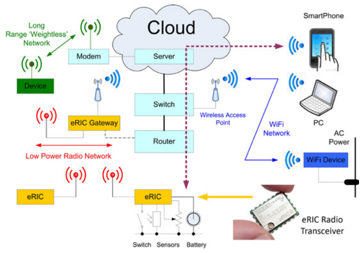
LPRS

Europe's leading supplier of short range radio modules and solutions.

The Internet of Things (IoT)

Transforming Daily Life

Mike Meakin looks at the role of the new 'eRIC' Radio Transceiver within the 'Internet of Things' (IoT). Industry analyst's hearts have been set a-flutter by the incredible prediction that there could be over 50 billion new devices connected to the Internet by 2020. This number exceeds today's human population of the earth by almost a magnitude and will almost certainly create the world's biggest 'club'.



A typical IoT local network with eRIC.

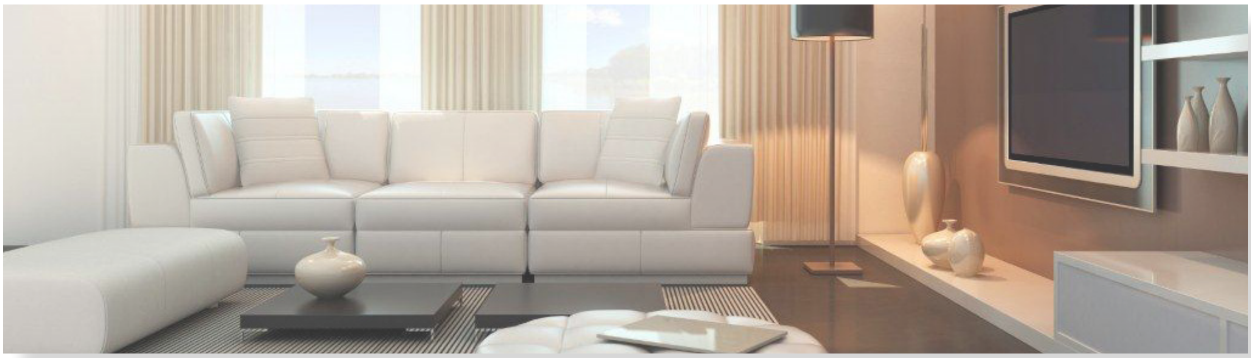
These new devices will not be the traditional internet connected PCs, phones or TVs but will comprise myriads of sensors and actuators that will talk in a common tongue, reporting their news and then obediently acting upon the terse commands of their masters, hidden somewhere in the 'Cloud'. This harmonious intercourse will also generate vast amounts of data, which, through careful analysis by trusted agents will provide us with blinding insights and offer the possibilities of efficiencies that may well offer a means to save our bloated planet. Or so, the analysts tell us!
Without doubt these predictions will come to be as we have already made some considerable progress in this direction with so called 'Machine to Machine' communication (M2M) devices that have, for many years allowed remote control and monitoring through both cellular networks and the Internet. All that will happen is that in some cases, the tentacles will become a little thinner and will be reaching into places that it is now hard to imagine. At a more humble level we are offered a hackneyed vision of refrigerators that automatically order pizza replenishment or central heating systems that respond to our distant wishes of perfect domestic bliss.

From industry to agriculture, in our homes and vehicles, any device that measures or senses the real world will be able to share its data, be controlled or monitored from anywhere else in the world.

Whilst some of these new devices will be connected by traditional wired network technology (Ethernet / other industrial protocols), many of them will be 'wireless', allowing battery powered portable operation and very small physical size. Many different wireless technologies now exist; this article will look at some of the 'pros and cons' of these different offerings.

The existing traditional infrastructure (light blue) comprises a cloud based server connected via broadband to an in-building switch and a network router. The server runs the data storage and processing services as a client of an IoT service provider such as Xively (was Pachube). This data can be made accessible from any other device connected to the Internet, which may raise data security issues. The data flow is bi-directional allowing both sense and control, to and from any connected device.

"Building penetration of Wi-Fi operating at 2.4GHz and above is quite poor. Many will have experienced this phenomenon as they struggle to achieve satisfactory room to room Wi-Fi communication within just a small house."



