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# Cost Efficiency for Load Devices Based on IOT

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***Abstract*** - Internet of Things or IoT is an interconnected network of physical devices connected to each other through the internet. The 'things' here refer to the physical object in the network that has its own unique IP address and has the ability to send and receive data over the network. It is a growing topic of interest these and will deeply affect our daily life. This thesis work aims to apply the IoT paradigm for controlling and monitoring of a smart lighting application. The implementation aims to reduce the energy consumption in addition to, achieve adaptability of the lights according to the surrounding environment. The implementation uses Service Oriented Architecture (SOA) to allow heterogeneity and interoperability between components.

***Keywords***: energy efficient, Internet of Things, Device Profile Web Service, automation, Key Performance Indicators, Web Services, Service Oriented Architecture

## I. INTRODUCTION

The Internet of Things (IOT) allows devices to be connected with the internet and, communicate and interact with each other. The IOT is connecting the physical world with the virtual one, by creating a digital entity for each object or device. Addressing billions of devices will not be a problem anymore due to the IPv6 addressing protocol. Applying Smart-Lighting and Building Automation System (BAS) are one of the main challenges for the IOT. The numerous amounts of data exchanged and the interoperability between all devices and meters require a strong network infrastructure capable of holding huge bandwidth and a standardized protocol for communication.

This implementation will give a holistic view of the energy consumption and will aid the management to analyse and monitor energy data, as well as report results to the enterprise level. These reports will guide the enterprise to take decisions regarding its consumption behaviour and controlling method.

State and private research groups are trying actively to bring IOT in our daily activities. An urban lighting model described in was presented in the "International science park" in china implementing the IOT. The model represents the IOT in 5 main layers: objects layer, sensing layer, preceptor layer, transport layer, and information layer. The object layer is subcategorized to moving objects, stationary objects and area. Each of these subcategories is divided to several kinds and has certain arguments identifying the object parameters. The sensing layer is responsible for converting all analogue signals such as temperature, light and motion into digital signal. Preceptor layer provide information about objects from RF tags which is then sent to the transport nodes. The transport layer then sends this information to the control layer where the control algorithm and processing of information takes place. The information layer can discover, delete and configure objects; moreover it can apply control action on lights. The power consumption for each individual lamp is measured and analyses in the control centre.

SOA for smart lighting application facilitated the interoperability between devices. Communications between devices in the system were done seamlessly, using messages defined in the internal service. All devices are aware of the current surroundings and lamps energy consumptions. This collaboration can be used for extending the control to several areas and more lamps. The use of a separate service for control helped in reducing the response time. However it is still recommended that devices directly control lamps without any intermediate nodes.

The use of DPWS facilitated automatic discovery and subscription to the metering devices. Energy messages provided the main data required for monitoring of the system. Thus the smart lighting implementation demonstrated an outstanding metering model based on DPWS. The model can be easily adapted for smart cities and, integrated in a smart grid in the future. Where utility companies easily subscribe to the DPWS meters and gather data autonomously.

For monitoring and analyzing the results a web based dashboard application was developed. The dashboard was design such that it serves different kind of users with different purposes. Moreover the application is user friendly and has an easy and informative interface that can be understood without guiding.

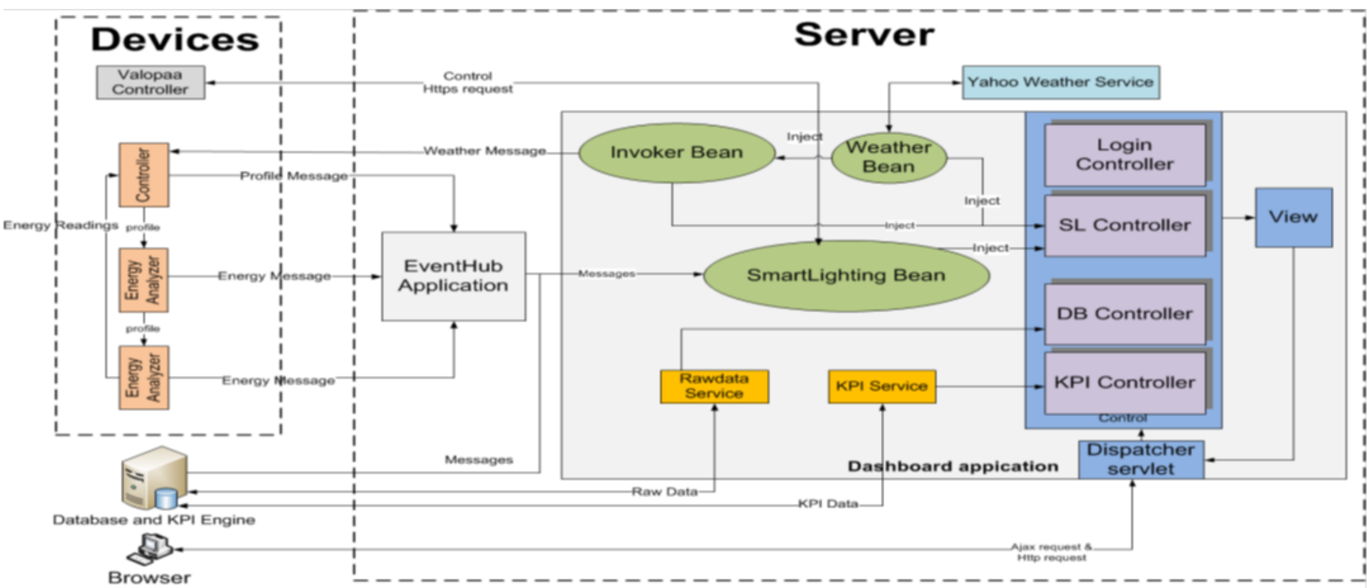
The server receives several messages and parses them automatically, regardless of the device type or vendor. New meter devices can be added without any pre-configuration required as long as, it supports DPWS and have same message format.

