The Cost of Wireless Standards

Putting a price on the invisible and paying for interoperability

It costs more and takes longer to develop a short range wireless standard than most people think. This article looks at the issues involved in taking a wireless standard from concept to a secure and interoperable specification, then estimates how much it cost to achieve that with Bluetooth, Wi-Fi and ZigBee.

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The Cost of Wireless Standards

How much does it cost to produce a wireless standard? And how long does it take? Surprisingly those aren't questions that are asked very often – probably because most developers are happy to use what already exists rather than starting again from scratch.

In the UK, some members of the smart metering programme have begun asking these questions, potentially for the wrong reasons. They've realised that ZigBee – the current front-runner for the UK smart metering deployment, can't provide the range to cope with every single house or block of flats, and have started wondering about whether it might make sense to start again from scratch.

A few years ago, when I was writing my book on the Essentials of Short Range Wireless I attempted to put some numbers to those questions. It seems an appropriate time to publish them, as the answers are a lot more and a lot longer than most people think.

Most of the short range wireless standards we know today started their lives at the end of the 1990s. At the time, even those involved in developing them were rather naïve about the time it would take. I recall sitting in early standards meetings for most of them, being shown roadmaps that would lead to completed specifications and real consumer products within eighteen to twenty-four months. Bluetooth even set itself up with the anticipation that everything would be done and dusted within three years and the board could then be disbanded. Despite the early optimism, it didn't happen that way for any of them.

The first question in trying to assess the cost for developing a standard is how to assess the end point, when it can be considered to be complete. It's a difficult call, as we've seen each of the short range standards go through multiple versions as they try to solve the two most intransigent issues – security and interoperability. So I've made a unilateral decision, which is the point at which the standard has shipped fifty million chips.

Fifty million seems a valid estimate for a number of reasons. Firstly you don't really discover the state of your security until you've shipped around that number of devices. The reason is simple – it's because most hackers, whether ethical or otherwise, won't bother trying to break a new standard until there are a few tens of millions of devices on the market, because there's not much kudos in cracking something no-one's aware of. So fifty million is enough to get them interested and find the problems. And it gives developers time to try and fix the first few security flaws. That generally needs a number of releases of a standard. How quickly that's done depends on the critical mass of developers contributing to it, which takes us neatly back to the volume of chips being shipped. Success brings resources into the process. Looking at the three main short range wireless standards, it took them around seven years to get security right.

Bluetooth	8 years
Wi-Fi	7 years
ZigBee	8 years

The time it takes to get security right

These are subjective times. Bluetooth took a little longer because it does more things. The point I've chosen for Bluetooth was the release of the 2.1 version of the standard, which introduced Secure Simple Pairing. Wi-Fi finally got its house in order with the release of WPA2, and ZigBee with the ZigBee PRO release and the Smart Energy Profile, which mandated its use. All of them will probably need further releases as hackers discover issues, but for now they're all considered fit for purpose.

The second reason for selecting the fifty million metric is interoperability. Interoperability is something that takes time. In the first few years of a standard there are relatively few devices available and their manufacturers collaborate closely to make sure they work. As the standard takes off, an increasing number of companies making products begins to expose areas which are open to interpretation, requiring further revisions of the standard and the development of more robust certification programmes. The time to reach that point is not dissimilar to the time to get security right.

Bluetooth	7 years
Wi-Fi	6 years
ZigBee	9 years, but not there yet

The time it takes to achieve interoperability

I'd argue that interoperability only really arrives when you can test your product against a test harness, rather than against golden units, by which definition ZigBee is still on the path towards attaining it. And the more optional features a specification has, the more difficult it is to achieve interoperability. It's a long, slow road, but all three are now well down it.

Comparing these times against how long it takes to reach the 50 million mark, it looks as if 50 million might be an over-optimistic figure. But I'd argue that it's still a relatively good point to look at costs. By this stage in their evolution, standards will have started to settle down and if they're lucky, seen the hockey stick of growth begins to kick in. After that, making cost comparisons becomes less meaningful as investment will move from standards evolution to commercial volume.

