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

Submission Title: [NICT's MAC Proposal Part 2]
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Abstract: [NICT's MAC Proposal Part 2]

Purpose: [NICT's MAC Proposal Part 2 to TG6]

NICT's MAC Proposal

------ Part2: BAN Group Superframe

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Outline

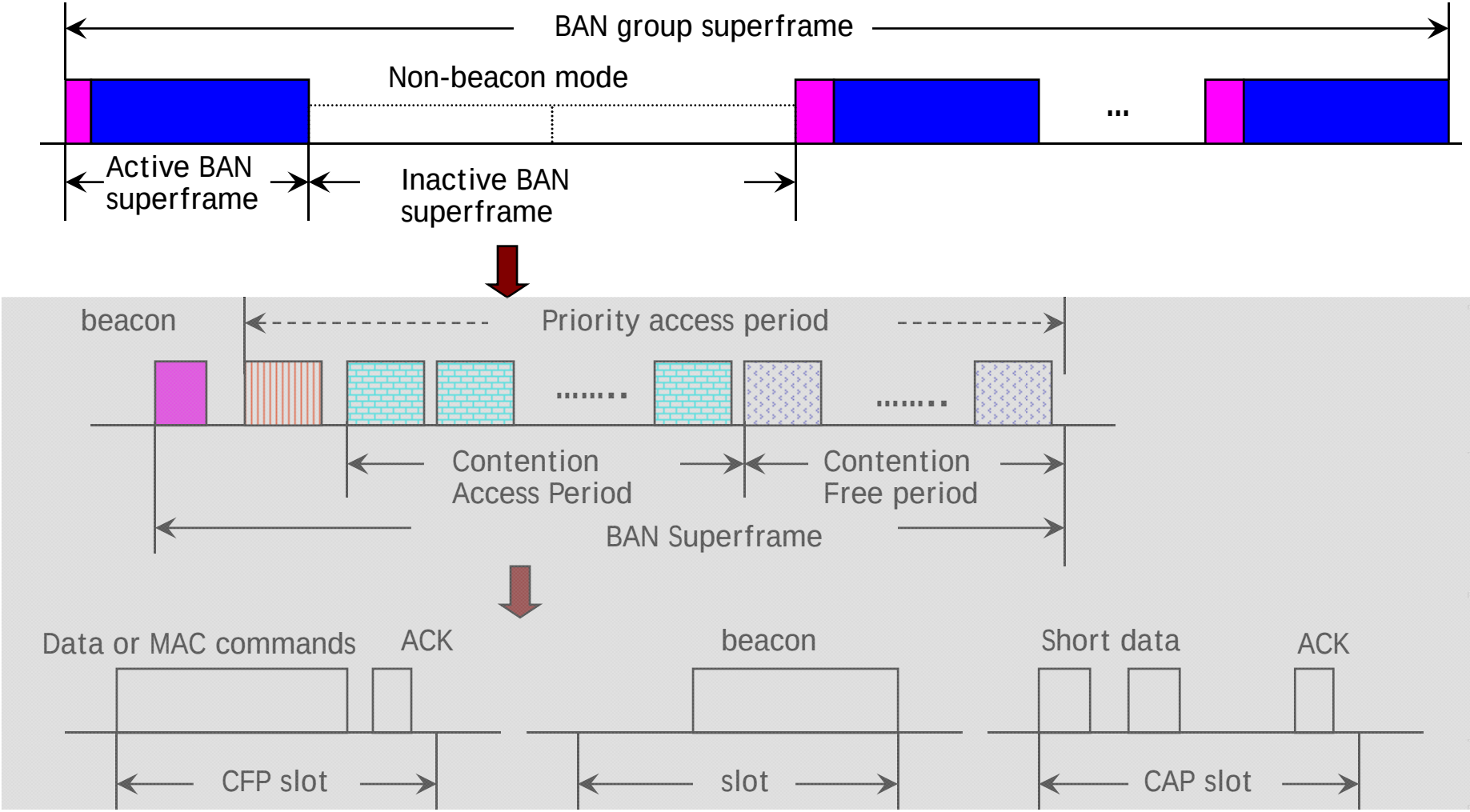
- 1. TG6 Requirement and Overview
- 2. BAN Group Superframe
  - 2.1 Introduction of BAN group superframe
  - 2.2 BAN group superframe concept
- 3. Performance Evaluation
- 4. Self-evaluation
- 5. Conclusion

