Collaborative Sharing of Quality of Service Information for Mobile Service Users

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• **Problem Description**
  – QoS-requirements vs. QoS-provisions, state-of-the-art solutions, identified challenge and research objectives

• **New Approach: Collaborative Sharing of QoS-information**
  – system design
  – case study: feasibility assessment in a mobile healthcare domain

• **Conclusions**
  – novelty
  – current and future research focus
User Computing Trends

Computers
- Many
- Timesharing
- One

Persons
- Many
- One

Personal Devices
User Mobility Trends

- **WWAN**: regional, international (e.g. GPRS, UMTS, HSDPA, satellites)
- **WMAN**: metropolitan area (e.g. WiMax)
- **WLAN**: campus/office-based (e.g. HyperLAN, WiFi)
- **WPAN**: in-house (e.g. BT, ZigBee, UWB)

different coverage & speed for a mobile user
Mobile Service

- example: health telemonitoring and teletreatment service
Quality of Service

- Quality of Service (QoS)
  - “collective effect of service performances which determine the (objective) degree of satisfaction of a user” (ITU-T, 1993)
  - QoS requirements and QoS provisions expressed quantitatively in terms of criteria
    - e.g.: speed, accuracy, dependability, security level and monetary cost
Problem Description
Required QoS vs. Provided QoS

• Success of service delivery depends on QoS provided by underlying heterogeneous networking environment
  – QoS requirements can change anywhere-anytime, e.g. patient’s emergency
  – QoS provisions can change anywhere-anytime, e.g. highly mobile user
• traditional QoS-management
  – e.g. admission control, resource negotiation/reservation

• Mobile Network Operators
  – user ‘lock-in’

• service providers
  – non-interactive applications e.g. mobile gaming
  – proprietary application-protocols, details concealed e.g. Skype

• identified challenge: user-centric approach
  – monitor ‘best-effort’ QoS > quantify patterns > predict ‘best-effort’ QoS
1. novel system: requirements and design
   - collaborative sharing of QoS-information for mobile users (Mobile Web 2.0 paradigm)

2. predictions feasibility assessment
   - collect extensive set of measurement data at user device
   - test hypothesis of collaborative QoS-information sharing by mobile users

Based on the above, point to a possible QoS-management framework
System Design
Collaborative Sharing of Information

- QoS Virtual Tags (QVT): encapsulates measurements and predictions information
System Design

Quality of Service Information System

measurements → processing → predictions engine → predictions

DB1
DBn
storage
System Design: QoS-management

- mobile service user
- application
- service infrastructure
  - QoS
    - measurements
    - predictions
  - SLAs
  - policies
  - QoS-configuration
- network infrastructure
Case Study
mobile healthcare services
MobiHealth System

- patient: COPD (Chronic Obstructive Pulmonary Disease) telemonitoring user
  - vital signs: ECG, heartrate, temperature, plethysmogram, oxygen saturation
  - carried 2 systems
KA-RTT Definition

- Performance criterion: *speed*, performance measure: *delay*
- Keep-Alive Round Trip Time (KA-RTT)
• new KA-RTT value every 10 seconds
MobiHealth User Mobility

- Timeframe: mid Nov - mid Dec 2007

Distance from L1 (home) (90% of time – below 1.7 km)
MobiHealth User Mobility (cont’d)

69.4% of time in 2 locations: L1 (home) and L2 (office)
KA-RTT Predictions

machine learning: 48 algorithms

48 models

best model: statistical significance tests

9 KA-RTT classification tasks

5 cat.: equal length distribution

4 cat.: distribution (Q25)

2 cat.: binary L-H threshold

probabilistic Bayes
distance lazy
logic rules threes

ML approach

task

days

experiment

location-network

trajectory

13 experiments

GPRS:L1->L2

GPRS:L2->GPRS-07/08

L2-GPRS

L1-GPRS

L2-WLAN

t/uni0072ajecto/uni0072y

app/uni0072oach

machine learning: 48 algorithms

48 models

best model: statistical significance tests

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GPRS:L1->L2

GPRS:L2->GPRS-07/08

L2-GPRS

L1-GPRS

L2-WLAN
Collaborative-Sharing of Information

- User cases
  - device 1 or device 2
  - device 1 measurements $\rightarrow$ for device 2 predictions
  - device 2 monitoring $\rightarrow$ for device 1 predictions
  - device 1 + 2 measurements $\rightarrow$ for device 1 predictions
  - device 1 + 2 measurements $\rightarrow$ for device 2 predictions
Device 1: Prediction Results

Device 1: Prediction Experiments vs Classification Tasks Accuracy Results [%]
Device 2->1: Prediction Results

Device 2->1: Prediction Experiments vs Classification Tasks Accuracy Results [%]

- Prediction Experiments:
  - d:1-1a
  - d:1-1b
  - d:1-1c
  - d:5-1
  - d:7-1
  - d:13-13
  - d:14-7
  - d:23-1

- Classification Tasks:
  - c1-750
  - c1-1000
  - c1-1500
  - c1-2500
  - c1-3000
  - c2
  - c3-500
  - c3-750
  - c3-1000

- GPRS Protocols:
  - GPRS:L1->L2
  - GPRS:L2->L1
  - GPRS:L1-07/08
  - GPRS:L2-07/08

- Other Protocols:
  - L1-GPRS
  - L2-GPRS
  - L2-WLAN

- Color Scale:
  - 0%
  - 10%
  - 20%
  - 30%
  - 40%
  - 50%
  - 60%
  - 70%
  - 80%
  - 90%
  - 100%
Device 1,2->1: Prediction Results

Device 1,2->1: Prediction Experiments vs Classification Tasks Accuracy Results [%]
Prediction Results

- predictive attributes: location, time, wireless network provider and technology
  - most accurate are logic-based algorithms: trees and rules

- device 1, device 2
  - accuracy > 75%: binary tasks, fixed location and network, having collected long history
    - 69% of time user spends in top 2 locations
    - recommended history – minimum 7 days

- device 1 → 2 or 2 → 1
  - accuracy > 65%+: binary tasks
    - accuracy changes on average $2 \pm 13\%$ than if use own history

- device 1,2 → 1 or 1,2 → 2
  - accuracy > 95%: binary tasks
    - accuracy changes on average $0 \pm 11\%$ than if use own history
Conclusions
Conclusions

- **Proposal**
  - system for collaborative-sharing of QoS-information
  - assessed technical feasibility of predicting KA-RTT delay value for health an operational telemonitoring system

- **Novel approach in QoS-management - empowering mobile service users**
  - builds upon a collaborative sharing of QoS-information (Mobile Web 2.0)
  - builds upon network provisions at ‘best-effort’ QoS level
  - beyond current QoS-management frameworks
  - beyond current user ‘lock-in’ in the network
  - no changes in the existing network infrastructures

- **Current research: validation through prototyping**
  - more predictive features not to end up with ‘data dredging’ (case: for device 1,2 → 1)
  - future research: more users, applications, location areas, longer time intervals, …
Questions & Answers