WiZi-Cloud: Application-transparent Dual ZigBee-WiFi Radios for Low Power Internet Access

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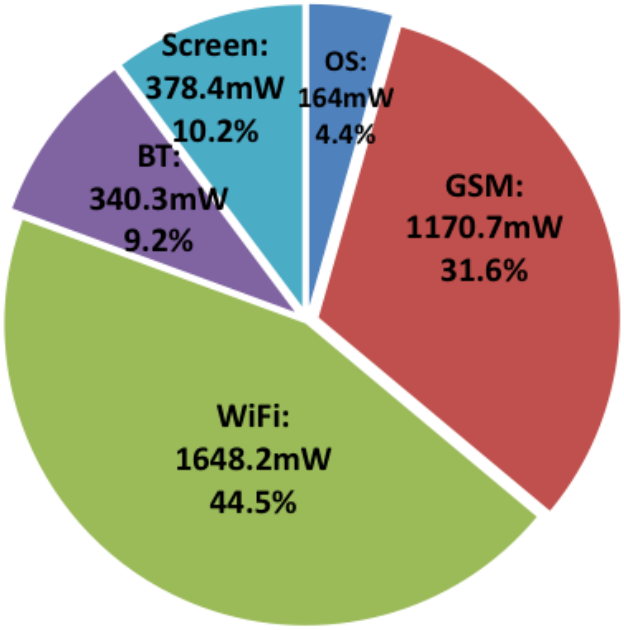
InfoCom 2011, Shanghai

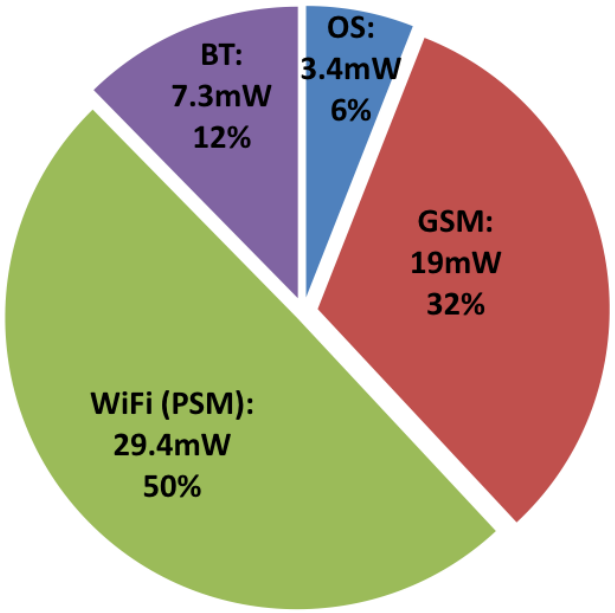
Quick Facts

- Mobile devices rapidly evolves in the past few years
- Ever increasing mobile Internet traffic
- Battery bottleneck

Energy Usage Breakdown: Active & Idle



Radios active, screen on



Radios idle, screen off

Reduce Network Energy Usage

- Optimize the network interfaces, WiFi, GSM, BT
  - power efficient protocol design
  - hardware design
- Alternative low power radio interface
  - Keep energy consuming interface off as long as possible, wake up only when needed
  - Low power alternative radio for traffic or signaling

WiZi-Cloud

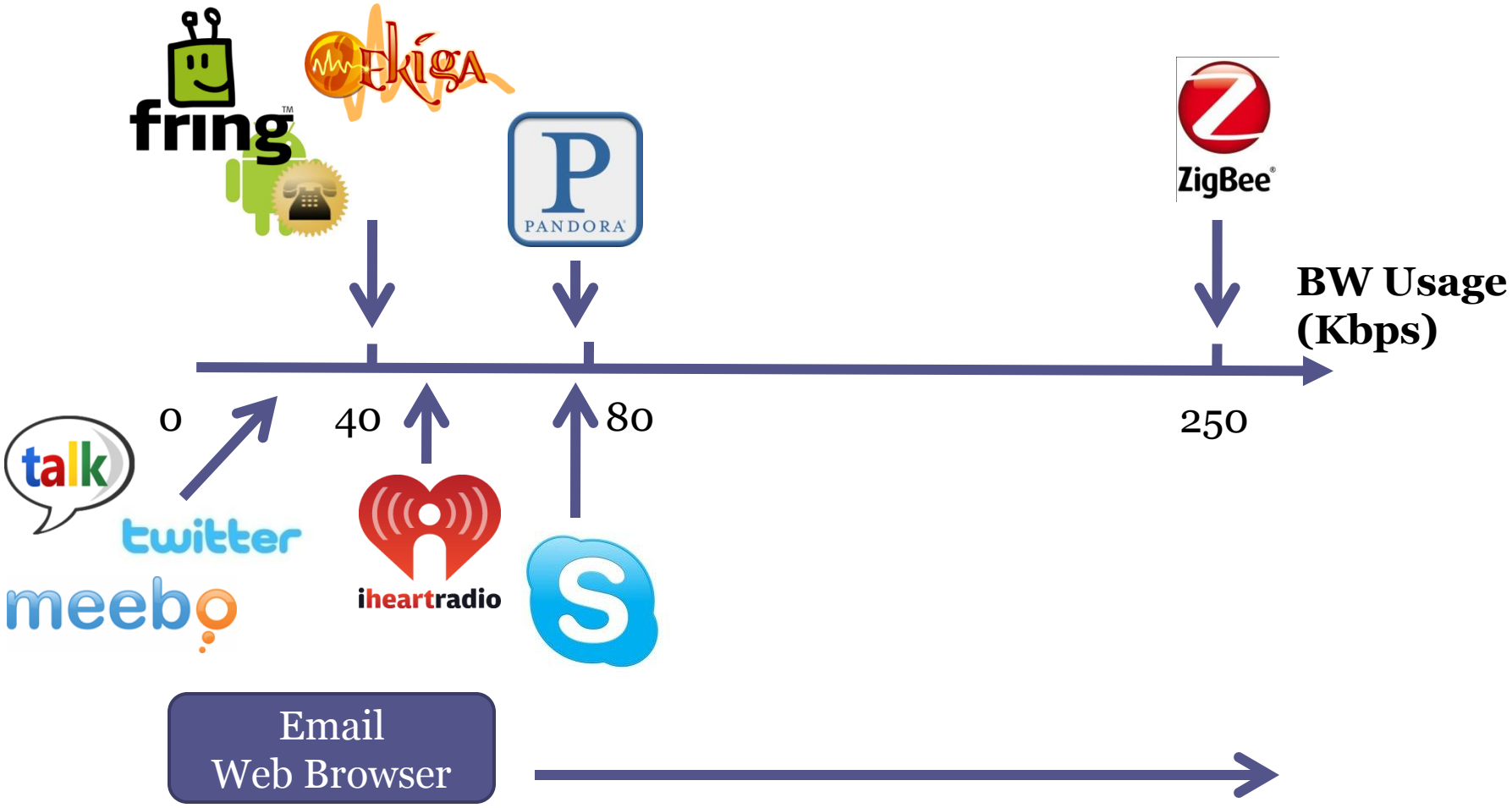
- Dual ZigBee-WiFi radios
- ZigBee has unique features
- Characteristics of energy consumption
- Feasibility study
- Complete design and prototype:
  - Main stream apps well supported
  - 300% energy efficient
  - Good coverage

