Sustainable Pervasive Computing Through Mobile Clouds

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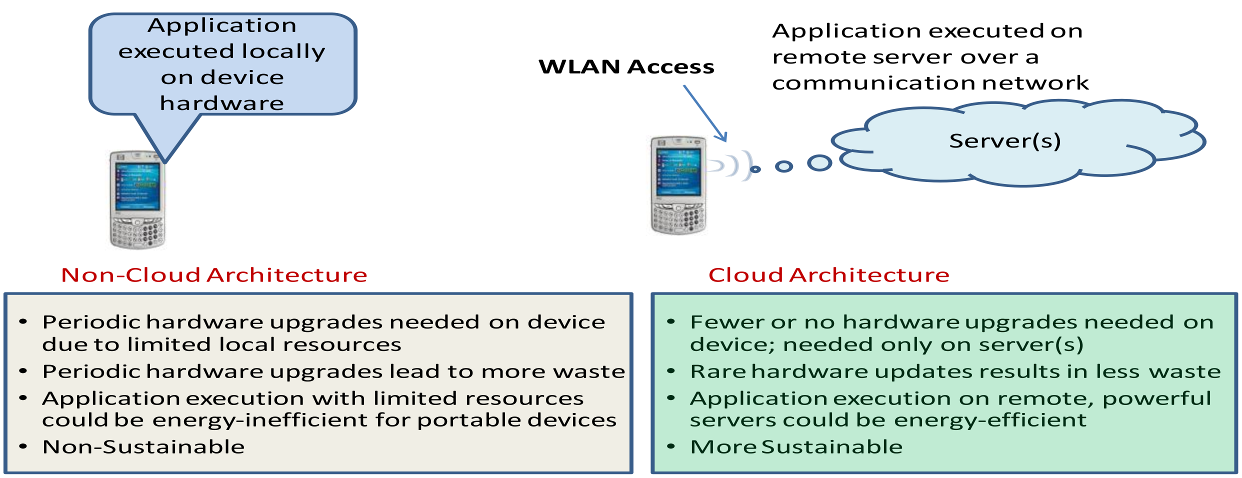
Background and Experience in the Field: During his years as a Ph.D. student at the University of Massachusetts-Amherst and since joining Wichita State University in 2008, the PI has established a strong record in designing algorithms and protocols for wireless networking and mobile computing, including those specifically targeting energy awareness and efficiency. This has led to numerous publications in top conferences and journals from 2007 to 2010, e.g., IEEE PerCom (1), ACM/IEEE IPSN (1), ACM MobiHoc (1), IEEE Transactions on Mobile Computing (2), and IEEE Transactions on Vehicular Technology (1). In the past year, the PI has worked on the emerging and broader area of sustainable and green networking with publications in the e-Energy conference and Green Computing workshop (part of ICPP conference). He served on the TPC of the first IEEE Green Computing and Communications conference, and gave an invited talk at the Green Computing workshop, both in the Fall of 2010. The PI has recently written two book chapters in the green computing area, one on green cross-layer mechanisms in wireless networks, and another on sustainability in portable computing.



Vision: Pervasive computing at scale via mobile phones has social implications in terms of electronic waste. There are 4.2 billion mobile phones in use globally, with less than 3% typically recycled according to a study by Nokia. Current mobile phones are replaced every 18-24 months, mainly to obtain devices with better performance. One approach to reduce electronic waste is to increase the lifespan of devices involved. We envision the realization of this approach through a cloud-based thin-client paradigm where individual consumer devices would have reduced capabilities acting as `dumb' terminals with most of the processing done at remote servers. This would allow most upgrades to be done at the servers, with little incentive for consumers to upgrade their devices. This approach would require greater reliance on software upgrades than hardware upgrades. There is likely to be an increased burden on communication within the thin-client paradigm which would then need the design of energy-efficient communication techniques.

Motivating Example: Consider a smart phone being used to play the game of Chess by a person who is traveling. The game could be played locally on the device itself, or it could be played online. In the former version, all the computing required to make a move by the computer (the game opponent in a two-player format) is done using the device's resources. In the latter, online version, all the computation is done through a powerful remote server and conveyed through communication to the device. It is easy to see that though more communication is required in the latter scenario by the portable device, the computation burden is significantly less. The latter scenario allows the user to play higher-level games without having to upgrade his/her device in the future. All the resources needed for improved performance is already at the server, or could be by an upgrade at only this one location.

Cloud computing is typically a client-server architecture, where the client can be any portable device like a laptop, phone, browser or any other operating system enabled device. Users of portable devices like to share documents, check email, surf the Internet on the fly, and represent an increasing segment of the population. A main issue with these portable devices is the constraints they present in terms of storage, memory, processing, and battery lifetime. By storing information on the cloud, and interacting with the cloud through communication, all these constraints can be easily met. An interesting point to note is that all these constraints of portable devices are based on hardware, and when using the cloud paradigm, hardware upgrades do not present any obvious advantages. Frequent hardware updates are now done at the cloud's servers, which are much fewer in number. Thus, each portable device can be utilized for many more years than what is typical now, reducing the manufacturing and recycling costs associated with this large-scale segment of mobile computing apart from electronic waste. These questions increasingly come to the fore with the rapid increase in cloud-based applications. Google recently announced its intentions to launch Chrome OS, a cloud-based operating system for computers, including smart phones. If it can be shown that the thin-client scenario still meets user QoS expectations, it will become easier to have it adopted. To test the feasibility of this vision, comparison of different types of local versus thin-client applications would be useful; e.g. word processing applications, video streaming, gaming. Important factors to consider would include mobility, possible reduction in energy consumption at the thin-client by outsourcing tasks to a powerful server, and the `thinness' of a client in terms of capabilities. Performance of thin-clients have been studied before, but not with the expectation of using dumb terminals that would possibly lead to longer lifespan. This would require identifying hardware components that typically motivate upgrades and whether a combination of execution at powerful remote servers, high speed network connections, and software upgrades can meet user expectations for common applications. Though it can be expected that the thin-client scenario cannot satisfy user expectations in terms of some criteria (e.g. improving local screen resolution), and thus cannot eliminate hardware upgrades completely, it is hoped that our research along with education about the environmental benefits of increased device lifespan would make *device turnover rarer*.