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Power- and Delay-Aware Mobile Application-Data Flow Adaptation

the MobiHealth system case study

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mobihealth
putting care in motion

Outline

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- Problem Description
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- Approach
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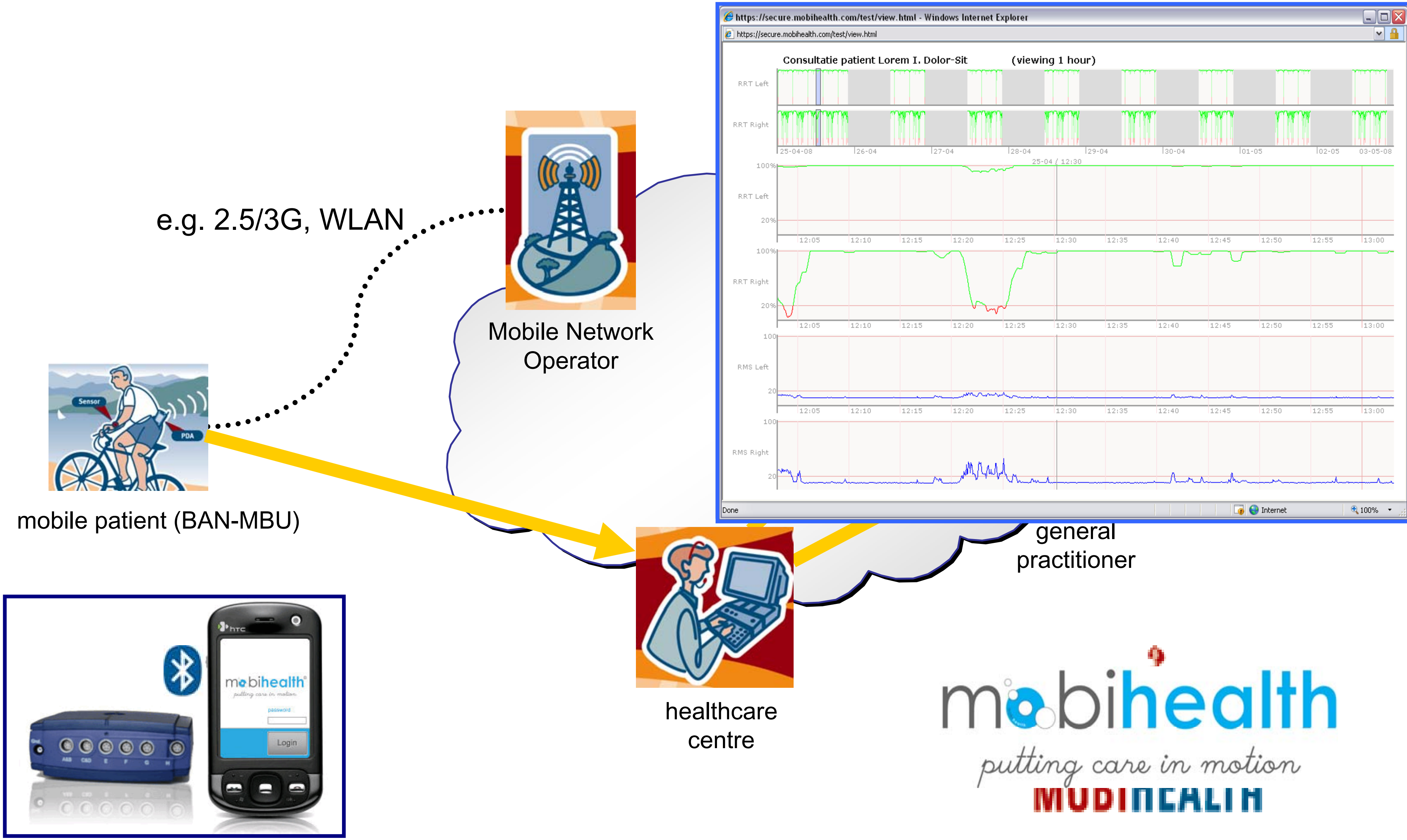
- Conclusions & Recommendations
  which NI choice is best for which application flow?