The implementation showed astonishing results for energy savings. The energy consumption was compared to some predefined schedule as a benchmark. An energy efficiency of 33.6% was achieved. Tests were performed mostly for clear and cloudy weathers. The efficiency is variable depending on conditions during the tests were performed. Environmental impact and CO2 equivalent were reduced subsequently.

Smart lighting is considered the one of the main solutions for energy reduction by means of controlling lighting Level according to desired need with minimum energy Consumption. Smart-Lighting systems utilize motion and light sensors for performing the control algorithms, most of the reviewed solutions have shown superior results in energy reduction by 30-40%.

## II. RELATED WORK

The software architecture of the smart lighting implementation shown in Figure was designed. It consists of the dashboard application, Event hub application, database, KPI engine and, programs hosted on the s-1000 devices.The Event Hub application works as a concentrator for the messages coming from the devices. It implements a DPWS client for discovering devices and subscribing to certain events with a given filters. The hub application then forwards the messages to the database and Dashboard application through a Camel endpoint.




The Dashboard application used to visualize the system data and results in a web application. The application contains a Smart lighting Spring bean that has all relevant values of the implementation. In the initialization method of the Smart lighting bean a camel context is initialized with and end point for receiving the messages from the hub. The endpoint then forward the message to parse Message () method, where uses the parser interface for parsing the message and generating the message data depending on the message name. If the message was a control message, the control parameters are passed together with the profile value to the Valopa manager object, which is responsible for sending Https control requests to the lamp controller. The Smart lighting bean is injected in the main controller for retrieving the data when needed.

The Weather bean is also injected to the main controller to provide the required weather data for the Ajax requests. The weather bean has an initialization method that gets the current weather from the Yahoo service every one hour.
Optimization model objective is minimizing the total energy cost, while the model is constrained by the requirements of

meeting the usage demand of appliances and ensuring the comfort of household. Air conditioner is used to keep the inner temperature level between minimum and maximum comfort levels. Household can use electrical batteries and PHEVs to get benefit from the fluctuation in the electricity price. We have observed that the usage of the HEMS model can reduce the household's energy bill and gives better solutions of all the experimented price tariff conditions.

We only utilize the uniform distribution in the simulation experiments which limits the benefit obtained from the HEMS. Therefore, in a future study, real world data can be used to analyze the past behavior of the household and a more realistic distribution can be utilized.

## III. METHODOLOGY

The thesis work starts with the research phase:

- Researching for smart-lighting applications, and studying their algorithms, benefits and limitations.
- Background study of the IoT, WS and DPWS.

Then the implementation phase:

- Design and implement the control algorithm in the devices.
- Designing web-services and messages required for energy measurements and data collection.
- Designing the dashboard application needed for monitoring and visualization.
- Work will conclude with verifying the results and checking possibilities for achieving better efficiency.

## IV. FUTURE WORK

This Thesis present a model for control and monitor of load devices. Due to the time constrain for this thesis it was difficult to test all possible conditions.

Only under these conditions the implementation was tested, thus it is advised to perform more test and analysis under different conditions.

The security subject was out of focus for this thesis work however, it is suggested applying Https requests in the future. Additionally more specific KPIs can also be added to have more generic view of the system performance. Furthermore it is advised to perform direct control from the devices over the load devices without intermediate nodes. This will help in improve user experience. Moreover it will allow achieving distributed control using multiple devices thus, extension of the implementation areas.

The temperature affects the lifetime of the devices, thus it is also advised to take into account device temperature in the control algorithm. This will allow reducing the dissipated energy through heating. Finally currently only automatic control is implemented however, in future work it is advised to apply manual control in order to override the system for meeting user needs and fine tuning.

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