



# IoT-Based Implementation and Mobility-Driven Management of the Smart and Energy Efficient Home Appliance Ecosystem

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**Abstract.** The Internet of Things (IoTs) have emerged as a disruptive technology and an enabling platform to ensure a connected world that offers improved life style, enhanced services, and socio-economic opportunities. Smart city systems can exploit the IoT platform to offer innovative solutions that transform conventional cities and societies into knowledge and technology-driven metropolises. Smart and energy efficient buildings and homes are central to the success of the smart city infrastructure.

**Objectives:** The proposed project aims to exploit the IoT infrastructure for deploying interconnected home appliances (eco-system implementation) that are manipulated through portable and context-aware mobile devices (eco-system management). The objectives of this project are to synergize the academic research and industrial development to (i) implement the home appliance ecosystem that communicates with devices and humans, and (ii) transforms conventional homes into energy efficient smart homes.

**Keywords:** Internet of Things · Mobile Cloud Computing · Smart homes  
Software engineering

## 1 Research Motivation and Solution Framework

Internet of Things (IoT) have become an enabling platform to interconnect humans, systems, services, devices and things to ensure a connected world to offer improved life style, enhanced urban services, work practices and interactions [1]. A study on the recent state of the IoT has highlighted that approximately 25 billion devices will be connected to the Internet of Things by 2020<sup>1</sup>. Smart city systems rely on the IoT platform to offer improved and digitized urban services such as smart health, transportation management, and energy efficient building and homes. Smart homes and buildings are the fundamental units for the implementation and operations of smart city

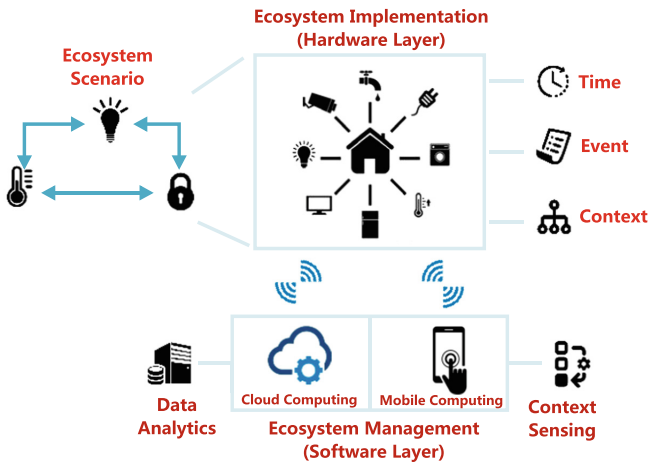
<sup>1</sup> D. Evans. The Internet of Things How the Next Evolution of the Internet Is Changing Everything, 2011. <http://www.iotsworldcongress.com/documents/4643185/3e968a44-2d12-4b73-9691-17ec508ff67b>.

systems. To date, some critical issues such as automation, security, self-adaptation and context awareness needs to be resolved to implement the IoT-driven smart cities and smart homes effectively and efficiently. The primary challenge is:

*‘how to exploit the IoT platform to develop self-adaptive and context-aware smart homes that increase energy efficiency while decreasing operational costs’*

The challenge highlights that in order to exploit IoT platform for building smart homes, (i) a trade-off between energy efficiency and operational costs needs to be maintained, and (ii) the system must be self-adaptive and context-aware.

**Solution Overview** - In order to address the challenge(s) above, i.e.; to support energy efficient smart homes, an overview of the proposed solution is illustrated in Fig. 1. Specifically, to implement a smart home we propose an ecosystem of the interconnected home appliances that operate dynamically and enable energy efficiency. For example, the ambient lighting in the home adapts itself based on the dynamic contextual information such as energy consumption, time of the day, or events in the surrounding. Moreover, based on the contextual information such as time or movements in the surroundings can trigger the surveillance, temperature control or background lights. The home appliance ecosystem needs to be monitored, analyzed and managed dynamically with human decision support is needed to deploy and customize an efficient and economic system.



**Fig. 1.** Overview of home appliance ecosystem to support energy efficient smart homes

The home appliance ecosystem needs to be implemented and managed as:

- *Implementation of the home appliance eco-system* is mainly the hardware level functionality. To implement the system, home appliances and devices needs to be equipped with sensors that sense the contextual information (time, event, energy consumption) and enable the communication among the home appliances. For example, when the surveillance system detects an unusual movement at a specific

time of the day such information must be communicated with the security system and lighting control.

- *Management of the home appliance eco-system* is primarily concerned with the software defined logic to manage and manipulate the appliance ecosystem. We utilize the Mobile Cloud Computing (MCC) that represents the state-of-the-art mobile computing technology to develop systems that are portable, context-aware yet resource sufficient [1]. The mobile computing layer consists of the context-aware and mobility-driven interface that empowers its user to interact with the ecosystem and manipulate it. The cloud computing layers supports all the processing and storage of the appliance ecosystem to support analytics and human decision support to manage and conserve the energy.

## 2 Contributions and Outcomes

We highlight the primary contributions of the proposed solution as:

- *Unification of mobile and cloud computing technologies* that supports the context-awareness and mobility of a mobile device with elasticity and analytics of cloud servers to manage home appliances and their eco-system in smart home context.
- *Applying the system engineering approach* to seamlessly integrate the hardware devices (for eco-system implementation) and software resources (for eco-system management). The integrated system enables the communication between devices and humans, and transforms a conventional home into an energy efficient smart home.

**Industry Academic Collaboration:** The project can foster academic-industrial collaboration - with our industrial partner<sup>2</sup> - to research innovative embedded systems (electrical and software) that leads to industrial scale development of commercialized product(s) to support smart buildings and homes. The collaboration can benefit the development of IoT-driven solutions that go beyond smart homes and address socio-economic challenges (e.g.; traffic management, disaster recovery) in the context of smart cities or digital societies.

**Novelty Beyond State-of-the-Art:** The research state-of-the-art primarily focuses on the security and energy efficiency of the smart homes based on cloud [2] and fog computing [3]. Our proposed solution aims to leverage MCC as state-of-the-art mobile computing technology [1, 4] to not only incorporate context-awareness but also support analytics and decision support to manage energy efficient smart homes.

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<sup>2</sup> MicroMerger (Pvt.) Ltd. is an IT Engineering company based in United Kingdom and Pakistan. [www.micromerger.com/](http://www.micromerger.com/).

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