

Purpose: Material for discussion in P802.15.6ma TG

Simulation results of performance evaluation for MAC of UWB-BAN draft of IEEE802.15,6ma in cases of random geographical distribution of multiple coexisting BANs

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Aim and Agenda

To confirm basic performance of MAC in UWB-BAN draft of IEEE802.15,6ma, updated computer simulation results with updated decision rule and layout will be presented in cases of random geographical distribution of multiple coexisting BANs.

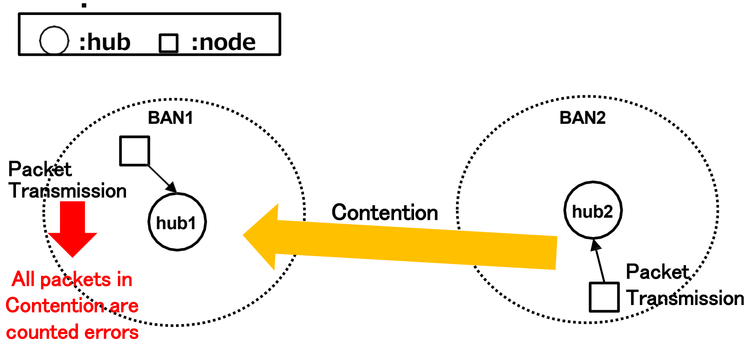
1. Update in calculation rule of packet error rate
2. Update in layout of coexisting BANs
3. Update in random geographical distribution of multiple coexisting
4. Simulation parameters in MAC
5. MAC Simulation Results
6. In case of the number of asynchronous BANs according to distance
7. Simulation Results
8. Summary

1. Update in calculation rule of packet error rate

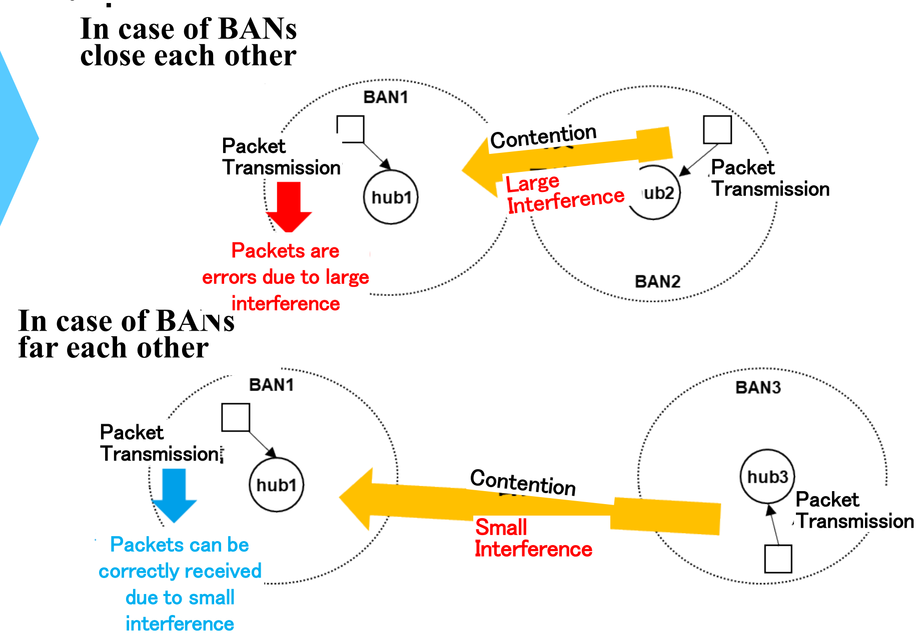
(1) In the previous packet errors analysis, all packets which have contentions were counted as packet errors. However, even if packets have contentions, some packets can be correctly received according to SINR.

(2) In this new packet errors analysis, packet errors may be counted more carefully considering SINR in case of contention.

