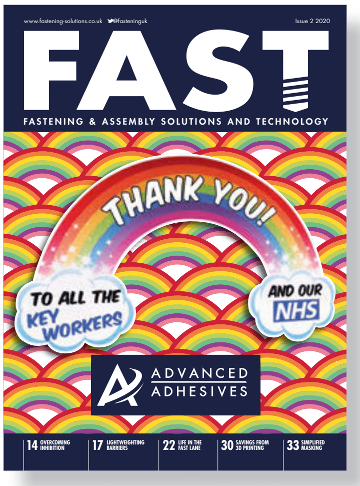
Published by
newelectronics

OUTLOOK 2021

DRIVING YOUR TECHNOLOGY AGENDA

Inspired by innovation



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Passionate about engineering

Contents

ACCELERATED DIGITALISATION

Despite the current pandemic, or because of it, many companies are accelerating their investment in 5G and embracing digitalisation

According to research carried out by Nokia and Nokia Bell Labs a so-called '5G+ combination of edge computing, data analytics, and private networking' are set to help drive rapid growth in the global economy, adding upwards of $8 trillion by 2030.

Their research suggests that spending on private 5G networks will actually outrun investment in traditional 'public' 5G cellular as companies and businesses look to invest in the digitalisation of their operations.

Described by Nokia and Nokia Bell Labs as a '5G+ ecosystem', the development of these private networks are expected to support the digital transformation of 'physical industries' over the next ten years, transforming them into 'augmented physical industries', effectively putting their innovation drive, at last, on a par with already-mature digital industries.

So just what do they mean by 'physical industries'?

Well, this includes factories, offices, smart cities, the broader public sector, transportation and healthcare.

5G networks, whether private or public, will bring together - in effect, acting as the glue that binds – the IoT, sensing technology machine learning and artificial intelligence, all of which will be supported by an ever expanding edge and cloud infrastructure.

Spending on edge and cloud hardware and platforms is set to soar over the coming ten years while investment in both private networks and AI (and machine learning) services is expected to match it – dollar for dollar!

Nokia Bell Labs says that the 'fourth industrial revolution' will spark a 'big value inversion' that will drive a revolution in safety, productivity, and efficiency, as well as in creating thousands of new jobs.

But it's not just the industrial space that is being revolutionised - digitalisation is impacting every aspect of our lives, from how we are educated to our healthcare systems, from how we work to the way in which we engage with one another at a personal level.

The Covid-19 pandemic has been described by many as providing a turning point for physical industries and is helping to drive digital change.

In many ways, the pandemic is acting as a catalyst for the broad range of changes that were already seen to be happening.

According to Nokia and Nokia Bell Labs, the pandemic has significantly accelerated the process of digitalisation and enterprises and industries have reacted to the economic challenges of the pandemic with increased levels of investment as they seek to accelerate digitalisation.

In fact the pandemic has been described as a strong facilitator of creativity and innovation. Working practices have rapidly adapted, with many employees now working from home and in the UK, as elsewhere, there has been a push among companies to digitise their processes.

Unchartered waters for many, but for organisations successful digital transformation has been delivered against all the odds.

In a survey of UK business leaders it was found that almost half of the businesses surveyed had successfully migrated their offering online with similar numbers stating that the virus had prompted them to adopt a digital solution that they had previously been hesitant to embrace.

The pandemic has prompted many organisations to think outside of the box, to look beyond accepted norms, when it comes to delivering digital transformation and investing in new areas of technology that many have never used before, such as artificial intelligence or augmented reality.

MA BUSINESS / MEGATRENDS

NEIL TYLER, Editor

Technology trends

The impact of the Covid-19 pandemic has been profound but the overarching technological trends, that have been driving the industry for the past few years, remain much the same.

Artificial intelligence, machine learning, robotics, drones, autonomous vehicles, extended reality and 5G and enhanced connectivity remain key drivers.

As Ivo Bolsens, Senior VP & Chief Technology Officer, Xilinx says in his contribution to this year's Outlook 2021, "The world is becoming smarter. From the smart phones in our pockets to today's smart cities helping manage traffic and transportation systems, Artificial intelligence (AI) is becoming pervasive across nearly every industry and impacting all our daily lives.

"This infusion of AI is also producing huge amounts of unstructured data that must be managed and processed, often in real time. The demands on hardware are skyrocketing, placing increasing reliance on innovations in chip architectures to deliver the performance improvements necessary to keep pace."

AI is undoubtedly one of the biggest tech trends at the moment, and during 2021 it is set to become an even more valuable tool, helping to interpret and better understand the world around us.

As Bolsens makes clear, the amount of data we collect is set to grow exponentially, so machine learning algorithms will become better informed and more sophisticated in terms of the solutions they generate.

Self-learning algorithms will spot new and innovative connections and insights that might otherwise have gone unnoticed by manual human analysis.

The automotive industry has had a very tough year but prospects are bright as the automotive sector continues to embrace electrification and autonomous vehicles, as Mark Burr-Lonnon, Senior VP EMEA, Asia and Global Service, Mouser Electronics points out in this year's Outlook 2021.

"What I find fascinating is how the industry will be structured over the longer-term. Will the OEMs like GM and Ford and the tier 1s like Bosch remain as the big players? Or will the tech companies emerge as new rivals? Whatever happens, there will be plenty of opportunities for electronics companies."

Initiatives around self-driving vehicles and electrification are set to continue at an increasing pace, not only benefitting the private car driver but also being developed to enable more efficient public transport networks.

Covid-19 has also accelerated interest in robotics, especially in the care and assisted living sectors, and they are expected to become increasingly important.

Robotic devices are being used to offer in-home help, as well as provide companionship at times when it may not be safe to send nursing or care staff into homes, while drones are increasingly be used to deliver a broad range of different services from logistics to monitoring public spaces.

The pandemic could also impact the roll-out of Extended Reality (XR), such as Virtual and Augmented Reality.

Long talked about, although yet to really deliver at scale, these technologies could come into their own as a result of Covid-19 where potentially dangerous situations that could risk viral transmission could be avoided by using virtual reality – both education and healthcare could see developments in this regard.

> "The impact of the Covid-19 pandemic has been profound but the overarching technological trends, that have been driving the industry for the past few years, remain much the same."

Underpinning all these technologies will be 5G and other advanced, high-speed networks, whether that's automation or real time data processing.

The rollout of 5G is accelerating with energy and utilities, mining, manufacturing, the public sector, healthcare and the transportation sectors; and companies based in Australia, Finland, Germany, Japan, Saudi Arabia, South Korea, the UK, and the US all looking at expanding or implementing 5G.

Companies that are at an "advanced level of 5G adoption" - classified as either in 'expansion' or 'implementation' mode - are said to be the only group to be experiencing a net increase in productivity (of over 10 percent) following the pandemic, and the only group able to maintain or increase customer engagement, according to the research conducted by Nokia and Nokia Bell Labs.

Many companies remain between initial planning, trials and deployment, while a growing number of large companies in advanced economies are set to invest in 5G over the next five years.

The breadth, depth and potential of 5G is immense in terms of the way society and business operate, and a growing number of organisations who are investing in the technology, via their own private networks, are already seeing clear operational benefits.

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A PERSONALISED MODEL OF PATIENT MONITORING AND CARE

Portable or wearable monitoring devices and point-of-care medical equipment promise improved patient outcomes and reduced pressure on healthcare services

Large-scale transformation in the way healthcare is delivered was already under way before the emergence of the SARS-CoV-2 virus put new impetus into medical innovation. Even before the 2020 pandemic, ageing populations in developed nations, the near-universal availability of mobile broadband connectivity, and the development of sophisticated sensing technologies were propelling the adoption of more personalised, digital or remote methods of monitoring and diagnosing patients.

