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Internet of Things Role in the Renewable Energy Resources

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Abstract

The concept of Smart Cities is becoming a reality as it evolves from conceptual models to developmental stages. Resilient, reliable, efficient and seamless energy and electrical power flow are essential parts to energize and power the services of smart cities such as smart hospitals, smart buildings, smart factories, smart traffic and transportations. All of these smart services are expected to run without interruptions by the use of smart energy and electrical power grids which are considered among the most important pillars for such cities. To keep the services of smart cities interconnected and in sync, the Internet of Things (IoT) and cloud computing are key in such transfers. The paper presents the role of IoT in renewable energy resources integration to electricity grid.

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Keywords: Smart energy; smart grid; smart cities; internnet of things; 6LoWPAN

1. Introduction

The World Wide Web is evolving from a traditional host that contains text, images, audios and videos to a physical host that enables users to control physical objects. Home appliances, remote CCV cameras and factory floors can be monitored and controlled using the Internet of Things (IoT) as communication media. The physical web concept is emerging nowadays. For example, smart energy frameworks utilizing IoT were reported to automate and control energy in buildings [1]. An IoT communication network is utilized in energy generations and consumptions in residential areas. The authors built an IoT-based experimental prototype that led to saving energy and left a positive impact on sustainability. Smart energy meters are used to allow for communication between

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consumers and utility command centers to exchange messages about energy and electrical consumption as well as well the status of home appliances [2]. This study extended to smart water and gas meters. The authors concluded their presentation with a set of guidelines for utilizing smart meters in smart energy monitoring and control systems. Figure 1 illustrates a broader picture of how energy and power from an essential part of smart cities [3]. As described in [3] real-time operation data from different objects such as smart electricity, gas and water meters, smart surveillance, smart transportation, smart environment and smart waste management systems are collected. The data then is forwarded to a smart cluster head (SCH) and the later transmits this information to local smart fusion nodes (SFN. As a result, an IoT-based smart decision is taken, and a control enabler center collects and exchanges the data for monitoring and controlling this scalable architecture [3]. A closer look at this conceptual smart city model shows how vital renewable energy resources and fossil fuel/coal energy as well as nuclear energy are in smart cities.

A smart grid consists of three major layers namely; system of systems, communication networks and applications layers [4-8]. Renewable energy resources are utilized as distributed generation (DG) units and installed nearby where the energy is converted and consumed. This kind of installation will reduce the need for long transmission lines, power losses and power substations [4-5]. Many reported literature showed the most popular renewable energy resources are solar energy, wind energy and hydroelectric energy [6-8].

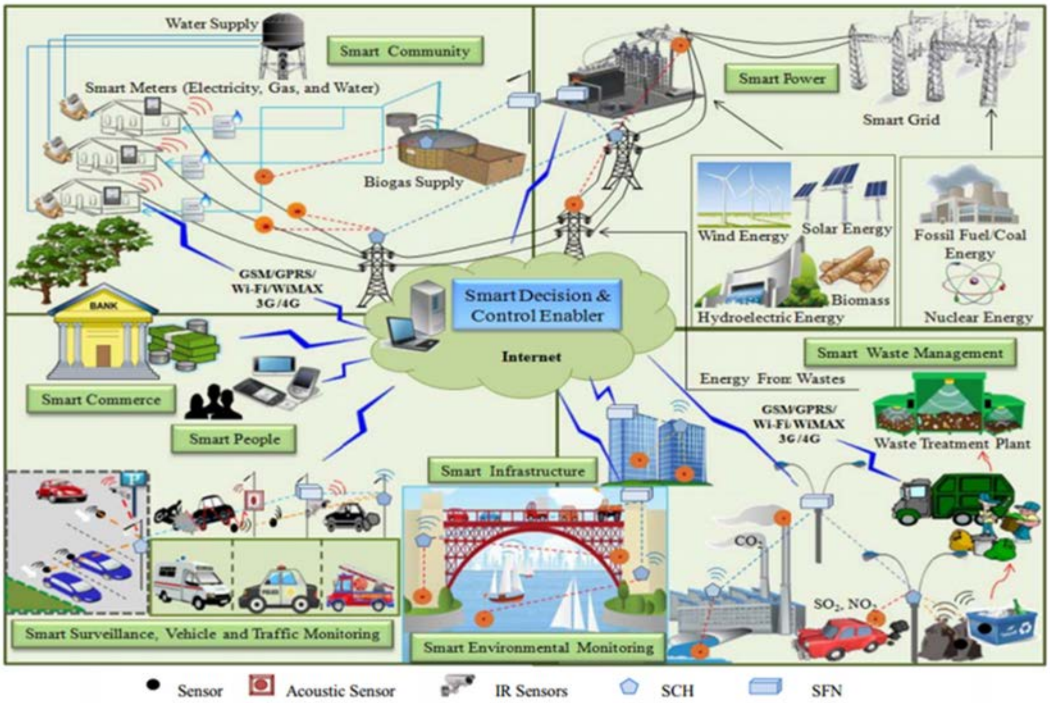

Fig. 1. Conceptual implementation of architecture in Smart Cities [3].

