

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

Submission Title: [Network Merging :
Design Strategies of An Ultra Low Power and High Reliability MAC]

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Re: [If this is a proposed revision, cite the original document.]

Abstract: [Network Merging , a WBAN-specific design strategy, is presented and analyzed. Without considering the unique features of WBAN, traditional wireless protocols fail the requirement and even induce negative impact. The unique features including the network mobility and imbalanced traffic loading are analyzed and corresponding design strategy, Network Merging, is suggested.]

Purpose: [Develop a Network Merging methodology for medical WBAN applications.]

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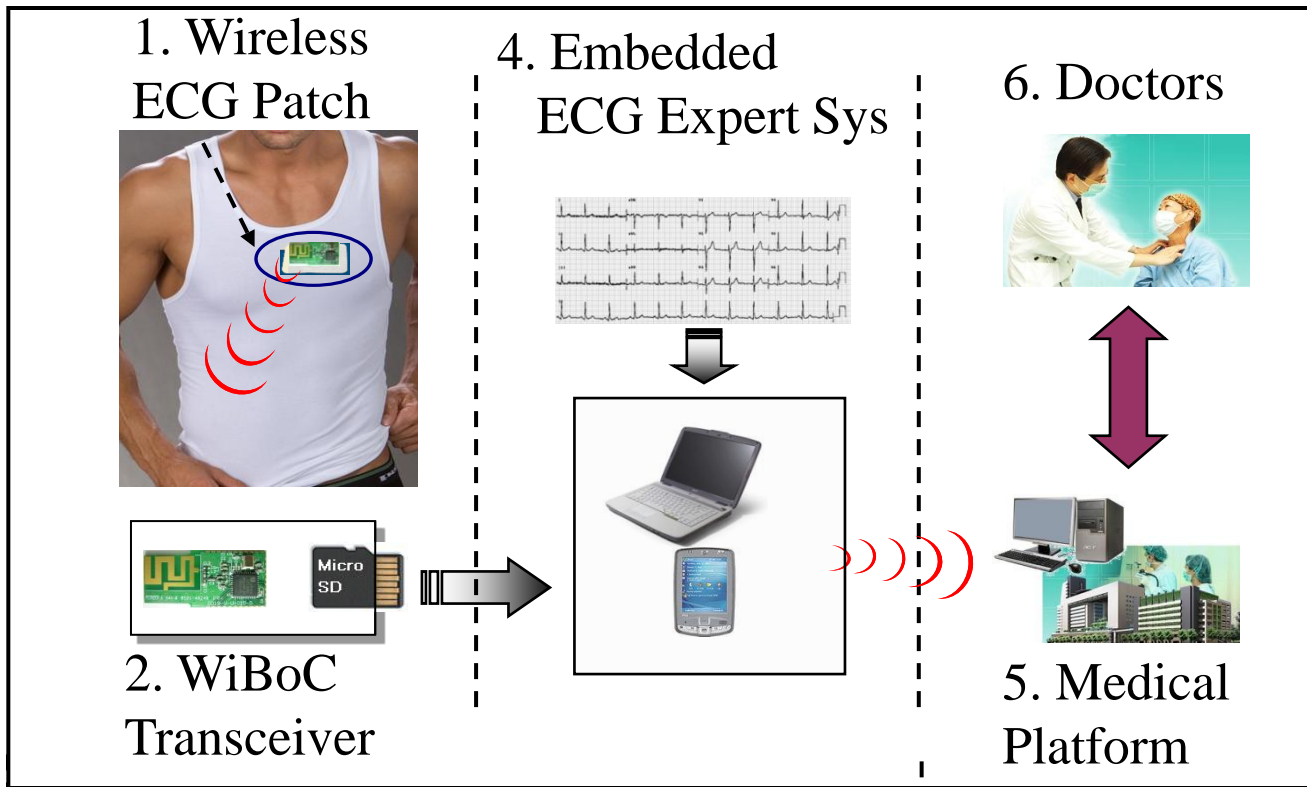
Network Merging

