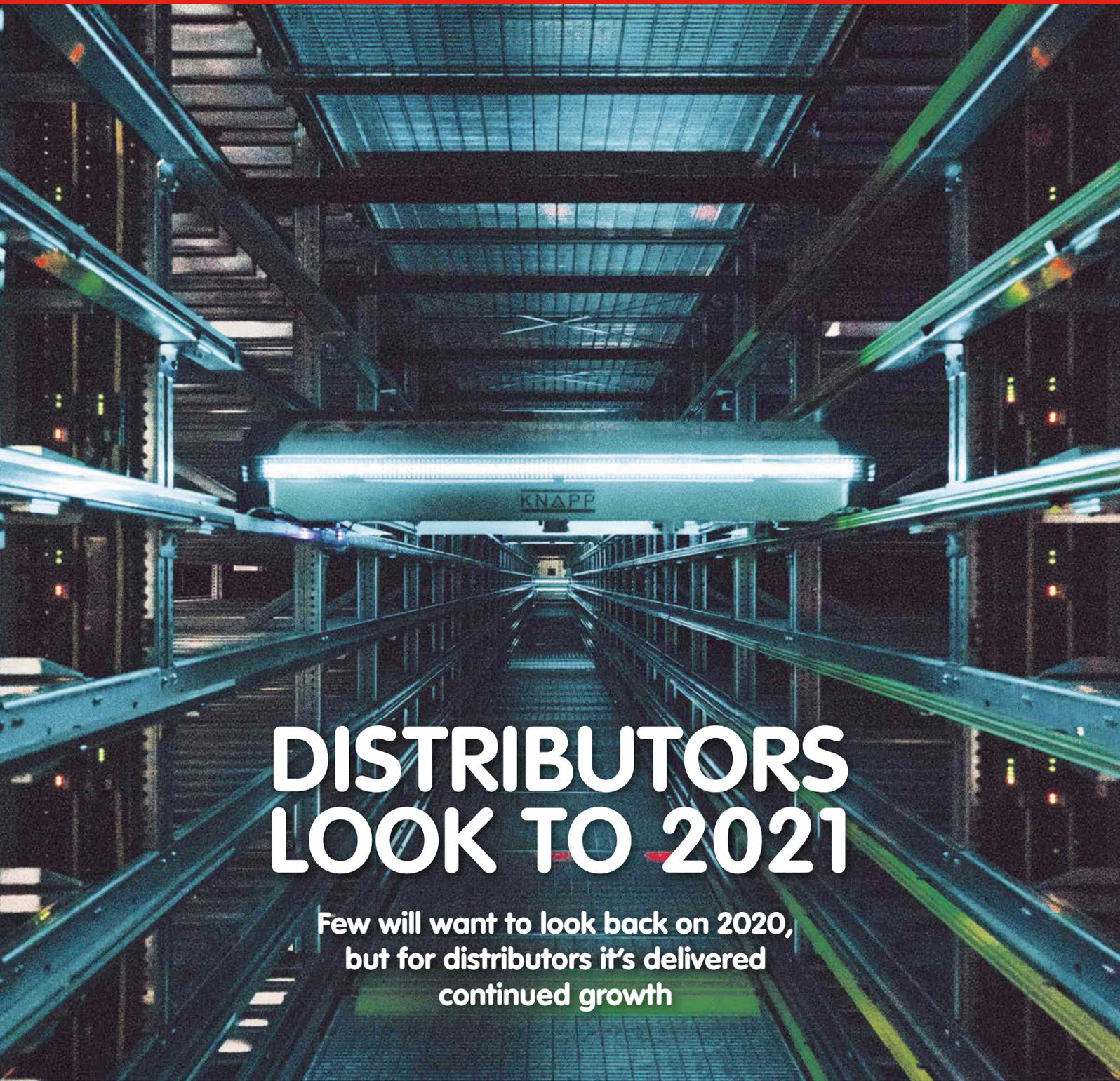


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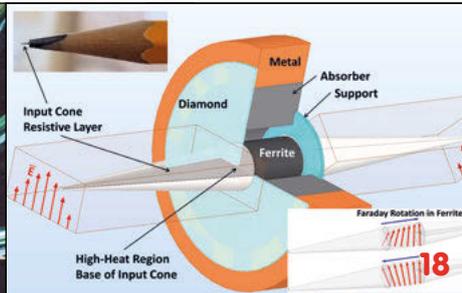


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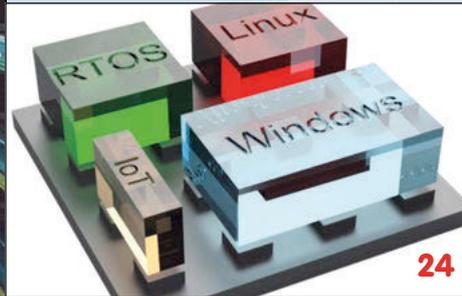
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# Record robotic sales

NEW FIGURES SHOW A SURGE IN THE SALES OF SERVICE ROBOTS, BUT THOSE FIGURES DON'T SHOW THE IMPACT THAT THIS TECHNOLOGY IS HAVING ON WORKERS



**A**ccording to the World Robotics 2020 – Service Robots report, published by the International Federation of Robotics (IFR), the sales value of professional service robots increased by a remarkable 32% to \$11.2 billion worldwide in 2018-19 and it's likely that sales will have risen strongly over the course of 2020 as a result of the COVID-19 pandemic, which has seen demand for robotic disinfection solutions, robotic logistics solutions in factories and warehouses or robots for home delivery boom.

While in terms of value the sales of medical robotics accounted for 47% of the total professional service robot turnover in 2019, the market value of logistics robots sold or leased shot up by 110% to almost \$2 billion.

Autonomous mobile robots are being used in warehouses and with investments in service robots for logistics being repaid within 2-3 years, and often much quicker, there's no surprise that businesses are looking to invest in the latest technology.

The use of logistics systems in non-manufacturing industries has been strongly driven by retail and warehouse solutions for major e-commerce companies.

For example, Ocado continues to morph into a technology business and recently acquired two US companies to boost the firm's 'robotic manipulation capabilities', paying £200 million for Kindred Systems and £20 million for Haddington Dynamics.

However, technology doesn't always come up with the solution. Walmart has dropped its plans to use roving robots to scan shelves and keep track of inventory, ending years of effort on the part of the world's largest retailer to automate the task – in fact Walmart now has more workers walking its aisles to package online orders and manage inventory problems.

According to research the deployment of robots isn't the biggest worry for workers – many of whom are transferred to new roles – but rather it's how robots change the nature of work.

The pace of work is accelerated and it's the software that manages automation that seems to be of most concern to workers.

Many have been angered by automated management and the scheduling algorithms behind it, rather than the automation per se, and believe that the real problem lies with how this software fails to provide them with the time and space for basic human needs.

It's about the here and now and for many people, who are having to contend with this new industrial revolution, that seems to have been forgotten by the tech evangelists promoting this brave new world.

Neil Tyler, Editor ([neil.tyler@markallengroup.com](mailto:neil.tyler@markallengroup.com))

**“Ocado continues to morph into a technology business and recently acquired two US companies to boost the firm's 'robotic manipulation capabilities’”**

**newelectronics**

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# Stable lithium battery design

RESEARCHERS DEVELOP NEW TECHNIQUE THAT EXTENDS NEXT-GENERATION LITHIUM METAL BATTERIES. **NEIL TYLER** REPORTS

Next-generation lithium batteries that offer lightweight, long-lasting, and low-cost energy storage have not been successfully commercialised due to the fact that while rechargeable lithium metal anodes play a key role in how well lithium batteries function, during battery operation they are highly susceptible to the growth of dendrites, microstructures that can lead to dangerous short-circuiting, catching on fire, and even exploding.

Researchers at Columbia Engineering have announced that they have found that alkali metal additives, such as potassium ions, can prevent lithium microstructure proliferation during battery use.

The research team used a combination of microscopy, nuclear magnetic resonance (similar to an MRI), and computational modelling to discover that adding small amounts of potassium salt to a conventional lithium battery electrolyte produced a unique chemistry at the lithium/electrolyte interface.

“Specifically, we found that potassium ions mitigate the formation of undesirable chemical compounds that deposit on the surface of lithium metal and prevent lithium ion transport during battery charging and discharging, ultimately limiting microstructural growth,” said PI Lauren Marbella, assistant professor of chemical engineering.

The discovery that alkali metal additives suppress the growth of non-conductive compounds on the surface of lithium metal differs from traditional electrolyte manipulation approaches, which have focused on depositing conductive polymers on the metal’s surface.

The work is one of the first in-depth characterizations of the surface chemistry of lithium metal using NMR, and demonstrates the power of this technique to design new electrolytes for lithium metal.

“Commercial electrolytes are a cocktail of carefully selected molecules,” Marbella SAID.

“Using NMR and computer simulations, we can finally understand how these unique electrolyte formulations improve lithium metal battery performance at the molecular level. This insight ultimately gives researchers the tools they need to optimize electrolyte design and enable stable lithium metal batteries.”

The team is currently testing alkali metal additives that stop the formation of deleterious surface layers in combination with more traditional additives that encourage the growth of conductive layers on lithium metal.

## CEA-Leti to build quantum-photonics platform

CEA-Leti has announced plans to build a quantum-photonics platform to develop next-generation technologies for key industries that require ultra-secure data transmission.

Quantum technology is expected to provide unconditionally safe data encryption that’s required by the finance, healthcare, energy, telecommunications and defence sectors as well as other essential industries.

Funded by Carnot, a French multidisciplinary network, the project will build on CEA-Leti’s silicon-photonics platform which will be complemented by new quantum characterization equipment for designing, processing and testing quantum-photonics integrated components and circuits. The institute uses photons to build quantum bits, or qubits, which are the best physical means for quantum communications.

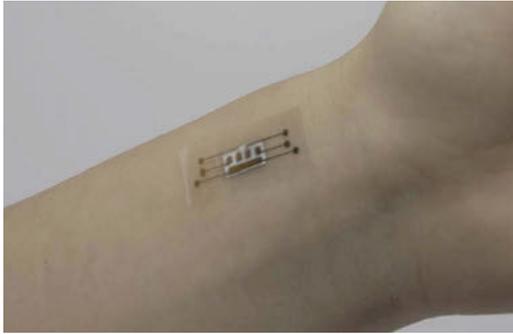
The three-year project will fabricate silicon-photonics circuits that generate single photons, manipulates them with linear optical components such as slow and rapid phase shifters and detects them with superconducting nanowire single-photon detectors (SNSPD).

