Survey on Energy Consumption Modeling Using Topology Controlling Methods for IoT Cloud Federation

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Abstract – Sustainable Energy-Aware Resource Management, Environmental data acquisition, Large-scale, cloud environment and Bigdata are being driven by recent technological developments such as Internet of Things (IoT) and Web of Tings (WoT). The efficient use of limited energy resources of multiple cloud environment based applications, which is critically important to support these advance technologies. The application of topology control methods will have a profound impact on energy efficiency and hence battery time period. In this survey, we majorly focus on energy efficiency problem and present study of topology control techniques. Here, the IoT Cloud energy management strategy is presented for optimizing the allocation of localized smart sensors. The thought of IoT Cloud as a mesh of IoT Cloud providers that is interconnected to provide a decentralized sensing system and actuating environment where everything is driven by network protocol in a ubiquitous infrastructure. In this system, a dynamic algorithm was able to improve energy sustainability in an IoT Cloud ecosystem. The medical cloud can distribute its own medical information to medical IoT devices via access points. The proposed dynamic energy-efficient algorithm computes particular amount of power allocation in each access point based on a buffer size and channel. The performance of the proposed algorithm is improved in terms of energy efficiency and it is observed to achieve desired performance.

Index Terms – Energy-Aware, Bigdata, Data acquisition, IoT, WoT, medical cloud, dynamic algorithm, mesh topology.

1. INTRODUCTION

The IoT is internetworking of physical devices embedded with electronics, software, sensors, actuators, and network connectivity that enable these objects to collect and exchange data. The IoT allows objects to be sensed and/or controlled remotely across existing network infrastructure,[4] creating opportunities for more direct integration of the physical world into computer-based systems, and resulting in improved efficiency, accuracy and economic benefit.[5] When IoT is augmented with sensors and actuators, the technology becomes an instance of the more general class of cyber-physical systems, which also encompasses technologies such as smart grids, smart homes, intelligent transportation and smart cities. Each thing is uniquely identifiable through its embedded computing system but is able to interoperate within the existing Internet infrastructure. Experts estimate that the IoT will consist of almost 50 billion objects by 2020.

Typically, IoT is expected to offer advanced connectivity of devices, systems, and services that goes beyond machine-to-machine (M2M) communications and covers a variety of protocols, domains, and applications. The WoT is a term used to describe approaches, software architectural styles and programming patterns that allow real-world objects to be part of the World Wide Web. Similarly to what the Web (Application Layer) is to the Internet (Network Layer), [1] the Web of Things provides an Application Layer that simplifies the creation of Internet of Things applications.[2] Rather than re-inventing completely new standards, the Web of Things reuses existing and well-known Web standards[3][4] used in the programmable Web (e.g., REST, HTTP, JSON), semantic Web (e.g., JSON-LD, Microdata, etc.), the real-time Web (e.g., Websockets) and the social Web (e.g., social networks).[6]

2. RELATED WORK

The emergence of the IoT almost certainly is the most important single development in the long evolution of energy management. The premise of energy management is controlling elements at a fundamental and granular level. In a world that is saturated in IoT devices, that control will be quite deep. The billions – and eventually trillions – of sensors and other devices that will create a mesh that will facilitate energy management services and procedures that would have been impossible otherwise. The IoT permits folks and things to be connected any time, any place, with anything and anyone, ideally utilizing any path/network and any service [5]. The IoT is anticipated to get massive volumes of sensor data [4].

As a result of the newest innovations in the computer hardware sector and therefore the reduction in hardware costs, large-scale data processing is turning into progressively economical.

Specially, with the recognition of utility-based cloud computing [6] that provides computational resources in an exceedingly "pay-as you- go" model, the tendency to gather a massive amount of data has been increasing over the last few years. In 2010, the overall quantity of data on earth exceeded one zettabyte (ZB). By the tip of 2011, the amount grew up to 1.8 ZB [4]. Further, it's expected that this number will reach 35 ZB in 2020. It is therefore apparent that sensor information has significant value if we are able to collect and extract insights from them. The wireless sensor network (WSN) environmental monitoring includes both indoor and outdoor applications. The later will fall in the city deployment category (e.g., for traffic, lighting, or pollution monitoring) or the open nature category (e.g., chemical hazard, earthquake and flooding detection, volcano and surroundings monitoring, weather forecasting, precision agriculture). The reliability of any outdoor deployment can be challenged by extreme weather conditions, but for the open nature the maintenance can be also very difficult and costly.

