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Wireless sensor network for berth supervision in marinas

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Introduction

- Berth supervision
 - One of marina management key challenges

- Berths
 - Transit
 - Contract

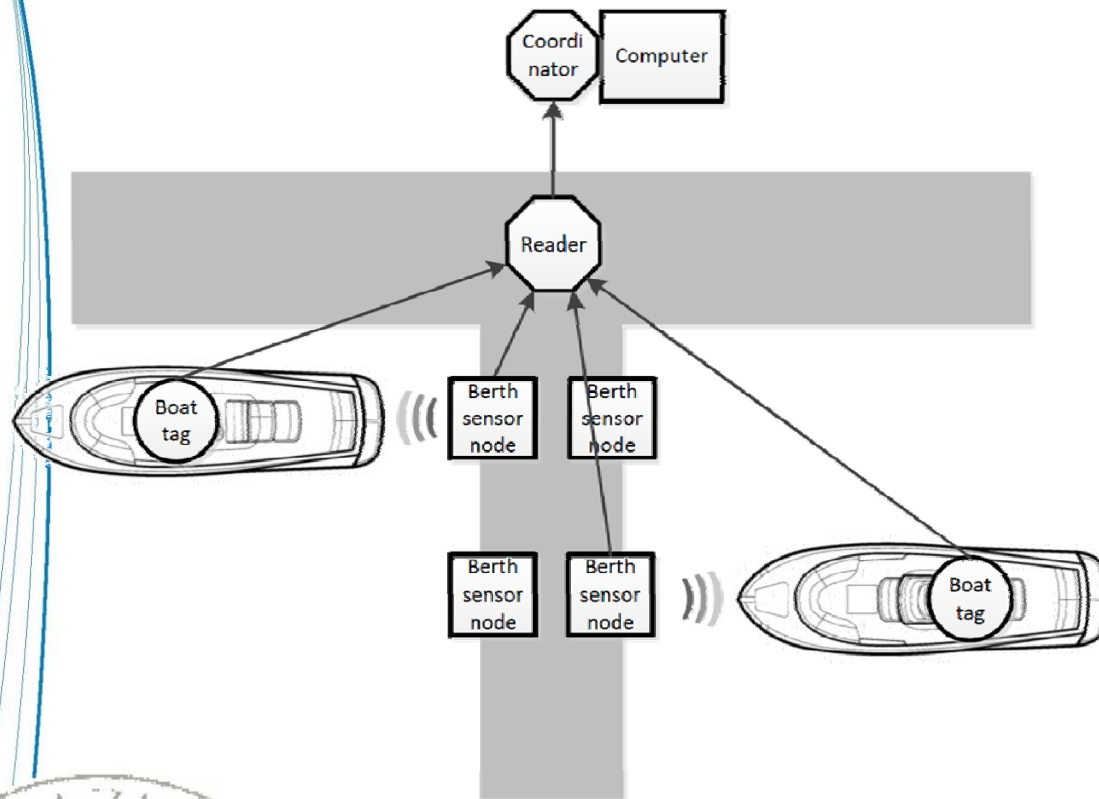




Introduction

- Berth supervision
 1. Berth occupancy control
 2. Boat identification
- Berth supervision automatization
 - Ultrasonic sensors
 - ZigBee tags
- Goal
 - Evaluation of ZigBee for RFID considering
 - Battery runtime
 - Large scale network support
 - Simple system infrastructure

