You've probably heard the expression. But what is it?

IoT: The Internet of Things

Ask most people what is meant by "The Internet of Things" or IoT and you'll receive a blank look and an "ummmm". Same with LoRa – occasionally, respondents will know it stands for Long Range but beyond that, little if anything. So what do these terms mean and why are they becoming more and more important?

By Ross Tester

You might believe that The Internet of Things (or IoT) is a very recent development, say the last couple of years or so.

It surprises many to find that the term was first used last century (OK, just – 1999!) by British entrepreneur Kevin Ashton. His vision, if you like, was a global network of "things" connected to radio-frequency identification (RFID) via the internet. IoT has gone a long way past that!

However, this wasn't the first time the concept was aired: in 1982, a modified Coca-Cola machine at Carnegie Mellon University in Pittsburgh, USA, became the first internet-connected device that wasn't simply a terminal. It was able to report its inventory and whether newly-loaded drinks were cold.

(Remember that the internet was originally "invented" for communication within, and between, universities – a relatively long time before it evolved into the internet as we know it today).

Several papers in the 1990s hinted at what has become the IoT. One even suggested **everything** would eventually be tagged or digitally watermarked so that it could be recognised. We haven't quite got that far yet.

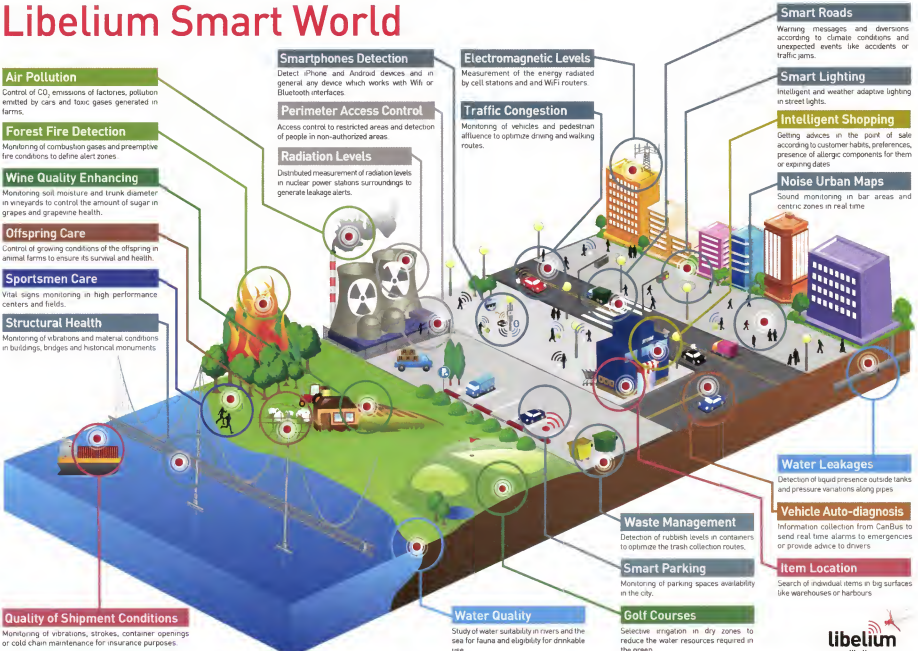
Yet – barcodes and QR codes on virtually all manufactured products are going a long way to making the prophecy a reality. We haven't quite got to barcoding people (although many have inserted tags under their skin – see Dr David Maddison's article on "Biohacking" in the August 2015 SILICON CHIP).

Obviously, computers and networks have come a long, long way since those days. And as more and more people upgrade to faster and more powerful computers, and migrate to faster and much higher capacity broadband (did someone mention the NBN?) so the number of devices connected to the 'net and the sending/receiving of data has also grown enormously.

So yesterday's dream has become today's reality – and

Internet-connected fridges (such as this Samsung) were set to become the "next big IoT thing" but while still available, haven't exactly set the world on fire!