In the discussion so far, we briefly introduced about IoT environment, sensing as a service model, and the WSN in the IoT paradigm. In this paper, we define energy sustainability in IoT Cloud federation, which allows the federated ecosystem to implement specific policies to dynamically select the exact destination where to allocate or migrate virtual sensors and actuators. Our approach leverages the dynamic deployment of containers to run services with good performances and reduced startup time. Although this means to assume that costs for the hosting service are strongly related to the availability and the effective energy consumption at the specific Cloud sensor node, our strategy is focused on to improve energy sustainability for the whole federated Cloud ecosystem.

3. ANALYSIS OF ENERGY EFFICIENCY PROBLEM DEFINITION

In this paper, we define nonselective sensing as the process of collecting sensor data from all possible sensors available, all the time without any filtering. While we acknowledge the importance and value of collecting large volumes of sensors data, a number of drawbacks of nonselective sensor data collection exist. Despite the fact that nonselective data collection could generate more value in the long term (e.g., due to discovery of knowledge that were not intended during the time of data collection), it definitely creates a problem (or difficulties) in the short term. The main issue in nonselective data collection is cost. Moreover, the processing and storing of data lead to more costs directly associated to the computational resource requirements (e.g., CPU, memory, and storage space). Further, processing more data requires more time which creates the problem of not being able to extract knowledge from the collected data on time. Crucially, another issue is energy consumption. Sensors are typically resource-constrained devices with limited access to energy. Nonselective sensing therefore leads to significant energy consumption and faster battery drain which create additional challenges related to the IoT infrastructure maintenance. Another challenge is network communication. Large-scale data transfers over the network without any kind of filtering lead to the continuous use of the communication radios continuously. This also leads to faster battery drain in addition to the heavy network traffic generated in the IoT infrastructure.

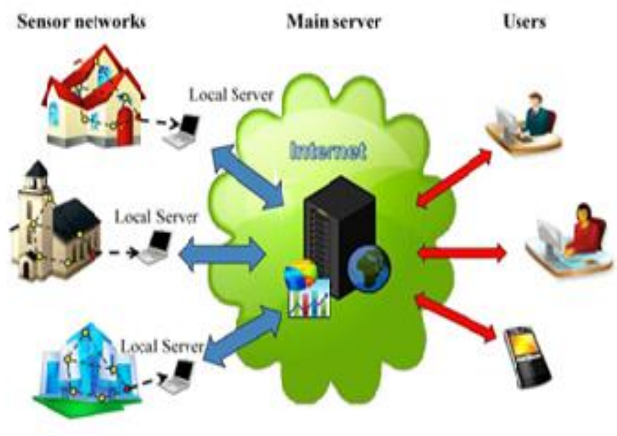

Fig. 1. Proposed platform can be installed on both mobile and static resource constrained devices. The platform provides easy ways to connect sensors.

Thus, energy is a critical factor, especially in the crowd sensing domain, where humans are involved in maintaining the sensing infrastructure. Therefore, we believe that on-demand selective sensing (i.e., perform sensing only under certain conditions) enables to avoid all the issues discussed above. To this end, we propose a scalable energy-efficient data analytics platform for on-demand distributed mobile crowd sensing called Context-aware Mobile Sensor Data Engine (C-MOSDEN).

Sensing as a service model, as illustrated in Fig. 1, show cloud IoT middleware (e.g., GSN [10]) works hand in-hand with multiple worker nodes (e.g., C-MOSDEN). We identify two fundamental components in this sensing as service architecture: 1) the cloud platform which manages and supervises the overall sensing tasks and 2) worker nodes that actually perform the sensing tasks as instructed by the cloud IoT platform. It is important to note that our objective is not to analyze the data and extract any knowledge. In this context, our objective here is to collect only the most important and relevant data, so the interested data consumers can use the data to extract the knowledge in an efficient manner with minimum use of computational resources, energy, time, and labor. Our proposed platform is ideal to be installed on worker nodes. Further, IoT middleware platforms such as GSN [10] can be used as the cloud middleware.

The cloud IoT middleware evaluates the availabilities of worker nodes and sends the requests to a specific number of selected worker nodes. More importantly, sensor data consumers may impose specific conditions on the data acquisition or transfer, such as sense only when a certain activity occurs.

4. ENERGY CONSUMPTION MODELING

The notations will be described as we introduce them in the upcoming sections. As denoted in (1), the total energy consumption of a mobile sensing platform at a given point in time (i.e., Δ) depends on two factors: 1) energy used for computational tasks (denoted by E_{CPU}) and 2) energy used for data communication tasks (denoted by EDCom). It is also important to note that the data communication can also be divided into two parts:

1) (E_{DCom}S2D) data communication between sensors (S) and the local computational device (D) (e.g., between external sensors and the mobile phone)

2) (E_{DCom}D2C) data communication between the computational device (D) and the IoT cloud middleware (C) as defined in equation (2).