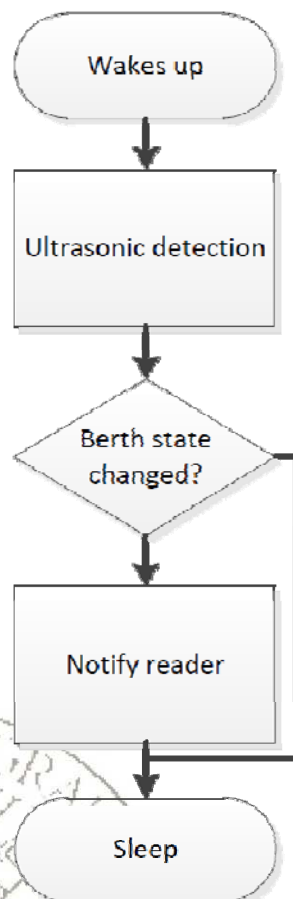
System layout



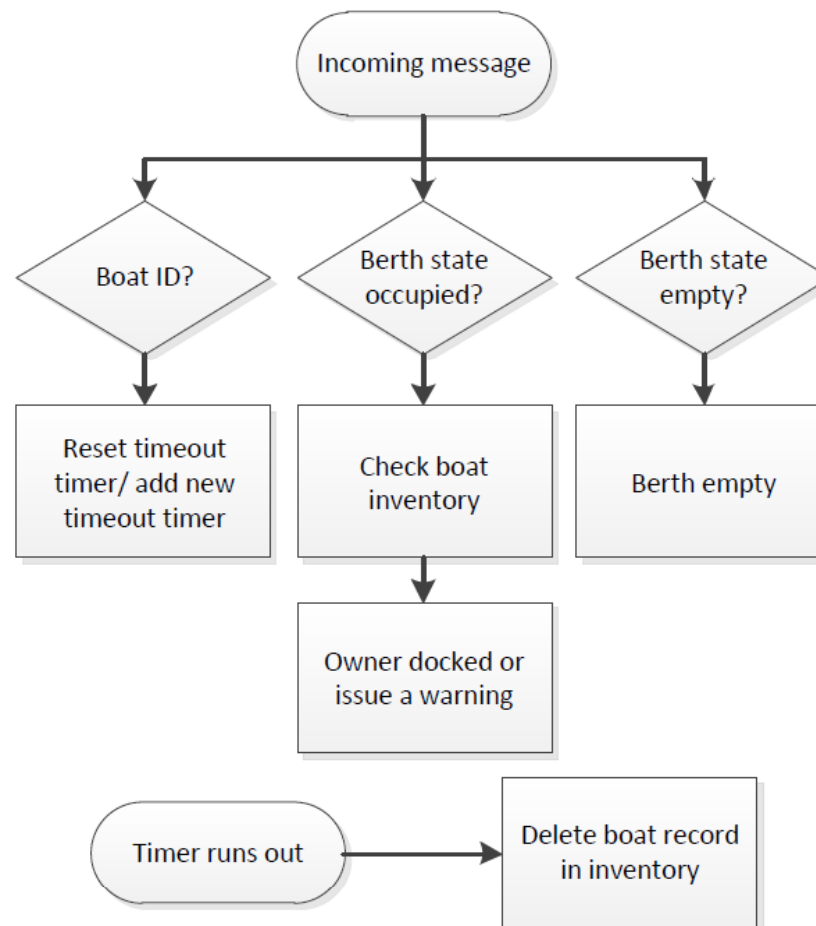
- Ultrasonic sensor
 - Robot El. SRF05
- Zigbee tag & readers
 - Meshnetics MeshBean Amp
 - Atmel Bitcloud stack

System operation

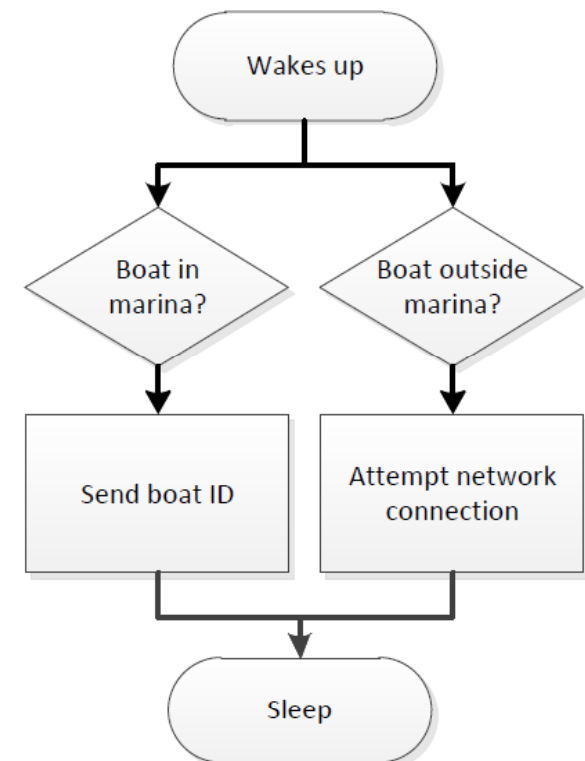
Ultrasonic Sensor



Computer



Tag





Large network support

- Node number limits
 - Zigbee: 65536 (16 bit)
 - Bitcloud: 100s
 - Atmel team: 112
 - Children table: **188** children
 - 49 B/child @ 16 kB of RAM

