Communication Networks For Smart Grids Making Smart Grid Real Computer Communications And Networks

This book presents an application-centric approach to the development of smart grid communication architecture. The coverage includes in-depth reviews of such cutting-edge applications as advanced metering infrastructure, distribution automation, demand response and synchrophasors. Features: examines a range of exciting utility applications made possible through smart grid evolution; describes the core-edge network architecture for smart grids, introducing the concept of WANs and FANs; explains how the network design paradigm for smart grids differs from that for more established data networks, and discusses network security in smart grids; provides an overview of communication network technologies for WANs and FANs, covering OPGW, PLC, and LTE and MPLS technology; investigates secure data-centric data management and data analytics for smart grids; discusses the transformation of a network from conventional modes of utility operation to an integrated network based on the smart grid architecture framework.

Stability is a critical concern in the design and maintenance of power systems. Different approaches have been proposed for the analysis of power grid stability in various scenarios depending on small or large perturbations and the speed of the phenomenon of interest. In this work, we consider the power grid as a group of flocking birds, as synchronization is the key issue in both contexts. The framework of partial difference equation (PdE) is used to analyze the system stability, when designing the communication network of the power grid network for conveying measurements between different power stations. Both the cases where communication network delay is negligible and non-negligible are studied here. The communication network design problem is formulated as an optimization problem under the consideration of a stable power grid. Corresponding optimization algorithms are designed to solve the problem. To convey measurements of the power network, wireless sensor networks is adopted, for its non-invasive and easy deployment properties. Periodic sleep scheduling is adopted to effectively save energy for the wireless sensor networks. To provide a controllable end-to-end delay for the communication networks, a dynamic duty cycle control approach is designed, featuring a single-hop delay controller based on the well known feedback control theory. The delay control approach also features a queuing delay adaptation scheme that adapts the duty cycle of each node to unpredictable packet rates, as well as a novel energy balancing approach that extends the network lifetime by dynamically adjusting the delay requirement allocated to each hop.

This comprehensive new resource demonstrates how to build smart grids utilizing the latest telecommunications technologies. Readers find practical coverage of PLC and wireless for smart grid and are given concise excerpts of the different technologies, networks, and services around it. Design and planning guidelines are shown through the combination of electricity grid and telecommunications technologies that support the reliability, performance and security requirements needed in smart grid applications. This book covers a wide range of critical topics, including telecommunications for power engineers, power engineering for telecommunications engineers, utility applications projecting in smart grids, technologies for smart grid networks, and telecommunications architecture. This practical reference is supported with in-depth case studies.

This brief focuses on the current research on security and privacy preservation in smart grids. Along with a review of the existing works, this brief includes fundamental system models, possible frameworks, useful performance, and future research directions. It explores privacy preservation demand response with adaptive key evolution, secure and efficient Merkle tree based authentication, and fine-grained keywords comparison in the smart grid auction market. By examining the current and potential security and privacy threats, the author equips readers to understand the developing issues in smart grids. The brief is designed for researchers and professionals working with computer communication networks and smart grids. Graduate students interested in networks and communication engineering will also find the brief an essential resource.

Presenting the work of prominent researchers working on smart grids and related fields around the world, Security and Privacy in Smart Grids identifies state-of-the-art approaches and novel technologies for smart grid communication and security. It investigates the fundamental aspects and applications of smart grid security and privacy and reports on the latest advances in the range of related areas—making it an ideal reference for students, researchers, and engineers in these fields. The book explains grid security development and deployment and introduces novel approaches for securing today’s smart grids. Supplying an overview of recommendations for a technical smart grid infrastructure, the book describes how to minimize power consumption and utility expenditure in data centers. It also: Details the challenges of cybersecurity for smart grid communication infrastructures Covers the regulations and standards relevant to smart grid security Explains how to conduct vulnerability assessments for substation automation systems Considers smart grid automation, SCADA system security, and smart grid security in the last mile The book’s chapters work together to provide you with a framework for implementing effective security through this growing system. Numerous figures, illustrations, graphs, and charts are included to aid in comprehension. With coverage that includes direct attacks, smart meters, and attacks via networks, this versatile reference presents actionable suggestions you can put to use immediately to prevent such attacks.

