Algorithmic Approaches for a Dependable Smart Grid

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Abstract We explore options for integrating sustainable and renewable energy into the existing power grid, or even create a new power grid model. We present various theoretical concepts necessary to meet the challenges of a smart grid. We first present a supply and demand model of the smart grid to compute the average number of conventional power generator required to meet demand during the high consumption hours. The model will be developed using Fluid Stochastic Petri Net (FSPN) approach. We propose to model the situations that need decisions to throttle down the energy supplied by the traditional power plants using game-theoretic online competitive models. We also present in this paper the power-down model which has shown to be competitive in the worst case scenarios and we lay down the ground work for addressing the multi-state dynamic power management problem.

Keywords Power grid · Renewable energy · Sustainable energy · Petri nets · Power down problem · Online algorithm · Competitive analysis

1 Introduction

The electricity grid is said to be the most challenging engineering endeavor in human history. Electric power is the driving engine of our society. With the shift

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towards renewable energy sources, such as biomass, wind, and solar on the power supply side and smart appliances and electric vehicles on the load side, there are enormous challenges in designing a reliable, effective and secure power infrastructure. The existing grid is primarily an open loop system designed to support only one-way dependable flow of electrical power supplied by conventional fossil, hydro and nuclear power plants. Tremendous transformations in information technology benefiting sectors such as industrial automation, health, finance, and communication, support the need for a radically different grid, which manages variable and distributed supply and demand from large battery storage systems, web-enabled appliances or electrical vehicles. There is a pressing need for new models, algorithmic techniques, and appropriate security designs such that the new grid can take advantage of technological advances.

A smart grid will incorporate sustainable energy sources to reduce the dependence on conventional power generation sources. The smart grid initiative seeks to augment the existing power grid by integrating sustainable and renewable power sources on the supply side, EVs, smart buildings and smart appliances on the demand side and extensive use of available information and communication technologies. Whereas, the existing grid has focused only on the unidirectional flow of electricity from the suppliers to the consumers, the goal of the smart grid is to introduce environmental friendliness and high degree automation through bidirectional flow of electricity and information as shown in the conceptual diagram of smart grid (Fig. 1).

National energy policy mandates 40% increase in the current installed renewable bulk wind energy and solar photo-voltaic (SPV). Both these sources of energy are geographically distributed. In addition, homes are increasingly

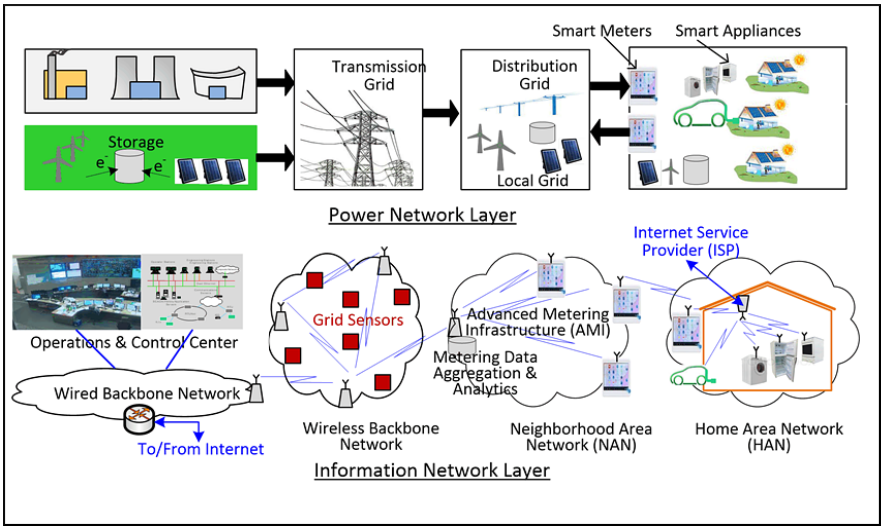

Fig. 1 Smart Grid Power and Information Flow Layers