As the coronavirus pandemic puts even more pressure on limited hospital facilities, medical service providers are accelerating the implementation of new technologies for testing and monitoring outside the hospital. Innovations in sensors now enable vital signs to be measured with clinical-grade accuracy at home and specimens tested at the point-of-care, eliminating the need to send samples for processing at a remote laboratory, and producing quicker results for faster diagnosis.

This marks a break with decades-old standard medical operating procedure. In the conventional model of medical treatment, a patient presented at hospital when symptoms became apparent, or for a routine annual check-up, was subjected to a one-time set of tests which would often be sent away for laboratory analysis before diagnosis or health assessment was made. In many cases, this diagnosis would come long after the original consultation, and on the basis of this single snapshot of the patient's condition.

This approach to treatment made sense when the sophisticated equipment required to monitor vital signs and symptoms was scarce, and only available in hospitals or other dedicated medical facilities.

The development of new medical sensing technology has created the conditions for a radically different conception of medical treatment. Instead of the large, fixed medical monitoring equipment used in hospitals, the new approach to patient monitoring uses devices which: Are small or even wearable; consume little power, so they can operate from a battery and provide accurate, clinical-grade measurements.

This enables medical monitoring and testing to be taken out of hospital and performed instead in local facilities such as GP practices, or in the patient's home. For even greater convenience for the patient, wearable devices such as patches can operate continuously and discreetly, to enable 24/7 monitoring anywhere.

Better diagnosis

The motivation to implement new remote monitoring technologies is partly to do with scarcity of resources. The pressure on hospitals when COVID-19 infections peaked proved that healthcare systems can quickly be overwhelmed by a rise in demand for acute care services. So it is a sensible long-term strategy to relocate patients who require monitoring of vital signs from a hospital bed to a clinic, or to their own home.

But just as important, monitoring with a portable or wearable device can provide more useful data and produce better patient outcomes. New medical monitoring technology allows for extended tracking of vital signs such as heart rate, heart rate variability, blood pressure, blood oxygen saturation (SpO2) and temperature. Through continuous monitoring, trends and patterns can be uncovered which cannot be detected in the single snapshot that a practitioner can capture in an appointment with a patient. The development in parallel of artificial intelligence (AI) diagnostic technology means that monitoring of the stream of data can be automated.

Instead of swamping the patient's physician with data, this AI-based approach uses technology to monitor the patterns in vital signs in the background, and only raise

ANALOG DEVICES / DIGITAL HEALTHCARE

GIUSEPPE OLIVADOTI, Marketing & Applications Director (Digital Healthcare), Analog Devices

a flag when personal intervention by a doctor is required. By detecting precursor signals, the early warnings of future morbidity, the patient and medical practitioner can work together on changes to medication, lifestyle or diet to prevent the onset of conditions which previously would have ended up in a visit to a hospital's acute care ward.

In addition, monitoring at home or at a point-of-care reveals information about the state of the patient's health in real life, not in the artificial, and often stressful, setting of a hospital ward. The latest multi-parameter wearable sensors can combine vital signs with measurement of other indicators such as motion and sleep to put the medical data in the context of the patient's lifestyle.

New breakthroughs

The introduction of this new mode of patient monitoring is the result of a series of developments in semiconductor technology and computer science in the 21st century.

In the field of optoelectronics, narrowband optical sensor chips have been developed which can perform photoplethysmography (PPG), which uses measurements of the reflection and absorption of light by blood vessels to calculate the heart rate, respiration rate and SpO2. Miniature MEMS motion sensors likewise can measure patient activity, such as exercise sessions and sleep quality, putting vital signs in context.

In hospitals, much of the equipment used for monitoring vital signs is bulky and power-hungry. By implementing this measurement capability at chip scale, semiconductor manufacturers such as Analog Devices make it possible to create products such as medical patches applied to the skin which can operate on battery power for days or weeks, while transmitting measurements wirelessly to a host device such as a smartphone. Via this host, the measurements can be uploaded securely to a cloud diagnostics service which can turn a stream of raw electrical signals into medically actionable data.

Technology expertise meets application know-how

It's one thing to be able to describe the functional requirements of the semiconductor and computing systems which enable a patient to wear a smart watch or a patch for monitoring their vital signs. It is quite another to implement solutions using these technologies in an actual product.

At Analog Devices, we have recognised that our service to healthcare technology innovators might start with semiconductor technology, but it cannot end there. That's why we support customers with a combination of technical experts and domain specialists in the medical market.

It is the job of the medical domain experts to understand intimately the application requirements, and key attributes, such as regulation and data privacy, which characterise the market. Customers developing complex medical products can innovate with more freedom, faster, and with greater confidence of a successful outcome when they are supported by experts who understand not only their technology but also their application.

> The introduction of this new mode of patient monitoring is the result of a series of developments in semiconductor technology and computer science in the 21st century.

In the field of vital sign monitoring, this application expertise is backed by development platforms. Our VSM (Vital Signs Monitoring) study watch, for instance, is a multi-parameter open development platform. Featuring a suite of sensors in a convenient wearable form factor, it provides a continuous set of vital sign measurements for use in the development of biomedical algorithms.

The VSM study watch implements PPG and ECG to measure heart rate and heart rate variability. Its MEMS accelerometer performs step counting. Sensors measure temperature and impedance, values used in algorithms to monitor stress and body composition. These capabilities support research carried out by medical and academic institutions to evaluate new use cases for remote patient monitoring.

The rewards of moving patient monitoring out of the hospital are clear for all to see. Drawing on precise, low-power, miniature components such as sensors, analogue-to-digital converters and digital signal processors, the robust VSM watch from Analog Devices and other such development platforms lay the groundwork on which innovative medical device manufacturers can build the monitoring devices of tomorrow.

INTELLIGENT SYSTEM DESIGN

As services and functions become more interdependent, how will engineers address this move to an era of 'system of systems'?

The word 'system' is extremely scalable; it can describe anything from a small SoC designed for wearable fitness trackers, to an entire cellular network, and even the infrastructure that enables data to be processed by cloud-based analytic algorithms. Each 'system' becomes part of a bigger 'system', giving rise to the term 'system of systems'. A lot of the complexity in those systems resides in software, but they depend on differentiated hardware to run those systems. This dependence is increasing as we enter a period of "domain specific compute".

Take 5G as an example. It is expected to connect more things, in new ways, operating in more diverse scenarios than any other mobile network that has come before it. This means, as a 'system', 5G networks will extend far beyond the traditional concept of a cellular service. Even the representation of a cell in this new network will be redefined and must be far more flexible.

Similarly, the move to electric and autonomous vehicles will enable new types of service vehicles, able to operate without a human in the loop for long periods of time. Again, the concept of a vehicle, when considered as a 'system', will need to be re-evaluated.

We can also see there will be greater convergence of these new systems, as they overlap to enhance and enable each other – with 5G, for instance, being used for transportation, industrial automation and consumer cases alike. As this happens it will accelerate the rate of change and the underlying technology will need to keep pace with this acceleration, as will the technologies that enable their design.

Identifying complexity

Complexity comes in many forms; the evolution of cellular technology could be defined by its migration through the digital modulation techniques used, from xDMA, WCDMA, QAM with OFDM and MIMO and now, with 5G, a combination of these operating in the millimetre wave radio frequency bands. This will demand an entirely new radio, but it is also clear that the use of mmW technology will have far-reaching implications throughout the entire network, extending to every aspect of the RF design and at every point there will be a need for new integrated solutions that simply did not exist before the demand for 5G emerged.

