Understanding the world of connected machines:
Making sense of Internet of Things

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What is the world of connected machines?

There is much discussion about a world of connected machines. This is sometimes called machine-to-machine (M2M) or the Internet of Things (IoT). Most agree that there is huge potential in connecting machines, but it is a vast and diverse marketplace and there is much confusion as to what it entails and how it will materialise.

A first step is to differentiate different areas of the marketplace. One key differentiator is whether the system is really just a remote control for a machine (eg setting the home heating system from a smartphone when away from the home) or whether it is divorced from any person and is a machine reporting on status (eg a dustbin notifying a database it is full). The “remote control” market is typically handled through cellular, Bluetooth and Wi-Fi and is already established and growing quickly as evidenced by demonstrations at key consumer and trade conferences such as the Mobile World Congress.

Another key differentiator is whether the machine communications is within a building such as the home or office, or whether “wide area” communications is needed. A home system might control the lighting in the building. A wide area system might send smart meter readings to an electricity supplier. Broadly, the former is “home automation” and can be delivered effectively already using solutions such as Bluetooth and Zigbee. Again, this is not discussed further here.

So we are left with wide-area, machine-oriented solutions. These form the bulk of the interesting new areas that people talk about when discussing M2M and the IoT. Unfortunately, neither of these terms is accurate. These are machines sending readings to a central database or computer that can take action – such as sending an electricity bill or scheduling a garbage truck. So it is not really “machine to machine” but rather sensor to database. This may seem pedantic use of semantics but there is an important point here that there is little reason for one “machine” – by which we generally mean a device such as a smart meter - to talk directly to another. Equally it is not really an Internet of Things. The Internet implies an interconnected network where my computer can access information on your computer. Instead, typically, only the “owner” of the machine, such as the electricity company, will be able to access its readings and communicate with the device. It is more like the “Intranet of Things” where connectivity is restricted to self-contained groups rather than the “Internet”. Again, this may seem pedantic, but it has important implications for installation, security and network architecture. These are just connected machines, not parts of some grand global network, but as will be explained, the simplicity of that concept is what will make it so powerful.

Indeed, most applications envisaged are self-contained in that the data generated is used just for that application. So, for example, in smart metering the meters report to electricity companies or in parking the car park sensors talk to parking applications. There may be some cases where sharing data more widely than this is valuable but at present it looks like these will be exceptions. Indeed, to be more specific, most machines will only ever send information to one place – the client database – and will only ever receive information from the same source.

So a connected machine in this sense is a device that communicates over a wide area network to its owner's computer system. This enables the computer to take appropriate action such as re-planning schedules. Boring, but incredibly valuable.

Where are we at the moment?

It is hard to state exactly where we are on the connected machines evolution. Ericsson, for example, predicts around 50 billion connected devices by 2020. This seems entirely plausible – it would only be 10 devices per person in the world who has a phone today. To date there are a few hundreds of millions devices deployed. So we might perhaps be 1% or so of the way to the vision of a connected world. Where connected devices have materialised they tend to be either short range devices in the home or high value wide-area devices. This is because short range devices can be accommodated today with in-home network solutions such as Bluetooth and Wi-Fi, while high value wide-area devices can tolerate the cost and battery consumption of using cellular communications. Examples of the former are home security systems through to sensors to remind us to water the plants. Examples of the latter are vending machines and high-end cars.

Most of the pieces needed for machine connectivity are now in place. Software that can gather data from machines across multiple networks and present it to the client's database system is now available from companies such as Jasper and Interdigital and this often includes intelligence that can simplify the deployment process such that when a device like a smart meter is turned on for the first time it is automatically configured by the network software rather than requiring the installation engineer to enter details into some remote terminal. Systems such as smart meters are being rolled out in some countries such as major deployments in the US. However, a key missing piece in the puzzle is a wide-area wireless solution that provides very low cost ($2 hardware, $2/year connectivity), 10-year battery life and ubiquitous coverage[1]. Experience with concepts such as mobile data has shown us that the market tends to bump along the bottom until all the pieces of the puzzle are firmly in place, at which point it only takes a small stimulus (the iPhone in this example) to result in explosive growth[2]. My view is that if it were possible for a device manufacturer to buy a wireless module for $2 or less that they could simply add to their machine and know that this would work anywhere in the world with no need for complex roaming agreements then this would stimulate the widespread deployment of connected devices. Of course, it takes some time for certain machines to be replaced or updated so growth may not be quite as fast as in the smart-phone arena, but could be many orders of magnitude faster than it is at present.

If we solve the wireless connectivity part of the puzzle with appropriate technology and with vision from operators it looks as if all the other pieces we need will be in place and we may be set for rapid growth.

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[1] We are working on a solution to exactly this problem with the Weightless standard for machine communications.

[2] Mobile data was initially offered around 2000 with the "WAP" protocol over GPRS. This was unsuccessful. Over the next decade a number of enhancements were made. These included 3G networks with HSDPA which provided good high speed connectivity, data tariffs that were much more attractive than the initial $50+ per month, location availability from the phone and much more. Even with all of this, mobile data remained disappointing until the final problem – the ease of access to the Internet from mobile devices – was solved with the touchscreen on the iPhone. This led to an explosion in data use which in turn drove growth in the Apps store leading to a virtuous spiral of take-up.

Which applications will lead?