§1. TG6 Requirement and MAC Protocol

MAC requirements

- Medical and multi-media applications
- Dependability and QoS guarantee
  - Life-critical message → Priority access and CFP
- Scalability
  - Possible multiple PHYs → TDMA
  - data rate
  - duty cycle and network size → BAN group superframe
- Power efficiency
  - → Power efficient beacon, non-beacon mode

Overview of MAC proposal



§2. BAN Group Superframe

§2.1 Introduction of BAN group superframe

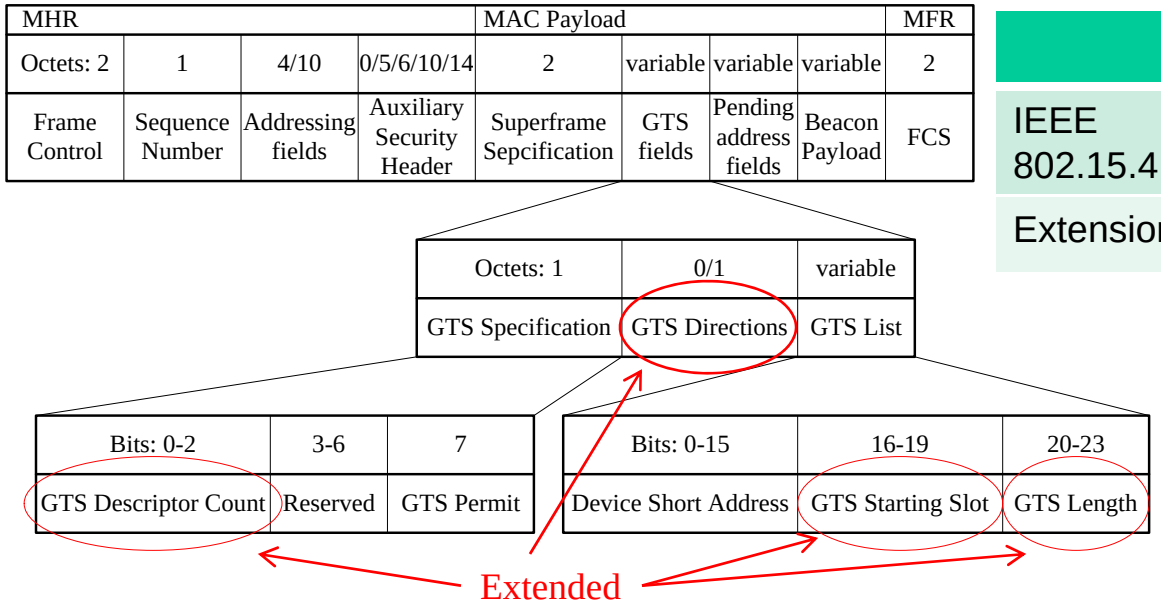
Motivations

- Dynamic BAN size
  - Up to 256 nodes in a piconet
  - Typical network size is about 10
- Dynamic duty cycle
  - Low duty cycle <0.1%
  - Medium and heavy duty cycle
- Dynamic data rate of real time traffic
- How to guarantee the QoS and maintain the low power consumption?

- How to support more devices using more slots?
  - Two methods:
    - Extend a superframe with more slots
    - Combine multiple superframes into a group

- An example of the minimum PHY Payload (PSDU) length of a beacon frame (assume with short address and no beacon payload, auxiliary security header and downlink traffic)