This highlights the double-layered nature of rising system complexity. As the systems are becoming more complex, the devices needed to implement these systems are often themselves being developed in parallel with the applications. Managing this level of complexity, from a design point of view, requires a system-level view and a new, intelligent approach to design. Underlying it all lies Cadence's deep knowledge of computational software, which provides the fabric to enable algorithms for design, implementation and verification.

This scenario isn't unique to 5G. The automotive industry is going through its own, very similar transition as it moves closer to full autonomy. Cars have, for some time, been considered systems; now, the boundaries of those systems are extending far beyond the physical periphery of the vehicle. All cars will be 'aware' of all other road users, both those that are autonomous and those that are not. The vehicle's system will now include everything that it could potentially interact with, because every interaction will need a reaction, and that reaction needs to come from the vehicle.

This accurately illustrates the way that system boundaries are being redefined, to include more and exclude less. The same approach is happening within the EDA industry, where the tools must now work more systemically and consider much more than they were originally designed to handle.

The system level challenge

It is apparent that the systems being

CADENCE DESIGN SYSTEMS

Cadence Design Systems enables electronic systems and semiconductor companies to create the innovative end products that are transforming the way people live, work and play. Cadence software, hardware and semiconductor IP are used by customers to deliver products to market faster. The company's System Design Enablement strategy helps customers develop differentiated products – from chips to boards to systems – in mobile, consumer, cloud datacentre, automotive, aerospace, IoT, industrial and other market segments. Cadence is listed as one of FORTUNE Magazine's 100 Best Companies to Work For.

CADENCE / INTELLIGENT SYSTEM DESIGN

REBECCA DOBSON, Corporate VP EMEA, Cadence

developed now will not exist in isolation. Autonomous vehicles will need high-speed, always-on, always reliable wireless connectivity to function. The 5G network will be important here, but so too will other forms of wireless communication, such as Wi-Fi. This complex landscape will define the specification of new solutions. And even within a car – the system of many systems inter-operating within an even bigger network with other cars and future smart city infrastructure – the architecture of the car is undergoing fundamental changes towards networked zones and several areas of centralised compute.

Meeting these requirements will require these new solutions to be developed with both safety and security at front of mind. Nothing can be put into service today without including some level of protection against cyber threats. Maintaining that level of security across system boundaries introduces a new requirement. Safety, too, becomes a multi-domain issue, as autonomous vehicles will rely so heavily on the 5G network, a safety-based approach to implementation will be a high priority.

These multi-modal, systemic design requirements are best addressed by subject matter experts. For this reason, many OEMs are now taking the approach of developing their own integrated solutions, often determining the usage of the underlying semiconductor IP or even developing their own silicon, causing a re-shuffling of the design chain. Manufacturers in vertical markets are (re)turning to in-house chip design purely because they are best placed to define the requirements and ensure they are met. The challenge they now face is engaging with EDA vendors that understand their needs and have the tools to meet them.

Today, integrated circuits are incredibly complex, with potentially billions of nodes that need to work flawlessly. Because of this, new designs often start with proven IP, but now that the applications have such domain-specific requirements, this IP must be more flexible, allowing for configurability.

Every aspect of the system has an impact on the overall functionality and performance, so the design of the IC must be approached from a system level initially. This means using a design environment that has been developed to support a more intelligent approach to system level design.

EDA tool flows must now comprise multiple tools, starting at the block (IP) and subsystem level with the right processor and design building blocks, to the "system-on-chip" level for defining the smallest physical details. That chip will need to be housed in a package and that package mounted on a PCB. The PCB will also need a housing and that enclosure may be placed within a larger cabinet or even a vehicle. The environmental conditions of that cabinet or vehicle will have an impact on how the chip performs, perhaps at the level of that smallest physical detail.

Observing how the operating environment will impact the chip once it is in the field is too late; that happens long after any design changes can be made to compensate for those environmental conditions. Design changes must be made when the chip is still in development, at the start of the process. This illustrates the scale of the design challenge and how it requires a new approach to system design in order to address it. Designers need to model the entire system using multi-physics analyses, including the AWR Design Environment platform for RF and microwave design, the Celsius Thermal Solver for electrothermal analysis, and the Clarity 3D Solver for electromagnetic simulation. Bringing this together in an integrated environment, including safety and security, enables faster time to sign-off. Cadence is enabling this integrated design process through intelligence, to save manufacturers huge costs and valuable design time.

> “As systems are becoming more complex, the devices needed to implement these systems are often themselves being developed in parallel with the applications.”

This is why Cadence has used its expertise in computational software to develop its Intelligent System Design strategy. It starts with optimised EDA tools that work together in a common digital flow, covering the IP, packaging and PCB design across multiple domains, including thermal and electromagnetic. This multi-modal approach is extended through system innovation, to add new capabilities to the design flow. Bringing this together demands the adoption of leading-edge technologies such as AI and machine learning, which Cadence harnesses through its expertise in computational software.

System boundaries are changing, and trends including 5G and autonomous driving are two noteworthy examples. The use of AI from the core to the edge is also forcing manufacturers to reconsider everything. Tackling the design challenges this presents can be daunting, but through its Intelligent System Design strategy Cadence continues to enable manufacturers to meet these challenges and manage escalating system complexity.

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FUTURE TELECOM NETWORKS

How the CSA Catapult is helping UK businesses to address the market for future telecom networks

The Compound Semiconductor Applications (CSA) Catapult has established an enviable record of helping companies translate research into commercial products. From a standing start in 2018, we have initiated over £60m worth of projects, mostly helping tier 1 automotive companies transition from internal combustion engines to battery-electric propulsion. These projects address the innovation challenges of bringing new products to market while creating entire supply chains using UK compound semiconductors.

Following this early success, we now see a greater opportunity to help UK companies address the market for future telecom networks, catalysing industry to develop and deploy critical parts of telecoms infrastructure.

The changing digital world

The modern world is increasingly dependent on digital services, supporting online working, financial transactions, e-commerce, logistics and tele-health. During the COVID lockdown, for example, data traffic increased by 120% in UK commuter towns, while London saw a drop of 60%. New services, such as virtual reality, will transform future society, creating new markets and industries, and unleashing the potential of global citizens. Digital connectivity brings communities closer together while reducing travel and environmental impact.

Digital services are reliant on telecom networks that link smartphones with office computers, data servers and cloud computing. As new services are developed, the demand for network capacity is forecast to grow by around 300% over the next 5 years. These services will play an increasingly important role in delivering economic growth, with financial transactions contributing £132bn to the UK economy in 2018 alone. Ubiquitous network access has the potential to distribute wealth creation more widely, helping to relieve pressure on existing economic hotspots.

To fully benefit from these services, and secure economic prosperity, the UK must remain at the forefront of telecom technology.

Building resilience

Telecom networks represent critical national infrastructure. The recent McKinsey report titled 'Risk, resilience and rebalancing global value chains' highlights the risks to telecom networks from malicious attacks and macro-political shifts. Mitigating these risks is upper-most in the minds of governments with new initiatives to develop supply chains based more on resilience than cost alone.

The recently announced Telecom Security Bill plans to mitigate risks by removing 'high risk' vendors from UK networks and diversifying the supply of telecom equipment. This bill is designed to strengthen supply chains, especially for mobile communication equipment.

There is a recognised lack of vendor diversity within the telecoms industry, which is considered by many economists to be a global market failure. Initiatives to address this market failure include the provision of open standards, such as Open-RAN, which specifies interoperability within the radio-access network (RAN). The move to open standards has the potential to open the market to new entrants. When combined with the Telecom Security Bill, open standards provide a once in a generation opportunity for UK companies to deploy an increasing proportion of future network infrastructure.