Introduction

m-health services
from MobiHealth project to MobiHealth^{TM} system

Health-monitoring services



MobiHealth System History

2002-2004: MobiHealth – EU IST-2001-36006 (5 countries)
m-health services: technically feasible? (emerging 2.5G/3G)

2005-2006: HealthService24 – EU eTEN-517352 (4 countries)
m-health services: clinically/commercially feasible?

2004-2008: Freeband-Awareness – Dutch BSIK-5902390
m-health services: proactively context-aware? (security/privacy?)

from 2007: MobiHealth BV – University of Twente (NL) spin-off
commercial m-health services: platform for any sensor system?

2007-2009: Myotel – EU eTen-C046230 (4 countries)
telemonitoring/teletreatment services: chronic neck-shoulder pain?

Problem Description

telemonitoring service:
battery consumption, delays vs. NIs status

Problem description

Focus: explorative study

- mobile: limited processing, communication, storage, battery capacity
- mobile health services need to support emergency & non-emergency cases
- health telemonitoring service performance:
  - data delay
  - battery consumption

=f (NIs status)

How to choose NI and parameterize application flow to

- match delay requirement to emergency/non-emergency case

and

- minimize battery consumption

Approach

measurements-based performance evaluation of telemonitoring service for different NIs

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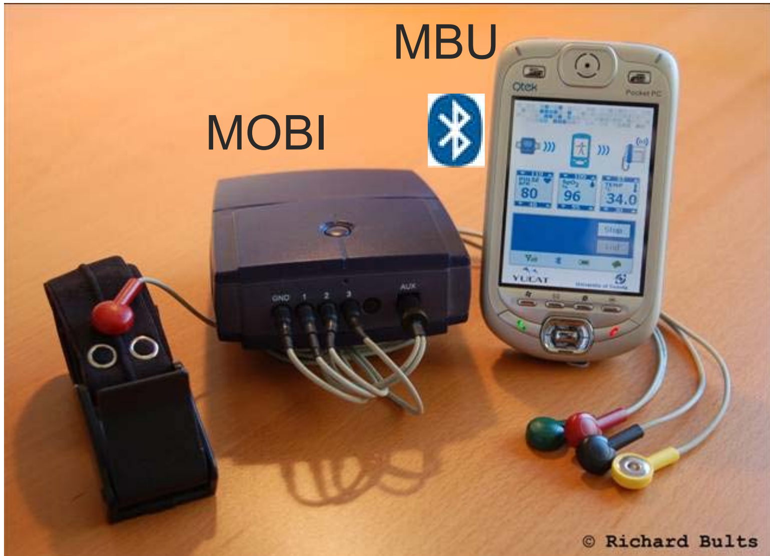
Measurements Setup

MobiHealth™ system used

- cardiac patient case: 3 leads ECG, heart rate*, SpO2, pleth, alarm (128 Hz)
- MBU: Qtek 9090, Windows Mobile® 2003 (!battery drain!)
- main battery: Li-ion polymer 1490 mAh
- NI: Bluetooth (always ON gathering data from MOBI™)
- NI: WLAN (802.11b, OS 'best-battery' setting)
- NI: WWAN-GPRS (class 10: 4+1/3+2 slots)

NI status: ON-IDLE-OFF

- Application flow: 5-14 Bytes, 128Hz
  - aggregation: 1 second of data
  - compression (ZIP): 38-85 %
  - TCP-IP end-to-end path
    - continuous: ~1.2-1.5, 5.5 or 7.7 kbps
    - bursts: 5.5 or 7.7 kbps, ~ Mbps