Design Strategies of An Ultra Low Power and High Reliability MAC

Outline

- U-PHI project, Taiwan
- Medical Wireless Body Area Network (WBAN)
- Requirements of medical WBAN
- Design strategy: Network Merging
- Evaluation of Network Merging
- Conclusion

Ubiquitous Personal Healthcare Inspector (U-PHI) project, Taiwan



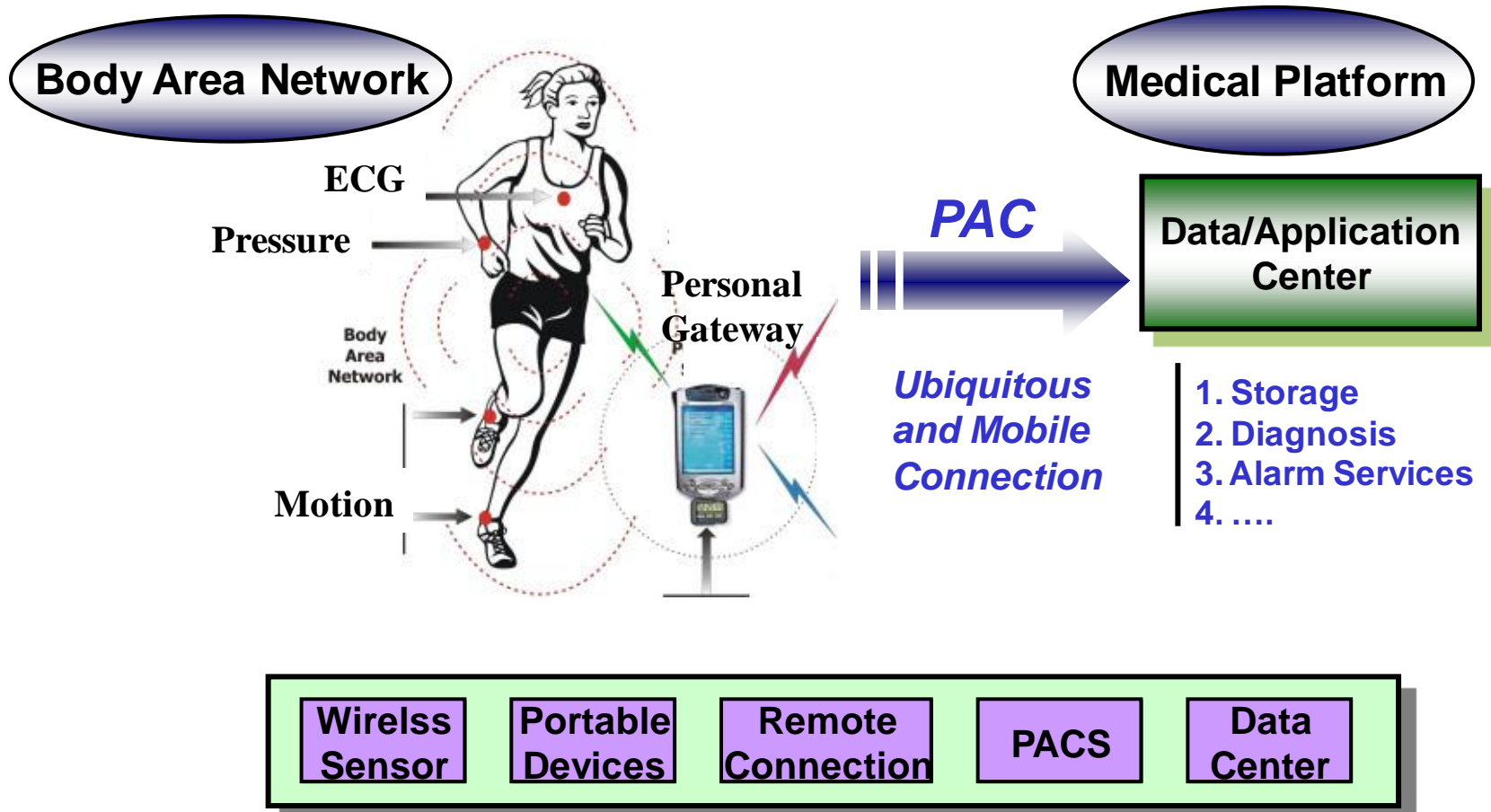
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Medical Wireless Body Area Network



Graph: E. Jovanov, A. Milenkovic, C. Otto, "A wireless body area network of intelligent motion sensors for computer assisted physical rehabilitation" in *Journal of NeuroEngineering and Rehabilitation*, 2005.

