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Generation energy-efficiency by Smart grid Data centers distributed & ICTs sustainability

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Abstract

Smart grid has modernized the way electricity is generated, transported, distributed, and consumed byintegrating advanced sensing, communications, and control in the day-to-day operation of the grid. Electricity is a coreutility for the functioning of society and for the services provided by information and communication technologies(ICTs). Several concepts of the smart grid, such as dynamic pricing, distributed generation, and demand management,have significantly impacted the operation of ICT services, in particular, communication networks and data centers.Ongoing energy-efficiency and operational expenditures reduction efforts in communication networks and data centershave gained another dimension with those smart grid concepts. In this paper, we provide a comprehensive survey onthe smart grid-driven approaches in energy-efficient communications and data centers, and the interaction betweensmart grid and information and communication infrastructures. Although the studies on smart grid, energy-efficientcommunications, and green data centers have been separately surveyed in previous studies, to this end, research thatfalls in the intersection of those fields has not been properly classified and surveyed yet. We start our survey byproviding background information on the smart grid and continue with surveying smart grid-driven approaches inenergy-efficient communication systems, followed by energy, cost and emission minimizing approaches in datacenters, and the corresponding cloud network infrastructure. Through a communication infrastructure, a smart grid canimprove power reliability and quality to eliminate electricity blackout.

Keywords: Smart grid, Data centers, distributed generation, energy-efficiency, ICTs, sustainability.

1. Introduction

Current energy distribution grid has been in use foralmost a century. The aging of equipment’s and increasingconsumer demands necessitate a revolution in the grid. By 2020,it is foreseen that the energy demand will almost be double thepresent demand. Increases in recent times in electricity costs andin associated emissions of greenhouse gases are having animpact on

societies to adopt business and lifestyle strategiesbased on sustainability practices. The existing electricity grid hasremained unchanged for about 100 years. It lacks the capabilityof providing information and communication. To realize thesecapabilities, a new concept has emerged the smart grid.Wireless Sensor Networks (WSNs) are becoming afundamental tool of the smart grid. Advanced information andcommunication technologies, monitoring and control andinnovative metering technologies via intelligent devices, will
Become increasingly important. The benefits of the smart gridare not limited to the power distributors but reach bothindustrial and residential customers as well. By deploying theproper control mechanisms, the power distributor can savemoney by avoided investments for additional capacity. Theindustrial and residential customers benefit from green, locally produced power and lower energy bills by automated shifting offlexible loads towards cheaper time windows. To enjoy thesebenefits, an integrated network for controlling (distributed)nergy sources is required.The initial concept of SG started with the idea of advancedmetering infrastructure (AMI) with the aim of improvingdemand-side management and energy efficiency, andconstructing self-healing reliable grid protection againstmalicious sabotage and natural disasters [204]. However, newrequirements and demands drove the electricity industries,research organizations, and governments to on advancedelectricity generation, advanced delivery, advanced informationmetering, advanced monitoring, advanced management andadvanced communication technologies. The smart managementsystem is the subsystem in SG that provides advancedmanagement and control services. The smart protection systemis the subsystem in SG that provides advanced grid reliabilityanalysis, failure protection, and security and privacy protectionservices.. Hence, in this paper, first the smart demand responsive energy management system under new comprehensive fieldtests with mesh network design based on AODV for wirelesscommunication is proposed. We present a real-time distributedmulti-agent algorithm for coordinating supply and demand in theresidential power network in an optimal way. An important goalof the algorithm is to improve the local consumption of theenergy produced by solar panels.

2. Related Work& Implementation

Implementation of wireless communications and data centers in connection with the smart grid is illustrated in Fig. 1, including the power flow in the grid. Electricity is transported to the consumers over the transmission and distribution system similar to the legacy grid, while in addition, consumers can become power generators and sell power the grid according to the novel distributed generation practices of the smart grid [1]. In the smart grid, all of the entities are connected through communications. In the figure only wireless technologies are presented but as will be discussed later on in this paper, using optical and wire line communications is also possible. In the figure, data collected from sensors and meters are fed into the utility headquarters and stored in cloud data centers.

2.1 ENERGY-EFFICIENT COMMUNICATIONS AND THE SMART GRID

Energy-efficiency has been an integral part of networks that consist of battery-run nodes such as sensor nodes or mobile phones while energy-efficiency of network equipment powered from mains such as base stations, switches, routers has not been under the spotlight until recently. In parallel to the increasing number of subscribers and their diverse demands, electricity bills of network operators have been skyrocketing. As a result, a significant amount of academic and industry efforts have been put into reducing the energy consumption of core and access network equipment. Along with the traditional electricity costs, large amount of GHG emissions of communication networks is foreseen to add more costs to the operators with the forthcoming carbon taxes and caps. Price-following demand management of smart grid can be employed by the communications infrastructure to reduce electricity bills where this can be also extended to emission-following load management of the equipment. On one side smart grid-driven approaches impact the way energy-efficient communication technologies are implemented, on the other side smart grid involves dense communications and it is impacted from energy-efficiency techniques. This section summarizes the works that study the mutual impacts of smart grid and energy-efficient communications. We have grouped these studies under wireless, wire line and optical networks and for each type of network, we focus on the appropriate smart grid domain.

