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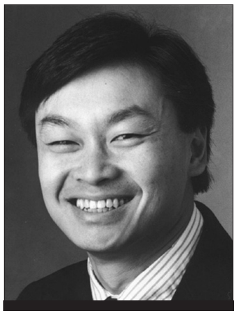
EDITOR'S NOTE

Smart Grids, Smart Cities Need Better Networks



Thomas M. Chen

Near the end of October 2009, U.S. President Obama announced $3.4 billion in federal stimulus grants for 100 projects related to the smart grid, as part of the American Reinvestment and Recovery Act, with another $4.7 billion expected to be matched by companies. The smart grid refers to a modernization of the existing power grid, which is characterized by unidirectional energy distribution, centralized energy generation, fixed consumer tariffs, and relatively simple meters. Most electricity meters are not capable of communications and must be read manually. Some meters are more advanced with communications capability, but the vast majority of them can only transmit data for remote reading and cannot receive data.

The smart grid will depend on a two-way digital communications network between the power utility and smart meters installed at houses — a system generally referred as an advanced metering infrastructure (AMI). A smart meter continuously monitors the electricity usage at a home for the utility company. In the reverse direction, the smart meter provides dynamic time-of-use pricing information to the consumer (e.g., higher tariffs during peak demand). The feedback information might also include instant reward incentives (e.g., to shut down appliances during peak demand), detailed data about the consumer's energy consumption, or information about the consumer's contribution to the overall system savings and carbon emissions.

The bidirectional exchange of information will change the traditional relationship between energy suppliers and consumers into a more cooperative one for mutual benefit. Given more information about the system, consumers are expected to benefit by making more intelligent decisions about their energy usage and expenses. At the same time, energy suppliers can manage demand and supply more effectively. Peak demand can be handled better by giving incentives to consumers to turn off high wattage appliances (air conditioning, electric water heaters, pool pumps, clothes dryers). If electric vehicles become common, the smart grid will be able to sense and accept consumer-generated energy (e.g., from solar panels and electric vehicles) to further reduce the need for "spinning reserve," the expensive practice of keeping turbines spinning in order to be ready to meet sudden demand spikes.

It is not difficult to imagine that the basic ideas underlying the smart grid — digital communications and advanced sensors to essentially create adaptive feedback loops — can be extended to benefit other types of "dumb" infrastructure. The most obvious example is the transportation grid. People living in big cities are very well acquainted with the problems of gridlock. For years, the intelligent transportation system (ITS) has been envisioned as an application of communications and sensor technologies to make vehicular traffic "smarter" by monitoring traffic conditions, distributing real-time traffic data, and enabling intervehicular communications. The benefits are easy to imagine: less congestion, better safety, faster travel times, and less fuel consumption.

So-called smart cities will take advantage of communications and sensor capabilities sewn into the cities' infrastructures to optimize electrical, transportation, and other logistical operations supporting daily life, thereby improving the quality of life for everyone.

It would be overly simplistic, and probably a big mistake, to believe that traditional networking technologies can simply be added into a city's critical infrastructure to make it "smart." TCP/IP was designed for a completely different environment than futuristic smart cities. TCP/IP enabled heterogeneous networks to interconnect via simple stateless routers and support best effort service. As needed, TCP could compensate for packet losses in the network and back off applications when the network was pushed toward congestion. Hosts were implicitly trusted.

The assumptions and requirements for smart critical infrastructures are very different, implying that networks for smart cities should be engineered quite differently. First, we must assume that internal and external parties can not be trusted. The network will be exposed to a broad range of attacks, and network security will be crucial. With lives at stake, the network must be designed to be resilient against active and persistent attacks. The network must be resilient against natural emergencies as well. Second, privacy will be a vital prerequisite to consumer acceptance. The Internet was not designed to provide any privacy. Protocols to add privacy have been created much later as an afterthought.

Given these requirements, it seems that networks for smart critical infrastructures will need new inherent capabilities such as fast self healing, sender authentication, and per-hop packet accounting for packet traceback. Hence, the problem is not engineering networks better; the real question is how to design radically new mission-critical networks with these capabilities built in. The design philosophy could be quite different from traditional networking, where the network is simple and complexity is delegated to the edges. Networks for critical infrastructures may have to be complex with new capabilities. The engineering challenges are daunting, but could lead to a new frontier in networking.

Now let me introduce this month's special issue on the topic of Improving Quality of Experience for Network Services. The guest editors have done a commendable job handling an unusually high number of submissions. As always, I welcome your feedback or questions at tom_chen@yahoo.com.