Although the information and communication technology (ICT) industry accounted for only 2 percent of global greenhouse gas emissions in 2007, the explosive increase in data traffic brought about by a rapidly growing user base of more than a billion wireless subscribers is expected to nearly double that number by 2020. It is clear that now is the time to rethink how we design and build our networks. Green Networking and Communications: ICT for Sustainability brings together leading academic and industrial researchers from around the world to discuss emerging developments in energy-efficient networking and communications. It covers the spectrum of research subjects, including methodologies and architectures for energy efficiency, energy-efficient protocols and networks, energy management, smart grid communications, and communication technologies for green solutions. Examines foraging-inspired radio-communication energy management for green multi-radio networks Considers a cross-layer approach to the design of energy-efficient wireless access networks Investigates the interplay between cooperative device-to-device communications and green LTE cellular networks Considers smart grid energy procurement for green LTE cellular networks Details smart grid networking protocols and standards Considering the spectrum of energy-efficient network components and approaches for reducing power consumption, the book is organized into three sections: Energy Efficiency and Management in Wireless Networks, Cellular Networks, and Smart Grids. It addresses many open research challenges regarding energy efficiency for IT and for wireless sensor networks, including mobile and wireless access networks, broadband access

networks, home networks, vehicular networks, intelligent future wireless networks, and smart grids. It also examines emerging standards for energy-efficient protocols. Since ICT technologies touch on nearly all sectors of the economy, the concepts presented in this text offer you the opportunity to make a substantial contribution to the reduction of global greenhouse gas emissions.

This 2-volume set constitutes the thoroughly refereed post-conference proceedings of the 10th International Conference on Security and Privacy in Communication Networks, SecureComm 2014, held in Beijing, China, in September 2014. The 27 regular and 17 short papers presented were carefully reviewed. It also presents 22 papers accepted for four workshops (ATCS, SSS, SLSS, DAPRO) in conjunction with the conference, 6 doctoral symposium papers and 8 poster papers. The papers are grouped in the following topics: security and privacy in wired, wireless, mobile, hybrid, sensor, ad hoc networks; network intrusion detection and prevention, firewalls, packet filters; malware, and distributed denial of service; communication privacy and anonymity; network and internet forensics techniques; public key infrastructures, key management, credential management; secure routing, naming/addressing, network management; security and privacy in pervasive and ubiquitous computing; security & privacy for emerging technologies: VoIP, peer-to-peer and overlay network systems; security & isolation in data center networks; security & isolation in software defined networking.

Power systems are increasingly collecting large amounts of data due to the expansion of the Internet of Things into power grids. In a smart grids scenario, a huge number of intelligent devices will be connected with almost no human intervention characterizing a machine-to-machine scenario, which is one of the pillars of the Internet of Things. The book characterizes and evaluates how the emerging growth of data in communications networks applied to smart grids will impact the grid efficiency and reliability. Additionally, this book discusses the various security concerns that become manifest with Big Data and expanded communications in power grids. Provide a general description and definition of big data, which has been gaining significant attention in the research community. Introduces a comprehensive overview of big data optimization methods in power system. Reviews the communication devices used in critical infrastructure, especially power systems; security methods available to vet the identity of devices; and general security threats in CI networks. Presents applications in power systems, such as power flow and protection. Reviews electricity theft concerns and the wide variety of data-driven techniques and applications developed for electricity theft detection.

This one-stop reference provides the state-of-the-art theory, key strategies, protocols, deployment aspects, standardization activities and experimental studies of communication and networking technologies for the smart grid. Expert authors provide all the essential information researchers need to progress in the field and to allow power systems engineers to optimize their communication systems.

Smart grid is the integration of renewable energy resources, and information and communication technologies into the electricity grid to achieve a reliable, costefficient, sustainable, and environment-friendly power grid. Nevertheless, the inherent intermittency of renewable energy resources poses serious challenges to the reliability of the power grid. In addition, smart grid requires a robust, reliable, efficient, and cost-effective communication network that meets its performance requirements. Finally, smart grid is a complex system that comprises components from both the power grid and communication networks. To understand the behavior of such a complex system, interactions and reciprocal effects between these components need to be fully investigated. There is, therefore, a need for research to: first, investigate the impact of massive integration of distributed energy resources to the grid and develop control mechanisms to mitigate their intermittency; second, to evaluate the performance of communication network protocols consistently with smart grid requirements; and finally to develop system-level modeling and simulation tools to study the interaction between the power grid and the communication network, and the effectiveness of smart grid applications. This dissertation aims to address these challenges through a comprehensive simulation-driven study of the smart grid. For the integration of renewable energy resources, we designed scenarios for different integration schemes, and propose a control mechanism to mitigate their variability. Through simulation experiments/ studies, we conducted a performance evaluation of these scenarios and validate the effectiveness of our control mechanism. For the communication network, we designed a network model and scenarios based on smart grid use cases. We then systematically compared the effectiveness of two representative wireless mesh network protocols- HWMP and AODV Protocols, and investigated the performance of WIMAX technology in smart grid communication networks with different modulation techniques. Finally, we designed a framework to explore co-simulation scenarios. Using the demand response and energy price as examples of smart grid applications and operating the communication network under various conditions, we implemented these scenarios and conducted a performance evaluation of smart grid applications by leveraging a co-simulation platform.