Key technologies

Delivering digital services of the future requires a step change in network performance, which can only be delivered through innovation, investment in new technologies, and the application of compound semiconductors. To be fully

COMPOUND SEMICONDUCTOR APPLICATIONS CATAPULT

The Compound Semiconductor Applications Catapult is a world-class, open access R&D facility to help UK businesses exploit advances in compound semiconductor technologies across key application areas such as healthcare, the digital economy, energy, transport, defence and security, and space. Its aim is to create economic growth, increased productivity and improved employment outcomes across the UK.

CSA CATAPULT / TELECOM NETWORKS

DR ANDY G SELLARS, Strategy Director, Compound Semiconductor Applications Catapult

resilient, the UK needs access to these technologies, and the supply chains on which they rely. The CSA Catapult sees a clear opportunity to help innovative companies develop key technologies for future networks while at the same time securing access to supply chains.

Mobile connectivity, from 5G and beyond, requires innovative technologies to deliver a step change in performance at the radio edge. While 3G and 4G networks used macro cell base stations, next generation mobile connectivity will combine macro cell and small cell base stations with beam steering techniques and highly efficient radio frequency transceivers – this will deliver higher bandwidth, reduced latency and optimal efficiency. UK companies developing these techniques use compound semiconductors, such as gallium nitride (GaN).

Increasing levels of data traffic at the radio edge will place additional strain on backhaul connections, with innovations required in millimetre wave and optical communications to deliver the necessary bandwidth. The UK has several companies developing RF and optical transceivers using compound semiconductors to meet these requirements.

Satellite communications will deliver services where base stations are not ideal, such as rural areas or to autonomous vehicles. Here, there is an opportunity for a constellation of low earth orbit cube satellites, such as OneWeb, which communicate using compound semiconductor chips.

Next generation encryption will combine software algorithms with digital chip encoding and quantum security, which is being developed by UK academics using compound semiconductors.

While data centres currently consume around 1% of the world's energy resources, highly efficient compound semiconductors will minimise energy consumption as data centres expand with the provision of new online services.

Building on a strong legacy

As we look to the future, the UK is in a strong position to develop key technologies for future telecom networks, with clusters of companies working at the leading edge:

- In North East England, a cluster of companies are developing world-leading optical, radio frequency and satellite communication technologies, complementing similar activity in Cambridge. These technologies are essential to future mobile networks.
- The Scottish photonics cluster is world-renowned. In addition Scotland, along with Surrey, hosts a dynamic industry that designs and manufactures cube satellites – capable of providing broadband coverage to rural areas and autonomous vehicles.
- The Western Gateway, encompassing Bath, Bristol and Cardiff, uniquely combines expertise in compound semiconductors, cybersecurity, digital chip design, network architectures and small cell base stations.
- Northern Ireland is home to world-leading research and manufacture of efficient data centre technology.
- A cluster of companies around Torbay develops the optical components required for future high-speed optical networks.

> "Delivering digital services of the future requires a step change in network performance, which can only be delivered through innovation, investment in new technologies, and the application of compound semiconductors."

Seizing the opportunity

High performance telecom networks are required to safeguard future digital services, and the associated prosperity. Developing these networks requires a combination of innovation and access to secure supply chains. Building on previous success, the CSA Catapult sees a great opportunity for UK companies to develop and deploy a larger proportion of critical telecoms infrastructure.

Based in South Wales, the CSA Catapult is a non-profit research and technology organisation. Our strategy is to accelerate the development of products using compound semiconductors, helping to grow UK industry while building long-lasting supply chains.

The Catapult's Innovation Centre features a design studio and highly specified laboratories, with dedicated engineers to help companies accelerate new products to market. Our laboratories are equipped with specialist optical and radio frequency equipment to help companies develop systems for radio edge, backhaul and satellite communications. As part of the world's first compound semiconductor cluster, called CS Connected, the CSA Catapult is developing sovereign sources of critical semiconductor materials, such as silicon carbide (SiC) and gallium nitride (GaN), to support future telecom networks.

CATAPULT
Compound Semiconductor Applications

www.csa.catapult.org.uk

GETTING SMARTER, CONNECTED AND MORE SECURE

As the world responds to new challenges, the next generation of end electronic products will need to meet high expectations and deliver even higher levels of security

It takes more than using the latest embedded devices for customers to develop ground-breaking products which deliver real change. Selecting a new device is only the start, and engineers working in Original Equipment Manufacturers (OEMs) of all sizes must be able to realise the potential that can be unlocked by each new part.

To do this, OEMs need to understand how to integrate the functions and capabilities provided by the latest devices into their application. They will also need a deep knowledge of their market and the trends that are happening within it to succeed.

Daily life is becoming a smarter and more connected experience for developers as well as for end users. And, as the levels of sophistication and connectivity continue to grow, the need to deliver smarter advanced security for connected applications is also growing.

Driven by market intelligence

Microchip identifies and understands the needs and trends across multiple markets, now and into the future. To help customers to respond to these trends, the technology values of each new solution must be conveyed accurately, clearly and quickly. The insights gained from monitoring different trends can benefit clients of all sizes, from major multi-nationals to the start-ups which drive grass-root innovation. Technology is moving fast and the path to developing new products and applications should be made as smooth as possible.

Microchip's wide range of partnerships with clients, of every size across every market sector, gives us insight into the unique needs of various applications. This enables our business units to create new devices that meet our client's needs for current and yet-to-be-realised end products.

Technology is a moving target

As technology continues to evolve, security must evolve at the same speed or faster and engineers must deliver secure connection to MCUs as well as to cloud servers.

The growth of cloud connectivity leaves OEM products more open to the risk of attack. For developers, this means that the products they create must keep their IP secure and maintain high levels of security for the users. The challenge is to bring emerging technologies to OEM customers in a way that puts safety at the forefront of technology.

To deliver the products of the future, the speed of development must be combined with an understanding of how technology is moving across different markets. When the first smartphones came out, consumer expectations changed dramatically. The first touchscreen excited the market, but that technology is now integrated into products at the lower end of the market. Cutting-edge technologies which are developed for high-end applications will soon be scaled to reach lower-cost devices.

The reality is that today's high technology will become mainstream in three or four years.

Product developers must envision where they should be heading and understand what they should be avoiding.

Game changing technologies

Today, the technologies which are providing the biggest disruption to the user experience are facial recognition, voice commands, machine learning, artificial intelligence and the Internet of Things (IoT). Scaling these technologies from high-end to individual applications in the mass market can deliver a more customised user experience and

MICROCHIP TECHNOLOGY

Microchip Technology is a leading provider of microcontroller, mixed-signal, analogue and Flash-IP solutions, providing low-risk product development, lower total system cost and faster time to market for thousands of diverse customer applications worldwide. Headquartered in Chandler, Arizona, Microchip offers outstanding technical support along with dependable delivery and quality.

MICROCHIP / SECURITY

MIKE BALLARD, Global Home Automation and Security Leader, Microchip Technology

simultaneously drive higher expectations.

What will these future applications do? Your front door may be able to recognise you and unlock itself automatically. A big trend in the US is the video doorbell that already allows you to talk to someone who is standing at the door when you are in another location. The combination of facial recognition and machine learning could also mean that your coffee maker will recognise you and then make the type of coffee that you prefer.

New drivers for technology are also coming from unexpected sources. The Covid-19 lockdown changed the world in just a few weeks and new market trends are appearing. So how will the electronics industry respond to these changes?

As working from home becomes the new norm, the risk of leaving home resulted in fewer cars on the road and a significant reduction in carbon emissions. Companies may embrace this concept more in the future and products may be needed to enable people to work together even when we are separated.