Wi-Fi

A Wireless Access Point (WAP) connects to the Switch providing a 'wireless' Wi-Fi connection for the network. This allows the familiar connection of portable devices such as smartphones and laptop PCs allowing both local and remote devices to be controlled and monitored by easy to use graphical interfaces. The ubiquity of Wi-Fi connections make this an attractive medium for the wireless data devices themselves and manufacturers such as Electric Imp and the Nest Thermostat do utilise this convenient medium.

One of the main considerations in using Wi-Fi is that building penetration of Wi-Fi operating at 2.4GHz and above is quite poor. Many will have experienced this phenomenon as they struggle to achieve satisfactory room to room Wi-Fi communication within just a small house. These microwave frequencies are absorbed by brickwork and are often completely defeated by the foil based linings used on plasterboard building materials.

The transmit power consumption (typically 5V @ 250mA) of a Wi-Fi based devices should also be considered as should the receiver quiescent current if continually powered. The diagram (page 1) shows this Wi-Fi device being powered by a mains power supply adapter as this is the most likely method to cater for such power demands. Wi-Fi does offer relatively high data rates (useful for streaming) but most IoT devices generate very small amounts of data so would have little need for this bandwidth.

The Wi-Fi device/radio processor will need to hold a substantial and compatible Wi-Fi protocol stack that, by itself will consume both space and system resources. Furthermore a secure mechanism for joining and re-joining a device to an existing Wi-Fi network (acceptable to a user) will need to be devised. This may leave little spare processing power and the use of an additional external applications processor will probably be required. In summary Wi-Fi is a convenient, but a power and resource hungry solution.

Bluetooth Smart

Another technology, again operating in the busy 2.4GHz frequency range, is Bluetooth's latest variant; Bluetooth Low Energy (BLE), recently rebranded as Bluetooth Smart. Traditional Bluetooth was designed for short range phone to phone/device applications such as file transfer and can be power hungry: to such an extent that smartphone users are reminded to switch off the service when not required! There are restrictions on the number of devices that can interconnect with each other and connection setup (pairing) is often both cumbersome and time consuming. BLE has addressed many of these problems, overall power consumption is greatly improved and connection set up time can be a few milliseconds.

Data sheet ranges of up to 100 metres are suggested but that will probably be open field Line of Sight (LoS). The use of 2.4GHz, a wideband receiver front end and data rates of 100kbps or more are always handicaps to great range.

"The use of 2.4GHz, a wideband receiver front end and data rates of 100kbps or more are always handicaps to great range."

Weightless (WhiteSpace)

There are, of course other means of connecting battery powered wireless devices to the Internet. An example being the recently announced 'Weightless' system that utilises the managed re-use of redundant TV frequencies (WhiteSpace) and sophisticated signal processing techniques to offer a promised 10km range and an eventual $2.00 chip cost. This topology eliminates the need for any existing local network infrastructure as devices communicate directly with extra-mural base stations. Using cellular techniques of frequency re-use these connections can potentially cover large metropolitan areas. This technology is still in the early stages of development but if and when established, will be most attractive for those applications where there is no internet connection within range.

Low Power Radio Bands

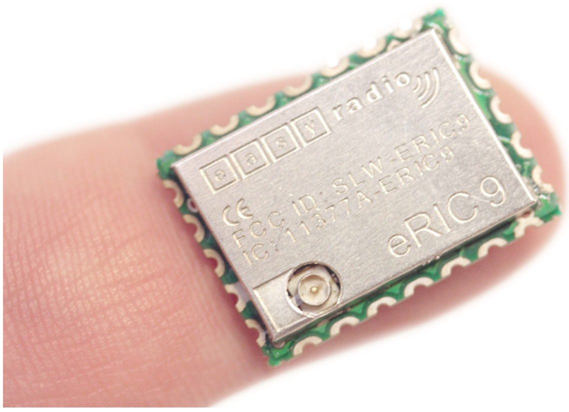
Probably the most interesting solution for local wireless network communication is the use of the generic low power radio bands. This is a well-established technology allowing 'licence free' operation on the Industrial Scientific and Medical (ISM) bands. The most usual operating frequencies, covering Europe, the US and much of the Rest of the World are the UHF frequencies of 434MHz, 868MHz (Europe) & 915MHz (US). These relatively lower frequencies penetrate buildings well and at the allowable power levels can easily offer ranges of up to 500m in open space. Furthermore the bandwidth and the architecture of the receivers can be tailored to the application with the benefit that narrow band (low data rate) receivers will offer much greater range, immunity to interference and allow multi-channel operation. Continuous receive and transmit power consumption of such devices is typically a magnitude smaller than Wi-Fi devices. It is also relatively easy to implement power saving schemes such as 'duty cycling' where devices wake up from 'sleep', sniff for RF activity and then return to sleep if no signal is detected. Such mechanisms can reduce average power consumption to sub micro amp levels allowing operation for many years from a single coin cell.

