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SMALL | SAFE | SECURE | ADVANCED | FAST | EASY
The news of a potential mega-merger between chipmaker Broadcom and its US rival Qualcomm continues the trend of consolidation within the electronics industry and its scale could reshape the industry that’s at the core of the mobile phone.

Broadcom has made an unsolicited bid of $130 billion for Qualcomm and, if successful, the deal would create a company worth more than $200bn.

According to the latest figures, the merged company would be the third largest electronics business after Intel and Samsung. Although Samsung may be an immediate target, if Qualcomm gets its ARM server chip act together, then Intel could also be in the crosshairs.

While there may be compelling financial benefits for the deal – and it could help to deliver more advanced semiconductor solutions, if Broadcom’s CEO Hock Tan is to be believed – many think it could face stern scrutiny from regulatory authorities, particularly China.

According to sources in Beijing, there are real concerns at the huge size of the proposed deal, especially when the Chinese government is making a concerted and strategic push into setting up its own semiconductor industry.

Chinese regulatory approval could also be affected by on-going sparring between Beijing and Washington over a number of technology deals. The Committee on Foreign Investment in the United States has already blocked a number of takeovers involving Chinese firms this year, including the proposed acquisition of Lattice.

Qualcomm has also come under fire over competition concerns and has agreed to pay fines amounting to almost $1bn following a Chinese investigation into anti-competitive practices.

Qualcomm is, according to lawyers in China, ‘on its radar’. China is making a major push to develop its own semiconductor industry under local champions, so it’s likely this deal will also have a keen political edge. Chinese chipmakers can be expected to raise concerns about the deal.

There’s no doubting this deal is likely to be very complex. While the chances of the Chinese government blocking the deal are slim, the firms may well have to sell certain business units for it to go ahead. And the EU may well flex its regulatory muscles, so it’s going to be an interesting year ahead for both companies.

Neil Tyler, Editor (neil.tyler@markallengroup.com)
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Broadcom launches Qualcomm bid

$130billion offer would create third largest semiconductor company. Neil Tyler reports.

Broadcom has launched an unsolicited bid for Qualcomm that values the comms specialist at $130billion. The rationale behind the offer includes creating a leading diversified communications semiconductor company, with Qualcomm’s cellular business complementing Broadcom’s portfolio. Should the deal conclude, Broadcom says its enhanced scale would accelerate innovation and deliver more advanced semiconductor solutions.

Hock Tan, Broadcom’s president and chief executive, said: “We would not make this offer if we were not confident that our common global customers would embrace the proposed combination.”

Combined, Broadcom and Qualcomm would become the third largest semiconductor company behind Intel and Samsung, with an ability to pressurise both organisations.

Meanwhile, Broadcom is still waiting for regulatory approval to buy Brocade for $5.9bn, while Qualcomm remains in talks to buy NXP for $38bn.

• Broadcom has also announced that it intends relocate its corporate headquarters from Singapore to the US.

Flexible THz detector uses graphene transistors

Researchers at Chalmers University of Technology have developed a flexible detector for terahertz frequencies which features graphene transistors on plastic substrates.

The device, said to be the first of its kind, has the potential to extend the use of terahertz technology to applications that will require flexible electronics, such as wireless sensor networks and wearable technology. At room temperature, the device can detect frequencies ranging from 330 to 500GHz.

One challenge has been the need to develop a process that enables the creation of low weight and cheap applications. While advances in polymer technology have promoted the development of flexible electronics and enabled the production of high frequency units on flexible substrates, Chalmers researchers have now developed a mechanically flexible graphene-based terahertz detector.

Translucent and flexible, the process is said to be suitable for a variety of applications, including THz imaging and a sensor for identifying different substances.

Robotics, AI funding announced

The Industrial Strategy Challenge Fund has allocated £68million to support research and innovation in robotics and AI systems.

Four research Hubs managed by EPSRC will receive £44.5m to support the development of robotic solutions for offshore energy, nuclear energy and space. The National Centre for Nuclear Robotics will receive £11.3m, with other grants to Robotics and Artificial Intelligence for Nuclear (£11.9m), Offshore Robotics for Certification of Assets (£14.3m) and Future AI and Robotics for Space (£6.7m).

Professor Philip Nelson, EPSRC chief executive, said: “These new Robotics Hubs will draw on the country’s research talent to nurture new developments in the field of robotics and provide the foundations on which innovative technologies can be built.”

Meanwhile, £16.5m has been allocated to work following a collaborative R&D competition run by Innovate UK, while 17 demonstrator projects will receive £3 million.A £4.3m grant to the NERC will fund five research projects developing sensors capable of working in the ocean’s extreme conditions.

• Eight medical researchers will share more than £8m from EPSRC. Included in the winning projects are the use of polymer bioelectronics in high resolution implantable devices and wireless communication with cells.
European semi consumption growing

Sales of semiconductors in Europe exceeded €2 billion for the third quarter in a row, according to DMASS. In its latest report, the distribution association notes that sales in Q3 2017 were €2.16bn, 19% more than in the corresponding quarter of 2016.

For the first nine months of 2017, DMASS says its members saw sales rise by 15.6% on a year to year basis to €6.48bn.

DMASS chairman Georg Steinberger noted: “It seems that, in 2017, we are certainly in for a record year. Newer designs will see higher component content, so the future looks rather positive from a sales and volume perspective.”

Growth is being seen in all product segments. Application specific, power discrete, memories, discrete components and optoelectronics all saw demand growing above average. Analogue and MOS micro sales were said to match the average, while sales of programmable logic, standard logic and sensors were slower.

Sales in Germany grew by 19.7% to €681m, while those in the UK and Ireland grew by ‘only’ 12.8% to €151m.

LiS battery pack under pressure

Stellite, Oxis Energy, M Subs and the National Oceanography Centre have developed a pressure tolerant lithium sulphur (Li-S) battery capable of powering autonomous vehicles at ocean depths of more than 6000m.

According to the partners, the cells can withstand a pressure of 664bar at a temperature of 4°C without being compromised on integrity. Rated at 300Wh/kg in standard conditions, the test cells were said to have achieved a density of 289Wh/kg at a pressure of 450bar.

Will it come out in the wash?

PRINTED GRAPHENE CIRCUITS SURVIVE 20 WASH CYCLES SAYS CAMBRIDGE TEAM. GRAHAM PITCHER REPORTS.

Researchers at the University of Cambridge, working with teams in Italy and China, have demonstrated that graphene can be printed directly onto fabric. In their work, the team incorporated washable, stretchable and breathable electronic circuits into fabric and believe this will open new possibilities for smart textiles and wearable electronics.

The circuits, made with cheap and environmentally friendly inks, were printed using conventional inkjet techniques and are said to survive up to 20 cycles in a typical washing machine.

Based on earlier work on the formulation of graphene inks for printed electronics, the team designed low-boiling point inks. Additionally, the researchers found that modifying the roughness of the fabric improved the performance of the printed devices.

“Other inks for printed electronics normally require toxic solvents and are not suitable to be worn, whereas our inks are both cheap, safe and environmentally-friendly, and can be combined to create electronic circuits by simply printing different 2D materials on the fabric,” said Dr Felice Torrisi of the Cambridge Graphene Centre.

The work is said to open opportunities for 2D material inks, with applications ranging from personal health to wearable energy harvesting and computing devices.

Moiré patterns to push electronic boundaries?

Moiré patterns could help electronics designers to push the current limits of size and speed, according to work undertaken at the University of Illinois.

At the macro scale, Moirés are optical phenomena. However, the researchers say that at the atomic level, arrangements of electrons are locked into place by atomic forces, forming nanoscale wires capable of transmitting electricity.