Libelium Smart World



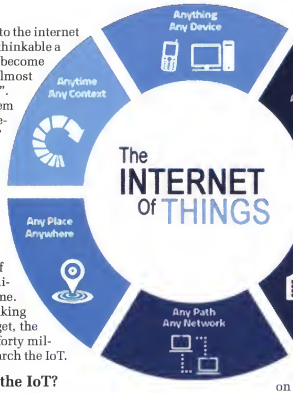
This graphic, courtesy of Spanish company Libelium gives an outstanding insight into the role IoT can and will play in the future. Libelium have developed an enormous range of IoT-based products, particularly in the agricultural, mining and related fields. (www.libelium.com).

then some. Things connect to the internet which would have been unthinkable a decade or so ago. They have become the Internet of Things, almost always abbreviated to "IoT".

You might also see them referred to as "connected devices" and "smart devices" but we'll stick to the IoT moniker.

It may be something as simple as having an on/off switch which can be simply read, or perhaps even controlled, over the internet. Or it may be an incredibly complex piece of equipment with lots of monitoring happening in real time.

Even Governments are taking notice – in their 2015 budget, the UK Government allocated forty million pounds to further research the IoT.



What "Things" are in the IoT?

This is one of the most attractive parts of the IoT – because those "things" can be virtually anything that has the "smarts" to connect to the 'net. That could be anything from a huge building (or even a whole town or city) to a circuit board you can easily fit in your pocket – and just about everything in between.

And if they don't have those smarts, a tiny module – or even a chip – can be attached or embedded which gives them same.

All they need is the ability to collect the required data and assemble it into meaningful packets, then transfer that to the internet.

Smart City, Smart Grids and Smart Energy Management wouldn't be possible without IoT. If you haven't come across those terms yet, just wait a short time!

We've all heard of internet-connected domestic fridges which can report low product levels (and even order replacements in some cases), report power outages and temperatures and even, in some really clever cases, call your mobile phone to tell you that you've left the door open! Really clever? No, actually quite simple for IoT.

But the things can also be much larger – the equipment in complex industrial plants, for example – and much smaller – such as the trackers regularly advertised in SILICON CHIP by KCS Trace-me (see outside back cover of this issue).

You should be starting to get the idea that the capabilities of the IoT are unlimited.

Let's bring it back to a personal level: you have a child (or a pet) who is prone to wandering off (or even grandpa with dementia!). Fit them with a tiny device (say on jewellery, a collar or even sewn into their pocket) and you'll never wonder where they have wandered to again! They will tell you, without even knowing they're doing so.

What if grandpa had a pacemaker fitted? Yep, there are now IoT pacemakers! Without having to cut grandpa open again, they let the heart specialist know instantly if something is wrong – with the pacemaker or grandpa!

Vehicle manufacturers are now connecting cars as IoT devices. For example, the Nissan LEAF electric car calls Nissan in Japan every day and reports its operation. Nissan engineers know something is wrong before the driver! Similarly, those fortunate enough to own a Tesla will know their vehicle operating software has been updated without any involvement from them – I believe it's now on version 8 and incorporates many "driverless car" features. And again IoT sends Tesla all the operational data.

There are almost endless applications in agriculture, many of which are already in existence. Stock can be fitted with low-cost IoT "tags" which can operate on many levels. At a minimum, they can operate as the human tracking example above – think of how much time and money would be saved when mustering a large herd of cattle.

At a higher level, the tag could report on the animal's health; even if it was pregnant or calving. Or it could report "market ready" parameters such as weight and fat content. At the same time, each of the dams on the property could be reporting their depth and the volumes of water being pumped. Each gate could be reporting if they were open or closed. The fuel tanks could not only report their levels but could call the fuel agent with an order for replenishment – all without human intervention.

Then there's all the on-farm data which has been traditionally gathered by hand: cropping information, soil moisture content, pH and chemical composition, for example. Now there are IoT applications to do it. (The Spanish company responsible for the graphic overleaf specialises in developing such applications).

We've even seen one robot which traverses fields and identifies weeds (against a record kept somewhere else). If a weed is identified, the robot sprays it – and only it – with a herbicide. Remember, these robots don't require any human intervention.

Getting the data out

We've already mentioned a few types of IoT sensors but there is virtually no limit to what they are measuring/reading and the data they are sending.

Because each Thing is effectively a node on the internet it doesn't take too much imagination (read programming ability!) to work out that the data can be used for whatever the user wants to use it for.