Further, we can define E_{DCom} based on the communication protocols as well, as presented in equation (3) (e.g., 3G, WiFi, Bluetooth, ZigBee, and Z Wave, etc.).

Typically, long range protocols consume significantly more energy than short range protocols. However, there are some other energy costs as well (e.g., operating system related computational tasks, display, and so on) where we denote them using a constant K in the following equation:

$$E_{Total} = E_{CPU} + E_{DCom} + K \quad (1)$$

$$E_{DCom} = E_{DCom}\mathrm{S2D} + E_{DCom}\mathrm{D2C} \quad (2)$$

$$E_{DCom} = E_{3G} + E_{WiFi} + E_{BT} + E_{ZigBee} + E_{Z\text{-}Wave} \quad (3)$$

$$E_{Total}\mathrm{S}\Delta = E_{CPU}\mathrm{S}\Delta + E_{DCom}\mathrm{S}\Delta + K\mathrm{S}\Delta \quad (4)$$

In equation (5), we introduce $S\Psi$ instead of $S\Delta$. In the scenario defined in equation (4), sensor data are collected using non-context-aware fashion. This means that the mobile sensing platform has been configured to collect data during the total time of the experiment (no activity-aware or location-aware capabilities have been used). In contrast, equation (5) defines the total energy consumption when context-aware capabilities are activated. As mentioned earlier, the context-aware capabilities are provided by the C-MOSDEN platforms at some cost. For example, in order to provide activity-aware and location-aware services, C-MOSDEN needs to perform some additional computations. Such additional computations need to be added to the total energy consumption equation. We use $ES\Psi\ \Omega$ to denote such overhead computational costs

$$E_{Total}S\Psi = E_{CPU}S\Psi + E_{DCom}S\Psi + KS\Psi + ES\Psi\Omega \quad (5)$$

Similarly, equation (6) denotes the total energy cost for data communication. At a given point of time, data communication energy cost is $E_{DCom}\Delta$. Total data transmission time is denoted by $\mathrm{TT}_{DCom}\mathrm{S}\Delta$

$$E_{DCom}\mathrm{S}\Delta = E_{DCom}\mathrm{S}\Delta \times \mathrm{TT}_{DCom}\mathrm{S}\Delta \quad (6)$$

It is important to note that in scenario $S\Theta$, the data communication is performed throughout the total duration (due to nonselective, non-context-aware sensing strategy). For example, let us consider data communication related energy consumption. $\mathrm{TT}_{DCom}\mathrm{S}\Delta$ is denoted by equation (7). The total duration of the scenario is denoted by $T_{TD}\mathrm{S}\Delta$. The network communication frequency (i.e., how frequently the data need to be sent to the cloud) is denoted by $T_{NCF}\mathrm{S}\Delta$. Therefore, the number of time that the mobile device needs to push data to the cloud (i.e., E_{DCom}D2C) due to its significance over E_{DCom}S2D

$$\mathrm{TT}_{DCom}\ \mathrm{S}\Delta = T_{TD}\ \mathrm{S}\Delta / T_{NCF}\ \mathrm{S}\Delta \times T_{DCom}\alpha \quad (7)$$

Then, we can define the energy consumption related to data communication ($E_{DCom}S\Psi$) for a given scenario Ψ which employs context-aware capabilities to reduce energy wastage as

$$\mathrm{TT}_{DCom}S\Psi = T_{ART}S\Psi / T_{NCF} \times T\alpha_{DCom} \quad (8)$$

$$E_{DCom}S\Psi = E_{DCom}\Delta \times \mathrm{TT}_{DCom}S\Psi \quad (9)$$

Finally, by applying (9)–(5) and (4), we can model the total saving as defined in the following equation:

$$\text{Total energy cost saving} = E_{Total}S\Psi / E_{Total}\mathrm{S}\Delta \quad (10)$$

5. ENVIRONMENTAL MONITORING

The IoT is when “things” – objects, people, even animals – are equipped with sensors and assigned an IP address.These sensors collect and send data over a network so that it can be used to make better decisions. With the IoT, people can monitor, measure, control and manage the physical world around them much more effectively and efficiently. Take something as simple as tracking a package from its origin at a factory to its destination.

In the past, the location of that package could only be determined at certain touch points – for example, when the package was first loaded onto a truck, or when it arrived at a distribution center by tracking when the bar code was scanned. But now, individual packages have sensors on them so they can be tracked literally as they come down the street toward your door. The package itself is sending continuous messages out as to its precise location. With the IoT, a retailer can identify a customer who has downloaded its mobile app when they walk into one of its stores. In that case, the customer’s smart phone is the intelligent sensor. The retailer can then personalize customer service to individuals based on their purchase history or preferences.

