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Matt Hancock, the Secretary of State for Health, has announced a £200million investment in technology to bring the NHS into the 21st Century.

Speaking at the Health and Care Innovation Expo in Manchester, the minister said that the health service was ‘downright dangerous’ using IT systems that were putting lives at risk.

The government has already thrown billions at NHS tech, establishing a digital exemplar scheme in 2016, that handed money to trusts to help fund the development of new approaches that could then be shared among others.

Hancock has announced a further £200m for that scheme, with the aim of creating the first exemplars for community, alongside those for acute, mental health and ambulance trusts. He also announced a new NHS App, that will allow patients to book appointments, order repeat prescriptions, see their medical records and set data-sharing preferences, across five regions of England.

According to Hancock, “Like good tech elsewhere, we need technology that makes life easier for hard-working and often overstretched staff. We need technology that can run basic tasks and processes more efficiently.”

We can all welcome that ambition because, as it stands, far too many hospitals operate multiple systems, none of which talk to one another. Add to that complexity the fact that GP practices, social care, pharmacies and community care providers are all using different systems and too many of them are reliant on antiquated ones, whether that’s fax machines or simply pen & paper note taking, where systems are unable to talk to one another, is it any wonder that IT systems in our health service are perceived as failing?

Whatever the benefits, however, the NHS has an appalling record of implementing schemes associated with implementing new technology - from the National Programme for IT, which cost £11billion, and was scrapped in 2011 to efforts to create a paperless NHS......in 2018, the record is far from impressive.

Hancock says that it’s time to put those failures ‘behind’ us and to be fair, rather than the top down approach taken in the past, this scheme looks to impose open, bottom-up standards to ensure interoperability, privacy and security.

There will be those who say that we should be spending limited resources on more doctors, nurses and new equipment, but £200million is a tiny sum in a healthcare budget worth £140billion. If handled correctly, it could deliver a return out of all proportion to its relatively small size.

Neil Tyler, Editor (neil.tyler@markallengroup.com)

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Calibration fault could cost millions

An error in a calibration method could lead microchip manufacturers to lose millions of dollars in a single fabrication run, according to the National Institute of Standards and Technology.

The error occurs when measuring very small flows of exotic gas mixtures. Small gas flows occur during chemical vapour deposition (CVD), a process that occurs inside a vacuum chamber when ultra-rarefied gases flow across a silicon wafer to deposit a solid film. CVD is used to fabricate many high-performance microcircuits containing billions of transistors, and builds up complex 3D structures by depositing successive layers of atoms or molecules. A complementary process called plasma etching also uses small flows of exotic gases to produce tiny features on the surface of semiconducting materials by removing small amounts of silicon.

These flow inaccuracies cause nonuniformities in critical features in wafers, directly causing a reduction in yields.

In response, NIST has developed a mathematical model of the Rate of Rise (RoR) process – which can be used to more accurately calibrate the regulator device known as a mass flow controller. The conclusion is conventional RoR flow measurements can have significant errors because of erroneous temperature values.

NIST found that without corrections for these temperature errors, RoR readings can be off by as much as 1 percent.
Finally receiving recognition

FEMALE BRITISH ASTROPHYSICIST DONATES £2.3M AWARD AFTER BEING DISREGARDED BY NOBELS FOR PULSAR DISCOVERY. BETHAN GRYLLS REPORTS

British astrophysicist, Dame Jocelyn Bell Burnell, has been awarded a £2.3million special Breakthrough prize in physics for her work in pulsars – a discovery, for which she was previously ignored by Nobels. Spurred by her own experience, Dame Bell Burnell is donating the money to the Institute of Physics to fund PhD studentships for underrepresented groups. These funds will not only go towards helping women in their journey to become physics researchers, but will also be used to support ethnic minorities and refugee students.

During her observations of a radio telescope, Dame Bell Burnell, noticed a strange signal — repeating pulses of radio waves. She took her findings to her PhD supervisor, Antony Hewish, who believed the signals to be artificial radio interference. However, after gathering more evidence, she identified three more repeating pulses from different areas in the galaxy. The signals were spinning neutron stars, or pulsars, which release beams of radio waves as they turn.

Despite making the discovery, it was Hewish that was awarded the Nobel prize for the pulsar work. Since then, Dame Bell Burnell became the first female president for the Institute of Physics and the Royal Society of Edinburgh, and has been involved in setting up the Athena Swan scheme, which aims to improve the lives of women in academia.

Although she believes this programme is helping tackle an unconscious bias against women, she deems that “more needs to be done.”

Safety platform for autonomous vehicles

Together with Hyundai Autron, Wind River is developing a software framework for safe, automated and autonomous driving.

Using IP from both companies, the platform will provide a framework for integrating advanced compute features found in connected and autonomous driving applications such as advanced sensing, Ethernet based communication, and artificial intelligence applications.

The platform will run on top of the VxWorks safety certified real-time operating system and leverage advanced system partitioning via hypervisor technology. This partitioning allows automakers to take software that is essential to safety critical functions like vehicle controls, actuation and sensing, and place it alongside less critical functions like infotainment and telemetry onto the same hardware architecture. As a result, this reduces the system’s dependence on any particular set of hardware. The net outcome is a software system with mixed criticality functions that is more flexible and cost effective for the automaker without undermining safety or security.
First SBCs able to support ISO CAN FD protocol

Infineon Technologies has released two new System Basis Chip (SBC) families, the Lite and Mid-Range+, which the company says are the first SBCs able to support the ISO CAN FD protocol for communication at 5 Mbit/s for a large variety of automotive applications.

An SBC is the central supply of power and communication for microcontrollers within electronic control units (ECU) in cars combining voltage supplies, communication bus interfaces (CAN, LIN) and supervision features. By combining these elements lower system costs are possible and the device is as much as 80 percent smaller than discrete solutions.

The Lite SBCs are entry level and incorporate one CAN transceiver addressing a broad range of applications such as in-cabin wireless charger, gear shifter or light control units. The Mid-Range+ SBCs are more powerful with one CAN and up to two LIN transceivers to support body control modules and gateway modules, for example.

Recent developments in the automotive industry require much faster communication capabilities. Originally, the CAN FD protocol was established for software updates during production and service events. Today, communication within the car and its connectivity to the outside world require an increased bandwidth and longer payload.

In addition to high-speed communication, these new SBCs afford significantly lower power consumption. They have an optional partial networking feature that reduces current consumption by putting the ECU in a sleep or stop mode when it is not needed.

All the SBC families include diagnostic and supervision features to support ECU functional safety concepts like under-voltage monitoring, window watchdog with reset, fail-safe operating mode and fail-safe output.

Socionext enhances sound quality

Socionext has announced a lineup of acoustics solutions under its “ForteArt” family of software IPs.

ForteArt looks to enhance the sound-related user experience, with applications including consumer products, public signage and automotive infotainment systems. The software IPs can be implemented with other vendors’ hardware, as well as with Socionext’s own SoC products.

Organised as a family of solutions ForteArt looks to address the increasing amount of broadcast and network video distribution that includes multiple sound channels such as 5.1ch, 7.1ch and 22.2ch. Because many home-use systems include only two speakers, sound effects are often compromised and not full quality.

The current ForteArt lineup includes a variety of technologies and solutions, such as “3D Surround Sound Solution” for reproducing “pseudo surround effect” with a two-speaker system, and a “Bass Boost Solution” which allows listeners to experience a deeper, richer bass sound even with low-cost speakers, by generating signals based on human hearing characteristics and adding those signals to the original sound.

In addition to consumer applications, the technologies can reproduce more stereoscopic and realistic sound for public viewing and digital signage.

For automotive systems, for example, ForteArt’s “3D Audio HMI” uses existing in-vehicle speakers, with sound-localisation technology, to help transmit sound next to the driver’s ears. The 3D Audio HMI enhances the driving experience and improves safety through audible navigational assistance and alerts. All of these solutions not only provide built-in functionalities within Socionext SoC products, but also in the form of software IPs which can run on customers’ own devices.