It takes different standards varying amounts of time to get to this level of shipments. Standards like Bluetooth and Wi-Fi got the benefit of a "free ride" as they were incorporated into mobile phones and laptops before many people used them. This gave the industry the income to support standards development and spin several generations of chips, both of which help to advance the standard to a robust level of maturity. In contrast, ZigBee and most of its fellow standards never got this helping hand. Because they came into existence as the primary, and often the only means for a device to communicate, they had to earn their living in every product that employed them. That's a much more difficult challenge, which means it took them a lot longer to reach that important fifty million mark.

	50 million	Interop	Secure
Bluetooth	**4 years**	7 years	8 years
Wi-Fi	**5 years**	6 years	7 years
ZigBee	**10 years**	9 years	8 years

The time to reach the 50 million shipment mark

You can debate the exact starting point for any of these standards. Wi-Fi is a good example, as it has a long history, dating back to 1988, when it originated as the proprietary WaveLAN standard. During the 1990s it was adopted and advanced by the IEEE as the 802.11 standard, but it wasn't until they started work on 802.11b, operating at 2.4GHz, that the scene was set for Wi-Fi as we know it today. But that's true for most wireless standards – they're preceded by up to a decade of proprietary or academic development.

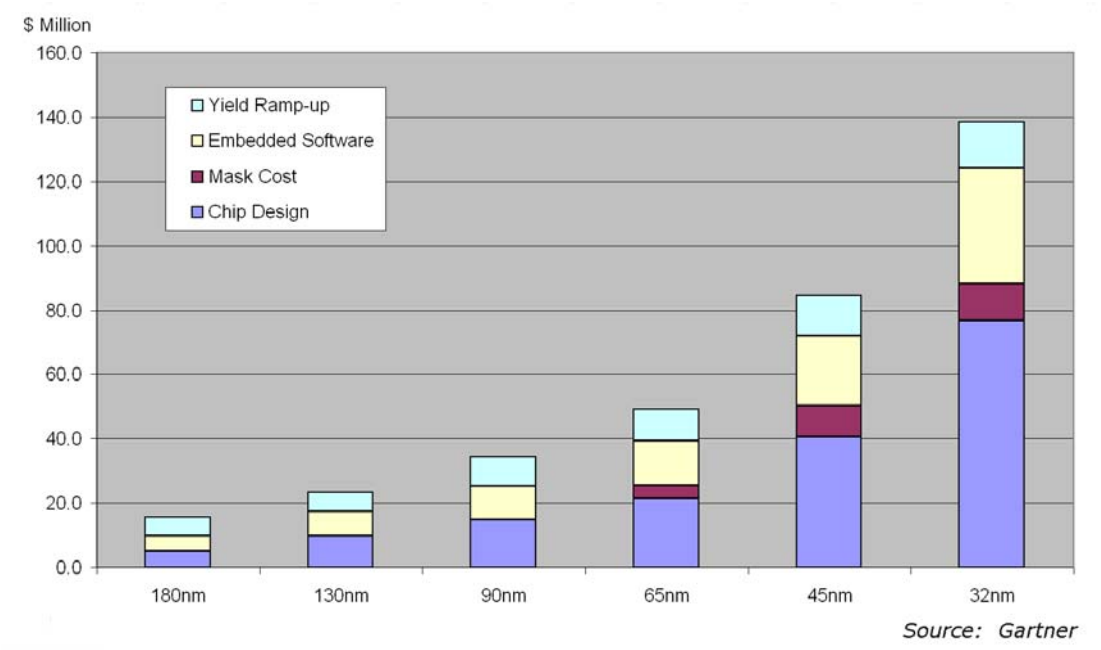
So what does that mean in terms of cost? To try and assess this I added up the Venture Capital investment that went into start-up companies working on each of the standards to get them to this

point, along with an estimate of the costs of internal development for established companies. To that I added the acquisition costs paid by companies to acquire start-ups who had developed relevant technology. As standards are developed by engineers who are funded by their companies, I've also tried to estimate what that might be, as it's a substantial outlay. I've not included any end product development costs – these are purely the costs associated with the development of the standard and the silicon development required to get the first 50 million chips to market. (For the purists, that also includes some Gallium Arsenide development in the Bluetooth figure.) The numbers don't include any revenue from these chip sales – it's just the cost to make them happen. Adding everything up produces the following estimates for the total development cost for each of these standards to reach the 50 million chip number:

