Quality of Service Information System: Get to Know the Performance of Your Mobile Network Operator Anywhere-Anytime

Wac, Katarzyna

Number 93, April 2013

ERCIM NEWS

www.ercim.eu

Special theme:

Mobile Computing

ERCIM News is the magazine of ERCIM. Published quarterly, it reports on joint actions of the ERCIM partners, and aims to reflect the contribution made by ERCIM to the European Community in Information Technology and Applied Mathematics. Through short articles and news items, it provides a forum for the exchange of information between the institutes and also with the wider scientific community. This issue has a circulation of about 8,500 copies..

ERCIM News is published by ERCIM EEIG
BP 93, F-06902 Sophia Antipolis Cedex, France
Tel: +33 4 9238 5010, E-mail: contact@ercim.eu
Director: Jérôme Chailloux
ISSN 0926-4981

Contributions
Contributions should be submitted to the local editor of your country

ERCIM News online edition
The online edition is published at http://ercim-news.ercim.eu/

Subscription
Subscribe to ERCIM News by sending email to en-subscriptions@ercim.eu or by filling out the form at the ERCIM News website: http://ercim-news.ercim.eu/

Next issue
July 2013, Special theme: Intelligent Cars

Introduction to the Special Theme

by Edgar Weippl and Pietro Manzoni

A few years ago, the IT industry forecast that consumer demand for data would surpass that of the voice market. At the time, few could conceptualize such an outlook. These days the data market is at least 70% larger than the mobile market, and still growing. Mobile technology has advanced in leaps and bounds over recent years, such that experts predict that, within the next few years, mobile computing will be strictly bound to cloud computing. Mobile cloud computing is set to impact and transform the mobile communication landscape and the whole computing infrastructure. Computing offloading, for example, is one of the main features of mobile computing to improve the battery life of mobile devices and to improve the performance of applications. However, there are many associated issues to solve, including efficient and dynamic offloading in a variable environment.

Mobile users may face certain problems, such as congestion owing to wireless bandwidth limitations, network disconnection, and signal attenuation caused by mobile users' mobility. Although many researchers have proposed solutions to optimally and efficiently allocate bandwidth, bandwidth limitation is still a major concern because the number of mobile and cloud users is increasing dramatically. 4G network and Femtocell are emerging as promising technologies that are revolutionizing bandwidth optimization, helping to overcome the traditional limitations. Efficient network access management not only improves link performance for mobile users but also optimizes bandwidth usage. Cognitive radio is likely to offer a solution to achieve wireless access.

Today's mobile phones harness the power of a computer, thus making sensitive information more widely available (eg information about user behaviour, GPS position, and personal data). Mobile phones are often fully integrated into social applications such as social networks, e-mail clients, messengers or data-harvesting analytics scripts on websites, enabling not only a holistic analysis of an individual, but also paving the way for new attack vectors operating against individuals and the companies they work for. Malware targeting mobile clients, especially those on the more open Android-system, have become very common.

Articles in the special theme

The articles presented in this issue reflect the many faces of our special theme, "Mobile computing", and address topics including: Mobile service platforms and new ways of establishing networks, privacy concerns and security challenges, location services and collaborative data capture.

The invited article by **Engin Kirda** summarizes a research project that focuses on Android malware detection. **Matthias Steinbauer et al** discuss effects of the convergence of cloud and mobile computing. **Francisco Barcelo-Arroyo et al** present results related to the important topic of providing indoor localization through the combined use of communication networks.

Different kinds of computing services form the focus of the first six articles:

Folino and Pisani describe a framework for generating decision tree-based models that use evolutionary algorithms to take automatic decisions regarding the offloading of mobile applications into a cloud environment. **Larkou et al** present SmartLab, an open IaaS cloud of smartphones that improves the efficiency of systems-oriented mobile computing research.

Mobile device networks also offer enormous potential for data mining. **Comito et al** have defined a distributed architecture with an energy-aware scheduling strategy that assigns data mining tasks in a peer-to-peer network of mobile devices.

Adelsberger and Tröster present a means of using smartphones to synchronize and control sensors wirelessly, more effectively, and in a more energy-efficient way than is usually the case for wireless synchronizing of multiple data streams.

With mobile Internet on the rise, the demand for wireless networks is growing at an unprecedented pace. **Hoekstra and van der Mei** describe new methods, developed in the Netherlands, that use smart algorithms to split traffic over the numerous overlapping networks in the country, thereby increasing wireless speed.

Moving towards the viewpoint of the user, **Jacobsson et al** describe a design concept for changing setups and user interface styles of smartphones by physically attaching phone shells or accessories such as jewellery or headphones to the device, enabling quick shifts between, for example, business and leisure modes.