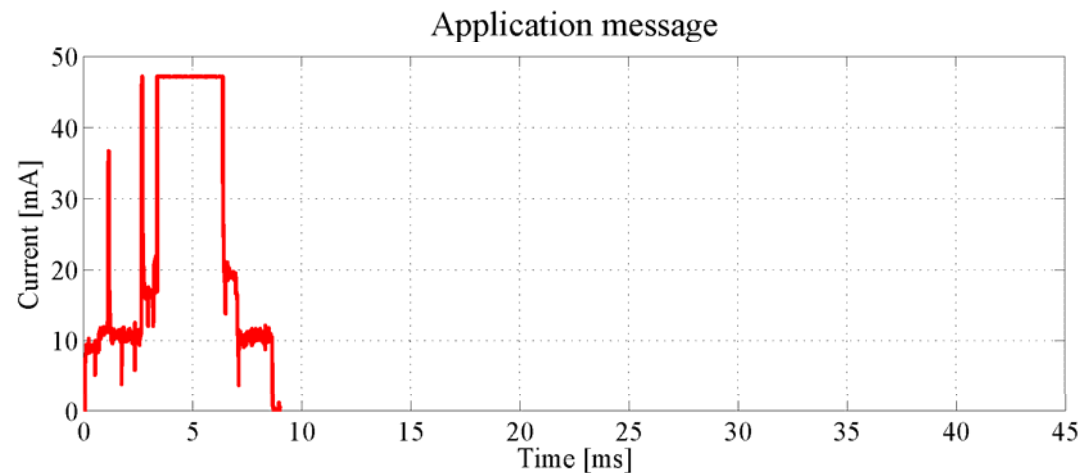
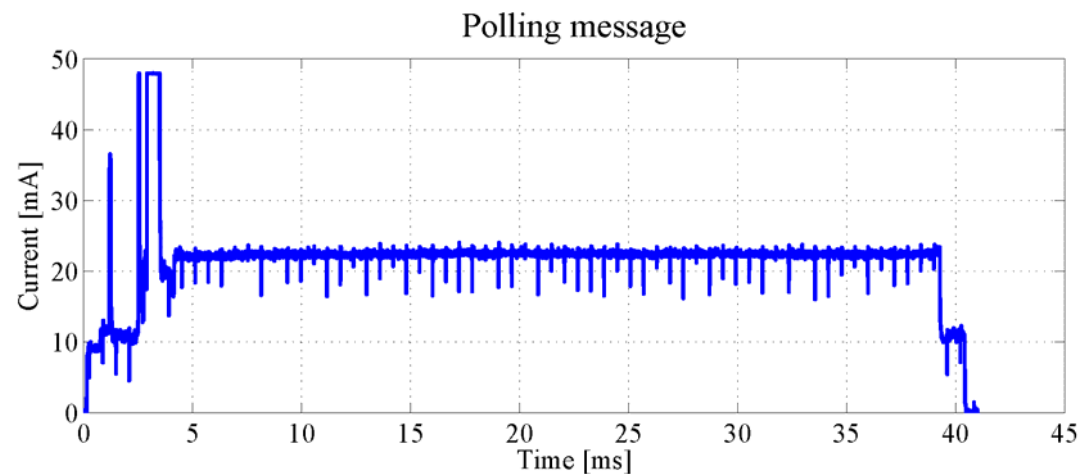


Power management

- Duty-cycle T_{sleep}
 - Berthing and departure takes over 10 min
 - Suggested $T_{\text{sleep}} = 3$ min
- Two wake states
 - Tag connected to the network
 - Sending application message
 - Tag outside the network
 - Runtime is a function of active channel scan parameters
 - Number of beacons (2)
 - Beacon response waiting time (140 ms)