(1) Previous Packet Errors Analysis (Rough Analysis)



(2) New Packet Errors Analysis (Precise Analysis)



2. Update in layout of coexisting BANs

- In previous packet error analysis, layout of BANs was assumed pentagon
- In new packet error analysis, layout of BANs are randomly distributed in a circle. Number of BANs can be more flexibly changeable.
- Diameter of the circle can be flexibly changeable.
- Random geographical distribution has been calculated according to the flowing manner.

➢ BAN location (x,y) can be calculated in case of circle with diameter d

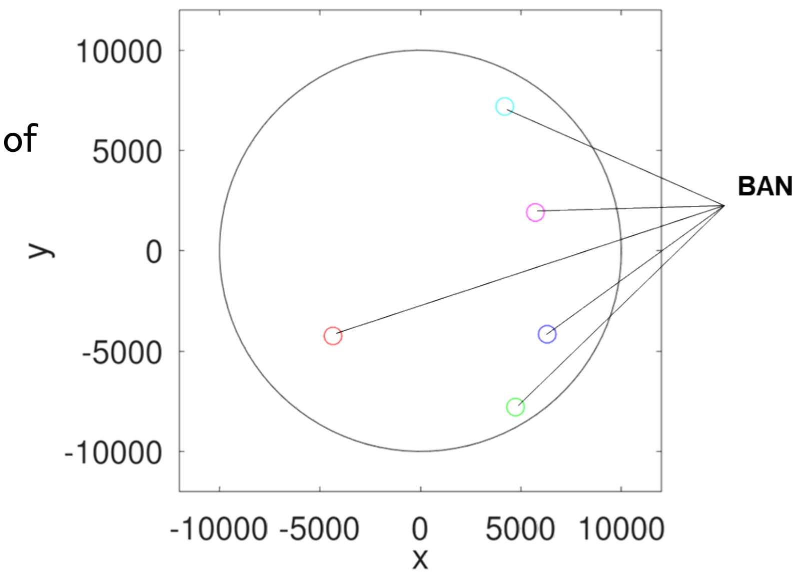
$$\begin{cases} x = r\sin\theta \\ y = r\cos\theta \end{cases} \quad 0 \leq \theta \leq 2\pi, 0 \leq r \leq d$$

➢ r and Θ can be calculated uniform random numbers in (0,1).

➢ BAN location can be derived

$$\begin{cases} \theta = 2\pi u \\ r = \sqrt{d^2 v} \end{cases}$$

Example: BAN Locations
In case of diameter r = 10m



3. Update in random geographical distribution of multiple coexisting

Simulation Specifications:

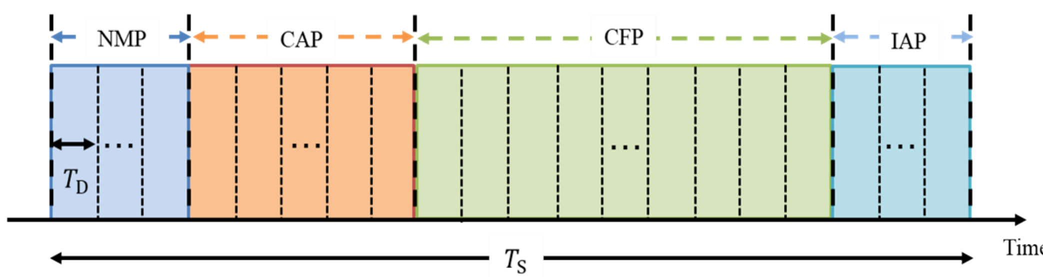
Diameter of circle inside which BANs are distributed	1.0, 2.5, 5.0, 7.5, 10
Number of Asynchronous BANS	0, 1, 2, 3, 4
Number of Simulation Trials	100

Where assumed that

- **Layout of BANs were reset every simulation trial,**
- **Asynchronous BANs were randomly selected in each simulation trial.**