Equipment manufacturers will be able to implement them without adding any equipment or making any changes to their hardware.

X-FAB boosts foundry capacity

X-FAB Silicon Foundries, the analogue/mixed-signal and specialty foundry group, is to double its 6-inch Silicon Carbide (SiC) process capacity at its fab in Lubbock, Texas in response to increased customer demand for high efficiency power semiconductor devices.

The company has purchased a second heated ion implanter for use in manufacturing 6-inch SiC wafers. Delivery is expected by the end of 2018, and production release is planned during the first quarter of 2019 in time to meet projected near-term demand.

This doubling of X-FAB’s SiC process capacity furthers its strategy to remain the premier 6-inch SiC wafer foundry and, according to the company, demonstrates its commitment to both the SiC technology and the SiC foundry business model.

Advantages of the 6-inch SiC process capabilities for power semiconductors include superior high voltage operation, significantly lower transistor On-resistance, much lower transmission and switching losses, extended high temperature operation as high as 400°F/204°C, higher thermal conductivity, very high frequency operation, and lower parasitic capacitance.

Systems with SiC power devices benefit from reduced system size and weight, and because they dissipate less heat are significantly more efficient compared to similar power semiconductor technologies.

According to Lloyd Whetzel, CEO of X-FAB Texas, “With the rising popularity of SiC we understood, early on, that increasing our ion implant capability would be critical to our continued manufacturing success in the SiC marketplace. This is just the first step in our overall capital plan for SiC-specific manufacturing process improvements.”
Ten years ago, the European Commission initiated a public consultation on existing requirements covering medical devices. After talking to a wide variety of stakeholders the Commission released its plan in 2012 to restructure the EU’s medical device regulatory framework, along with a regulation that would replace existing directives for medical devices and active implantable medical devices.

As a consequence, manufacturers of medical devices who sell within the European Union (EU) are faced with major changes in the EU’s decades-old regulatory framework. The Medical Device Regulation (MDR) was officially published on 5 May 2017 and came into force at the end of May last year.

“The MDR will replace the EU’s current Medical Device Directive (93/42/EEC) and the EU’s Directive on active implantable medical devices (90/385/EEC),” explained Richard Poate, Medical Health Services Business Line Manager at TÜV SÜD Product Service.

According to Paul Jenkins, a Medical Health Service Team Leader at TÜV, “Manufacturers of medical devices that have already been approved will have a transition time of three years until May 2020, to meet the requirements of the MDR and that transition period can be extended until May 2024 in certain circumstances.”

As Poate explains, the MDR differs in several important ways from the EU’s current directives for medical devices and active implantable medical devices.

**Advanced preparation advised**

The EU’s new medical device regulatory framework means that manufacturers of medical devices face major changes, as Neil Tyler reports

“Changes include a significant expansion of the scope of products covered, more rigorous requirements for clinical evaluation including changes to clinical investigations, mandatory unique device identification (UDI) mechanisms, and increased post-market oversight by EU Notified Bodies,” he explained.

Looking in more detail at these changes they mean that the definition of medical devices and active implantable medical devices covered under the MDR will be expanded significantly and, according to Jenkins, will include “devices that may not have a medical intended purpose, such as coloured contact lenses and cosmetic implant devices and materials. Also, for inclusion will be devices designed for the purpose of “prediction” of a disease or other health condition.” He continues, “The MDR will also require device manufacturers to review the updated classification rules and update their technical documentation accordingly by considering the fact that class III and implantable devices will have higher clinical requirements and a regular scrutiny process.”

Crucially, manufacturers will now be required to collect and retain post-market clinical data as part of the ongoing assessment of potential safety risks.

“These changes will result in a dramatic increase in the time and resources needed by manufacturers to conduct the required studies and to maintain post-market documentation,” according to Poate.

Also, under the MDR, all currently approved devices will need to be recertified, in accordance with the new requirements. “Manufacturers with currently approved devices will have three years to demonstrate compliance with the MDR’s new requirements,” explained Jenkins, “although exemptions are under negotiation.”

It is also important to note that, as an EU regulation, the MDR will have the force of law throughout the EU after the date of application. This approach will eliminate country-by-country interpretations of the requirements permitted under current directives and is also likely to speed up the actual effective date of the MDR’s requirements across the EU.

“The complex development process for medical devices, combined with the changes, are likely to make the transition period a complicated and time-consuming process for most device manufacturers,” said Poate.

“Because of these complexities, as well as the impact Brexit is expected to have, we are advising medical device manufacturers to stay current on the progress of the MDR through the regulatory approval process, as well as additional changes that may impact them.”
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The cutting edge of technology

The Cockcroft Institute is unique among institutions, bringing together industrialists, scientists and engineers to advance the science and technology supporting particle accelerators. By Neil Tyler

Named after the Nobel prize winner Sir John Cockcroft, who, together with Ernest Walton, won the Nobel Prize for splitting the atom for the first time in 1932, the Cockcroft Institute was set up to carry out research into, and the design and development of, particle accelerators.

The Institute is an international centre of excellence for accelerator science and technology and is located in a purpose-built building on the Sci-Tech Campus adjacent to the Daresbury Laboratory and the Daresbury Innovation Centre in Cheshire, in the North West of England. It is a joint venture between the Universities of Lancaster, Liverpool and Manchester, and the Science and Technology Facilities Council (STFC). Recently, it was joined by the University of Strathclyde.

When, or more likely if, people talk about accelerators they tend to think about the massive accelerators, CERN for example, that are being used to reveal the nature of matter and to help us better understand what actually happened at the point when the universe was created.

But accelerators are not only being used for this type of work, in fact the technology is being used to develop new materials and technologies - security scanners and medicines, for example - that could radically change the way in which we live.

“The work we carry out here at the Institute, is cutting-edge,” explains Professor Carsten P. Welsch, Head of the Liverpool Physics Department and Head of Communications at The Cockcroft Institute.

“We are working to push the limits of our ability to control and understand processes that are happening not only at the smallest scale, but at the speed of light.

“While particle accelerators may be best known as being ‘atom smashers’, the experiments from which we are beginning to better understand the basic properties and fundamental forces that shape our universe, their use is certainly widespread and growing.”

Put simply, accelerator science is about accelerating elementary particles, such as electrons and protons, and then colliding those particles at the speed of light. While charged subatomic particles tend to be used, it is also possible to use whole atoms of elements such as gold or uranium, which are much heavier.

“Using a circular accelerator, once we have reached the desired energy level, we can collide particles, creating new particles as well as confirming theoretical particles. For example, the Higgs boson which was proposed in 1964 by the physicist Peter Higgs and confirmed by the ATLAS and CMS collaborations based on collisions carried out in CERN,” explains Prof. Welsch.

“We are setting free particles that have not been seen since the universe was created. We are testing theories and identifying new particles.”

A ten year anniversary

“When the Institute was set up, our vision was to improve and design better particle accelerators,” says Prof. Welsch. He continues, “The Institute was established ten years ago and today we have around 250 staff on site, both professional and students. We also work closely with industrial collaborators both here in the UK and overseas.”

According to the Professor, the Institute and the study of particle accelerators have come a long way in that time.

“When we were set up, accelerator science, as it is understood today, was not an independent science. There were no structured PhD programmes and the engineers and scientists working on the space...
Accelerators are now key pillars of modern research across a host of scientific disciplines and countries.

Accelerator applications extend beyond medical applications, described previously and include: material analysis and detection of fraud, investigation of biomolecules, pharmaceutical process control, food preservation, and homeland security.

“We are working on security and medical applications that will start to appear in a matter of a few years,” explains Prof. Welsch.

When the decision was made to set up the Institute it was decided that it should comprise of three elements.