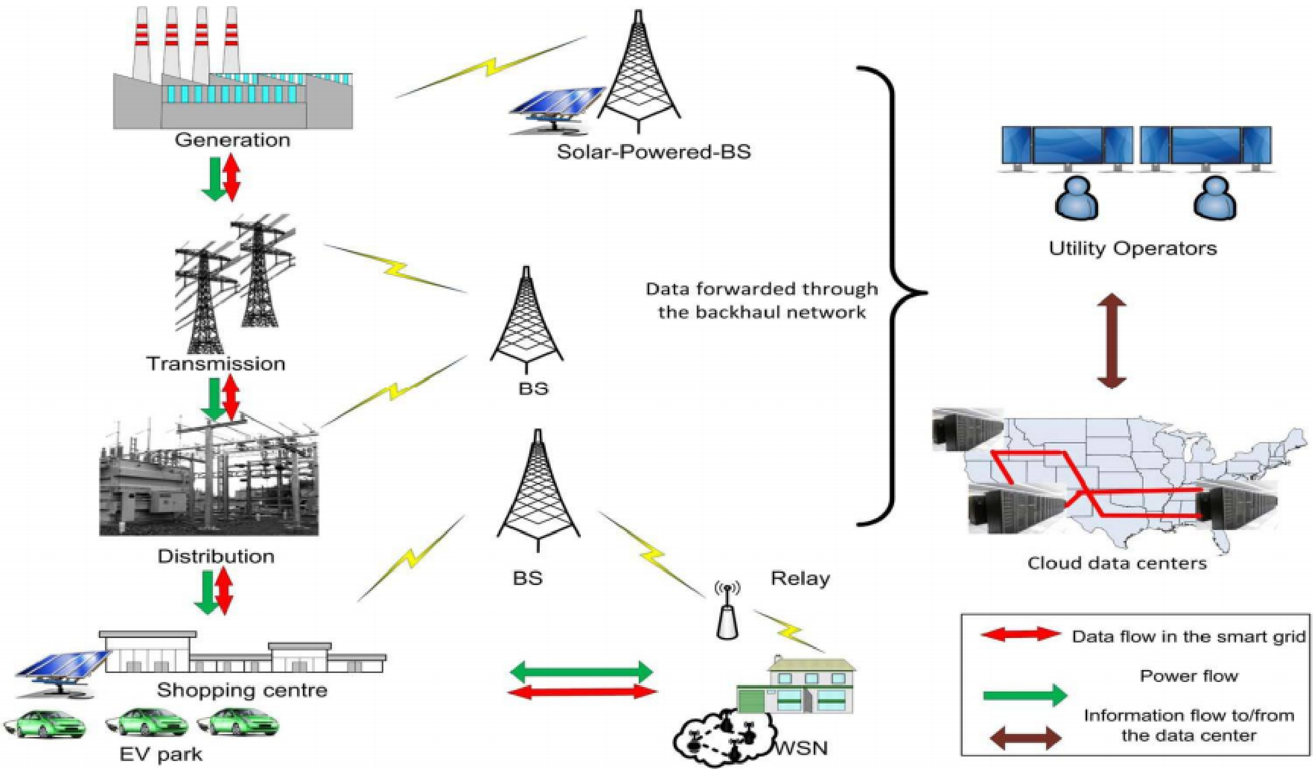

Fig. 1. Smart grid, wireless wide area solutions and Internet data centers.

Energy-efficiency of battery-run, hand-held devices and Wireless Sensor Networks (WSNs) are beyond the scope of this survey since their energy-efficiency aims at increasing the lifetime of the network or the device considering their limited battery power. The smart grid can be roughly divided into three domains in terms of communication coverage and functionality; Smart Grid Home Area Network (SG-HAN), Smart Grid Neighborhood Area Network (SG-NAN) and Smart Grid Wide Area Network (SG-WAN). SG-HAN is a single residential unit with smart appliances, an energy display, power consumption control tools, storage, solar panels, small-scale wind turbines, electric vehicles and a smart meter. A SG-NAN corresponds to a group of houses possibly fed by the same transformer. Advanced Metering Infrastructure (AMI) collects smart grid data from the premises in a SG-NAN and aggregates the meter data before they are sent to SG-WAN which connects SG-NANs to the utility operator. From the utility perspective, besides metering, equipment in the field needs to be monitored and controlled. Hence the equipment in the field are managed by a separate network which is called as Smart Grid Field Area Network (SG-FAN). The geographical scale of

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a SG-FAN is similar to SG-NAN therefore similar communication technologies are applicable for both. These network domains can be implemented using a variety of communication technologies.