Requirements of medical WBAN

- Ultra Low power
 - Tens of hours to years battery life time

Endoscopy
>12 hours



Pacemaker
>5 years

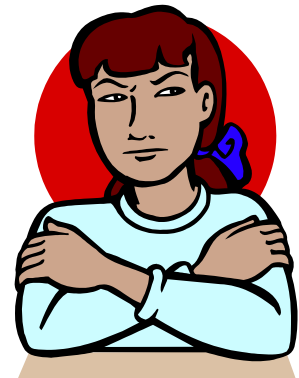


http://www.olympus-europa.com/endoscopy/2001_5491.htm

<http://www.healthnode.org/taq/pacemaker/>

Requirements of medical WBAN

- Who needs ultra Low power?
 - End devices does.
 - Low power solutions of sensor network does not work due to its uniform power consumption!
- Energy efficiency of end device is more important than central device.
 - User rather recharges specific device than all devices.
 - Especially when number of devices > 24 (EEG, Neuron Apps)
 - ● Save End devices!



Requirements of medical WBAN

- High reliability (Qos of medical apps)

- Definition? (#0644)

- Latency < 20ms ?
 - Jitter < 2ms ?
 - Reaction > 99.99% ?



- ✓ Real-time Display
 - ✓ Lossless data storage

- Sure thing :

- Both real-time & data integrity should be considered for medical traffic.

- Medical traffic loading > Traditional Real & non-Real traffics

- Need higher Channel efficiency

- Avoid packet collision to increase capacity

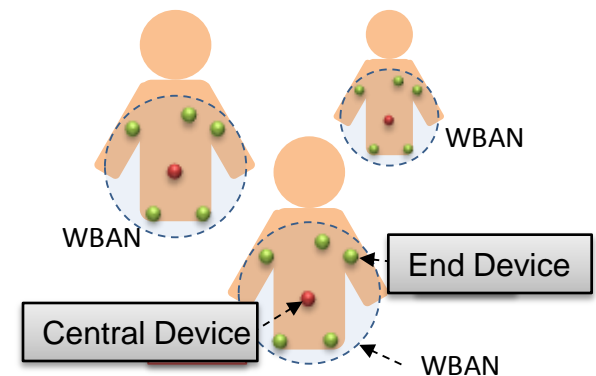
Design strategy: Network Merging

- Network Merging is a collision free protocol, which promises up to **4x** user number increase & **29%** battery life time improvement.

That is,

5 simultaneous users → 20 users

30 days battery life → 40 days



Design strategy: Network Merging

- Collision is the major source of power consumption.

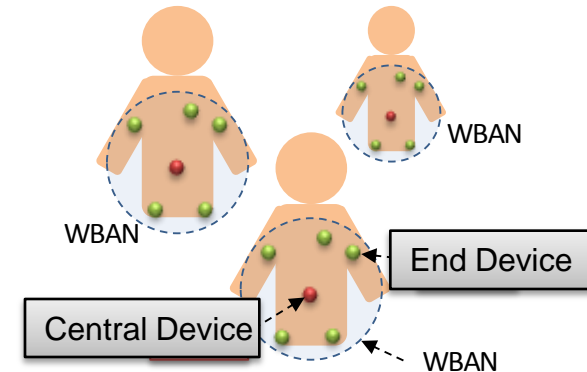
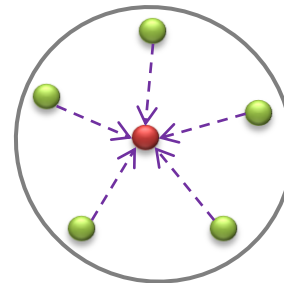
Power waste in traditional sensor network

- Overhearing ✗
- Idle listening ✗
- Control message ✗
- Packet collision** ✓

Due to the “simple star”
feature of WBAN

Design strategy: Network Merging

- Simple Star Topology
 - 3-5m radio range can cover most medical apps.
 - Upload-oriented traffic.