There is understandable interest in predicting which machine applications will lead the connected machine world. Of course, as mentioned above, there are already some deployed applications so it is not so much which will be first as which will take us towards the first 1 billion connected devices. Trying to predict what will happen next is just as difficult as attempting to predict the top selling applications in the Apple Apps Store in advance of the launch of the iPhone (would you have predicted Angry Birds?). It may well be that multiple applications develop simultaneously just as has happened in the world of mobile data. The best we can do is make some general observations about some of the more obvious areas:

- Smart metering is clearly a lead application because of regulatory mandates in some countries that require rollout to happen over coming years.
- The energy market (refineries, wind turbines, etc) is also a fertile area for machine connectivity albeit much smaller than the smart meter market.
- Smart city applications such as smart dustbins, rental bike monitoring and street light management are promising because of the limited coverage requirements and the clear need for productivity improvements in delivering city-wide services. However, this is balanced by the complex procurement and ownership issues where budgets may be held by local authorities but services sub-contracted to commercial providers.
- The healthcare market is potentially enormous and valuable. Simplistically it divides into those solutions that can be directly purchased by consumers or private healthcare providers and those that require National Health Service approval and / or funding. The former might include enhanced pregnancy testers, pill dispensers with reminder functions, heart rate monitors and fall alarms. These could be quickly purchased and deployed. The latter includes automatic medicine dispensers and monitoring of key indicators such as blood sugar with alert functions. Because these will often be regulated and because they may require linking to national systems they will take much longer to gain approval.
- Consumer devices are a promising, if broad, category which might include devices like washing machines, connected TVs or even home weather stations. Some of these will use the home network but there are strong advantages in others having a simple and direct connectivity back to the manufacturer[3].
- Automotive tends to be a late adopter of wireless technologies as do trains and planes.
- Asset tracking is another potentially enormous market but to realise its full potential requires widespread or even global coverage. So while tracking within buildings or as eg parcels pass through key checkpoints is entirely possible, tracking of things like shipping containers as they move around the world is currently much more difficult.
- Areas such as the military might have great demand for machine connectivity in areas such as tracking soldiers or key items of equipment or monitoring the status of weapons but it is unclear as to how quickly they might deploy such solutions (or even if they already are!).

[3] As an example, to connect a washing machine to the in-home Wi-Fi may be rather tricky, requiring the right Wi-Fi node to be selected and a password entered on a device with limited user interface. This may cause many user complaints and returns. Simpler to have the washing machine connect directly to an external network without any user intervention. As long as the cost of this connection is very low it may well be preferred by manufacturers and users.

Privacy and security

Any system that gathers information and takes action on it will need to address legitimate concerns over privacy and security. Of these, security is the simplest and can broadly be addressed using appropriate encryption and authentication within the various layers of the system. It is helped by keeping communication between a machine and its client computer, thus preventing others "hacking in" to machines. Privacy is more complex. In some cases there may be few issues – for example few will be concerned about whether their local street lamp is reporting a broken bulb or not. Others applications such as healthcare may raise deep concerns. Privacy will need to be addressed on an application-by-application basis and based on demonstrating that the application delivers benefits to the end user that strongly outweigh any potential privacy issues.

Where might it end up?

What does a world of connected machines look like? Of course it is almost impossible to predict. Connecting machines will lead to changed behaviours that then changes the applications and so on. Equally, it is easy to get carried away with visions of an "Internet" of connected machines. My prediction is that connected machines will just work better. Washing machines will be better optimised for water hardness based on the location where they are deployed, can have new programs downloaded as new washing powders come onto the market and so on. Dustbins will be emptied when they are nearly full, not on a routine weekly cycle. Meters will be read automatically. Cars are now mostly recalled to have software updates which in the future can be delivered over the air and so will not need to be recalled so often. Finding a parking space will become simpler. Broken street lamps will be repaired quicker. Cracks will be spotted earlier in bridges with fewer failures or disruptions. Home devices will automatically connect to the correct home network with no need to enter the password into the fridge. And so on. The world will be a better, less frustrating place to live in. Productivity will improve through less human intervention leading to growth. Some of the key societal problems such as assisted living will be much ameliorated through sensors in the home and on the person. But in just the same way that we only notice street lamps when they don't work, we may hardly notice that we live in a world of connected machines. Indeed, that could be the ultimate aim of the connected world – we stop noticing the machines at all.

Biography

William is CTO and one of the founding directors of Neul, a company developing the Weightless machine-to-machine technology and network, which was formed at the start of 2011. He is also CEO of the Weightless SIG.

Prior to this William was a Director at Ofcom where he managed a team providing technical advice and performing research across all areas of Ofcom's regulatory remit. He also led some of the major reviews conducted by Ofcom including the Spectrum Framework Review, the development of Spectrum Usage Rights and most recently cognitive or white space policy. Previously, William worked for a range of communications consultancies in the UK in the fields of hardware design, computer simulation, propagation modelling, spectrum management and strategy development. William also spent three years providing strategic management across Motorola's entire communications portfolio, based in Chicago.

William has published 12 books, 100 papers, and 18 patents. He is a Visiting Professor at Surrey University, a member of Ofcom's Spectrum Advisory Board (OSAB) and a Fellow of the Royal Academy of Engineering, the IEEE and the IET. His biography is included in multiple "Who's Who" publications around the world. William has a first class honours degree in electronics, a PhD and an MBA. He can be contacted at william.webb@neul.com.