KILOGRAM’S FUTURE IN THE BALANCE

Work is underway to replace the International Prototype of the Kilogram (IPK). Could the artifact which defines the unit of mass be facing retirement?
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COMMENT
Has an “unquestionable failure” to make safety the priority put self-driving developments at risk?

NEWS
Stratview Research points to strong growth in the space electronics market that’s set to reach $1.6bn in 2023

Stadium Group to partner with Maker Life in order to deliver educational SBC kits to primary schools

Intel announces the sale of its IoT software subsidiary, Wind River, to asset firm, TPG

As CYBERUK kicks off in Manchester, how is the UK’s National Cyber Security Centre taking the fight to all forms of cybercrime?

INTERVIEW
The customer first, last and always
Since his appointment as CEO in 2016, Hassane El-Khoury has sought to refocus the business. Here, he talks to Neil Tyler about his on-going plans for Cypress Semiconductor

COVER FEATURE
Kilogram’s future in the balance
International research efforts have developed to the point where the kilogram can be defined using fundamental constants. By Graham Pitcher

CONSUMER ELECTRONICS
Get smart, get connected
As more devices are termed ‘smart’, the market for consumer electronics is increasingly being driven by the need for enhanced connectivity

WEARABLES
What’s the compromise?
When it comes to delivering wearable devices the balance between power and performance remains the key design challenge

RESEARCH & DEVELOPMENT
Close to the edge
As we enter a period of hyperconnectivity, could brain inspired technologies help to bring data processing and analytics to the devices of the IoT?

EMBEDDED DESIGN
Congestion schemes
When it comes to tackling congestion on programmable devices, companies are using a variety of techniques, Chris Edwards explains

ENGINEERING MANAGEMENT
Combining the physical with the virtual
Mixed reality is starting to have an impact on the commercial world bringing the physical and virtual together. By Neil Tyler

MISSION STATEMENT
New Electronics keeps designers and managers abreast of the latest developments in the world’s fastest moving industry
The news that Uber has been forbidden by the US state governor of Arizona to resume self-driving tests is certainly a blow for the company but it has also raised some serious questions regarding the self-driving concept itself.

The decision follows an accident in which Elaine Herzberg was killed crossing a road in the city of Tempe when she was struck by one of the company’s autonomous vehicles.

When the state’s governor wrote to the firm confirming the ban he said that there had been an “unquestionable failure” to make safety the top priority.

Safety protocols have been queried as a video of the incident shows that the operator was looking down, rather than directly at the road, for about five seconds before the accident.

Doubts have also been raised by the dashcam video Uber provided to the police. Other road users, who uploaded their own dashcam videos, show that night time visibility at the time was far better than Uber suggested.

Plenty of companies have also said that their technology would have handled the situation differently and safely, while Velodyne - the firm that designed the collision-avoidance sensors that Uber employs – is said to be “baffled” by the accident.

It’s been a difficult few weeks for the proponents of self-driving what with the contradictions that have arisen around the Uber accident and now with the news that a Tesla vehicle, operating on Autopilot, crashed in California last week.

Could the fall-out from these accidents stall the development and testing of self-driving vehicles? Fatalities like these present an unprecedented liability challenge because self-driving vehicles involve such a complex system of hardware and software often made by outside suppliers.

From the events of the past few weeks could it be that autonomous vehicles are much further away from being ready for unattended use on public roads than we’ve been led to believe? Have the promoters of “self-driving” cars radically underestimated the complexity of the problems they are trying to solve?

The benefits of self-driving cars are clear, but are we rushing to bring this technology to market?

While it might cost more and take longer, if this technology is to be accepted worldwide then it will be crucial that accidents of this sort are investigated openly and their findings made public.

Neil Tyler, Editor (neil.tyler@markallengroup.com)
**Significant growth for space market forecast**

THE SPACE ELECTRONICS MARKET IS LIKELY TO REACH $1.68BN BY 2023. **BETHAN GRYLLS REPORTS**

The space electronics market is forecast to see significant growth, for both existing and new players, over the next 5 years, according to Stratview Research.

The market is projected to reach $1.557.9million globally by 2023 driven by increased satellite production, the entry of new commercial space companies and rising demand for cheaper components.

The findings suggest that satellites will remain the growth engine of the global space electronics market between 2018 to 2023, and with the expected launch of more than 4,000 satellites during that period demand for electronics in the satellite segment is set to surge.

According to Stratview Research, ICs are expected to remain the most dominant component type with the demand for smaller, lighter and less power-hungry devices driving the market.

Based on the product type, radiation-hardened and radiation-tolerant electronic segments are expected to see healthy growth rates over the next five years, with the latter segment likely to witness higher growth driven by demand for commercial-off-the-shelf components, small satellites and lower launch costs from commercial space companies.

**Potential for ‘invisible’ displays**

A bright-light emitting device just millimetres wide and fully transparent when turned off has been built by engineers at the University of California (UC), Berkeley. The light emitting material is a monolayer semiconductor, that’s just three atoms thick and could pave the way for invisible displays.

UC says it has overcome the barriers in utilising LED technology on monolayer semiconductors, allowing for such devices to be scaled from sizes smaller than the width of a human hair. This means the lateral dimensions can be made larger to offer higher light intensity, while the thickness can be kept small.

By laying the semiconductor monolayer on an insulator and placing electrodes on the monolayer and underneath the insulator, UC says it was able to apply an AC signal across the insulator. During the moment when the AC signal switches its polarity from positive to negative (and vice versa), both positive and negative charges are present at the same time, creating light. This works in four different monolayer materials, all of which emit different colours.
Inspiring a future generation

EDUCATIONAL SBC KITS AIM TO MAKE PROGRAMMING FUN. NEIL TYLER REPORTS.

Stadium Group has announced a partnership with Maker Life, a developer and provider of simple build-your-own computer project kits designed to educate parents, teachers and children about programming.

The kits are being developed using the low-cost, credit card-sized Raspberry Pi Zero W and BBC micro:bit single board computers (SBCs). Stadium is the exclusive manufacturer of power and cable products for the Raspberry Pi-based Maker Life kits.

Intended to help children of primary school age, the kits look to help them understand and engage in programming and coding and develop the skills necessary for the digital economy.

Maker Life has collaborated with parents, educators and STEM coordinators to create kits that offer an introduction to projects such as building a clock or a weather station. Each kit contains the components needed to complete a project, including the power supply and cables, and is intended to be easy to assemble using a simple step-by-step guide.

The kits are currently available using the English language, but bespoke localised language versions are expected where volume allows. According to Maker Life, the range of kits is set to grow rapidly over the course of the next two years, with up to 45 variations available by the end of 2019 compared to the four that are currently available. Commenting Charlie Peppiatt, Stadium CEO, said: “It is important that industry steps up to the challenge of inspiring the next generation of programmers, to ensure that the right skills are available to manage the demand for future technologies in this increasingly digital world.”

Charging ahead

A high-powered, environmentally safe lithium-sulphur substitute has been developed by a team at the University of Texas at Dallas, which it claims could drastically lengthen battery life.

According to Dr Kyeongjae Cho of the Erik Jonsson School of Engineering and Computer Science, lithium-sulphur batteries have several advantages over lithium-ion. They’re less expensive to make, weigh less, store almost twice the energy of lithium-ion batteries, and are better for the environment.

The team says it has also overcome sulphur’s poor electrical conducting capabilities, which means it can become unstable over just several charge-and-recharge cycles. Dr Cho says they were able to produce a sulphur-carbon nanotube substance that created more conductivity on one electrode and a nanomaterial coating to create stability for the other.

Origami poised to improve smart clothing

Researchers believe a form of origami that involves cutting folded pieces of paper, known as kirigami, has inspired a way to build malleable electronic circuits.