The "smart grid" generally refers to a class of digital technology that allows for two-way communication between the electric power utility and its customers, as well as sensing along the transmission and distribution lines. Smart grids offer many benefits to utilities and consumers - mostly seen as large improvements in energy efficiency on the electricity grid and in homes and offices. Little is known about how different communication architectures compare, what data carrying capacities they offer, and how to solve data collection and management problems that may arise. This dissertation specifically focuses on these challenges from the perspective of the power distribution network. In the first part of this work, possible communications technologies for the power distribution level are suggested and compared, and a wireless mesh network architecture proposed and shown to meet the communication requirements of the power distribution system. In the second part of this dissertation, a linear chain multi-hop wireless communication architecture is proposed and shown through analysis and simulations to meet application requirements in terms of data-carrying capacity. Finally, in the last part of this dissertation, the looming issue of how to communicate and handle consumer data collected by electric utilities and manage available communication network resources is considered.

Smart grids can be described as a new generation of smart power networks that integrate actions coming from all connected end-users. This infrastructure provides bidirectional communications between end-users and the grid operator, and therefore extends the attack surface against the power system. However, one point that has been

constantly overlooked and has not received the attention it deserves concerns the interdependencies and communications between all the assets that make up the new power grids. These interdependencies in communications are a fundamental pillar, as they represent the means by which all devices communicate within the smart grid network. Information transmitted through these intercommunications contains not only customer and consumption data; but also status checks, instructions to execute, orders for devices to redirect power flow, etc. Therefore, their protection is essential to protect the privacy of the customers and prevent attacks which could cause blackouts, power overloads, device malfunctions, data tampering, or even catastrophic cascading effects that could bring down the power grid itself in more than one country. For this purpose, this study focuses on the evaluation of these interdependencies, and their architectures and connections in order to determine their importance, threats, risks, mitigation factors and possible security measures to implement. To obtain this information, experts in the fields and areas related directly with smart grids were contacted to gather their know-how and expertise.

Smart Grid: Networking, Data Management, and Business Models delivers a comprehensive overview of smart grid communications, discussing the latest advances in the technology, the related cyber security issues, and the best ways to manage user demand and pricing. Comprised of 16 chapters authored by world-renowned experts, this book: Considers the use of cognitive radio and software-defined networking in the smart grid Explores the space of attacks in the energy management process, the need for a smart grid simulator, and the management issues that arise around smart cities Describes a real-time pricing scheme that aims to reduce the peak-to-average load ratio Explains how to realize low-carbon economies and the green smart grid through the pervasive management of demand Presents cutting-edge research on microgrids, electric vehicles, and energy trading in the smart grid Thus, Smart Grid: Networking, Data Management, and Business Models provides a valuable reference for utility operators, telecom operators, communications engineers, power engineers, electric vehicle original equipment manufacturers (OEMs), electric vehicle service providers, university professors, researchers, and students.

This SpringerBrief discusses the rise of the smart grid from the perspective of computing and communications. It explains how current and next-generation network technology and methodologies help recognize the potential that the smart grid initiative promises. Chapters provide context on the smart grid before exploring specific challenges related to communication control and energy management. Topics include control in heterogeneous power supply, solutions for backhaul and wide area networks, home energy management systems, and technologies for smart energy management systems. Designed for researchers and professionals working on the smart grid, Communication Challenges and Solutions in the Smart Grid offers context and applications for the common issues of this developing technology. Advanced-level students interested in networking and communications engineering will also find the brief valuable.