ZigBee Overview

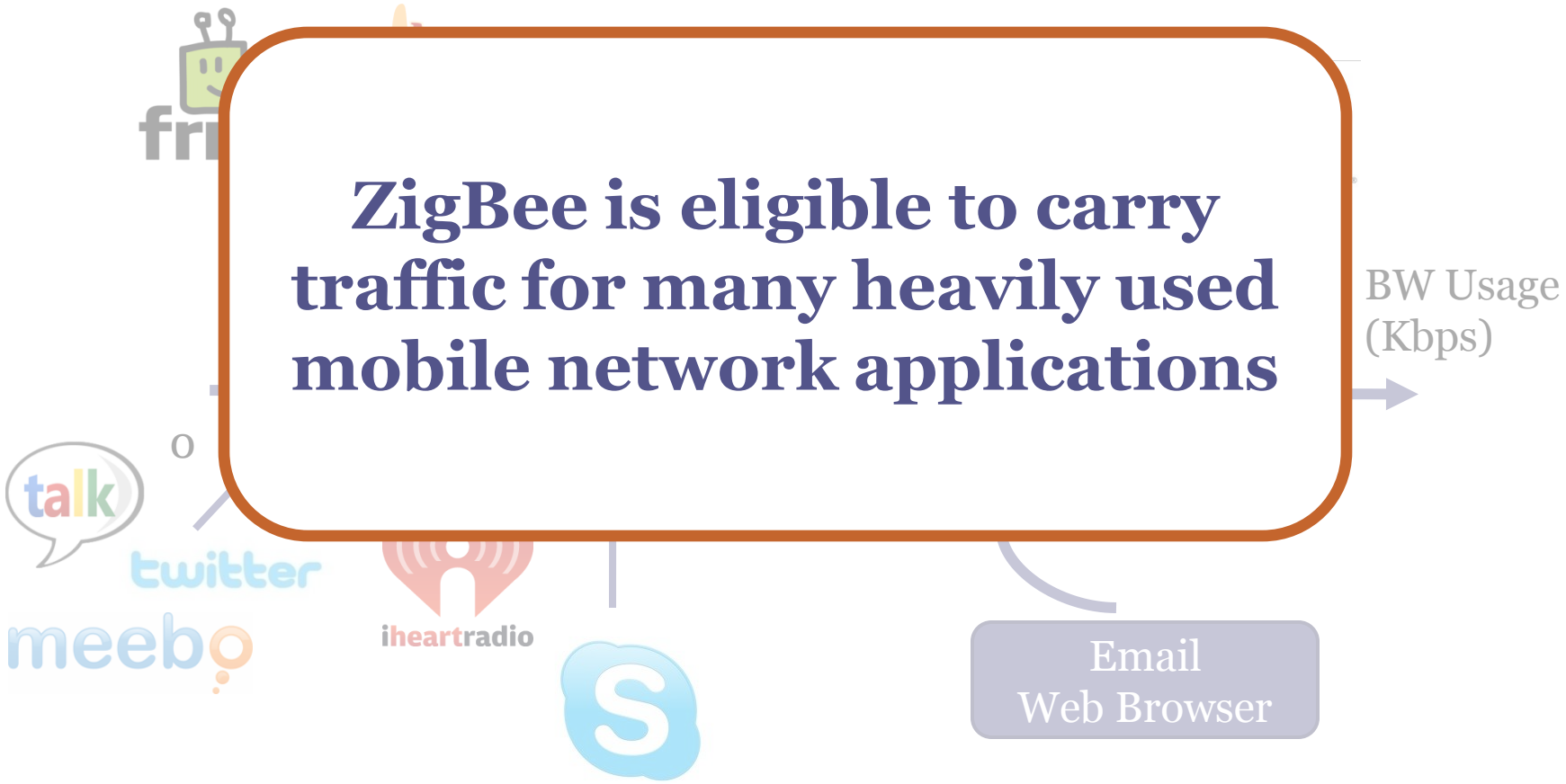
- Ultra low power
- Low data rate (250Kbps)

Big limitation?