Professor Harley Johnson said: “2D materials create Moiré patterns when stacked on top of each other and are skewed, stretched, compressed or twisted. The Moiré emerges as atoms form linear areas of high electron density. The resulting lines create what is essentially an extremely thin wire.”

Prof Johnson’s group is focusing on types of devices that can be made using Moiré engineering. “Being able to engineer the Moiré pattern itself is a path to new lightweight and less-intrusive devices that could have applications in the biomedical and space industries,” he concluded.

Optical on silicon technology

A spin out from Queen Mary University of London (QMUL) has received investment to help it commercialise a material technology which could cut the energy used by optical communications, while increasing transmission rates.

Chromosol, founded by Professor William Gillin (pictured), will develop technology to allow the manipulation of light directly on silicon. While optical communication is quicker and more energy efficient than the traditional copper infrastructure, previous attempts to create such products have suffered from low yield, high cost and integration complexity. Chromosol’s technology aims to address and alleviate all of these problems.

Prof Gillin, director of QMUL’s Materials Research Institute, said: “Chromosol’s technology is easy to integrate and is compatible with existing processing techniques, providing a simple solution to a growing problem.”

The company has been backed by IP Group. “We’re delighted IP Group is supporting Chromosol and we look forward to working closely with them to commercialise our work,” Prof Gillin concluded.
Bristol plans quantum centre

A £43M INVESTMENT IN A NEW QUANTUM TECHNOLOGIES INNOVATION CENTRE HAS BEEN ANNOUNCED BY THE UNIVERSITY OF BRISTOL. NEIL TYLER REPORTS

The University of Bristol is looking to set up the world’s first open access Quantum Technologies Innovation Centre (QTIC), with the aim of taking quantum research from the laboratory and into the commercial world. The £43million QTIC is being funded in partnership by the West of England Local Enterprise Partnership, industrial partners and the University of Bristol. It will be based in the University’s new enterprise campus, to be built in the heart of the city.

More than 200 researchers at the University will work alongside companies to develop prototypes and help to establish new quantum businesses. It is intended that the centre will provide affordable specialist incubation facilities for businesses looking to create new products and services for applications such as secure communications, sensors, simulators and ultra-powerful computers.

The UK Government anticipates that quantum technology could be worth £1billion to the UK economy in the next 10 years.

The new facility is expected to open in 2021 and, once complete, will include a mixture of specialist labs, incubation facilities, office space, meeting rooms and conference facilities to co-locate industrial engineers and entrepreneurs with University researchers.

Alongside a talent academy, which will train people ranging from apprentice technicians to PhD qualified quantum engineers and entrepreneurs, an enterprise hub is being planned. This will support start-ups and early incubation of new businesses, as well as providing access to technology, finance and manufacturing.

mCube acquires Xsens

MEMS motion sensor specialist mCube has acquired 3D motion sensing and tracking company Xsens from On Semiconductor.

Described as a ‘late stage growth company’, mCube fabricates MEMS accelerometers with a CMOS signal-processing ASIC in a single chip and has already shipped more than 300million sensors to manufacturers of smartphones, tablets, wearables and other IoT devices.

Xsens has developed a suite of technologies that convert motion sensor measurements into application data and its solutions have been used to create CGI animations and by automotive manufacturers to enhance the ergonomic design of vehicles.

Ben Lee, mCube’s CEO, said: “We expect sensor fusion solutions will become more critical for motion-tracking applications and through this acquisition will look to take the complexity out of MEMs sensors.”

Silicon Labs advances IoT functionality

Silicon Labs has released multiprotocol software for its Wireless Gecko SoC and module portfolio. The move, said to enable simultaneous operation of Zigbee and Bluetooth LE on a single SoC, is likely to enable advanced functionality for IoT applications such as smart lighting, home and commercial automation platforms, without incurring additional cost and complexity.

Dynamic multiprotocol software will allow users to commission, update, control and monitor Zigbee mesh networks directly over Bluetooth with smartphone apps. The software also makes it easier to deploy scalable indoor location-based service infrastructure by extending Zigbee-based connected lighting and building automation systems with Bluetooth beacons.

Tom Pannell, senior director of marketing, IoT Products, said: “Customers like the idea of multiprotocol connectivity, which will enable them to add Bluetooth to Zigbee.”

New optical opportunities

Structured beams of light which exhibit strange behaviour could have such applications as super-resolution imaging and communications, according to researchers at the Harvard School of Engineering and Applied Sciences, who have developed a tool to generate new states of light in a different way.

“We have developed a metasurface; a new tool to study novel aspects of light,” said Professor Federico Capasso. “This optical component makes possible much more complex operations and allows researchers to not only explore new states of light, but also new applications for structured light.”

The metasurface is said to connect two aspects of light: orbital angular momentum; and circular polarisation, or spin angular momentum.

While the fact that light can carry orbital momentum is said by the team to be a relatively recent discovery, it’s this property which enables beams in the shape of corkscrews. Previous research has used polarisation to control the size and shape of beams, but the connection was limited because only certain polarisations could convert to certain orbital momentums.

The device can be designed so that any input polarisation of light can result in any orbital angular momentum output. This means any polarisation can yield any kind of structured light – such as spirals, corkscrews and vortices of any size. The device can also be programmed so that one polarisation results in one vortex and a different polarisation results in a completely different vortex.
A report on industrial digitisation has suggested that Britain’s manufacturing sector could benefit by as much as £455 billion if, over the next decade, it can unlock the benefits of the fourth industrial revolution (Industry 4.0) by deploying robotics, 3D printing and artificial intelligence (AI).

The report – Made Smarter – was commissioned by the Government to look at industrial digitisation and the review, chaired by Jürgen Maier, the UK and Ireland head of Siemens, found the UK economy would benefit immensely.

According to the report, by working together, the Government and industry could put Britain at the forefront of these new technologies, giving the economy a much-needed productivity boost and a potential net gain of 175,000 highly skilled jobs.

Innovate UK’s chief executive Ruth McKernan said: “The innovation eco-system has a key role to play in delivering the ambition in this review and Innovate UK stands ready to work with government and industry to drive forward the recommendations Juergen Maier sets out.”

Maier said that, while there would be considerable benefits, robotics and AI would displace some jobs. “The best thing we can do is to make ourselves ready for it in a very proactive way and that means training our people ... we need to up-skill 1 million existing workers in the industrial and manufacturing sector.”

The review considered three themes: adoption; innovation; and leadership. Amongst its proposals was the building of a more visible national digital ecosystem.

A National Adoption Programme will be piloted in the North West, focused on increasing capacity of existing growth hubs and providing more targeted support.

The Review also recommended up-skilling 1 million industrial workers to enable digital technologies to be deployed and successfully exploited through a Single Industrial Digitalisation Skills Strategy.

It also urged the creation of 12 ‘Digital Innovation Hubs’, along with eight large scale demonstrators and five digital research centres focused on developing new technologies as part of a new National Innovation Programme. It also called for a new national body, the Made Smarter UK Commission. This would have responsibility for developing the UK as a leader in Industrial Digitalisation Technologies and skills.

These proposals were backed by CBI director-general Carolyn Fairbairn, although she warned that the UK was facing intense international competition from countries that already had advanced plans to embrace Industry 4.0.

David Wells, managing director EMEA for business process management specialist Pegasystems, said: “Technologies like robotics, AI and virtual reality have a role to play in every sector and their integration into manufacturing is inevitable. It’s imperative, however, that the type of AI being integrated into industrial systems is ‘future-proof’, won’t cause unforeseen problems in the near future and can be adapted quickly.”

Wells suggested the primary challenge associated with the implementation of AI would be to make it more transparent. “How has a machine come up with a particular result? We need to know where a calculation or a model hasn’t quite worked correctly and have the ability to rectify it.”

