Mobile tools for building maintenance

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Mobile Computing in Facility Management

Imagine the ability to monitor and control your building systems from your mobile phone. With advances in Information Technology, the integration of mobile devices with building management and automation systems is rarely exploited.

Mobile solutions are currently being designed for personal communication and collection of information for various applications. The integration of mobile devices with inventory and stock systems, of which an example would be to check if spare parts are available for repair of a building system, like a pump, or if the part needs to be ordered. My research involves the use of building performance information, collected from sensors, meters and actuators for controlling building equipment, to support maintenance engineers and improve their decision-making process.

This research is part of a project named ITOBO (Information and Communication Technology for Sustainable and Optimised Building Operation). ITOBO focuses on applying optimised maintenance procedures based on building performance levels and delve into aspects of building control. ITOBO, the Science Foundation Ireland (SFI) Strategic Research Cluster for Sustainable and Optimised Building Operation, is undertaking research in Information and Communication Technology that will enable us to develop a holistic, methodological framework for life-cycle-oriented information management, and decision support in the construction and energy-management sectors. The specific goal is to develop an anticipating (smart) building that operates on an energy-efficient and user-friendly basis while reducing its maintenance costs.

Through the utilisation of data warehousing methods for collecting processing and analysing data from multiple sources, built on the flow of data from both the existing Building Management Systems (BMS) and an additional Wireless Sensor Network (WSN) deployment, a basis is provided to extract relevant aggregated building performance data for a maintenance management system. In order to deploy such a system, the Environmental Research Institute (ERI) Building, which is owned by UCC, is being used as our living laboratory.

The ERI Building incorporates green technologies for heating and generation of hot water for occupant requirements. Renewable technologies for renewable energy from solar and

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geothermal heat require specialised maintenance routines for inspection, cleaning and repair in order to optimise operations and conserve energy. The mobile application for providing building performance and maintenance information must define a schema for these systems, their components, relevant performance measures for building operatives to identify inefficiencies, associated maintenance routines and maintenance task history. This information schema provides a basis for the context of the mobile maintenance solution.

Currently in Facility Management (FM), practices include scheduled maintenance and corrective maintenance tasks. These tasks involve inspection, repair and replacement activities to be performed by maintenance engineers. The engineer has to inspect what caused the problem, diagnose what may be the solution for this problem and, finally, implement a solution.

Over time, through the storage of electronic records of maintenance activities, a history profile of building equipment will be available to support further FM tasks within the recorded building(s). Allied with this history profile and coupled with building performance data, a maintenance engineer will be able to perform FM tasks far more effectively and save on energy wastage and overall maintenance costs. My research aims to address these issues by introducing a software platform to support the provision of building maintenance and performance data to facility managers and building engineers for more energy- and cost-efficient maintenance activities.

Data Representation of Building Performance

The essential interaction and representation of building performance and maintenance information forstakeholders. Data must be presented clearly and unambiguously so the user can precisely interpret and trust what they see. Early attempts at displaying energy consumption data involved the use of graphs to inform the user of trends within their building systems. The onus is on the software application to display a message, an alert via sound in the form of audio alarms, or send email/text message to users in a manner that is acceptable and intuitive.

With respect to data representation, there is also the ability to provide a deeper insight into the operations of the building plant through the proper use of graphical methods. Tufte proposes a number of guidelines for graphs that depict building performance. These include the use of a grey grid outline for graphs, labelling which is clear and helpful; the maximum number of data streams recommended is six and font should be SansSerif.

An example of the user interfaces developed is presented in Figure 1. This view supports the graphical representation of energy consumption data, such as electricity, gas and water consumption. Peaks in energy consumption can easily be identified but the user can select