What can 250Kbps do?



What can 250Kbps do?

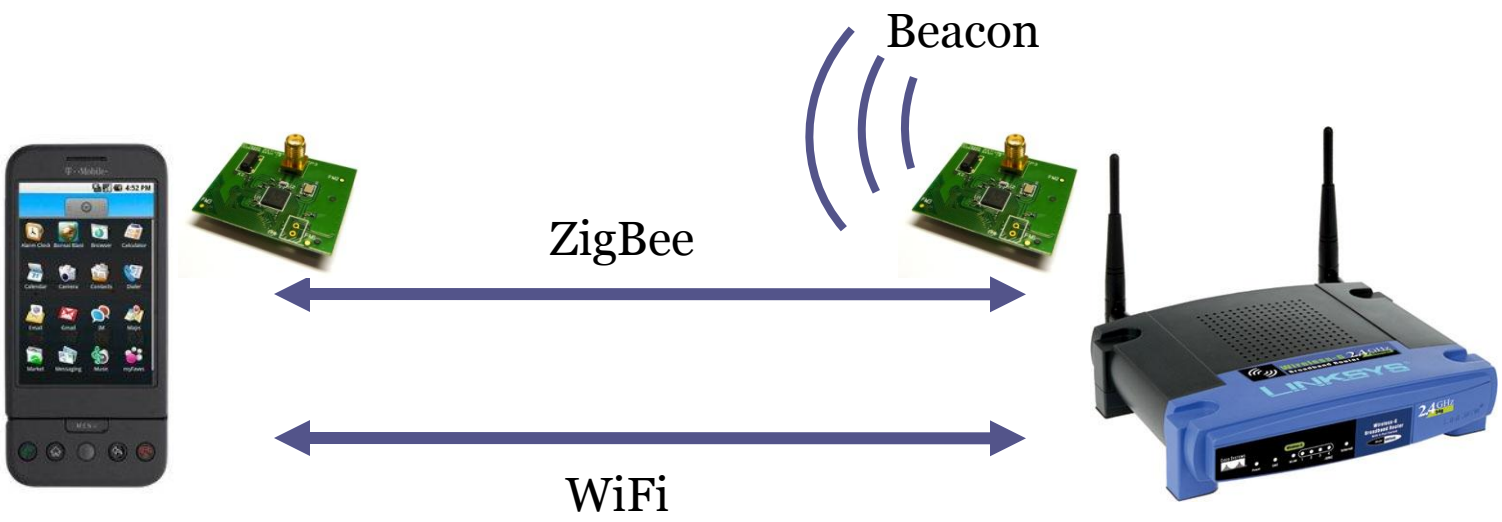


Outline

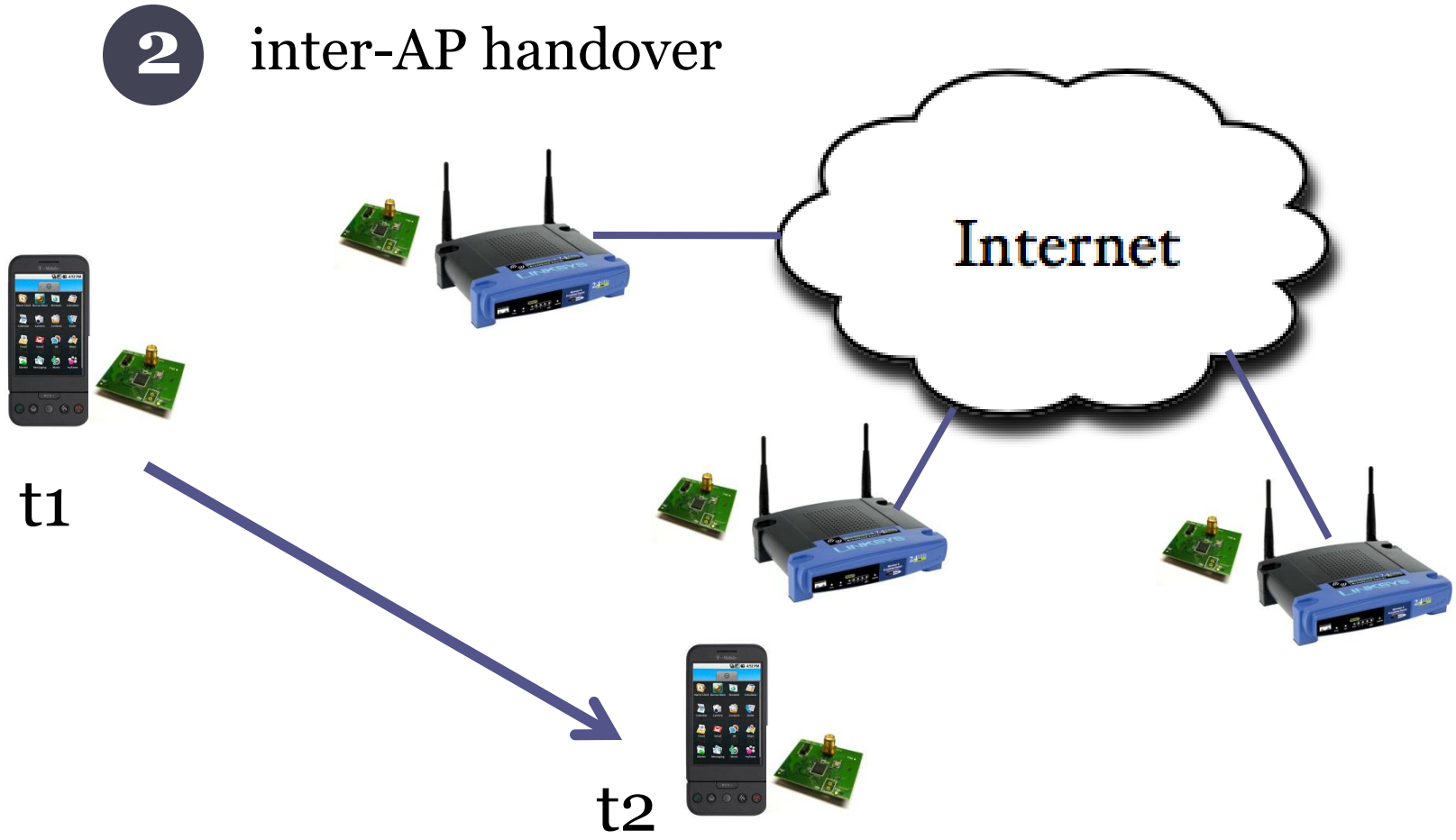
- WiZi-Cloud System Design
- Prototype & Observations
- Evaluation
- Conclusion