The team says that it has created tiny sheets of strong, yet bendable electronic materials made of select polymers and nanowires; and believes this innovation could lead to improvements in smart clothing, electronic skin and other applications that require pliable circuitry.

The study, which includes computational modelling contributions from Temple University researchers, employs ‘nanofillingment’ engineering and ‘strain’ engineering – a strategy in semiconductor manufacturing used to boost device performance.

Without kirigami, the polymer - known as PthTFB - can be deformed up to 6% from its original shape without changing its electronic conductivity. With kirigami, the team says the polymer can stretch up to 2,000% and the conductivity of PthTFB will increase by three orders of magnitude.

SpaceX to provide broadband services via satellite constellation

SpaceX has been given approval by the Federal Communications Commission (FCC) to launch 4,425 low-Earth orbit satellites, so to provide broadband services.

This is said to be the first approval of a U.S.-licensed satellite constellation and will use frequencies in the Ka (20/30 GHz) and Ku (11/14 GHz) bands to provide global Internet connectivity.

Over the past year, the FCC has approved several requests that hold promise to expand Internet availability and says these approvals are the first of their kind for a new generation of large, non-geostationary satellite orbit, fixed-satellite service systems, and it will continue to process other, similar requests.

Unravelling the secret to ‘electric bacteria’

A bacterium, known as Shewanella oneidensis, could be nature’s microscopic power plant.

As part of their metabolism, the bacteria have developed a way to transfer electrons from the interior of the cell across their outer membrane to a receiving surface in the outside world.

Associate professor Moh El-Naggar of USC Dornsife explains that the process is akin to the way humans use oxygen to breathe and in their research, suggest the bacteria uses nanowires to accomplish this electronic feat.

According to associate prof. Ek-Naggar, harnessing energy from living, organic sources holds potential for new sustainable technology. A microbial fuel cell, for example, could generate electricity by capturing electrons from the bacteria on an electrode.
Asset firm, TPG, has announced that it is to acquire Wind River from Intel.

According to Wind River President, Jim Douglas, the existing executive management team will continue to lead the newly independent Wind River after the transaction closes and that is expected to occur in the second quarter of 2018.

“Our technology team is focused on backing strong, market-leading companies in growing industries,” said Nehal Raj, Partner and Head of Technology investing at TPG. “We see a tremendous market opportunity in industrial software driven by the convergence of the Internet of Things (IoT), intelligent devices and edge computing. Wind River is well positioned to benefit from these trends and we plan to build on its strong foundation with investments in both organic and inorganic growth.”

Over the past 40 years Wind River’s software has been used to run the computing systems of manufacturing plants, medical devices, aircraft, railway, automobiles, and communications networks.

“This acquisition will establish Wind River as a leading independent software provider and it is well positioned to advance digital transformation within critical infrastructure segments with our comprehensive edge to cloud portfolio,” said Douglas. “TPG will provide the company with the flexibility and financial resources to fuel many of our future growth opportunities as a standalone software company.”

According to Tom Lantzsch, Intel’s senior vice president and general manager of the company’s Internet of Things Group the move to sell Wind River is intended to sharpen the company’s focus on growth opportunities that are better aligned to its data-centric strategy.

“Wind River will remain an important ecosystem partner, and we will continue to collaborate on critical software-defined infrastructure opportunities to advance an autonomous future,” Lantzsch said. “We expect this transition will be seamless for our mutual customers and partners.”

Intel sells Wind River

INTEL SELLS ITS IOT SOFTWARE SUBSIDIARY WIND RIVER TO ASSET FIRM TPG. NEIL TYLER REPORTS

Upgrade to BrainChip Studio

BrainChip, a developer of software and hardware accelerated solutions for advanced artificial intelligence (AI) and machine learning applications, has announced an upgraded release of BrainChip Studio, version 2018.1. BrainChip Studio is an AI-powered video analysis software suite that supports high-speed object search and facial classification for law enforcement, counter terrorism and intelligence agencies.

Among the new features in the latest release is the ability to find objects from a variety of camera views, enable large-scale Linux deployments, and add an API that simplifies integration with other applications.

The software’s one-shot object training, a unique characteristic of spiking neural networks, is able to create a spiking neural network model of an object in its initial captured orientation. With the new auto-rotation feature, BrainChip Studio will automatically create multiple rotated models, improving the ability to locate the object in other camera views, where the orientation may vary depending on the installation.

In addition, this latest version of BrainChip Studio now runs on Linux, enabling cost-effective, large-scale server installations.

“Linux is prized by some of our customers because of its cost-effectiveness in larger installations,” said Bob Beachler, BrainChip’s Senior Vice President of Marketing and Business Development. “As an added benefit, the streamlined nature of the Linux OS provides a 10 percent performance improvement for BrainChip Studio, compared to Windows.”

The 2018.1 release also includes a version of BrainChip Studio that can be controlled with an API-level interface, enabling the functionality of BrainChip Studio to be integrated into third party applications, either off-the-shelf video surveillance software or end-users’ custom software.
Unlike GCHQ, its secretive parent, the UK National Cyber Security Centre (NCSC) is very upfront. The website is stuffed with information and its senior staff are regular speakers at conferences around the UK and the world. It was established in October 2016, as a part of the 2016 National Cyber Security Strategy – a government initiative to make the UK the safest place to live and do business online after an earlier study determined that cybercrime is a big threat to the UK as conventional crime and warfare. It is a “one-stop shop” leading the fight against cybercrime, bringing together different parts of government departments, GCHQ and MI5 and works with law enforcement bodies such as the police Regional Organised Crime Units and the National Crime Agency.

NCSC sees a cybercriminal spectrum, ranging from at one end, the spotty teenager hacker in his bedroom, through to “hacktivists” using hacking techniques to promote a cause; organised criminal groups; some large corporations; and ending with nation states. Each of these have different motives and objectives for their attacks and part of the ambitions of the centre includes getting a better understanding of these. Other ambitions include reducing the number of attacks that get through, building strong methods for responding to those attacks that do get through the defences, and making the UK a place where technology can thrive.

At the heart of the NCSC’s approach is the Active Cyber Defence (ACD) programme. Its intention is “to protect the majority of people in the UK from the majority of the harm caused by the majority of the cyber attacks the majority of the time.” That is – to make life as difficult as possible for potential attackers. In some ways it is a bit like physical security for your house. No matter what you do, a determined person who isn’t worried about causing damage will get in. But, most potential intruders will move from a strongly defended home to an easier target.

ACD is still in early stages and is being implemented through a number of evidence-based strategies, with evidence being initially gathered from work on government systems. However, the intention is that as the organisation gains in-depth knowledge the lessons learned will be rolled out to a wider audience. It is already building links with industry in critical areas, such as energy, finance and telecoms.

Identifying malicious content

A first activity is takedown. When NCSC identifies a site that is a source of malicious content, for example pretending to be HM Revenue and Customs, it requests that the hosting organisation remove it. In its first year it had 121,479 taken down in the UK with a further 18,067 sites worldwide. Several thousand e-mail sites pretending to be government departments have been closed down. So far, the hosts’ responses have been largely supportive, but NCSC will consider “naming and shaming” if necessary.

DMARC is an international system to protect e-mail domain owners from having their domain name used for spoof messages. NCSC is working to get the system adopted across the public sector. In its first year of operation the number of spoof messages from @gov.uk has fallen consistently.

Web Check is a simple set of tests for finding security issues with websites. The output is a clear list of issues, together with suggestions for resolving them. In eight months, Web Check has run over 7million individual tests on nearly 7,000 domains, creating 4,108 advisories on issues such as certificate management, out of date software being used, and poor TLS. Most of these were fixed within two days of the notification. Any public sector website can request a Web Check.