The user perspective is also present in different mobile service platforms. The near ubiquity of smartphones makes them ideally suited for transport planning services. **Capra et al** introduce the TravelDashboard project, which will allow customizable trip planning according to personal preferences, also incorporating user-generated content with information on issues such as crowdedness of buses. In the same vein, **Cuesta et al**'s CoMobility platform also allows travel planning but integrates carpooling with public transportation. **Wac** focuses on a Quality of Service Information System and reports on a mobile application that uses measurement data provided by mobile users to predict a network's expected performance.

Conti et al discuss opportunistic computing, a self-organizing dynamic networking paradigm that combines pervasive environmental network devices with mobile devices to allow communication and services. They present the CAMEO middleware platform, which focuses on the management and elaboration of context information in such opportunistic networks.

The pervasiveness of mobile devices has raised interest in collecting their sensor data via "crowd sensing". **Haderer et al** address the needs of various research communities with their APISENSE platform, which gives researchers an online environment in which they can set up an experiment without in-depth technical knowledge while ensuring the privacy and security of the participants collecting the data.

Privacy and security are, indeed, important issues as consumers and companies enter the world of mobile computing with unprecedented enthusiasm, and a number of contributions in this issue are dedicated to them.

One reason for the widespread use of mobile devices is, of course, the wide availability of Wi-Fi networks. Transmitting data over unsecured networks has well-known risks, but **Cunche et al**. go further and show how the automatic search for networks enabled on most smartphones can be used to not only fingerprint individual devices, but also to identify social links between their owners.

Networked calendars and other collaborative applications are very popular but pose considerable security challenges. **Imine and Rusinowitch** have developed a decentralized and secure shared calendar that is independent of third-party servers, instead allowing users to share their calendar events in dynamic groups in ad-hoc networks.

Constantino et al present an implementation of the cryptographic FairPlay framework for Android smartphones. It protects users' privacy in opportunistic networks by ensuring that information is exchanged with other users' devices via Bluetooth only if they have matching interest profiles, which can be determined without sending sensitive information in plaintext.

Achara et al have examined the information that can be gained from smartphones to educate users about risks. The Mobilitics project investigates both the Android and iOS operating systems and apps for these platforms for potential privacy leaks and has found that many apps access information not necessary for their operation.

One way of making apps more secure can be found in **Costa et al's** proposal for a security-enabled app marketplace, where applications are analyzed to ensure that they comply with the security policy and can be installed without affecting the device's security configuration.

While GPS-based localization offers a multitude of location-based services (eg, navigation) in outdoor environments, indoor mobile environments require different approaches, some of which are presented in the next three contributions.

Laoudias et al's Airplace indoor positioning system uses a radiomap built from received signal strength (RSS) fingerprints. This radiomap is transmitted to the user's Android smartphone upon entering the building and allows the device to determine its position based on the signal strength it receives from surrounding wireless access points without revealing its personal state.

RSS fingerprinting is also one of the three techniques that are combined in the user localization method presented by **Ševčík**, the others being dead reckoning and sequential Monte Carlo filtering. The prototype displays the position of the user on a floor plan. Further developments are planned to allow navigation to a selected point on the map and augmented reality.

Afyouni et al focus on the representation and management of spatial data and location-dependent query processing required for the development of efficient and flexible context-aware indoor navigation systems. They developed a hierarchical data model of an indoor environment and algorithms that utilize it to process location-dependent queries continuously and effectively.

Finally, we have four contributions dedicated to applications. From bus travel to oil spills, they present four innovative uses of mobile computing combined with crowdsourcing. While **Falcao e Cunha et al** present their MOVE-ME multimodal travel planning project with user contribution, **Segrelles et al's** TRENCADIS allows the secure sharing, organization and searching of medical images on mobile devices and has been prototyped for breast cancer diagnosis and treatment.

The papers by **Trigueros et al. and Martinelli et al** both present applications for environmental monitoring with a strong focus on crowdsourcing: Trigueros and Peinado's U-AirPoll is a novel approach to distributed and collaborative air quality measurement, while Martinelli et al.'s ARGO Sentinel allows volunteers at sea to immediately report sighted oil spillages.

From localization and transportation services to sensor control and environmental monitoring, we hope you enjoy the contributions in this issue, which show the wide applicability of mobile computing and give us a taste of things to come.

Regarding the future, we can see that the area of mobile computing, within the wider area of the Information and Communications Technologies (ICT) is a very promising and strategic discipline. The European Commission, through its new program "Horizon 2020", has presented an €80 billion package for research and innovation funding, as part of the process to create sustainable growth and new jobs in Europe.

In particular, and strongly related to mobile computing, ICT in Horizon 2020 will be a crucial actor and will support the development of solutions for industrial leadership, by supporting the development of the next generation of computing thanks to advanced computing systems and technologies supported by enhanced network infrastructures, technologies and services for the future Internet, including content technologies and information management.