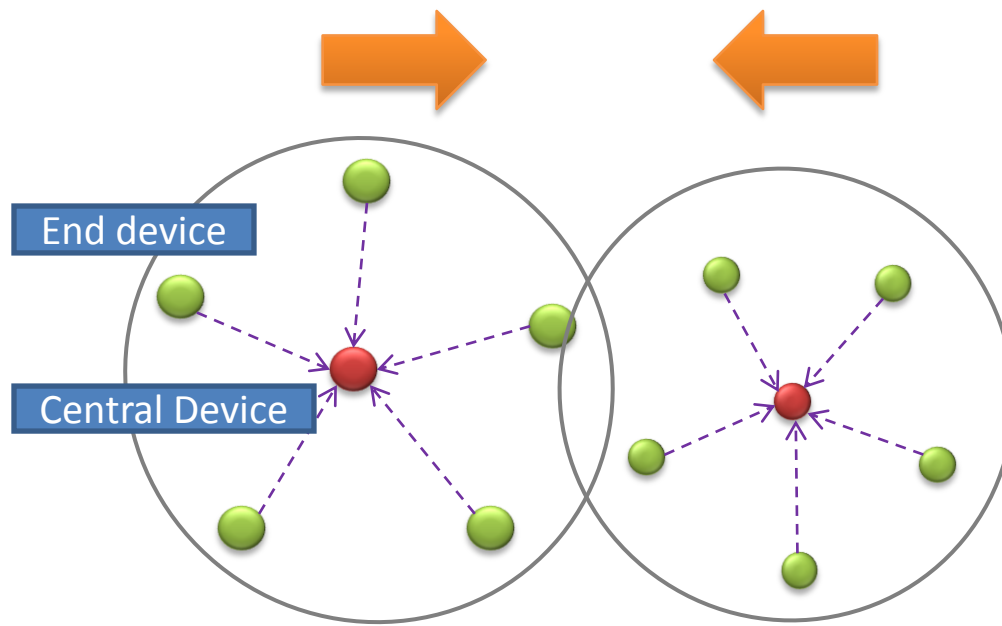
Power waste in traditional sensor network

- Overhearing **✗** Rx only! Not a problem of end device
- Idle listening **✗** ∴ End device is only a TX in most medical apps
- Control message **✗** Assume traffic loading >> overhead
- Packet collision **✓**

● Collision is the major source of energy waste in WBAN!

How does Network Merging solve collision?

- Network Merging synchronizes the Tx schedules of multi-WBAN.



- (1) Neighborhood discovery
- (2) Schedule Synchronization

How does Network Merging solve collision?

- Why not Beacon or CSMA/CA? *

(Beacon: cellular network, Bluetooth;
CSMA: sensor, ad hoc, mesh networks)

- CSMA/CA

- ✓ Low Power

- ✗ Poor channel efficiency

- Beacon (Polling)

- ✓ High channel efficiency

- ✗ Very low power

but suffers inter-network collision

Can not be used in high density WBAN.