The Domain Name System (DNS) is a critical element of the internet. A hierarchy of servers allows an end user machine to hunt for an address in the internet. The NCSC has worked to create the Public Sector DNS service, through which all DNS requests from public sector machine can be routed. It blocks access to known “bad” URLs: in one week during December 2017, it saw 1.23billion requests of which 273,329 requests were blocked. The system also analyses the requests, and has identified security issues in the source computers, including malware families and phishing emails.

Other work, still in early stages, includes work on ways to improve the security of routing on the internet and developing the Threat-o-Matic, a hub to link all elements of ACD.

Since it recognises that it is not possible to stop all threats, NCSC is also developing expertise in incident management. In its first year it was given a major test when the WannaCry ransomware infected over 230,000 computers around the world. In the UK the main target was the NHS, and the NCSC worked with a number of NHS organisations to provide support and advice. While WannaCry was the real headline grabber, in its first year the NCSC received 1,131 incident reports of which 591 were “significant” and 30 required cross-government response.

With cyber security is a significant issue for all computer users, there are many opinions on what to do. The NCSC approach of combining active security with gathering evidence is already, after only 18 months, replacing opinions with hard facts.

Leading the fight against cybercrime

AS THE 3 DAYS OF CYBERUK KICK OFF IN MANCHESTER THIS WEEK, DICK SELWOOD PROFILES THE UK NATIONAL CYBER SECURITY CENTRE, BRITAIN’S LEAD AGENCY IN THE FIGHT AGAINST ALL FORMS OF CYBERCRIME
The customer, first, last and always

Hassane El-Khoury talks to Neil Tyler about his on-going plans for Cypress Semiconductor

"The technology world has changed and it’s no longer just about the silicon," says Hassane El-Khoury, the youthful CEO of Cypress Semiconductor. So if it’s not about silicon, what is it about? "Software," he contends. "Software is what pulls silicon devices together."

Following in the footsteps of long time CEO TJ Rodgers, El-Khoury was appointed CEO in 2016 at which point he embarked on a corporate transformation that has placed the customer at the very heart of its operation.

“Everything we do has to be driven by what they need,” El-Khoury explains. “We no longer simply supply silicon, but rather everything designers need to build systems.

“In the past few years it has become obvious that the days of simply delivering a ‘bunch of chips’ to your customers was over. They are looking to the delivery of systems and we, as a business, need to better understand the boundaries within which they work.

“We need to become a cognisant player in this market, ensuring that all of our products work together as well as providing the necessary software. All of which means that our customers are better placed to do what they do best.”

Using the company’s infrastructure and technology he has driven through significant changes to the business. Cypress version 3.0, as he likes to describe it, is now focused on delivering solutions to its end customers.

“I inherited a strong legacy of embedded systems and solutions. But, in order to achieve significant growth and outperform the market, I knew we’d need to pivot and target specific markets. Those we identified were: automotive, industrial and consumer.”

In the past 18 months that focus has brought clear results.

“Through a combination of focusing on what we need to do to win in these markets, engaging with our customer base and through the sharp execution of strategy, we are now outgrowing the market by a significant margin.”

According to El-Khoury, his contribution has been to, “Bring a coherent vision to the business. If you have that, then everyone – no matter who – will rally around and deliver on that vision and strategy.

“Success comes from explaining where we need to go and why. People will get on board when they know what they have to do, and what’s expected of them.”

El-Khoury’s decision to restructure the business was delivered relatively quickly.

“My aim was to have everything done by December 2016 not only to reassure Wall Street and our investors, but to hit the ground running with customers. I didn’t want to be issuing revised instructions as the year progressed.”

A challenge, certainly after following a long-term CEO of 34 years, but he found a business, as he describes it, “much like a coiled-spring. I pointed it in the right direction and let it go.”

Last year that uncoiled spring delivered impressive levels of growth of around 17 percent.

“Breaking that down, consumer grew by 19 percent, while our IoT business, acquired from Broadcom in 2016, grew 45 percent. But we saw growth across all our divisions and we significantly out-performed the market.”

While he accepts that the company benefitted from strong market growth, he contends that, “it wasn’t the market, but rather our execution that delivered for the business.”

That execution has focused on solving problems that customers are looking to have solved, according to El-Khoury.

“It’s about being relevant. We are providing customers with processing and connectivity capabilities, but beyond that adding security, software and content, providing them with a better experience without having to leave a familiar development environment.”

He points to the company’s unified software tool suite that looks to streamline IoT product designs.

“Our ModusToolbox is an easy-to-use software suite that enables IoT developers to design in the functionality they need, while leveraging our various solutions.”

According to El-Khoury he’s tried to get the company away from an industry mindset which he describes as “build it and they will come!”

He says, “what I mean when I say that is, why use smaller nodes, 28nm, 14nm etc. if it doesn’t address problems customers need solving? Cypress lives to address problems now and, more importantly, deliver solutions.

“We need to listen better to our customers and let them define their problems. We need to find out from them what we can do to help them. Just because we can do something doesn’t mean that we should. Without focus, it’s very easy to lose your way.”

El-Khoury sees the company’s strong growth in 2017 being driven by the demand for connectivity.

“What we’re calling the era of IoT is putting the changes we saw in the PC and mobile eras to shame. The trouble when talking about the IoT is that it can mean everything or nothing.

“Without connectivity, a thing remains a thing, so we’ve doubled down on delivering connectivity as well as ultra-low power devices. Our customers’ customers won’t buy a device if the power is insufficient or they have a poor connection. Solve these problems and you’ll be successful when you go to market.”

The company’s success in 2017 was helped by numerous design wins from the likes of Amazon and Nintendo.

“We saw strong growth in our consumer space last year. Our
second pillar is industrial and there we’re looking for GDP plus growth, so around 4-5 percent growth. It’s a slow adopter of new technology.

The automotive space has been another star performer for the company.

“We play in the HMI space, memory and in ADAS,” El-Khoury explains.

“The success of ADAS will depend on changing the driver’s behaviour and that will not happen overnight. We’ll need to see its general adoption and it’ll take a while before consumers are comfortable at letting control go to something else they neither see or really understand.

“As for removing the steering wheel, good luck with that!”

Cypress 3.0 is 18 months old, but the company continues to evolve fast.

“We may need to pivot again,” El-Khoury concedes, “but not just yet.”

Hassane El-Khoury

Hassane El-Khoury is president and chief executive officer of Cypress Semiconductor and a member of the company’s board of directors. He was previously executive vice president of Cypress' Programmable Systems Division, managing its standard and programmable MCU portfolio, including PSoC devices, and its automotive business.

Prior to that, El-Khoury ran Cypress’ automotive business unit targeting the infotainment, instrumentation cluster and Advanced Driver Assistance Systems (ADAS) segments.

Prior to joining Cypress, El-Khoury served in various engineering roles with Continental Automotive Systems in the US, Germany and Japan.
International research efforts have developed to the point where the kilogram can be defined using fundamental constants. By Graham Pitcher

When is an uncertainty of 30 parts per billion just not good enough? The answer is when you’re developing a system intended to replace the International Prototype of the Kilogram (IPK).

The IPK, a metallic cylinder made of 90% and 10% iridium (PtIr), has been closely guarded at the Paris headquarters of the Bureau International des Poids et Mesures (BIPM) since 1889. As such, it’s the artefact which defines the unit of mass in the SI system of measurement. According to the SI, ‘the kilogram is the unit of mass; it is equal to the mass of the IPK’. But the mass of PtIr masses, similar to the IPK, have been seen to fluctuate.

There are seven base units in the SI system: ampere; kelvin; second; metre; candela; mole and kilogram. Today, only the kilogram is defined by a physical artefact. But work underway around the world has reached the point where the IPK may be retired in the near future.

