the hammersmith group
research report
february 2010

The Internet of things: Networked objects and smart devices

the hammersmith group
new york: 203 rivington street, suite 3a
new york, ny 10002
massachusetts: 259 south main street
bradford, ma 01835
t 917 447 8800
f 978 372 2949
thehammersmithgroup.com

It all began with a coffeepot.

A coffeepot that was connected to the Internet (before it was even called the Internet) and which provided information about its status (long before there was Twitter).

In 1991, researchers at Cambridge University shared a single coffeepot among several floors. The researchers were frustrated by the fact that they would often climb several flights of stairs, only to find the coffeepot empty. They set up a videocamera that broadcast a still image to their desktops about three times per minute — enough to determine the level of coffee in the glass pot.[1] Several years later, that coffeepot had become one of the first Internet web cam sensations, with millions of hits worldwide.

That coffeepot was a proof of concept for today's networked objects and the Internet of Things.[2] Since then, the price of processing power has dropped significantly, and a number of projects are demonstrating the benefits of adding processors, sensors, and transmitters to a range of objects.

"The question is no longer 'is this possible,' but rather 'will this feature bring me enough new customers to offset the small marginal cost of the hardware?" said Mike Kuniavsky, a partner of ThingM, a ubiquitous computing device studio.

The Internet of Things[3] comprises a digital overlay of information over the physical world. Objects and locations become part of the Internet of Things in two ways. Information may become associated with a specific location using GPS coordinates or a street address. Alternatively, embedding sensors and transmitters into objects enables them to be addressed by Internet protocols, and to sense and react to their environments, as well as communicate with users or with other objects.

Embedding processing power into objects enables a range of potential communications: person-to-device (e.g. scheduling, remote control, or status update), device-to-device, or device-to-grid (e.g. appliances that are aware of fluctuating electricity prices, and which schedule loads during off-peak pricing hours).

However, just because you can embed processing power into an object doesn't necessarily mean that you should.

"There was a brief period in the late 1980s when cars 'spoke' to their owners, telling them that the door is open or the lights are on. It didn't last. That information could be communicated just as easily with a light on a panel or a chime," said Rob Faludi, a professor at New York University's Interactive Telecommunications Program and a co-creator of Botanicalls, a sensor-transmitter combination that allows plants to communicate with people.

"One of the reasons that automation isn't as successful as it could be is that it often doesn't address actual problems or needs," said Faludi.

One of the best examples of the technology-for-technology's-sake approach is the 'intelligent door' manufactured by the fictional Sirius Cybernetics Corporation in Douglas Adams' *Hitchhikers' Guide to the Galaxy*. The doors combined embedded processing power, sensors, and the ability to communicate with users. The doors thanked users every time they were opened or closed — annoying the living hell out of the characters in the books.

Technology should be a means to an end rather than a goal in and of itself. Fraser Hickox, the former General Manager of Research and Technology at the Peninsula Hotel Group, observed that some problems could be addressed with technology, while others could be addressed with design. The point was not to needlessly show off technology, but to address users' actual problems, needs, or inefficiencies in the simplest, most effective, and cost-effective manner — in essence, the Occam's Razor of design and technology.

"Does every device need to talk with every other device?" said Faludi. "Probably not."

---

1 Let's put aside the fact that a new coffeepot would have been much less expensive than a videocamera, ok?

2 And, quite possibly, YouTube and reality television as well.

3 See also, Hammersmith's research report Web 4.0, The Internet of Things.

Market size and assumptions

Today, there are roughly 1.5 billion net-enabled PCs and slightly over 1 billion net-enabled cellphones. The present "internet of PCs" will move towards an exponentially larger "internet of things" according to Georgetown University Communication, Culture & Technology professor Michael Nelson, the former director of Internet Technology at IBM, and the former director of Technology Policy with the Federal Communications Commission, and advisor to Al Gore.

Within 5-10 years, Nelson expects that 100 billion devices will be connected to the net.

"Trying to determine the market size of the Internet of Things is like trying to calculate the market for plastics, circa 1940. At that time, it was difficult to imagine that plastics could be in everything. If you look at information processing in the same way, you begin to see the vast range of objects into which logic, processors, or actuators could be embedded."