4. Simulation parameters in MAC

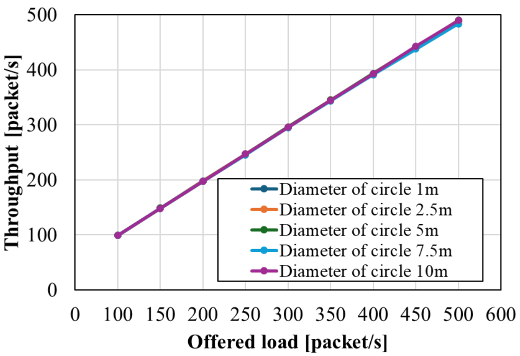
T_S	4 ms	Number of BANs	5
T_D	40 µs	Number of Nodes (/BAN)	5
Number of superframes	250	Maximum number of retransmission (CFP) times	5
Number of NMP slots	5	Maximum number of retransmission (CAP) times	5
Number of CFP slots	60	Maximum number of random waiting slots (CAP)	10
Number of CAP slots	30	Normal packet (CFP)	Poisson distribution
Number of IAP slots	5	Normal packet (CAP)	Poisson distribution
Gap	0 ~ 499	Packet length	2000 bit
Tx power	-10 dBm		



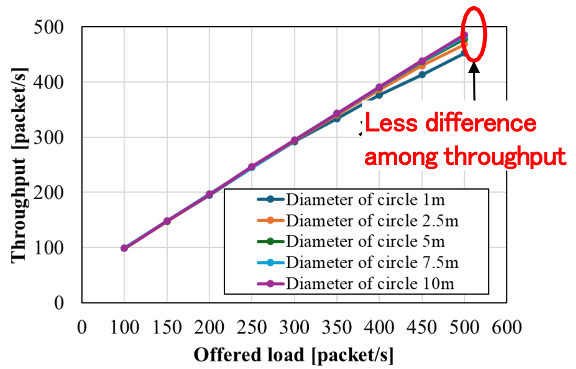
5. MAC Simulation Results

Throughput versus Packet appearance probability λ or offered traffic load in cases of different no. of coexisting BANs and covering geographical range

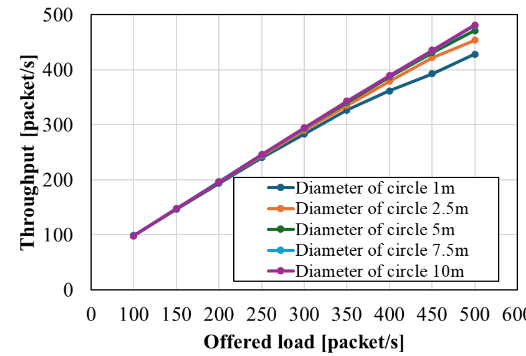
No. of Asynchronous BANs = 0



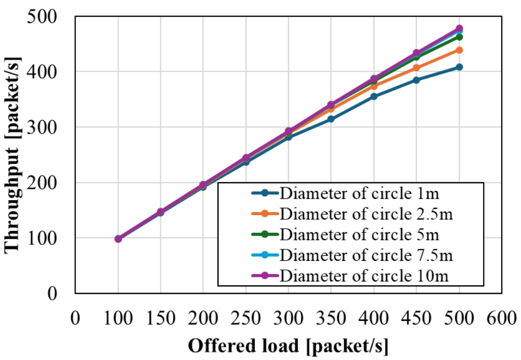
No. of Asynchronous BANs = 1



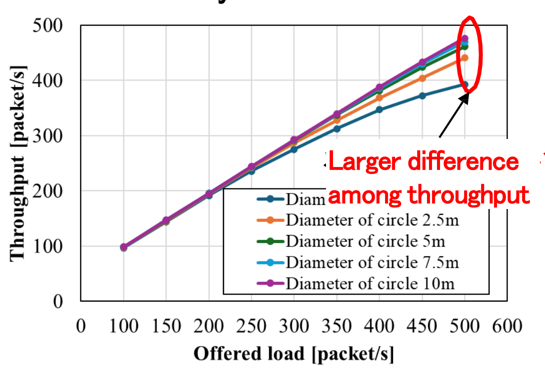
No. of Asynchronous BANs = 2



No. of Asynchronous BANs = 3



No. of Asynchronous BANs = 4



It is noted that larger variance of throughput according to packet appearance probability λ or offered traffic load in case of the larger number of asynchronous BANs.