Resource allocation is an important issue in wireless communication networks. In recent decades, cognitive radio-based networks have garnered increased attention and have been well studied to overcome the problem of spectrum scarcity in future wireless communications systems. Many new challenges in resource allocation appear in cognitive radio-based networks. This book focuses on effective resource allocation solutions in several important cognitive radio-based networks, including opportunistic spectrum access networks, cooperative sensing networks, cellular networks, high-speed vehicle networks, and smart grids. Cognitive radio networks are composed of cognitive, spectrum-agile devices capable of changing their configuration on the fly based on the spectral environment. This capability makes it possible to design flexible and dynamic spectrum access strategies with the purpose of opportunistically reusing portions of the spectrum temporarily vacated by licensed primary users. Different cognitive radio-based networks focus on different network resources, such as transmission slots, sensing nodes, transmission power, white space, and sensing channels. This book introduces several innovative resource allocation schemes for different cognitive radio-based networks according to their network characteristics: Opportunistic spectrum access networks – Introduces a probabilistic slot allocation scheme to effectively allocate the transmission slots to secondary users to maximize throughput Cooperative sensing networks – Introduces a new adaptive collaboration sensing scheme in which the resources of secondary users are effectively utilized to sense the channels for efficient acquisition of spectrum opportunities Cellular networks – Introduces a framework of cognitive radio-assisted cooperation for downlink transmissions to allocate transmission modes, relay stations, and transmission power/sub-channels to secondary users to maximize throughput High-speed vehicle networks – Introduces schemes to maximize the utilized TV white space through effective allocation of white space resources to secondary users Smart grids – Introduces effective sensing channel allocation strategies for acquiring enough available spectrum channels for communications between utility and electricity consumers

Data science, data engineering and knowledge engineering requires networking and communication as a backbone and have wide scope of implementation in engineering sciences. Keeping this ideology in preference, this book includes the insights that reflect the advances in these fields from upcoming researchers and leading academicians across the globe. It contains high-quality peer-reviewed papers of ‘International Conference on Recent Advancement in Computer, Communication and Computational Sciences (ICRACCCS 2016)’, held at Janardan Rai Nagar Rajasthan Vidyapeeth University, Udaipur, India, during 25–26 November 2016. The volume covers variety of topics such as Advanced Communication Networks, Artificial Intelligence and Evolutionary Algorithms, Advanced Software Engineering and Cloud Computing, Image Processing and Computer Vision, and Security. The book will help the perspective readers from computer industry and academia to derive the advances of next generation communication and computational technology and shape them into real life applications.

This book constitutes the refereed proceedings of the Third EAI International Conference on Smart Grid and Internet of Things, SGIoT 2019, held in TaiChung, Taiwan, in November 2019. The 10 papers presented were carefully reviewed and selected from 22 submissions and present results on how to achieve more efficient use of resources based largely

on the IoT-based machine-to-machine (M2M) interactions of millions of smart meters and sensors in the smart grid specific communication networks such as home area networks, building area networks, and neighborhood area networks. The smart grid also encompasses IoT technologies, which monitor transmission lines, manage substations, integrate renewable energy generation. Through these technologies, the authorities can smartly identify outage problems, and intelligently schedule the power generation and delivery to the customers. Furthermore, the smart grid should teach us a valuable lesson that security must be designed in from the start of any IoT deployment.

This SpringerBrief explores the opportunities and challenges posed by the smart grid. The evolution of the smart grid should allow consumers to directly communicate with their utility provider. However, complex issues such as architecture with legacy support, varying demand response and load management, varying price of power, and so forth can lead to various decision making challenges. It is essential to identify the scope and challenges of the smart grid in a comprehensive manner so as to ensure efficient delivery of sustainable, economic, and secure electricity supplies. This book provides an overview of the smart grid and its key advances in architecture, distribution management, demand-side response and load balancing, smart automation, electric storage, power loss minimization and security. Readers interested in a basic knowledge of electric grid and communication networks will find Evolution of Smart Grids useful. Readers who want more insight on smart grid research will also find this book a valuable resource.

Smart technology has significantly enhanced the efficient management of electric power supply systems. Despite the benefits of these advances, the complexity of such systems has proven to be difficult for testing purposes. Smart Grid Test Bed Using OPNET and Power Line Communication presents an innovative perspective on the design, development, and implementation of an expandable test bed for smart grid applications. Highlighting pertinent topics such as intrusion detection, user interface, and performance evaluation, this book is an ideal reference source for researchers, academics, engineers, students, and professionals interested in the latest advancements for smart grid technologies.