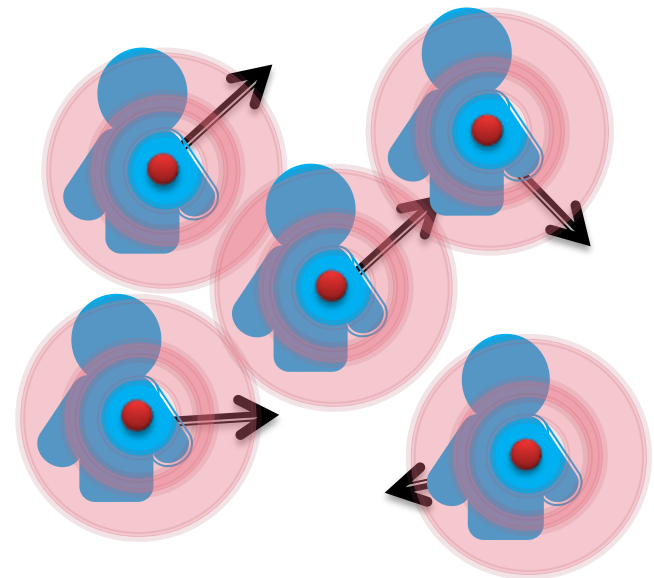


● 240 sensors / elevator.
(24 nodes x10 people)

* ShihHeng, Cheng, ChingYao, Huang, Power model for wireless body area network, BioCAS, Baltimore, MD, Nov, 20-22, 2008

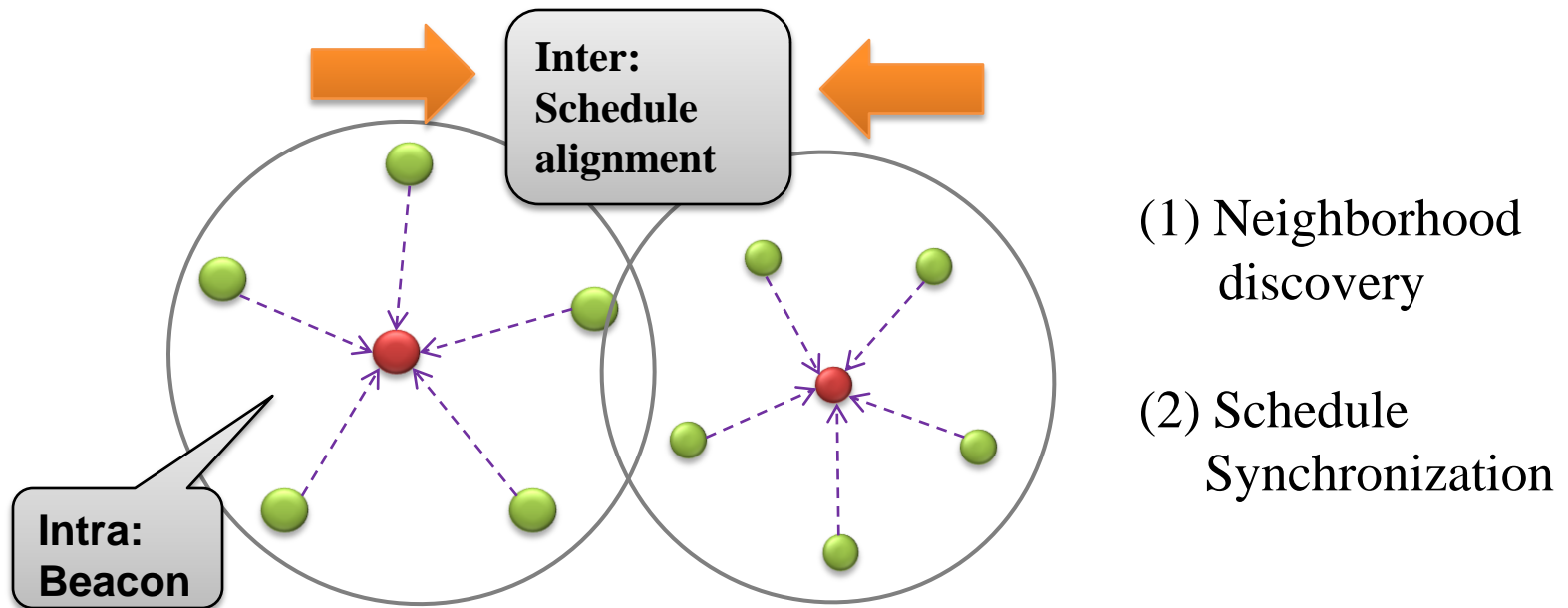
How does Network Merging solve collision?