“We settled on a three-fold mix,” continues Prof. Welsch. “We wanted academic institutions out of which ‘crazy’ new ideas could emerge, and academics capable of providing longer-term vision of what could be possible and what accelerators and the science around them could deliver in the future.

“But, while we wanted these institutions to be able to deliver breakthroughs in new technologies, we also wanted industrial collaborators. We needed them to bring those academics back to earth and to encourage greater focus in terms of developing and delivering designs, as well as in the testing, building and assembling of hardware.”

As a result, the Cockcroft Institute is very much a collaboration between academia, national laboratories, industry, and the local economy.

“We’ve brought together the best accelerator scientists, engineers, educators and industrialists who, working together, can conceive, design, construct and use the very latest instruments of discovery at all scales,” explains the Professor.

One of the key aims of the Institute is to educate the next generation of accelerator experts, and while this is being done through the training of research Fellows, considerable efforts are made to also inspire school students and the wider public.

The Institution is also responsible for a spin-out – D-Beam – which has become the newest member of the STFC CERN Business Incubation Centre.

Prof. Welsch is one of the founders of the company which, last year, unveiled its first commercial device, a sensor that can detect the smallest amounts of beam losses. The loss of particles in a beam accelerator can introduce unwanted ‘noise’ into experiments and can, in extreme situations, actually damage the equipment.

Robust and reliable sensors are therefore critical to ensure accelerators function correctly.

“It’s a great example of taking cutting edge research and creating commercially available tools,” explains the Professor. “It helps us to improve our understanding and control of particle beams.”

**International collaboration**

The Cockcroft Institute leads the UK’s participation in a number of flagship international experiments through a visitor programme and participation in joint projects.

The Institute contributes to large scale research facilities, such as the Large Hadron Collider (LHC) at CERN, its High Luminosity upgrade programme and the Future Circular Collider projects via the European Design Study EuroCirCol.

Groups from the Institute are also involved in the ALPHA experiment at CERN, and have been leading the development towards an ultra-low energy storage ring at FLAIR and are also a major contributor to the new ELENA facility at CERN.

CI researchers are helping push the boundaries of high intensity accelerators through contributions to the European Spallation
Wakefield Experiment, is a proof-of-materials accelerators,” explains Prof. Welsch. “These include latter laser and particle beam-driven plasma wakefield acceleration, as well as dielectric laser, photonic bandgap and meta materials accelerators,” explains Prof. Welsch.

**New particle physics experiments**

Shrinking the size of accelerators, “to make them more practical,” according to the Professor, is seen as crucial and to that end the Institute is involved in cutting edge R&D programmes looking into “frontier accelerators and novel accelerators”.

AWAKE, which stands for Advanced Wakefield Experiment, is a proof-of-principle compact accelerator project, which aims to accelerate electrons to very high energies over short distances, not the thousand, or so, metres that currently tends to be the case.

The collaboration, based at CERN, involves several UK-based research groups and is supported by the UK Science and Technology Facilities Council (STFC) and has been able to demonstrate the use of plasma waves or so-called wakefields as new way to build small-size, affordable, high-energy particle accelerators.

Accelerating particles to greater energies over shorter distances could enable more laboratories and hospitals to use accelerator science. It could also prove very important in a wide range of industrial and medical applications, such as more compact light sources for patient diagnostics and cancer treatments.

According to Prof. Welsch, “These breakthrough results show, for the first time, that proton-driven electron beam acceleration offers a promising pathway towards the highest energy beams provided by a very compact accelerator. This has the potential to enable entirely new particle physics experiments.”

“Our team in Liverpool is developing simulation tools and advanced diagnostic techniques to support and optimise AWAKE, helping to pave the way for entirely new applications.”

The AWAKE collaboration accelerated electrons in plasma for the first time. Electrons injected into AWAKE at relatively low energies of around 19 MeV (million electronvolts) ‘rode’ the plasma wave and were accelerated by a factor of around 100; to an energy of almost 2 GeV (billion electronvolts) over a length of 10 metres.

Current state-of-the-art particle accelerator technologies, considered for the next generation of electron accelerators, promise gradients in the range of just 30–100 million volts per metre (MV/m). These represent today’s most advanced technology for the overall distance over which acceleration can be sustained.

The next steps of AWAKE aim to achieve gradients of 1,000 MV/m.

Plasma is a special state of matter that can be induced by ionising a gas. In AWAKE, rubidium is heated to convert it into a gas and it is then ionised with a laser beam. A proton beam (called the drive beam) is injected along with the laser pulse and causes the plasma to oscillate in a wave-like pattern.

AWAKE gets its drive-protons with an energy of 400 GeV (billion electronvolts) from CERN’s Super Proton Synchrotron (SPS), which is the last accelerator in the chain that delivers protons to the 27km LHC. A beam of electrons (called the witness beam) is injected at a slight angle into the oscillating plasma and get accelerated by ‘surfing’ plasma waves.

While previous experiments of wakefield acceleration have relied on using electrons or lasers to drive the wake, AWAKE is the first to use protons.

“The use of particle accelerators has changed massively since the creation of the Institute,” concludes Prof. Welsch. “Their impact on everyday life is significant and growing. It’s not just about understanding the fundamental building blocks of physics anymore.”
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By 2020, for every human, there are expected to be 26 smart devices and if that forecast from Intel is accurate, that means around 200 billion connected ‘things’.

The collection of data, whether from smart home devices, connected cars or wearables, is the very foundation of the Internet of Things (IoT) and this rests upon the deployment of sensors. As the world becomes more connected, the function of the sensor will become ever more essential.

“Sensors will be one of the major growth markets of the future,” says Thomas Riener, Senior VP at ams. “Everything is getting connected and as things become connected, these smart devices need to be given a way to see, hear, feel and smell.”

“The sensor is vital,” agrees Ben Lee, CEO of mCube, a company that specialises in what it calls ‘the Internet of Moving Things’ (IoMT), a term Lee coined to distinguish mCube’s offering. “The original raw data has to be accurate, otherwise the processor is just processing data that is ‘garbage’.”

“The IoT comprises of three key elements, that’s the sensor, the connectivity (microprocessor) and the Cloud platform. Sensors are the start of the process, but I wouldn’t call them the heart of the IoT,” suggests Patrick Nicholson, Managing Director, Fen Technology. “For example, if you’ve selected the wrong communication channel, it can become overloaded and as a result, data can’t be accessed. You need all these components to work together of course, but what’s really important is what you do with the data.”

According to Lee, the IoT has helped to drive the sensor industry and the way in which mCube operates. “Our customers don’t often have the capability to develop custom algorithms for motion and sensor fusion software, some of them don’t even understand electronics. More of our customers are asking if we can provide the entire module.”

Lee explains that mCube’s recent acquisition of Xsens was driven by this trend. “We wanted to become the best in sensor fusion software and module system development, so leveraging Xsens’ expertise to support and grow the IoMT market was essential.”

IoT focus

For companies like ams the IoT is becoming a key focus, according to Riener. “The first wave of semiconductor demand was the PC, the second was the mobile phone. We believe the IoT is the third.”

While Lee agrees with Riener, he argues that the term itself is flawed. “We are starting to see the end of the rise of the smart phone and people are beginning to worry what’s next.” He suggests that the IoT has derived from a panicked search for the ‘next wave’, with the industry “throwing everything that could possible happen” under the same phrase.

He explains this is what inspired him to coin the term, IoMT. “You need to have a focus and define what part of the IoT market you’re in. For mCube we’ve identified things that are moving.”

Lee points to an interesting mCube use case with gas pipes in Japan – something which one wouldn’t consider as ‘moving’.

After an earthquake, pipes can move, he explains, posing stress upon the joints which can lead to leaks and ultimately, explosions. mCube sensors were placed onto the pipes to detect and measure tilt to avoid accidents in the future.

