IoT DEVICE COMPONENTS REPORT

SIMPLIFICATION DEMANDS SOLUTIONS NOT JUST COMPONENTS

Digi-Key ELECTRONICS

Simplified device design demands solutions not individual components

IoT lives and dies on the success of the applications it enables. The first two decades have seen enormous efforts made to understand how all the complex and inter-related technologies can work together and interoperate to create the devices needed to enable the applications but now, as deployments hit significant scale, we're entering a competitive market place in which trialling and pilots are taking a backseat to speed of deployment. This means device designers are increasingly looking for a simplified and accelerated approach in which building blocks of functionality can be rapidly integrated into devices

This simplification will be vital to enable economies of scale as device volumes rise to the tens of billions originally predicted to have happened by now. It also plays a critical part in the success or failure of organisations' IoT initiatives. Complex devices, developed in isolation, will result in delay to time-to-market as integration work and compliance with regulations slow the device creation process. This in itself will cost money but, of more concern, could also cost the opportunity to lead a new market segment because of delay allowing competitors to win customers.

In this report IoT Now managing editor, George Malim, assesses how approaches to IoT device components are being simplified and examines the trend towards utilising a smaller number of pre-integrated sub-assemblies to both save cost and accelerate time-to-market.

There is a lot of good news available to organisations looking to create IoT devices

There is a lot of good news available to organisations looking to create IoT devices. Costs for many of the key components are on a downward trend. Everything from cameras to chips and sensors to displays is reducing in price and larger volume IoT deployments will see greater purchasing power and access to economies of scale become a reality. As illustrated in **Figure 1** the average cost of IoT sensors was US$1.30 in 2004 and is expected to have come down to 38 cents this year. That figure is perhaps weighted towards the bottom end of the market but we are also seeing increased commoditisation of other key components that is substantially reducing the bill of materials (BOM) cost associated with IoT devices.

The question of cost

Cost is still the key determining factor regarding whether an IoT service gets the green light and the cost of the device accounts for around one-third of that decision-making equation, as detailed in **Figure 2**. This means that device cost can easily make or break an IoT business case and therefore every cent on every component counts – especially for deployments likely to involve large numbers of devices. Yet cost of components in raw dollar terms cannot be the only consideration.

Software developer, Allerin, has modelled a home automation project in which a company is building sophisticated connected home solutions. The solution includes cameras, motion sensors, smart locks and hubs that orchestrate various home appliances. The firm estimates the hardware development may cost as much as US$4-5 million for this type of service. This contrasts with the $15,000 estimated cost of a data visualisation application for a customised IoT gadget that helps detect the electrical signal of a human body and presents the data in a graphic form.

The components therefore represent a substantial part of the cost of the overall solution even though costs for many items have been steadily reducing during the lifetime of IoT. Parallels can be drawn between the commoditisation of IoT connectivity, which for low bandwidth applications can be less than a dollar a month, and many IoT components which are similarly low-priced. This is proving to be a compelling driver for many lower-value IoT applications which suddenly make business sense because the device, application and connectivity can all be put together at a cost that enables a service to generate profit.

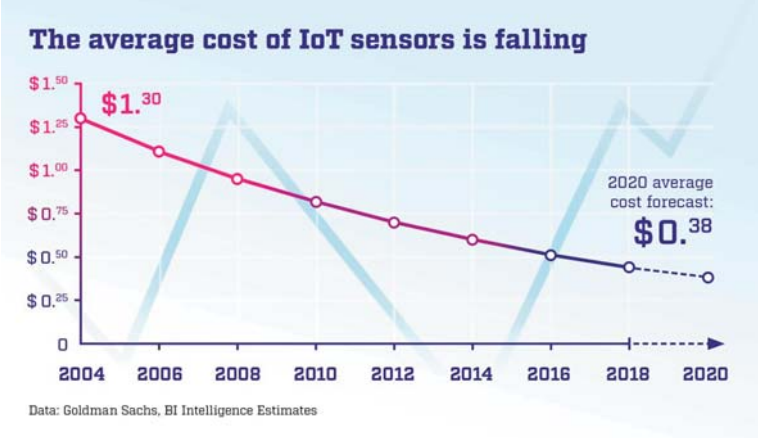

Figure 1: IoT sensors have continued to reduce in price

Of course, volume will come to many market segments, production efficiencies will be made and competition will grow, all of which will contribute to reducing today's cost for these types of components