- New collision source: inter-network collision.
Reason: Moving network
 - WBAN moves with the position of user.
 - Traditional sensor network usually consider static or slowly move topology.
 - MANET considers “node” mobility. However, “network” mobility is more complex.



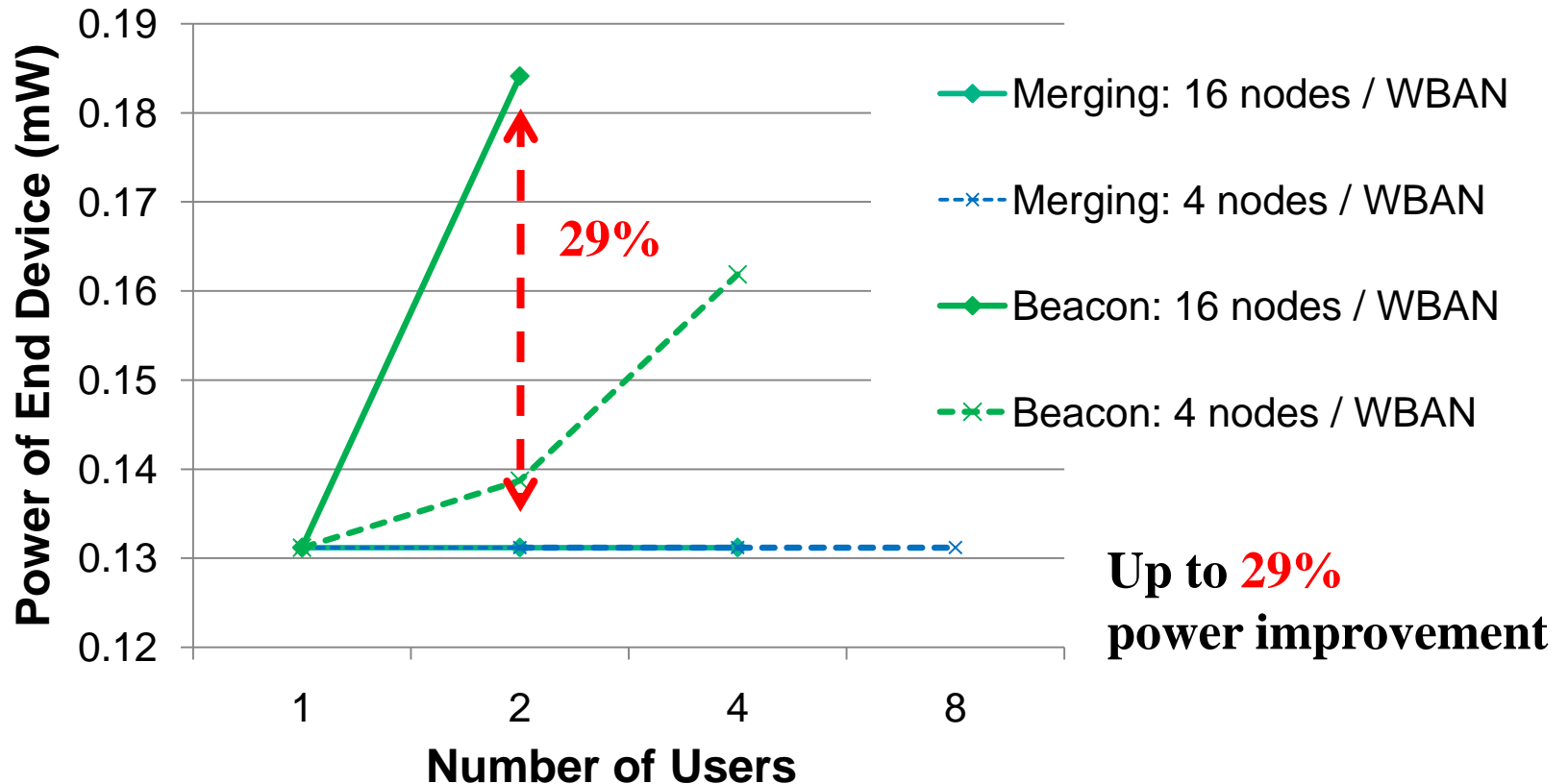
How does Network Merging solve collision?