This SpringerBrief addresses the main security concerns for smart grid, e.g., the privacy of electricity consumers, the exchanged messages integrity and confidentiality, the authenticity of participated parties, and the false data injection attacks. Moreover, the authors demonstrate in detail the various proposed techniques to secure the smart grid’s different communication networks and preserve the privacy of the involved. Over many years, power grid has generated electricity from central generators and distributed it in one direction from the generation stations to end-users; also, information is one directional so that the grid’s control center doesn’t get enough information about customers’ requirements and consequently can’t prevent electricity losses. So, the electricity grid is merged with information and communication technology to form smart grid. The main target of this incorporation is to connect different parties of power grid to exchange information about grid conditions and customers’ requirements, and consequently, improve the reliability and efficiency of electricity generation and distribution. That upgrade of the power grid exposes it to the cyber security threats that the communication networks suffer from, such as malicious attacks to forge the electricity consumption readings or price, extract personal information for residential consumers, such as daily habits and life style, or attack some grid’s resources and equipment availability using denial-of-service attacks. Also, novel threats are introduced in smart grid due to the power grid nature, such as false data injection attack, in which the adversary compromises several measurement units and injects false information about the grid conditions that mislead the grid’s control center to make wrong decisions for the grid and consequently impact on its stability and efficiency.

Advances in Smart Grid Power System: Network, Control and Security discusses real world problems, solutions, and best practices in related fields. The book includes executable plans for smart grid systems, their network communications, tactics on protecting information, and response plans for cyber incidents. Moreover, it enables researchers and energy professionals to understand the future of energy delivery systems and security. Covering fundamental theory, mathematical formulations, practical implementations, and experimental testing procedures, this book gives readers invaluable insights into the field of power systems, their quality and reliability, their impact, and their importance in cybersecurity. Includes supporting illustrations and tables along with valuable end of chapter reference sets Provides a working guideline for the design and analysis of smart grids and their applications Features experimental testing procedures in smart grid power systems, communication networks, reliability, and cybersecurity

Appropriate for researchers, practitioners, and students alike, Communication and Networking in Smart Grids presents state-of-the-art approaches and novel technologies for communication networks in smart grids. It explains how contemporary grid networks are developed and deployed and presents a collection of cutting-edge advances to help improve current practice. Prominent researchers working on smart grids and in related fields around the world explain the fundamental aspects and applications of smart grids. Describing the role that communication and networking will play in future smart grids, they examine power delivery and the complete range of features and services available through smart grids. The book is divided into two parts: Smart Grids in General and Communications and Networks in Smart Grids. Its comprehensive coverage includes: Management of locally generated powers in micro grids Multi-perspective service management in virtual power plants Distributed algorithms for demand management and grid stability in smart grids Electric distribution grid optimizations for plug-in electric vehicles Communication technologies, networks, and strategies for practical smart grid deployments—from substations to meters Ontology-based resource description and discovery framework for low Carbon grid networks QoS in networking for smart grids Outlining an optimum method for the design of distributed electric power supply and communication networks, the book reports on key ICT system engineering trends for regional energy marketplaces supporting electric mobility. It considers the spectrum of related topics in communication, IT, and security to provide you with the understanding needed to participate in the development, design, and implementation of future smart grid communications and networks.

Efficient transmission and distribution of electricity is a fundamental requirement for sustainable development and

prosperity. The world is facing great challenges regarding the reliable grid integration of renewable energy sources in the 21st century. The electric power systems of the future require fundamental innovations and enhancements to meet these challenges. The European Union’s “Smart Grid” vision provides a first overview of the appropriate deep-paradigm changes in the transmission, distribution and supply of electricity. The book brings together common themes beginning with Smart Grids and the characteristics of new power plants based on renewable energy and /or highly efficient generation principles. It covers the advanced technologies applied today in the transmission and distribution networks and innovative solutions for maintaining today’s high power quality under the challenging conditions of large-scale shares of volatile renewable energy sources in the annual energy balance. Besides considering the new primary and secondary technology solutions and control facilities for the transmission and distribution networks, prospective market conditions allowing network operators and the network users to gain benefits are also discussed. The growing role of information and communication technologies is investigated. The importance of new standards is underlined and the current international efforts in developing a consistent set of standards are described in detail. The presentation of international experiences to apply novel Smart Grid solutions to the practice of network operation concludes this book. The authors of the book worked for many years to develop Smart Grid solutions within national and international projects and to introduce them in the practice of network operations.