The University paradigm may also change, as classes are moving online; and, there is a rise in the use of home-based products for health monitoring and even virtual healthcare appointments.

Will the long-term result of these changes be that business moves to a more communication-based model? Will using a ride-sharing app on your phone replace owning a car? And will the new products be able to learn on their own and write their own code?

Creating the future

Engineers have great ideas for applications that respond to new opportunities. However, they often do not have the internal design resources and expertise to develop them. Working closely with a major global partner, like Microchip, can make a real difference in delivering the performance expected of next-generation products to the right markets at the right time.

To enable companies to create products which break new ground, they must have access to the resources which support advanced development as well as to proven software and a solid security platform.

The wide range of partnerships that Microchip has in virtually every sector of the market gives us market insight that we share with our customers directly or through third-party partners. It is important for engineers to be able to have the building blocks for new devices and to implement the security which protects their users as well as their products and reputation. This means that all the secure elements of a new product or application must be connected to deliver the most robust levels of security.

The support which helps customers capitalise on using the latest technologies and devices enables applications to be delivered across different markets. The size of these customers ranges from major companies with significant resources and revenue, to smaller start-ups where the focus is on innovation and individualism. This could include a university student who may be using an easy-to-use maker board to develop their revolutionary new application.

“Microchip’s role is to connect the dots between shaping the capabilities of each new device and helping customers to keep pace with technology when they are creating that new device.”

A new device may do a million things. Microchip’s role is to connect the dots between shaping the capabilities of each new device and helping customers to keep pace with technology when they are creating that new device.

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A RETURN TO BETTER TIMES

After a turbulent and disruptive year there are reasons for optimism in the electronics sector for 2021

There is no doubt that 2020 will be remembered for all the wrong reasons. The COVID-19 pandemic has wreaked havoc across multiple sectors, and for a lot of companies, the sole focus has been on business survival.

That said, there are some positives to take from the way that many organisations have pivoted in response to life in the new normal. As governments around the world sought to address the global shortage of critical medical supplies such as ventilators and PPE, many manufacturers diverted resources in support of national efforts to design and build much-needed equipment, often overnight.

Indeed, one of Mouser's customers in Malaysia which had historically focussed on making parts for hand-tools re-ordered its business in the shortest timeframe to supply components for the healthcare market. It was this kind of responsiveness and agility, replicated many times around the globe, that has helped companies weather the storm.

Showing admirable resolve

In the electronics industry, I have been impressed by the strong sense of resolve exhibited since the pandemic began. Electronics, as a sector, has always looked to do something new and different. And this innovative flair has really come to the fore in recent months, as design engineers have used any hiatus in business activity to create smarter products that answer specific needs. That is why, despite being a period of unprecedented turbulence, Mouser has seen consistent business activity throughout the year-to-date, as engineers have continued to source components and start new projects. Yes, in many cases production lines might have ground to a halt, but innovation has not stopped, and a lot of design engineers have been extremely busy in the background, adding value and bringing new ideas to life.

There are other positives to take. National lockdowns have resulted in extended periods of working from home. While there is no doubt that many of us miss the day-to-day interaction provided by the office, remote working has delivered some notable benefits. Software packages such as Zoom have become second-nature to most, and it is often faster and more productive to set up meetings online than face-to-face. The sudden popularity of video conferencing has made it easier for extended teams to come together – and this has to my mind often resulted in more in-depth discussions with our customers.

Many of us were possibly sceptical of widespread remote working when the pandemic began. But here at Mouser, we have coped with this new set-up, and I think the positives of this flexible approach far outweigh the negatives. Also, if this trend is here to stay, there will be plenty of opportunities in the electronics sector, as new collaborative communication tools are developed.

What's next?

Looking back on 2020, it is fair to say that the electronics industry has made the most of what has been an extremely challenging period. Mouser, as an online business with a large inventory, was well equipped to cope with the sudden change. But the challenge now – as for every organisation – is to remain flexible and agile to cope with any further disruptions that might come along. There is also a need to anticipate the business opportunities that will emerge as the world starts to get back on its feet.

Considering the turbulence of the last few years, predictions are difficult and predominantly short term, but with that in mind, I'll share five of my predictions for

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Mouser Electronics, a Berkshire Hathaway company, is an authorised semiconductor and electronic component distributor focused on New Product Introductions from its manufacturing partners for electronic design engineers and buyers. The global distributor's website, Mouser.com, is available in multiple languages and currencies and features more than 5 million products from over 1,100 manufacturer brands. Mouser offers 27 support locations around the world to provide best-in-class customer service and ships globally to over 630,000 customers in 223 countries/territories from its 93,000 sq. m. state-of-the-art facilities in Texas.

MOUSER / DISTRIBUTION

MARK BURR-LONNON, Senior VP EMEA, Asia and Global Service, Mouser Electronics

the year ahead, all of which will have an impact on our sector:

5G makes a big impact:

The rollout of 5G has taken longer than many of us might have expected with the epidemic arriving at a critical time in the deployment phase. However, I hope to see rapid progress with 5G infrastructure built in 2021, with an acceleration in the construction of base stations and other equipment. That activity will lead to a surge in demand for relevant electronic systems and components. The challenge for the sector is to be ready for that anticipated uptick in business to avoid bottlenecks caused by shortages of parts – something that Mouser is well prepared for with high Inventory levels of more than $845 million of stock.

Automotive gets back in gear:

The carmakers have had a tough year, with new vehicles sales in free-fall and production lines grinding to a halt. But there are already signs that the industry is bouncing back, as pent up demand starts to filter through – and I believe that momentum will be sustained in 2021. Longer-term, prospects are bright as the automotive sector continues to embrace electrification and autonomous vehicles. What I find fascinating is how the industry will be structured over the longer-term. Will the OEMs like GM and Ford and the tier 1s like Bosch remain as the big players? Or will the tech companies emerge as new rivals? Whatever happens, there will be plenty of opportunities for electronics companies.

Healthcare goes remote:

The epidemic is likely to have a profound effect on specific sectors, and healthcare is one area where deep-rooted, long-lasting change will take place. We have already seen a shift to more online services, as patients access their GPs through video links. I think this will continue across 2021, as the healthcare industry embraces technology such as sensor-based remote monitoring of patients. Again, much of this technology will be delivered by electronic suppliers, whose innovation will help underpin transformational change.

Content will be king:

As an online distributor, web analytics are critical to our business, and our visitor statistics show some interesting trends over the past few months. With more engineers working from home, we have seen a sharp increase in the consumption of online technical resources such as articles, block diagrams and case studies. Mouser's Applications & Technologies site offers tutorials, white papers and technical guidance to help visitors with their design projects. With less time spent commuting, engineers have been keen to come to the website to learn and keep up to date. So, I think relevant, well-written technical content will be increasingly important in a changing world, as engineers seek out information for their professional development.

2021 will exceed expectations:

And now to an overall prediction of business activity for the year ahead.

> “Looking back on 2020, it is fair to say that the electronics industry has made the most of what has been an extremely challenging period.”

Firstly, though, it is worth noting that 2020 – for all its unpredictability – has resulted in consistent trading across the year. Here at Mouser, our sales globally are up around 6 per cent to date, and there are high hopes for the final quarter. That gives us confidence in the future, and I think the electronics industry will enter 2021 on a strong upwards trajectory which will continue across the year. The focus for us as a company is to carry on doing what we do best: that is, supplying engineers with the latest parts first, and helping our customers to innovate and create without delay. Around 20 per cent of our huge inventory is NPIs (new product introductions), and that commitment to supplying the latest technology will remain a focus throughout the year.