Due to the environment, the sensor needed to be wireless and have a battery that lasted at least 10 years, Lee adds, and both of these are among the trends he identifies within the market.

“We’re seeing an increasing need
for miniaturisation and a reduction in power consumption such that the technology can disappear while consumers enjoy the benefits of improving daily life.”

He imagines a sensor-led future where the IoT becomes something he calls ‘the Internet of Nothing (IoN)’, in which everything will be connected, but the physical smart devices, i.e. the mobile phone, will disappear.

“He imagines a sensor-led future where the IoT becomes something he calls ‘the Internet of Nothing (IoN)’, in which everything will be connected, but the physical smart devices, i.e. the mobile phone, will disappear.”

“Humans weren’t meant to do all this finger swiping and staring at small screens,” he contends. “In the future, you’ll still be able to communicate with anyone in the world, but in a more natural way. You’ll no longer be relying on a particular device, but ‘invisible’ technology which is everywhere.”

“Today you’re wearing one sensor, like a FitBit. In the future, you’ll be wearing thousands. You’ll put your pyjamas on, for example, and they’ll be full of sensors that will help you sleep better – but you won’t be aware of their presence.”

“I’m deeply convinced the networking of devices is going to grow further and provide more demand for sensors,” adds Rienner.

But for Nicholson, the future is in the software not the hardware. “It will be about how clever the device is and what value-added features can be included. These additional features will be based on the data companies collect from their customers.”

**Software is the key**

With an app, Fen Technology has enabled a smart lawnmower to remotely cut grass. “That’s a useful feature,” explains Nicholson, “but the really useful part is that we gave the company customer insight, revealing how they used the lawnmower.”

He points to predictive maintenance as a huge market when it comes to the IoT.

“If you have a sufficient data set you can carry out clever analysis and identify trends. You then begin to not only understand your customers, but you can also intelligently predict the future.

“We are going towards this idea of the IoN, driven by easier interoperability, but unfortunately they’ll be a natural limit. Not just because of the cost restrictions, but because of the actual usefulness of the information. There has to be an intelligent reason as to why something becomes connected. Otherwise it just becomes a premium product which won’t see any valuable return in sales or data.”

Despite Nicholson’s reservations, Intel envisions a similar scenario to Lee. A connected world where devices – such as weather drones and smart street lamps - work together to improve safety, efficiency and lifestyle, powered by the data detected by billions of sensors.

Occi is an example of this kind of ‘seamless’ technology already in practice, pushed by the challenge that online ‘pure players’ like Amazon, which utilises web cookies to gain customer insight, pose on retail stores.

“A store is covered in mesh sensors every 100sq metres which are configured with a unique algorithm. One ‘master’ sensor is connected to the Internet and each is designed to detect RF and Wi-Fi signals from a shopper’s smartphone to sense geolocation and movement,” explains Gabriel Mulko, Occi’s Marketing Manager.

Data can be enhanced further, with shoppers signing up to loyalty schemes that enable the geo-data to be merged with receipt purchases.

Above: Sensors are the heart of the IoT, used to collect data about an object, such as movement, or about an environment, like air quality information

**“Companies need to have a focus and define what part of the IoT they’re in. For mCube it’s the IoT.”**

Ben Lee

This means that the store can make intelligent changes to layout, or tailored discounts.

“For example, if a customer spent 10 minutes looking at TV sets, but didn’t purchase one, the store could offer that customer 10% off TVs for the next visit,” says Mulko.

In a move intended to help streamline large-scale IoT deployments, Purdue University and the University of Virginia have developed a fabrication technique called ‘transfer printing’ that produces ‘electronic stickers’. This bypasses several manufacturing steps and the associated costs by using a single wafer to build an almost infinite number of thin films holding electronic circuits, the researchers say. It also enables any object to sense its environment or be controlled.

A sticker could, for example, be placed onto a non-electronic, unconnected object like a flower pot. In theory, it would transform the flower pot into a connected object, sensing temperature changes that could affect the plant’s growth.

The sensor is an integral part in the IoT and as more things become connected, the world will start to rely more and more on the data they collect.

However, as Nicholson says, “the companies that are going to ‘win’ will be the the ones that understand how to use that data.”
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IoT security is notoriously lax leading to headline grabbing attacks that seed fear among consumers and threaten adoption. Typically, only nine percent of vendor budgets go on security implementation and testing. Even if we allow for the fact this low figure may be due to security being outsourced, it’s clear that security is too often, a secondary consideration with production and time-to-market dictating spend.

This failure to observe basic security best practice means a vast number of devices are susceptible to the same few attack vectors. These issues provide the attacker with that first foothold from where they are able to carry out further compromise, potentially gaining full control of the device, gather data or even using it to attack the user’s network.

So, what are the top ten fails that are threatening to derail the IoT?

1. **Mobile apps**
   It’s often not the device but the mobile app it talks to that presents the single biggest threat. Decompiling the app allows the attacker to take advantage of issues such as a failure to implement SSL, either at all or incorrectly, allowing comms to be intercepted. For example, research into the Mitsubishi Outlander PHEV SUV mobile app provided access to the vehicle’s alarm, door entry, lighting and HVAC controls. Static credentials that see a password to the API put on the mobile app is another big no no, and we often find insecure storage of data on apps. Other issues include too many app permissions, enabling the attacker to masquerade as a legitimate connection.

2. **API/web services**
   The mobile app interacts with a web service to send data to the vendor’s servers and that means the API is being published to the public internet. Vendors often assume that because it’s only intended to interface with the mobile app, the API is obscured. This isn’t the case and an attacker that reverse engineers the app will have direct access to the API and be able to interact with the web service. This can have severe repercussions. If the vendor has failed to put in place strong session management, users can view one another’s data. Not implementing encryption properly is another common issue, as we saw recently with the Tapplock which had failed to implement AES 128 encryption properly. Injection attacks are another problem associated with web services which allow the attacker to potentially access all the customer data that service has access to.

3. **Web apps**
   Some IoT devices allow the user to view their data via a web browser for ease of use such as in the case of fitness trackers. Web apps are notoriously flawed and this could again lead to customer data leakage, as seen in the Under Armour MyFitnessPal data breach.

4. **Radio Frequency Communications**
   Standards such as Wi-Fi, Bluetooth, ZigBee and Z-Wave, if implemented insecurely, can expose customer data and the device itself to attack. Communications can be intercepted in a Man-in-the-Middle attack (MitM) or even hijacked and abused as we saw with children’s toys My Friend Cayla and the Teksta Toucan. Poor Bluetooth device pairing that uses default PINs is a common way to gain control of these devices.

   The standards themselves can sometimes have issues. Recently we saw how the Z-Wave standard could see devices downgraded to an earlier version, allowing the attacker...
Additional security mechanisms can be put in place such as BGA (Ball Grid Array) packages which, when combined with good PCB design, can make it harder to tap into signals, while authentication mechanisms such as SAM modules, Atmel CryptoAuthentication or MaxiDeepCover devices can be used to store keys securely, although it is still necessary to consider key generation. Many embedded systems lack a good source of entropy making it difficult to generate sufficient randomness to issue keys securely.

6. Firmware
Again, the assumption is often made that no-one is going to look at the firmware, so it seldom gets encrypted and signed. This makes it trivial for an attacker to reverse engineer and use the firmware to carry malicious updates into the device.

7. Infrastructure
Considering the impact on the wider network is essential whether the IoT device is deployed domestically or commercially. Security should at a minimum seek to ensure the implementation of least privilege, ensuring access is only awarded as needed, while password security should seek to eliminate the use of default, simple or re-used passwords, and the timely application of security updates and software patches should also be made mandatory.