In 2005, the International Committee for Weights and Measures, recommended that the kilogram be redefined in terms of a fundamental constant of nature and the General Conference on Weights and Measures then agreed in principle that the kilogram should be redefined in terms of Planck’s constant.

So how do you get from Planck’s constant to the kilogram? The answer to that is a Kibble Balance, previously known as a Watt Balance.

Dr Ian Robinson, a Fellow at the National Physical Laboratory (NPL), has been working on the Kibble Balance since it was first conceived. He said: “The term ‘Watt Balance’ confuses people. It wasn’t invented by James Watt; rather, it measures power in watts. Naming it a Kibble Balance is an improvement and a fitting tribute to Dr Bryan Kibble, who died in 2016.”

It was Dr Kibble who thought...
up the idea of the balance in the mid 1970s, aiming to link electrical and mechanical units by equating electrical and mechanical virtual power. “At the time,” Dr Robinson noted, “SI resistance was available via the calculable capacitor, allowing the Kibble Balance to determine SI voltage or current via Ohm’s Law.”

While that approach couldn’t meet the uncertainty required by the scientific community for the redefinition of the mass unit, the discovery in the 1980s of the Quantum Hall Effect brought, according to Dr Robinson, ‘unprecedented stability and reproducibility to the electrical units’.

“The Kibble Balance is one thing which NPL can claim as its own,” Dr Robinson continued. “The concept was thought up here by Bryan Kibble and nobody else was thinking in that way. The Kibble Balance will, effectively, become the way in which mass will be determined in the future.”

Dr Robinson said that, in theory, mass could be measured electrically by equating the mechanical energy needed to raise a mass over a known distance to the amount of electrical energy consumed by a motor in raising the mass. But losses mean the values don’t equate satisfactorily.

The Kibble Balance works by ‘weighing’ the mass against the force produced by a current flowing through a coil suspended in a magnetic field. “Because the mass doesn’t move,” Dr Robinson said, “there are no relevant losses. But you do need to know the relationship between current and force that depends on field strength and the length of wire in the coil.”

Dr Kibble realised that if a second experiment was performed, in which the mass was removed and the coil was moved through the field at a measured velocity, then the relationship between the voltage generated by the coil and its velocity would be exactly the same as the relationship between the force and the current.

The results of the two experiments, when combined, allow electrical power to be equated to mechanical power. If you measure voltage using the Josephson effects, current using the quantum Hall and Josephson effects, acceleration due to gravity using a local gravimeter and velocity using a laser interferometer, it is possible to relate mass to the Planck’s constant. “It’s not easy to do,” Dr Robinson said, “but it is possible to do the experiment to the level of uncertainty that you require.”

Having developed a prototype Kibble Balance, NPL sold it to Canada’s National Research Council (NRC) in 2009, which embarked on a programme to improve its performance.

Dr Barry Wood, an NRC Fellow, has not only been closely involved with the improvement programme, but also with the international effort to replace the IPK. “We did some preliminary measurements, which were OK, but then we rebuilt the suspension of the coil. That allowed us to do alignment in vacuum in situ and to get around a series of problems, including reducing noise; it’s probably why NPL had inconsistent results over the years and was a major step forward.

“Then, in late 2013,” he continued, “we generated a set of results which were, at the time, the best achieved. We used four masses of different types and got good results.”

NRC’s initial results measured Planck’s constant to an uncertainty of 68ppb, while the second round cut that to 35ppb.

“We then stripped it down again and found another set of problems,” Dr Wood recalled, “mainly to do with noise and the interferometer. We changed some of the electronics and optimised the data acquisition system to allow data to be acquired more quickly.” More tests with the four masses followed, allowing uncertainty to be cut to 19ppb. “But our latest result is 9.1ppb,” Dr Wood enthused.

What helped to achieve that result? “Lots of little improvements,” Dr Wood explained. “It’s a huge experiment, with a lot of different parts. We asked whether a particular change would make a difference or whether it might be too hard to fix. We’ve been fixing each thing as we go and it’s been a long process, with hundreds of changes.”

NPL’s Dr Robinson believes that the Kibble Balance, having determined the value of Planck’s constant to an uncertainty of 5ppb, will, effectively, become the way in which mass will be determined in the future.

“If you have enough Kibble Balances and they are independent of each other, they can check each other. That’s powerful and one of the reasons why this work continues. We’re now looking to replicate them and labs around the world should be able to run them.”

According to Dr Robinson, if you have enough balances contributing – even if they’re not at the highest accuracy – you can still get good results. “If they are all independent and working correctly, their results will scatter randomly,” he explained. “The uncertainty of the mean of the results...
from all the balances will, in general, decrease by the square root of the number of balances involved. For example, with 16 balances worldwide, each with an uncertainty of 16ppb would give a 4ppb overall uncertainty on the realisation of SI mass as long as those balances are independent.”

What does the NRC plan to do now? “The work is slowing,” Dr Wood admitted. “We could, perhaps, start again and address things we thought were too difficult, but a result of 9.1ppb is ‘pretty good’, so we can take our time.

“Work will continue, but we won’t be determining Planck’s constant in the future. We’ll be working on a unit of mass for Canada.”

Having sold its MK II Kibble balance to the NRC, NPL is now developing a new balance. “Building the initial balance represented an enormous investment,” Dr Robinson asserted. “It took many person-years to develop the first two, but they’ll be cheaper in the future because there won’t be the need to do the same level of research.”

He said the new version of the Kibble Balance is ‘simplified, but accurate’. “We’re not sacrificing accuracy,” he continued. “We have new ways which promise accuracy, but with simplicity and cost effectiveness.

“We’re working our way towards this via a couple of machines which will check the technology. We’ll then go for a finished machine and are looking to make this in 2020 or so.”

One aspect of the project is to update the electronics. “You have to keep paddling, particularly when there’s electronics involved,” he noted. “The industry moves quickly and things become obsolete in a couple of years. We’ll need to keep the electronics up to date so we can maintain the balance.”

At the moment, Dr Robinson and his colleagues are updating electronic components that are probably 20 years old. “It’s so we have a chance of manufacturing the balance. That work will continue because we can’t necessarily choose parts that will remain available for ever.”

Another project, NPL’s new demo balance features what Dr Robinson calls ‘old bits of kit’. “However, in the next few months, we’ll be shrinking the electronics from something the size of a desk to something with an A4 footprint that’s 90mm high.

“We know how it’s going to happen,” he continued, “but there’s an enormous amount of electronics involved in all the different balances – everything from microwaves to lasers to the measurement of picovolts.”

Now Planck’s constant has been set, is that the end of the IPK? “A series of committees is involved,” Dr Wood pointed out. “The BIPM’s Consultative Committee for Units said ‘do your best’ and submit results by July 2017 and everyone did that to the best of their abilities.

“Now, things will go to the General Conference on Weights and Measures in November 2018. All major countries have endorsed it so, unless they change their minds, it’s a done deal.

“So far,” he concluded, “we’ve been measuring Planck’s constant. Now, we’ve optimised the value and if you put that value into our measurement, it will tell you what the mass is. And we could also tell BIPM what the mass of the IPK really is.”

Above: A close-up view of NRC Canada’s Kibble Balance

SI units set to change

Following the General Conference on Weights and Measures in November 2018, there will still be seven base units in the SI system – second, metre, kilogram, ampere, kelvin, mole and candela. Of these, the kilogram, ampere, kelvin and mole will be redefined by choosing exact numerical values for the Planck constant, the elementary electric charge, the Boltzmann constant and the Avogadro constant, respectively. The remaining three base units are already defined by physical constants.

“The revision of the SI will fix the numerical values of the Planck constant (h) and the elementary charge (e),” said Dr Robinson. “The Josephson constant (2e/h) and the von Klitzing constant (h/e^2) will have new fixed numerical values, so there will be no need for the 1990 conventional values.