The final objective is to provide answers to societal challenges such as health, demographic change and wellbeing (eg, e-health, self management of health, improved diagnostics, improved surveillance, health data collection, active ageing, assisted living); secure, clean and efficient energy (eg, Smart cities; Energy efficient buildings; smart electricity grids; smart metering); smart, green and integrated transport (eg, smart transport equipment, infrastructures and services; innovative transport management systems; safety aspects); climate action, resource efficiency and raw materials (eg, ICT for increased resource efficiency; earth observation and monitoring); and finally inclusive, innovative and secure societies (eg, digital inclusion; social innovation platforms; e-government services; e-skills and e-learning; e-culture; cyber security; ensuring privacy and protection of human rights on-line).

Please contact:
Edgar Weippl
SBA Research/AARIT, Austria
E-mail: EWeippl@sba-research.org

Pietro Manzoni
Universitat Politecnica de Valencia, Spain
E-mail: pmanzoni@disca.upv.es

sumers of the transport system) and open data (ie data from public transport networks and public institutions). The format of public data within the open data initiatives prevents non-experts from using them directly, and thus it requires additional semantics, as provided by "Linked Open Data" [1][2] .

In summary, CoMobility provides a systematic approach to (i) accessing open, integrated and semantically annotated transportation data and street maps, (ii) combining them with private data, and (iii) supplying mechanisms to allow the actors to share and search these data. Therefore, the CoMobility conceptual architecture provides the means to perform the following tasks (also depicted in Figure 1).

First, the platform can identify, select, extract and integrate data from different and heterogeneous sources, stemming from the transportation, geographical and energy domains. Second, data from public institutions is obtained automatically in the form of open data. Third, these data are annotated as linked data, and a set of heuristics generate links between data items from different sources without human intervention. Fourth, these data are integrated with private data provided by users themselves. And finally, CoMobility provides intuitive and customized data analytics and visualization, allowing individuals to become aware of the environmental impact of their transport choices.

The CoMobility platform is provided on the Internet "as a service", where both public transport information and data provided by users themselves are stored and accessed "in the cloud". The cloud approach is necessary as scalability is one of the most important requirements of this kind of wide-range service architecture. The platform needs to access a great amount of data, which is also stored in the cloud – both the private data of carpoolers, and the public data accessed in a linked open data approach. Users are able to access their information in several formats, particularly in mobile devices (currently, Android devices) and web applications. Through these devices, they are able to plan their paths in the transport network, moving from a shared car to the underground, and from there to a bus line; and at the same time receiving an estimation of the saving of both money and energy.

With this system, we hope to encourage social and individual change towards a new - more efficient and environmentally friendly - model of transport.

Link:
VorTIC3 Research Group (Rey Juan Carlos University):
http://www.vortic3.com

Reference:
[1] Linked Open Data.
http://linkeddata.org/
[2]T. Heath, C. Bizer: "Linked Data: Evolving the Web into a Global Data Space", Morgan & Claypool, 2011.

Please contact:
Carlos E. Cuesta, Paloma Cáceres, Belén Vela and José María Cavero
VorTIC3 Research Group, Rey Juan Carlos University, Madrid, Spain
E-mail: carlos.cuesta@urjc.es,
paloma.caceres@urjc.es,
belen.vela@urjc.es,
josemaria.cavero@urjc.es

Quality of Service Information System: Get to Know the Performance of Your Mobile Network Operator Anywhere-Anytime

by Katarzyna Wac

Quality of Service Information System (QoSIS) focuses on measurement-based performance evaluation of wireless access networks provided by diverse mobile network operators in diverse locations and times. We have developed an Android OS mobile application that uses measurement data provided by real mobile users living in the Geneva area to predict the networks' expected performance. Measurement data, and therefore predictions, are available for Swiss operators: Swisscom, Sunrise, Orange CH, as well as French operators: SFR, Bouygtel and Virgin.

The effectiveness of any mobile service depends on the quality of service (QoS) provided by the wireless access network it uses. However, the QoS is often unknown, as public and private wireless access network providers, mobile network operators (MNOs) for instance, tend to not disclose detailed, real-world QoS-information. For marketing purposes, these providers usually advertise only the best data rate values for their networks.

According to the 4G vision, in the near future wireless access networks of various providers - employing different wireless access technologies - will be ubiquitously available for mobile service users. Also, a seamless handover between these networks will support users' mobility. Ideally, users should have a priori knowledge about the QoS provided by different networks. Based on that knowledge, a mobile device, on behalf of its user, could make an informed choice about which wireless access network provider and technology to use for the preferred mobile services of the user.