8. Updates
IoT devices can start out secure but through the discovery of new issues become vulnerable or the addition of new functionality, such as an upgrade to the mobile app, can introduce vulnerabilities. It’s therefore vital to have an update mechanism in place in the event of new vulnerabilities becoming active. Typically, this will see support for over-the-air (OTA) updates, however, OTA can lead to complacency among developers who then assume any security issues can easily be fixed post-release. OTA can also become an issue in itself if not properly secured as it acts as a vehicle over which to propagate rogue or malicious updates.

9. Passwords
A failure to implement effective passwords is a major stumbling block for IoT devices. Default passwords may be left in place, or it may be hard for the user to change them, making the device vulnerable from the moment it is activated. It’s rare that we see the use of two-factor authentication on IoT products which seems crazy when it is so easy to put in place.

10. Customer data
Poor storage of customer data can also result in compromise. Even if the vendor has implemented database encryption the data is unlikely to be encrypted when in transit. It also pays to consider your service provider and how your cloud service is configured. As we saw recently in the case of the Swann security camera and FLIR camera made by Lorex Technology, one compromise can affect multiple vendors. In that particular instance, a vulnerability concerning weak authorisation at the cloud provider, Ozvision, saw users able to view one another’s camera feeds.

These ten examples illustrate how vendors are repeatedly failing to apply simple security best practice and are continuously exposing their customers to attack.

Author details:
Ken Munro is a Partner at Pen Test Partners

“Vendors are repeatedly failing to apply simple security best practise and are exposing their customers to attack.”
Ken Munro
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One size does not fit all when it comes to the Industrial Internet of Things (IIoT). Only customisation and integration will deliver, as Darren Hobbs explains.

The Industrial Internet of Things (IIoT) is not a homogenous market and is challenging for typical semiconductor vendors who prefer to supply off-the-shelf standard components into the industrial space.

One-size does not fit all in IIoT applications - only customisation together with integration, yields the cost, power, size and optimisation needs that will enable the proliferation of the IIoT.

Designs are all about connectivity and it won’t be only a single part that is affected – manufacturing, logistics, the supply chain, energy supply and transportation are all expected to be transformed by the ability of the IIoT to streamline operational functions and create new levels of efficiency.

As well as connecting that data to the Cloud, the IIoT adds another layer of sensing, giving a more granular view of operations, enabling any variable that could affect production to be clearly viewed. Production and processes can be modelled more accurately, leading in time to the whole system operating autonomously.

The IIoT has provided a huge opportunity for OEMs to create new devices and services. Hardware companies are developing products that will be deployed to make the IIoT function. The connectivity with the Cloud gives OEMs the potential to move into service provision and offer remote diagnostics and management services, upgrades to software and many other Cloud services, adding further revenue streams.

For customers the IIoT offers the chance to streamline their businesses by reducing the amount of waste generated. It also enables them to optimise production and accurately view and model the whole process. Owners of plants are able to see their consumption of raw materials and other metrics in real time. They can also monitor the condition of equipment, allowing better planning of maintenance to keep the plant running optimally and reduce unplanned downtime.

Unprecedented demand
The extensive use of sensors has created an unprecedented demand for components. The intelligence of IIoT systems is both centralised in the Cloud and distributed widely in smaller intelligent devices.

These distributed devices are small, low-powered and normally contain sensors, actuators or both, depending on the application. They include devices such as smart valves, thermostats, flow sensors, cameras and level sensors. They also need networking capability.

Often situated in remote or hard-to-reach areas, battery power is used frequently, placing an emphasis on power consumption. To achieve the required specifications in all these areas usually requires custom silicon – which in many cases costs less than one would expect.

For a particular customer we work with, their first introduction to the IIoT was through smart valves for the oil and gas industry. These devices can be built using off-the-shelf components, but this often
proves inefficient. They end up taking more space than necessary, are more expensive and are over-specified. These negatives can often be overlooked for less smart devices that rely on traditional computers for intelligence, but for IIoT applications the component count was much higher and the BOM costs expanded rapidly for the required ASSPs.

Custom silicon had the potential to cut those BOM costs, while optimising performance and cutting energy consumption.

The most advanced silicon process nodes, such as the Fin-Fet process nodes are typically only economical for the high-volume consumer segments or fundamental to achieve the speed and data-density needs of data-centre products. However, the smart edge devices that make up the IIoT segment can be well serviced by the more mature planar process nodes, that utilise heavily depreciated, and thus cheaper semiconductor fabs.

From almost two decades of focused development in these mature nodes to satisfy the mobile phone market explosion, these nodes are awash with extensive, silicon proven IP and integration expertise. That, together with a laser-like focus on cost and optimised low-power design, has led to a fantastic opportunity for the IIoT to exploit.

Historically, custom silicon has been considered as too expensive for small players, but the heavily depreciated fab and extensive IP libraries have opened up the possibility of custom ASICs for smaller customers. As well as reducing BOMs by up to 80%, custom ICs enable differentiation of products, which is essential in what is becoming a crowded market. Custom ICs offer greater security as they are harder to copy, and they also give the customer more control over the availability of the IC – which is important, as IIoT applications will usually have a longer lifespan than normal silicon.

Custom approach
The S3semi customer, detailed above, was a prime example of what is possible when using custom silicon. The industrial control manufacturer wanted to try a custom IC, but had no experience of the design and procurement process. It wished to increase its top-line revenue, by adding value to its existing products (such as enhanced connectivity), whilst also increasing its bottom-line through cutting the BOM costs.

The product chosen for the trial was a connected smart valve controller, which needed to be able to support multiple sensors for pressure, temperature and diagnostics. Current consumption needed to be less than 4mA. The controller was also required to support both Fieldbus and HART communication protocols. The customer also wanted to offer different product tiers.

If the device was built from off-the-shelf components, it would require a 16-bit microcontroller, Fieldbus modem and Flash memory, as well as discrete ADCs and other discrete analogue functional blocks that would include references, RTCs and DACs.

The design would have a high BOM cost, which would grow as the product tiering cost was accounted for.

Based on the desired functionality and future roadmap items provided by the customer, we gained an understanding of the customer’s needs, both for the present and the future. With those details, it was possible to create a custom silicon solution using its rich IP portfolio.

The design used TSMC’s mature 180nm process node and was based around a low-power ARM Cortex-M4 processor. The custom ASIC incorporated all of the fundamental building blocks of the system, including 14-bit ultra-low-power SAR ADCs, 12-bit DACs, power switches, analogue multiplexers, op-amps, sensors and power management.

For memory, the IC included Flash and SRAM, and for communications, a Fieldbus Medium Access Unit, and the HART interface were incorporated along with SPI, Parallel, UART and I2C interfaces.

Having all the main blocks integrated in the custom IC led to BOM savings of over 80%. Other benefits included meeting a strict power budget, a smaller form factor, higher levels of reliability and an improvement in signal integrity.

The silicon design is harder to copy than a discrete solution, so also offers a higher level of IP protection. These features differentiated the design from those of competitors and provided a solid base that the customer could build its different tiered products around.

Customising the IIoT
The IIoT offers a win/win situation for both the OEM and its customer. The OEM through its connected products can readily up-sell by adding new service capabilities, and today customers can see a real difference in their processes through the transparency and granularity that the IIoT offers, perhaps ultimately leading to a “pay as you use” model.

To take advantage of the IIoT requires a deep understanding of the benefits, and its, sometimes, confounding requirements. Goals such as low-power operation and low cost are hard to meet using off-the-shelf components, especially when the functions of the device include demanding tasks, such as precision sensing in noisy industrial environments.

But these demands can be readily met by leveraging from mature and cheap process nodes that are ideally matched to IIoT application spaces. The proven IP repositories for these nodes, integration expertise and system knowledge available through companies like S3semi, can offer an easier way to achieve results that can provide a significant BOM reduction, combined with size and power reductions, all in a single piece of silicon.

Author details
Darren Hobbs is the Director of Marketing and Strategy at S3 Semiconductors
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When it comes to developing devices with IoT connectivity you need to be flexible.