The project will build demonstrators for transmitting and receiving information in a quantum-based system to deliver ultra-secure cryptography. For example, the demonstrators will realise an integrated qubit transmitter, as a circuit generating single photons and entangling them. An integrated qubit receiver will be built to detect the photons.

Beyond these demonstrators, the CEA-Leti team will also focus on integrating the qubit transmitter and the qubit receiver on one platform to address quantum computing applications.

# Soft electronics breakthrough

NUS RESEARCHERS HAVE TACKLED PROBLEMS WITH SOFT ELECTRONICS TO DEVELOP A FLEXIBLE AND HIGHLY RELIABLE SENSOR. **NEIL TYLER** REPORTS



Soft electronics are used extensively when it comes to real-time health monitoring or in enhancing the sensing abilities of robots, but a big challenge in using such materials has been found to be their lack of reliability. Unlike rigid devices, being elastic and pliable makes their performance less repeatable. This variation in reliability is known as hysteresis.

A team of researchers from the National University of Singapore (NUS) have come up with a new sensor material that has

significantly less hysteresis and, as a result, enables more accurate wearable health technology and robotic sensing.

The research team, led by Assistant Professor Benjamin Tee from the Institute for Health Innovation & Technology at NUS, found that the soft sensor's material properties can change in between repeated use, which then affects the reliability of the data and its accuracy, limiting the sensors' possible applications.

In response the NUS team have developed a material which has high sensitivity, but with an almost hysteresis-free performance. They developed a process to crack metal thin films into desirable ring-shaped patterns on a flexible material called polydimethylsiloxane (PDMS).

The team integrated this metal/PDMS film with electrodes and substrates for a piezoresistive sensor and characterised its performance. They conducted repeated mechanical testing, and verified that their design innovation improved sensor performance.

Their invention, named Tactile Resistive Annularly Cracked E-Skin, or TRACE, has been found to be five times better than conventional soft materials.

"With our unique design, we were able to achieve significantly improved accuracy and reliability. The TRACE sensor could potentially be used in robotics to perceive surface texture or in wearable health technology devices, for example to measure blood flow in superficial arteries for health monitoring applications" said Asst Prof Tee.

"Our long-term goal is to predict cardiovascular health in the form of a tiny smart patch that is placed on human skin. This TRACE sensor is a step forward towards that reality because the data it can capture for pulse velocities is more accurate, and can also be equipped with machine learning algorithms to predict surface textures more accurately," explained Asst Prof Tee.

## TI licences Imagination's B-Series GPUs

Imagination Technologies has announced that its BXS-4-64 GPU will be included in Texas Instruments (TI) Jacinto processor families for automotive applications.

The BXS GPUs have been designed to offer up to 60% higher performance for automotive graphics applications, like surround view technology, due to a bespoke design tailored for the automotive market.

IMG BXS is the first XS GPU IP with added safety features and a design process conforming to ISO 26262 to help customers achieve ISO 26262 certification. It includes Imagination's new B-Series multi-core architecture, leveraged for higher performance and safety capabilities. The architecture incorporates new features and safety mechanisms, such as Tile Region Protection, in addition to existing features such as hardware virtualization.

Jim Kennedy, Platform Engineering Director for TI Processors, said, "Imagination's BXS GPUs enable us to introduce differentiated automotive processors with higher performance, lower bandwidth and enhanced safety capabilities. IMG's new multi-core technology also helps us scale our technology for future processor designs."



## Exein unveils embedded security solution

According to edge security specialist Exein, just a few lines of code embedded in the firmware is all it takes to offer multi-layer, virtually impenetrable protection for Internet of Things (IoT) devices.

Exein, based in Rome and San Francisco, has developed what CEO Gianni Cuzzo describes as, "the fastest security countermeasure ever built" - an open-source mathematical model that can detect threats autonomously at speeds significantly faster than many other solutions.

Platform agnostic, the Exein Core is a developer tool operating as an embedded component from within hardware. Once grafted into firmware, Exein Core uses convolutional neural networking to learn the legitimate behaviours of a device and can then detect anomalies and external threats at unprecedented speeds without the need for cloud computing support.

The potential for this product is said to be enormous. According to McKinsey, "the worldwide number of IoT-connected devices is projected to increase to 43 billion by 2023".

Firmware is the Achilles Heel - a security soft spot that is typically awarded just 1% of protection budgets and continues to offer easy ingress for criminals.

"It's not just about thwarting ransom threats," said Cuzzo. "The exploitation of firmware can affect our safety too. Aviation, automobiles and home safety systems can all be targeted. Exein Core, applied to the firmware of any and all IoT equipment at the manufacturing stage or retrofitted to existing devices, can stop such attacks. This is a world-changing product that represents an entirely new way of approaching IT security".



## Distributors supplying first all-in-one PC from Raspberry Pi

Farnell and OKdo are supplying the new Raspberry Pi 400, an all-in-one personal computer, created by Raspberry Pi and based on the popular Raspberry Pi 4 single-board computer.

Taking the form of a keyboard, the Raspberry Pi 400 enables users to simply plug in a USB-C based power supply, mouse and micro-SD card configured with a suitable operating system, such as Raspberry Pi OS, to start exploring the world of computing and electronics.

At the heart of Raspberry Pi 400 is the 64-bit BCM2711 system-on-chip, which integrates a quad-core Arm Cortex-A72 CPU running at 1.8GHz, and a VideoCore VI graphics processor supporting OpenGL ES 3.1 and Vulkan graphics, H.264 and H.265 video, and sophisticated image processing capabilities. 4GB of LPDDR4-3200 DRAM provides space for the most demanding use cases.

The Raspberry Pi 400 provides a variety of connectivity and interfacing options: two USB 3.0 ports and a single USB 2.0 port for peripherals; two micro-HDMI ports, supporting up to 4k resolution; Gigabit Ethernet, 802.11ac wireless networking and Bluetooth 5; and a standard 40-pin GPIO port, supporting Raspberry Pi HAT expansion boards.

Raspberry Pi 400 is available on its own, or as part of a kit containing a power supply, a mouse, an HDMI lead, a 16GB micro-SD card with Raspberry Pi OS preinstalled, and a copy of the Raspberry Pi Beginner's Guide.

# HoriZone RA development kit

NEW DEVELOPMENT KIT TARGETS EDGE-TO-CLOUD IOT APPLICATIONS. **NEIL TYLER** REPORTS

Avnet Silica has launched the HoriZone RA development kit, which is designed to enable 'proof-of-concept' for edge-to-cloud Internet of Things (IoT) applications requiring secure communications.

Powered by Renesas Advanced (RA) microcontrollers for secure IoT endpoints and edge devices, the kit delivers enhanced security features for Resource Constrained Embedded Systems (RCES) connected to Avnet's IoTConnect Cloud Platform based on the Microsoft Azure cloud.

The multi-sensor solution is highly scalable, providing a seamless path from proof-of-concept to project through to deployment, including all the required building blocks. The kit includes sensors for humidity, temperatures, ambient light, air quality and air pressure, plus microphone, digital accelerometer, digital gyroscope, and inductive proximity sensor for positioning information.

The board integrates several components from Renesas, including the RA RA6M3 microcontroller, which is suitable for IoT applications that require TFT, Ethernet, security, large embedded RAM, and USB High Speed (HS). Also included are the ISL88014 voltage supervisor and ISL80102 synchronous boost converter for power management. Out of the box, engineers will be able to quickly start developing IoT endpoint and edge devices for a broad range of applications, including industrial and building automation, metering, healthcare, and home appliances.

"IoT growth has increased embedded design complexity exponentially," said Juerg Siegenthaler, Manager 3rd Party Management Avnet Silica. "IoT devices are complex, and with shortening project timelines, the HoriZone cloud-ready platform has all the necessary building blocks that offers designers a ready-made and highly scalable solution for developing new IoT use cases quickly."

## HES-DVM simulation flow for FPGA designs

Aldec, an expert in mixed-HDL language simulation and hardware-assisted verification for ASIC and FPGA designs, has introduced a HES-DVM simulation acceleration flow for Microchip's PolarFire, SmartFusion2 and RTAX/RTAX FPGA designs using its HES-MPF500-M2S150 prototyping board

Simulation acceleration techniques have been around for some time, but most products are based on FPGAs from one or two leading FPGA vendors. Usually, it does not matter which FPGA family is used on the simulation acceleration board if the design is coded using synthesizable RTL.

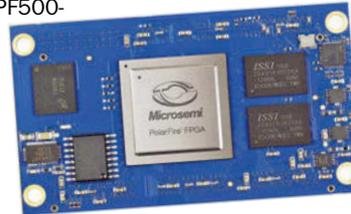
However, growing design complexity, along with shrinking design cycles and

shorter time to market, are taking engineers down the path of re-usable IP blocks from the FPGA vendor, instead of developing RTL code. The drawback with this is that the designs become dependent on the given FPGA technology, and the re-usable

IP blocks usually require far more computational power to simulate than pure RTL code.

Aldec's HES-DVM looks to overcome these challenges and removes a key verification bottleneck.

With the latest release of this powerful EDA tool, users of PolarFire, RTAX/RTAX and SmartFusion2 devices wishing to take advantage of Microchip IPs can accelerate their RTL simulations using Aldec's HES-MPF500-M2S150, which features the largest devices available in both families.



# Arduino kit simplifies IoT development

OPLÀ IOT KIT, THE FIRST OPEN PROGRAMMABLE IOT PLATFORM THAT ALLOWS ANYONE TO BUILD CUSTOM IOT DEVICES, UNVEILED BY ARDUINO. **NEIL TYLER** REPORTS

Arduino, the IoT development platform, has launched the Oplà IoT Kit, the first open programmable IoT platform that allows anyone to build custom IoT devices, with full control over personal data.

The entry-level kit comes complete with a set of 8 self-assemble projects ready to show users how to easily turn everyday devices into 'smart devices'.

The Oplà IoT Kit makes it possible to manage and control connected devices from multiple interfaces, such as the Oplà hardware device, custom web dashboards and the iOS/Android mobile app.

The 8 IoT projects offer different experiences for each user based on their individual level of expertise, from maker to professional. This includes 4 out-of-the-box projects that are ready to deploy around the house: remote controlled lights, a home weather station, a smart garden and a thermostat control. In addition, there are 4 projects for users to grasp core IoT concepts and how they can be integrated into real-life applications: home security alarm, solar system tracker, remote messaging and inventory management - all of which can be monitored and controlled via the Arduino IoT Cloud.