Beacon frame format



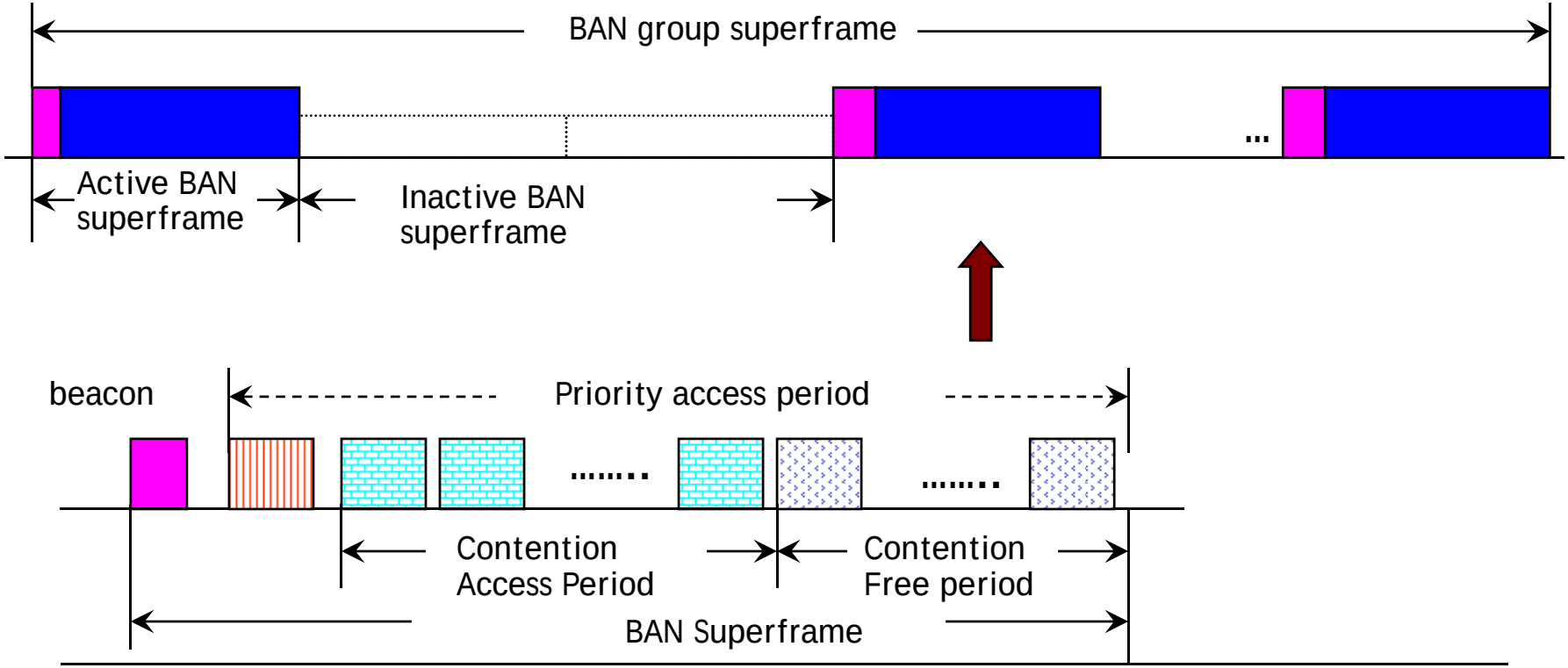
	1 GTS	Maximum condition
IEEE 802.15.4	17 bytes	35 bytes (7 GTSs)
Extension	19 bytes	1070 bytes (256 GTSs)

34.24 ms for 250 kbps, or
85.6 ms for 100 kbps
Impractical for BAN applications

§2.2 BAN group superframe concept

BAN group superframe

- A BAN group superframe consists of *N* superframes
  - Each BAN superframe can be active or inactive
  - Beacon interval is defined by beacon order