The report’s recommendations will now be considered by the Government. Business Secretary Greg Clark said: “The UK manufacturing sector has the potential to be a global leader in the industrial digital technology revolution. Government and industry must promote the benefits of adopting emerging digital technologies.”
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Identifying and experiencing a problem that can then be fixed is crucial when it comes to developing a great product. So says Christian Smith, president and co-founder of TrackR, a West Coast US start-up that, over the past seven years, has developed a range of coin-sized tracking devices that can be attached to things like wallets and passports, to help users keep track of where they are through an app.

“With a simple tap, you can locate lost items or if you've lost your phone you can press a button on the device which will cause your phone to ring, even if it’s on silent,” Smith explains.

The company has come a long way in a relatively short space of time. Based in Santa Barbara, it has recently closed a $50 million Series B funding round intended to fund the company’s expanding product portfolio, which now incorporates sound and light into its personal item tracking products.

TrackR is ramping up its efforts to integrate with Amazon’s Alexa and Echo speaker products to use voice commands to find lost items and is providing a platform for a growing list of OEMs interested in using its tracking technology.

“Amazon has invested in TrackR and we are using Alexa to enable people to simply ask where their phone is and then get a location,” Smith explains.

Born in California, Smith and his business partner Chris Herbert, the company’s CEO, were at university together when then came up with the concept after a trip to the beach.

“We were both attending UC Santa Barbara at the time and looking to become engineers; I’m a mechanical engineer and Chris is an electrical engineer,” Smith explains.

“We’d gone surfing on Pismo beach, but when we returned to our parked car we couldn’t find our keys. The car was parked below the high tide line and would have ended up submerged if we hadn’t been able to find someone with a metal detector who found our keys in the sand,” Smith says.

People lose things all the time.

“We depend on our memory to know where things are located,” Smith explains, “so we thought why not have the computers around us memorise where objects are located?

“How could we create a system where a computer reliably remembers where we had placed something and where we could find it?”

TrackR was their response and they set up the business in July 2009, demonstrating their first product at CES in 2010.

Taking the idea and putting it into practice was a challenge. “We entered a business plan competition and won and used the winnings, together with help from family and friends, to launch a basic product which we were then able to display at CES,” Smith says.

“We saw a lot of interest at CES 2010 and an article in the Wall Street Journal helped generate interest in what we were doing. That was a big inflection point for us,” he suggests.

After CES TrackR was formally launched at the DEMO conference, where new products are unveiled, and the company went on to win an award for its efforts.

“The next critical step was to get the capital funding necessary to fund the development of further prototypes,” Smith explains. “Without that, it would have been almost impossible to carry out revisions on different boards. It’s not a cheap endeavour and we were having to do this before the advent of crowdfunding.”

The development of the product was not without its issues; at the time, few phones had the capability to interact with an application. “The standards weren’t in place and most phones weren’t focused on apps.”

While it was certainly a period of trial and error the company sought and was given help and advice.

“We got advice from, among others, a local entrepreneur, Tooey Courtemanche, who was CEO of Procore,” Smith explains.

“Tooey saw our demo and listened as we explained our concept and then stopped us. ‘While you’re both great engineers’, he said, ‘remember that for a business your size sales will solve your problems.’ He made us realise that being good engineers wasn’t enough, we’d need to know how to be good salesmen too.”

Funding challenge

While funding was initially hard to come by positive media coverage resulted in angel investors taking note and sales began to take off, generating revenues for the fledgling business.

“People were getting interested in tracking lost items using their smartphones,” Smiths explains.

Another major inflection point for the business was the development of Bluetooth Low Energy and its use in the iPhone 4.

“That changed the game for us,” Smith says, “and beyond that the arrival of crowdfunding made it much easier to innovate.”

Crowdfunding provided a platform that enabled the business to invest and, crucially, experiment.

“It meant we could test our ideas out. We’ve now run multiple
campaigns to fund various projects. Some have worked; others, like TrackR glasses, haven’t.

“We were able to test our ideas and make rapid changes to our product roadmap. Trial and error was crucial, but so too were quick development cycles and learning from the market.”

To begin with, TrackR turned to local manufacturers who were identified and recommended by mentors and friends. According to Smith: “This allowed us to very quickly establish a level of openness and trust.”

Both Smith and Herbert were ‘rationally optimistic’ that there was a device tracking market waiting to be served.

“That optimism wasn’t miss-placed. We’ve been able to create a market that didn’t exist 10 years ago and are now working with a host of major OEMs to embed our tracking technology into their products.

“What’s exciting is the potential size of the market. With more than 1.2 billion smartphones out there, the opportunities are huge.”

Smith concedes there have been significant ups and downs in getting to where they are today.

“We’ve been persistent and I think that’s been crucial. Any start-up needs to have the tenacity to bring their ideas to life. We were obsessed with solving a real problem. People too often talk of having a passion for this or that, but to succeed you need to be obsessed. Passion can fade in the face of challenges and problems.

“And you will be confronted by problems, every single day. What’s crucial is how you respond to them. My advice? Be creative when it comes to problem solving because, more often than not, a simple elegant solution does exist.”

Having raised more than $60 million to date and continuing to expand with new products, strategic partnerships, and innovative software such as the TrackR Crowd Locate network, TrackR is well placed in the fast growing intelligent tracking space.

“We have and continue to redefine personal organisation to ensure nothing ever need be lost for millions of consumers ever again,” Smith concludes.
Set up in 1956, Roke Manor Research has over the past 70 years established itself as a world-class electronics engineering consultancy. Based in Romsey, it provides independent advice to clients across a variety of markets whether that’s defence and national security, high grade manufacturing or the automotive sector.

“Our aim has always been to maximise our clients’ investments in science and technology whether that’s government or industrial partners,” explains Professor Mark West, head of Roke’s Information Security practice. “We look to provide independent advice while at the same time solving technically challenging problems.”

Roke was originally set up and run by Plessey and primarily undertook research looking at military communications systems.

As the site’s reputation grew over the next 30 years, it attracted a growing number of technology contracts. These were, in the main, for defence applications, but by the mid-1980s Roke was working on asynchronous transfer mode switching for the commercial telecommunications market and GSM cellular telephony.

Roke has changed hands several times, with Siemens taking part-ownership in 1990 following its acquisition of Plessey. Today, it is now wholly owned by the Chemring Group, which acquired it from Siemens in 2010. But, despite changes in ownership, Roke has retained a reputation for excellence for world-class innovation and engineering.

It is a recognised software centre of excellence and offers a broad range of capabilities that include array processing, communication algorithms and wireless protocols.

“We also have a significant sensing element to the practice which is supported by our acoustic processing, image processing and detector capabilities,” explains Prof West.

Roke continues to add to its resources and recently extended its acoustic processing capability to include temperature and airflow tomography, damage detection within industrial systems and steerable directional microphones.

Roke also works with 3D vision processing, for making measurements of scenes and determining topologies of objects, as well as processing 2D images. That capability has extended to autonomous platforms providing Roke with a range of offerings across intelligent unmanned systems.

Another significant and growing capability is extracting knowledge from large volumes of complex data, in particular ‘big data processing’, ‘machine learning’ and ‘packet processing’.

“We provide advice, consultancy and research into all associated areas,” says Prof West. “From the underlying physics, materials, test, measurement and compliance to designing for large scale manufacture. Another important part of our work is providing rapid prototyping.”

Roke also offers hardware services providing on-site test equipment, manufacturing and design capabilities and it is able to analyse, protect and validate information in secure systems.

“Our role is to help our clients better understand the technical complexities of modern and future systems. We have more than 350 engineering consultants on-site who are working to develop new concepts, capabilities and systems. It’s certainly a challenging environment,” Prof West notes, “and one that has become more applied and tied in
with development, looking to provide clients with complete solutions. “We’ve been around for a while and have extensive experience in both the civil and military domains,” he adds.