*heart rate is derived from 3 leads ECG

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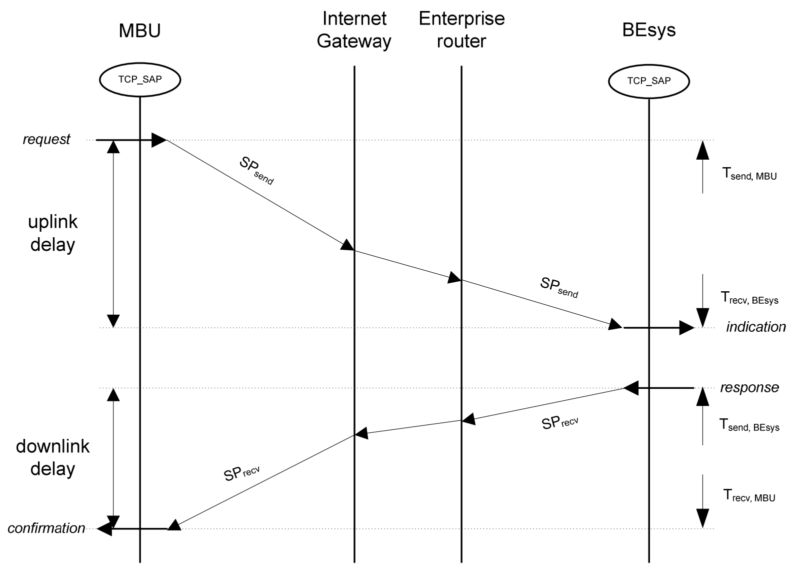
Approach: Measurements

Application-delay: App-RTT

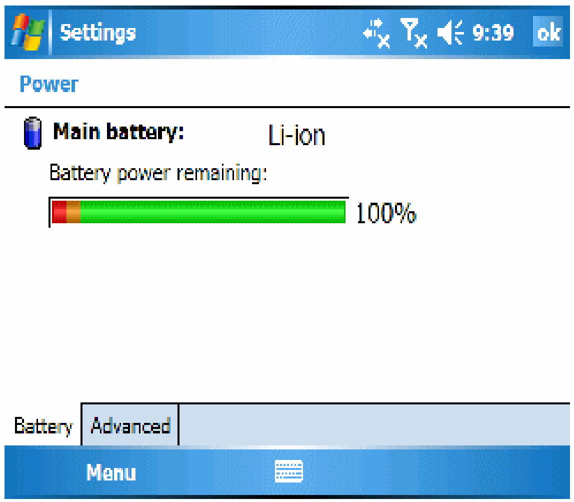
- system response time for: telemonitoring/teletreatment
- does not require MBU & BEsys clocks synchronization
- MBU: measures it every 10 seconds