More projects will be released in the future as online tutorials, in addition to projects shared by the community of users on Arduino Project Hub.

The Oplà IoT Kit is intended for beginners, but it is also a valuable resource for experienced users. It is based on the Oplà unit, which is a carrier board with an OLED colour display, on-board sensors (temperature, humidity, pressure, IMU, light), capacitive touch buttons, buzzer, colour LEDs, 24V relays, SD card reader. The carrier includes a slot for a battery with an integrated battery charger, which makes the device portable and wireless.

The kit also contains an MKR WiFi 1010 board and a round plastic enclosure, and two more external sensors, such as motion sensor and moisture sensor. Thanks to the swappable MKR WiFi 1010 board, users will be able to choose another connectivity method by plugging another board from the MKR family in order to switch to GSM, LoRa, NarrowBand or more.

The Oplà IoT Kit acts as the physical interface of the Arduino IoT Cloud, which allows users to build dashboards and plot data in real-time, while browsing values along a timeline. This is all controllable from a mobile with the Arduino IoT Remote app.

Compatibility with Amazon Alexa enables seamless voice control to integrate custom connected devices into a real-life setting. The kit comes with a 12 months subscription to the Arduino Create MKR Plan, with premium access to the Arduino IoT Cloud.

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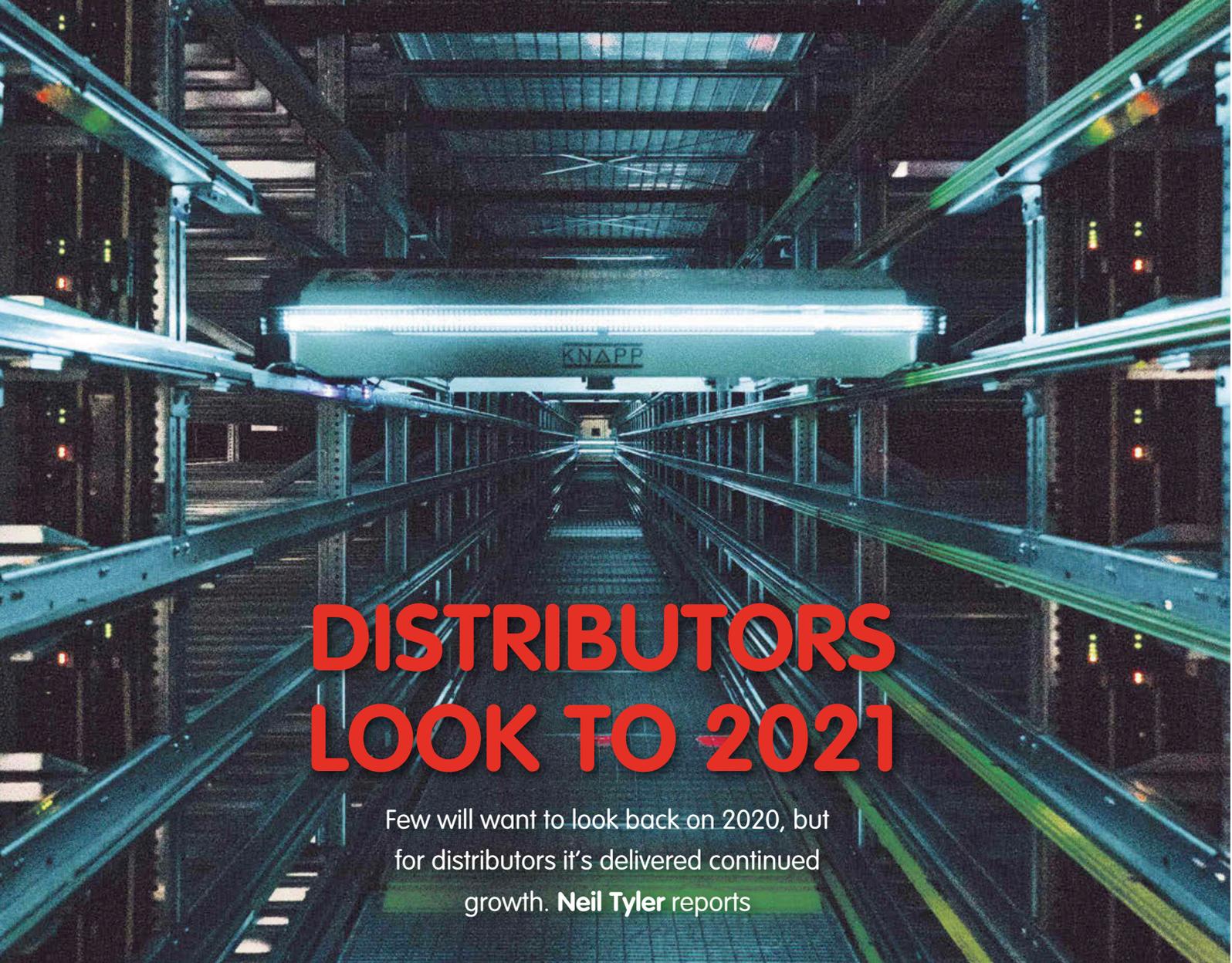
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# DISTRIBUTORS LOOK TO 2021

Few will want to look back on 2020, but for distributors it's delivered continued growth. Neil Tyler reports

The Covid-19 pandemic has had a massive impact on the global economy, and for many companies the focus has had to be on simply surviving through to 2021. For those that make it, there's no doubt that things will look markedly different.

Not only have businesses had to contend with a massive supply shock, which started in China in February, but a demand shock too that continues to reverberate across the Americas and Europe.

The crisis caused by the pandemic and the likelihood of a deep recession have exposed weaknesses in supply chains and many companies have had to revisit their supply networks, review their operations for vulnerabilities and take numerous actions to better manage risk and ensure greater robustness.

"Like most distributors with

operations in Asia we knew what the potential problems could be when the pandemic first appeared," explained Rob Rospedzhowski, President, Sales, Farnell EMEA, "but none of us expected the severity of the pandemic and the challenges it has poised for our supply chains, our customers and the sectors we serve."

"The pandemic has shown that global supply chains can be very fragile, especially if they involve single source products," added Chris Beeson, Group Senior Vice President Electronics, Electrocomponents.

According to research conducted by the Institute of Supply Management, 75% of companies suffered supply chain disruptions due to transport restrictions and half had no contingency plan for supply chain disruption leading back to China.

"Firms need to consider supply



**"The challenge now is to balance building resiliency into the supply chain, without compromising efficiency or adding excessive costs"**

Chris Beeson

options from multiple, geographically disparate sources, where possible," said Beeson. "It's no longer enough to focus on reducing procurement and production costs through techniques such as just-in-time and lean manufacturing. The challenge now is to balance building resiliency into the supply chain, without compromising efficiency or adding excessive costs."

Despite these challenges business activity has held up. The third quarter saw economies in Europe and the US register strong growth, while engineers have continued to innovate. As a consequence distributors, both here and in the US, have made the most of this difficult period and continued to provide customers with competitively priced, high quality products that are fit for purpose, meet specifications and that are delivered on time. Distributors have had to adapt

and have helped their customers more when it comes to sourcing components.

“Purchasing patterns have changed. We had a strong online presence online already across EMEA, but over the course of the pandemic some markets have moved from around 80 per cent of our business being online to over 90 per cent,” said Rospedzhowski. “Customers are now working from home so we’ve seen an increase in demand outside of normal operating hours. Demand has now moved across a much wider time frame.”

“Although still in the middle of the pandemic, customers are now looking to get back to some form of normality and it seems like they are increasing design and production,” added Mark Laing, UK & Ireland Regional Business Development Manager, Digi-Key Electronics. “Hopefully the positive trend will continue. Many customers are receiving unplanned orders right now. We know our customers rely on stable supply chains to stay in business, and Digi-Key’s business model is designed to deliver continuity and consistency.”

“Throughout 2020, customers have been burning through any inventory that they have built up and we are already starting to see demand building up. Some of the high volume users of components in the automotive and consumer electronics sectors are ramping up quickly now,” said Steve Rawlins, CEO, Anglia Components. “New consoles are coming up and demand for 5G is kicking in. We expect to see lead times lengthening in 2021 and it may even be a boom year.”

Rawlins added that Anglia was also seeing increased demand in terms of access control, smart buildings and other areas which contribute to public safety and well-being.

“We’ve found that the pandemic has accelerated technologies and concepts by as much as ten years. Customers are moving rapidly from

thinking ‘we could add this function to our product’ to ‘we must add it.’ Projects that have been sitting on the shelf waiting for funding or resource have been dusted down and implemented.”

### Investment

For a number of distributors significant investments were planned for 2020 and beyond, and most have continued to invest significant amounts, whether in new facilities or services.

“In a crisis like this, the crucial thing is to look past it. Those who maintain investment will bounce back quickly as the market recovers, which it will, probably sooner than we think,” observed Rawlins.

“Customers have embraced online ordering and we are seeing an increase in demand for value-added procurement services,” added Beeson. “Our digital infrastructure and data analysis tools have allowed us to adapt swiftly to new working restrictions, varying customer demand and changes in buying behaviour.”

According to Beeson, Electrocomponents has focused on delivering a more scalable and efficient business model. It has invested in a newly expanded and highly automated distribution centre in the Americas, which is now operational, and its distribution centre in Germany is on track to open in the summer of 2021.



**“We’ve found that the pandemic has accelerated technologies and concepts by as much as ten years.”**

Steve Rawlins

Below:  
Electrocomponents’ new facility in Bad Hersfeld is due to open in 2021



“Despite the uncertainty, we are continuing to invest as we meet these new challenges with innovative new solutions, while providing consistency and efficiency for customers,” said Laing. “Digi-Key’s brand new 2.2 million square foot Product Distribution Centre is opening in 2021 which will provide an even better service for our customers. We know what our customers want and we continue to invest where it is most important - the right parts, available in stock, delivered accurately and on time.”

Crucially, customers are still designing, building and innovating across most markets and continue to require support from distributors.

“Mouser has maintained high inventory levels, and we have continued to invest heavily in our facilities,” said Mark Burr-Lonnon, Senior VP of Global Service & EMEA and APAC Business, Mouser Electronics. “Furthermore, we have expanded our online resources for design engineers, including our Technical Resource Centre, the Customer Resource Centre, the Price and Availability Assistant, Online Calculators, and the Mouser-Molex custom cable creator. Online resources remain a key part of our efforts to serve our customers.”