WiZi-Cloud System Design

1. Intra-device interface handover

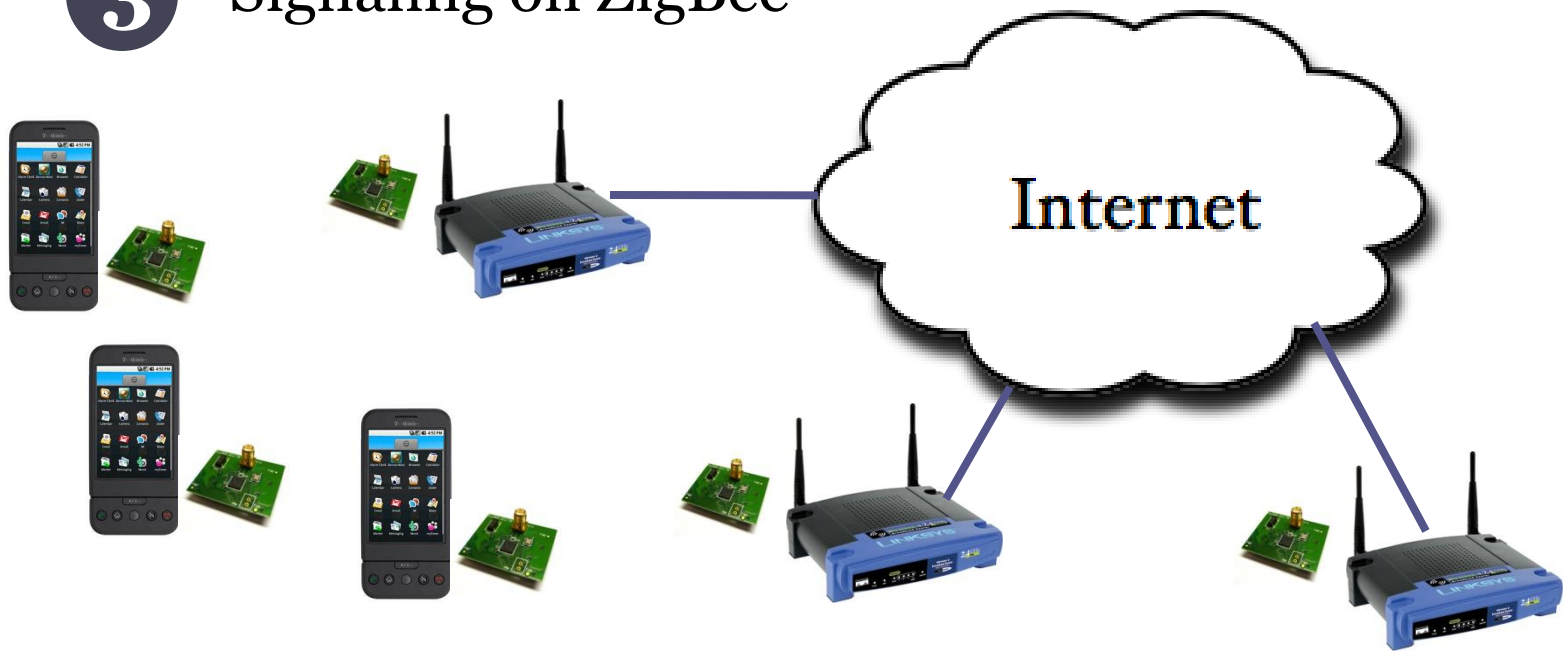


WiZi-Cloud System Design

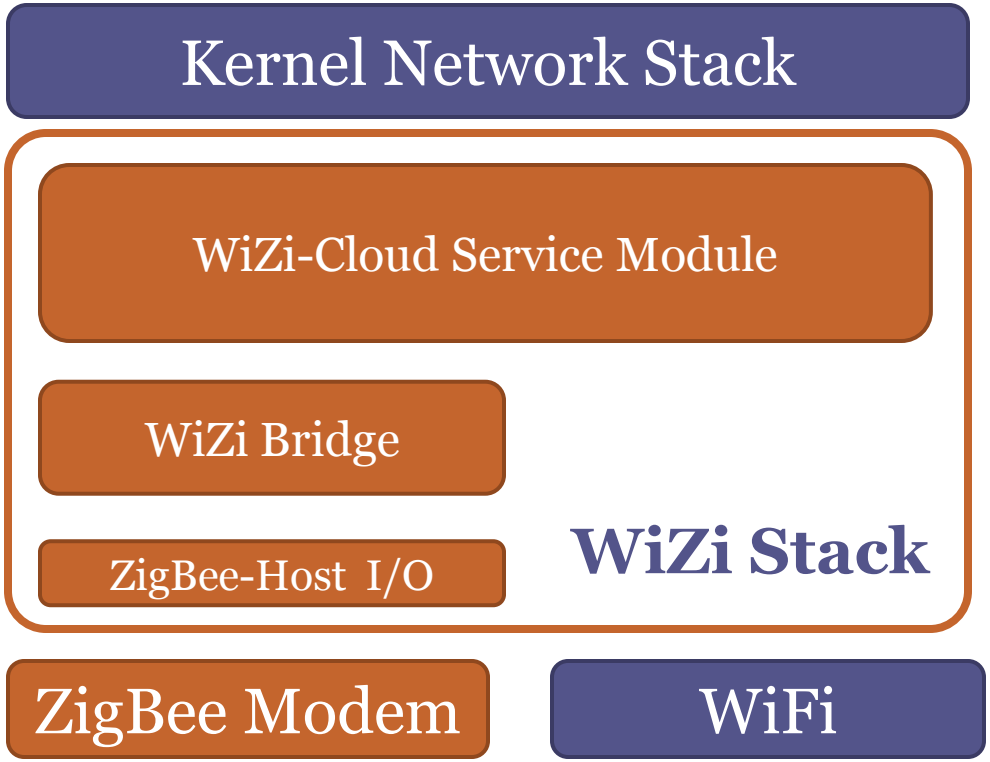


WiZi-Cloud System Design

3 Signaling on ZigBee



Software Architecture



- Leverage existing HW/SW
- Seamless intra-device/inter-AP handover
- Flexibility for handover policy design

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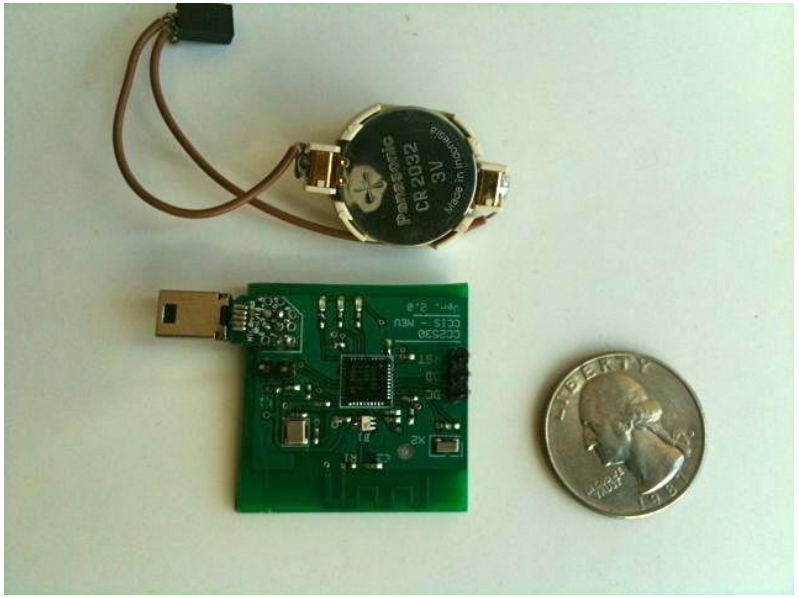
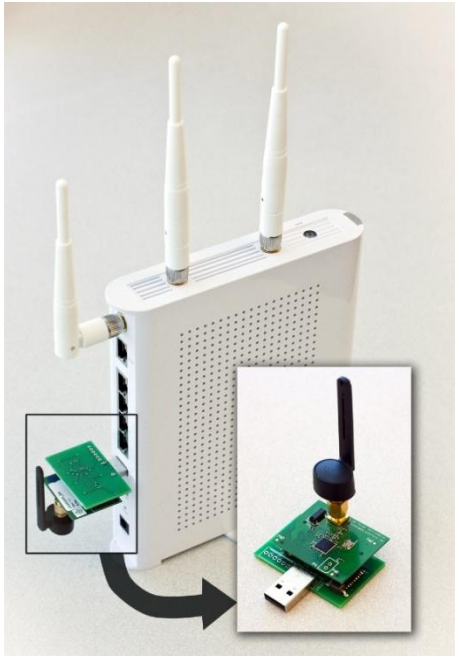
Client Prototype

- Android G1, with modified Linux kernel, UART support
- User space WiZi stack
- ZigBee USB dongle



AP Prototype

- OpenWrt based (Linux) AP firmware
- On-board serial port, USB port



Observations

- Throughput vs. energy efficiency
- Work with slow data links
- Flow control on ZigBee-Host link is critical
  - Limited MCU and storage capability on ZigBee
  - ZigBee RF link fluctuates
  - Flow control overhead: trade off throughput for reliability
  - Pipeline!!!