Bluetooth	$ 1,800 million
Wi-Fi	$ 820 million
ZigBee	$ 950 million

The cost to reach the 50 million chip shipment point

For all of these standards, the evolution was broadly similar. The standard starts with a mix of large companies, and start-ups which rely on VC funding. As the standard takes off, more of these start-up companies are acquired by existing semiconductor companies who either did not start their own development, or wish to acquire some market-leading technology that came from a start-up. At some point after the 50 million mark is reached there's usually one successful start-up left which has a dominant position, with the rest having fallen by the wayside, or having been acquired. For Bluetooth that's CSR, for Wi-Fi it was Atheros (although they were acquired by Qualcomm last year) and for ZigBee it's Ember. The cost of Bluetooth is inflated in the table above by the feeding frenzy that occurred as established chip companies paid over the odds for some of the start-ups when they realised they were lagging behind the market leaders.



The rising cost of chip design

What this demonstrates is that it's not cheap to develop wireless standards. To get a standard to a state that's fit for market costs around a billion dollars. The reason that companies take this gamble is the potential scale of sales if the standard takes off. Despite the frightening $2 billion price tag for developing Bluetooth, the annual revenue for Bluetooth chips exceeds that and will probably

continue to do so for at least the next decade. And once a standard has reached that level, incremental developments become cost effective. The same economics apply to Wi-Fi, which is not far behind in terms of shipments. But it's increasingly difficult to repeat that trick and will become more so in the future. That's because the cost of designing chips is rising. A recent analysis of chip development costs from Gartner (shown above) illustrates that they are growing inexorably as device geometries shrink.

At the time that the Bluetooth, Wi-Fi and ZigBee standards started being developed, it cost around $3 million to get a new radio chip to market, with around the same again for firmware. Today most designers approaching a new chip would probably start working with a 65nm process. To reach the 50 million mark, along with the evolution of security and interoperability, requires around five different vendors spinning several versions of their silicon – realistically a total of a dozen different chips. At Gartner's estimate of $50 million per chip, that's a starting cost of $600 million, just for the silicon. This means that any organisation driving a new standard needs to have a convincing argument that it has the potential to sell over a billion chips every year. Otherwise the companies involved in it will not recoup their investment.

That's the reason that most of the recent "standards" which have appeared are essentially proprietary solutions, led by a single chip vendor. That's not to say that there are no new opportunities. DECT ULE and Bluetooth Smart (previously known as Bluetooth Low Energy, Bluetooth Ultra Low Power and Wibree, which indicates that a standard can devour quite a lot of marketing money as well) have both built new standards on the back of existing expertise. Even these take time – around 10 years for DECT ULE and six years for Bluetooth Smart, and precious few products are available on the market yet for either of them.

It's questionable how much room there is for another standard within the existing spectrum allocations. However, there is the siren call of brave new spectrum in the form of white space, which is waiting to be conquered by the likes of Neul (who gave us CSR and much of Bluetooth). That may well be the best opportunity for anything fundamentally new in wireless standards – so keep an eye on the Weightless SIG.

Against the reality of the development costs and time, it is both simplistic and dangerous to argue for new spectrum and new standards just because you don't like what's already there, or because you think it's less than perfect. But in the UK, that's a mantra that is being chanted by some of those involved in the smart metering specifications. It's a nonsense approach.

Developing a new wireless standard is a serious undertaking. Thinking you can take a radio and a couple of protocols and whisk them together like Gordon Ramsay or Jamie Oliver to produce something better is a recipe for disaster. Good wireless standards take time. And anything other than good wireless standards tend to sacrifice security and interoperability, making them a very dangerous and short-sighted waste of time.

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