How Smart Devices, Online Social Networks and the Cloud Will Affect the Smart Grid's Evolution

Xi Fang, *Member, IEEE,* Satyajayant Misra, *Member, IEEE,* Guoliang Xue, *Fellow, IEEE, and* Dejun Yang, *Member, IEEE*

Arizona State University, Tempe AZ, USA

Information and communication technologies will play an essential role in the next-generation electrical grid system—the smart grid. And yet at the same time, information and communication technologies are themselves in the midst of a sea change, driven by market transformations in smart devices, online social networks and the cloud.

Let us review, in turn, how power grids of the future might evolve alongside advances in mobile devices, social networking technology and cloud computing.

Smart mobile devices such as smartphones and tablet computers are playing an ever-greater role in ubiquitous information collection, organization, dissemination and sharing. Existing, mature mobile service ecosystems, provided by companies like Apple, Google and Microsoft, may be used as cost-effective platforms to support smart grid supply-side and demand-side services, which will bring customers closer to each other and the grid itself.

Recently, a number of companies have started to offer mobile services for smart grid applications. Ireland's EirGrid, for example, released the iPhone application SmartGrid, which provides customers with a real-time view of key energy-related data, including system demand, wind forecasting, carbon emissions and so on.

Thus, information management based on mobile services is promising. But we need to consider some practical issues. First, such mobile services require support from advanced communication and information infrastructure embedded into the smart grid, and yet this infrastructure that is under construction may not have been optimized for mobile services designed for smart grid applications. Second, the smart grid is supposed to support many time-sensitive mechanisms, such as control of demand-response systems, but mobile services by definition rely on an unreliable wireless medium. The shortcomings of that medium can exacerbate communication losses and errors.

One of the most important ways the smart grid will differ from the traditional grid is it offers real-time information about user behavior and easily obtainable system status. Social networking and related online sharing services provide a convenient way to not only significantly improve information dissemination, but also control power consumption collaboratively during system outages, and improve system utilization and effectiveness as a result. For instance, recently, during hurricane Sandy, several electric utilities kept their customers updated through Twitter and Facebook, and used the services to post restoration schedules.

"Social Metering," a service developed by GreenPocket, enables users to share their experiences in energy conservation with other users. It tells users how well they are doing compared to their friends and recommends how to use energy in positive ways.

As electric and hybrid-electric vehicles are becoming more popular, they are expected to become an integral part of future power systems. Already, the social networking services "PlugSurfing" and "PlugShare" enable electric vehicle drivers to share information about the status of charging stations. More advanced services are sure to develop. For example, to avoid power system performance degradation that could result from uncoordinated charging, users will be able to collaboratively optimize their individual and collective charging profiles.

Although information sharing based on online social networks can improve the level of power consumption collaboration and system resource utilization, there are several potential issues. The most obvious risks to users concern privacy preservation and security. User information sharing opens a door for economic competitors or personal adversaries to track private behavior, information that would be much harder to obtain in traditional electrical systems. Also, hackers may compromise social media accounts to propagate incorrect or misleading information. And since disinformation can be easily magnified in a social network, it could trigger mass user behavior that results in undesirable events in the grid.

Cloud computing, which is fast becoming the dominant paradigm for computer services, is especially well suited to handle a smart grid's computational needs and information management, storage, and integration. Computational resource demand will be high and very dynamic, making highly scalable information storage and computing platforms, as found in the cloud, extremely desirable. Demand varies quite drastically just in the course of a day: Peak loads coupled with high information flow tend to occur in daylight hours, while both the load and information processing needs decline at night.

A well-functioning smart grid requires the information to be widely and highly available. Cloud storage provides a cost-effective way to improve the level of information integration, utilization, persistence and the smart grid.

In view of these advantages, it is hardly surprising that cloud services have recently been launched specifically for the smart grid. For example, Silver Spring Networks offers a service, "SilverLink," that uses the cloud and software-as-a-service to give utility workers access to real time data for monitoring grid systems and receiving alerts. This kind of service has the potential to reshape the way utilities access their data, making data access faster, cheaper, simpler and more standardized. Moreover, such services may enable valuable smart grid data to be distributed across different utility organizations, enabling participants to unlock value otherwise hidden in their smart grid investments.

As electric utilities consider availing themselves of cloud services, information security and privacy are bound to be concerns. Since reliance on the cloud involves some relinquishing of direct control of information, a systematic design for meeting computational and data management needs—one that addresses all possible security and privacy issues—is desirable.

Taking these considerations in account, the "pay-as-you-go" model used in cloud services will be a cost-effective solution for electric utilities and energy companies. The availability of cloud computing promises to be, indeed, a big cost saver for utilities as they undertake the massive reconstruction of power systems that lies ahead.

Xi Fang, IEEE Member, received the B.S. and M.S. degrees from Beijing University of Posts and Telecommunications, Beijing, China, and received the Ph.D. degree in computer science from Arizona State University, Tempe, AZ, USA. His research interests include algorithm design and optimization for smart grid, cloud computing and wireless network. He received several best paper awards at IEEE conferences, and was runner-up at another.

Satyajayant Misra, an IEEE member, is an assistant professor in computer science at New Mexico State University. His research interests include design and optimization of architectures and protocols for wireless and wired communication networks, supercomputing and the smart grid. He serves on the editorial boards for several IEEE journals, as well as conference executive committees. A paper he co-authored was a runner-up to the best-paper award at IEEE ICNP 2010.

Guoliang Xue, an IEEE fellow, is a professor of computer science at Arizona State University. His research interests include survivability, security and resource allocation issues in wireless networks, social networks and smart grid. With over 200 published papers in those areas, he is an associate editor of the IEEE/ACM Transactions on Networking and of IEEE Network magazine. He served as technical program co-chair of IEEE's INFOCOM'2010, which took place in San Diego.

Dejun Yang, IEEE Student Member, received his B.S. from Peking University, Beijing, in 2007. Currently he is a Ph.D. candidate in the School of Computing, Informatics, and Decision Systems Engineering at Arizona State University. His research interests include economic and optimization approaches to networks, crowdsourcing, smart grid, big data and cloud computing. He has received several best paper awards at IEEE conferences, and was runner-up at another.