This book bridges the divide between the fields of power systems engineering and computer communication through the new field of power system information theory. Written by an expert with vast experience in the field, this book explores the smart grid from generation to consumption, both as it is planned today and how it will evolve tomorrow. The book focuses upon what differentiates the smart grid from the "traditional" power grid as it has been known for the last century. Furthermore, the author provides the reader with a fundamental understanding of both power systems and communication networking. It shows the complexity and operational requirements of the evolving power grid, the so-called "smart grid," to the communication networking engineer; and similarly, it shows the complexity and operational requirements for communications to the power systems engineer. The book is divided into three parts. Part One discusses the basic operation of the electric power grid, covering fundamental knowledge that is assumed in Parts Two and Three. Part Two introduces communications and networking, which are critical enablers for the smart grid. It also considers how communication and networking will evolve as technology develops. This lays the foundation for Part Three, which utilizes communication within the power grid. Part Three draws heavily upon both the embedded intelligence within the power grid and current research, anticipating how and where computational intelligence will be implemented within the smart grid. Each part is divided into chapters and each chapter has a set of questions useful for exercising the readers' understanding of the material in that chapter. Key Features: Bridges the gap between power systems and communications experts Addresses the smart grid from generation to consumption, both as it is planned today and how it will likely evolve tomorrow Explores the smart grid from the perspective of traditional power systems as well as from communications Discusses power systems, communications, and machine learning that all define the smart grid It introduces the new field of power system information theory

With the increasing worldwide trend in population migration into urban centers, we are beginning to see the emergence of the kinds of mega-cities which were once the stuff of science fiction. It is clear to most urban planners and developers that accommodating the needs of the tens of millions of inhabitants of those megalopolises in an orderly and uninterrupted manner will require the seamless integration of and real-time monitoring and response services for public utilities and transportation systems. Part speculative look into the future of the world’s urban centers, part technical blueprint, this visionary book helps lay the groundwork for the communication networks and services on which tomorrow’s “smart cities” will run. Written by a uniquely well-qualified author team, this book provides detailed insights into the technical requirements for the wireless sensor and actuator networks required to make smart cities a reality.

Appropriate for researchers, practitioners, and students alike, Communication and Networking in Smart Grids presents state-of-the-art approaches and novel technologies for communication networks in smart grids. It explains how contemporary grid networks are developed and deployed and presents a collection of cutting-edge advances to help improve cu

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Electric power systems are being transformed from older grid systems to smart grids across the globe. The goals of this transition are to address today’s electric power issues, which include reducing carbon footprints, finding alternate sources of decaying fossil fuels, eradicating losses that occur in the current available systems, and introducing the latest information and communication technologies (ICT) for electric grids. The development of smart grid technology is advancing dramatically along with and in reaction to the continued growth of renewable energy technologies (especially wind and solar power), the growing popularity of electric vehicles, and the continuing huge demand for electricity. Smart Grid Systems: Modeling and Control advances the basic understanding of smart grids and focuses on recent technological advancements in the field. This book provides a comprehensive discussion from a number of experts and practitioners and describes the challenges and the future scope of the technologies related to smart grid. Key features: provides an overview of the smart grid, with its needs, benefits, challenges, existing structure, and possible future technologies discusses solar photovoltaic (PV) system modeling and control along with battery storage, an integral part of smart grids discusses control strategies for renewable energy systems, including solar PV, wind, and hybrid systems describes the inverter topologies adopted for integrating renewable power covers the basics of the energy storage system and the need for micro grids describes forecast techniques for renewable energy systems presents the basics and structure of the energy management system in smart grids, including advanced metering, various communication protocols, and the cyber security challenges explores electric vehicle technology and its interaction with smart grids