2. Internet of Things Concepts

The world is shifting toward more interconnectivity and more conductivity. It has become an integrated global community through multiple technologies, and numerous areas of applications and services. IoT concepts are leading to a world where real, digital and virtual things are converging to make our cities smarter and more intelligent. Nowadays, traditional web technology is empowered by IoT to connect physical objects (things) such as home appliances and smart grid devices with a unique address for each thing [10-11]. This has been made possible with the help of the IPV6 protocol which has 2^{128} unique IP addresses compared to 2^{32} addresses used by IPv4. Using IPV6, billions of objects can be connected, monitored and controlled at the same time [12-14].

As IoT is becoming more of a reality nowadays, academics and industrial professional are classifying it into two categories; Consumer Internet of Things (CIoT, hereafter IoT) and Industrial Internet of Things (IIoT) [15-16]. Popular IoT applications are smart phones, wearable, TVs and home appliances. On the other hand, the popular IIoT applications are smart factories, grids, machines, cities and cars. Figure 2 illustrates these two categories [15].

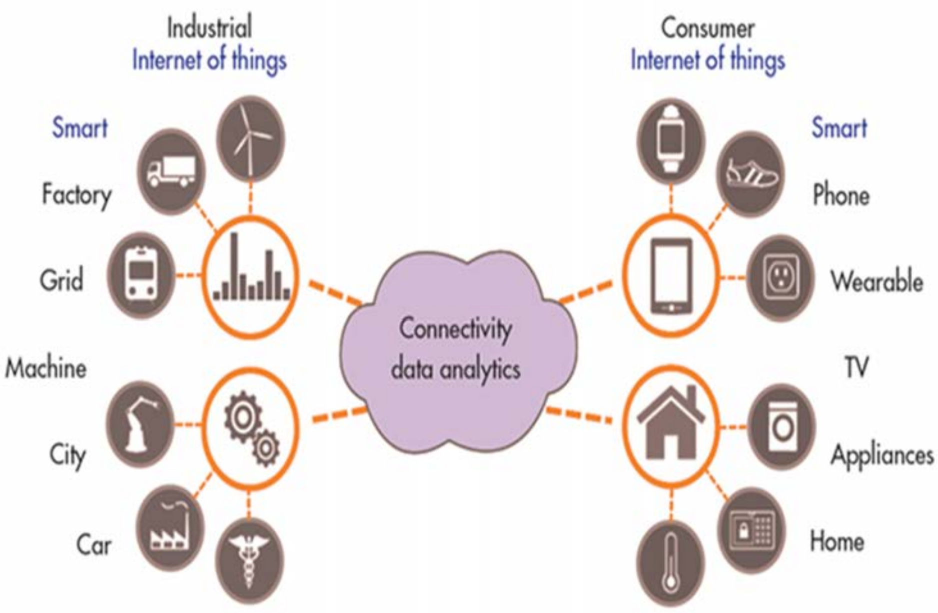

Fig. 2. Internet of Things calcifications [14].

3. Proposed IoT/IIoT Conceptual Framework for Renewable Energy Resources

The NIST smart grid conceptual model has seven domains one of which is the consumption domain [17]. The consmption domain is the primery candidate for the cogneration and installation of renewable energy resoruces. As shown in figure 3, there are three different types of consumers namely; residentail, commical and industrial. Renewable energy resources such solar, wind and haydro are installed for all types of consumers. In terms of communication netwroks, the consumption domain is is divded into three different neworks: home area netwrok (HAN), business area network (BAN) and industrial area network (IAN) [18-19].

Many communication protocols are utizled in these networks such as ZigBee, PLC, Z-Wave, WiFi, WiMax, 3G/GSM and LET. Figure 3 shows the protocols of communcation networks that utilize at the same time within one grid [19]. As mentioned in section 2, there are two categories: IoT and IIoT. This paper proposed the utilization of both to integrate three different consumer communication networks to the smart grid networks.

Each renewable energy resource is considered as an object and it is assigned a unique IP address. Using bidirectional communication, it becomes possible to monitor each object as control is done via its unique IP address. This eliminates the need for several communication protocols within the same grid.