Benefit of BAN group superframe

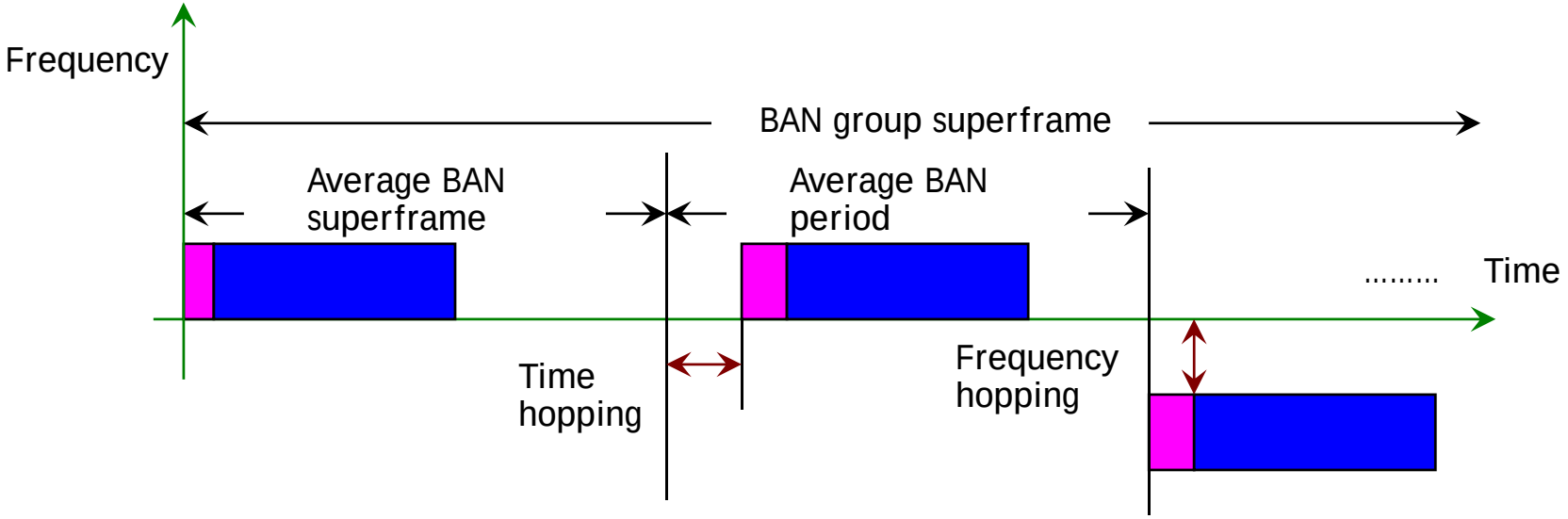
- To provide data rate and QoS support
  - Totally there can be up to *N*Nf* GTS in a BAN group superframe
  - More than one slot in a BAN group superframe can be allocated to a link
- To provide dynamic duty cycle support
  - Scheduled and synchronized active and inactive period
  - Power saving by optional beacon listening
  - Easy for multihop support and radio resource computation
- To provide a hardware clock to upper layer
  - BAN superframe can be time unit

Why it is better than a long BAN superframe?

- Short and practical beacon frame
- Extension to 802.15.4
  - Easy for chip maker
- Clock offset after beacon in the BAN superframe
  - Some devices may enter inactive mode after the beacon until its slots
- More flexibility

Interference and coexistence consideration

- BAN superframe can do time hopping or frequency hopping to avoid jamming attacks



Beacon frame structure

- BAN single superframe beacon
  - Bit-wise synchronization
  - BAN superframe management
  - Sequence number
  - Pending traffic
- BAN group superframe beacon
  - BAN group superframe management

§3. Performance Evaluation

Simulation assumption and definition

- A perfect physical channel
- Packet errors are due to packet collision, lifetime and buffer overflow
- Traffic
  - Periodical traffic
  - Poisson distribution of best-effort traffic
- Star topology
- Communication and power consumption includes slot request, ACK and re-transmission

Simulation parameters

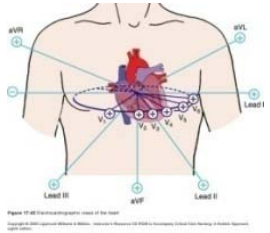
Parameters	Value
Data rate	250 kbps
Slots in BAN superframe	16
Slot duration	240 symbols
Symbol time	16 μs
PHYSymbolsPerOctet	2
CAP Retries	3
ACK wait duration (max.)	54 symbols
ACK command	5 Octets
GTS Request command	11 Octets
MAC Header	9 Octets
PHY Header	6 Octets

Parameters	Value
Tx power consumption	36.5 mW
Rx power consumption	41.4 mW
Sleep power consumption	42 μW