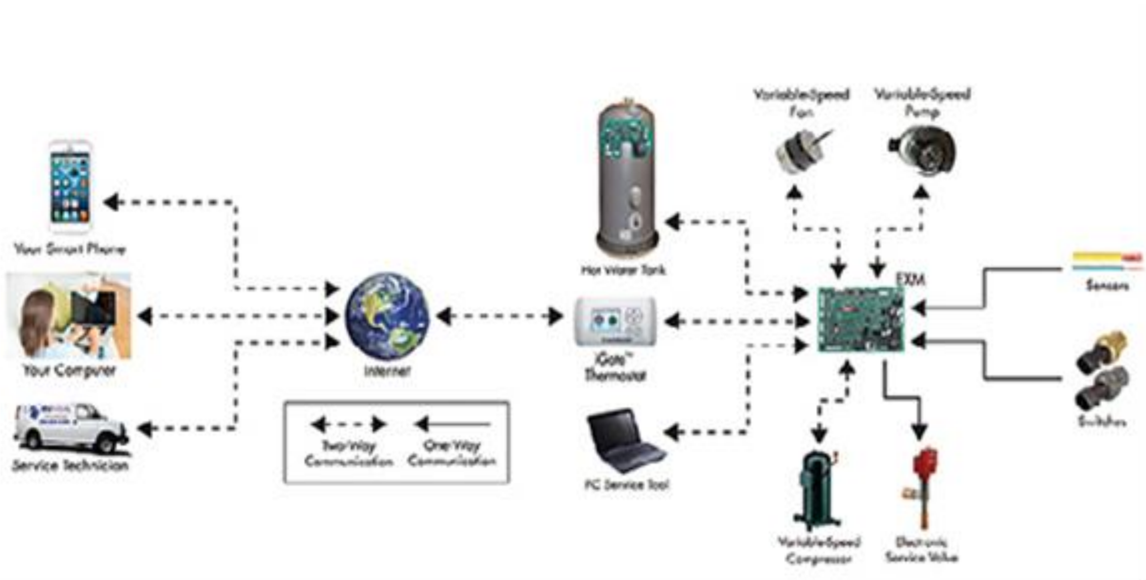

Fig.2. Proposed System of Environmental Monitoring using different objects via IOT

Supplying the market requires maintaining a certain balance impacted by a number of factors such as economy state, sales performance, season, supplier status, manufacturing facility status, distribution status, and more. The expenses associated with supply present unique challenges given today's global partners. The associated potential or real losses can dramatically impact business and future decisions.

IoT manages these areas through ensuring fine details are managed more at the system level rather than through human evaluations and decisions. An IoT system can better assess and control the supply chain (with most products), whether demands are high or low.

IoT also reduces the risks associated with launching new or modified products because it provides more reliable and detailed information. The information comes directly from market use and buyers rather than assorted sources of varied credibility.

6. TOPOLOGY CONTROL METHODS

Increasingly, mesh networking is emerging as a unique design for interconnecting a huge number of network devices, particularly for smart home applications. Mesh networks accept on wireless nodes instead of centralized access points to form a virtual wireless backbone.

Thus, mesh networks provide the ability to attach wirelessly devices and computers directly, while not a telco or ISP link. All mesh get together within the distribution of information in the network, and mesh networks will relay messages using a routing technique. In a mesh arrangement, network nodes provides network links with surrounding nodes, enabling traffic to hop between nodes on many paths via the network. The mesh networks are said to be self-healing, self-organizing and climbable, merely by adding several nodes.

Fig.3. Smart Home using Mesh Topology in IOT Environment

Internet of Things (IoT) network meshing allows a high degree of integration for interlinked things such as lights and thermostats that contain embedded sensor technologies. It permits these devices to communicate without relying on dedicated hub services. For designers, this makes it comparatively straight forward to create a network of connected devices, inexpensively. Also, there are lots of technology options available for connecting IoT devices, including mobile networks, Wi-Fi, the cloud or Bluetooth they are collaborating further to develop connected home products.

7. CONCULUSION AND FUTURE WORK

The proposed platform was collected solely the data those are relevant to the data consumers, thereby reducing the energy consumption and processing requirements. We have a tendency to show the importance of selective sensing through the reduction of computational requirements. Moreover, these paper addresses all phases of the sensible development from scratch of a full custom WSN platform for environmental monitoring applications. The system starts by analyzing the application requirements and process a group of specifications for the platform. In general, we were able to successfully reduce the energy consumption and network communication requirements through selective sensing. Although the context-aware functionalities are generated a small quantity of overhead that was disclosed the cost savings and benefits far outweighed the inflated complexness. In future works, we have tendency to enrich the energy consumption with privacy-preserving data analytics capabilities.

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