Suitable Radio Protocol

If following this path the next consideration will be the choice of a suitable radio protocol that defines the packetizing of the 'bits' of data and how and when messages are sent and received. Many proprietary standards exist (e.g. ZigBee) and if interoperability between different manufacturer's devices is required then one of these must be chosen. There is then, often a mandatory requirement to 'join the club' and before placement on the market submit the product for extensive compatibility testing and approvals. This is not without significant upfront costs. Whilst 'standards' are just that, they do change over time often by additions that may bring issues of back compatibility with existing devices already installed in the field.

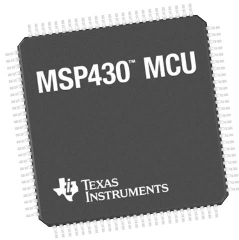
The need for sophisticated proprietary protocol stacks with their inherent complexity should perhaps therefore be questioned and before deciding upon the use of a 'standard' it may be prudent to look at the actual task demanded.

In the scheme illustrated (page 1, domestic or small commercial environments) it is likely that the devices (a small number) will always be within wireless range of a 'base station' (Gateway) so there may be little need for a complicated 'mesh network' where each device acting as a repeater can extend range. The devices will probably be sending and receiving infrequent, short command and control messages. They may also be battery powered (e.g. wall mounted thermostat, humidity sensor or LCD display) and power hungry transmission time will need to be greatly restricted.
At their most basic, the message payload could simply comprise a source and destination address, a few bytes of data and a security checksum – adding up to a modest total of some tens of bytes in all. Writing such communication software for wired connections is straightforward, however sending data over radio links is much more difficult as they will be subject to noise and interference. The receiver will produce digital white noise on its data output in the absence of signal, pulse widths will be distorted by 'jitter' and long strings of ones or zeroes will not be tolerated by the AC coupled signal path.



easyRadio

This problem was addressed some years ago by Low Power Radio Solutions (LPRS) who developed 'easyRadio' that combines a low power radio transceiver with an embedded microcontroller to provide a simple to use, serial data in, serial data out interface. A well established range of modules is available but until now the embedded microcontroller has not been exposed to the user. The latest of these modules is eRIC, the easyRadio Integrated Controller module that has been designed specifically for deployment in 'Internet of Things' networks. It is based on a Texas Instruments (TI) System-on-Chip device that combines a radio transceiver and an integrated MSP430 microcontroller. The built in operating system resides in a protected memory partition and the other partition is made available for



user programs that can be generated and compiled using the free TI Code Composer Studio software.

The multiple I/O lines can thus be easily configured to interface external circuitry to the generous internal resources. In many cases all that may be required is just a battery and a sensor. A 'free' on-chip internal temperature sensor is even provided!

The embedded operating system provides familiar easyRadio services that include serial input/output and the simple configuration of operating frequency, power outputs and data rates etc. without the need to write a single line of code!

Networked eRIC devices communicate directly with an eRIC-to-WiFi or an eRIC-to-Ethernet Gateway that transports messages to and from the Router and the Internet. The data within the messages is encapsulated by software running on the bridge and the use of suitable Internet Protocols to allow communication with the Cloud based server.

eRIC offers simplicity and minimal cost for sensors and actuator nodes and will therefore be a good choice for application in many home/factory environments operating under the umbrella of the 'Internet of Things'.