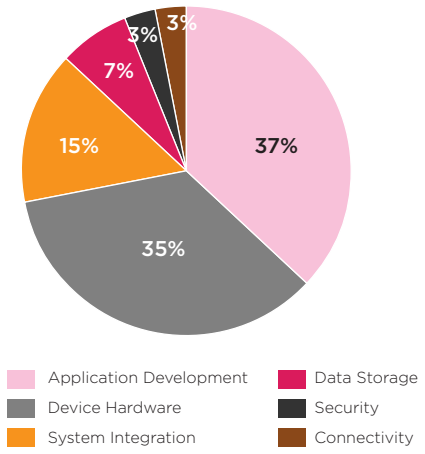

Figure 2:
Cost division for investment in IoT technologies

Source: BUSINESS INSIDER - How the internet of things will explode by 2020

Cheaper components are not available for all IoT devices. Many still are premium products and lack of market scale, the newness of the innovation and the high cost of the materials involved will conspire to keep costs at a level that constrains their addressable market. Advanced functionalities and components are therefore likely to remain the preserve of higher-value IoT applications while commodity functions will continue to widen the number of viable IoT business cases. A 5G module, for example, is currently at a price point, north of US$150, that precludes it from inclusion in cheap computing devices for education applications in developing markets.

Of course, volume will come to many market segments, production efficiencies will be made and competition will grow, all of which will contribute to reducing today's cost for these types of components. However, don't mistake the commoditisation of some IoT sensors and some IoT connectivity as a signal that all IoT components are – or will soon be - at the bottom of the pricing curve.

BOM-proof specification

The bill of materials is traditionally seen as the means to control device costs and consumer electronics companies have been devoted in their efforts to shave a few cents of each component in order to hit attractive retail price points. However, while the BOM provides easy to understand insight into the cost of device components, there is a less direct link between the BOM, the price point of the product or service and the likelihood of user uptake when it comes to enterprise IoT.

Selecting cheaper, lower performance microcontrollers might reduce the BOM expense but it could also mean the deployment lacks flexibility, can't support future features or is unattractive to higher value customers. Industrial end-customers, for example, seldom buy equipment without a service plan and customers in IoT often pay for a service with the devices bundled in to a service fee. This separates the cost of the device from the cost of the service and puts less emphasis on the BOM cost than for a sell-and-forget consumer electronics device.

In addition, IoT devices, especially in industrial IoT, have a longer lifespan so spending more to achieve greater levels of future-proofing can be the more efficient decision – even though it might appear on paper to be a BOM-busting move. Organisations should therefore be less fixated on the overall BOM cost and focus on understanding more about the future capabilities of each line item on the BOM before deciding whether the component represents good value. Don't forget that a cheap component that needs replacing during a ten or 15 year deployment will cause a truck roll that could cost a few hundred dollars, far outstripping a small incremental component cost increase for one with additional capabilities.

Uncertain certification costs

Beyond the limitations of the BOM, other factors significantly influence overall hardware costs. Certification and compliance with regulations, whether for electronic device regulation or for communications regulatory compliance, are all required and, for those constructing hardware themselves, this often is necessary at the component or sub-assembly level. Certification can be a costly process and replicating work done by others can be counter-productive and cause delay.

IoT device certifications are obligatory to prove that the IoT device fits the international standards before release and connectivity integrator Axible, points out that this stage has the potential to devour a large part of a budget. The firm reports that the CE verification of a simple Sigfox device in the European Union is around US$10,000. It therefore will make sense for most to use pre-certified units and avoid bespoke development that invalidates certification.

A manufacturer of hair straighteners, for example, does not want to become an expert in the minutiae of microchip, battery and connectivity performance

Functional blocks

In stark contrast to the traditional approach to IoT device development, which has seen companies or their partners specify components on an individual basis and then go through lengthy and costly integration processes to enable a working device, increasing numbers of developers are adopting the approach of buying blocks of functionality. Such functional blocks, examples of which are listed in **Figure 3** enable a suite of capabilities to be acquired, similarly to a sub-assembly, that brings a set of pre-integrated components together for an organisation to add to their device.

In addition to rapidly and cost effectively addressing certification requirements, acquiring device capabilities in functional blocks radically simplifies the development of IoT hardware. Specification of the individual components of a device is often not part of the skillset of a typical organisation looking to digitise its business. Traditionally, this would be outsourced to a device development house which would specify the individual components and arrange sourcing of these. However, by adopting blocks of functionality, the process is greatly simplified and islands of pre-assembled components can be brought together.

A manufacturer of hair straighteners, for example, does not want to become an expert in the minutiae of microchip, battery and connectivity performance. It just wants to provide its product-as-a-service to its consumers in a secure, reliable, cost efficient and attractive way that allows its customers to have a good experience while enabling headroom for profit. Taking pre-integrated, pre-certified functional blocks and making these central to device design simplifies, accelerates and can reduce overall device costs.

