Little power leads to big things

Ultra low power communications will contribute to an upcoming technological revolution, but balanced design strategies are needed. Isaac Leung writes.

Ultra low power (ULP) communications is currently predominantly used in the industrial space. It is found in sensors and devices which run on batteries and energy harvesters, usually for monitoring of infrastructure and facilities.

In many cases, these devices sit dormant until they have gathered the data needed, before turning on briefly to transmit the data, and then lapsing into standby again.

But as the demand for granular and remote control trickles down into the wider world, ULP communications is set for a boom as the much touted but little-understood "Internet of Things" starts becoming a reality.

The thinking behind the "Internet of Things" is for a burgeoning number of devices, or things (think tens of billions globally) to be connected to the Internet by 2020.

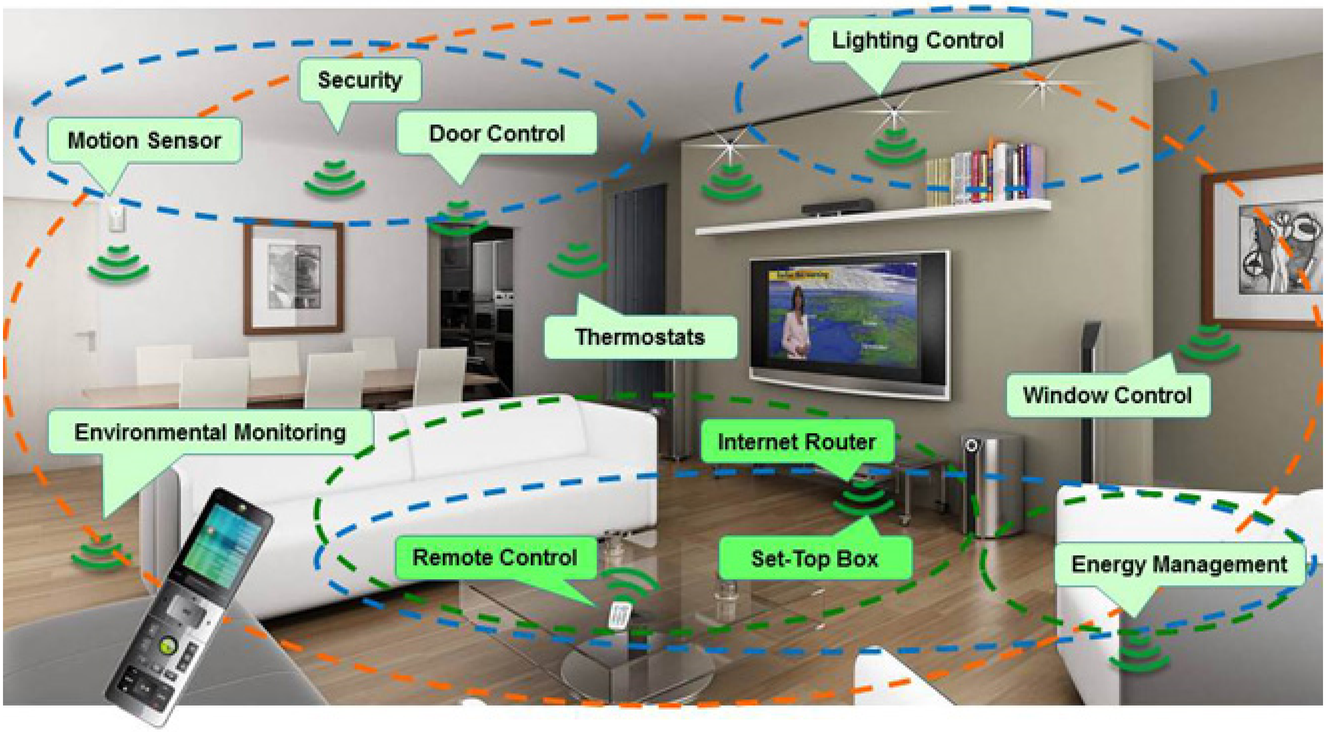

Image 1: A smart home setup. Credit: GreenPeak Technologies

ULP communications will be an enabler of this new paradigm, because while many devices may have access to mains or regularly recharged batteries, many others will not, and will need to operate for years, if not for the entire product lifetime, on miniscule batteries, or run on energy harvesting technology.

Remote monitoring and control is a large part of the "Internet of Things", and for the average home, there may be tens if not hundreds of sensors and switches for doors, lights, climate control and security. All of these will have to run in a truly wireless manner – and still be capable of transmitting and receiving information.

Optimisation strategies

Various chip-level design factors affect power consumption, such as the chip manufacturing geometry, the architectural build-up of the chip, and the system level design.