**Defence and National Security**

When it comes to working with the military, Roke continues to be involved with a variety of projects. One high profile project is the enhanced protection for UK Armed Forces through the ICARUS programme, which is a modular active protection system that can detect and react to threats, such as rocket propelled grenades, within 10µs. Roke is responsible for the design of the open systems architecture under prime contractor Leonardo.

Another project involves Roke’s STARTLE technology which emulates a mammal conditioned-fear response mechanism for threat detection.

“STARTLE is a kind of augmented intelligence that can cope with very complex situations to help inform and support human decision making,” explains Mohammad Dabbah, a senior consultant at Roke. “It works by mimicking how an animal’s brain detects threats and then cues sensing and processing. It is able to detect threats rapidly using sensors to enhance the assessment of that threat.

“The ability to manage massive amounts of data is critical,” explains Dabbah. “At Roke we’re well placed to see its impact. It can be quite overwhelming. Driven by the mass deployment of sensors we are increasingly being asked to develop smaller platforms capable of on-board processing in real-time, there’s certainly a big shift away from centralised processing and the demand is now for significant computational power on devices themselves.”

The growing importance of machine learning brings with it a number of issues, as Dabbah explains.

“As machine learning moves beyond defence and into the commercial world we need to better understand human machine interaction. More critical analysis is required, we need to better understand why machines make the decisions they do – can we trust them? We certainly need to make the process more transparent.”

While the best known application of STARTLE has been its deployment with the Royal Navy it is also being used for the detection of sophisticated computer network threats.

The technology has been successfully used in detecting penetration test activity in real-world computer networks, and can use intercept-derived data from local and cloud-based storage.

While defence and national security have been key drivers for Roke, Prof West says that it has always sought to maintain a strong commercial presence.

“While we work across different customer domains, we recognise that defence and national security have always been a critical part of what we do here, but it’s becoming more important that we develop and maintain a vibrant commercial footprint. There are advantages in having a good commercial portfolio, whether in terms of growth or in sharing technological advances across sectors.

“Whatever the sector, however, we are seeing growing interest in the Internet of Things and in connectivity in general.”

Prof Mark West

In Roke’s Face-to-Face competition, teams were tasked with identifying and then securing the vulnerabilities in intelligent household gadgets like smart locks, security cameras and even coffee machines.

“Whatever the sector, however, we are seeing growing interest in the Internet of Things and in connectivity in general. As a consultancy we are being asked, in essence, to track technology trends and monitor how people are engaging with and using technology and what impact that will have on the businesses operate.”

The work that Roke is contractually engaged with is certainly varied. Project Hero is a case in point.

Working with Jaguar Land Rover, Roke developed an off-road vehicle for the Austrian Red Cross.

The vehicle comes with an autonomous unmanned aerial vehicle (UAV) system to aid search and rescue missions.

“Our involvement in this project revolved around our Autoland system,” explains Dean Thomas, an sensors and autonomous expert at Roke. “It was originally funded by the Ministry of Defence and enables UAVs to land safely, accurately and autonomously. Last year a drone was successfully landed on a moving platform as part of a Royal Navy exercise.”

The challenge with Project Hero was landing a drone on a moving vehicle.

“Autoland uses a vision positioning system, so there’s no need for a GPS signal,” Thomas explains. “The cameras on the drone match what it sees with a stored version of the target. It can then deduce the position of the aircraft in relation to the landing platform – that data is being updated continuously.”

**Security**

Roke has expanded its UK operations and recently opened a second office in Gloucester, employing 20 new staff, specialising in cyber security.

The growth in the Internet of Things has pushed the issue of security up the agenda.

“As the IoT expands into new and varied markets so cyber security becomes more important and is something in which we have...
invested heavily,” explains Prof West. “Understanding security and providing and managing security are essential. What does it mean, who controls the data, how do you look to secure devices – all of these issues need to be better understood.”

According to Prof West, with security now taking centre stage it is apparent that it can’t simply be retrofitted. “Security needs to be at the heart of everything we do. From my experience it’s best to break it down into separate areas whether that’s confidentiality, availability, integrity of data etc. For example, can data be changed and if so, who by?”

When it comes to securing devices West makes the point that it needs to be balanced with usability and in the commercial environment consideration needs to be given to power management.

“There’s a trade-off and designers need to understand that and think at the system level. People need to understand the different facets of security; there are different levels of security and the appropriate technical mechanisms need to be understood and used.”

Roke has over time built up a series of relationships with universities around the UK. “Our engagement with academia is extensive. We have helped set up the Cyber Security Academy in Southampton University, alongside Northrup Grumman and DSTL. It’s a good way to engage with students and is an opportunity for graduates to come and work with us,” Prof West contends.

According to Prof West, there is far more commercial awareness at universities today.

“We are involved in a lot more joint bidding for projects, so universities are increasingly looking at work that is relevant to industry. As a result, we get access to some of the best thinking and research.

“Attracting talent to work in cyber security, for example, is a challenge,” Prof West continues.

The cyber security industry is in a critical need of more professionals to secure businesses, governments and homes.

“A recent report predicted that the shortfall of skilled cyber workers could reach 1.8 million globally by 2022, so when we were asked by the Cyber Security Challenge UK – we’re one of its sponsors – to host a challenge, we jumped at the chance.”

Roke ran a Face-to-Face competition in which specialised cyber-units were asked to defend a simulated smart home at Roke’s Romsey site.

These teams were tasked with identifying and then securing the vulnerabilities in intelligent household gadgets like smart locks, security cameras and even coffee machines.

“Our aim was for them to discover as many vulnerabilities as possible within the system.

“The types of scenarios that we put to the candidates were based on real-world issues, but with an added twist to really see who had the necessary skills and potential to join the profession.

These competitions,” Prof West continues, “are a great way for candidates to experience what the industry is like and for employers to pick out potential recruits.”

Autonomous vehicles

In April 2017, Greg Clark, the Secretary of State for Business, Energy and Industrial Strategy, gave the go-ahead to 5*StarS as part of the national strategy to establish the UK as a global centre for the development, testing and commercialisation of connected autonomous vehicles.

Roke, together with other partners including HORIBA MIRA, Ricardo, Thatcham Research and Axillium Research, is receiving grant funding from Innovate UK to launch the ‘Automotive Cyber Security through Assurance’ project.

“The 5*StarS project is looking at how to address the increased threat from cyber security with the proliferation of connected and autonomous road vehicles,” says Graeme Simpson, Roke’s lead for Commercial Cyber Protection.

The consortium will research and develop an assurance methodology to assure that connected autonomous vehicles components and systems have been designed and tested to the relevant cyber security standards throughout their whole lifecycle.

“Our aim is to develop a 5 star type consumer rating framework, analogous to existing EuroNCAP type ratings for vehicle safety,” Simpson explains.

“It is so important that we clarify and understand the risks associated with connected autonomous vehicles for the insurance industry, but also in increasing consumer confidence.

“Wherever there is a digital element in the car, it is vulnerable to attack,” says Simpson. “Both consumers and insurers need to know what potential risk this connectivity has.”

Whether it’s developing a technology concept, prototyping or demonstrating a capability, Roke has established over the past 70 years a strong track record of delivery, enabling clients to make the best use of technology and that looks set to continue.
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Technology manufacturers are increasingly being encouraged to think about the circular economy – the concept that materials and goods should be kept in circulation for longer rather than follow the traditional ‘linear’ model of make, sell, use, then dispose. Getting this right needs everyone in the chain to play a role, especially engineers and designers. What has caused that shift?