For many, smart grids are the biggest technological revolutionsince the Internet. They have the potential to reduce carbondioxide emissions, increase the reliability of electricity supply,and increase the efficiency of our energy infrastructure. Smart Grid Applications, Communications, and Securityexplains how diverse technologies play hand-in-hand in building andmaintaining smart grids around the globe. The book delves into thecommunication aspects of smart grids, provides incredible insightinto power

electronics, sensing, monitoring, and controltechnologies, and points out the potential for new technologies andmarkets. Extensively cross-referenced, the book contains comprehensivecoverage in four major parts: Part I: Applications provides a detailedintroduction to smart grid applications—spanning thetransmission, distribution, and consumer side of the electricitygrid Part II: Communications discusses wireless,wireline, and optical communication solutions—from thephysical layers up to sensing, automation, and control protocolsrunning on the application layers Part III: Security deals with cybersecurity—sharpening the awareness of security threats,reviewing the ongoing standardization, and outlining the future ofauthentication and encryption key management Part IV: Case Studies and Field Trials presentsself-contained chapters of studies where the smart grid of tomorrowhas already been put into practice With contributions from majorindustry stakeholders such as Siemens, Cisco, ABB, and Motorola,this is the ideal book for both engineering professionals andstudents.

Discusses concepts of smart grid technologies, from the perspective of integration with cloud computing and data management approaches.

Cyber physical systems emerge when physical systems are integrated with communication networks. In particular, communication networks facilitate dissemination of data among components of physical systems to meet key requirements, such as efficiency and reliability, in achieving an objective. In this dissertation, we consider one of the most important cyber physical systems: the smart grid. The North American Electric Reliability Corporation (NERC) envisions a smart grid that aggressively explores advance communication network solutions to facilitate real-time monitoring and dynamic control of the bulk electric power system. At the distribution level, the smart grid integrates renewable generation and energy storage mechanisms to improve reliability of the grid. Furthermore, dynamic pricing and demand management provide customers an avenue to interact with the power system to determine electricity usage that satisfies their lifestyle. At the transmission level, efficient communication and a highly automated architecture provide visibility in the power system; hence, faults are mitigated faster than they can propagate. However, higher levels of reliability and efficiency rely on the supporting physical communication infrastructure and the network technologies employed. Conventionally, the topology of the communication network tends to be identical to that of the power network. In this dissertation, however, we employ a Demand Response (DR) application to illustrate that a topology that may be ideal for the power network may not necessarily be ideal for the communication network. To develop this illustration, we realize that communication network issues, such as congestion, are addressed by protocols, middle-ware, and software mechanisms. Additionally, a network whose physical topology is designed to avoid congestion realizes an even higher level of performance. For this reason, characterizing the communication infrastructure of smart grids provides mechanisms to improve performance while minimizing cost. Most recently, algebraic connectivity has been used in the ongoing research effort characterizing the robustness of networks to failures and attacks. Therefore, we first derive analytical methods for increasing algebraic connectivity and validate these methods numerically. Secondly, we investigate impact on the topology and traffic characteristics as algebraic connectivity is increased. Finally, we construct a DR application to demonstrate how concepts from graph theory can dramatically improve the performance of a communication network. With a hybrid simulation of both power and communication network, we illustrate that a topology which may be ideal for the power network may not necessarily be ideal for the communication network. To date, utility companies are embracing network technologies such as Multiprotocol Label Switching (MPLS) because of the available support for legacy devices, traffic engineering, and virtual private networks (VPNs) which are essential to the functioning of the smart grid. Furthermore, this particular network technology meets the requirement of non-routability as stipulated by NERC, but these benefits are costly for the infrastructure that supports the full MPLS specification. More importantly, with MPLS routing and other switching technologies, innovation is restricted to the features provided by the equipment. In particular, no practical method exists for utility consultants or researchers to test new ideas, such as alternatives to IP or MPLS, on a realistic scale in order to obtain the experience and confidence necessary for real-world deployments. As a result, novel ideas remain untested. On the contrary, OpenFlow, which has gained support from network providers such as Microsoft and Google and equipment vendors such as NEC and Cisco, provides the programmability and flexibility necessary to enable innovation in next-generation communication architectures for the smart grid. This level of flexibility allows OpenFlow to provide all features of MPLS and allows OpenFlow devices to co-exist with existing MPLS devices. Therefore, in this dissertation we explore a low-cost OpenFlow Software Defined Networking solution and compare its performance to that of MPLS. In summary, we develop methods for designing robust networks and evaluate software defined networking for communication and control in cyber physical systems where the smart grid is the system under consideration.

