Deploying the "Internet of Things"

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Abstract

This paper explores the value in distributing and networking intelligent devices. Value is derived from distributing intelligence to each device locally. Further value is derived from having transparent access to these devices remotely. Extracting this value depends upon overcoming the issues of transparent connectivity, data concentration, and device interoperability. Some examples of successful, valuable applications are offered to illustrate how one might help deploy the "Internet of things."

1. Introduction

By now, we are all familiar with Metcalf's law: that the "value" or "power" of a network increases in proportion to the square of the number of nodes on the network. Echelon Corporation was founded with the goal of vastly increasing the number of networked nodes by making it both economic and valuable to network everyday devices in homes, buildings, factories, transportation systems – in short, just about everywhere. While we are an OEM company, one that sells technology and infrastructure products to others who make finished products, we have learned a great deal about the value in our customer's applications for networking devices. We have also found that a primary motivator for such networking today is to improve energy efficiency. In this paper, and with additional detail in my talk, I will provide some actual applications along with some of the challenges we all face in deploying the "Internet of things."

2. Energy Savings as a Motivating Force

There are three case studies I would like to discuss, each having energy related cost savings as a primary motivator. The first example is in building automation, the second is in electrical distribution, and the third demonstrates the economic necessity of networking light bulbs (!) well, at least some of them. In each of these projects, Echelon was more involved than as usual in our supplier role, so I am more familiar with the details and economic rationale than is normally the case.

2.1. Demand Reduction On Command

In commercial office buildings today, about 80% of the energy consumed is for Heating, Ventilation, Air Conditioning (HVAC), and lighting. Echelon's corporate headquarters in San Jose is completely automated with the products of our customers so HVAC, lighting, access control, elevators and other main building systems are all on a single network with transparent access to all the devices. Furthermore, all the building automation devices are certified as interoperable devices by an independent trade association called LonMark® International. This association, made up of companies, installers, and end users of products using Echelon's LonWorks® technology, certifies products as being open and interoperable. At our headquarters, we are participating in an energy conservation study with Lawrence Livermore National Laboratory (LLL). In this study, LLL provides energy status over the Internet to the building facilities management company we use in San Francisco, some 50 miles north. This company monitors energy price information published by LLL over the Internet. Upon detecting that the price of energy has risen beyond a threshold, they send a SOAP message to our building controllers, which in turn, set each office into energy savings mode. Within minutes of the LLL energy status change, our building's energy consumption is reduced by one third. We can maintain that state at no significant discomfort to the building occupants for four hours. This system is fully automatic, and requires no human intervention whatsoever. Additionally, it should be noted that our building is not distinctive from a construction standpoint in that it is the typical, poorly insulated, single pane windowed, office building that you would find in Silicon Valley.

Proceedings of the 2005 Symposium on Applications and the Internet (SAINT'06)
0-7695-2262-9/06 $20.00 © 2006 IEEE

2.2. Utility Automation

In June of 2000 ENEL, the largest electric utility in Italy, and Echelon entered into an agreement in which Echelon would supply communications infrastructure components to ENEL. ENEL had decided to replace every residential and light commercial electricity meter in their service area, all 27,000,000 of them with intelligent, communicating meters of their specification. These meters were designed to provide energy management, load control, and better service to their customer base of over 90% of Italy's population. This project was essentially completed by the end of 2005. ENEL has given the project costs as approximately 2 Billion Euros, which includes the costs to procure the hardware, install the data systems, procure the meters and install them, and integrate these new devices into their business systems. They have reported publicly that they are now saving in excess of 500 million Euros per year. The system is projected to have a life of at least 15 years.

This savings does not come from reading the meters remotely. In Europe, unlike in the U.S., an electricity meter is located inside the house and is read about once every 3 years, or when someone moves out. The bill is estimated monthly in the intervening time between reads. Instead, the savings comes from being able to know and balance the loads in the distribution network, theft prevention, accurate billing due to more precise metering, the integration of pre-pay capabilities within the standard meter, time of use pricing, being able to remotely disconnect electrical service, dynamically being able to adjust how much power a customer may use during times of power shortages, and a host of other applications. Additionally, the system provides ENEL with a platform for offering fee based services within the home should they choose to do so. Based upon this experience, and the favorable economic return that ENEL has and will enjoy, Echelon has designed a system of similar capability that is targeted for the rest of the world rather than being tailored to the Italian environment. We are actively trialing the system, called the Networked Energy Services (NES) system, with utilities around the world today.

2.3. Automating Outdoor Lighting

Surprisingly, there is good economic justification for putting individually controlled outdoor municipal and roadway lights on a network. The city of Oslo in Norway has done a pilot program that proves the point.

In Norway, all lighting accounts for 15% to 20% of the TOTAL yearly demand for electricity for the entire country. Street lighting alone is 38% of the energy used for lighting in Norway. Three years ago, to comply with a government directive to remove capacitors containing PCBs, the city of Oslo decided to not only remove those outdoor lights containing the PCBs, but to install a modern system that would save energy, provide better service, and serve as a model for environmental responsibility[1].

