Mobile Phone as an Application Development Platform: some Research Issues

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Abstract

This is a seed fund proposal to embarking on studying and tackling the scientific and technological challenges facing application developers on mobile platforms. Specifically we will, through literature review, building experimental platforms, and setting up collaborations with top experts from academia and industries, make an effort to 1) understand the existing technology and research problems on mobile platforms, 2) identify the niche area for IEP to target in the future, and 3) develop a base for proposals to external funding applications.

Background

Low-cost ICT user devices like mobile phones and smartphones have made unprecedented penetration into developing countries[1], forming a usable hardware base of ICT that 1) may potentially leapfrog the era of fixed-line infrastructure and PCs and 2) enables the development of locally-relevant ICT applications and contents (like education, healthcare, social networking, government services and commerce) to meet the need of the impoverished populations of the world.

However, as a software development platform, mobile phones pose much more serious challenges to application developers than desktop systems. With a bewildering array of phone architectures and connectivity networks (cellular network, adhoc network, GPS, sensor network, RFID, Broadband), application development on such devices requires programmers to have a high level of sophistication in low-level technical concerns [2]. Besides the issue of data security (air broadcast) and HCI (screen/input device), developers also need to carefully address the issue of the efficient use of resources (i.e. battery, bandwidth, computing, etc.) and the issue of fault-tolerance of unreliable connection and devices, if just for the resulting application to be usable at all. Moreover, to release the full potentials of mobile applications, developers need to take into account a completely new dimension of software: context-awareness [10]. That is, the mobile application should be aware of its operating context, such as location, nearby devices, motions, carrier tariff, as well as the lighting, acoustics and imagery of the surroundings.

For developing countries, such technological barrier is especially frustrating as it blocks the tapping of local creativity and talents within the community who best understand the local needs and their cultural and social contexts but are less sophisticated technical-wise.

Therefore there is a real need in understanding the scientific and technological challenges facing application developers on mobile platforms and addressing these challenges through applied research works. Obviously research work on mobile platforms is wide-ranging and crosscutting both academia (including system research, application domain research as well as algorithmic and semantic research) and industries (involving phone manufacturers, mobile carriers, system software and middleware vendors as well as application and contents developers). Thus we need to be, on one hand, selective in addressing a limited number of key research issues that fit well with IEP expertise and, on the other hand, proactive in seeking collaborations with leaders in the field from both academia and industry.

Moreover, with the strategic importance of mobile plat-

[1] ITU report ‘Measuring the Information Society 2010: Executive Summary’.

forms for ICT enabled sustainable development, the work done in this project will be very relevant to the sibling projects of UNU-IIST on pervasive ICT, e-healthcare, e-learning and e-governance.

Programme and Methodology

The aim of this project is to 1) understand the scientific and technological challenges facing application developer on mobile platforms by doing literature review, building experimental platforms (using existing open-source or proprietary software), attending important conferences and exchanging with top experts in the field, 2) identify, in addition to potential collaborators from academia and industry, the niche area in the field for IEP to target or concentrate on, and 3) publish preliminary reports to build a base for proposals to external funding applications.

More specifically, the project will start by carrying out investigations into the following three crucial aspects of mobile platforms, which can potentially be the initial foothold of IEP in the field:

a) Reliability: the algorithm and architectural challenges in designing and implementing mobile platforms that are fault-tolerant of unreliable connection and user devices;

b) Energy-efficiency: the scientific challenges in deriving, analyzing, and validating energy-efficiency strategies for network-wide algorithms based on wireless connections [3].

c) Simpler programming models: how to invent a simplified model that support 'business logic' level programming in a 'context aware' style is of crucial importance in tapping creativity of a broader base of developers.

Compared to PC and fixed-line networks, a major difference of mobile platforms is the unreliability of connection and devices. Past experiences teach us that software techniques are usually better than hardware technologies in achieving failure tolerance. For instance, Google's data center exploits a large number of cheap commodity (i.e. unreliable) hardware, which they find to be more cost-effective (in both performance and robustness) than a small number of expensive quality-built hardware. The secret lies in some advanced software deployed on top of the hardware that implements task duplication and automatical failure recovery.

Another major difference of mobile platforms is that the processing units are hand-held devices operated by battery, which make the issue of battery life and power savings a crucial one. Thus much research has been done in the area of low-power design, power management and the balance between computation and communication power at say device, circuit and micro-architecture level [3, 6, 5]. In this project we will concentrate on power aware design of mobile applications at network level, characterised by coordination and topological design decisions for algorithms to minimise power consumption (with or without a performance constraint) or maximise some performance metric (subject to a power budget) on a network-wide basis.

In the last few years MapReduce [4] has been a hugely successful programming model for large dataset processing on datacenter clusters. MapReduce model factors out low-level concerns like fault-tolerance, parallelisation, resource allocation and usage optimisation into the underlying runtime system so that application developers can focus on the 'business logic' in the Map and Reduce functions. Its popularity has driven its adaptation and implementation on mobile platforms [1]. However, one drawback is that MapReduce is optimised for batch processing of large datasets. On mobile platforms where each processing unit is interactive in a unique context and for applications that are more than dataset processing, we may need enhanced programming models that go beyond MapReduce.