Environmental pressures from waste, a growing focus on the carbon impact of our buying behaviours and concern over the availability and accessibility of critical resources is stimulating governments, societies and business to look at new ways of doing things. Resource intensive sectors like manufacturing have been under particular pressure to reform. There have been some huge gains in resource efficiency and productivity in the last couple of decades. A global combination of innovation, regulation, rising material value and changing cultures has seen renewed interest and action to improve our resource productivity. For example, in the B2B ICT market, assets are routinely remanufactured or refurbished for secondary markets and Apple recently committed to stop mining for its iPhone materials at some point in the future.

Industrial design and better engineering are the keys to making this happen. But it is also fair to say that the sector is under increasing scrutiny as electronics continue to proliferate. NGOs, such as Greenpeace, ifixit and the Restart programme, as well as Government itself, are becoming increasingly vocal in expecting industry to respond positively to this agenda.

Eco-design
Eco-design means designing electrical products in a way that reduces their environmental impact and incorporates some of what has been discussed earlier. It was described as the ‘unsung hero’ in reducing domestic energy use and in Europe is governed by the EU Eco-design Directive.

The Directive covers product types which the EU believes cause 40% of all greenhouse gas emissions and sets energy limits. It will increasingly set out design requirements to manage e-products at the end of their first life. The Directive is a ‘framework’, which means that specific product policies are developed that sit beneath it. To support this work, standards are being developed to define some core ‘material efficiency’ qualities, such as: how easy products are to repair; remanufacture and upgrade procedures; and how much recycled material they contain. The standards will also look at how to communicate where critical raw materials and other material efficiency information are within the supply chain. Be under no doubt: legislation will be coming soon to shape the way in which electronics can be treated at the end of their life. What might be expect?

You will have seen the letters ‘EU’ a few times already and are probably wondering how Brexit will impact the circular economy and eco-design as these are very much EU initiatives. The current thinking is that these laws will be bought into the UK and won’t change. The Environment and Business Departments appreciate that product requirements are set internationally and don’t want to reduce the level of environmental protection.

However, that doesn’t mean there is nothing to worry about. There is a real risk that the UK will withdraw from CE marking, which techUK and other manufacturing and trade bodies believe could be disastrous. The UK is also set to leave REACH, which could restrict the supply of substances upon which electronics manufacturers rely. Furthermore, there are signs that the Department of the Environment is interested...

Craig Melson
in understanding how they can incentivise design changes.

Some of the areas currently under most discussion are design for repair and design for reuse/recycling.

**Designing for repair**

Making sure goods can be repaired is widely considered the best way to ensure they can stay in circulation for longer. Average product lifespans have increased recently and recycling organisation WRAP estimates that ICT products are 53 to 96% more durable than consumer expectations, depending on the category. This hasn’t happened accidentally; it has been because of innovation, technological advancement and better design.

Repair did have an image problem, but is becoming ‘cooler’ as consumer expectations change and things like ‘upcycling’ have taken off. In the tech and ICT sector, there has been a lot of momentum from industry and government recently. The EU is completing five studies and the tech sector (including the UK) is reviewing the positive impact of repair and the policies that we feel are needed to make it happen.

There have been reservations in the past, such as concerns on the impact of repair on new product sales and the safety risks of untrained people attempting repairs that could result in further damage, fire or injury. techUK has been working with Electrical Safety First on the obvious pitfalls of attempting DIY repairs and promoting official repair channels as the only viable route. It is fair that there is a long way to go on this.

For the engineers though, how can tech goods – and consumer goods in particular – and the things that go in them be optimised for repair at the design stage? Goods have got cheaper, more compact and more software defined, so making sure they can be fixed easily is an issue, but there are some basic principles that should be observed.

Placing those components most likely to fail inaccessibly is something to avoid, as is integrating them to other components to the extent they can’t be swapped out for upgrade. Not using glue where possible helps, as does avoiding proprietary fastenings or screws that need specialist tools. Labelling panels and ports with indications of which way to open them is also essential and manufacturers are increasingly asked to provide repair and safe disassembly instructions online and with the product.

**Designing for reuse and recycling**

When something can’t be repaired, the next step in the circular model is to see how a product can be reused or recycled. Learning lessons from the business to business server market, new business models have developed that can see tech repurposed as well as value extracted from the raw materials.

So what is the role for designers and engineers?

Whilst innovation and functionality should guide design, it’s probably fair to say that worldwide regulations have had a significant impact on how electronics are designed. Designing a product so it can be taken apart more readily may sound counter-intuitive, but it helps to reduce costs by rationalising the number and cost of materials, shows compliance with regulations and makes it easier to extract value from broken or end of life goods.

Goods (such as laptops and TVs) need to be able to be disassembled in a few minutes, which can dictate where PCBs, power supplies and ports need to be located and designing for quick disassembly is all about simplifying where ‘stuff’ is in the device. Using the smallest number of components, different materials, fastenings and avoiding glue will make it easier for remanufacturers or recyclers to take a product apart, or to harvest components for reuse, as will other steps such as making sure products can be taken apart with a couple of basic tools.

**Conclusion**

The circular economy is only going to become a bigger priority and it is more than likely that engineers and the electronics sector will be the ones who deliver the designs and engineering that mean complex electronics and electrical goods can be reused.
Security is becoming an important part of the design process, but what are the issues? By Graham Pitcher.

A report published earlier in 2017 by consumer body Which? reinforced the perception that companies designing products for the Internet of Things don’t take security seriously enough.

In what it called a ‘snapshot’ investigation, it set up a network featuring such smart gadgets as wireless cameras, smart padlocks and children’s toys, then hired a team of ethical security researchers to hack it. While some of the devices proved harder to hack than others, eight of the 15 appliances on the network had at least one security flaw.

According to Alex Neill, managing director of home products for Which?: “Manufacturers need to ensure that any smart product sold is secure by design.” But do designers know where to start? Some observers think that not all engineers do.

What is security?
So what is security? “There are several related concepts,” said Roger Shepherd, an IoT security consultant, “such as reliability, security, safety and privacy – and the differences can be difficult to tease out. But we need to be concerned about all these concepts and, if pressed, I’d say security is about the integrity of function and data.”

Haydn Povey, CTO of SecureThingz, agrees. “There are many facets. A technical view considers managing confidentiality, availability and privacy, but if you
Most people care about security, but don’t know enough about it.” Haydn Povey

needed. “Understand what needs to be kept secure,” he continued, “and the threats to your system. When you build a system, you make choices – such as wired or wireless comms – and you must consider security when making those choices.”

Alongside where security needs to be applied comes the question ‘how secure should my product be?’. Povey believes the answer to this question comes from the development of a protection profile. “Protection profiles are something which have come out of the Common Criteria world. They help you to determine what are the assets you’re protecting, the consequences of losing control and the type of attackers you might have to deal with.”

Shepherd believes the level of security applied to a particular product varies. “But your product shouldn’t undermine the security of a wider system,” he highlighted. “For example, a domestic IoT device might leak a Wi-Fi password and that could undermine the security of a home network. You can determine the appropriate level of security by performing a risk assessment, which should be at the heart of everything you do.”

Povey continued: “From a scientific perspective, you should ask what’s the value and impact of an attack? Will it be a company value – for example, the Equifax hack – or is the worst thing that can happen is someone can hacking one device? Determine the impact of an attack and what resources need to be applied to make that attack. At one end of the scale, it might be someone hacking for vulnerabilities; at other end, there’s ransomware and state actors with infinite resource looking to take down power stations.”

Attacks can have a range of impacts. As Povey noted, there are corporate impacts, such as the Equifax hack and the attack on Target in the US. And the recent WannaCry virus provides another example of the effect of security lapses. “Ransomware is one of the worst attacks; the people behind them are smart and it’s the latest business model. I have seen examples of people demanding $1million per month as ransom.”