Much like other distributors Mouser has continued to invest opening a new Customer Service Centre building, deploying state-of-the-art automation, in order to enhance efficiency, productivity, accuracy and speed of dispatch.

“Customers want to be able to schedule component orders in advance. It gives them predictability and visibility, securing their product orders ahead of time. Orders can now be scheduled in various ways, depending on quantities and whatever works best for them,” said Burr-Lonnon. “Effective communication remains critical to success. We are in constant contact with our customers to ensure that they experience consistency of supply. They see us



Left: Digi-Key's new Product Distribution Centre opens next year

as a facilitator, and they expect us to have an in-depth understanding of the market.”

### Operations

In response to Covid-19 distributors have not only had to engage differently with their customers but have also had to alter working practices too.

“We have been investing in initiatives to ensure the safety and wellbeing of employees in the workplace – our own, as well as our customers’,” said Beeson. He continued, “We very quickly implemented flexible working practices including new support structures for home working and resources to help our employees stay mentally and physically well. We have made changes to our operating procedures in our 12 distribution centres around the globe, including the provision of PPE, social distancing measures and split shifts.

“Another early initiative was an employee assistance programme and wellbeing hub to keep colleagues connected.”

According to Beeson four key themes have emerged as a result of the pandemic.

“There are the accelerating need for businesses to work digitally; the heightened importance of supply chain continuity; an increased focus on innovation and efficiency; and improved safety in the workplace,” he explained.

Anglia, which is a privately owned

business, has been in the fortunate position to be able to take the long term view, according to Rawlins.

“The market will recover, and we’ve kept our dedicated team together which I believe has put us in a strong position when it does,” Rawlins said. “We haven’t had to make anyone redundant. We did furlough staff, however, but most of them are now back at work.

“To protect those working from the office, we have invested heavily in PPE, including installing Perspex screens for safe distancing and further protection for the staff.”

For distributors, like many businesses trying to operate in these unique times, employees have faced many different challenges, whether in their personal lives, such as having children at home because schools are closed, or other interruptions to normal routines.

“We are certainly proud of the many ways Digi-Key employees have stepped up to support our customers. Many have put in overtime at our Product Distribution Centre, and some have even completely switched over to working at the PDC for several weeks, putting their regular responsibilities on hold,” said Laing.

“Unprecedented numbers of employees at all levels have shown up on weekends and are staying late, just to make sure every order gets out the door in time.

“While other companies may be experiencing long shipping delays, our

team is doing everything possible to ensure customers don’t experience any differences in their orders and deliveries from Digi-Key.”

### So what will 2021 bring?

Most distributors see continued business growth into 2021, in part due to the resilience shown by the electronics industry throughout 2020.

“There is now pent-up demand in Europe, and that is likely to result in growth of at least 8% over the coming 12 months. Anecdotally, there has been talk of a tremendous amount of innovation taking place in our industry, as engineers have made the most of quieter times during lockdown, so there could be a wave of new projects emerging as we begin the new year,” suggested Burr-Lonnon.

The question of risk is an interesting one, according to Beeson, as it is always embedded into the world of technology and business in general. “One lesson from 2020 is that you always need to be prepared and quick to respond to a changing business environment; this has certainly been tested this year. It’s extremely important to be aligned to all aspects of business, including component shortages, changes in government policies, trade policies, logistic resources, and pricing trends.”

The impact of the pandemic will be with us for some time and will continue across 2021 and with issues like Brexit, recession, trade disputes and continued in-fighting between the US and China to contend with distributors will face a host of challenging factors throughout the year.

How they will respond is summed up succinctly by Laing.

“Most of these factors are out of our control. All we can do at Digi-Key is to continue to focus on what we can control, that is listening to our customers, investing in products and services which will make their lives easier, and keeping our employees safe.”

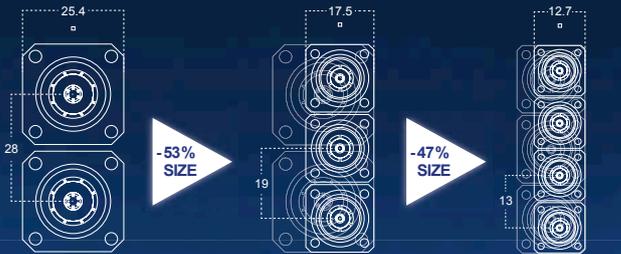


**“Although still in the middle of the pandemic, customers are now looking to get back to some form of normality and it seems like they are increasing design and production.”**  
Mark Laing



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# Data privacy concerns

Professor Antonio Capone of the Politecnico di Milano University talks to **Neil Tyler** about smart city data and the issue of privacy

**B**ased at the Politecnico di Milano University in Italy, Professor Antonio Capone is leading a team of experts in applied and basic research that is focused on the Internet of Things (IoT), and the university's IoT Laboratory is conducting research into how to design for the implementation of complex IoT systems.

In particular the professor's team is targeting different vertical application scenarios whether that's smart buildings, factories or smart cities. The IoT Laboratory's work is focused on all the elements that form part of the IoT technology stack whether that's sensors and actuators for remote monitoring and control, communication systems, edge computing, cloud platforms or advanced user interfaces.

"The Laboratory is a test-bed for the collection of information from the physical world and operates much like an open "platform" for the development of different vertical applications," explains Prof. Capone.

The IoT Laboratory provides support to applied research that's aimed at the design, development and testing of solutions related to the IoT, and its services are offered to Politecnico di Milano research groups as well as to external public and private parties, as part of collaboration agreements and research projects.

"At the moment we are currently working across a number of different domains but one area of particular interest is smart cities," explains Prof. Capone.

When it comes to collecting data it's necessary to use thousands of touchpoints that citizens will come into contact with every day. Each IoT device that gets integrated into a smart city will be used to collect

data which will then be used to inform usage and help optimise services for citizens.

"One significant area of research that we are involved in is related to smart devices and their use in the smart city to monitor pedestrian numbers and movement," explains the professor.

"We have created what we call 'smart gates', essentially an evolution of flow monitoring devices that are equipped with cameras and that use wireless technology – such as Wi-Fi and Bluetooth – to monitor pedestrian traffic."

By regularly and accurately analysing the data that's provided by these 'gates' it's possible to draw insights on how pedestrians navigate the city, identifying problems and issues that will, in turn, lead to better decision making.

"We have been using these devices to analyse the movement of people using public transport. These 'gates', together with an associated app, are able to provide us with data that is helping us to better understand and monitor traffic flows. We can use that data to identify patterns, estimate flow and by using the associated camera technology to better understand who is using the network – not just numbers but their gender and age," according to the professor.

Prof. Capone says that these types of devices will start to appear more frequently in the coming years and will become increasingly viable in cities as they use data-driven solutions to address everyday challenges, benefiting not just people, but the environment and the wider economy.

## Data privacy

While Prof. Capone is a keen advocate of smart cities and believes that one of their key benefits is that they will enable authorities to leverage data to create safer, more sustainable societies he is concerned that there needs to be a better balance between privacy and how the technology is deployed and the data is used.

“Look, in the EU we have GDPR to regulate our privacy. It was established to ensure that data was accessed and used with the consent of the user, but I don’t believe that the legislation is sufficient,” he argues.

“In Europe we are in possibly the best position to understand and strike a better balance between technology and privacy. There is one aspect that, in my opinion, needs to be reformed and that is around the whole concept of consent.”

At present the professor believes that the way in which consent is obtained from a user is inadequate.

“Consent is not in the full control of the user, due to the way in which it is implemented. Simply clicking your ‘acceptance’ is not sufficient. I think most people do so without truly understanding what they are doing. We need to force applications and systems to allow the average user to really be in control of their privacy settings.

“That can be achieved by using easy to understand and user friendly

interfaces, but also by providing a general repository of all consents made by the individual, so that they can be reviewed, updated and amended. That would hand control back to the individual,” he believes.

According to the professor there are a number of projects that are trying to create such a single point, in order to better manage privacy concerns.

Concerns over privacy have become more apparent in light of the on-going pandemic and the use of smart technologies to monitor how crowded services are getting or helping to manage occupancy levels while ensuring social distancing

“IoT and connectivity will play a crucial role in reassuring citizens that they are safe, but their privacy has to be taken into account.

“What is interesting is that with the advent of new technologies like edge computing and 5G it will be possible to process video, for example, in the camera or in a local data centre without the data having to be stored. This means that you can be more accurate about what you record and what you extract from a video.

“If you can control what gets taken and guarantee what and how that is then used I think we can overcome concerns regarding privacy,” according to Prof. Capone.

When it comes to technology trust and transparency are critical, and the only way to really ensure that is to have multiple controls over the data, according to the professor.

“One key lesson that we’ve learned is that no single service provider should have control over data, there needs to be an external authority that can control the data bases or ensure that the data is used only as permitted.

“It could be conducted through the specific extraction of data or you could use a certification method which would be responsible for how data is distributed. Responsibility needs to be distributed and in Europe, where the use and access to data is a highly sensitive issue, I think it’s possible to achieve.”

Whether a tighter form of orchestration will be possible when it comes to managing data is still being discussed, and it will have to be part of a much broader public sector response to smart city projects.



**“When it comes to privacy there is one aspect that needs to be reformed and that’s consent.”**



Politecnico di Milano University

# ANALOGUE AI FEELS THE POWER

Switching out of digital may cut machine learning's energy demands, as **Chris Edwards** discovers

**D**eep learning has an energy problem. Model sizes have been spiralling up, and doing so at an increasing rate as users exploit cloud servers armed with graphics processing units to crunch the numbers.

Geoffrey Burr, principal research staff member at IBM Research's lab in Aldmaden, claimed at the Linley Spring Processor Conference earlier this year that the energy consumed by the GPUs typically used to train a deep neural network (DNN) like ResNet-101, which at 44.5 million trainable parameters is today not particularly large, could provide a typical US home with energy for two weeks.

As model size continues to spiral upwards, the number of floating-point operations needed to train them doubles every three-and-a-half month. "That is an unsustainable curve unless you do significant hardware and software innovation."