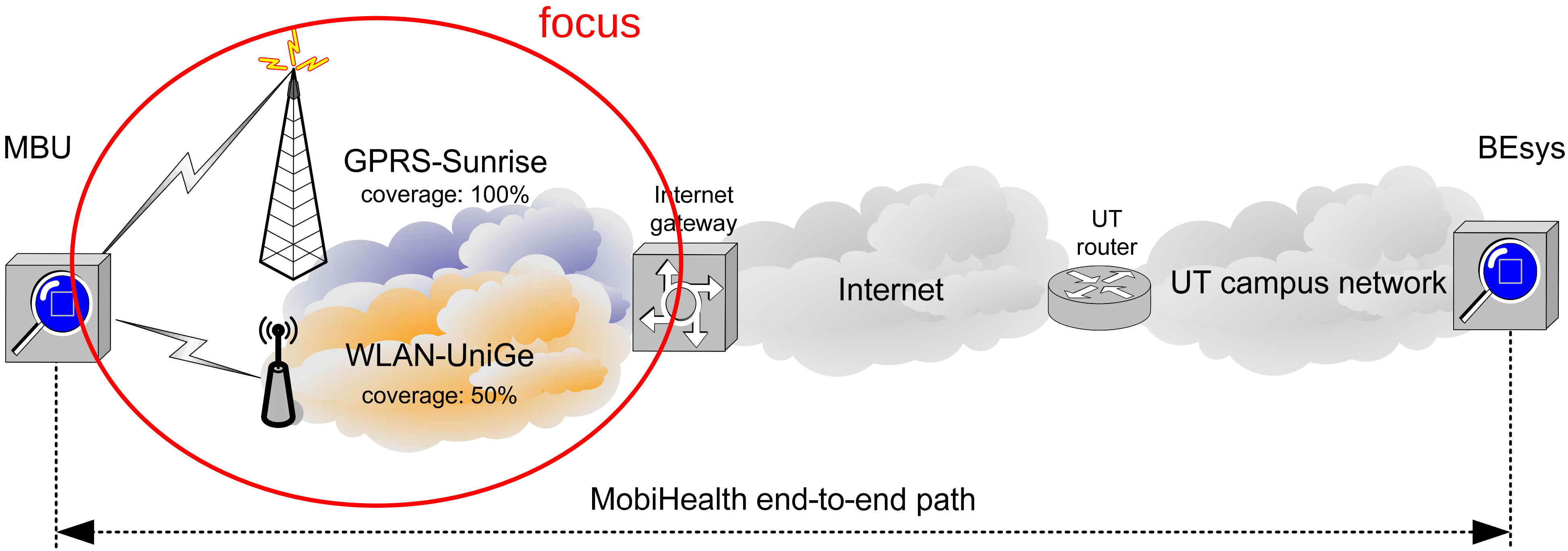
Approach: Measurements

Remaining battery level (Windows Mobile®)