It also allows Things to work together to do certain tasks that they have been programmed for – for example, the same company that supplied the graphic on page 27, Libelium, recently told us the Dutch authorities are using IoT to keep track of users on the hundreds of kilometres of canals, lakes and inland harbours of The Netherlands.

It's not just assisting in navigation, that is getting from point A to point B – paying tolls, for example. IoT can even automatically stop traffic on approach roads and open a lifting bridge as a riverboat or barge approaches and closing it once it has passed.

Costs have been dramatically reduced because of the massive decrease in manned bridges!

Where does the data go?

Answer: anywhere you like! Having the data is one thing, using it is another. Ignoring (for a moment) just how the data gets from point A to point B, it is generally encrypted for security and sent to a server on the Internet – for example, to "The Cloud" (another term still not well understood).

Somewhere else (hence, the Cloud) there is a program running to do something – anything from storing the data in a database which others can query via their device (eg, a notepad computer or mobile phone) or even have an action happen because of that data – "warehouse X is below stock on widget Y – refill".

Usually, IoT relies on wireless connectivity. Sure, you'll find some IoT devices hard-wired but the vast majority rely on wireless, such as WiFi, Bluetooth, ZigBee and cellular, or emerging technologies such as LoRa (see panel) and cellular M2M (machine to machine).

Indeed, it's wireless connectivity which has spawned a large part of the IoT. And conversely, the burgeoning IoT is also responsible for the rapid development of many new wireless technologies such as Sigfox, LoRaWAN, Symphony Link and Ingenu.

IoT in action

In the past, a piece of equipment in a factory might have had a thermostat on it, with an alarm sounded if it got too hot. With IoT, that thermometer has become many active temperature sensors, either flagging temperatures outside operational norms or, more likely, wirelessly reporting temperature data on a continuous basis to a computer in the maintenance area. It could then warn of unusual temperatures as part of that plant's ongoing records.

So IoT simply means things which are able to connect to the Internet and send or receive data. Or more formally, a robust network of connected devices. How many devices? At last count, BILLIONS (but who's counting?)! The analyst firm Gartner says that by 2020 there will be over 26 billion IoT devices. Others say this is way too low – perhaps as many as 100 billion.

In fact, the IoT is already having a major impact on our lives – and this is only going to grow as more and more devices join in.

Just some of the benefits of IoT are:

- remote monitoring and control of equipment
- fault reporting (or better still, potential fault reporting before the fault occurs)
- fault action (self-repair, bypassing, etc)
- advanced data analysis and action
- more agile (and faster) communications networks
- automation
- real-time performance analysis
- reduced costs
- enhanced safety
- tracking "things" – knowing where they should be and/or going where they should be!

About LoRa

One of the more interesting wireless technologies emerging is LoRa. As we mentioned earlier, most people would know the name means Long Range – that's up to about 50km or so line-of-sight (LOS) in non-urban areas – but there is a lot more to it than increased range.

For a start, it's very cheap to not only integrate into Things but is also cheap to use. With so much competition around these days, that's important! But what is it?

LoRa is a radio modulation format that gives longer range than straight frequency-shift-keying (FSK). It uses a particular spread-spectrum technique called Chirp Spread Spectrum (CSS) and it uses forward error encoding in combination with whitening and interleaving, meaning the wireless signal is less prone to interference and/or errors and is therefore cable of being received over a significantly longer distance.

To put that in simpler language, it has been described as a "frequency modulated (FM) chirp". (If you're *really* interested, the LoRa patent can be read in full at www.google.com/patents/US7791415).

It uses lower frequencies than WiFi, around 860MHz to 928MHz (depending where you are) with a low transmitter power. Normally the lowest data rates mean the longest range and vice versa.