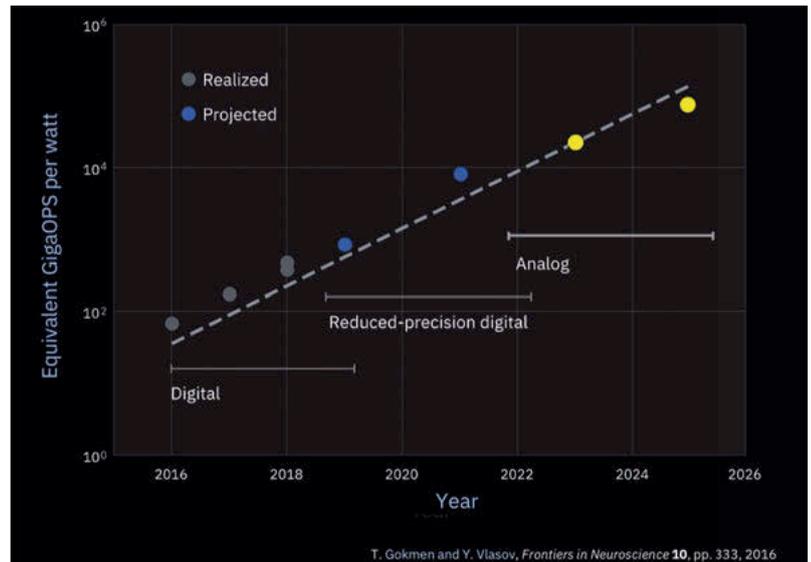
Though training needs the most energy while it's running inferencing, when the models are deployed, presents a major problem, not least because training only runs once in a while. Inferencing in embedded applications such as autonomous vehicles will have to run non-stop.

There is one clear target for energy reductions, though.

Elisa Vianello, embedded AI programme director at CEA-Leti, says memory accesses dominate the energy equation. "Moving data to and from the processor requires 90 per cent of the energy," she says, pointing to a need for novel architectures that can cut the cost.

During his firm's autumn processor conference at the end of last month, Linley Gwennap, principal analyst and president of the Linley Group, noted: "To reduce the power of moving data

Right: Analog processing could prove dramatically more energy and area efficient



T. Gokmen and Y. Vlasov, *Frontiers in Neuroscience* 10, pp. 333, 2016

across the chip, some vendors are implementing in-memory architectures to either move the compute close to the memory or move compute into the array itself and use memory cells to perform certain computations."

Some suppliers are achieving this proximity using architectures that either are FPGAs or resemble them in the way they distribute memory blocks through an array of hardwired and programmable logic blocks. Although there is still a process of back and forth with the data values as they move in and out of arithmetic logic units (ALUs), the load capacitance and resulting energy consumed along those paths is a fraction of that needed to send words over even an onchip bus.

IBM and a number of start-ups see the opportunity to go much further and push computation into the memory cells themselves, a move that is somewhat easier for inference today than for training.

## Accuracy and reliability

One common observation of deep-

learning pipelines when you move from training to inference is a massive reduction in the accuracy and even reliability needed for calculations.

Training relies on the ability to compute gradients for long chains of neuron weight that can be extremely small. This leads to the need to use floating-point arithmetic because of its ability to maintain precision over a large dynamic range, just as long as the coefficients in each calculation are reasonably close to each other.

Today, in the digital domain, 8bit integer arithmetic can handle many of the operations needed without degrading quality more than a few percentage points. Some work has indicated the compression can go further by trimming some weights down to 4bit, ternary or even binary. Energy can easily fall by an order of magnitude.

"We need a change in the compute paradigm," Burr says. Alongside work on approximation in digital IBM is looking at processing in the analogue rather than the digital domain. "We are working on it because it could

offer a hundred-fold improvement in energy efficiency.”

Whereas even at 8bit resolution a fast multiplier needs hundreds of gates, matrix multiplication in the analogue domain can be handled using little more than a group of resistors and bitlines.

“You can use what we call resistive processing unit: encode the neuron weights into the conductances you find on the crossbar array,” Burr explains.

Non-volatile memory technologies readily provide the variable resistances needed for analogue arithmetic. IBM is working on phase-change memories on experimental devices today and may switch to resistive RAM in the future. Flash is a more mature option. A start-up that is sampling to a small group of advanced customers and which expects to go into production later on in 2021 is Mythic AI, using a 40nm embedded flash memory that started at Fujitsu and which is now owned and supplied by UMC.

With each individual cell operating as a multiplier, millions of parallel operations become feasible. Instead streaming weight coefficients in and out of ALUs together with the sensor data, those weights can sit inside the multi-megabyte non-volatile memory array permanently. Those weights only change when the model needs to be updated, which helps overcome long-standing issues with the write endurance of most non-volatile memory technologies.

**Problems need addressing**

Though analogue processing could prove dramatically more energy and area efficient as a result the path to making it happen is far from free of problems.

“A lot of the non-volatile memories that are being proposed for deep learning are plagued with a lot of variability and stochasticity,” says IBM Research scientist Robert Bruce, though it is possible to trade density for greater fault tolerance he adds.

The need to deploy large numbers

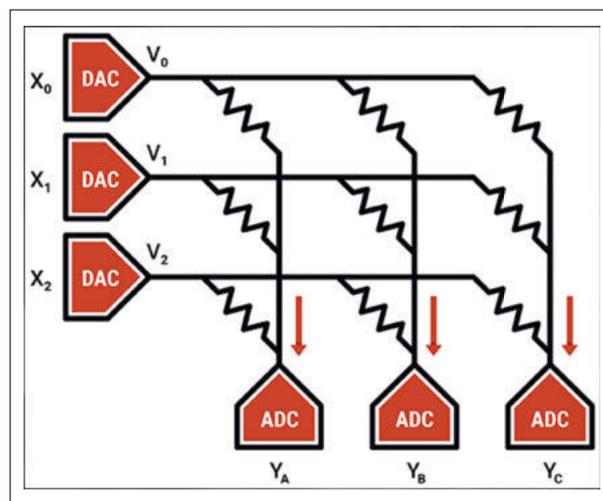
of digital-to-analogue and analogue-to-digital converters that need to operate with greater levels of accuracy and resolution than conventional memory sense amplifiers come with their own yield and variability issues.

Tim Vehling, senior director of product development at Mythic, says their core array macro calls for 27,000 working data converters. “A lot of our IP is how we test. We use redundancy all over the place and we have pretty advanced calibration techniques that we do at build time and also use at runtime.”

Although error correction and redundancy can overcome many of the issues, there is a level of uncertainty in the analogue computations that is not encountered in digital implementations that reduces model accuracy. But this is not necessarily a permanent loss. “When we port a network from a digital model we do have to do some redesign. We do retrain the model to accommodate the analogue effects,” Vehling says.

The retraining for analogue AI devices will typically take place on digital servers because of their lower resolution. Though Bruce says inference is the near-term goal for IBM’s technology, the aim at the computer giant is to have analogue take on more of the heavy lifting in training so that it can put the chips into server blades and

Below: Mythic uses an array of Flash memory transistors to make dense multiply-accumulate engines



reverse the staggering growth in energy consumption. That will also remove the need to adjust training for analogue inference though it will take some breakthroughs in training techniques to make work.

Using a heavily customised combination of SRAM and converters, Ambient Scientific expects to be able to push training into edge devices. Though the company is secretive as to how it works until a clutch of key patents are approved, Ambient CEO GP Singh claims their architecture will support resolutions all the way from 4bit to 32bit. The throughput of the array is expected to be 4.3TOPS/W at 8bit resolution, which is close to Mythic’s claim for their flash-based array. That throughput/power ratio drops four-fold for each doubling in resolution as the converters need to take more time and handle more charge on each calculation.

A key question is whether the overall energy savings made possible by the shift to analogue will be enough to carve out an advantage over highly tuned digital-only implementations. Arm claims its Ethos-N77 used with distributed SRAMs can achieve 5TOPS/W, as long as it is implemented on leading-edge CMOS that will generally incur a higher wafer cost than the older processes used in the analogue-oriented designs and tend to be used on large models that run in an embedded-Linux computer. The characteristics of analogue may push it closer to the edge.

One area where analogue is likely to have an advantage is in always-on sensing where a more limited AI model that runs at leakage-power levels watches for events before triggering a more capable and power-hungry back-end.

“There are naysayers who say it doesn’t work: that there’s no way analogue could have the accuracy,” Vehling argues. “We are showing it does work. It’s an exciting time: we are starting to see a different way to do compute.”

It doesn't take a crystal ball to know where the future of wireless is heading. With inexhaustible demand driven by 5G, 6G and beyond, ultra-high definition video, autonomous driving cars, security applications and IoT, the sky's the limit for utilising the higher ends of the electromagnetic (EM) spectrum.

Meeting this demand requires products capable of capitalising on the mmWave bands which presently cover the frequencies between 30 GHz to 500 GHz. These higher frequencies, however, present a significant problem that design engineers must address - standing waves. Without control, these unwanted waves can attenuate power output, distort the digital information on the carrier and, in extreme cases, damage internal components.

To counteract the problem of standing waves at lower microwave frequencies, engineers rely on Faraday rotation isolators – more commonly known as isolators - a two-port, input and output, component that allows EM signals to pass in one direction but absorbs them in the opposite direction. Unfortunately, traditional isolators fall short at the higher frequencies required for next-gen wireless applications.

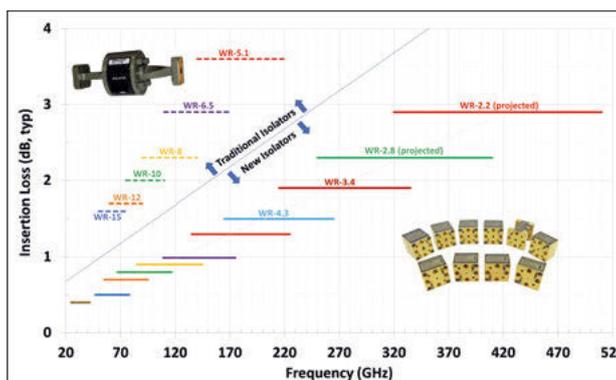
A big part of the problem is that the first isolators were designed more than a half century ago, but with recent advancements, companies at the cutting edge of mmWave technologies are gaining the ability to launch products that operate optimally at stratospheric frequencies.

"The new series of waveguide isolators have been a key enabling technology for VDI, and a large advance from what was previously available," explained Jeffrey Hesler, PhD, CTO of Virginia Diodes.

VDI is a manufacturer of state-of-the-art test and measurement equipment - such as vector network analyzer, spectrum analyzer and signal generator extension modules

# ADVANCES IN MMWAVE ISOLATOR DESIGN

Improvements in the critical characteristics of isolators are benefitting electronics manufacturers looking at next-generation wireless, as **Dr. Dave Rizzo** explains



for mmWave and THz applications.