One trend driving this growth is the lower cost and increased market share internet-enabled mobile phones. Formerly, desktops and laptops were the primary — and in some cases, only — source of internet access. Widespread mobile access to the internet will drive innovations in content, commerce, entertainment and gaming. Many of these innovations will be driven by the fundamental insight that the information needs of users on the go are very different from the information needs of the same user while at a desktop computer.

Another trend driving this growth is that more media is being distributed as bits rather than as atoms. As a result, traditional entertainment systems are converging and are being incorporated as widgets on an internet platform (such Boxee and Hulu) rather than as discrete physical devices. Similarly, wired hotels such as the Peninsula Tokyo, which cater to international travelers have replaced the conventional radio in their suites with an IP radio that can access worldwide stations via the internet. Going forward, there will likely be more ways to create mash-ups of digital media, entertainment, and networked objects.

Nelson points out that there are different ways to calculate the market size. "Some smart devices are basically just networked appliances, so the market for these is a subset of the overall market for home appliances. That sector in particular should pick up as the real estate markets recover."

In addition, the proliferation of intelligent and green buildings has the potential to drive adoption of sensors and devices with embedded processing power.

The performance of even the greenest buildings and most efficient systems can be improved by real-time monitoring in order to detect patterns and anomalies. Over the long term, collecting, analyzing and benchmarking this information allows for better-informed investment decisions. A thorough body of information can inform public policy and incentive decisions, as there is still considerable confusion regarding the relative payback periods various 'green' capital expenditures.[4]

In addition, as an asset management tool, smart devices complement 'intelligent buildings' in which various systems are converged onto an IP platform. In some of these buildings, comprehensive Facilities Management Systems (FMS) can track energy and utility usage down to the level of individual fixtures. However, the sector has been slow to adopt new technologies, preferring to invest in top-line growth via acquisition and development rather than seeing the wisdom in investing in technologies that can increase net operating income by reducing operating costs.

According to the U.S. Green Building Council, less than 1% of buildings are considered high-performance. This number reflects both the real estate sector's traditionally slow acceptance of new technologies as well as the potential for market growth as awareness of the business case for certain technologies becomes more robust.

Networked objects generate significant information trails

Embedding sensors and transmitters into objects allows them to sense and react to their environments. Embedded logic also

4 See also, Hammersmith's Costs & Benefits of Intelligent Buildings.

enables remote control and monitoring, and provides the opportunity to monitor and analyze constant data feeds, which has implications for real-time data and real-time search. The Gartner Group projects that by year-end 2012, physical sensors will generate 20% of non-video internet traffic: "The extent and diversity of real-time environmental sensing is growing rapidly as our ability to act on and interpret the growing volumes of data to capture valuable information increases."

USC's Julian Bleecker created the term 'blogjects' to describe objects that blog. Bruce Sterling coined the word 'spimes' to describe "a location-aware, environment-aware, self-logging, self-documenting, uniquely identified object that flings off data about itself and its environment in great quantities." Adam Greenfield describes 'informational shadows' of networked objects: "The significance of technologies like RFID and 2D barcoding is that they offer a low-impact way to 'import' physical objects into the datasphere, to endow them with an informational shadow."