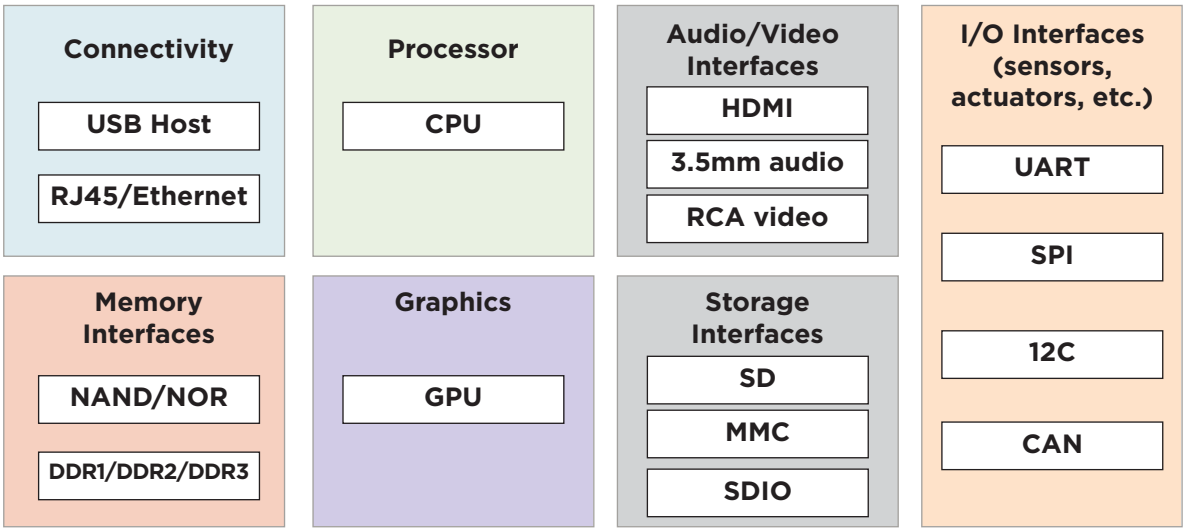

Figure 3: Some functional blocks of IoT components

Conclusion

With Cisco Systems research estimating that almost three-quarters of IoT projects fail, it's clear that hardware, which accounts for 35% of IoT technology investment, has a significant role to play in the success or failure of an IoT project. There are extensive variables that hardware design must take into account that go far beyond specifying the best performing component at the lowest possible price. That, of course, is a fundamental and largely unchanged goal but it must be tempered by greater understanding of the nature of each IoT deployment.

Long lifespan IoT device deployments must factor in the likely need to upgrade the product so investment in additional components to enable over-the-air (OTA) updates which would initially cost more but ultimately cost less can be justified. Similarly, paying more to install LTE or 5G connectivity now could result in a later saving over being confined to a lower bandwidth technology.

Hardware that is expected to ship in very large volumes is also complex to design and component selection will be decided based not only price and performance but also on availability. It's critical that the supply chain behind such devices is robust and able to handle the expected uplifts in demand.

Highly-specialised applications might require sector-specific components that may cost more than generic sensors but are the only way for this type of high value service to operate. This must be taken into account at the outset and the device designed with the components needed in mind.

Component specification is heavily dependent on the nature of the individual IoT device, the applications it enables and its deployment landscape. This is certainly not a one-size-fits-all arena and it is complicated further by fragmentation in geographical regulation, technological standardisation, likely volumes to be shipped and the lifespan of each deployment. What is clear is that a low BOM cost alone is no longer an indicator of optimised component specification. The other factors detailed in this report must also be taken into consideration alongside avoidance of repeating existing development, innovation and certification.

Colin Chapman, the founder of racing and sports car maker, Lotus, said his design philosophy was to: "Simplify and add lightness." This is a good philosophy for developers of IoT hardware but it is also necessary to add speed to the design process. Simplify where possible, take a lighter weight approach by using pre-existing blocks of functionality and integrating them into the device, and achieve speed by accessing the development work of others to address certification requirements.

By achieving a fine balance between cost, functionality, compliance and time-to-market, IoT hardware can optimally address the requirements of the service it enables but, make no mistake, this a complex calculation that requires in-depth and highly specialised knowledge across several different disciplines.