“The Josephson Effect and Quantum Hall Effect can then be used to make direct SI electrical measurements, to their full accuracy. There will be a final, small, change to the electrical units as the world switches to the revised SI, but the change will reunify the SI and make it fit for the 21st Century.”
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As more devices are termed ‘smart’ the market for consumer electronics is increasingly being driven by the need for enhanced connectivity. By Neil Tyler

S
maller form factors, excellent functionality, improved levels of performance and a lower bill of materials are constantly being demanded of engineers developing complex electronic products. While in the consumer space, they also have to contend with issues of operability, compatibility and pricing.

The consumer market is one in which the prefix ‘smart’ is now being added to a growing list of products as companies look to integrate them with the Internet of Things (IoT).

The rise of personal assistants are driving demand for artificial intelligence and machine learning capabilities, and intelligent platforms are giving consumers the capability to operate appliances via their mobile phones as well as facilitating lighting or central heating systems.

Commenting, Brian Bedrosian, vice president of marketing for the IoT Business Unit at Cypress Semiconductor, said: “People see their mobile devices as integral components of their lifestyles, and they expect to be able to extend this richer user experience into the home through the ability to directly control their connected devices.”

Smartphones

According to Dave Moon, Senior Product Marketing Manager for the Advanced Optical Solutions business unit at ams, “When it comes to the consumer market it’s dominated by high volume products and the biggest of them all remains the smartphone. No other market services the volumes you see in this space.”

Moon adds that a recent slowdown in smartphone sales has been mirrored by faltering levels of innovation and many markets have reached saturation point.

“For manufacturers, differentiation is now key - most are focused on authentication and voice,” he suggests.

As smartphone sensors continue to evolve, companies are looking at facial recognition for unlocking devices. Phones are expected to recognise users without scanning but rather by monitoring other unique attributes such as an individual’s voice, the way they move or the pattern of their typing.

“ams is investing heavily in 3D technology. It offers depth and as a result, is an interesting tool for authentication and is much safer than using a thumbprint, which can be easily compromised,” Moon contends.

An interesting example of differentiation is ams’ collaboration with X-Rite, a specialist in colour science and technology, to develop a mobile solution that embeds colour management technology directly into a smartphone for accurate colour matching.

Based on a spectral sensor and optical components packaged into a miniaturised module from ams, the module is intended for integration in the back side of a smartphone.

Augmented reality (AR) is seen by many as another important differentiator and in future mobile phones could take AR mainstream.

Several mobile device manufacturers have already released AR toolkits for mobile app development and the next step is likely to see smartphones that not only capture and alter images, but project them into the real world – both digital projectors and holographic displays are already in development.

Innovation in sensor technology, cameras and wireless functionality means that smartphones are becoming more capable.
With the demand for voice recognition growing, designers are under pressure to integrate the technology into more products.

STMicroelectronics, for example, recently launched the X-Cube AVS software package that’s been designed to make it possible for the Alexa Voice Service (AVS) to be enabled and run on its STM32 MCUs. According to ST, it has been designed to specifically cater for standard MCUs rather than the more power hungry and expensive devices usually used to support voice. The aim being to make Alexa available to a much wider range of developers and allowing simple connected objects to support advanced conversational user interfaces.

“There’s no doubting that we’re seeing an explosion in the demand for voice activation and command,” agrees Bedrosian, “but while there’s a lot of interest, I think we’ll see the initial hype being tempered over time. Voice can be more expensive to deploy; you need a microphone at the front end, a module to process the sound and a connection to the Cloud.

“Not everything can be voice enabled or have multiple microphones deployed either. The success of voice will depend greatly on the ability of smart devices to accurately sense the identity and location of the speaker, and that will require high-accuracy microphones.”

Cypress has developed a local user voice interface (LUVI) that can be customised to understand different voices and dialects. Voice profiling means that devices can be made secure. They respond only to, “specific voices or commands,” Bedrosian explains.

While voice may be the dominant technology, Bedrosian suggests that it’s inter-product connectivity - or rather the ease with which products can be connected within the consumer space - that is fast becoming the key driver and providing the ‘wow’ factor that so many analysts argue is currently missing from the consumer space.

“Whether by Bluetooth or Wi-Fi, the connection to the network or Cloud is becoming increasingly important. The ease with which devices can be connected, or the ‘boarding’ process, has certainly got a lot easier as standards have evolved,” says Bedrosian.

Bluetooth is now being included with almost every Wi-Fi connected product coming to the market and Cypress, for example, has a single chip solution that can deliver Bluetooth mesh connectivity.

“In the past, users needed to be close to a Bluetooth device to control it within an added hub. Bluetooth mesh networking technology means that devices within the network can now communicate directly with each other, providing coverage throughout the home,” he explains, “and that helps to simplify the app discovery process.”

Cypress’s Wireless Internet Connectivity for Embedded Devices (WICED) software development kits can support both state-of-the-art Bluetooth connectivity and mesh networking capabilities.

“Low-power mesh networking of devices,” Bedrosian explains, “not only enables them to communicate with each other, but also with smartphones, tablets and voice controlled assistants.”

The company’s PSoC 6 is a flexible MCU which comes with built-in Bluetooth Low Energy wireless connectivity and integrated hardware based security, all of which is packaged in a single device.

“Software defined peripherals can be used to create custom analogue front ends or digital interfaces for innovative systems components and it offers flexible wireless connectivity options, including fully integrated Bluetooth Low Energy (BLE) 5.0,” says Bedrosian.

The PSoC architecture also features CapSense capacitive sensing technology supporting touch and gesture interfaces.

“A few years ago, Apple introduced the WAC protocol (Wireless Accessory Configuration) which provides automatic wireless connectivity with a built-in automatic discovery profile certified for authentication identification and the like,” says Bedrosian. He continues: “It provides a great user experience and in the consumer space, ease of use, access and discovery are crucial components when it comes to delivering uninterrupted connectivity in increasingly crowded home networks.

“Authentication, in which devices are automatically registered with an authentication engine in the Cloud which then validates the product and then shares that information with the carrier, is also becoming more important,” according to Bedrosian.

Authentication raises the issue of security and while bringing products to market quickly has been a crucial aspect of the consumer market, it’s a market in which small companies are resistance to security on the grounds of cost.

While Bedrosian accepts that this may have been true in the past, he believes that, “recent well publicised cyber-attacks are now influencing the way design engineers are engaging with security.”

He concludes: “If you’re looking to provide users with a secure and seamless connected media experience, then you have to deliver a reliable, secure and robust solution.”
While the performance of wearable devices continues to improve, engineers continue to struggle to deliver improvements in power management.

The power/performance profile for wearables isn’t helped by the fact that they can only use small batteries. Bigger batteries mean bigger devices, and that’s not what the consumer wants, so there is intense interest in reducing battery size, increasing battery efficiency and researching new ways to power these devices.

The power/performance issue is accentuated by the growing use of sensors and the fact that they need to be ‘always-on’ in order to sense, track, classify and store data.

According to Managing Director, Dr. Jacob Skinner of Thrive Wearables, the rapid improvements being made in silicon could provide a solution. This, he explains, sees processor designs using lower and auto-adjusting silicon voltages, deploying more efficient process architectures and optimising instruction sets.

“The backdrop to processor developments is a continuing drive to integrate processing ‘nodes’ right at the front end of wearables sensors, so that the data transfer (and power drain) ‘up the chain’ is minimised,” he explains.

A good example of this trend is Bosch’s BMA400 low power accelerometer series. This accelerometer draws less than 1µA in full operation, but can independently process sensor data. For example, it can convert the long data stream of three-axis motion into step counting.

It does this by allowing the main (host) microcontroller to remain off for most of the time that’s required for tracking a user’s activity, and is then woken up by the accelerometer itself, say every 100 steps. The sensor becomes the component that manages the overall duty cycle of the microcontroller, helping to reduce system power while increasing the efficiency.