It is noted that the larger packet traffic or offered load, the larger throughput in case of less than 5m in diameter, but a little difference of throughout in case of more than 5m in diameter.

packet appearance probability λ or offered traffic load

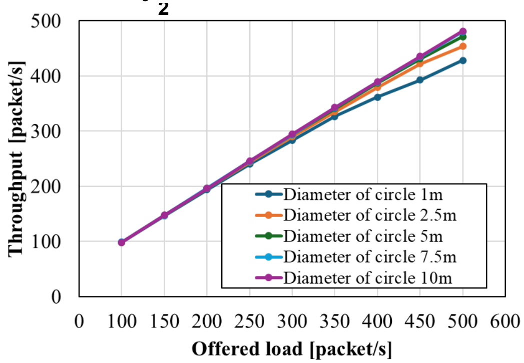
6. In case of the number of asynchronous BANs according to distance

- Although in above simulation, assumed that number of asynchronous BANs are fixed, then the fixed number of asynchronous BANs are randomized in geographical distribution,
- In practical implementation, according to distance among BANs, the number of asynchronous BANs may change.
- By using the same simulation specification, packet error rate and throughout have been analyzed as by the same way in 3. and 4.

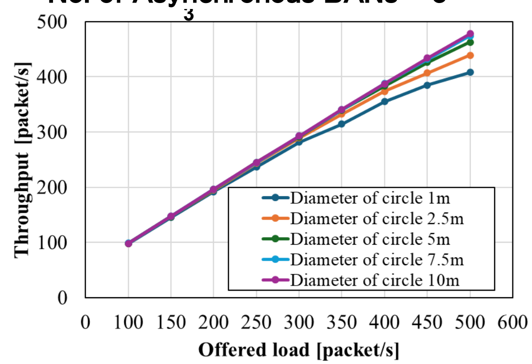
7. MAC Simulation Results in case of the number of asynchronous BANs according to distance

Throughput versus Packet appearance probability λ or offered traffic load in cases of different no. of coexisting BANs and covering geographical range

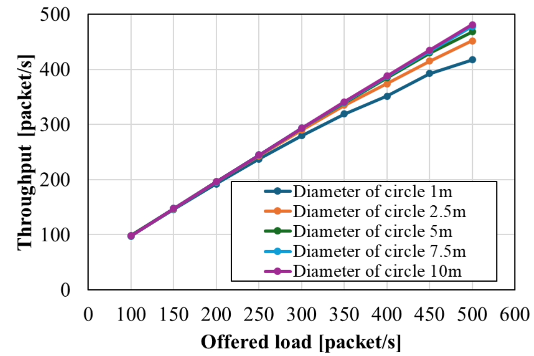
Case of asynchronous BANs at random
No. of Asynchronous BANs = 2



Case of asynchronous BANs at random
No. of Asynchronous BANs = 3



Case of asynchronous BANs according to distance



packet appearance probability λ or offered traffic load

- In the specification of this simulation, the number of asynchronous BANs is set randomly from 1 to 4.
- Therefore, the result of this simulation is the average of the result in 5., and it is intermediate to the result in the case where the number of asynchronous BANs is 2 and 3

8. Summary

- Simulations are performed in cases of different decision rule of packet error rate and geographical distribution of coexisting BANs,

- The simulation confirms that throughput is quite dependent on the number of asynchronous BANs. In case of coexisting BANs closer than 5m, throughput may significantly degraded as increase of asynchronous BANs. However, in case of BANs far than 5m, throughput is a little different even different number of asynchronous BANs,

- This simulations confirm that if a group BAN coordinator can control the number of asynchronized coexisting BANs less than 5 within covering range of 5m in diameter, then packet error rate can be under controlled and result in permissible throughput in a certain range of packet traffic or offered load. The covering range 5m is dependent on transmission power of each BAN.

- This simulation is meaningful in a sense that the new standard MAC of IEEE802.15,6ma is robust against some non under controlled coexisting BANs, Thank you for your attention