If security is a bit of a mystery, then where do you start? “Most people care about security,” Povey asserted, “but don’t know enough about it, so the best place to start is a protection profile, which should highlight the risks and the consequences.

“For instance, you could be exposed to a class break, which could be a supply chain issue.” This relates to the use of a commercially available device – for example, a Wi-Fi module – which either has poor security or, worse, no security at all. “You have to be careful,” Shepherd warned, “particularly with component suppliers. You have to ask yourself whether the Wi-Fi module you’ve selected is secure. You have to be careful with your supply chain because if you’re not, that could bring all sorts of problems.”

Questions

Povey’s advice is to ask your suppliers such questions as what is their root of trust? What is their update mechanism? And, importantly, how will they support you in the future?

One thing which Povey is keen to emphasise is that users have a responsibility to understand the consequences of their decisions. “Designers need to ask themselves whether they’re using the right tools. For example, does my compiler enable versioning? Do the chips I’m using have a secure domain where I can hide and manage secret information; what’s known as a trusted execution environment. So not only are there design decisions
to be made, purchasing decisions will also influence security.”

Shepherd pointed the curious engineer towards the Internet of Things Security Foundation’s website (see box). “Take a look at its ‘Security Compliance Framework’, which covers corporate, process and technical aspects, amongst others. While there, look at the best practice guides.”

There are architectural issues to be dealt with. “Ideally, each device should be fundamentally unique; it should be designed so that it isn’t exposed to class breaks,” said Povey. “That means adopting a zero trust model in which you always authenticate people and services. You also need good ‘hygiene’, such as switching off unused ports.”

Many companies – especially those developing IoT products – may worry about the cost of security. “These companies need to stop thinking about security as a cost,” Povey said. “Rather, it’s a way of enabling the next generation of high value applications to be developed. Things like pay per use instead of retail, enablement and data analytics will all be enabled by security and shouldn’t be seen as an expense.

Maintaining security

Security isn’t a matter of ‘fit and forget’; once you have it in place, it needs to be maintained. Asked how frequently security needs to be reviewed, Shepherd said: “From the start! Security needs to be ‘baked’ into the product implementation and support processes.”

Software updates are a critical issue in maintaining security and it’s important for designers to know how this will happen. Some will use wired communications, but many devices will need to be updated ‘over the air’, or OTA. “OTA brings connectivity issues,” Shepherd observed. “But there is also management of the update size and, potentially, cost issues.”

Povey agreed that OTA bring issues. “It needs a modular approach so the entire code base isn’t updated every time – something that’s important for embedded systems. Make sure you implement version control and modular updates.”

In Povey’s opinion, updating software needs a base level set of services. “But you also need a mechanism which identifies when you’ve been compromised.”

There is also manufacturing security to be considered, with IP theft one of the industry’s major concerns. SecureThingz is working with the industry to enable identity to be injected at the fab or in the distribution chain. This ensures a device is valid and that no counterfeit devices get mixed into those going to market.

“If you’ve spent a lot of money developing your product,” Povey said, “the last thing you want to see is copies of that product on the street.” Counterfeiting is a huge problem; an example is a home appliance vendor which contracted for 500,000 units to be made, but found out that 1.2 million devices had been sold in China alone.

“If you talk about building in security, companies say one thing; ask them about protecting their investment in R&D, they see a value.”

Should the electronics industry be doing more? “An interesting question,” said Shepherd. “There are industry efforts, such as the IoTSF, but one problem is that, as yet, security does not seem to be demanded by the market. Until the demand is there, we won’t see investment.”

And will the Government need to legislate? “Perhaps there is enough in the existing laws and regulations and what is needed is more proactive use of them,” he concluded.

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**IoT Security Foundation Annual Conference**

The 2017 IoTSF annual conference – taking place on 5 December at Savoy Place in London – will bring vendors and users together with security experts, researchers and key stakeholders to discuss security ‘in the round’. Attendees at the event – entitled ‘Knowing it’s safe to connect’ – will learn how companies are providing security capabilities and how users are implementing them. This will be framed by a bigger picture view of the contemporary issues and a look at the future from the research perspective.

- **Session 1: The IoT security big picture**
  A high level look at IoT security and a business panel exploring the adoption of security.

- **Session 2: IoT security research themes**
  Briefings and talks that address aspects of IoT security impacting industry.

- **Session 3: IoT security in action 1**
  A case study of a company that deployed a consumer product rapidly and then had to fix errors and manage the business impact.
  The session will also include a panel session to highlight how to go about product security – and how not to.

- **Session 4: IoT security in action 2**
  The virtues of a collaborative approach to security are explored and the session will conclude with an expert panel discussing how to leverage security for business benefit.

For more and to register, go to [www.iotsecurityfoundation.org](http://www.iotsecurityfoundation.org)
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iven the massive spikes in power consumption incurred by microprocessors and memory when they ramp up to top speed, it is no surprise that much of the attention in circuit design is aimed at trying to find ways to keep digital power under control. But in sensor nodes and other low-energy systems where battery lifetime is a critical concern, often the enemy of the circuit designer is the slow quiet leak. And this is where analogue and mixed-signal subsystems often reign. While the processor and memory sleep, the analogue I/O and clock circuits need to keep running for long periods because they are the eyes and ears of the product.

A further problem for mixed-signal designers is trying to work out ways to get high quality signals with low noise when the voltage rails they deal with are now reliably less than 1V. This affects circuits such as op amps as the voltage drop of any transistor in the output path restricts how many of them can be used and whether the devices can operate fully. The number drops quickly to just two. One option is to simply to never let them switch fully.

Forty years ago, two researchers working in Switzerland showed how to model transistors that never fully switch on in usable analogue circuits, such as oscillators for low-energy wristwatches, as well as bandpass amplifiers. The ‘weak inversion’ topologies described by Eric Vittoz and Jean Fellrath of the Centre Electronique Horloger in Neuchatel now fall under the banner of sub-threshold and near-threshold design. The technique can deliver impressive energy savings, as long as you do not want to process data in a hurry — with very low swings in voltage, transistors become far less responsive.

Weak-inversion design sat on the sidelines for several decades because other techniques delivered a better performance:cost ratio. Renewed interest in sub-threshold design arrived with concern over the power consumption of digital circuits, though their application has been limited because of their performance problems. Now, sub-threshold is back as part of a growing portfolio of analogue design techniques that try to attack the dual problems of falling voltages and the need to save power in micro power sensors.

Subthreshold circuitry makes it easier to deal with the tiny outputs of energy sources such as small solar cells and vibration harvesters. Many of these find it difficult to generate even as much as 1V of output. In order to handle such low voltages, novel techniques and transistors are needed. Take a simple function such as a bandgap voltage reference. Traditionally, these were constructed using bipolar devices — CMOS engineers could use parasitic bipolar transistors to do the same job. But low voltages call for native MOS versions.

A decade ago, researchers from the University of Pisa developed a sub-1V nanowatt voltage reference that coupled a transistor operating in the subthreshold region with another in full saturation. But a constant consumption of almost 70nW just for a single analogue function running for long periods of time easily adds up to a significant proportion of the total...
energy needs of a micropower sensor. An option proposed by a group led by David Blaauw at the University of Michigan is to take an I/O-capable transistor, which works at high thresholds, and stack that on top of a so-called zero-threshold voltage transistor: one that switches on fully at less than 100mV. By carefully adjusting sizes relative to each other, their temperature dependencies cancel out. This provides a stable voltage reference and overcomes one of the biggest problems of subthreshold design: its much higher susceptibility to process variation. By choosing maximum-length devices, the leakage of the zero-threshold transistor can be kept low. In a test chip fabricated in a 130nm process, the voltage reference consumed slightly more than 2pW and occupied a silicon area of 1350µm².