MOUSER ELECTRONICS

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EMPOWERING THE EDGE EVERYWHERE

As embedded processors take on the edge, ethical AI has now become a critical issue

The pace of edge computing is advancing so fast that today's "breakthrough" is eclipsed in a short time by another, and then another. In this environment, it's not easy to extract one or two things that will drive this technology, but I want to highlight two important factors: machine learning at the edge and the need for a common code of AI ethics to provide trust as AI becomes a ubiquitous part of edge computing.

Only recently, data from edge nodes was aggregated in a gateway and sent to a cloud data centre where massive computational resources could tackle ML training and inferencing. With the expansion of the smart edge in thousands of Industrial and IoT applications, it became clear that the latency, energy, and always-on connectivity required to send data to the cloud for processing and get a return response was untenable for most edge applications.

A better approach was to split the processing and analysis functions between the cloud and the edge itself. Thus, edge computing arrived.

However, with the growing complexity of the applications, the smart edge had to evolve – from smart to intelligent.

The intelligent edge is not just about fast response time but is also about training the edge to take decisions locally based on a set of real-time data, without the aid of the cloud or the gateway. Of course, systems could be built such that the edge reaches out to a local gateway or the cloud in case it is presented with a scenario it is not trained for, but such situations by design are expected to be very few in an intelligent edge network.

In a constantly evolving world, a true intelligent edge should have the means to evolve as well, so as not to limit the lifetime of the product in the field. It is imperative that product developers think about the future possibilities and build in a balanced set of attributes to enable in-field enhancements. That could come in a couple of different ways: having sufficient compute and memory capability and a way to receive the updates. This benefits both consumers and the manufacturers - consumers can receive the latest features delivered on their device and manufacturers can extend the lifetime of the device as well as build brand loyalty and revenue streams through additional services and support.

Many of these intelligent edge devices are in resource-constrained environments, where they must compute and communicate using little energy.

Additionally, most edge application solutions must be inexpensive, frugal with power, typically operating from tiny rechargeable batteries, possibly using energy harvesting. Adding ML functionality would make them power-hungry and too expensive to be practical. There were doubts if the required intelligent performance could ever be achieved with a small and inexpensive device.

Today, microcontrollers and crossover applications processors have blossomed. In our view, this represents what will ultimately become a new domain, where machine learning is performed right at the edge, consuming milliwatts of energy while delivering truly remarkable compute performance.

This is not a pie-in-the-sky prediction; but such highly capable MCUs and crossover applications processors are available now and are making their way into thousands of applications. The next generation of these edge processors will have dedicated neural network processing engines to provide astounding ML inferencing performance while also improving energy efficiency.

An MCU-based edge solution can now perform tasks such as secure face

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NXP Semiconductors enables secure connections and infrastructure for a smarter world, advancing solutions that make lives easier, better and safer. As the world leader in secure connectivity solutions for embedded applications, NXP is driving innovation in the secure connected vehicle, end-to-end security and privacy and smart connected solutions markets.

NXP SEMICONDUCTORS / EDGE COMPUTING

RON MARTINO, Senior VP and General Manager, Edge Processing business at NXP Semiconductors

recognition using tiny, inexpensive IR sensors that are difficult to 'spoof'. This is achieved through the use of 'liveness' detection in which a 'warm body' with precise characteristics is sensed, differentiating a human face from even a high-resolution photo or mask, all within the span of hundreds of milliseconds with a false-positive rejection accuracy approaching 99%. A high false-positive rejection accuracy is required in cases where security is paramount, be it the front door of a smart home or access to heavy machinery in an industry, where granting access to the wrong person because of incorrect detection (false-positive) is more dangerous than rejecting a genuine user (false-negative).

This brings us to the next issue we would like to see gain more attention in 2021: ethical AI.

Ethical AI

As processors bring AI and ML to more applications, the issue of endowing the technology with a moral compass becomes not just a theoretical conjecture but a here and now reality. The problem, fundamentally, is that ethics is subjective with widely varied views, driven by geography, culture, values, and governments, thereby making it challenging to "define" a universal set of AI ethical principles. This becomes even more challenging on a global scale, as cultures may have different views on what is acceptable and what is not.

Fortunately, this issue has not been lost on the tech industry or by several governing bodies around the world, which are taking steps to develop policies and laws focusing on a human-centric approach to AI ethics. These initiatives envision ethical codes of AI conduct based on the principles of transparency, fairness, safety, and privacy. If these initiatives can be harmonised into a universal ethical code and adhered to, then people can be assured that the AI/ML will act to enrich lives - by making bias-free decisions, by protecting personal privacy, and by ensuring that lives will not be invaded by companies, industries, and governments without consent. This is not a trivial task, but is required if AI/ML is part of our future. Without these guiding principles, there may come a time when the public at large will no longer accept AI. Therefore, we believe attention to ethical AI will be one of the most important developments to watch in 2021.

At the hardware and software level, ethical AI/ML cannot be achieved as a "bolt-on" extension, but rather must be thought through and implemented from the inception of a system. That includes high-level, broad-based security that is grounded in the silicon, software layers that add additional levels of security and AI/ML applications that conform to the ethical principle of bias-free training and essentially obey the Asimov's first law (paraphrased for ML): ML may not injure a human being or, through inaction, allow a human being to come to harm. This means controlling action a device can do to prevent commitment of a moral crime; autonomous judgement to not cause injury – e.g. knowing when to stop a task if injury to humans is imminent; and including privacy indicators for transparency of what function a device is performing – e.g. listening-only mode or recording mode, etc. that are made clear to humans.

> We believe attention to ethical AI will be one of the most important developments to watch in 2021.

Conclusion

In summary, for industrial and similar applications, moving machine learning into the edge means better performance, while for people it brings AI closer to their personal lives. So, practically speaking, intelligent edge compute and ethical codes for AI are not as disparate as they seem but are joined at the hip, or rather at the edge, where the data is generated.

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BECAUSE EVERY ELECTRON IS SACRED...

Without doubt, it is the efficient use of available power that is driving much of the demand seen in the semiconductor industry today

While the media focuses on the sections of the semiconductor industry that innovates around massive processing performance, you could be forgiven for thinking that smaller and faster is the industry's only motivator. In fact they only form a small part of the bigger picture.

Once digital decisions have been made, they must be translated into motion or stored in the cloud, all of which requires the efficient use of power.

Industry 4.0, or Industrial IoT (IIoT), has provided much of the impetus to move from purely mechanical or electromechanical to more intelligent and refined connected electronic systems. However, this requires more equipment that draws electrical power. Should this be implemented without regard for electrical efficiency, part of its premise will be lost. Parallels can be drawn here with the computing industry mandating higher efficiencies for power supplies as the number of computers and servers in use rapidly grew.

Penetrating every market segment

As industrialised nations consider their carbon footprints, efficient consumption of the power used is a common binding theme. In an industrial context this encompasses a wide range of applications, such as power supplies and motor control systems, along with battery chargers due to the increasing use of autonomous guided vehicles (AGV). With this continued growth in installed electrical equipment it can be expected that further regulations will also emerge, or existing regulations tightened.

Then there are robots and, increasingly, collaborative robots (cobots) whose drive systems also need to be power-efficient, compact, and lightweight. And, as we encourage people and goods to move from private road transportation to greener alternatives, options such as rail also need to expand while additionally upgrading to more efficient control systems. Finally, energy delivered via high power transmission systems (HVDC) need to ensure that the power generated moves from source to point-of-use with as little loss as possible.

The same also applies to other markets: automotive is moving to 48V power electrical systems and drives; white goods must consume less energy while also being quieter.