- MBU: measures every 5 seconds



Measurements setup

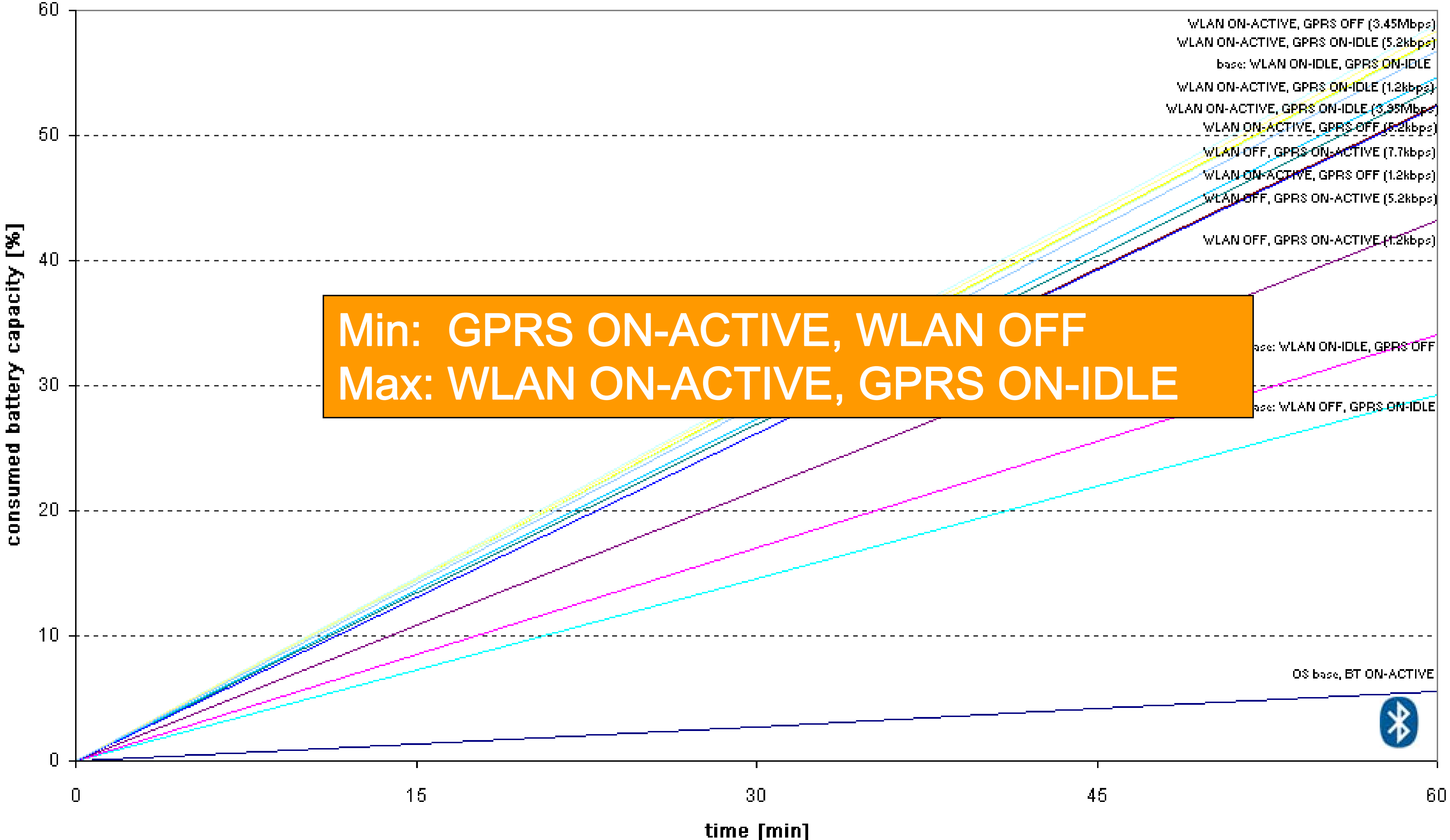


BAN

BEsys

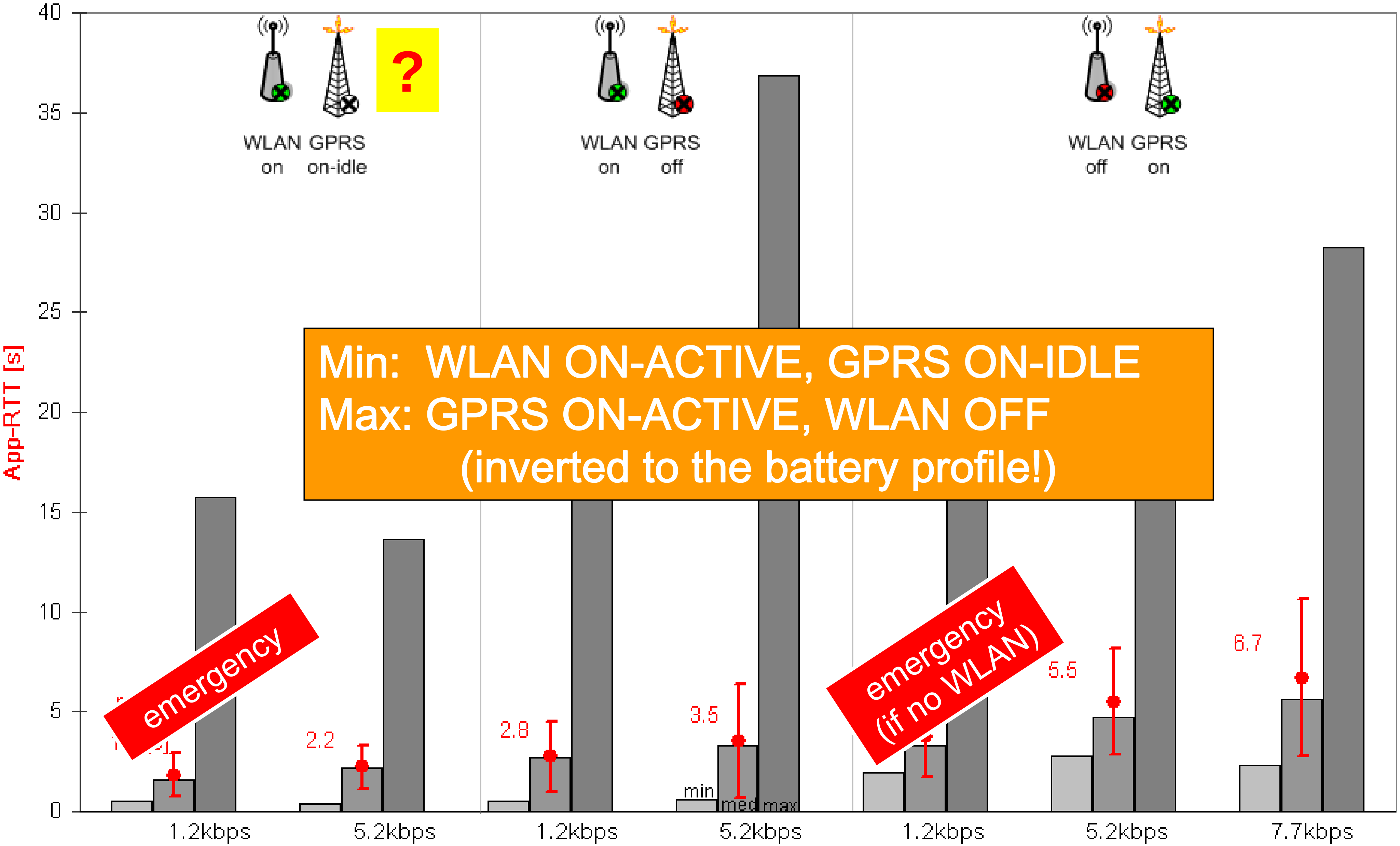
Selected Findings

NI choice: consumed battery capacity

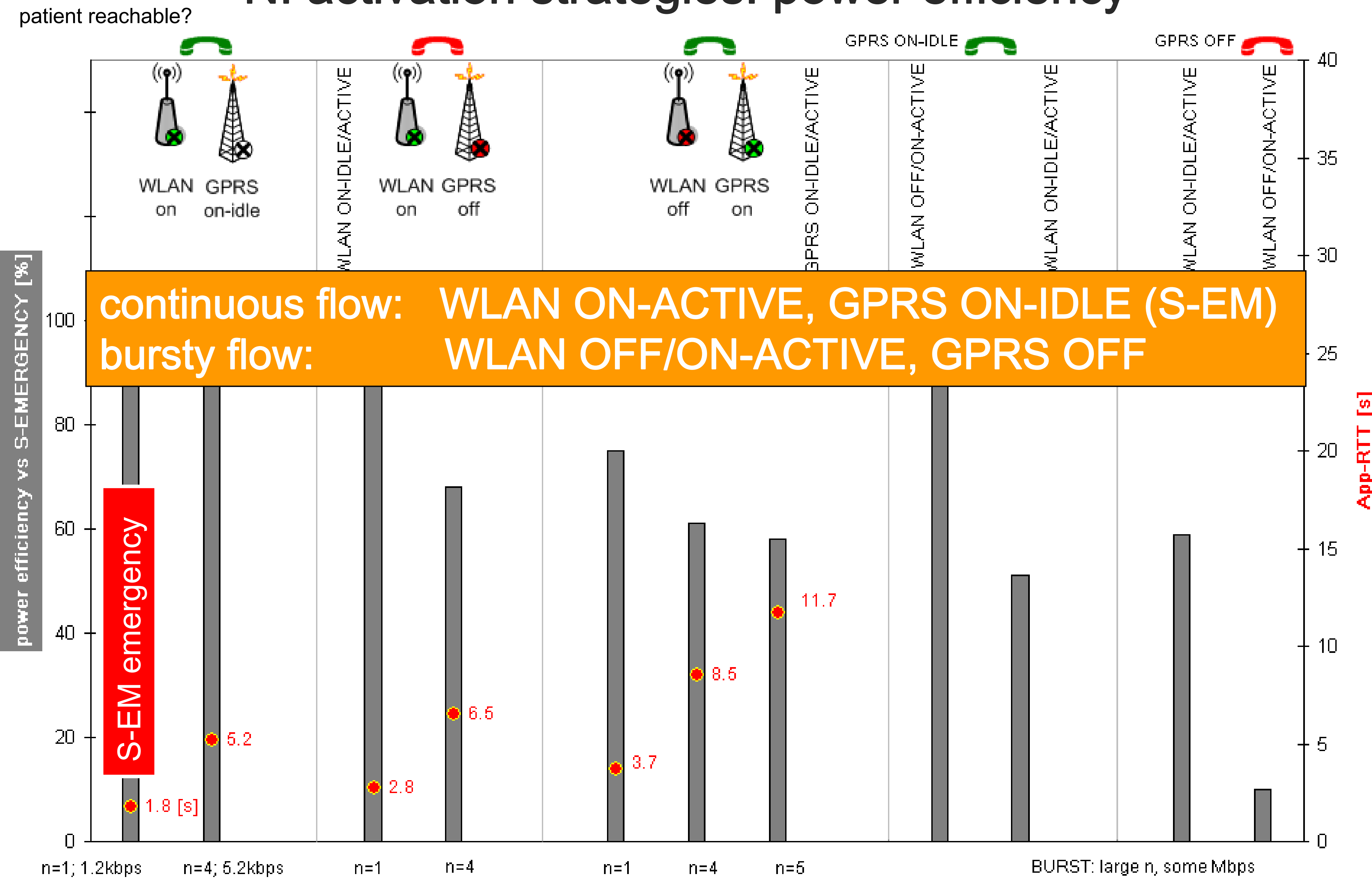


Min: GPRS ON-ACTIVE, WLAN OFF
Max: WLAN ON-ACTIVE, GPRS ON-IDLE

NI choice: App-RTT delay



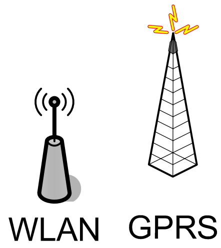
NI activation strategies: power efficiency



Conclusions & Recommendations

telemonitoring service:
which NI choice is best?

Conclusions & Recommendations



- GPRS vs WLAN have complementary profiles
  - GPRS: power consumption lower, App-RTT higher than WLAN