Richard Edgar, Director of communications technology marketing at Imagination Technology, believes that the isolation of device functionality is one possible way forward. He describes this approach as creating ‘power islands’.

“Although you may acquire data, you don’t necessary have to do anything with it and for the data you do need to transfer, you don’t need high data throughput,” Edgar contends. “By designing a system that reacts only under certain scenarios or perimeters, we can preserve power.

“What we need to weigh up is how much we can reduce the time the cell is awake, against the possibility of missing important information and processing data accurately or in real-time.”

Edgar suggests that power amplifiers are one of the main problems when it comes to power consumption, with around 80% of today’s communication solutions having most of their power spent by one.

He says this is ‘avoidable’ and can be easily rectified by replacing existing power amplifiers with a low range 0dbm one. “If you do that, and the device is only communicating a few 100bytes on a daily basis, you should be able to extend battery life.”

Engineers are looking to use smaller nodes as a possible route to better manage power consumption and are also considering desensitising their devices.

“Usually the market wants you to deliver improved specifications and ever more sensitivity,” explains Edgar, “but by focusing on performance it will be a hindrance if you’re trying to save power.

“You have to establish what the best compromise is,” Edgar continues. “For example, do you need a wearable that transmits 100m or 1m? If it’s
“Usually the market wants you to deliver improved specifications and even more sensitivity, but by focusing on performance it will be a hindrance if you’re trying to save power”

Richard Edgar

University, this technology can be directly printed onto a single textile substrate and establishes a standardised platform for flexible biobatteries.

Assistant Prof. Choi believes that textile-based wearables hold promise, but says the challenge lies in creating a ‘truly self-reliant and stand-alone wearable sensing system that does not rely on an external power source’.

“The microbial fuel cells (MFCs) used in this work are arguably the most underdeveloped for wearable electronic applications because microbial cytotoxicity may pose health concerns,” he says. “Work into wearable MFCs has been quite limited but, if we consider that humans possess more than 3.8x10^13 bacterial cells compared with 3.0x10^13 human cells in their bodies, the direct use of bacterial cells as a power resource is conceivable for wearable electronics.

“Most microorganisms use respiration to convert biochemical energy stored in organic matter into biological energy, adenosine triphosphate, in which a cascade of reactions through a system of electron-carrier biomolecules sees electrons transferred to the terminal electron acceptor,” Assistant Prof. Choi continues. “Most forms of respiration use a soluble compound as an electron acceptor, such as oxygen. However, some microorganisms respire solid electron acceptors to obtain biological energy.

“These microorganisms can transfer electrons produced via metabolism across the cell membrane to an external electrode. MFCs typically comprise of anodic and cathodic chambers separated by a proton exchange membrane so that only H+ or other cations can pass from the anode to the cathode. A conductive load connects the two electrodes to complete the external circuit.”

Unlike traditional batteries and other enzymatic fuel cells, MFCs have whole microbial cells that can be used as a biocatalyst to provide stable enzymatic reactions and longer lifetimes.

Assistant Prof. Choi believes that it’s possible for organic fuels, such as wastewater, sweat and urine, to be used as fuel to support bacterial viability, providing the long-term operation of the MFCs.

Another possible energy source is energy harvesting, which Edgar believes could pave the way for longer lasting wearables, with movement as the most plausible way to generate power for wearables. He does raise some concerns over the cost of placing an energy harvesting technology into silicon and reasons that complete reliance on energy harvesting is not feasible, rather it should act as a complementary way to power devices.

Overall though, Edgar believes that - at least in the short term - the solution to extending battery life is to ‘design chips that consume less power and to make compromises when it comes to the design, taking into account its market application’.

“There’s only so much we can do on the engineering side. It does rely upon other changes and techniques, like developing new battery technologies,” he says. “That is being held back as the most promising research seems to use rare materials and they are, by their very nature, hard to come by.”

Alternative power sources and techniques are emerging, but whether or not they will provide long term solutions is another matter. It appears the answer for now is to assess whether performance can be lowered without affecting the overall purpose of the device too drastically.

That trade-off will be dictated by consumer reaction, but they will need to be better informed. Having their technology cake and eating it is, as yet, not possible when it comes to balancing power and performance issues.
“W e are entering a new era where artificial intelligence (AI) systems are helping to shape the future world,” said CEA-Leti’s chief scientist, Barbara De Salvo.

Speaking earlier this year, she described a number of emerging technologies, such as neuromorphic hardware and ultra-low power microdevices, that are helping to create a radically new, digital communication architecture for the Internet of Things (IoT) with analytics processing taking place at the edge and at the end devices instead of in the Cloud

“With billions of easy-access and low-cost connected devices, the world has entered the era of hyper-connectivity, enabling people and machines to interact in a symbiotic way with both the physical and cyber worlds,” De Salvo said. “AI is at the centre of this revolution.”

Speaking at ISSCC 2018, De Salvo said that this architecture will include human-brain inspired hardware, coupled with computing paradigms and algorithms that “will allow for distributed intelligence over the whole IoT network, all-the-way down to ultralow-power end-devices.”

There’s a growing consensus that the potential efficiencies of processing data at the edge, rather than at distant data centres or in the Cloud, will be significant, but reaching that long-term goal will be a challenge. For example, IoT battery-powered devices lack the processing power to analyse data and a power source to support data processing.

Transformative approaches will be needed to “address the enduring power-efficiency issues of traditional computing architectures,” and De Salvo called for a “holistic research approach to the development of low-power architectures inspired by the human brain, where process development and integration, circuit design, system architecture and learning algorithms are optimised.”

De Salvo contended that optimised neuromorphic hardware provided a highly promising solution for future ultralow-power cognitive systems that could extend well beyond the IoT.

“Emerging technologies such as advanced CMOS, 3D technologies, emerging resistive memories, and silicon photonics, coupled with novel brain-inspired paradigms, such as spike-coding and spike-time-dependent-plasticity, have extraordinary potential to provide intelligent features in hardware, replicating the way knowledge is created and processed in the human brain,” she said.

De Salvo added that work looking at how the brain operates, was helping researchers to better understand the emergence of connectionism, novel neuroimaging techniques and the functioning of neural networks, “all of which may provide models for brain-inspired technologies.”

She noted that the convergence of miniaturisation, wireless connectivity, increased data-storage capacity, and data analytics, was helping to position the IoT at the epicentre of profound social, business and political changes.

She pointed to significant gains in the performance and applications of machine learning, driven by vast data storage in images, videos, audio and text files. These gains have been essential to the dramatic improvement of learning/training approaches and algorithms, as well as the increased computational power of computers. This includes parallel computing for neural network processing, which has compensated for the slowing down of Moore’s Law below the 10nm node.

According to De Salva, deep learning is the most popular machine-learning field.

“Today, for tasks such as image or speech recognition, machine-learning applications are equalling
or even surpassing expert human performance,” she said. “Other tasks considered as extremely difficult in the past, such as natural language comprehension or complex games, have also been successfully tackled.”

Future applications will require even more analysis, understanding of the environment and intelligence, and machine-learning algorithms will require even more computing power to become pervasive.

**Intelligence to the Edge**

“Bringing intelligence to the edge or to end-devices means doing useful processing of the data as close to the collection point as possible, and allowing systems to make some operational decisions locally, even semi-autonomously,” De Salvo explained.

Controlling real-time distance learning locally will be essential for many applications, whether that’s landing drones or navigating driverless cars and De Salvo said any delays caused by having to send data to the Cloud could lead to disastrous results.

“Privacy will also require that key data doesn’t leave the user’s device, while transmission of high-level information, generated by local neural-network algorithms, will have to be authorised,” she said.