Zero-threshold transistors are not the sole preserve of IC designers, however. Advanced Linear Devices recently launched a device that puts four zero-threshold PMOS transistors onto a discrete device. Robert Chao, CEO of ALD, says the devices were developed to support applications in energy harvesting, as well as signal-conditioning circuits for IoT sensors. Although variation is an issue of subthreshold design, Blaauw and his colleagues have found aspects of weak-inversion transistor operation can work in favour of some types of analogue circuit. Transconductance improves in the subthreshold region as long as parasitic capacitances can be kept low. Various teams have harnessed this idea by revisiting the telescopic cascode amplifier, which stacks multiple MOS transistors on top of each other. Conventionally, the architecture limits the voltage swing of each, but this is less of a problem in a circuit intended for transistors that are operating deep in the subthreshold zone.

To overcome the problem of process variation, amplifiers for slow-moving signals take advantage of pseudo-resistors constructed from transistors. Circuits not only use these pseudo-resistors to tune the circuit dynamically, but also provide very high resistance values that are difficult to achieve with entirely passive structures on an IC. Near-threshold operation is not the only possibility for low-voltage analogue. However, circuit designers have to cope with the limited gain of conventional circuits or suffer high leakage power. One option is to use assistance circuitry to modify behaviour dynamically and so only incur high current levels when necessary.

One approach used by Franco Maloberti and colleagues from the University of Pavia is to have an auxiliary circuit that looks at the incoming signal and adjusts the operation of the op amp so that it can respond better to increases in slew rate. Another approach they have pursued, along with colleagues from the University of Istanbul, is the option to move even further into the territory of sampling that began with chopper-stabilised amplifiers. The result is a sampled op amp. While the concept only works for low-bandwidth signals of up to a couple of thousand hertz, it greatly reduces the quiescent and operating power. Implemented on a 180nm process, a single-ended version of the sampled-data op amp showed a gain of more than 40dB and a bandwidth of 2.5kHz, while consuming just over 60nW.

There is also some good news for SoC designers in the push to smaller geometries. The core performance of the core transistor is, according to designers working on these advanced nodes, much better than equivalent planar transistors. Problems arise in other ways. One, which has proved less important in reality, is the quantised nature of the finFET because the effective width is set by the fin count. In practice, the improved matching performance outweighs the problems. The finFET is far from free of issues. There are problems with parasitics that stem from the complex interactions between the fins and the metal interconnect around. And though density is rarely an issue in analogue circuits, the need to follow the strict routing requirements of nanometre processes to avoid difficulties with manufacturing and variation caused by stresses around the edges of transistor arrays makes layout much more of an iterative and time-consuming process. Even with such problems, the drive below 1V continues to yield viable analogue and mixed-signal designs.
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Living on the Edge

Many IoT applications stand to benefit from high-performance edge processing and cloud computing. Farhad Fallah explains how to connect an FPGA board to Amazon’s AWS cloud computing services.

As the deployment of Industrial IoT systems continues to proliferate, the streams of data transferred to the cloud skyrocket, drastically increasing the cost for cloud computing. To solve this, many systems designers are adopting edge computing, in which data processing is done close to the source (for example, sensors) in a bid to reduce data transfer, storage and processing costs, plus address a few other concerns over Cloud Computing, in particular security.

Big Data is a broad label for the growing amount of data generated by IoT devices and smart systems. For instance, some aircraft engines have more than 5000 elements that are monitored at relatively high sample rates. Most of the data is transferred to a ground station for the real-time monitoring of the engine and for future R&D work. But this is only part of a growing trend. Most ‘smart’ systems produce vast amounts of data which needs to be processed immediately or be stored for subsequent processing.

To store Big Data, huge datacentres are required. These are often costly, need a spacious climate-controlled environment and require regular maintenance. The alternative is Cloud Computing, the on-demand delivery of compute power, applications and other IT resources, with cloud providers – such as Amazon with its web service (AWS) – providing a simple way to access their servers, databases, processing and platforms and storage devices.

The benefits of Cloud Computing are many-fold and include cost efficiency (no need to invest in and maintain your own hardware), scalability, resource availability (for all your users irrespective of their geographic locations), lower latency (as you can specify servers that are closest to the relevant users/customers) and peace of mind in terms of back-ups.

However, there are a few disadvantages to the cloud too, the biggest of which is that no provider can guarantee 100% availability. Data security and privacy are also causes for concern, both on the cloud and for data in transit.

Latency can be an issue for Big Data, and doing computationally intensive tasks on the cloud will increase the cost. Of these concerns the last two, in particular, can be negated through edge processing, where much of the computationally intensive work is performed near the source data.

Benefits here include real-time or near-real-time data processing and reduced network traffic, as you need only transfer the product of the edge processing, thus resulting in lower Cloud Computing costs. Security and privacy can be improved by keeping the sensitive data – or Hot Data – within the edge processing environment and only sending less sensitive (cold) data to the cloud.

FPGAs have the edge

There are technologies that can be used for edge processing applications. These include the use of traditional CPUs (scoring high in terms of flexibility), application-specific processors (such as GPUs) and ASICs/SoCs (scoring high on performance). However, it is FPGAs that are slotting into most edge processing applications. Why is
this so? Well, let’s consider the requirements.

Edge processing needs to be high-performance and in this respect an FPGA can perform several different tasks in parallel. For example, consider executing many non-dependent computations (such as A=B+C, D=E+F and G=H+I). On a CPU, these would have to be performed sequentially, with each sum requiring a few clock cycles. In an FPGA, an array of adders could do the computations in parallel, possibly requiring only a single clock cycle.

Power efficiency is essential too, as the end product may well be battery-powered. With an FPGA the function (design) need be the only circuit present, whereas the architecture of a CPU or GPU may not be fully utilised. Also, with an FPGA comes the benefit of reprogrammability.

Higher security is afforded too because the edge processing functions are hard wired into the FPGA. It is also possible to encrypt the transaction bus and to even go as far as designing your own processor.

Connecting
A prime example of where edge processing is extremely useful, and in which FPGAs can play a significant role, is within an embedded system in which data derived from images needs to be transferred. For example, in the automotive sector Advanced Driver Assistance Systems (ADAS) are under development to make driving safer, easier and more comfortable, and ADAS is regarded as a significant step towards fully autonomous cars.

The data processed by an ADAS can be used to notify the driver of problems or to automatically trigger responses such as deceleration, braking and/or the execution of a manoeuvre. The data can also be useful outside the vehicle.

Let’s discuss the embedded vision system first though by considering an ADAS demo unit that was built for this year’s Embedded Vision show in Santa Clara, California. The demo comprised a TySOM-2-7Z100 prototyping board (see Figure 1) which includes a Xilinx Zynq XC7Z100 device and a TySOM-FMC-ADAS daughter board to interface with four 960 x 540 pixel cameras.

The processing was shared between a dual-core ARM Cortex-A9 processor and FPGA logic (both of which reside within the Zynq device) and began with frame grabbing images from the cameras and applying an edge detection algorithm (‘edge’ here in the sense of physical edges, such as objects or lane markings). This is a computational-intensive task because of the pixel-level computations being applied (more than 2million pixels). To perform this task on the ARM CPU a frame rate of only three per second could have been realised, whereas 27.5frame/s was achieved in the FPGA.

The ARM CPU was mainly used for superimposing detected edges over the initial camera images, colour-space conversions, the formation of a composite image (see Figure 2) and outputting it to an HD buffer. The FPGA and CPU could also work together to recognise and distinguish between obstacles and pedestrians close to the car and to provide lane departure warnings.

What goes up
Sending the processed data to the cloud for further processing and/or storage is then a relatively simple task. Firstly, an AWS account would be created along with an AWS IoT environment. Next, we would configure a Thing (seeing as it is the IoT) and download the public and private keys needed for secure communications with the cloud.