Innovating beyond purely finer geometries

While digital systems, such as processors and artificial intelligence, benefit from ever finer lithography, silicon built with a high quantity of analogue components do not. Many passive components, such as capacitors and inductors, do not shrink, meaning that innovation needs to happen elsewhere. Power devices, such as IGBTs and MOSFETs, also fail to benefit from finer lithography. Instead, suppliers require an intimate understanding of the physical properties of the device's structure, along with the interaction at the junctions of different materials, to deliver improvements.

Progress here has seen continuous improvement in reducing parasitic effects and other parameters, while increasing switching speed. Such improvements in static and dynamic losses deliver efficiency improvements and reduce heat dissipation in power supplies and control systems, such as servo drives. Packaging is another key area of innovation. Today's package structures ensure that any dissipated heat can be removed easily, thanks to the elimination of conduction losses between the die and package, while simultaneously shrinking the package and maintaining reliability and supporting automated optical inspection quality regimes.

The control techniques employed have

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Toshiba Electronics Europe (TEE) is the European electronic components business of Toshiba Electronic Devices and Storage Corporation. TEE offers European consumers and businesses a variety of innovative hard disk drive products, plus semiconductor solutions for automotive, industrial, IoT, motion control, telecoms, networking, consumer and white goods applications. The company's portfolio encompasses integrated wireless ICs, power semiconductors, microcontrollers, optical semiconductors, ASICs, ASSPs and discrete devices ranging from diodes to logic ICs. Formed in 1973, TEE has headquarters in Düsseldorf, with branch offices in Germany, France, Italy, Spain, Sweden and the UK.

TOSHIBA ELECTRONICS EUROPE / POWER

ARMIN DERPMANNS, Head of Semiconductor Marketing and Operations, Toshiba Electronics Europe

also advanced, allowing designers to address the impact these parasitic effects can have. This, coupled with increases in switching speeds in power converters, enables advancements to be attained that cannot be achieved from manufacturing process improvements and physics alone.

Perhaps the past decade's most important development has been the large-scale introduction of wide bandgap (WBG) technology such as silicon carbide (SiC) and gallium nitride (GaN). These overcome many of the limitations of silicon, as determined by physics, and allow the use of innovative power solutions that can maximise performance. These are pushing applications involving power conversion into the domain of 99% efficiency or better.

Blending digital with analogue

While the IIoT focuses on data sharing and analysis, the signals entering such systems, and the actuators implementing the outputs, are still operating in the analogue domain. Digital processors, in the form of microcontrollers, are an essential part of the mix but it is not raw processing power alone that is required. Instead, highly integrated and sophisticated control mechanisms that, in some cases, operate almost autonomously, are more important than pure processing performance and need to be integrated alongside digital processors.

Toshiba offers a range of microcontrollers that integrate such control mechanisms, such as an integrated Vector Engine that handles the majority of the complexity behind field-oriented control making it simpler for such efficient motor control technology to be integrated by designers.

While semiconductor vendors have benefited from lithography shrinks and increases in wafer sizes, this does not mean that pricing for these devices should be defined purely on die area alone.

Semiconductors are an investment-intensive business, requiring enormous sums to establish new manufacturing processes, new packaging, and additional capacity in manufacturing facilities. As old technologies 'go digital', and existing applications become ever more integrated, the level of support and expertise expected from them is growing too. Today's microcontroller-based systems may include motor control, digital power conversion, graphical user interface, network connectivity, and also security. Each of these would have been handled as individual disciplines in the past.

The move to WBG is not a drop-in replacement. Inherent understanding for gate drive, parasitic parameters, and long-term ageing are different compared to the silicon MOSFETs and IGBTs they are replacing. The approach to controlling the switching process and many other aspects also require careful consideration for a successful design that provides long-term reliability. WGB will also continue, for some time, to be more expensive than the silicon alternatives they replace. For semiconductor suppliers, this requires a capacity assessment: how will the demand on next-generation superjunction MOSFETs be impacted by the market adoption of SiC, and how should we best plan for this change?

> "While digital systems, such as processors and artificial intelligence, benefit from ever finer lithography, silicon built with a high quantity of analogue components do not."

Interactions with semiconductor vendors need to factor in the long-term total cost of ownership (TCO), and system-level and end-user benefits that result, rather than purely the cost of every single component on the board.

Conclusion

Without doubt, it is the efficient use of available power that is driving much of the demand seen in the semiconductor industry today. Regardless of whether something needs to reduce noise, minimise heat generation, or needs a smaller footprint or volume, it is the masterly handling of electrons that lies at the core of the issue. However, the semiconductor industry's value here is much more than the products it supplies. Its application-level expertise, role as consultant, and deep market insights are as important as its ability to innovate at every level, from process, through package and die, to the resultant systems our customers develop.

TOSHIBA

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MEETING AI PROCESSING DEMANDS

The evolution of chip architectures is accelerating so the right tool for the right job is critical

The world is becoming smarter. From the smart phones in our pockets to today's smart cities helping manage traffic and transportation systems, Artificial intelligence (AI) is becoming pervasive across nearly every industry and impacting all our daily lives. This infusion of AI is also producing huge amounts of unstructured data that must be managed and processed, often in real time. The demands on hardware are skyrocketing, placing increasing reliance on innovations in chip architectures to deliver the performance improvements necessary to keep pace.

Just as it took an army of thousands of engineers and billions in R&D investments from hundreds of companies to deliver the continuous improvements in chip performance associated with Moore's Law, the same will be true of the silicon chips powering AI workloads. It's not a one-size fits all world, and it will not be one company or chip architecture that will dominate.

So, how can your hardware keep up with every-increasing demand of AI processing? The answer is Domain Specific Architecture (DSA). DSAs are the future of computing, where hardware is customised to run a specific workload. DSAs closely match compute, memory bandwidth, data paths, and I/O to the specific requirements of an application workload. This delivers a much higher level of processing efficiency compared with general purpose CPU and GPU architectures.

The downside of fixed silicon

DSAs can be built using a dedicated silicon device, but that can have-drawbacks. First, a critical part of the landscape is the increasing demand for not only faster, better and cheaper, but also sooner. To keep up with the pace of innovation, manufacturers are expected to create and deliver new services in shorter timeframes than ever before. More specifically, in less time than it takes to design and build a new ASIC-based DSA. This creates a fundamental market misalignment between the market demands on innovation and the time it takes to design and build ASICs.

Second, ASICs are hard to do. The complexity of designing advanced-node ASICs is growing exponentially, significantly increasing the risk of failure. A single, small mistake can have huge implications, not the least of which include non-recurring engineering (NRE) costs. A complex 7nm ASIC, for example, costs several hundred million dollars just in NRE, with costs projected to rise further as device geometries shrink to 5nm and beyond. Third, such fixed-silicon implementations are not future-proofed. Changes to industry standards or other fluctuating requirements can quickly render the device obsolete. These are just some of the downsides of fixed silicon.

So how can the industry continue making architectural advancements and build DSAs fast enough to keep up with the pace of innovation? The solution lies in adaptive computing.

The power of adaptive computing

Built on FPGA technology, adaptive computing allows DSA's to be dynamically built in silicon. Adaptive computing therefore allows the DSAs to be dynamically updated as requirements change; freeing us from lengthy ASIC design cycles, and exorbitant NRE costs. It enables over-the-air (OTA) updates not just for software, but also for hardware, which is especially important as processing becomes more distributed. For example, the 2011 Mars rover Curiosity as well as the recently launched Perseverance both contain adaptive computing.

XILINX

Xilinx develops highly flexible and adaptive processing platforms that enable rapid innovation across a variety of technologies – from the endpoint to the edge to the cloud. Xilinx is the inventor of the FPGA, hardware programmable SoCs and the ACAP, designed to deliver the most dynamic processor technology in the industry and enable the adaptable, intelligent and connected world of the future.