"The compact size, extremely low insertion loss, and the wide bandwidth have allowed us to use isolators in a wider variety of our systems than was previously possible, and have led to significant improvements in key system performance metrics such as source power and sensitivity," said Hesler.

By understanding these advancements in each of the five properties of isolator functionality, designers can better harness isolators to improve their mmWave products.

## High isolation

Isolation is a measure of how much of the signal traveling in the reverse direction passes back through the isolator and because isolators are intended to prevent this from happening, the higher the isolation, the better.

"The issue that mmWave system designers face is impedance mismatches and the resulting reflections between components,"

Above: A comparison of insertion losses

stated David Porterfield, Founder and CEO of Micro Harmonics Corporation (MHC), a specialist in design solutions for mmWave component products. Under a two-phased NASA contract awarded in 2015, the company successfully developed an advanced line of isolators for WR-15 through WR-3.4 (50 GHz to 330 GHz) applications.

"In mmWave systems, the distance between components is often more than a wavelength, putting reflected signals out of phase," continued Porterfield. "The out-of-phase reflected signal can perturb the operating point of the upstream component. As you sweep frequencies, the phase changes and you get nulls, dips and degraded performance. However, when you insert an isolator between components, the reflected signal gets absorbed and the problem goes away."

The highest possible isolation occurs when the reverse wave is rotated exactly 45° into the plane of the isolator's resistive layer. Isolation can degrade by as much as 10 dB when the signal rotation is off by just 1°.

"The only way to confirm such precision is to fully characterise each isolator on a vector network analyzer," said Porterfield. "This validates total compliance, as opposed to just spot-checking at a couple of frequencies in the band."

## Low insertion loss

While isolation is the namesake of

these components, the suppression of the reverse wave can't come at the expense of attenuating the forward, input signal. Insertion loss is a measure of how much loss a signal incurs as it passes through the isolator in the forward direction.

For traditional style isolators, insertion loss is low in the microwave bands, but at mmWave frequencies the loss becomes increasingly problematic. For instance, in the WR-10 band (75-110 GHz) the insertion loss can exceed 3 dB, meaning half of the signal power is lost. In the WR-5.1 band (140 -220 GHz) the loss climbs to more than 5 dB. Because of high losses, traditional isolators are often precluded for use in mmWave systems.

"A designer's main fear is that the isolator will significantly degrade the strength of the final output," explained Porterfield. "It can be frustrating for engineers to try and tune the standing waves out of each system, usually with limited success. Many of the alternate methods used are narrow band in nature, so that the solution may work well only over an insufficiently narrow band of frequencies."

Faraday rotation isolators operate by using ferrite discs to rotate the signal. However, the traditional method to manufacture them has been to use ferrites that are substantially longer than the minimum required length, and then tune the magnetic bias field to achieve optimal performance. This delivers good isolation, but at a much higher insertion loss.

Porterfield pointed out a two-fold problem with this workaround. First, there is more of the lossy ferrite in the signal path, and second, the ferrite loss parameter increases at lower magnetisation levels.

To minimise loss, it is essential that the ferrite length be reduced as much as possible. The design developed for NASA saturates the ferrite with a strong magnetic bias

field, which allows for the shortest possible length of ferrite to achieve the ideal 45° of rotation. This lowers the insertion loss to less than 1 dB at 75-110 GHz and only 2 dB at 220-330 GHz.

"The extension of isolator technology above 220 GHz is an impressive technical feat, and a key technology that enables us to deliver accurate measurements with higher sensitivity than we were previously able to achieve," noted VDI's Hesler.

### Low port reflection

A good isolator must also have low port reflections. Voltage Standing Wave Ratio (VSWR) is a measure of the reflections at the input and output ports. A good range at mmWave frequencies is 1.5:1 or less; 1:1 equals no reflection.

The importance of low port reflections is often overlooked. An isolator with high port reflections creates an alternate set of standing waves. The adjacent components are still adversely impacted by out-of-phase signals reflected back into their ports. High isolation and low insertion loss are of little value if the port reflections are large.

### High power rating

Power in the reverse traveling signal is absorbed in the isolator, resulting in heat. The more heat it can handle, the higher the power rating. Historically, high heat was not an issue as there was very little power available at mmWave frequencies. However, as high power sources become

**"A designer's main fear is that the isolator will significantly degrade the strength of the final output."**

David Porterfield

available, the importance of power ratings increases.

To handle the problem of high heat loads, some newer isolators are already incorporating diamond heat sinks into their design. Diamond is the ultimate thermal conductor, approaching 2200 W/m·K (watts per meter-Kelvin), more than five times higher than copper. Diamond effectively channels heat from the resistive layer in the isolator to the metal waveguide block, and thus lowers operating temperatures for improved reliability.

### Small footprint

Minimising the size and weight of mmWave components is especially important in modern wireless applications.

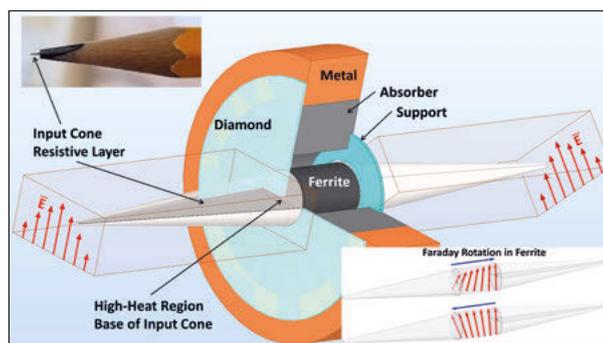
"A standard traditional-style isolator in the WR10 band is about 3 inches long, with a cylindrical section in the centre that's about 1.3 inches in diameter," observed Porterfield. "But the newest design shapes are rectangular and can be as small as 0.75 inches per side and 0.45 inches thick."

The same technology used to reduce insertion loss, utilising the shortest possible length of ferrite, also partially accounts for the reduction in footprint.

In addition to the five critical characteristics, other properties of modern isolators improve their utility at mmWave frequencies; for instance, wide bandwidth. Standard waveguide bands typically extend to 40% on either side of the centre frequency. Newer, high-performing isolators operate over extended bandwidths exceeding 50% from centre frequency, giving designers greater freedom to build more bandwidth into their systems.

Additional advances include isolators that operate in cryogenic conditions, which is critical because a traditional isolator designed for room-temperature operation will perform poorly when cooled.

Below: An example of a MHC isolator core





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## Debugging P2P resistance using path segmentation in IC reliability verification

By Slava Zhuchenya

In integrated circuit (IC) reliability verification, point-to-point (P2P) resistance simulations identify when net parasitic resistance may affect circuit reliability and performance. Debugging

using individual resistor body data can, to a certain extent, point designers to the location where there might be a high resistance point [1]. Designers can also use path segmentation to better identify and reduce total effective P2P resistance.

P2P simulations report nets containing out-of-range effective P2P resistance values between device pins and ports (pin-pairs). However, designers must be able to identify which segment of a reported pin-pair path is contributing to the high resistance value, especially if the reported P2P effective resistance is a much higher value than expected, which may indicate a routing mistake or false violation.

While individual resistor body resistance values provide some value, designers must factor in the relationship of those resistances to other polygons in the complete interconnect circuit. If there are multiple parallel paths, a high resistance value for one polygon does not necessarily mean that resistor body

contributes greatly to the total effective path resistance. There may be smaller parallel resistances that together cancel out the effect of that higher resistance polygon.

Coordinate-based P2P simulation lets designers place source and sink points along the net interconnect at selected locations. These points enable measurements not easily calculated using individual resistor body data. Placing sources and sinks along the interconnect path polygons when setting up P2P simulations allows designers to segment portions of the routing that contain parallel paths to get effective series total resistances.

In particular, shorting multiple sources and sinks enables accurate segmentation of parallel paths that factor in how the paths combine. This principal allows designers to segment their interconnect tracing along parallel paths to get accurate path segmentation of more complicated interconnect traces, where the path must be split at a portion of the tracing that has parallel branches. This path segmentation process can be repeated, increasing the granularity by further breaking down path segments as needed, until designers understand how to fix the routing to decrease the total effective resistance.

When a P2P simulation result is significantly higher than what is typically expected, segmenting the net to isolate and identify a high resistance point can be an effective way to begin navigation to the problem areas causing P2P violations in an IC layout.

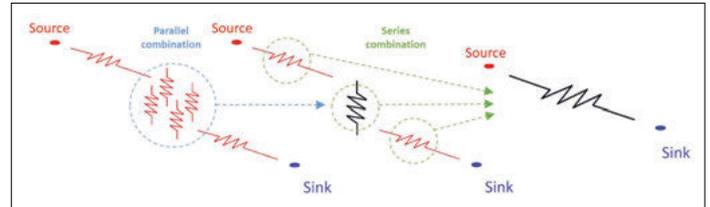


Figure 1. Parasitic resistor body network (red) combined into effective resistance (black).

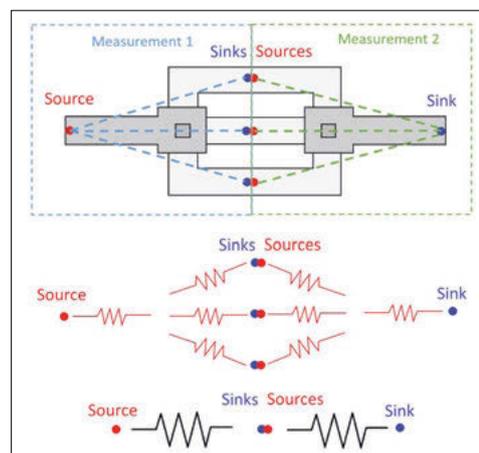


Figure 2: Segmentation of a parallel path.

For more information, download a copy of our technical paper, [Debugging P2P results through resistance segmentation](#).

# VR can be good for your health

Imagine being told by a neurosurgeon that the area of interest in your brain is “around about here” as he or she points to a model of a skull. You may trust the surgeon but if he or she could show you the entry route, and indeed the cause of the problem, it may reassure you more.

If he or she could explain why the operation will begin at this part of the skull and why the incision will be at a particular angle, you might feel more at ease. Using a virtual reality (VR) headset allows this exchange and has been found to reassure patients, and mean they enter the operating theatre more relaxed.