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  - Energy efficiency
  - Throughput
  - Coverage
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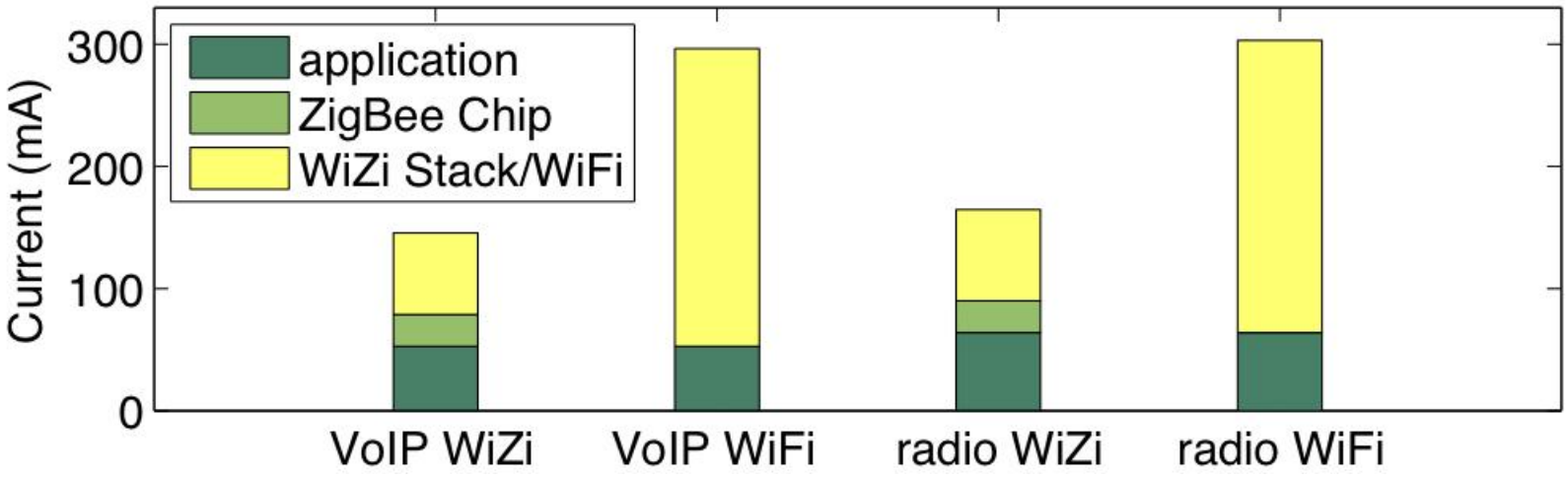
Evaluation 1. Energy Efficiency

- Evaluate with real mobile applications
- Test same app with ZigBee & WiFi
  base performance

Sample App.	Latency Sensitivity	Traffic Load
VoIP, stream audio	high	moderate
Email	moderate	moderate
Web	low	high

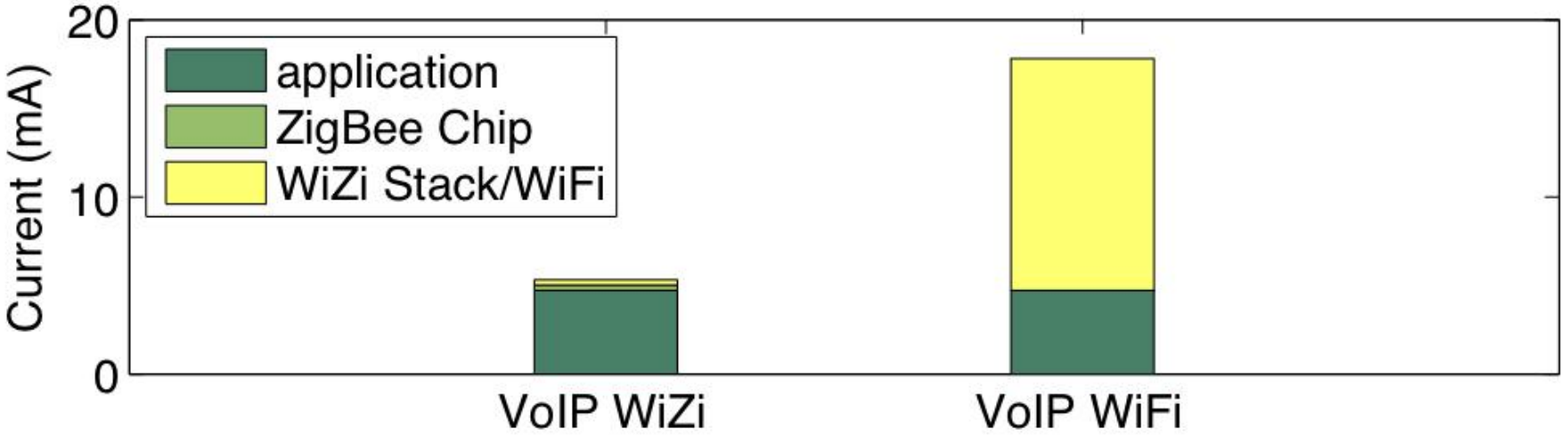
Evaluation 1. Energy Efficiency

- VoIP & Stream Radio
  - High delay sensitivity
  - Moderate traffic load
- Active mode: reduce energy usage by 50%



Evaluation 1. Energy Efficiency

- VoIP standby time: extended by 3 times!