To date, there are no unbiased, external providers of such information in the mobile business landscape. Users, who gain personal experience of various mobile services, may eventually use their acquired knowledge to manually reconfigure their devices and share their knowledge with family and friends. However, there is no service platform enabling users to collaboratively share their collected knowledge.We are developing a Quality of Service Information System (QoSIS) to fill this gap. QoSIS distributes predictions to mobile devices about the QoS provided by the different wireless access networks available at a given geographical location and time. These predictions are then used by a mobile device, on behalf of the user, to choose a wireless access network provider and technology to be used. The knowledge furnished by QoSIS also allows mobile service providers to adapt their service delivery to the predicted QoS, thus increasing the service quality and improving user experience.

Mobile devices, on behalf of their users, can contribute to the QoSIS database in a collaborative information-sharing manner by submitting collected data about the QoS provided during their mobile service use, given the selected wireless access network provider and technology. The principal dimensions of the QoSIS database are: geographical location, time, wireless access network provider and wireless access technology. QoSIS is based on a QoS prediction engine. Based on machine learning algorithms, the engine builds a heuristic from which to derive predictions.

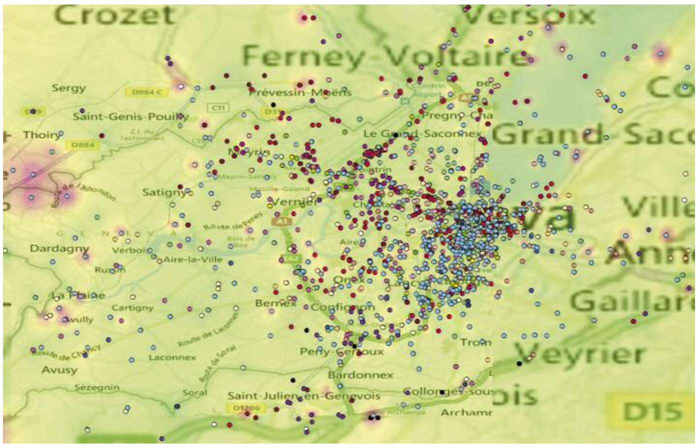

Figure 1: QoSIS service coverage in Geneva area (background colors indicate performance level, dots indicate separate network cells) (status: end of 2012)

Figure 2: Most frequent users' mobility paths for which QoSIS service is available (dots indicate separate network cells) (status: end of 2012)

We have assessed the feasibility of deriving predictions in a case study based on delay measurement data collected from the mobile device of a health telemonitoring service user. We have shown that it is feasible to predict the value of delay for a device, based on its own measurement data or on data collected by another device being used at the same location and time and using the same wireless access network provider and technology. It is also feasible to predict the value of delay for a device, based on delay measurement data collected by both devices [1].

In contrast to existing approaches, the proposed QoSIS is entirely user-driven: mobile service users collaboratively create the QoS-information that would provide the basis for QoS prediction for other users. QoSIS therefore implements the Mobile Web 2.0 paradigm. In line with this approach, we have also assessed the business scenarios for an enterprise based on QoSIS services - provisionally named "QoSIS.net". This enterprise could provide a QoS prediction service to its customers: mobile service providers and MNOs, as well as mobile service users. As part of the case studies, we have investigated business-to-business (B2B) and business-to-consumer (B2C) scenarios for QoSIS.net. We have shown that these scenarios are beneficial for all parties in terms of increased revenue, increases in mobile service quality and improvement of mobile user's experience [2].

The Quality of Life technologies group at University of Geneva, Institute of Services Science, is developing the QoSIS.net project. Future activities include deployment of QoSIS.net in the mHealth area – benefiting mobile patients and their caregivers by providing QoS-assurance for health telemonitoring and treatment services [3].

Links:
http://www.qosis.com/
http://www.qol.unige.ch/

References:
[1] K. Wac, M. Hilario, B.J. van Beijnum, et al: "QoS-Predictions Service: QoS Support for Proactive Mobile Services", Wireless Network Traffic and Quality of Service Support: Trends and Standards, IGI Global Publisher, 2010
[2] K. Wac: "Collaborative Sharing of Quality of Service-Information for Mobile Service Users", PhD thesis, Information Systems, June 2009, University of Geneva, Switzerland.
[3] K. Wac, M. Bargh, B.J. van Beijnum, et al: "Power- and Delay-Awareness of Health Telemonitoring Services: the MobiHealth System Case Study", IEEE JSAC, Special Issue on Wireless and Pervasive Communications in Healthcare, 27(4): 525-536, IEEE Press, May 2009.

Please contact:
Katarzyna Wac
University of Geneva, Switzerland
Tel: +41 22 379 0242
E-mail: Katarzyna.Wac@unige.ch