Using 3D medical imaging, patients can ‘tour’ a virtual model of their own brain to understand the area at the centre of the procedure. The surgeon can point out some of the obstacles that the surgical team has to be aware of. A VR ‘run through’ before the operation has been found to help patients, particularly younger ones who may not understand the medical terms but are at ease with VR through gaming.

## Take a seat

In other areas of surgery, VR is being used by surgeons to plan procedures. Stanford Medical Center, the school of medicine at Stanford University, opened its Neurological Simulation Lab in 2017, using a VR system by Surgical Theater. The software creates a 3D model of the brain, compiled using MRIs (magnetic resonance images), CT (computed tomography) scans and angiograms (where dye is injected to show the paths of blood vessels).

Students sit in comfortable, cinema-style reclining chairs, facing three large screens. Wearing VR headsets, an avatar leads them through the areas of the brain,



Virtual reality can be used inside and outside of the operating theatre, in the classroom and in consultations to reassure patients ahead of surgery. By **Alex Brinkley**

pointing out any deformities in the bone which might make entry difficult or any changes in tissue which might indicate a tumour.

The 3D model shows the precise location of a tumour or aneurysm. The 360° view means the surgeon can plan the most effective route for the surgery and improves accuracy in surgery. For example, it can make the surgeon aware of an artery close to a tumour, which cannot be seen from an x-ray. VR ensures there are no unplanned surprises during the procedure.

“We can plan out how we can approach a tumour and avoid critical areas like the motor cortex or the sensory areas,” said Gary Steinberg, MD, PhD, a neurosurgeon and Chair of Neurosurgery at Stanford University.

During the operation, surgeons can refer to a 3D rendering which provides more detail than

Above: The Neurological Simulation Lab uses VR to explore patients’ brains in detail. Photo: Stanford Medicine/ Paul Sakuma

is possible with video feeds, said Steinberg.

## Educational tools

Continuing research means that even experienced surgeons have to learn new procedures. For each ‘new’ technique, it is estimated that at least 25 operations need to be completed for the surgeon to perform at a basic level of safety - and 75 to 80 for optimal proficiency. To overcome the problem of finding this number of ‘practice patients’, many companies offer immersive technology for surgeon training.

One is Osso VR, a VR surgical training platform, based in California. Co-founder Justin Barrad trained as an orthopaedic surgeon but originally wanted to be a gamer. The immersive training tool is used by medical students, experienced surgeons learning a new technique, as well as sales reps, demonstrating medical

devices. Proprietary simulation software allows users to 'run through' a procedure.

Studies show that using VR improved surgical performance in terms of knowledge of instruments, the flow of operation, forward planning and knowledge of a specific procedure.

London-based Fundamental Surgery, offers a multi-user platform to allow students to collaborate in a virtual operating theatre. Users can access FundamentalVR remotely from around the world, allowing specialist consultants to host lectures and train multiple students.

It has recently introduced HomeVR, with educational simulations accredited by medical bodies and using standalone VR headsets, such as Oculus Quest and HTC Vive Focus Plus. Both simulation platforms use HapticVR, to bring the sense of touch to the immersive operating experience. The software is hardware-agnostic and can mimic the physical cues, the medical tools and tissue variation that would be experienced in the operating theatre, with haptic technologies providing tactile vibration and force feedback. Data tracking provides analysis from hundreds of data points. It measures and records surgical gaze, respect for tissue and efficiency of movement, displayed



as real-time feedback on a single dashboard.

In the operating theatre, internal views of a patient via video feeds provide valuable insight throughout a procedure. A common complaint, however, is that the surgeon has to turn his or her head to look at a separate screen which is often placed at a 90° angle to the operating table.

To avoid neck craning, a company in Seattle, Proprio Vision, says its light field imaging system simplifies complex information to create interactive 3D visualisations for surgeons to use in real time.

The system uses a light field camera array to capture all the light radiating through the space between the surgeon and the patient on the operating table and Nvidia Quadro RTX 6000 GPUs for imaging

Above: Osso VR is used to practise procedures and train with new instruments

**"We can plan out how we can approach a tumour and avoid critical areas like the motor cortex or the sensory areas."**  
Gary Steinberg

processing. The company found that using GPUs accelerates the 3D point cloud triangulation for images between six to 10 times faster than using a CPU. This speeds up the surface reconstruction to develop low latency 3D light field rendering.

The system captures the live view and fuses it with a pre-operative image, using multi-modal image rendering and registration, image processing and correction, 3D geometry reconstruction and CT segmentation. Using a VR headset, the surgeon can examine at microscopic levels and navigate freely, says the company. The high-definition volumetric representation of the surgical field can be magnified and re-focused and frees the surgeon from surgical microscopes or loupes.

Advances in image processing, namely high bandwidth processing with reduced latencies brings VR opportunities for remote guidance, as someone wearing a headset can experience a medical procedure remotely to receive tuition and guidance. It can introduce remote training for routine operations and encourage collaboration as specialists can examine the same medical scenario to contribute their specialist knowledge without having to take extended periods away from their main duties.

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WF40ESWAA6MNNO module has integrated driver IC ST7701S on module, the interface supply voltage range from 2.5V to 3.6V, typical value 2.8V. WF40E module can be operating at temperatures from -30 to +80 ; its storage temperatures range from -30 to +80 .

These panels are ideal for home and building automation having the same form factor as a light switch.

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# Time sensitive networking

Real-time processing that leverages time-sensitive networking in tactile Internet environments is a new and important application area, as **Markus Gruber** explains

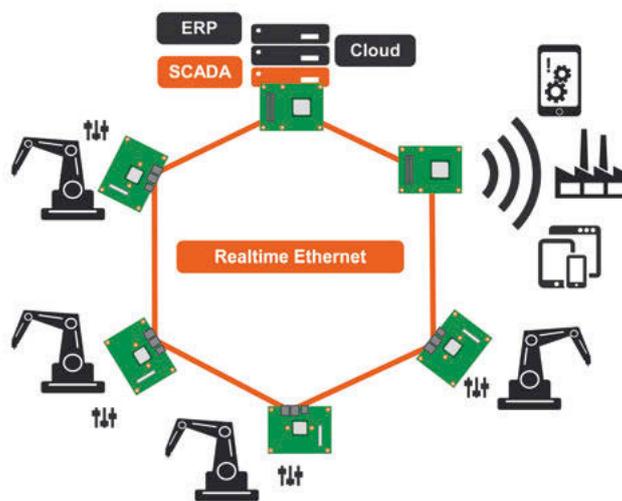
Today, unlike in the past, connected industrial devices are expected to communicate directly with enterprise applications. In order to gain detailed and differentiated insight into their own production operations, some companies are even running these applications directly on industrial end devices.

Whether the purpose is real-time analysis or full-blown AI algorithms, the integrity of these applications is quickly compromised if their components are not optimally matched.

It is important to guarantee that devices and systems can continue to perform their core functions in real-time. Modern industrial engineers therefore need a concept that allows the integration of IT and OT technologies in a single device. Such a solution platform should ideally take advantage of standard IT networking and data processing while being deterministic, secure and reliable.

An important component for the realisation of such real-time data communication networks in the industrial Internet of Things (IIoT) is time-sensitive networking (TSN). TSN technology comprises a number of standards, such as IEEE 802.1Q for virtual LANs via Ethernet, time aware shaping (TAS) as standardised in IEEE 802.1Qbv for guaranteed minimum transmission latency, or real-time synchronisation via the precision time protocol (PTP) defined in IEEE 1588.

PTP is responsible for time synchronisation between nodes. A master sets the time and the



individual slaves synchronise their clocks with two-digit nanosecond accuracy. Based on these synchronised clocks, packets can be time stamped and sent. This means PTP networks can synchronise themselves with two-digit nanosecond accuracy, whereby the travel time of the IP packets naturally also impacts the ultimate real-time behaviour of the application.

In the case of the I219 Intel Ethernet interface, the clock synchronisation is based 100% on this standard component, giving it the dual advantage of being cast in hardware and not requiring any additional proprietary applications or dedicated hardware.

## Workload consolidation

At the same time, industrial devices are required to integrate enterprise functions, such as real-time edge analytics. Industrial systems, traditionally based on clearly defined functional units, are now grouped

together on a multi-core processor under the heading 'workload balancing at the edge'. This increases the importance of using hypervisor technologies in industrial real-time systems.

Virtualization technology allows some processor cores to perform data analysis, while others can be reserved for data acquisition or control tasks. As a result, real-time tasks such as robot control or vision-based AI, which is also ideal for collaborative robotics, can run on completely separate virtual machines (VMs) within a server platform alongside less time-critical applications such as remote administration or cloud connectivity.

A proof of concept (PoC) of such a TSN-capable RTOS system with industrial real-time control was first presented by congatec, Intel and Real-Time Systems during a live demo at Embedded World a year ago. The industrial application server platform of this PoC is based on the principles of workload consolidation and TSN via Ethernet.

## Real-time application server in practice

At the heart of the demo platform is a COM Express Type 6 module (conga-TS370). Equipped with an Intel Xeon E2 processor, it can provide up to six CPU cores for multitasking. Thanks to the RTS Hypervisor from Real-Time Systems, the processor is divided into multiple machines, each with its own operating system, whereby each VM is assigned one or more CPU core(s) and the required IOs.

Figure 1: Time-sensitive networking allows the realisation of real-time control via Ethernet as well as the implementation of tactile Internet sessions

**Author details:**  
Markus Gruber  
is R&D Manager  
and TSN Expert at  
congatec

The PoC platform uses three VMs in parallel and in real time to control real machines and devices. The first VM employs four CPU cores and uses the Linux operating system to control a Basler vision camera and an Arria 10 FPGA board connected via PCIe. The FPGA board executes AI algorithms for vision-based object detection created with the Intel OpenVINO toolkit. As a result, camera images are captured and verified at extremely high frame rates.

A second independent VM runs real-time Linux and controls a servo motor that holds an inverted pendulum in an upright position. When the balance of the pendulum is disturbed, for instance by touching it, the system reacts in real time and steers the pendulum back to its starting position – completely independently of the other operating systems running or being booted in parallel.

The third VM runs an operating system to perform security tasks and, as the edge OS, provides the uplink to the cloud. To demonstrate the independence of these applications and their real-time behaviour on a single server platform with multiple machines, the individual operating systems can be rebooted for testing purposes without this process impacting the other systems. Even the critical real-time behaviour of the pendulum control remains unaffected.