De Salvo warned that the use of millions of cameras for example, would require data to be locally analysed, as sending it to the cloud would likely result in bandwidth issues and communication costs.

“We need new concepts and technologies that can bring AI closer to the edge and end-devices,” she explained.

“The primary design goal in distributed applications covering several levels of hierarchy, is to find a global optimum between performance and energy consumption,” De Salvo continued. “This requires a holistic research approach, where the technology stack is redesigned.”

According to De Salvo that process is underway and companies are addressing embedded applications by developing specialised edge platforms that can execute machine-learning algorithms on embedded hardware.

She noted impressive power improvements (down to a few watts) by exploiting Moore’s Law and by using hardware-software co-optimisation.

To optimise energy efficiency, research has focused on hardware designs using Convolutional Neural Network (CNN) accelerators, De Salvo noted. Off-chip storage devices, such as DRAMs, significantly increase power consumption, but mobile apps using low-power programmable deep-learning accelerators can consume less than 300μW.

**Power requirements**

Bringing intelligence into low-power IoT-connected end-devices that support applications such as habitat and medical monitoring, will be significantly more difficult than traditional networked mobile devices at the edge, according to De Salvo.

“Most connected end devices are wireless sensor nodes containing microcontrollers, wireless transceivers, sensors and actuators,” she said. “The power requirement for these systems is critical – less than 100μW for normal workloads – as these devices often operate using energy-harvesting sources or a single battery over several years.”

De Salvo said scientists inspired by the human brain are now pursuing radically different approaches to neuromorphic systems.

“They are implementing bio-inspired architectures in optimised neuromorphic hardware to provide direct one-to-one mapping between the hardware and the learning algorithm running on it,” she said.

These architectures include spike coding, which encodes neuron values as pulses or spikes rather than analogue or digital values, and spike-timing-dependent-plasticity, a bio-inspired algorithm that enables unsupervised learning.

The human brain’s intelligence and efficiency are strongly linked to its extremely dense 3D interconnectivity, there are approximately 10,000 synapses per neuron, and billions of neurons in the human brain cortex.

“The hierarchical structure in the cortex follows specific patterns, through vertical arrangements or µcolumns, where local data flow on subcortical specialised structures, and laminar interconnections, which foster inter-area communications build the hierarchy.

“Based on these considerations, it is clear that emerging 3D technologies, such as through-silicon vias and 3D monolithic integration, also called CoolCube, will be a key enabler for efficient neuromorphic hardware;” she said.

Outlining silicon technologies that will be vital in creating brain-inspired hardware, De Salvo cited resistive memories or ReRAM, Fully Depleted Silicon on Insulator and silicon photonics.

“Thanks to its suitability for low-power design, FDSOI technology is a great candidate for neuromorphic hardware;” she said.

In deep-learning architectures, high-performance reconfigurable digital processors based on 28nm FDSOI have already shown power consumption in the range of 50mW, a level of power efficiency achieved by introducing optimised data-movement strategy and exploiting FDSOI back-biasing strategies.

De Salvo noted that a large-scale multi-core neuromorphic processor called Dynap-SEL, based on 28nm FDSOI, had also been demonstrated.

“New materials to interface devices with living cells and tissues, new design architectures for lowering power consumption, data extraction and management at the system level, as well as secured communications are the next domains that I expect will experience intense development in the years ahead;” De Salvo concluded.
When it comes to tackling congestion on programmable devices companies are using a variety of techniques, as Chris Edwards explains

Now more than 30 years old, the field-programmable gate array has evolved from a glue-logic device that made it possible to customise boards easily to a complete configurable system-on-chip (SoC). Hardwired 64-bit processors, digital signal processing (DSP) engines and dedicated memory arrays have helped overcome the FPGAs density handicap versus fully custom silicon even for projects that expect to move into high volume.

The problem for any configurable device like an FPGA is its hunger for routing resource – it needs far more than an ASIC built using dedicated masks. This tends to spread logic blocks further apart to avoid routing congestion. But performance calls for closely related logic circuits to sit near each other.

“Most of the delay is in the routing,” says Craig Davis, senior project marketing manager at Intel’s programmable systems group. This consideration makes the interaction between placement and routing one of the most important factors in high-performance design. Complex logic blocks and hardwired cores that are fixed in place constrain the job of the placement and routing and can easily lead to unwanted congestion. The tools used today place a strong emphasis on alleviating this congestion and in reducing the impact of routing delays.

Specialised resources within FPGAs often provide mechanisms for freeing up routing and so avoid the congestion that can lead to designs that run slower than expected. Xilinx tools will, for example, move signals with very high fanouts onto global clock trees if they are not required for clock distribution in the design. Ron Plyler, Xilinx’s product marketing manager for physical implementation tools says the optimisation techniques were conservative for the Virtex 7 series, but can be more aggressive on the more recent UltraScale families because they “have a much richer and more flexible clocking architecture, which enables a superset of 7-series optimisations”. He adds: “This happens at the end of placement when the global clock placement and resource allocation is settled and timing estimates are more accurate.”

Plyler says a common technique for reducing congestion overall is to focus on the Rent exponent – a measure of the number of connections each block within the design needs. Tool reports provide connectivity measurements for each block and the optimisation tools can focus effort on elements that tend to increase the Rent exponent. “These strategies reduce congestion by selectively reducing the utilisation of structures that tend to increase Rent and congestion,” Plyler says. Those structures include slice multiplexers, carry chains and LUTs with more than one output.

“Another area where we are focusing effort on reducing congestion is to provide specific recommendations,” Plyler adds. These are through a report that offers quality-of-results suggestions. “These are more on the level of ‘surgical strikes’ where we try to pinpoint exact causes of congestion and identify specific logic to refine. We also plan to integrate our incremental compile flow to both increase predictability and reduce the overall compile time it takes to incorporate suggestions and evaluate their successes.”
In its Stratix 10 family of devices, Intel’s programmable systems group decided to place registers at every possible switching location within the programmable interconnect to support a number of common timing-improvement strategies. The ‘hyper-registers’ have limitations – they do not have asynchronous-reset inputs so as not to consume excessive routing resource – but their sheer number is intended to create many more opportunities for pipelining.

“It’s a mux and a register, and it’s bypassable. With a configuration bit you can choose which registers to use late on in the design flow,” Davis says.

Traditionally, adding pipeline stages involves routing to a register that sits alongside a LUT, all of which incurs a delay. Ideally, the tools would pick up a LUT halfway along the original path to balance the delay. As device utilisation increases, this becomes difficult. “With hyper-registers, you’ve got so many you can generally put the new register smack in the middle every time,” Davis claims.

Some circuits do not benefit from pipelining because they employ long feedback paths. Intel recommends the use of Shannon decomposition, which demands more intensive changes to the RTL. When the optimisation works it can push the feedback loop down to a single multiplexer by reconfiguring the logic that feeds into that final logic stage. In effect, the logic precomputes values ready for the final decision taken by the gate with the feedback element.

Intel’s Quartus tools help identify opportunities for pipelining and more advanced transformations such as Shannon decomposition. “It will do speculative changes to your design: what happens if I take asynchronous clears out of the design? That often provides more opportunities for retiming so it can show the increase in clock speed if I put the registers in,” Davis says.

Even without RTL changes, there are many complex combinations of settings the design tools understand that provide opportunities for optimisation. Singapore-based EDA tools supplier, Plunify, has found machine learning to be a good way to unlock effective combinations for different types of FPGA design.

Plunify’s algorithms have found cases where moving logic out of hardwired blocks can improve overall timing, possibly because it can reduce the congestion caused by the need to dedicate routing to connect to the fixed-location cores. “Sometimes we are surprised by the algorithm. Even though, from a hardware designer’s point of view, one should utilise as many DSPs as possible, a group of settings that limit the number of DSPs that you use in a design can result in drastic improvements,” says HarnHua Ng, co-founder and CEO of Plunify.