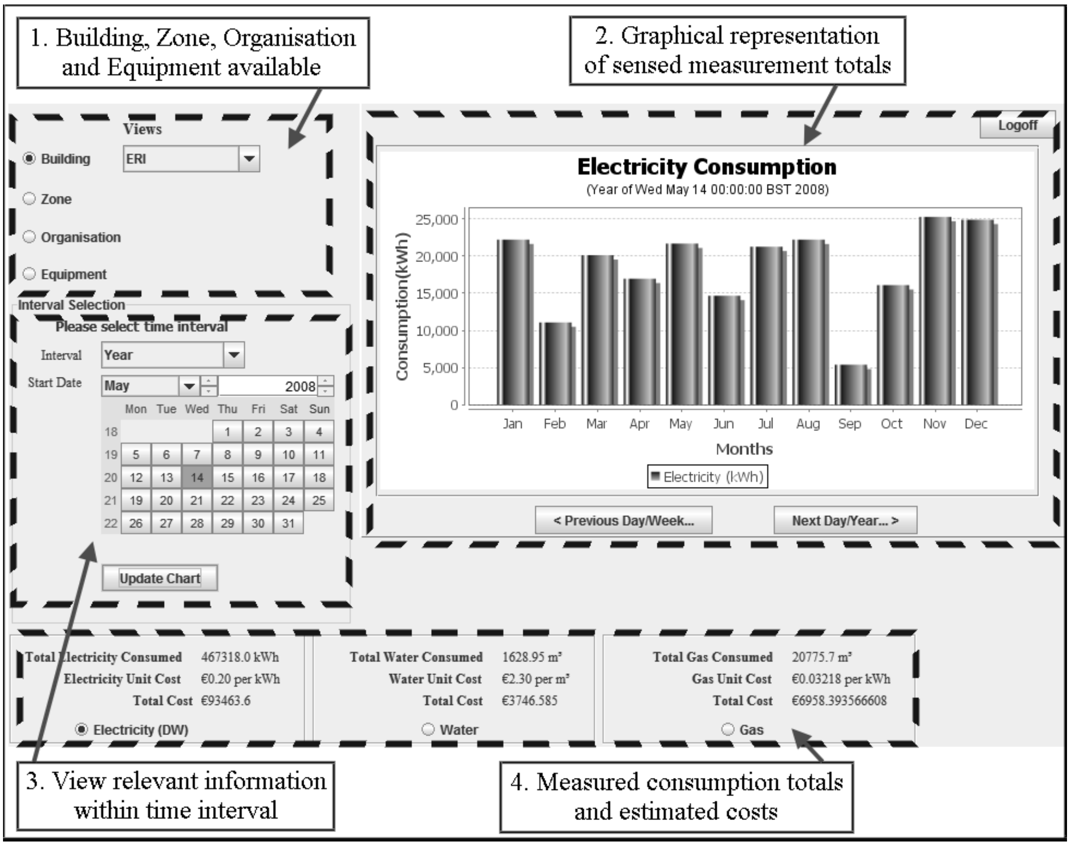

Figure 1: Building Engineer View displaying Electricity Consumption of ERI in 2008

a specific time interval to further evaluate the causes of excess consumption. Basic cost calculations are displayed that can enable an energy manager or a facility manager to improve planning for future budgets. Also, the view can be further refined to check on the different buildings that are being managed by the user and the building equipment being maintained by a maintenance engineer.

The resulting communication of information for Facility and Energy Management in buildings integrates multiple people in a variety of distinct technical roles with their individual responsibilities in respect to energy consumption. It assists energy managers in utilising building resources more efficiently and cost–effectively, as well as integrating the building occupants to allow them to be more environmentally-aware in their building resources usage.

Building Performance Context Information for Mobile Devices

Following the presentation of building performance data, a mobile device is to be used to facilitate the building operative view. In order to provide building performance and maintenance data to mobile devices, a suitable information structure must be designed to achieve a robust mobile application, with timely delivery of relevant data to building operative.

Applications within mobile devices can greatly benefit from the integration of context information in order to create a more effective user experience. Context rules were defined to provide an overall structure to the FM application. Access to relevant building performance and maintenance information is displayed to the user in a timely and effective manner depending on the user role and the location that the user works from. Other elements may include the type of device and the time that the user accesses the system, which also govern the data presented to the user.

To address the context of a FM domain application, four main aspects were evaluated in relation to the system user, maintenance location, user device and time of access.

1. **User Context**
   Using predefined roles to classify system users, building operators are presented with user interfaces that are specifically designed for their day to day activities. The view of maintenance task information is complemented by relevant performance measures of the equipment they are maintaining. Each user is provided with a customisable menu system to enable quick access to core work screens.
2. **Location Context**
   Users are presented with information about the location(s) they manage or inhabit. Building performance and maintenance data may be collected from multiple sites so user will want to view specific location information, from zone level conditions to building level energy consumption.
3. **Device Context**
   Depending on the type of device, the user can access data over different networks, with differing screen dimensions and device data processing and memory restrictions. Catering for devices such as mobile phones and laptops is enabled through abstraction and hierarchies of building performance and maintenance information. With a user of a laptop, large graphs can be displayed, while a mobile phone user requires summary information.
4. **Time Context**
   Users are presented with up to date information on the performance of their relevant building(s) when they log into the system. Quick access to timely data will assist the user in reviewing and analysing their facility more effectively. Monthly, weekly and daily information should be automatically collated and analysed automatically according to user requirements.