Evaluation 1. Energy Efficiency

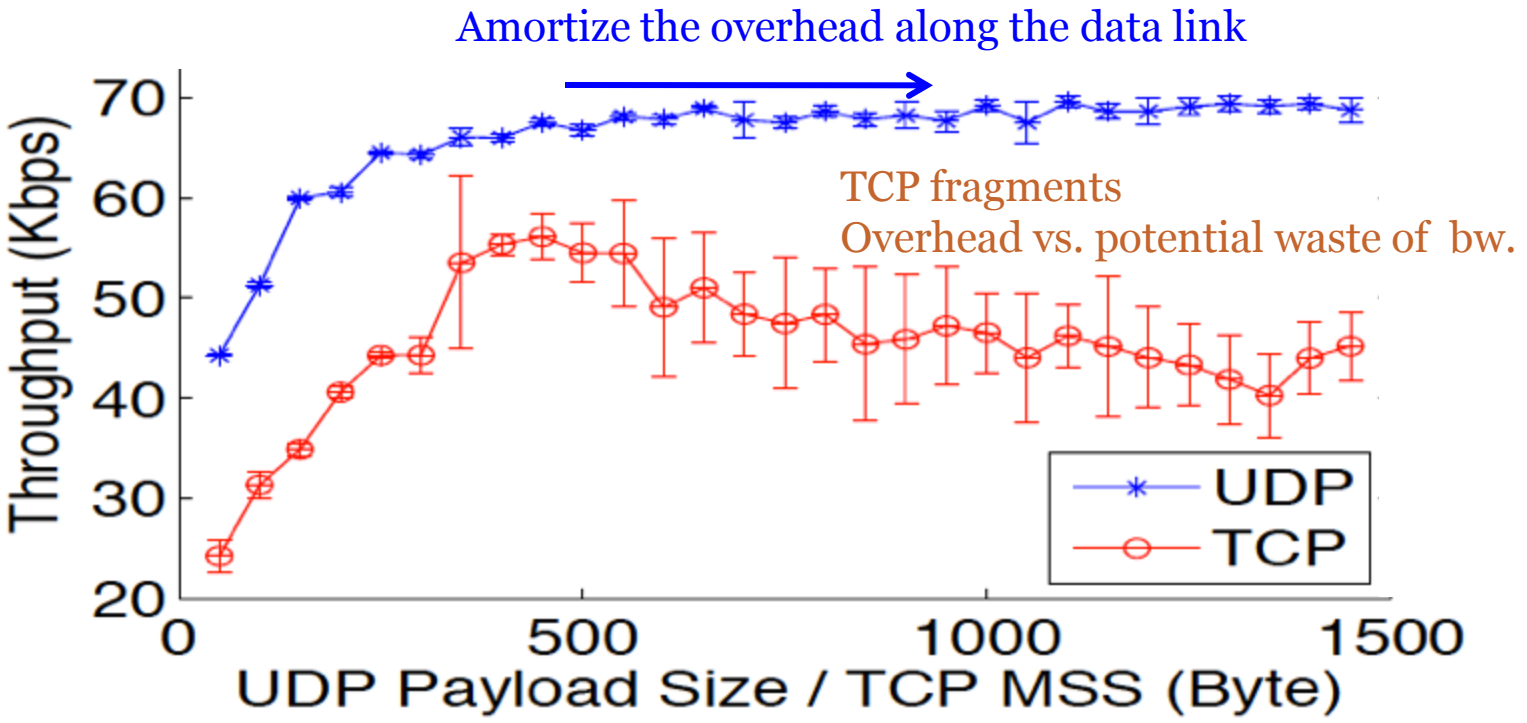
- Web browsing: low delay sensitivity, high traffic load
  - Browse Google Reader on G1
  - Download the top 14 Engadget news feeds, with text and images

	Avg Current (mA)	Loading time (sec)	Energy (Joule)
WiZi	199.6	**239.8**	196.2
WiFi	297.4	**93.4**	112.9