Ref. Chipcon CC2420

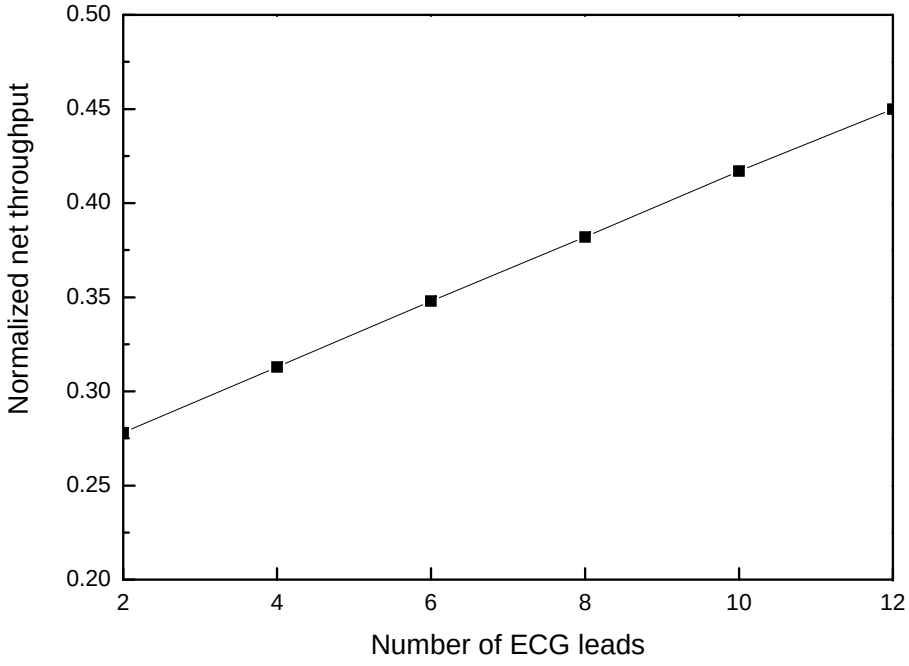
Simulation time	30 s
Simulation rounds	50,000 times

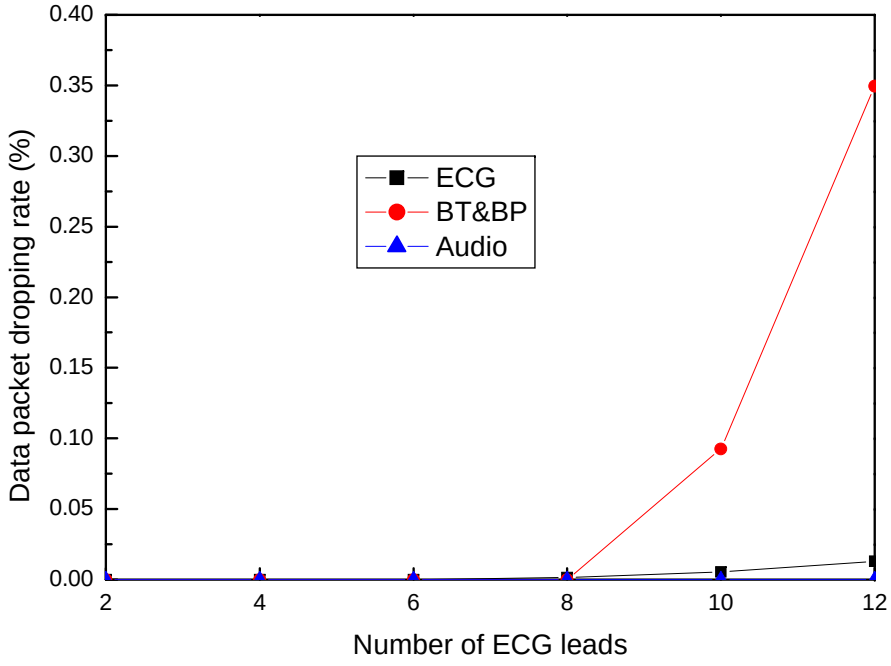
Scenario: mixed medical traffic and audio traffic