The IP protocol is utilized using the 6LowPAN communication protocol and it is based the IPv6. 6LoWPAN has a limited frame size of 127 bytes, and it has more space for a payload of 65-75 bytes [14]. Using the 6LowPAN protocol makes the network faster and scalable. The scalability feature allows more devices and appliances to be integrated within the network. For example local batteries storage, home appliances and smart meters can be considered as objects. Each one of these objects will have a unique IP address, and it can be monitored and controlled remotely.

Also, the same can be extended to include other devices of the electricity grid such as circuit breakers, capacitor banks, relays and phase-measurement units.

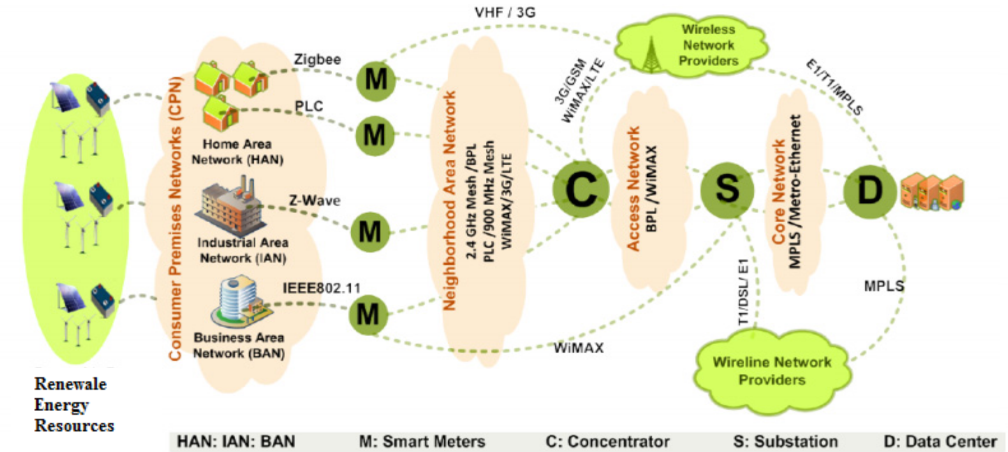

Fig. 3. Consumer communication area networks with multiple protocols. [18]

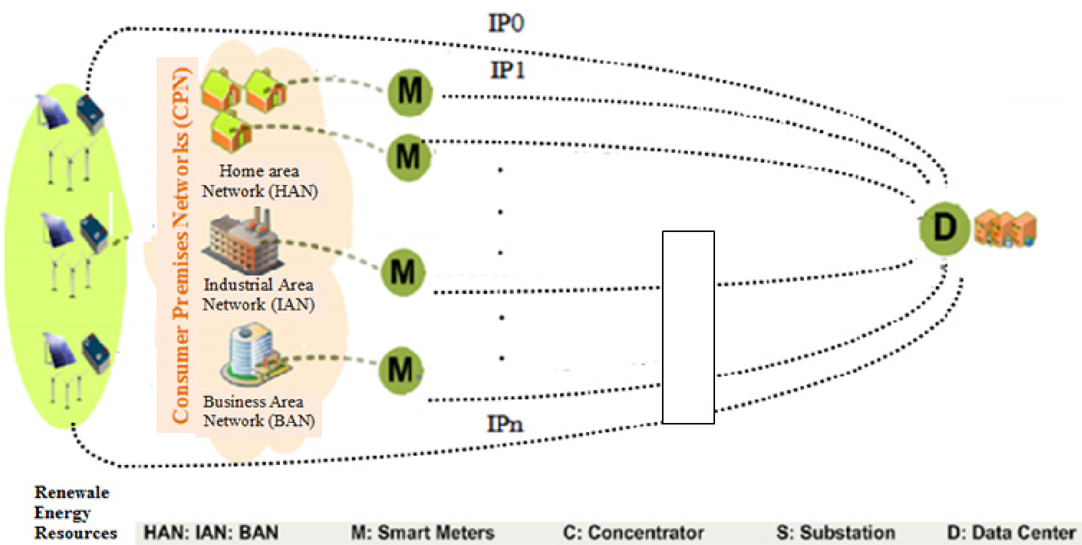

Fig. 4. Proposed Consumer communication area networks with one protocol utilizing the IoT concepts.

Consolation

This paper proposed an IoT/IIoT conceptual model to integrate renewable energy resources sing one common network protocol instead multiple protocols. The advantage of such utilization makes the electricity grid more robust and scalable. This concept can be extended to include not only the consumption domain but also other such as the distributions and generations domains.

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