According to Peter Wenzel, Global Director of Raspberry Pi, Single Board Computers and Software, Premier Farnell and Farnell element14, technology is helping to fuel innovation and is providing design engineers with new “tools” with which to innovate.

“Over the last twelve months we have seen some exciting new products being brought to market that continue to broaden opportunities and provide the ability to build products and bring them to market,” he suggests.

Earlier this year, for example, Farnell element14 launched the GraspIO Cloudio - a Raspberry Pi expansion board - enabling end to end IoT development and deployment via Drag and Drop programming on a mobile device.

“The versatility of GraspIO Cloudio has made it popular with makers, for example, in a wide range of application environments,” Wenzel explains. “Cloudio has unlocked physical computing applications with Raspberry Pi with potential applications including Voice Control, Speech Output, IFTTT Integration, Sensor Monitor and Dashboard and Camera and Custom Notifications.”

According to Wenzel, this is just one of many products in the market that are helping to develop ideas and then commercialise them.

Many applications designed for the Internet of Things (IoT) do not require high bandwidth or permanent connectivity needing to connect only from time to time to check in and send small data packets. This saves connection costs while enabling smart and affordable connectivity solutions with long battery life.

“To deliver this the wireless standard NB-IoT was created,” explains Chris Young, an Embedded Software Specialist at Avnet Silica. “It offers up to 250 kbps bandwidth and supports a particularly large number of connections per base station. NB-IoT further offers an additional 20 decibel link budget.”

Given the right infrastructure, this makes it possible to increase network coverage even in areas with previously poor coverage. It also boosts interference immunity and transmission quality.

Young says that NB IoT allows more data to be transmitted in the licensed band and provides higher bandwidth. It can also address a much larger number of applications.

The base station infrastructure for NB-IoT is usually already in place, and all that’s typically required is a software update of the base stations. Only a few locations need an additional hardware upgrade and that’s simple to implement.

Areas of application can be found wherever limited data rates, such as Sigfox LPWAN, which can send 144 messages per day at 12 bytes in the direction of the cloud, are no longer sufficient.

However, NB-IoT has its limits and a valuable addition is Cat M1 - a 3GPP Release 13 standard that offers a higher peak data rate of up to 1Mb/s full duplex compared to NB-IoT and supports mobile solutions, something which NB-IoT cannot do because the network must establish a new connection after leaving a cell. Cat M1 also supports Voice over LTE (VoLTE).

“Measuring 10 to 15ms, latency is significantly lower here compared to NB-IoT, where values range from 1.6 to 10s. Combining these two technologies with 2G EGPRS fallback for regions where NB-IoT has not yet been rolled out, multi-mode connectivity cards can generate extremely high network coverage for the large number of mass use cases that benefit from many years of battery operation and do not require a constant connection at high data rates,” says Young.

Many mobile M2M applications are flawed by the fact that the management of the SIM cards can prove complex.

According to Young, “A lot of the effort can, however, be avoided by using eUICC compatible SIM technology. It makes SIM cards and components reprogrammable, allowing new Mobile Network Operator (MNO) profiles to be deployed ‘over the air’ at any time. A change of MNO and services is therefore always possible.

Flexible designs

In search of IoT connectivity for your devices, then you need to be flexible. By Neil Tyler
– regardless of whether this means a change in the manufacture of the device, commissioning, start-up or even a transfer of ownership or relocation.

**Arduino shield**

An application-ready Arduino compatible board has been developed by Avnet Silica that supports LTE Cat NB1, LTE Cat M1 and 2G EGPRS plus optional eUICC compliant SIM cards.

Based on the Arduino Uno R3 specification, it is suitable for small and medium sized industrial batch applications and as a starting point for high volume custom designs.

Standardisation of the Arduino connector format means that designers can access a variety of standard components.

“There’s a rich ecosystem of microcontroller or application processor boards as well as Arduino expansion shields. In a few simple steps, NB-IoT/Cat M1 connected IoT gateways, devices and smart sensors can be assembled on the basis of the open source Arduino standard,” explains Young. He continues, “The advantages of this include the use of commercial-off-the-shelf (COTS) hardware to avoid NRE costs; it is also the vendor independence from a specific solution that OEMs appreciate. There is usually a second provider of a comparable solution, which intensifies competition and lowers procurement costs.”

According to Young, a large open source ecosystem increases design security and enables long-term availability, which secures the investment in an OEM solution long into the future.

The NB-IoT Sensor Shield with optional eUICC compatibility is based on the Quectel BG96 module and supports FTP/HTTP/MQTT and TLS as well as PPP/TCP/UDP protocols. It not only provides flexibility but extremely low power consumption – around 10μA in power-saving mode – that results in exceptionally long battery life.

In spite of its energy-efficient design, it also offers the option to integrate geolocation for all common standards such as GPS, GLONASS, BeiDou/Compass, Galileo and QZSS.

The flexibility of the shield is enhanced by the Pinod connector, which can be used as an alternative to the Arduino shield interface to the processor board.

The NB-IoT Sensor Shield supports operating systems such as Android, Linux and Windows. The modem is controlled with the AT command set via UART or USB interfaces. The board also has its own network stack, including SSL/TLS encryption. In addition, further free network stacks for COAP and MQTT clients are available based on the ARM mbed eco-system. This allows application libraries, component libraries, and toolchains to be used unchanged across multiple MCUs, allowing for the portability of own code and reducing NRE costs.

At the heart of the mbed solution is the established and widely used open-source CMSIS-RTOS RTX.

**IoT application development**

IoT expert SensiEDGE recently unveiled a new SensiSUB system-on-module (SoM) starter kit.

Building on the company’s Bluetooth-enabled SensiBLE IoT SoM, the SensiSUB can deliver higher range and more reliable frequency bands to penetrate obstacles and reduce interference.

“The new device is intended for advanced Internet of Things (IoT) applications, including smart factory, smart home, smart grid and smart city deployments,” explains Milan Yudkovich, founder and CEO of SensiEDGE.

It features a low power ARM 32-bit Cortex-M4 CPU with FPU, and a range of serial interfaces (including SPI, I2C, UART, ADC, CAN, USB and GPIO), and combines a SPIRIT1 low-power RF transceiver, offering certified sub-1GHz connectivity (in three frequency versions: 433 MHz, 868 MHz and 915 MHz), with a suite of fully customisable sensors (including 3-axis accelerometer, magnetometer and digital gyroscope, plus pressure, microphone, relative humidity, ambient light, temperature and UV sensors).

SensiSUB’s hardware-ready configuration provides a complete, self-contained RF platform in a small form factor (20x30mm) that enables wireless connectivity without prior RF expertise.

“Our new SensiSUB is a certified solution that helps developers with limited or no RF expertise accelerate the design phase of projects and reduce the time-to-market for IoT applications,” says Yudkovich.

“As seamless connectivity becomes a standard requirement, this IoT module – and others like it – will help product and system designers integrate complex RF functionality into their prototype embedded designs, enabling a new generation of engineers to more easily realise their concepts.”
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Twenty years ago, it looked like a concept that was ready for primetime: putting programmable logic inside ASICs and SoCs. At the time, the move seemed inevitable. ASIC mask prices were rising fast, driven by the need to pull more and more from a bag of optical tricks to keep Moore’s Law on track. The cost of respins alone seemed enough to persuade designers to leave some reprogrammable “sewing kits” in their SoCs to let them iron out bugs after tapeout instead of committing tens of thousands of dollars more to the project to get some new masks.

Despite the apparent attraction as mask costs soared towards $1 million and beyond, suppliers of embedded field-programmable gate array (FPGA) cores found it hard to gain any traction. Both start-ups and established FPGA players such as Actel dipped their toe in the water but couldn’t find a customer base.