Tests and results

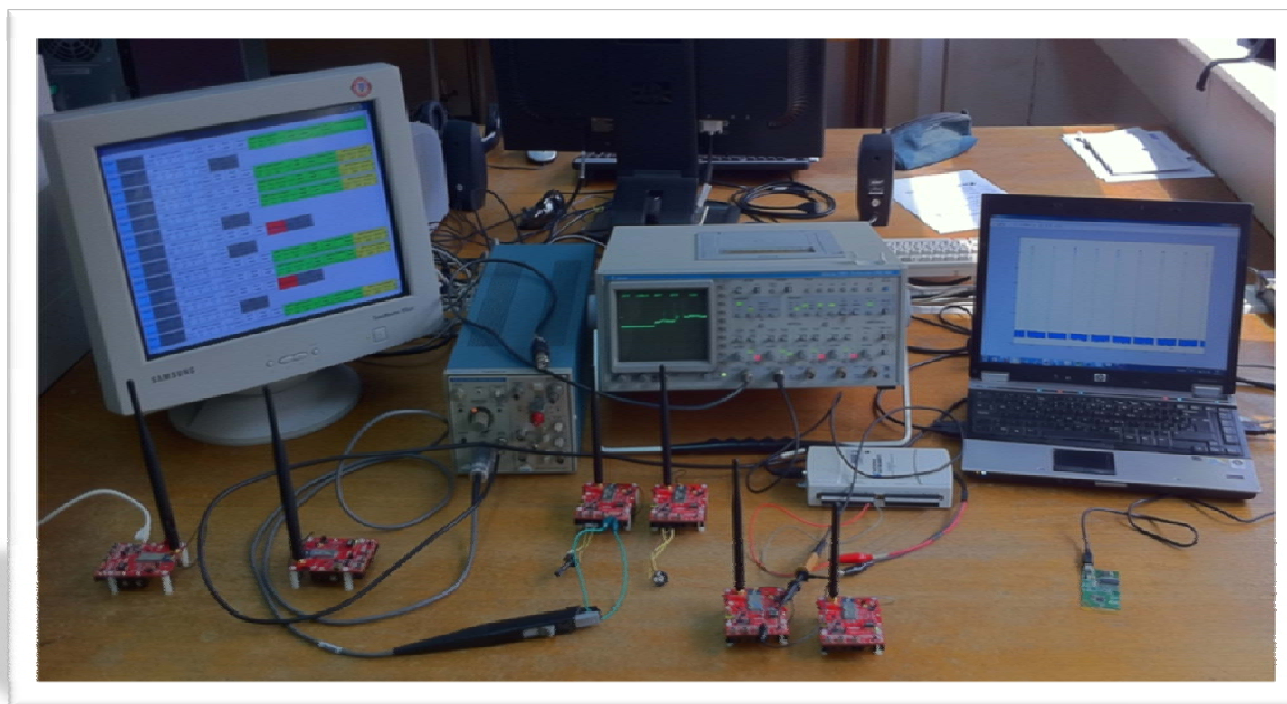
➤ Polling vs. application message



Tests and results

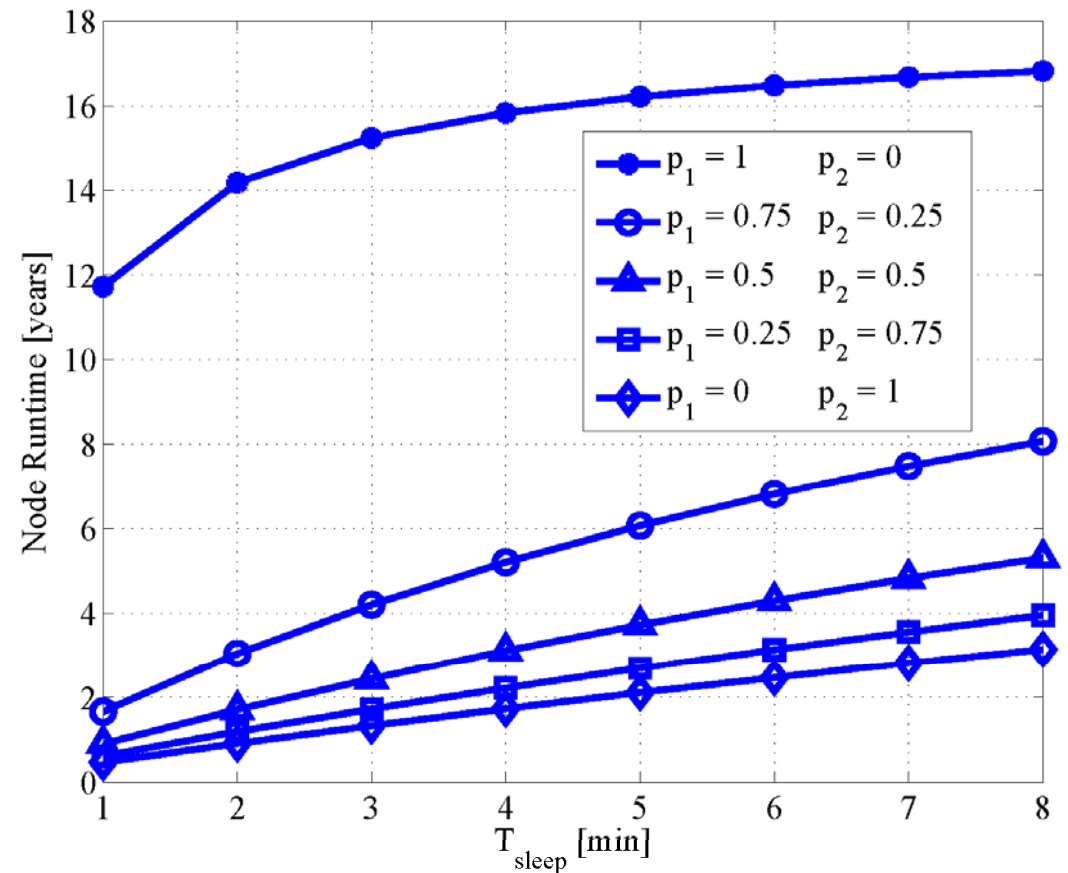
A. Power consumption and node runtime

State	Duration	Consumption
Tag in network	9 ms	0.73 mJ
Tag outside network	789 ms	51.99 mJ
Ultrasonic measurement	285 ms	19.32 mJ