A comprehensive resource that covers all the key areas of smart grid communication infrastructures Smart grid is a transformational upgrade to the traditional power grid that adds communication capabilities, intelligence and modern control. Smart Grid Communication Infrastructures is a comprehensive guide that addresses communication infrastructures, related applications and other issues related to the smart grid. The text shows how smart grid departs from the traditional power grid technology. Fundamentally, smart grid has advanced communication infrastructures to achieve two-way information exchange between service providers and customers. Grid operations in smart grid have proven to be more efficient and more secure because of the communication infrastructures and modern control. Smart Grid Communication Infrastructures examines and summarizes the recent advances in smart grid communications, big data analytics and network security. The authors – noted experts in the field – review the technologies, applications and issues in smart grid communication infrastructure. This important resource: Offers a comprehensive review of all areas of smart grid communication infrastructures Includes an ICT framework for smart grid Contains a review of self-sustaining wireless neighborhood that are network designed Presents design and analysis of a wireless monitoring network for transmission lines in smart grid Written for graduate students, professors, researchers, scientists, practitioners and engineers, Smart Grid Communication Infrastructures is the comprehensive resource that explores all aspects of the topic.

This book covers the recent research advancements in the area of charging strategies that can be employed to accommodate the anticipated high deployment of Plug-in Electric Vehicles (PEVs) in smart grids. Recent literature has focused on various potential issues of uncoordinated charging of PEVs and methods of overcoming such challenges. After an introduction to charging coordination paradigms of PEVs, this book will present various ways the coordinated control can be accomplished. These innovative approaches include hierarchical coordinated control, model predictive control, optimal control strategies to minimize load variance, smart PEV load management based on load forecasting, integrating renewable energy sources such as photovoltaic arrays to supplement grid power, using wireless communication networks to coordinate the charging load of a smart grid and using market price of electricity and customers payment to coordinate the charging load. Hence, this book proposes many

new strategies proposed recently by the researchers around the world to address the issues related to coordination of charging load of PEVs in a future smart grid.

This brief presents a comprehensive review of the network architecture and communication technologies of the smart grid communication network (SGCN). It then studies the strengths, weaknesses and applications of two promising wireless mesh routing protocols that could be used to implement the SGCN. Packet transmission reliability, latency and robustness of these two protocols are evaluated and compared by simulations in various practical SGCN scenarios. Finally, technical challenges and open research opportunities of the SGCN are addressed. Wireless Communications Networks for Smart Grid provides communication network architects and engineers with valuable proven suggestions to successfully implement the SGCN. Advanced-level students studying computer science or electrical engineering will also find the content helpful.

The book presents a broad overview of emerging smart grid technologies and communication systems, offering a helpful guide for future research in the field of electrical engineering and communication engineering. It explores recent advances in several computing technologies and their performance evaluation, and addresses a wide range of topics, such as the essentials of smart grids for fifth generation (5G) communication systems. It also elaborates the role of emerging communication systems such as 5G, internet of things (IoT), IEEE 802.15.4 and cognitive radio networks in smart grids. The book includes detailed surveys and case studies on current trends in smart grid systems and communications for smart metering and monitoring, smart grid energy storage systems, modulations and waveforms for 5G networks. As such, it will be of interest to practitioners and researchers in the field of smart grid and communication infrastructures alike.

While there is a comprehensible need for communication networks sustaining reliable information transfer between varieties of entities in the electric grid, there are many issues associated to network performance, correctness, interoperability, and safety that require being resolved. A secure, reliable, and economical power supply is closely associated to a fast, proficient, and reliable communications infrastructure. This development goes hand in hand with the rapid growth in the demand for communications. This is not just a question of higher bandwidths but also of communications requirements for new energy applications, including meter data management, distribution automation, and demand response, to name just a few examples. This book will focus on identifying prospects to modify communication protocols that have been designed for network traffic control to provide better service to smart grid applications and to supervise power flows in the smart grid between traditional and renewable generation sources and between utility-owned and customer-owned assets. The rapid increase in distributed energy resources today is impairing the power quality of the distribution grid. That's why grid operators need to be able to respond quickly in critical situations.Telecommunication Networks for the Smart Grid delivers practical approaches to the advancement of smart grid communication architecture with real world examples and in-depth case studies. The coverage includes detailed reviews of such revolutionary applications as advanced metering infrastructure, distribution automation, demand response and synchrophasors; examines safe and sound data management and data analytics for smart grids; explores the transformation of a network from conventional modes of utility operation to an integrated network based on the smart grid architecture framework. Covering a wide range of critical topics, including telecommunications for power engineers, power engineering for telecommunications engineers, utility applications projecting in smart grids, technologies for smart grid networks, this book will be of immense guiding tool for students, practitioners as well as researchers.