Developers go to component-level to optimise expenditure

As IoT matures, many use cases depend on cost efficiencies in order to make the business case work. This extends across all aspects of an IoT application or service but, where specific hardware is required, the costs of individual components need to be carefully considered in order to ensure optimised expenditure. In addition to this, factors such as maintenance, development costs and whether to buy-in components or bundles and sub-assemblies needs to be made. Josh Mickolio, the supplier business development manager for wireless products at Digi-Key Electronics, tells IoT Now how organisations are assessing their approaches to component specification for IoT devices

IoT Now: What are the complexities of balancing the need for bespoke IoT devices with the need to get to market quickly? Is it really necessary to go down to the individual component level for every deployment and device?

Josh Mickolio: Designing a solution from the ground up involves so many critical design components that the time-to-market is greatly underestimated in most cases. Budget overruns, certification delays, security concerns and even the death of the project are often results of underestimating these complexities.

It's absolutely not necessary to build a solution by designing each component. Unless a company has design resources with experience in IoT solutions, it's highly recommended to utilise finished components, those that have been previously fully-developed by other specialists, as often as possible. This may include benefits such as being able to specify pre-certified hardware, hardware-software solutions that work immediately out of the box or require little engineering effort to optimise. In addition, organisations can benefit from using a turn-key solution to prove out their concept and to assess its return on investment potential.

IoT Now: Aside from accelerating device development, are organisations looking to simplify their supply chains by utilising fewer individual components and buying building blocks of functionality much like sub-assemblies in the automotive industry, for example? ▶

JM: This situation is increasingly common. These building blocks didn't exist just a few years ago so there is still a large learning curve on how to integrate it all and what a solution needs to include. The hardware and software providers know that, for their customers to be successful, they have to work closely with partners or provide a solution themselves that is more functional or design-ready. The aim is to remove as much customer risk as they can.

IoT Now: What components does it make most sense to bring together into a productised bundle or part for integration into a device? Are there some functionalities that fit logically together that you have identified and can share?

JM: Hardware is a slow follower as markets develop and grow, and integration here makes the most sense for hardware designers. Size efficiencies, system cost and integration, and expanding interoperability of a hardware platform are always benefits to designers. Bringing processing capabilities to the radio, adding sensor interfaces to microcontroller unit (MCU) or lower-level processing to the sensor have helped define edge intelligence as we know it today. Without being able to significantly lower the costs and having additional security integrated into the hardware, a simple smart device would be too expensive for most business cases.

IoT Now: Does the idea of using a smaller number of pre-integrated components need to be considered from the first phase of design or can organisations retrospectively look to adopt this approach?

JM: It should be considered from the start of the project or, at the very least, as a reference design for what the final solution is expected to be. It's much easier to design cost out of a solution when you have one that works. If a discrete component design is the first approach it's wise to look at integrated boards, break-out boards and other hardware that brings together your target components list, these devices are helpful to identify components that can be used in a lower-level design.

IoT Now: Are there cost saving implications as well - can this approach bring together faster time-to-market, greater simplicity and lower cost and therefore change the economics of IoT solution deployment?

JM: Very much so. Costs add up significantly during design, though the economics over the life of the project can be impacted as well. Certification savings, costs of re-design - and re-certification - when components are end of life as well as maintenance are often overlooked areas.

Josh Mickolio
Digi-Key Electronics

IoT Now: How does Digi-Key help and how do you see the company's role?

JM: We can see the world of IoT evolving in real-time. We have more than 1,000 suppliers and most of them have a significant interest or offering in IoT. Where suppliers need guidance with identifying target devices, integrations or partners, we help fill those gaps with data and customer feedback. Our role is presenting the right product to a customer quickly and accurately, while ensuring the highest capability for our customers to be able to design, test and deploy with that product. ■

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The Internet of Things comes into its own

The world of technology is changing faster than ever these days, and the pace of new technology introduction to wireless applications has not subsided. The Internet of Things (IoT) is fuelling innovation in nearly every part of our lives, writes Robbie Paul, the director of IoT Business Development at Digi-Key Electronics

Connecting the 'things' that were never connected before is leading to new data insights that translate into meaningful change and create business value. IoT is a mega-technology trend that will not only be an endurance test for legacy systems but will also shape the fate of small and big companies in many different industries. Estimates are for 50 billion IoT connected devices by 2020 and 100 billion by 2025.

There are four legs to the IoT stool. Sensors and Connectivity are two of the four legs of the IoT stool. The other two are intelligent hardware (microcontrollers) and intelligent software (machine learning).

With the proliferation of IoT, the need for a greater diversity of sensors has exploded across all industries. At Digi-Key we've seen firsthand ▶

Robbie Paul
Digi-Key Electronics

Creating a safe environment for customers and employees is essential to doing business

how this demand has skyrocketed. We sell more than 60 million sensors each year, and have over 130,000-part numbers available, and counting. Temperature sensors are by far the most popular, followed by accelerometers, driven by the popularity of activity tracking IoT devices. Environmental sensors are third, focusing on sensors measuring pressure and humidity.