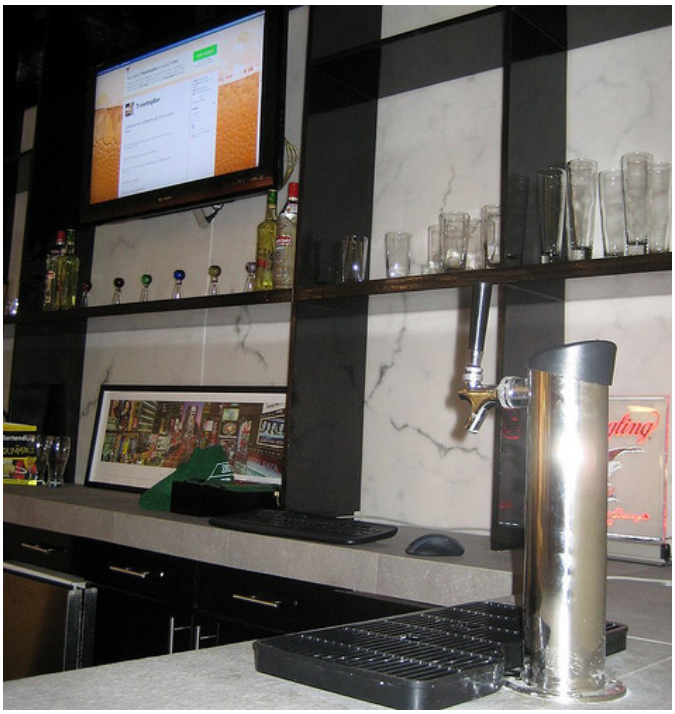
Devices can also communicate with each other, for the benefit of users. Rob Faludi gives the example of a wired toaster and fire alarm in a networked home: "It is not an intuitive connection until you think about how the alarm seems to go off each time you make toast. There ought to be a way to have the fire alarm 'learn' that smoke in the kitchen at the same time each morning might mean toast instead of a life-threatening fire. Or have the fire alarm build gradually over the course of 15 seconds rather than going right to full volume. The neighbors would appreciate this."

A range of products — from the whimsical to the practical — demonstrates the benefits of embedding processing power into objects and tracking the information trails.

Botanicalls uses the same technology to enable plants to communicate with people. It uses sensors to determine when the water level in the soil is low, and transmitters communicate the plant's status to users via text or tweet. The digital ad agency **360i** created a networked beer keg connected to Twitter — the tap is connected to an electric Keg-Meter that tweets (in the persona of Ben Franklin, no less) whenever a beer is drawn.

Networked objects create a mashup between physical objects and information shadows. Applying Sterling's concept of spimes that track usage, a washing machine could let you know information such as how many loads you've made over the course of its product lifetime, average number of loads in a week, and the relative costs of doing your loads at peak electricity times as opposed to waiting until off-peak hours. This sort of information could help

Below: Botanicalls combines a transmitter with a moisture sensor to enable plants to communicate their needs to people.
Right: The Tweeting Bar at digital ad agency 360i combines a transmitter with an electric Keg-meter, and it communicates in the persona of Ben Franklin, a staunch beer advocate. Both technologies use Twitter as a vehicle for communication.



users make more informed decisions, and could help manufacturers recommend more appropriate models, based on consumers' actual usage habits, when the time comes to replace them.

Networked objects blur the line between bits and atoms. "Physical objects now become avatars, or representatives, of services," said Kuniavsky. "Everyday things like shoes are augmented by technology, and as they do that, they become widgets on the screens of other computers."

For example, the **Nike+iPhone** embeds an accelerometer into a pair of sneakers, enabling it to measure the distance and pace of a run or walk. While the physical object — the sneakers — can function in an analog capacity, the added value is in the information shadow that the networked sneakers generate. The software creates a record of workouts and tracks calories burned without having to manually enter this data. In the words of Jeff Jarvis, the combination of technologies makes the shoes "googley." Lastly, a social media layer allows users to engage in challenges with other users.

"The Nike+iPhone product embeds computing power into the product design, not as an adjunct," said Kuniavsky. The benefit of this combination is that it not only provides a service, but provides actionable information that can influence behavior.

Similarly, Vitality, Inc. has created the **GlowCap**, a networked screw-on cap for a standard prescription bottle that wirelessly links to the Internet through an embedded sensor and transmitter. GlowCap address the problem of patients who forget to take their prescriptions.

The Nike+iPhone embeds an accelerometer into a pair of sneakers, transforming sneakers into networked objects that create actionable information trails.

Consumers or caregivers use their computer to program when the pills need to be taken. A light on the cap flashes at the scheduled times. If no action has been taken, a three-tone reminder alert sounds after half an hour. If the bottle still has not been opened, the system makes an automated reminder phone call to the patient or a caregiver. The GlowCap system compiles adherence data which can be shared with authorized users. A limited version, which only gives one alert per day and which doesn't track usage, is available from Amazon.com.