Figure 2 presents the Building Operative view to compare the performance of the heat pump, solar and underfloor heating circuits over a selected period of time. Other options will be available to cater for options such as heat pump coefficient of performance to other measures of defining heat pump performance levels, such as power consumption

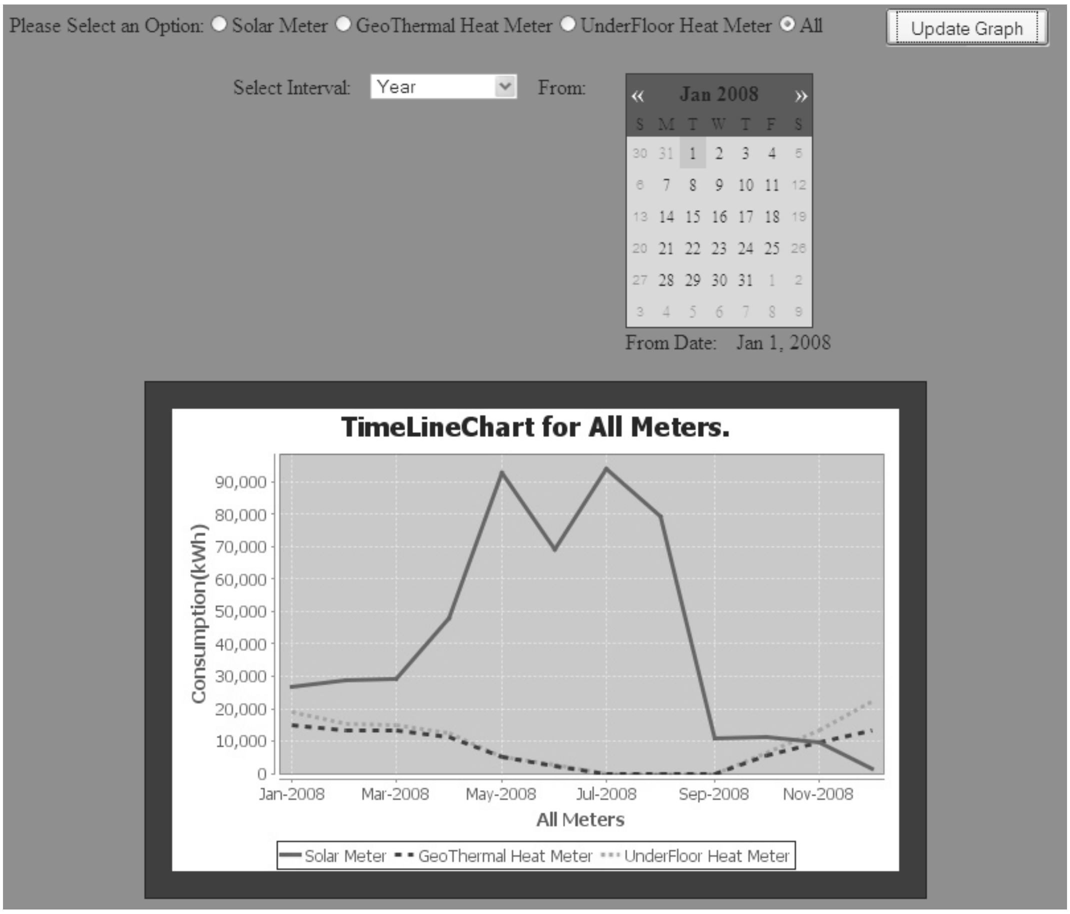

Figure 2: Building Performance View — Comparison of Energy Generation from Solar and Geothermal sources and Energy Consumption of Underfloor Heating in ERI for 2008

rate. They can enter the time interval they are interested in viewing, a diagram will be displayed, and the Building Operative can view normal or irregular performance of the selected building component.

In summary, a Web-based platform has been developed to support the provision of context-sensitive data to mobile clients to assist the decision-making processes of maintenance engineers. Providing building component performance and maintenance history gives a building operative, who is unfamiliar with system being maintained, an overview of problems and repairs on the device or system. With the availability of context-defined information, maintenance data is easier to access and easier understood compared to traditional BMSs.

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