Health and Safety trends

The COVID-19 crisis has brought several IoT solutions to the forefront. The overarching goal of these solutions is to assist in preventing the spread of the virus, which can be transmitted by air as well as by touch or on surfaces. IoT solutions can mitigate some of these risks by monitoring and controlling key transmission modalities.

The US Environmental Protection Agency (EPA) has reported that Americans are spending 90% of their

time in buildings "where the concentrations of some pollutants are often two to five times higher than typical outdoor concentrations." IoT solutions for air quality monitoring include CO2 and particulate matter sensors in addition to the more common sensors that measure temperature and humidity.

Creating a safe environment for customers and employees is essential to doing business. For many businesses, implementing social distancing solutions is now necessary to control the flow of customers through a store. This provides a unique opportunity for sensors as there are several occupancy monitoring solutions available that make it easy to keep a constant, accurate count of the number of people in, say, a retail establishment, and that also provide a notification as full capacity is approached. As public life continues to reopen, optical sensors are a key piece of the occupancy monitoring solution and are being used in a novel way.

Sanitation is also essential to maintaining a safe and health work environment during the pandemic. Establishing a cleaning and sanitising schedule is relatively easy, but maintaining and showing compliance to outside agencies without disrupting productivity can be a challenge. Even a simple system with high-visibility indicators to notify staff to begin scheduled cleaning processes coupled with automatic data recording and collection can go a long way to ensuring compliance. Furthermore, with optical sensors, non-contact switching and activation can be enabled and used to control almost anything. As policies and procedures continue to evolve throughout the COVID crisis, optical sensors will be more important than ever for monitoring and controlling for health and safety.

Trends in Connectivity

Low power wide area network (LPWAN) radio technologies are available on cellular infrastructures and have been around for a few years now. Narrowband Internet of Things (NB-IoT) and Long Term Evolution Machine Type Connection (LTE-M) are popular. The advantage of these technologies is their leverage of existing cellular towers that are used for voice and high bandwidth traffic. However, a device that needs only occasional reporting and control does not require a high bandwidth, and since many are battery-operated, there was a need for lower power and lower bandwidth standards that these technology standards enable.

Other technologies that do not leverage existing cellular networks and must have infrastructures built anew include Sigfox, LoRa/LoRaWAN and NB-Fi to name only a few. The disadvantage to these is requiring an uplink to couple to the broader internet. While these non-cellular network operators provide this uplink as a service, it is yet another computer network system to negotiate.

Software Defined Radios (SDRs) allow a developer to experiment with entirely new modulation schemes. Even if you don't have the expertise, experimenting with an SDR can teach you a lot and it is fun. It is simple to do today with off-the-shelf SDRs. One such SDR is the

The ADALM PLUTO off-the-shelf SDR

Analog Devices Advanced Learning Module PLUTO (ADALM-PLUTO) from Analog Devices and available for off-the-shelf shipping for less than US$150 as of August 2020. They interface to a personal computer over a USB link, contain an FPGA that is easily reconfigured, have extensive support for the programming language Python, and can transmit and receive signals over a range from 325MHz to 3.8GHz. If you really want to know and use RF, you can start at this level.

Artificial Intelligence and Machine Learning

Artificial intelligence and machine learning are starting to play greater roles in sensor deployment. One example of this is the **Google Nest**, which sets temperatures based on its surroundings, when people are coming and going, whether it's a weekday or weekend. The Nest device is continually gathering data, analyzing it, and sending it to a cloud server to notify the user of its findings.

Not only does deep data analysis contribute to greater convenience for the user, but it also results in significant cost savings. A great example of this is some of the commercial applications for sensors that we've seen in the agriculture industry. Specifically, we're seeing a lot of farmers use moisture sensors to manage their irrigation systems. These sensors arm the farmers with rich data and automatically turn on the irrigation system if they detect the crops need moisture. As sensors continue to progress, we expect that this intelligence and connectivity will be taken to a higher level. For example, tapping into the **Weather Channel** data, learning it is going to rain tomorrow, and determining not to activate the sensors. We'll also see the fusion trend here - combining temperature, humidity and pressure to give a more complete environmental picture.

The bottom line is we're using sensors and connectivity today in rudimentary ways. We gather all of the data but don't actively use most of it. Artificial intelligence and machine learning will be integral to helping us make data richer and more useful – and that will make all the difference in the world.

Artificial intelligence and machine learning are starting to play greater roles in sensor deployment

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