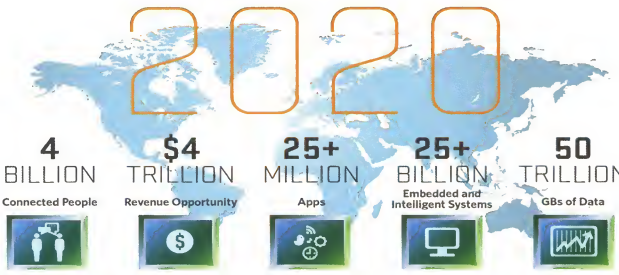
Because of its very low power requirements, LoRa is ideal in battery-operated IoT devices and has found many users in this area. Indeed the LoRaWAN (LoRa Wide Area Network) specification (owned by Semtech) is intended for wireless battery-operated Things in regional, national and even global networks with data rates between 0.3kb/s and 50kb/s. While that may seem to be fairly low speed, the upper end of the standard can achieve some quite impressive results.

The LoRa alliance is an open, non-profit association of members who believe that the IoT era is now. It was initiated by industry leaders with a mission to standardise Low Power Wide Area Networks (LPWAN) being deployed around the world. LoRaWAN is a global specification created by the LoRa Alliance to drive a single standard for seamless interoperation across the industry.

For experimenters, the good news is that LoRa modules are available for the Arduino Waspmote and the Raspberry Pi, among other platforms.

Key features of LoRa Technology and the LoRaWAN protocol are:

- **Long range** – deep penetration in dense urban environments and deep indoor coverage with much longer range in rural areas.
- **Low cost** – reduces both upfront infrastructure investment as well as ongoing operating cost.
- **Low power** – the LoRaWAN protocol was made specifically for low power and enables multi-year battery lifetime.
- **Standardisation** – LoRaWAN ensures interopability among applications, IoT solutions and telecom operators to speed adoption and deployment.
- **Geolocation** – enables tracking applications without GPS or additional power consumption.
- **High capacity** – supports millions of messages per base station, ideal for public network operators serving many customers.
- **Security** – embedded end-to-end AES128 encryption of data, ensuring optimal privacy and protection against unauthorised access.



Source: Mario Morales, IDC

If you thought the IoT was big now, here is IDC's forecast for just over three years away!

- better service – and happy customers!

Naturally, there will be some disadvantages:

- potential for IoT devices (or their links) to be hacked or even infected, either for gain or simply malicious.
- potential for IoT devices themselves to become clandestine surveillance devices, reporting information to someone, somewhere . . .
- fragility – there is increased reliance on a working internet connection – and we all know how (un)reliable it can be!
- reliance on power being always on, which comes at a cost.
- increased bandwidth usage, which comes at a cost.

Other IoT examples

An internet-enabled security camera is a good example of an IoT "Thing". While it may only see a particular scene, many can also detect movement – and send a warning to somewhere else . . . over the internet.

At an "entertainment" level, it's people from all over the world playing games with each other – via the internet, obviously. Then you have the hobbyists and tinkerers working out how to make their "things" do more, work faster, gain an advantage over their opponents . . . and much more.

At a business level, it's about efficiency and security – efficiency in the way materials and goods are handled, transported, sold and used; security in all its iterations from to protection against loss or damage through to timely and accurate financial data. Mission-critical applications can benefit from assurance that every facet is where and when it is supposed to be and is operating exactly as it is supposed to be.

Train cars passing a certain point can report their location and even what they have on board to a waiting receiver (it doesn't even have to be trackside) ready to be promulgated to a network. If a particular car doesn't report in, or if a car that isn't supposed to be in that train does, investigations can begin.

Go larger yet again: sensors placed along a dam wall which measure the strain by sensing tiny changes in their location and feed the data, via the net, to a control room hundreds or even thousands of kilometres away. Beyond a certain tipping point, alarms can be generated warning of possible collapse.

These are just a few of the already-in-place IoT applications. And there are thousands (or more likely hundreds of thousands or even millions!) more – with thousands of new ones every day.

Because of its relatively low cost, businesses and corporations all over the world are jumping on the IoT bandwagon – and probably just as many start-ups help them to do so.

Innovation

IoT applications don't rely on expensive legacy processes or infrastructure. There are so many IoT processes and products emerging that bypass the bottlenecks of the past simply because the information required to do so is instantly available – and available at miniscule cost.

An example? You've all seen those TV programs where a passenger relaxing in the airport bar, misses their boarding call and necessitates having their baggage removed from that flight. In the past, that was a manual search through the luggage of perhaps 300-400 people, with consequent delays in flights. Now, each bag can be tagged to say "here I am!" so it can be offloaded in minutes. And all the other bags can tell sensors their destination ports and be routed correctly.