The key to determining the effective combinations involves many compilation runs. Plunify originally launched its InTime optimiser last year for use by customers on their own design databases. “Because it’s machine-learning software, more data is required than the average FPGA flow generates,” Ng explains, noting that customers may not have sufficient servers to support the data-gathering process. Earlier this year, Plunify introduced a service to do the analysis based on its accumulated data and make the configuration changes that will improve timing.

Plunify co-founder and COO, Kirvy Teo adds: “In terms of what can be done, we have seen designs pass timing from as bad as 2ns worst negative slack. The results have surprised even ourselves. Usually what happens is that, when we get a design, the user has tried all the aggressive settings that they can get their hands on. Usually it doesn’t get the best results. But we have found groups of settings that work better. If you set everything to be aggressive the software churns without getting good results.

“For this to work you need a lot of data. Each time you run you should store data and use that for your next runs and that will really change the game. The one with the most data will ultimately win this. The difficult part is how to use this data, but that has always been a challenge for machine learning apps,” says Teo.

The rise of machine learning and the response from FPGA makers will see a further level of complexity added to the design process. Victor Peng, Xilinx CEO sees ‘an explosion of data’ coming: “It will require a different form of computing. We are really at an inflexion point where we have moved beyond the FPGA. It is a new product category: the heterogeneous processing platform. Because of that, we will be able to accelerate a broad range of workloads.”

In the case of Xilinx’s upcoming Project Everest devices, a network-on-chip (NoC) will help reduce congestion across the devices, which will deploy billions of transistors through the use of a 7nm process. The NoC is intended channel data between the programmable fabric and specialised compute engines designed for tasks such as machine learning, alleviating congestion in the finer-grained routing fabric. It will represent one more step in the war against congestion in programmable devices.
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Mixed reality is starting to have an impact on the commercial world, bringing the physical and virtual together. By **Neil Tyler**

Let’s start with the basics. When we talk about mixed reality what do we mean and how should it be defined?

According to Matthew Bumford, Head of Sales and Marketing at Kazendi, a HoloLens Development Studio, mixed reality (MR) is, “a technology that looks to blend the physical world with the virtual and provide the user with a better understanding of the real world.”

Recognising real objects and then allowing holograms to physically and accurately interact with them, Kazendi is among a growing number of businesses that are using MR to work with clients to create and deliver innovative mixed reality projects.

“Initially, our focus was on the Amazon Echo and Google Glass,” explains Bumford, “and applying these technologies to the needs of commercial clients developing a variety of prototypes. With the arrival of Microsoft’s HoloLens in 2016 we looked to shift that focus and started to explore the commercial application of the HoloLens.”

HoloLens is a virtual reality (VR) headset with transparent lenses and Kazendi uses it to create solutions that look to address real-world corporate problems.

Comparing MR to VR and augmented reality (AR), Bumford suggests they support very different applications.

“VR requires a closed tethered helmet that provides the user with a fully immersed, pre-built environment. AR, by contrast, overlays digital displays in the real world, using pre-set digital markers. When it comes to MR, it blends the two. You get to see the real world without the need for pre-set digital markers to formulate content.

“MR does everything in real time, merging real and virtual worlds together to produce new environments and visualisations,” he contends.

Crucially, it enables physical and digital objects to co-exist and interact in real time.

“From a commercial perspective VR may be great for training, gaming and immersive entertainment, but beyond that, it’s currently limited by the need for massive computing power and the fact that users will need to be tethered to powerful computing systems,” Bumford suggests. “By contrast, AR can live in your pocket on your mobile phone, but tends to be limited when it comes to large scale digitisation, currently it just isn’t supportable.”

Bumford says that MR and AR are likely to merge in the future. “It’s early days and we’re still playing with the terminology,” he insists.

As the hardware gets smaller and more ergonomic, Bumford believes it will be possible to fit it into glasses or contact lenses and when that happens it will open up the technology to more applications and end markets.

“At the moment these technologies are cumbersome to wear. The large headsets are limiting, but for engineering and construction that’s not an issue. In fact, Microsoft are developing a specific hardhat for..."
use in the industrial space.”

According to Sriram Chilamkurthi, Business Development, Kazendi, “Many industries will benefit from using MR and HoloLens users will gain from having access to the HoloLens ecosystem.”

**HoloMeeting app**
Remote collaboration and communication are viewed as the “next big thing,” according to Bumford, and Kazendi has developed the HoloMeeting app for HoloLens, supported by Windows’ MR ecosystem.

“HoloMeeting has been designed to bring dispersed teams together by simplifying remote communication and collaboration,” explains Chilamkurthi.

“It can be used in remote workspaces and allows for much greater and more fluid collaboration and comes with a variety of features,” he explains.

HoloMeeting offers a live view feature for example, which allows it to be used in the field as a form of remote assistance or as a training tool.

“It can be used in a manufacturing process to assist engineers with these remote assistance capabilities,” Bumford suggests.

HoloMeeting allows the integration of holograms within a real-world environment which means that individuals are able to meet in a holographic space. They can also interact with 3D and 2D content.

“That capability is new and is supported by a gaze tracker and spatial sound,” explains Bumford.

“Each person in a meeting will wear a HoloLens and will see a holographic cube in their view which is the immersive collaborative space.”

Whatever is shared in the workplace becomes visible to everyone else in the meeting.

“Whether that is, for example, a pdf or a 3D model, once placed in the cube it becomes visible. It will also be possible for participants to manipulate the document or model.”

Once the object is taken out of the cube, however, only the host will have access to it, providing a level of control and direction to the meeting.

According to Chilamkurthi, HoloMeeting has access to a variety of 3D modelling software such as Revit, Maya, Rhino and AutoCad, but work is being carried out to make the HoloMeeting app compatible with over 60 different file types.

“HoloMeeting comprises of three elements,” says Chilamkurthi. “The first element is the shared workspace itself which increases the immersive and collaborative potential of holographic meetings.

“The second is the gaze input. When someone dials in to a meeting they are represented by an avatar that moves as they do,” he explains.

If a person decides to walk around the shared workspace, other users are made aware of where they are, relative to themselves, and where various attendees are looking.

It allows movement and helps to make the meeting a more immersive and collaborative experience, according to Bumford.

“Not only can participants view models, prototypes, charts, visualisations, and documents, but they can do so from a range of different angles which helps to enhance the working experience.

“It also means that all participants, not just the host, can be made aware of what everyone is doing. We’re targeting upwards of 20 users, beyond that and the advantages are limited,” Bumford suggests.

The final key feature of HoloMeeting is its use and deployment of spatial sound. As users move around the shared space, the direction from which they are heard changes as they move.

“If a colleague walks from the right to the left, the sound will also transition from your right ear to your left and if multiple people talk at the same time it’s now possible to clearly hear all parties instead of dealing with a blur of noise,” Bumford says.

The HoloMeeting app provides a significant improvement on current videoconferencing and remote meeting solutions, but it’s the use of spatial sound that makes for a more realistic conversation. That has been acknowledged as being one of the main problems for users when it has come to remote meetings.

According to Bumford, HoloMeeting provides the opportunity for real-time collaboration in ways that were not possible before. “We’re looking to work with academia and companies from across different industries. Clients are varied but one, in the automotive space, is using the HoloMeeting app so that their internal design teams can now meet more regularly. They no longer have to travel between their offices in the UK and Europe, which they are currently doing every two weeks.”

Global design teams for example, will now be able to work together; can complete individual tasks; check progress with their peers and, ultimately, deliver a far more collaborative project.

“Our aim,” according to Bumford, “is to use this technology to change the way teams and companies organise their work processes.”
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