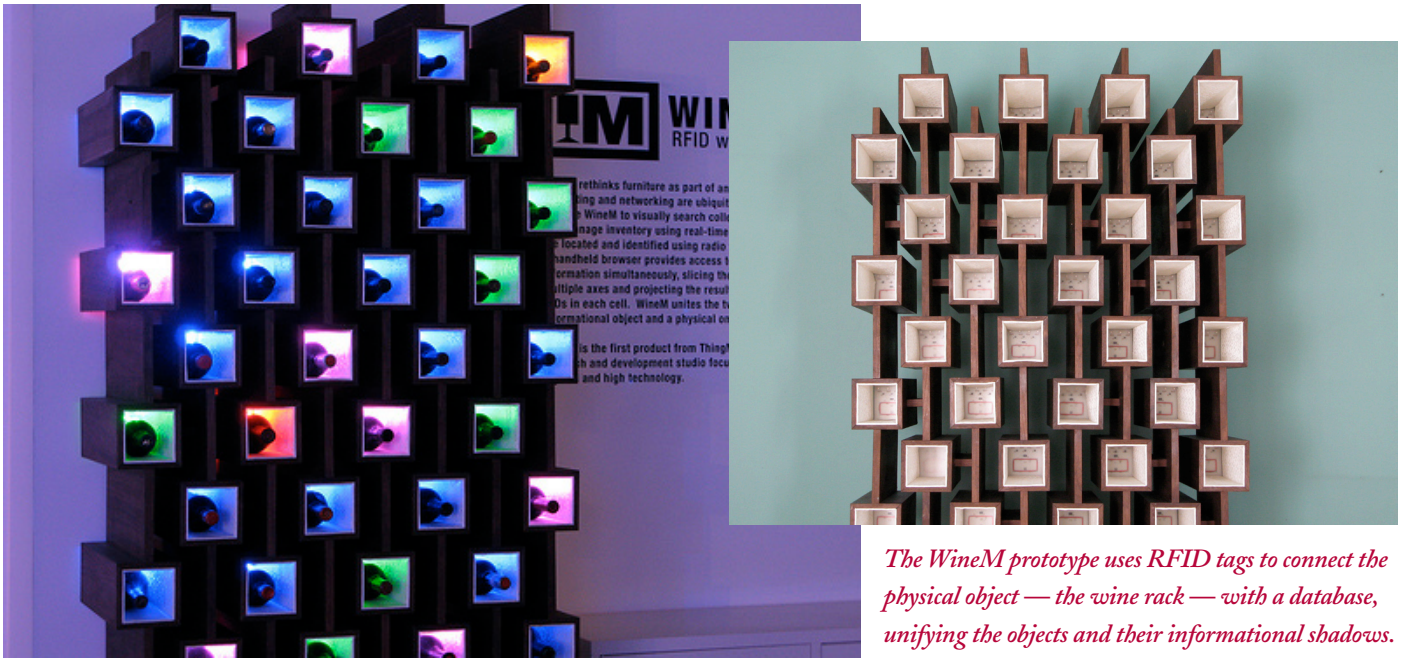
Botanicalls is an elegantly simple concept that enables plant-human communications. The product consists of a sensor to measure moisture in the soil with embedded ethernet connection which sends tweets such as "Water me please," "You didn't water me enough," or "Thank you for watering me!"

According to the Botanicalls site, the concept came about in part because people — especially technologists — seldom have time to stop and smell the flowers, let alone water them. Plants that might otherwise be neglected are given the ability to call people and request assistance. People who are unsure of their ability to effectively care for growing things are given visual and aural clues.

"There is potential to scale up this technology as part of a comprehensive strategy to reduce water usage," said Christine Lichatz, principal of Gardenworks, a sustainable landscape design firm which has done projects for the Navy Yard in Groton, CT.

ThingM designed **WineM**, an intelligent wine rack that demonstrates the benefits of unifying the object and its information shadow. It uses RFID tags to connect individual bottles to a database, and to identify which one bottles match the user's query in terms of selection criteria.

"Wine is an ideal product for this sort of application, since it has such a rich information shadow: where it was made, critic's ratings, and when it is ready to drink," said Kuniavsky. "It can do all of the standard database things like show you just the Napa 2003 Cabernet Sauvignons, but it can also display which wines



The WineM prototype uses RFID tags to connect the physical object — the wine rack — with a database, unifying the objects and their informational shadows.

are ready to drink. For example, you can say: show me all the French wine in different colors by region. Now show me the ones whose current market value, as determined by an online auction service like WineBid, is between $50-100. Since it's on the net, it can text you when your supply of your favorite wine is running low, or when there is a sale on it."