3. Experimental Work

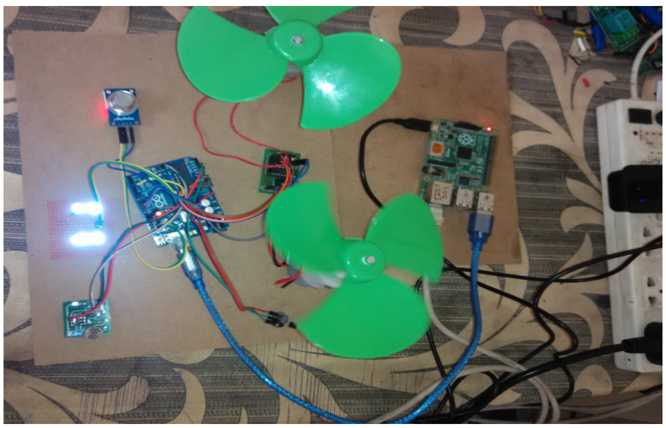

Fig 2: Project with Kit1

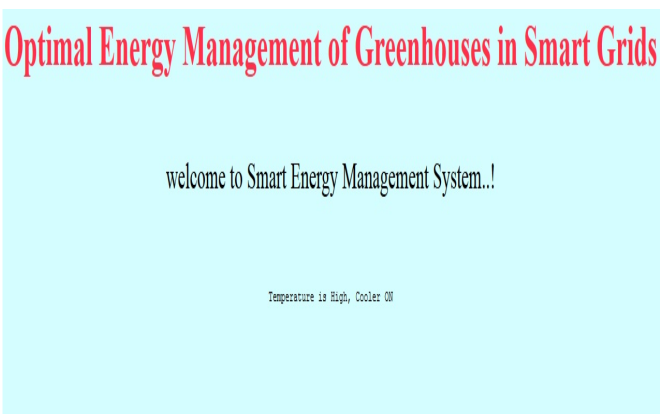

Fig 3: System in web page welcome screen.

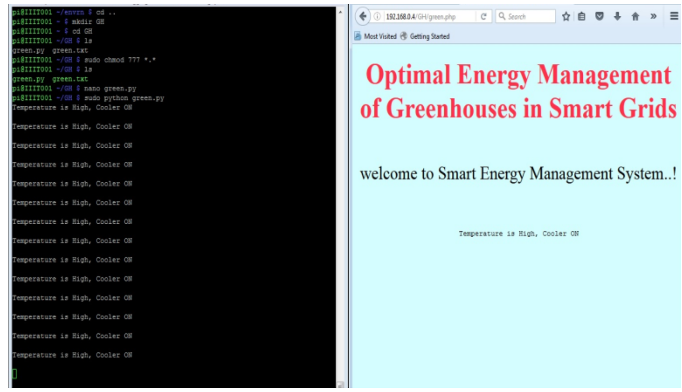

Fig 4: Web Screen with monitoring values.

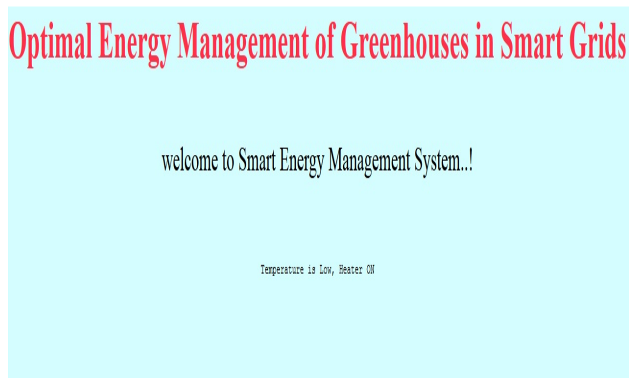

Fig 5: Web Screen 2.

4. Conclusion

In the proposed system, we present the background and motivation for smart grid communication infrastructures. We are going to show that a smart grid built on the technologies of sensing, communications, and control technologies offer a very promising future for utilities and users. We review several industrial trials and summarized the basic requirements of communication infrastructures in smart grid paradigm. Efficiency, reliability and security of interconnected devices and systems are critical to enabling smart grid communication infrastructures. Interoperability must be achieved while avoiding being isolated into noncompetitive technical solutions and the need for wholesale replace of existing power communication systems. Alignment behind technical standards must be balanced with creating an environment that encourages innovation so that the overall communication infrastructure may continue to evolve. Based on the above survey, we can focus on those challenges to smart grid communication infrastructures in both system design and operations to make it more efficient and secure.

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