Personal energy metering

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1 Introduction

Every day each of us consumes a significant amount of energy, both directly through transportation, heating and use of appliances, and indirectly from our needs for the production of food, manufacture of goods and provision of services. As part of the wider Computing for the Future of the Planet framework [5], we are investigating a personal energy meter which can record and apportion an individuals energy usage in order to supply baseline information and incentives for reducing the environmental impact of our lives [6]. It could provide a mechanism to raise awareness of our consumption and help us reduce our impact. This would depend on a global sensor network and poses a number of challenges: new sensor systems are required both to account for the energy used and to determine the identity and activities of users.

A position paper at the *Pervasive* conference sets out more details of our vision and outlines our research agenda [1].

2 Apportionment

One of the most interesting challenges of a Personal Energy Meter is in apportioning the energy costs of large shared resources such as office buildings and public transport to individuals. Economists warn of 'grave inefficiencies' resulting from scenarios where bills are split evenly without regard for individual consumption as each person minimises their own losses by taking advantage of others. It is this phenomenon that encourages people to order the most expensive items from the menu when out for dinner with a group of friends: if the final sum is to be divided evenly, nobody wants to be subsidising his fellow diners. The same is true of energy consumption in shared buildings: in a house of four where all bills are split, the marginal cost to any individual of turning on an appliance is only a quarter of what it would otherwise be.

Context awareness offers the potential to change this balance and apportion energy costs to those who cause them to be incurred, which may provide incentives to make reductions. We have explored how sensor systems installed in many buildings today can be used to apportion energy consumption between users, investigating the differences between a number of possible policies to evaluate the case for apportionment based on energy and usage data collected over the course of a year. We also studied the additional possibilities offered by more fine-grained data with reference to case studies for specific shared resources, and in our paper *'The case for apportionment'* discussed the potential and challenges for future sensor systems in this area [4]

3 Metering

A key ingredient for apportionment mechanisms is data on energy usage. This may come from metering devices or buildings directly, or from profiling devices and using secondary indicators to infer their power state. We have presented a novel method for decomposing power measurements of programmable devices which we hope will help make this process simpler and more accurate [8].

4 Context

Contextual information provides crucial cues for apportioning the use and energy costs of resources, and one of the most valuable sources from which to infer context is location. Indoor location systems have been the subject of much research over the past two decades, but while many systems can deliver impressive results very few are suitable for widespread deployment outside research environments due to the extensive bespoke infrastructure that must be installed and surveyed. This is costly in terms of both money and time, and impractical in most buildings. A key ingredient for a personal energy meter is a low cost, low infrastructure location system that can be deployed on a truly global scale.

Bluetooth-based systems are particularly attractive as they have low power requirements and almost everyone already carries a mobile phone and has a computer on his desk; however, location systems to date have relied on the inquiry mode to constantly scan for devices. This process is very slow, can be a security and privacy risk and is not supported on many new handsets. We have investigated the use of low-level Bluetooth connections to track mobile devices within a field of fixed base stations and are constructing a building-wide tracking system based on this technique [2].

A Personal Energy Meter could even include the human energy we each expend as we go about our lives. We have also demonstrated that the same location systems used to infer usage of shared resources can also provide accurate data about our own consumption [7, 3].

5 Summary

A Personal Energy Meter that provides live information on consumption apportioned to individuals represents a very significant step forwards from the current common situation of a static, approximate and time consuming audit of a building or organisation. It is dependent on developments in a number of computing technologies — in particular, sensors and sensor networks to provide data both on usage and on interactions and a common world model to allow information to be collected wherever the user might be. We hope that it will provide important insights and incentives to help us each control our own footprint.

References

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