The embedded C MQTT standard would be the ideal Software Development Kit, because it is secure and requires minimal bandwidth. An application would then be prepared to run on the ARM CPU to publish the data onto the cloud.

However, imagine a scenario under which we have data from thousands of vehicles going to the cloud. Analysis of the data could be performed on the cloud and made available for traffic systems or highway maintenance organisations, for example. There may also be instances where data from the cloud feeds into an edge-processing application, in which case applications are also available from AWS.

In summary, there are both advantages and disadvantages associated with cloud computing. However, many of the disadvantages can be overcome through edge-processing; an activity for which FPGAs are particularly suited.
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Across telecommunication systems gallium nitride (GaN) is helping to transform mobile networks. By Helen Duncan

Of all the new semiconductor device technologies that have been introduced over the past few years, gallium nitride (GaN) is arguably generating the most far-reaching effect across a number of different applications areas. As well as making a significant impact in power electronics, GaN is bringing new levels of performance to solid-state RF and microwave hardware. Many commercially available GaN amplifiers focus on providing high levels of saturated output power, but they also offer better linearity and efficiency, wider bandwidths, and lower noise, than competing technologies.

In recent years GaN amplifiers have been gaining ground over traditional vacuum tube devices such as Travelling Wave Tube Amplifiers (TWTA) in many defence and satellite communications applications, where their superior lifetime and reliability is also an advantage.

The benefits of GaN amplifiers are now starting to make their mark in telecommunications systems too, both in cellular base stations and in wireless backhaul, although the high operating voltages make them unsuitable for use in handsets. Exploiting the superior performance of GaN devices will be crucial to achieving the ambitious energy-saving targets for 5G networks as they are rolled out, particularly as the ITU is aiming for a 1000-fold improvement in energy efficiency per transported bit compared with 4G.

“The use of GaN technology is continuing to grow,” says Liam Devlin, CEO of Cambridge-based MMIC design house Plextek RFI. “GaN has proven capability for high power RF and microwave amplifiers, and we’re now starting to see increased availability of GaN components operating at mmWave frequencies. I believe we’ll see increasing adoption of GaN transistors in place of LDMOS for cellular base station PAs, including for 5G when these are deployed – initially in the sub-6GHz band but later in the proposed mmWave bands.”

The reason for GaN’s success is its unique physical properties, specifically the wide bandgap which is 3.4eV compared to 1.4eV for gallium arsenide (GaAs). This large bandgap gives the GaN material a high breakdown field, allowing chips to operate at much higher voltages than other semiconductor devices, and this enables them to be used in higher-power applications that would cause breakdown in other technologies.

In a recent report, analysts Yolé Developpement forecast that by 2025 GaN will account for over 50% of the market for RF power devices above 3W, up from 20% in 2015. Although the proportion of the market belonging to GaAs RF power devices is set to drop slightly, Figure 1 shows that most of this growth will occur at the expense of silicon LDMOS, which is currently widely used in cellular base stations. The size of this market – which does not include PAs in handsets and mobile terminals – was estimated by Yolé to be $1.5 billion in 2016, set to grow to just over $2.5 billion in 2022.

Strategy Analytics, on the other hand, values the market rather lower, but is in agreement on the growth prospects. RF GaN vendors include Wolfspeed, Infineon, MACOM, Qorvo, and Ampleon.
Infineon’s family of GaN transistors for mobile base stations was first introduced two years ago, and they were designed to build smaller, more powerful and more flexible transmitters by providing higher efficiency, improved power density and greater bandwidth than LDMOS. The wider bandwidth was not only ideal for making it easier to upgrade base stations to LTE-Advanced, where up to five 20MHz bandwidth component carriers can be aggregated to increase data throughput, but also to pave the way for the transition to 5G technology. Infineon’s figures showed the GaN devices achieving 10% higher efficiency and five times the power density of LDMOS transistors.

MACOM introduced its MAGb series of GaN power transistors in early 2016 for use in LTE macro base stations, also aiming to challenge the longstanding reign of LDMOS for that application. Boasting superior efficiency, bandwidth and power gain, but with a linearity and a price tag to match those of LDMOS, the power transistors targeted all the main cellular bands in the frequency range 1.8 GHz to 3.8 GHz. The series includes single-ended transistors providing up to 400W peak power, dual-transistors, and single-package Doherty versions with up to 700W peak power output. MACOM also pointed to a power efficiency improvement of up to 10%, and package size reduction greater than 15%, over legacy LDMOS offerings. The transistors also have a wider bandwidth – reducing the number of parts needed to cover the major cellular bands – and make it easier both to linearise with digital-pre-distortion (DPD) schemes and to implement Doherty energy-saving.

**GaN-on-SiC**

While MACOM’s process is GaN-on-Si, Qorvo’s recently-introduced devices – like those of Infineon – use a GaN-on-SiC (silicon carbide) process. Although pricier than GaN-on-Si, GaN-on-SiC offers superior thermal conductivity; it therefore allows higher average power levels to be handled, as well as improving efficiency and linearity. Qorvo’s asymmetric 2.5 – 2.7GHz Doherty amplifier, launched in August this year, features two pre-matched, discrete GaN-on-SiC High Electron Mobility Transistors (HEMTs) in a single package, to maximize linearity, efficiency and gain in base station designs.

Qorvo has also been the first to announce GaN devices for mmWave 5G base stations, with a 39GHz front-end module (FEM) having launched at the International Microwave Symposium in June. Other vendors are initially proposing GaAs and microwave components.

"GaN has proven capability for high power RF and microwave amplifiers and we’re seeing increased availability of GaN components.”

Liam Devlin

It is not only in base stations where GaN has the potential to boost performance. With such a dense network and high data rates, 5G will demand a rapid, massive rise in backhaul capacity, and it is likely that microwave and mmWave point-to-point links will provide most of this, since they are significantly cheaper and more convenient than fibre to install. County Durham-based Filtronic Broadband is already designing and manufacturing transceivers for backhaul applications in E-band (71 – 76GHz and 81 – 86GHz), and has described the suitability of GaN for use in this frequency band in the future. Currently their GaN subsystems are aimed at the traditional 6GHz to 11GHz long-haul radio bands, but development is planned to extend this up to mmWave frequencies.

Figure 2 shows the chip layout of a 15GHz line-of-sight GaN PA MMIC PA with an additional output coupler and power detector, developed by Plextek RFI for a customer’s backhaul application.

**UK centre of excellence**

Recognising the potential of GaN has also been the main reason for the establishment by Innovate UK of the Compound Semiconductor Applications (CSA) Catapult in South Wales – an area that was already established as a centre of excellence for GaAs and GaN technologies. Although the UK no longer has an indigenous commercial fab for III-V RF devices since the sale of RFMD’s Newton Aycliffe facility four years ago, there is a thriving ecosystem of component, subsystem and system design and manufacture in this country that has compound semiconductors at its heart. The CSA Catapult aims to stimulate innovation in this area, and 5G mobile communications – along with space and defence applications – will be a clear target.
The LT6658 expands the capability of precision voltage references by including dual output buffers capable of sinking 20mA, and driving 150mA and 50mA, respectively. Six options are available with different internal reference voltages, and each output voltage can be adjusted using external resistors. With two outputs, the LT6658 can be operated as a reference and regulator, as a reference plus a virtual ground, as a dual tracking ratiometric supply, or combined as a single 200mA voltage reference.

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  - B-Grade: 20ppm/°C Max
- High Accuracy:
  - A-Grade: ±0.05% Max
  - B-Grade: ±0.1% Max
- Low Noise: 1.5ppm_p-p (0.1Hz to 10Hz)
- Load Regulation: 0.1ppm/mA
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