The new lights come from multiple manufacturers who use Echelon's power line communication technology within each light fixture for communication. The lights communicate to an Internet edge server provided by Echelon that manages each group of lights and communicates alarms and status back to a central data management site. Also integrated into the system are sensors that measure ambient light and the amount of traffic on the road. In this way, Oslo can control the light on the road providing a safer environment, such as when it rains during the day, as well as an energy saving environment by using individual dimming of the bulbs and dawn and dusk. The pilot project is only 120 of the 250,000 lights managed by the city of Oslo. The pilot has been running for over 6 months and has so far generated an energy savings of 70% over the old lights that it replaced. According to Philips[2], one of the vendors in the project, 45% of the savings is due to dimming the individual bulbs. The balance of the savings is primarily due to more modern bulbs and electronics. The pilot is expected to expand to 20,000 lights by the end of 2007. Hafslund, the company managing the system for Oslo, claims that the pilot system is currently generating a 15% return on the investment, primarily from energy savings, improved billing, and more efficient maintenance. All this with the environmental benefits from reduced energy consumption, fewer bulb replacements due to longer life from dimming, safer lighting and less light pollution.

3. Problems, Problems, Problems

With all these benefits, one could easily jump to the conclusion that the "Internet of Things" will happen practically overnight. However, it will not. There are a lot of non-intelligent things in the world, and replacing them takes time. For example, even with an aggressive installation rate of 700,000 meters per month, it took a total of 5 years for ENEL to complete their project. Replacing all the lights in a city means closing down one lane of a main road to change out the fixtures. Building Automation systems such as the one we have at Echelon typically are not changed out until they wear out. This can be 15 years or more. It is just a fact that the things that consume the most energy and thus have the most energy savings potential are large, expensive pieces of equipment. Finally, the people that install these systems need to be trained on the new systems for the installations to be successful. People can only be trained so quickly.

Society can make a choice to accelerate these changes. Businesses can be given incentives, laws can be passed, regulations imposed such that society could enjoy a world of less pollution and fewer carbon emissions. And, as Echelon, Enel, and the City of Oslo have all shown, moving to an Internet of things brings positive returns, so that first movers enjoy lower costs and higher quality than their peers. However, this is a difficult choice to make. It always seems (*in the short term*) less expensive to pollute than not to pollute. It always feels less risky (*in the short term*) to do things the way they were done before. Nevertheless, the world does change, and in this case it will too. The supply of energy simply cannot continue to increase and easily meet the demands of the developed and quickly developing nations. The only way to have both economic growth and enough energy is to use what we can generate much more efficiently. I believe we are at this point now. As the recent devastation of hurricane Katrina has shown, a disruption of only 1% of the world's oil and gas processing capability has a dramatic affect on the price of energy around the globe. That is a symptom of a system running at its capacity.

These sorts of social issues are not the only impairments to deploying the Internet of things, however. There are a number of technical issues that still need the attention of the technical community.

3.1. Internet Communication Issues

It is still very difficult to place a device with a packet switching wireless modem (GPRS) on the Internet, where another machine connected anywhere can initiate packet communication to that device over the GPRS network. Service providers today balk at the idea of handing out routable IP addresses to always on endpoints, even when they are dynamic and must be resolved with DNS. Without being able to initiate communication from machine to another, the applications in this paper are not possible.

It is also very difficult to get a wireless service provider to terminate a VPN at the service center and allow the service center to do the authentication and hand out the IP addresses. This would be an alternative to getting a routable IP address from the service provider, and is what is being used in the Oslo pilot.

3.2. Security

The devices that are worth networking for energy savings are important ones that we all depend upon. The thought of making them accessible on the Internet always raises the issue of security. Standard means of providing security, SSL and Ipsec, are effective, but difficult to implement in embedded devices. Also there are deployment issues in installing the latest security patches on millions of devices.

The solution to this problem also solves a scalability problem. Millions of devices can generate an incredible amount of data. This data should not be blindly passed upstream, but instead filtered and concentrated. At the concentration points, one can use standard security protocols and limit the deployment issues. For example, in the ENEL system, there are approximately 250,000 data concentrators for the 27,000,000 meters. Of course, below the concentrator one still needs security, but the concentrator can serve a firewall function and limit the outside attacks that can be mounted on the devices below it.

3.3. Interoperability

All these devices will not come from a single source, yet they need to do more than just connect to each other, they need to understand and process what they are saying to each other. This requires standardization above the communication protocol layers. The LONMARK International Association provides this for systems using Echelon's technology, but something is needed for IT systems talking to devices as well. To this end, Echelon and its competitors and customers are trying to develop an open standard with the OASIS organization based upon SOAP/XML to convey the rich semantics of inter-device communication. Participation from interested parties is most welcome.

4. Conclusions

The distribution of intelligence to ordinary devices, coupled with a transparent, ubiquitous communications infrastructure can yield tangible benefits in energy savings, pollution control, quality of service and convenience. These benefits can result in returns on investment that are very competitive with the sorts of investment decisions companies make to generate superior returns for their shareholders. While issues remain, both technical and structural, first movers today are showing striking economic returns in their applications to network ordinary devices. These successes also fulfill society's need to reduce conventional and carbon atmospheric pollution. In spite of the force of psychological inertia present in preserving the status quo, the spread of these successes will result in the inevitable deployment of an Internet of Things.

5. References

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6. About the Author

Robert A. Dolin is the system architect for Echelon Corporation. He has been with Echelon since 1989. He is the principle or co-inventor of fourteen of Echelon's patents, and was one of the designers of the LonWorks protocol, the network development system environment, the Neuron® C programming model, and LonWorks network management. In May 1995 he was named as Echelon's Chief Technology Officer. Before joining Echelon, he worked at ROLM Corporation for 11 years, where he was one of the principle developers of its fully distributed PBX telephone system. At ROLM he also held positions of first- and second-line management as well as worldwide responsibility for system architecture. He has a B.S. degree in Electrical Engineering and Computer Science from the University of California at Berkeley.

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