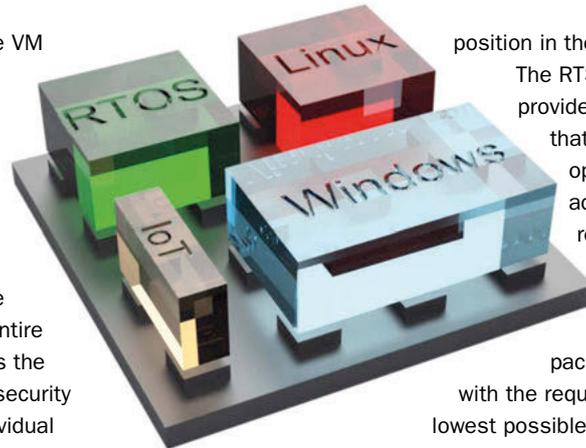
Although all these applications run in parallel on the same hardware platform, the hypervisor can easily

restart a non-real-time VM while the real-time VMs continue to run uninterrupted. This makes it possible to deploy software updates to individual applications without having to interrupt the control tasks of the entire system. It even allows the effective isolation of security vulnerabilities on individual enterprise VMs because they do not affect the entire embedded system.

**Real-time control**

Another important feature of the conga-TS370 board is the Intel i219-LM GbE LAN controller as it natively supports IEEE 1588 PTP time synchronisation. In the PoC platform for industrial application servers, the i219-LM determines the source and destination of PTP packets while using the integrated timer to coordinate them. The controller also works together with the operating system to line up packets for TSN transmission within a defined timeframe.

Since the release of Linux Kernel 4.20, additional support for the time aware priority shaper (TAPRIO) and earliest transmit time first (ETF) according to IEEE 802.1Qbv has also been available. These modules allow developers to configure systems in such a way that Ethernet TSN packets can be prioritised regardless of their



position in the transmission queue. The RTS Hypervisor, in turn, provides a privileged mode that allows a guest operating system to access system network resources within a few microseconds. This makes it possible to process TSN packets in guest VMs with the required priority and lowest possible latency.

Figure 2: The RTS Hypervisor enables multiple real-time and general purpose operating systems to run across virtual machines on a multi-core X86 processor

Consequently, the use of these powerful, flexible hypervisor-based IloT systems can reduce business costs, minimise potential sources of error and extend product lifecycles without enterprise class software upgrades disrupting the hard real-time system.

**TSN as future industry standard**

Today, real-time communication is still based on a variety of mostly proprietary deterministic transmission and traditional fieldbus protocols that often require expensive components and drivers to match. In addition, the ability to plan and implement industrial real-time platforms is limited by the fact that the choice of manufacturers and matching product portfolios for these highly specialised transmission systems is restricted.

TSN Ethernet provides a way to use the same Ethernet cable for regular network traffic and prioritised TSN traffic as long as the network components support the required standards such as IEEE 1588 PTP or IEEE 802.1Qbv TAS.

Consistently implementing these IEEE TSN standards in standard industrial network components will have an impact on the prevalence of licensed, proprietary real-time transmission protocols. At the very least, these hitherto closed systems will have to open up more and more. And to do so, they will need TSN and hypervisor technology to be able to continue leveraging existing resources.

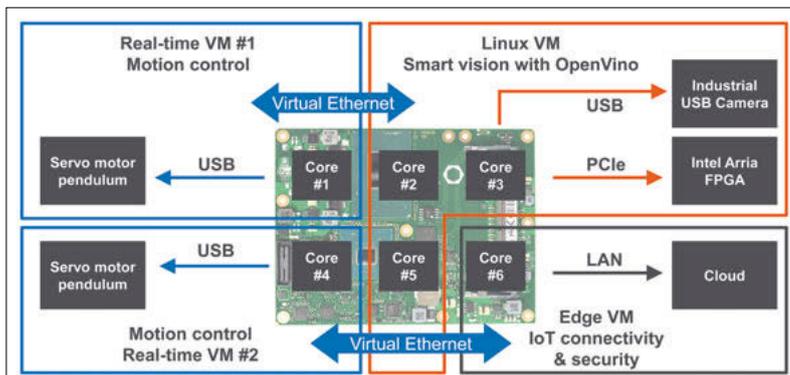


Figure 3: congatec has virtualized multiple operating systems on a 6-Core Xeon CPU in cooperation with Intel and Real-Time Systems. The operating system has physical access to the Ethernet controller



# THE IVI REVOLUTION HAS BEGUN

Next generation IVI looks to support new in-car experiences, providing manufacturers with a crucial differentiator in a competitive market. By **Neil Tyler**

**W**hen it comes to buying a car consumers are increasingly less likely to simply focus on the look or driving characteristics of the vehicle, instead a growing number are taking into account issues concerning connectivity and the ability of the vehicle to provide seamless integration of mobile devices.

They also have an interest in simpler and more convenient operations through touch concepts, or using voice or gesture control, as well as with various customisation options concerning light, audio and seat settings.

Changes to vehicle interiors are continuing apace as the industry moves towards autonomous driving and this trend is seeing merging IVI (in-vehicle infotainment) and ADAS (advanced driver assistance systems) being developed that will not only improve the driving experience but ensure increased safety.

This trend is only set to intensify when the introduction of level 3 and 4 autonomous vehicles turn the actual process of driving a car

into a secondary task and this, in turn, will open up a whole new range of possibilities for passenger entertainment.

“The future of automotive transport will be defined by two domains; the driving function and the in-car, passenger experience. As the driving function becomes increasingly autonomous, the passenger experience becomes more important, which is where the in-vehicle infotainment (IVI) revolution begins,” said Enrico Salvatori, Senior Vice President & President, Qualcomm Europe.

“Vehicles will eventually evolve to serve drivers and passengers alike as all-in-one information, communication, travel and entertainment hubs.”

Over the past 20 years IVI has evolved from analogue to digital systems, to touch screens and connectivity, and now to smart, configurable high-definition displays, according to Salvatori and with the advent of 5G and the possibilities of private, low latency high bandwidth network slicing, “an entirely

new generation of infotainment functionality, quality, experience and diversity is set to be unlocked.”

“The potential for IVI is enormous,” said Salvatori, “think configurable clusters, heads-up displays with overlays to identify objects, hazards, and places of interest. And from a passenger perspective, this new connectivity affords enhanced entertainment and a more immersive experience.”

## **In-vehicle safety**

Simple and convenient operation through touch concepts with voice and gesture control are expected to open up a new range of possibilities for passenger entertainment and the drivers of the future can expect to operate in a purely digital cockpit.

However, the safety of the driver when handling these systems is a concern and gesture and proximity sensing are seen as replacing knobs and touch screens for infotainment as well as when it comes to operating the vehicle itself.

Today most gesture-sensing

systems are based on time-of-flight (ToF) cameras which can be both costly and complex.

To address this Maxim Integrated has developed a data acquisition system that designers can use to add dynamic hand-gesture controls to vehicles. Featuring integrated optics and a 6x10 infrared (IR) sensor array, the MAX25205 can detect swipe and hand-rotation gestures but without the need for ToF cameras.

According to Maxim this gesture solution is able to complement voice commands, especially when the driver finds themselves in a scenario where voice command is not as effective, and will allow many more models to deploy gesture capabilities.

“Although ToF-based systems enable gesture-sensing in a host of luxury models, automakers want to be able to use this feature in higher volume product tiers as well,” said Sachin Garg, associate vice president at MarketsandMarkets. “What designers have needed is a much lower cost alternative to today’s systems in order to make the economics of gesture-sensing controls more feasible.”

Commenting Szu-Kang Hsien, executive business manager Automotive Business Unit, Maxim Integrated, said, “By offering a dynamic gesture control for automotive applications at low cost, automakers can now avoid the prohibitive costs of time-of-flight camera solutions and offer gesture sensing in more car models.”

**The connected age**

In a world where self-driving cars are ubiquitous, autonomous vehicles could lead to safer and more intelligent transportation, and, as carriers continue to invest in 5G networks, research into autonomous driving is accelerating.

“Automakers are focused on drivers and also passengers,” explained Salvatori, “and in the same way that mobile phone use has risen,

so too has the desire on the part of motorists to use their vehicles in the same way they use their smartphones – whether it’s checking directions, making an online booking or accessing media.

“Soon, consumers will come to expect an in-vehicle experience that acts as an extension of their digital home or office environment, in which, instead of focusing on driving, they can use their time as they please.” According to Salvatori over time consumers will see a combination of media content, vehicle specific and consumer-centric information merging as automakers look to deliver a seamless, passenger-first experience in the car, keeping a careful eye on safety and mitigating driver distraction.

“Vehicles are rapidly evolving from rolling networks of proprietary systems to becoming connected mobile platforms. Automakers are looking to adapt to a platform-based strategy where systems will scale within the vehicle and across vehicle models,” he contended.

**Unlocking IVI’s potential**

The potential for new, video-based services is a huge, untapped opportunity for the automotive industry. Consider the demand for vehicles designed for ridesharing that need to differentiate services for the rear seat passenger.

“The growing prevalence of high-performance computing platforms in cars and the increasing sizes and



**“The future of automotive transport will be defined by two domains; the driving function and the in-car, passenger experience”**  
Enrico Salvatori

numbers of displays in vehicles are driving demand for more real-time and photorealistic 3D experiences, for both improved usability and to enhance the customer experience. To make these experiences a reality, 3D designers and HMI development teams need to create integrated tool-chains that facilitate the experience from the design process, all the way through to implementation,” said Salvatori.

Catering to the connected customer is not a goal that can be achieved in isolation. Automakers are having to work with telecommunication service providers to build data plans that cater for different levels of content access.

New content and data models in which certain services are already included in the cost of the car could be popular in some markets, for example.

“Looking forward, to a world where autonomous vehicles are the new normal, in-car entertainment will play a key role in how automakers are perceived. In the same way automakers have come to collaborate with tech companies, open collaboration with content providers and media companies will provide a huge opportunity to the automakers,” said Salvatori.

“Eventually we will extend in-vehicle entertainment beyond cars to create a digital ecosystem, where consumers can seamlessly connect to music, or a video series, and continue watching from where they left off outside of the vehicle. This interconnected digital ecosystem will enable automakers to provide a personalised experience for consumers.”

As the industry approaches full autonomy, automakers are focused on their in-car entertainment design strategies, to provide an immersive experience for users.

For content providers, media companies and automakers, providing a seamless experience across different vehicle segments, modes of transport and several smart devices are expected to deliver unprecedented new user experiences.

Below: Honda e’s infotainment displays occupy two 12.3-inch LCD touchscreens on the full-width digital dashboard





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