These information trails represent potential additional revenue streams for manufacturers. Whereas conventional appliances represent a one-time only sale, the first wave of networked objects combine an initial purchase with a monthly subscription for premium service.

For example, **BodyTrace** is a networked bathroom scale that launched in September of 2009. It wirelessly uploads users' weight to the BodyTrace website, generating weight and BMI charts and recommendations from the data. The website offers a range of features focused on diets and weight monitoring, including a food diary and intake calculator, and a social networking component. However, the company is offering the web service at a monthly surcharge above and beyond the cost of the product itself.

Similarly, Ambient Devices' Orb is a glass ball which can be programmed to display different lights that represent different information (pollen count, a stock portfolio's performance, etc.). The device comes pre-programmed for certain information streams, and customized data represents a slight additional monthly charge.

Smart appliances support energy conservation through demand response strategies

Consumers' electrical bills imply a flat rate. However, energy prices fluctuate throughout the day. 'Smart' appliances that communicate with the energy grid can also be scheduled to take advantage of lower energy prices during off-peak hours.

Barry Katz of Greenworks Consulting observed that devices that display household power consumption in real time have the potential to encourage conservation.

Consumers can't make informed decisions regarding fluctuating energy prices unless they know the electrical price at a particular time and the usage 'cost' of running a particular appliance. Smart devices and networked objects have the potential to change that by displaying real-time pricing and performance data. "It can give consumers the ability to make informed decisions. What is the financial impact of switching your diswashing and laundry

to off-peak hours. Or what is the real-time savings by lowering the temperature in your refrigerator and freezer by one or two degrees?" said Katz.

"As anyone who's driven a Prius knows, there is a competitive aspect to conservation once performance numbers are displayed. Sometimes you just want to beat your own best scores," said Katz. "We're not quite there yet for households, but the industry is slowing moving in this direction."

Ambient Devices' **Energy Orb** changes color to display information such as the state of the power grid, so that consumers can know at a glance if they are in peak-pricing hours. Southern California Edison (SCE) plans to invest $1.7 billion to install 5 million SmartConnect wireless meters in southern California homes between 2009 and 2012. These meters allow consumers to track real-time usage and pricing of energy.

Other companies within this space of note include **AMEE**, for measuring and managing carbon footprints, and **Pachube**, a real-time data brokerage platform that enables users to share realtime sensor and environmental data.

Networked objects can create lifestyle benefits

Embedding a small amount of processing power into appliances can create significant lifestyle benefits. Networked objects can serve users better — and can help modify users' behavior in positive ways — by reminding them of schedules, deadlines, or other household needs.

For example, some universities and multifamily buildings are connecting shared appliances such as washer/dryers to the building's web site, so that residents can remotely reserve time slots (rather than waiting around for half of an evening for one to become free). Some of these machines can also text or tweet when their load is done. In theory, this is not considerably different than the GlowCap, using the technology to provide scheduling and timely reminders.

While the new appliances are priced at a slight premium, one hacker demonstrated that existing appliances can be retrofit with roughly $30 of parts on a 20 year old machine.

Coming full circle to Cambridge University's wired coffee pot, Seattle's Hotel 1000 (H1K) presents a possibility for enabling a networked coffeemaker to communicate with the room's alarm clock.

The H1K is, along with the Peninsula Tokyo, one of the most wired hotels in the world. Matt Hagerman, general manager of H1K, said, "I would like to emphasize that this is something which is possible with existing technology, but it is not something which we are doing yet. In a connected hotel, it is possible to connect a guest's wake-up call to the coffee maker in the room, so that they have a hot cup of coffee ready just after their alarm call."

Constantine A. Valhouli *is a principal with The Hammersmith Group, a strategy consulting firm. Hammersmith concentrates on real estate and technology (intelligent buildings, smart devices, and networked objects). Valhouli holds an MBA from Columbia Business School and an MA in interactive telecommunications from Georgetown's Communications, Culture & Technology program. He is a Charles G. Koch fellow in economics and public policy.*