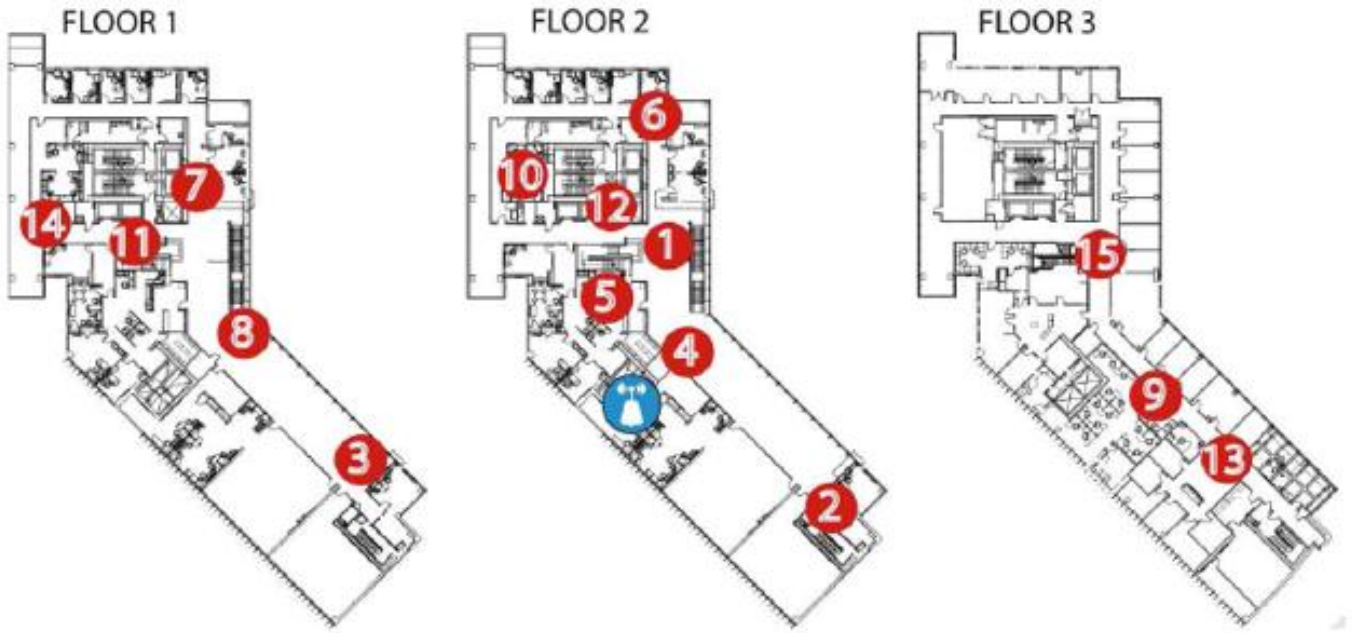
WiFi preferred for large traffic volume

Evaluation 2. Throughput

- iperf 30 sec test, averaged over 10 runs

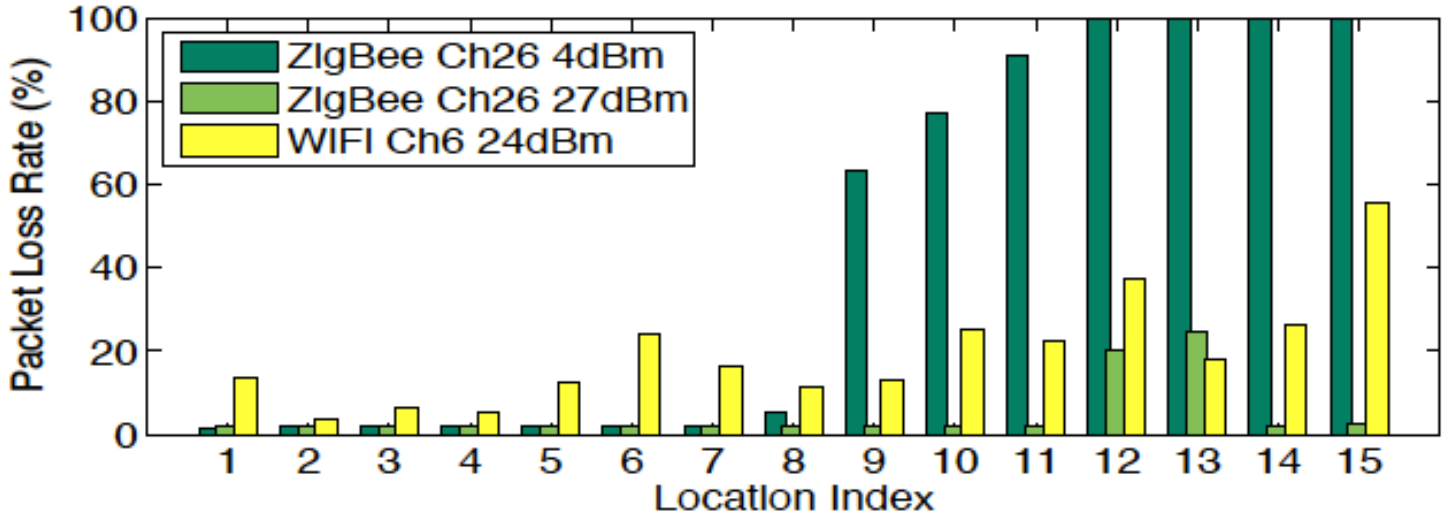


Evaluation 3. Coverage



- 3 floor college building
- Broadcast test to measure Packet Loss Rate
- WiFi Ch6 24dBm
- ZigBee Ch26 4dBm / 27dBm → **case for signaling**

Evaluation 3. Coverage



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Conclusion

- Energy consuming WiFi is a critical issue for mobile devices
- Designed and implemented WiZi-Cloud prototype (SW/HW)
- Evaluation with real mobile applications
- Great improvement for proper applications

Thanks!

http://www.ccs.neu.edu/home/noubir/wizi