GreenPeak Technologies offers ULP wireless data communication controller chips for smart home applications. According to founder and CEO Cee Links, while digital chips continue to ramp up in capabilities and thus power consumption, there is a certain sweet spot for power consumption within the analogue/mixed signal chip market.

Selecting these sweet spots are an essential first step in creating a communications system with ultra low power consumption.

Two strategies, which together reduce power usage are: low peak current during communication (transmission or receiving of data); and low leakage during standby mode.

ULP communications operate on the same general principles as ULP MCUs: energy consumption is the product of power used and the time it is used. The goal is to reduce one or both sides of the equation.

“When the chip is working (transmitting or receiving) one tries to minimise the time the chip is really switched on, and also that only those parts of the chip are powered are really used,” said Links.

The same applies for the chip’s sleep mode: only those parts of the chip which are necessary to wake up the chip should be powered.

“There is no magic here: smart engineering and experience is the key,” Links said.

Short and sweet

Victoria-based Clarinox Technologies has, for the past 11 years, focused on wireless communications for embedded technologies. Clarinox solutions have a wide range of application areas from automotive industry to medical and telecommunications to consumer electronics.

According to Clarinox owner Trish Messiter, one of the best ways to reduce the power required for data transmission is to use the maximum available data rate during transmission, resulting in a shorter transfer time and thus conserving energy.

“In addition, if possible, utilise the received signal strength indication (RSSI) to adjust transmit power (i.e. if closer, use a lower transmit power),” Messiter added.

Using compression techniques to reduce the amount of data needing to be transmitted can also help, although in most ultra low power applications, the amount of data to be transmitted tends to be already miniscule.

In fact further attempts at optimisation through coding compression algorithms may turn out to have its own cost and energy penalties in the bigger scheme of things, since it increases the processing load.

A simpler way of reducing the size of the data transmitted would be to establish protocols for communications.

“For example, instead of sending temperature in ASCII form which is easier to read, it could potentially take only one quarter of that space if binary data values are sent,” pointed out Messiter.

“Similarly, instead of sending error codes in ASCII verbose form, an index could be used (i.e. send 0 instead of “NO ERROR”, send 1 instead of “VALVE CANNOT BE CLOSED” etc.).”

Avoiding interference

While all solid chip design includes measures to minimise the impact of EMI/EMC, ULP communications designs tend to be more sensitive to the effects of interference. If one is trying to minimise energy usage, failed attempts at transmission due to interference have a bigger cost.

Even more challenging is the interference which could occur if there are other signals in the same band, such as WiFi and Bluetooth co-existing on the 2.4GHz band. Minimising interference and optimising performance requires in-depth knowledge of these transmission technologies.

“When a Wi-Fi-chip and a ZigBee-chip are in the same box, one can make sure that every chip waits for its turn to transmit, and avoid interrupting the transmission of the other,” said Links. “For inbound signals there are mechanisms like “listen-before talk” – if there is something going on, wait a moment and then listen again to see if the medium is free.”

“To avoid making devices wait for each other too often, different channels can be selected to stay out of each other’s hair. ZigBee for instance has an agile frequency assignment protocol (within RF4CE) – to reduce the number of so-called collisions.”

Challenging balance

According to Messiter, design by definition is the challenge of developing the optimal compromise between conflicting constraints. In the case of ULP communications, this is truer than ever.

For example, lowering the operating voltage can reduce power consumption in a straight-forward manner, but also increases delay and reduces clock frequency. This could in fact result in an overall rise in power consumption.

There is also the problem of reducing power use without reducing range, and increasing design and chip cost. The balance between multiple inter-connected variables must be maintained.

“Concentrating on one item in itself may be fairly straightforward, but excelling in one area without sacrificing another area is a very tough challenge,” said Link.

Technology and more advanced design tools could be the answer. Clarinox, for example, has developed sophisticated tools in house for debugging and optimisation of the software, which in turn gives the ability to adjust and tune the power consumption of their solutions.

With these tools, designers can analyse the information and communication protocols, and monitor the variables millisecond by millisecond to help optimise designers.

Unprecedented connectivity

Continued development of ULP communications solutions will be a key in ushering in an era when hundreds of devices per household will be connected to the Internet, opening up new opportunities for interaction and control.

ULP communications are considered a necessity for the “Internet of Things”: it will allow manufacturers to quickly and easily integrate Internet connectivity into a wide variety of devices and structures, and be assured of their constant availability with minimal maintenance.

In addition to the obvious implications like smart homes, the Internet of Things, with its increased number of nodes and thus improved monitoring and control, has the potential to improve healthcare, allow more efficient agriculture, provide early warnings for disasters, enhance asset tracking and improve the efficiency of buildings and facilities.