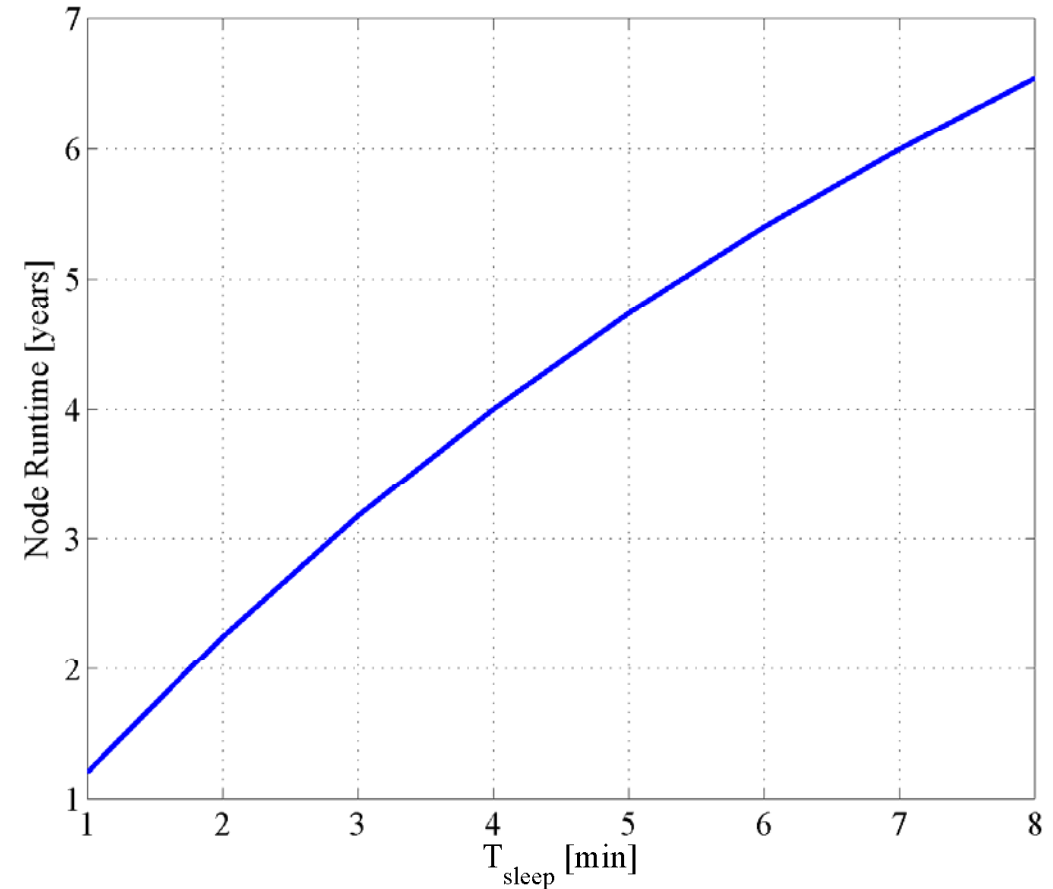
Boat tag runtime

- p_1 - percentage of time that boat remains in the marina
- p_2 - percentage of time that boat remains outside the marina
- 1100 mAh alkaline battery



Sensor runtime

- Berth sensor nodes are always connected to the network
 - Power consumption depends only on the characteristics of the sensor
- Runtime over three years
 - with $T_{\text{sleep}} = 3 \text{ min}$



Tests and results

B. Field test

- Ultrasonic sensor calibration
 - Tagged and untagged boat docking and departure
- Accurate system performance was proven



Conclusion

- Automated berth supervision system
 - Drawback is that it doesn't provide boat location
- Runtime performance ($T_{\text{sleep}} = 3 \text{ min}$, 1100 mAh battery)
 - Boat tag - over 1,5 years
 - Sensor node - over 3 years
- Off-the-shelf components, 1-piece price estimate
 - Sensor node - 130 €
 - Tag - 50 €
- Battery powered infrastructure
 - Low cost, fast installation