If you've experienced a lost bag you'll know how incredibly frustrating it can be. So as airlines adopt new IoT technology, every bag will get to where it is supposed to – unless some human interferes and manually re-routes it!

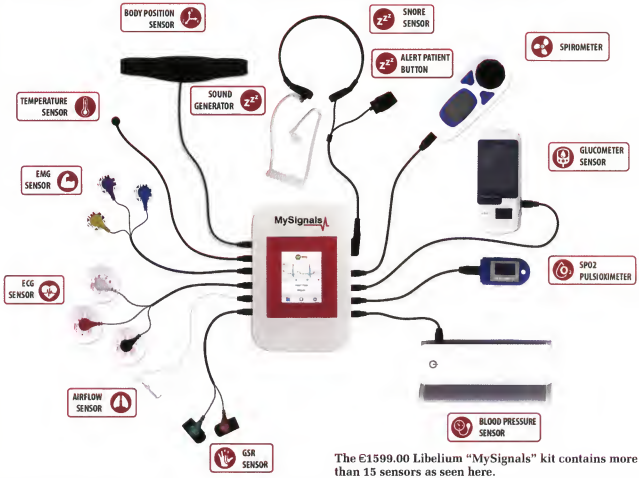
We mentioned safety earlier. One major power utility in the US placed IoT sensors on critical equipment to continually monitor and predict faults.

The data from those sensors (eg temperature, overvoltage, etc) translates into action, preventing blackouts and saving millions of dollars.

Machinery and equipment in any industrial application will wear. IoT can report excess wear and/or failure so the company can determine immediately what needs attention or service, usually significantly in advance of when they'd know "the old fashioned way".

Even if you don't think you're using the IoT right now, just stand by for the IoT explosion!

A "Real World" IoT Application: MySignals Platform



The €1599.00 Libelium "MySignals" kit contains more than 15 sensors as seen here.

As we went to press, an interesting email arrived promoting an IoT device/application which ably demonstrates what the IoT is capable of today.

It's a product called "My Signals" and is described as a development platform for medical devices and eHealth applications.

It measures more than 15 different biometric paramaters which are then sent to The Cloud, ready to be used (despite their all-encompassing disclaimer!) by health care professionals, specialists, researchers, OEM customers ... or even just to have an ongoing record of your own health.

A device such as this could find a place in a doctor's surgery, with the doctor using as many sensors as appropriate to monitor and read his/her patient's symptoms. The doctor wouldn't even need to record the data because it would all be done automatically in that patient's file, to be either reviewed later or, if necessary, to be referred to a specialist for opinion.

Conversely, it could be used in the patient's home (especially remote patients) with the data sent to a central location for review. When you think about it, the applications are endless.

As they say, "MySignals changes the future of medical and eHealth applications".

"MySignals" is merely the starting point allowing both software and hardware developers to use the platform to think of a whole range of innovations in the health care field.

App developers (who don't want or need to cope with hardware issues) have a quick prototyping platform to work with. Conversely, hardware developers, researchers and makers have complete access to the MySignals PCB and electronics.

MySignals has a Libelium IoT core with CE, FCC and IC certification. It includes cloud access along with Android and iPhone Apps. The hardware is also compatible with Arduino SDK so developers don't have to re-invent wheels. Data gathered by MySignals is encrypted, then sent to the developer's private account at the Libelium Coud. One year of free Cloud storage and history visualisation is included with the MySignals.

There are models using WiFi, LoRa and cellular (3G/4G).

Specific health research users can choose from any of the 15+ sensors used to monitor 20 biometric signals that are currently available, or can design and build new sensors which particularly suit their field. Current sensors include everything from scales and ECG monitors through to temperature, blood glucose and blood pressure monitors.

The information about MySignals didn't come direct from Libelium but from Cooking Hacks, an associate, who specialise in electronic kits and components for makers, universities, high schools and students who want to be a part of the IoT revolution.Learning kits start at about $AU24.00

You can contact them at: www.cooking-hacks.com; email info@cooking-hacks.com or phone +34 (Spain) 976 547 492. SC