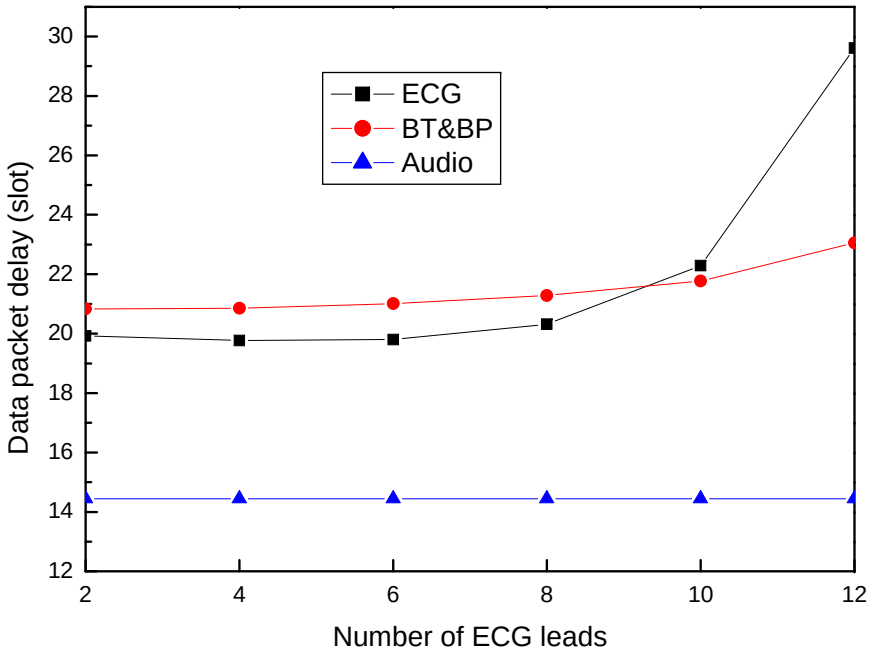


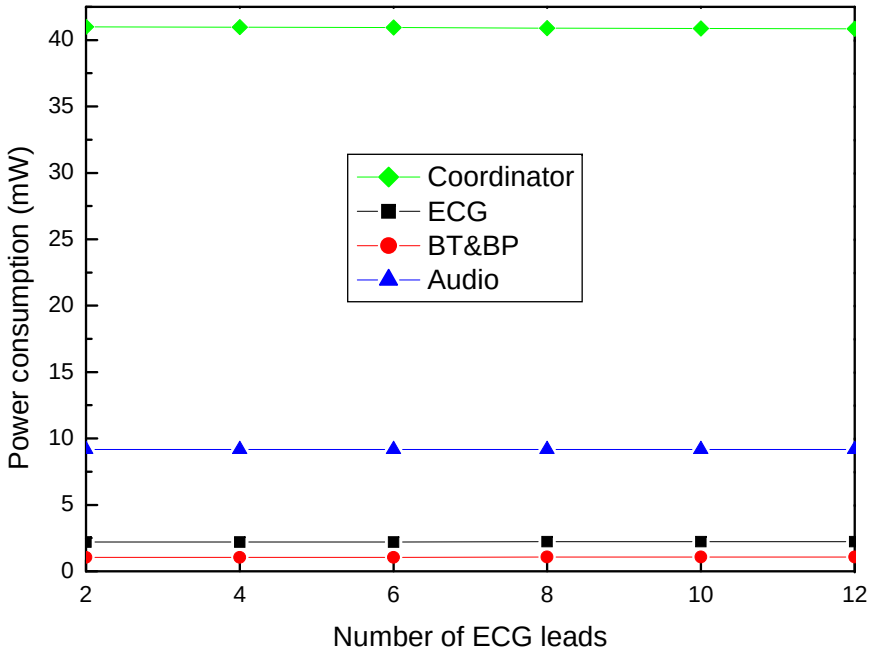
Applications	Leads/ Sensors	Traffic load	Payload (bytes)
ECG	2,4,6,8,10,12	4.352 kbps/lead, 8 packets/s/lead	68
Body temperature (BT)	1	1.6bps, 1packet/5s	1
Blood pressure (BP)	1	3.2bps, 1packet/5s	2
Audio	2	30kbps each	68

- Commands contend in CAP and data transmit in GTS
- A BAN group superframe consists of two single superframes


Normalized net throughput
0.50
0.45
0.40
0.35
0.30
0.25
0.20
2
4
6
8
10
12
Number of ECG leads


Data packet dropping rate (%)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
ECG
BT&BP
Audio
2
4
6
8
10
12
Number of ECG leads


Data packet delay (slot)
Number of ECG leads
ECG
BT&BP
Audio
30
28
26
24
22
20
18
16
14
12
2
4
6
8
10
12


Power consumption (mW)
Number of ECG leads
Coordinator
ECG
BT&BP
Audio
40
35
30
25
20
15
10
5
0
2
4
6
8
10
12

§4. Self-evaluation

- MAC transparency
  - TDMA
- Scalability
  - BAN group superframe
  - Minislot in CAP
- QoS and dependability
  - GTS in BAN superframe
  - PAP
  - Emergency mode
- Power efficiency
  - Inactive BAN superframe
- Topology
  - Star topology
- Interference and coexistence
  - Optional TH and FH of BAN superframe
- Easy to implement

§5. Conclusion

- BAN group superframe
  - Flexible and practicable
  - Support medical and multi-media traffic
- Performance simulation
  - Mixed medical and audio traffic
- Welcome cooperation