- Network Merging overcomes both intra & inter network collision.



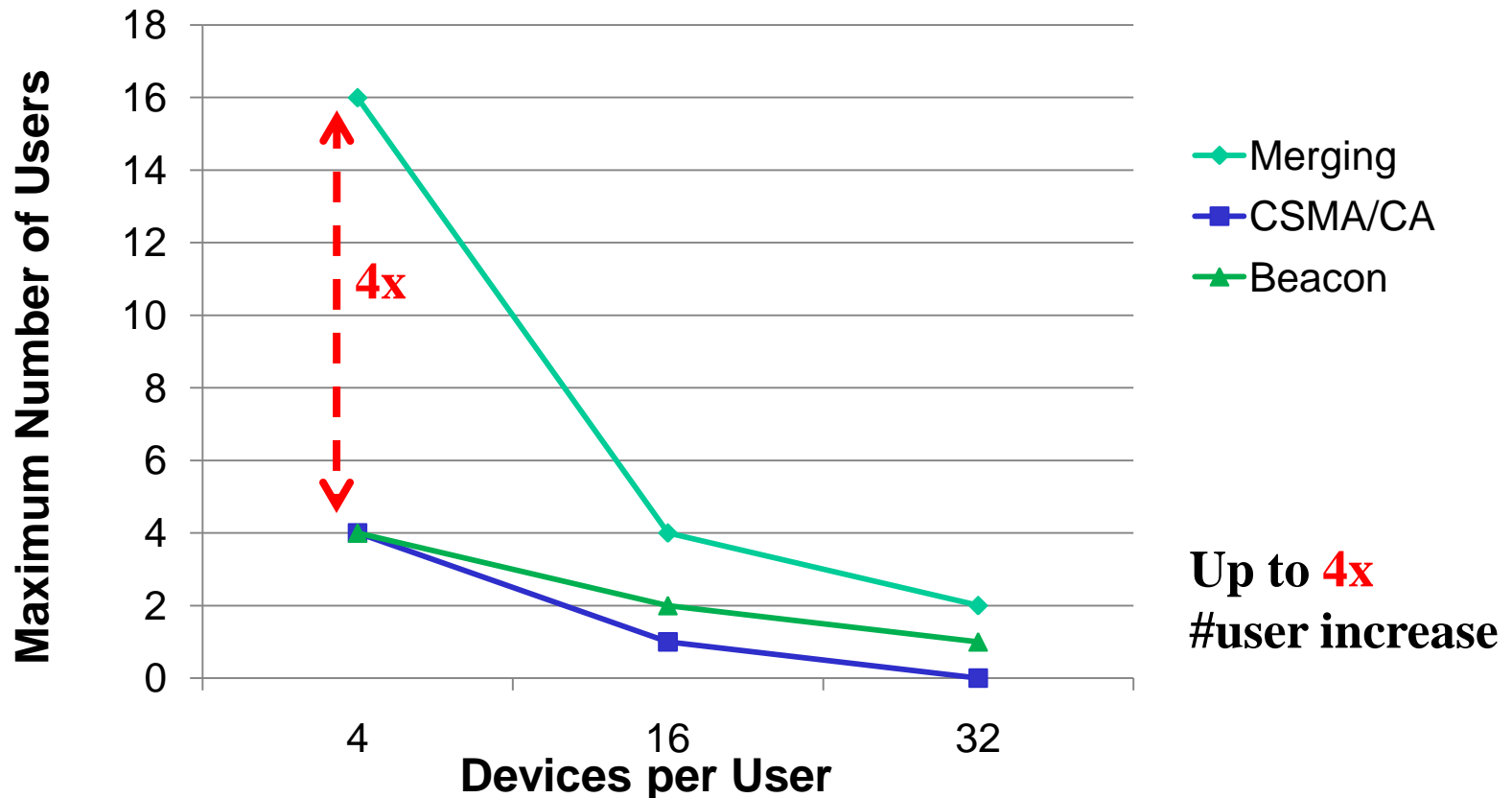
Evaluation: Network Merging

- Synchronize Tx schedules of multiple WBANs



Evaluation: Network Merging

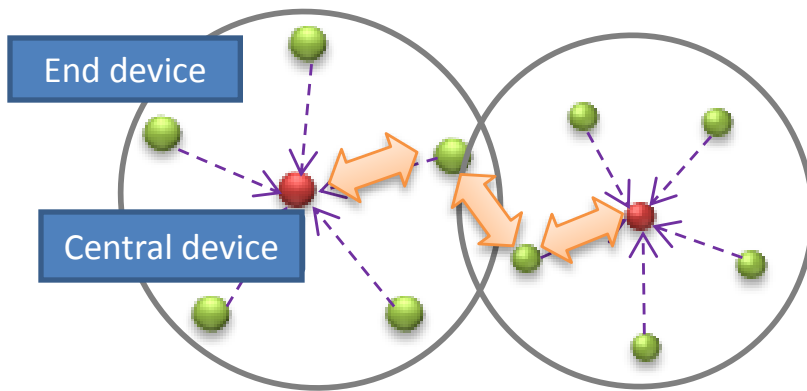
- Synchronize Tx schedules of multiple WBANs



Open issues

- Direct or Assisted network merging?

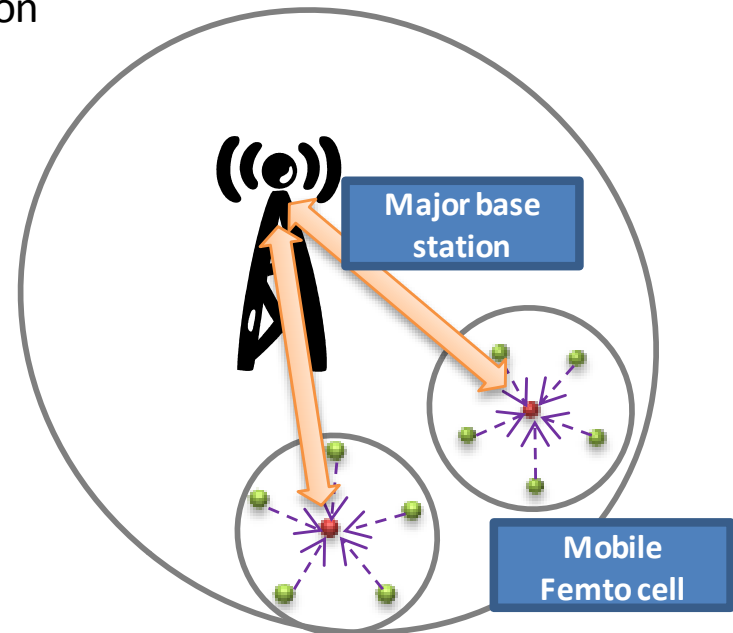
↔ Path of Inter-network communication



(a)

Direct network merging

✗ Routing overhead of end device



(b)

Assisted network merging

✗ Accurate localization

Open issues

- Is there a better approach?

Overview of network merging

Advantage	Approach	Comparison with traditional solutions	Open issues
Optimize both power efficiency & channel capacity.	Solve the inter-WBAN collision by neighbor discovery and schedule negotiation.	<ul style="list-style-type: none">● Beacon: very low power efficiency● CSMA/CA: very low channel utility	Tradeoff between direct and assisted inter-WBAN communication.

Conclusion

- Two major requirements:
 - low power & high reliability
- Two unique features:
 - Simple Star & Moving Network
- Network Merging
 - Solve intra & inter network collision
 - Meet two WBAN requirements.

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