Patrick Soheili, vice president of business and corporate development for Adicsys, can trace its roots to M2000, which managed to score some design wins a decade earlier. Newer start-ups such as Flex Logic and Menta have tried to make the routing overhead less onerous. When it launched its fourth-generation embedded-FPGA core, Menta focused on the most commonly used connection configurations between lookup tables (LUTs) to try to bring the overhead down. Flex Logic CEO Geoff Tate claims relative interconnect density is his start-up’s main differentiator: “Our cofounder came up with a more efficient interconnect and we end up using fewer metal layers and still achieve utilisation of 90 per cent or more.”

Although silicon area remains an issue, markets are emerging that make the cost aspect take a back seat compared to other concerns. Several years ago, in the belief that the time has come for embedded-FPGA cores, Achronix decided to branch out from selling just standalone parts. Although it fabs its own Speedster FPGAs at Intel, the company chose to port its custom core IP to TSMC’s 16nm finFET process to cater for the larger potential customer base that uses the Taiwanese foundry.

Since then the company has changed its focus to present itself as a “data acceleration” company in recognition of the shift in attitudes, according to Steve Mensor, vice president of marketing at Achronix. Instead of concentrating on design teams’ financial costs such as mask changes, the aim is to highlight other costs such as power consumption and the ability to build highly flexible data accelerators that can change their algorithms at runtime. In the short term, the key market for Achronix is in 5G communications.

Tate has seen the same trend: “Historically, [wireless telecom has] been one of the few high-volume applications for discrete FPGAs. But they have problems: they can’t get data in and out of the FPGA fast enough. They also have the issue of the protocols becoming more...
Machine learning

Despite his scepticism over the chances for embedded FPGA in general, Soheili sees machine learning as the one place the technology can score: “I think it’s maybe time for them to show up. You might be able to use a million LUTs or a hundred thousand of them in chunks and use them for functions that you know are going to change.”

One option for machine-learning designs Soheili says is to use package-level integration: “Maybe have it in the form of a chiplet so you don’t change the ASIC.”

Intel’s Programmable Systems Group is pursuing the chiplet path, using the company’s EMIB technology to interconnect chiplets inside a package. Initially, this has been employed to put high-speed transceivers around a standalone FPGA core but the same technology would allow FPGAs and ASICs to sit alongside each other.

Mensor says the need to drive down power consumption and make full use of the high bandwidth of onchip interconnect points to a need for monolithic integration. As well as providing generic LUT-based blocks, both Achronix and Flex Logic have developed arithmetic blocks that are tuned for the kind of processing used in today’s deep-learning pipelines aimed at embedded systems such as self-driving vehicles, speech processors and robots. The chief focus is on 8bit multiply-adds as this bit resolution has quickly emerged as the sweet spot for performing inferencing in machine learning based on deep neural networks. But it’s a fast-moving field with new variants of the deep-learning architecture appearing on a weekly basis.

Achronix offers customers the ability to define their own arithmetic units that can be dropped in alongside the LUTs and readymade DSP blocks and replicated through the array. Tate says Flex Logic expects to add further variants of the arithmetic core for machine learning over time. “We expect that customers who engage will tell us ‘here’s what we really want to do’,” he says.

Mensor says the machine-learning customers at Achronix see their use of embedded FPGA as strategic and not just a way to prototype designs that will ultimately be hardwired: “All the conversations involve CEOs. The use is more integral and architectural with applications that are very heavy in machine-learning functionality.”

Like Mensor, Tate expects acceleration to be a factor in helping to promote the use of embedded FPGAs beyond machine learning. Tate points to the success of the Xilinx Zynq product line in helping to convince microcontroller manufacturers to adopt the technology. “I think most would like to have their own Zynq-like offerings for acceleration functions,” he says.

Security will be one of the targets for FPGA-based acceleration in MCU, Tate reckons. “There will be some hardwired cores they have for encryption. But there are a lot of flavours for encryption, which suits embedded FPGA. The other thing they can use embedded FPGA for is I/O functionality to address things such as non-standard versions of SPI.”

“We are working with the MCU guys to show them they can merge the two: I/O support and acceleration,” Tate says. “And we have other ideas to make FPGA behave more like processors, to make it easier to swap things in and out. We have a tiling approach to the embedded-FPGA design: each of those tiles could run a different piece of code. Then you can treat it more like a multicore processor where you can think of each core running a subroutine, and created without having to learn RTL.”

The open question is whether the attractions of embedded FPGA in these markets can overcome the cost objections and finally accelerate its growth.
Industry 4.0 remains an extremely hot topic, encompassing as it does IoT, cloud computing and automated data exchanges. It is also accommodating automated configure-to-order (CTO) within manufacturing scenarios, which gives companies the ability to define customer-specific functionality in a controlled process.

Within manufacturing, CTO is fast becoming a cost-effective alternative to engineer-to-order (ETO) practices and is regarded as a better way of managing the growing number of customer-specific product variants; though switching from ETO to CTO is not without challenges (see box).

Offering product variety is considered key to the survival of most OEMs as it allows them to improve supply and demand alignment. Or, to put it another way, if one OEM doesn’t offer a particular feature set there’s a chance a competitor will. Similarly, the need for new combinations of features (including new ones) may be indicative of a new trend.

Unfortunately, a growing number of product variants leads to greater product and supply chain complexities; threatening margins and introducing quality risks.

The first step is therefore the analysis of market requirements and their representation in a Feature Tree. It allows only valid feature permutations; e.g. a car manufacturer won’t offer an option whereby a car can have a soft-top and a sunroof. As engineers, working with colleagues in procurement, QA, HR, finance etc., we can then create a Variant Tree to give ourselves sight of the complexities associated with all variants. Complexities will include component costs, lead times, inventory logistics, tooling costs and operator skills. In addition, it could be that each product variant requires its own test strategy. And what about certification? Regulatory compliance? There’s also the documentation to consider; schematics, bills of materials, assembly instructions (for manual operations) and output files for automated assembly lines.

However, this should not be uncharted waters for some. As a process, CTO can be thought of as automating many aspects of build-to-order (BTO), which most OEMs and many CEMs already operate; e.g. part-building products (base units) and holding them in Kanban until the required variant and quantities thereof are known.

As OEMs and CEMs push further into Industry 4.0, the automated steps for CTO will need to increase in number and link to form unique flows for each possible product variant. Understandably, automated CTO will require bullet-proof data management within a highly integrated supply chain.

Given that component data is available from the engineering tools, it can be leveraged in a CTO model so that product variants start to exist the moment engineers bring together hardware, software and mechanical elements. But are today’s tools and methodologies up to the task?

**Fragmented**

Many engineering departments manage their design data within their organization’s enterprise resource planning (ERP) system. Characteristics of an ERP include real (or near real) time performance and a common database;

However, ERP software is typically focused on business processes and the utilization of resources. For this reason, some companies also use one or more complementary solutions/tools for:

- **Product lifecycle management (PLM)** – the process of managing the entire life of a product from inception through to disposal/recycling if applicable. It covers all stages in
between such as engineering design, manufacture, test, commissioning and in-service maintenance and support.

Product data management (PDM) - a subset of PLM, is the use of software tools to track and control data related to a product, or variant thereof. Data tracked includes technical specifications, materials/components needed and costs. PDM will also include CAD models, drawings and associated documents. Metadata will include the identification of file owners, file check-in and check-out details, and change management.

Material requirement planning (MRP) and manufacturing resource planning (MRP II). Both are predecessors of ERP though are still widely used, independently and as modules of more comprehensive ERP systems. They are designed to facilitate decision making for production line managers, increase the efficiency of the production line and help managers determine the timing of raw material purchases (and quantities).

Document management systems (DMS) - used to track, manage and store documents, reduce paper and keep records of the various versions created and modified by different users (history tracking).

However, the above tools are point solutions; isolated pockets of improvement through automation. Between the pockets is a host of manual activities, such as phone calls and emails made between engineers to clarify issues. Things get worse when a design is signed off and the bill of material needs to tie in with physical items. More calls need to be made, this time between engineers and purchasers and between purchasers and suppliers.