- App-RTT vs power consumption
  - minimal App-RTT if continuous application flow
  - minimal power consumption if application flow in bursts

- ? WLAN App-RTT lower when GPRS ON-IDLE than when GPRS-OFF

- Optimal choices:
- emergency: continuous flow (App-RTT efficient)
  - WLAN ON-ACTIVE (GPRS ON-IDLE)
  - GPRS ON-ACTIVE (WLAN-OFF)
- non-emergency: bursty flow (power efficient)
  - WLAN ON-ACTIVE/-IDLE (GPRS ON-IDLE) → n=4 seconds of data
  - GPRS ON-ACTIVE/-IDLE (WLAN-OFF) → n=6 seconds of data
  - larger n are not power-efficient enough to be considered (+ patient unreachable)

Future work

- More measurements
  - NI activation-deactivation (ON-OFF) and NI-NI WLAN-GPRS handovers
  - multiple MBU-devices, NIs, different locations (mobile!) and times
  - detailed study on delay variation as f(NI)
  - multiple application data flows with different App-RTT requirements

- NI activation strategy vs.
  - monetary cost of networks usage
  - security considerations

- Further QoS/QoE considerations for the Mobihealth system
  - requirements & provisions
  - towards dependable system

→ dynamic system adaptation e.g. self-healing

www.mobihealth.com

www.mobihealth.org

www.healthservice24.com

www.awareness.freeband.nl

www.myotel.eu

Thank You!