Power- and Delay-Aware Mobile Application-Data Flow Adaptation
the MobiHealth system case study

Katarzyna Wac (Kate), PhD student
Pravin Pawar, Bert-Jan van Beijnum, Richard Bults
Mortaza Bargh, Arjan Peddemors
Outline

• Introduction
  m-health services: from MobiHealth project to MobiHealth™ system

• Problem Description
  telemonitoring service: battery consumption, delays vs. NI choice

• Approach
  measurements-based performance evaluation of service for different NIs

• Conclusions & Recommendations
  which NI choice is best for which application flow?
Introduction

m-health services
from MobiHealth project to MobiHealth™ system
MobiHealth System History

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

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?

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 =f (NIs status)
  • battery consumption

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
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)

- 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
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

MBU

GPRS-Sunrise
coverage: 100%

WLAN-UniGe
coverage: 50%

Internet gateway

Internet

UT router

UT campus network

MobiHealth end-to-end path

BAN

BEsys

© Richard Blais
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

Min: WLAN ON-ACTIVE, GPRS ON-IDLE
Max: GPRS ON-ACTIVE, WLAN OFF
(inverted to the battery profile!)

emergency (if no WLAN)
NI activation strategies: power efficiency

continuous flow: WLAN ON-ACTIVE, GPRS ON-IDLE (S-EM)
bursty flow: WLAN OFF/ON-ACTIVE, GPRS OFF

patient reachable?
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
  - 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
Thank You!