Automated CTO (as part of Industry 4.0) is all about having far greater digital connectivity and avoiding all the time-consuming, manual and prone-to-misinterpretation communications. It also promises to remove the wealth of admin tasks that currently distract us from our core activities; engineering, adding value etc.

The ultimate goal? Any company operating truly automated CTO (and therefore within Industry 4.0) could be characterised as:

- Not having any physical/geographic limitations and is connected to sister companies, partners and suppliers via the cloud;
- Is competing against similarly omnipresent companies;
- Emails and phone calls are seldom necessary and are activity discouraged;
- There are seamless exchanges of data between all engineering design tools (e.g. electrical/electronic CAD and mechanical CAD), PLM, ERP, PDM and DDM tools etc;
- Extremely flexible – and offering as many product variants as is practical;
- In step with all market needs (i.e. a dynamic Feature Tree);
- Having engineers that create modular components (be they hardware, software, mechanical etc.) that can be automatically configured in (only) legitimate combinations (i.e. as policed by the Variant Tree).

Regarding this last point, it will be interesting to see how engineering time can and should be valued moving forward. The creation of the modular components requires up-front human effort, but ROI becomes increasingly dependent on automation.

In summary, variety-induced complexity is a necessary evil under CTO. Companies that stand to do well will be those that set out not to reduce complexity but rather find the optimum tools and processes with which to embrace it.
The Ryzen Embedded V1000 processor, when combined with rugged COM Express (RCE) modules, can be used in extreme conditions and safety-critical applications, as Maximilian Kolpak explains to Neil Tyler.

It would be fair to say that despite regular annual processor launches, performance increases in the high-end embedded sector have been marginal, at best, in recent years.

However, the launch, by AMD, of the Ryzen Embedded V1000 processor with its Zen micro-architecture could be said to have broken that malaise with a sizeable increase in the instructions per clock cycle - up 52%. The added availability of simultaneous multi-threading has also more than doubled the performance when compared to its predecessor.

Significantly, the Ryzen has also been designed to provide a level of performance - in terms of graphics - that had tended to be associated with high-end graphics cards with several hundred watts of power dissipation.

“With up to 3.6 TFLPOS, the Ryzen V1000 family, is able to offer that level of performance to embedded processors and the graphics are twice as powerful,” explains Maximilian Kolpak, Product Solution Manager at MEN Mikro Elektronik.

Four independent displays with a resolution of up to 4k UHD and 10 bit colour depth can be controlled and both HDMI 2.0b and DP/eDP 1.4 are supported.

In terms of interfaces, the V1000 processor includes up to four USB 3.1 Gen 2 interfaces with transfer rates of up to 10Gbps, Gigabit Ethernet and up to 16 PCIe Gen 3.0 lanes for generic expansions, 2x SATA Gen 3.0 for storage media and High Definition Audio, besides typical embedded interfaces such as UART, GPIO, I2C, LPC, SPI and SM bus.

“Despite a comprehensive set of features however, as the TDP of the V1000 processors starts as low as 12W and scales up to a maximum of 54W, it does not have a high energy consumption,” says Kolpak. “Thanks to VITA 59 support, a Rugged COM Express (RCE) module – even the 54W version – can be cooled entirely without fans. This is much more than can be achieved with conventional COM Express modules, where the limits are usually 25-35W, depending on the module size.”

Based on the COM Express standard of the PICMG, RCE modules can offer everything that COM Express module does. The pin-out and form factor are identical. However, the VITA 59 specification adds a wing extension to COM Express modules for embedding in a standard aluminium frame (CCA), which is narrowly specified to ensure optimal thermal connection.

“Waste heat is dissipated laterally from hot spots such as the CPU, memory and voltage transformer via a heatspreader and board (PCB) to the frame, which then dissipates it via conduction directly to the surrounding housing. These measures reduce the module’s thermal resistance to the
housing, reducing temperature rises by up to 5°C,” according to Kolpak.

“Overall, this leads to lower thermal stress, thereby among other things prolonging service life and ultimately, reliability.”

Because the VITA 59 compliant COM Express modules don’t need fans to cool the V1000 processors even at heat outputs of 54W, systems are much less susceptible to failures than fan-cooled systems. As a result, Rugged COM Express is suitable for systems that need to combine high-end embedded performance with high availability, especially in rugged environments such as in road, rail and commercial vehicles.

“This ties in very well with the creation of the standard, because originally Rugged COM Express was developed primarily for the railway sector, as the cooling concept benefits the requirements of EN 50155, where resilience to high temperature fluctuations in an extended temperature range is important,” says Kolpak.

RCE modules also offer protection against high electromagnetic compatibility (EMC), since the aluminium housing shields the electronics against outgoing and incoming electromagnetic radiation from all sides. In addition, conformal coating, which is a protective coating for the modules, provides reliable protection against challenging environmental conditions such as dust, moisture or even chemicals. Secure fixing of the frame on the carrier board also provides particularly high resistance to shock and vibration. Amplitudes of up to 5G for vibration and up to 50G for shocks are realistic.

In-vehicle applications
Due to the processors’ wide performance bandwidth, the application fields for these RCE modules are extremely diverse.

In the high-end sector, situational awareness applications – for instance, route monitoring with artificial intelligence for traffic sign recognition or automatic brake triggering in case of anomalies such as a fallen tree – are particularly suitable. The same applies to any mobile application – from collaborative robots and autonomous intralogistics systems to self-driving cars – that is exposed to great temperature fluctuations as well as shocks and vibrations. In such applications the comprehensive GPU support of the AMD processors, which can also be combined with discrete AMD GPUs, is a major benefit, along with the high scalability of the AMD embedded graphics.

When it comes to lower performance, the range of applications extends all the way to multi-display cockpit systems with four independent displays for self-driving vehicles and multifunctional edge systems with virtual machines or even robust mobile devices for maintenance using augmented reality.

A module for extremes
MEN Mikro Elektronik is a manufacturer and initiator of the VITA 59 specification for COM Express, and has developed the CB71C module which is fully compliant with the COM Express Type 6 pin-out and is available as an ultra-robust Rugged COM Express module including a CCA aluminium frame that acts as a heat sink and protection against harmful environmental effects.

With a scalable selection of V1000 processors with 15 to 54W TDP and supporting up to 32GB of soldered DDR4 RAM; optional ECC for safety-critical applications; 16GB on-board eMMC providing space for the OS and applications as well as 11x PCIe Gen 3.0, 3x USB 3.1, Gen 2 (10Gbps), 3x USB 2.0 along with 4x DisplayPort and 1x Gigabit Ethernet, the module is capable of supporting all the high-speed interfaces of the COM Express Type 6 specification.

In addition, the CB71C integrates a powerful board management controller with monitoring functions for safety-critical applications. To guarantee high data and application security, it has a Trusted Platform Module and provides real-time memory encryption on the hardware side to protect against physical and inter-VM memory attacks.

“There are a variety of applications that can be implemented with standard COM Express Type 6 modules. That’s why the new CB71C is also available in the regular CB71 COM Express version.”

“Meeting the same high demands that are placed on Rugged COM Express, it is developed and manufactured to the highest quality standards, such as DIN EN ISO 13485 for quality management and DIN EN ISO 14971 for risk management,” says Kolpak.

These MEN modules don’t require any special or complex qualification, since all that changes is that the ‘wings’ are dropped and the CCA is replaced by a classic COM Express cooling solution.

“Such quality standards are ideal for applications that require high availability, robustness, and quality; or industry-specific certifications that need to be supported by high-quality documentation and generally require an end-to-end audit trail,” explains Kolpak.

Customers for these modules are found in sectors ranging from medical technology and power plant maintenance, to industrial automation as well as payment, ticketing and vending systems that rely on high quality and long-term stability.
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