In addressing the three research topics, the IEP has the distinctive assets in 1) deep understanding of concurrent and distributed systems as well as their formal modelling and verification, and 2) extensive expertise in design and formal semantics of novel programming models, e.g. functional (which inspired MapReduce), concurrent and distributed (potentially useful for context-awareness). Moreover, they have direct access to world leading-edge work on 1) design of real-time, probabilistic and stochastic algorithms in distributed systems for fault tolerance or other purposes, 2) the quantitative modelling and verification techniques required to analyse power consumption and reliability and 3) the novel security architectures for mobile platforms.

Thus our strategy for the project is to utilise existing expertise and resources to quickly break into the field and find a niche from which we can expand and gradually build a strong research portfolio targeting the scientific and technological challenges on mobile platforms.

Plan of Work

The work involved in the project requires the recruitment of three fellows (F1, F2 and F3). They, together with the Principal Investigator (PI), are the main working force of the project. Moreover, the Kwiatkowska group and Roscoe group at Oxford are external collaborators with expertise in quantitative analysis of power management [8, 9] and security architectures for mobile platforms [7] resp. UNU-IIST e-learning programme are internal collaborators providing help in the context of m-learning applications.

The programme of work will be broken down into five work packages organised into three main phases. The first phase (3 months) consists of literature review of research works on mobile platforms and familiarisation with existing mobile platforms and applications (WP1). WP1 lays the foundations for the rest of the project and will be undertaken F1, F2, F3 and PI.

The second phase (approximately 5 months) consists of three parallel activities: 1) building an experimental platform for mobile applications (WP2) 2) identify and develop interesting ideas for novel applications in m-learning (jointly with members of e-learning programme) and implement prototypes on the mobile platform (WP3), and 3) mastering the leading quantitative model checker tool, Prism[2], (with knowledge transfer from the Oxford group) and doing case studies on important energy-efficiency and fault-tolerance algorithms for mobile platforms found in the literature (WP4). WP2 will be undertaken by F1, F2 and PI, WP3 by F2, F1 and PI, and WP4 by F3 and PI.

The third and final phase (2 months) includes summary of the findings and report writing-up (WP4). WP4 will be undertaken F1, F2, F3 and PI.

There will not be deliverable for WP1. For WP2, the deliverable is an experimental mobile platform with some test applications while the deliverable for WP3 is a novel application in m-learning and its prototype implementation. For WP4, the deliverable is the Prism models of selected case studies and experimental results. For WP5, there will be three reports, one is a survey on existing mobile platforms and key research issues; another is an implementation paper on novel m-learning applications with a small survey on important mobile applications in e-learning (joint paper with e-learning programme); the third is a case-study paper on using Prism to analyse energy-efficiency and reliability.

[2] http://www.prismmodelchecker.org/

Budget of the project

Recruitment The recruitment of three fellows for 9-10 months will cost 8500 USD each. Total expenditure: USD 25,500.

Research visit and conference attendance It is expected the PI will visit experts on mobile platforms from academia and industry in Hong Kong, Mainland China, Europe and North America: one long-distance visit (say to Europe or USA) costs around 1000 USD in travel expenses and 1000 USD in accommodation and subsistence (7 days); 2 short-distance visits (say to Mainland) will cost 500 USD in travel expenses (200-300 USD for one return air ticket) and 500 USD in accommodation and subsistence (say 5 days). It is expected PI and the fellows will attend 1 regional and 1 international conferences. We estimate conference attendance costs around 1,400 USD for an international conference and 600 USD for a regional conferences. Total expenditure: USD 5,000.

External visitors We will share one leading expert visitor on mobile platforms with the pervasive ICT project. In addition we will invite another leading expert visitor, who is partially-funded on subsistence, USD 500 for 5 days, to do knowledge transfer. Total expenditure: USD 500.

Consumables and Equipments We request USD 2,500 of Equipments to purchase mobile phones, routers, PC and other hardware to set up an experimental environment.

Total: USD 33,500

Relevance to Beneficiaries

The results of the project will benefit IEP as well as other UNU-IIST programme. The experimental platform, survey report and external research collaborators will be useful to E-Learning, E-Healthcare and E-Governance projects. The technical skills on quantitative model-checking will be useful to pervasive ICT project.

Moreover, after the project we expect we should have identified the key scientific and technological challenges for us to address on mobile platforms, set up collaborations with relevant external partners and built a solid base for proposals to external funding applications, say MSTDF and FP7.

Dissemination and Exploitation

The work will be disseminated via publications in appropriate journals and conferences. In addition, the experimental platform, case studies, project reports and publications will be made freely available via a dedicated project website, maintained by the PI.

References

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