XILINX / ADAPTIVE COMPUTING

IVO BOLSENS, Senior VP & Chief Technology Officer, Xilinx

Perseverance uses adaptive computing for its comprehensive vision processor. Built using an FPGA-based platform, it accelerates AI and non-AI visual tasks, including image rectification, filtering, detection and matching. The images that Perseverance sends back to NASA will have been processed using adaptive computing.

If a new algorithm is invented during the eight months it will take Perseverance to reach Mars, or a hardware bug is discovered, adaptive computing allows hardware updates to be sent remotely, over the air or over space in this case. These updates can be done as quickly and easily as a software update. When the deployment is remote, such remote hardware updates are more than just a convenience, they are a necessity.

Adaptive computing can be deployed from the cloud to the edge to the endpoint, bringing the latest architectural innovations to every part of end-to-end applications. This is possible thanks to a wide range of adaptive computing platforms – from large capacity devices on PCIe accelerator cards in the data centre, to small, low power devices suitable for endpoint processing needed by IoT devices.

Adaptive computing can be used to build all manner of optimised DSAs, from latency-sensitive applications such as autonomous driving and real-time streaming video, to the signal processing in 5G and the data processing of unstructured databases. And with today's hardware abstraction tools, software and AI developers can now take full advantage without needing to be hardware experts.

Adaptive computing accelerates the whole application

Rarely does AI inference exist in isolation. It is part of a larger chain of data analysis and processing, often with multiple pre and post stages that use a traditional (non-AI) implementation. The embedded AI parts of these systems benefit from AI acceleration of course. The non-AI parts also benefit from acceleration. The flexible nature of adaptive computing is suited to accelerating both the AI and non-AI processing tasks. We call this whole-application acceleration and it will become increasingly important as AI permeates through ever more applications.

We've talked about the power of adaptive computing, but there are more tricks up its sleeve.

Enabling entirely new systems

Adaptive computing is enabling entirely new systems that would not be possible with other technologies. It not only enables rapid architectural innovation, it also enables swapping between architectures - while the system is running. These new systems provide significant performance, power and cost improvements that are just not possible with fixed silicon like CPUs and GPUs and ASICs.

For example, in modern vehicles, there are many cameras, each of which is monitored by software and increasingly AI. The processing of a front facing camera and a rear facing camera are usually mutually exclusive – only one is being monitored at a time, depending on the direction of travel.

"Adaptive computing can be deployed from the cloud to the edge to the endpoint, bringing the latest architectural innovations to every part of end-to-end applications."

Adaptive computing allows them to share processing resources. When moving forward, only the front video steam needs to be processed, and when moving backwards, only the back one is processed. When the car is moved from "drive" to "reverse", the hardware is reconfigured to implement the rear camera processing algorithms which may be different than the front facing ones. This gives a higher overall performance, but at the same time, reduces power consumption and cost. For the end-consumer, that translates into more features for less money.

Conclusion

Moore's Law as defined, is dead. The spirit of Moore's Law however is alive and kicking. Adaptive computing and architectural advances such as DSAs are helping to maintain the faster, better, cheaper we've all become accustomed to. At the same time, adaptive computing is delivering on the market need of "sooner" by eliminating the lengthy design cycles required to build new ASIC-based DSAs. This trend will continue the rapid architectural advancements that keep the spirit of Moore's law alive, long after the real law has ceased. That's the paradox of Moore's Law.

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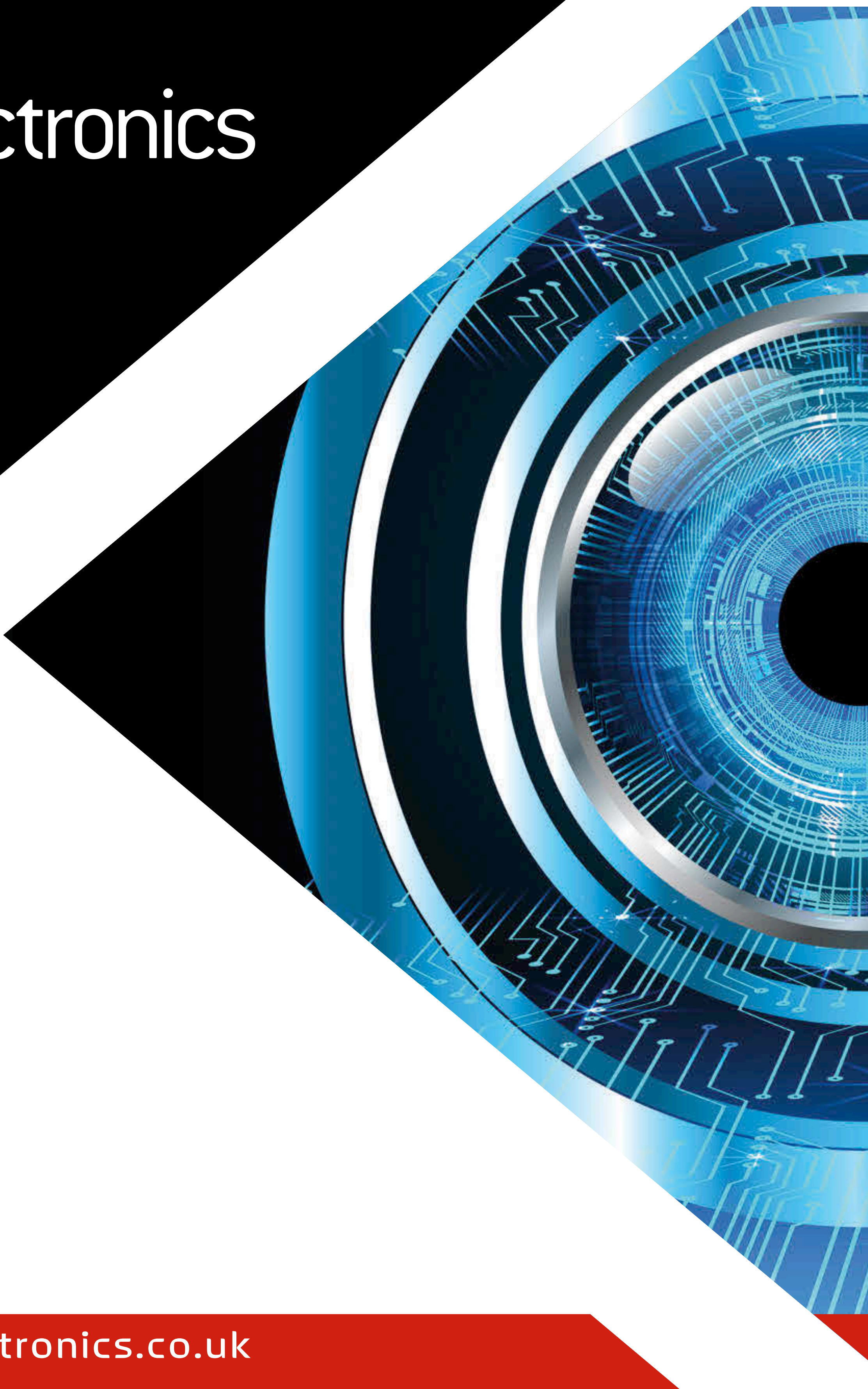
Outlook 2021 is
published by
MA Business
Hawley Mill
Hawley Road
Dartford
Kent DA2 7TJ

MA BUSINESS
A MARK ALLEN GROUP COMPANY

Printed by Pensord

OUTLOOK 2021

Published by newelectronics



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