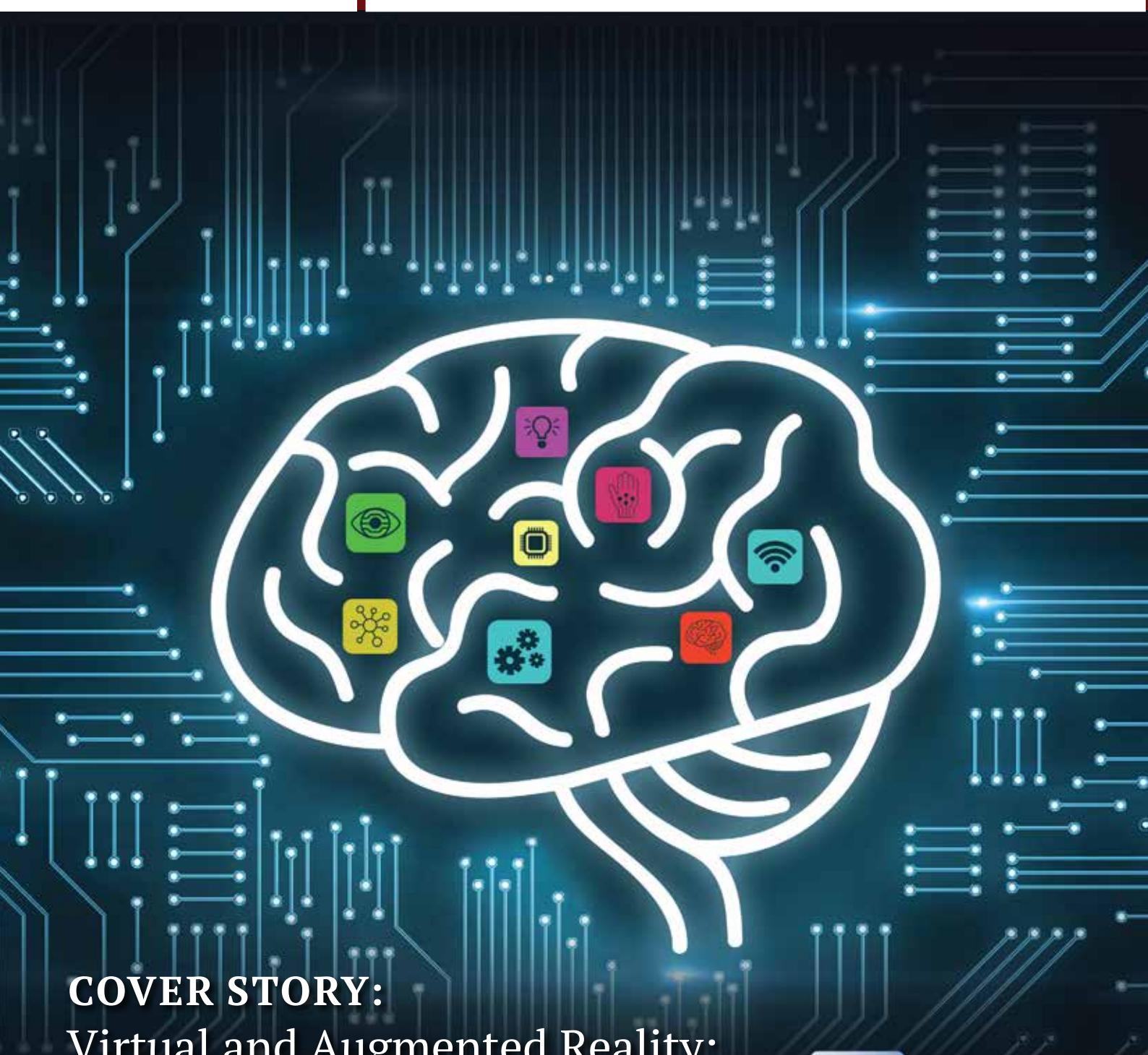


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**Virtual and Augmented Reality:
Believe the Hype**

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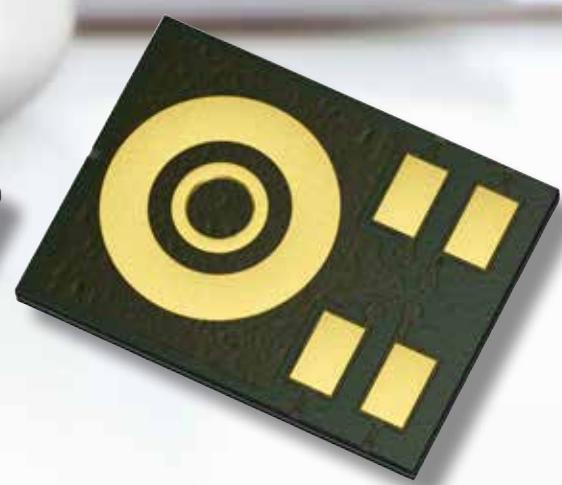


New capacitive MEMS design boosts audio pickup quality

The latest generation of microelectromechanical system (MEMS) microphones based on Infineon's unique sealed dual-membrane technology defines a new benchmark for high-end applications, enabling a whole new audio experience for a large range of consumer devices.

In theory, it's simple: Microphones convert sound pressure waves into electrical signals. In reality, microphones offer a different performance, and several parameters are key in determining the performance of dedicated features and applications. The potential of today's cutting-edge devices can be severely limited by poor quality of the provided audio raw data.

Read more in the article starting on page 21.



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EDITOR'S LETTER

Why You Must Care



THE ELECTRONICS INDUSTRY has always made for strange bedfellows. Friends and partners routinely drag each other to court, leaving lawyers and judges to sort out arcane legal matters, while simultaneously signing design and supply contracts that paradoxically signal amicable relationships. Apple Inc. only last year ended (has it really?) its patent war with Samsung Electronics. The first salvo was fired long before Steve Jobs died in 2011. But during the nearly decade-long squabble, the two routinely inked supply agreements involving the supply of critical components.

It is a fractious market. No doubt. Companies routinely fight in the morning and kiss in the evening. No single electronics enterprise today can claim to have singlehandedly developed any of the industry's leading products. By the time a product reaches the consumer or enterprise market, it will have been touched by many hands. Multiple minds will have contributed pieces to it. Tussles over intellectual property (IP) are woven into the very fabric of the industry. Resolving the conflicts takes time and requires the involvement of lawyers. Today, the industry is embroiled in a different kind of quarrel — one that is pitting countries against high-tech companies, courts, and regulatory bodies. In the meantime, though, the companies continue to operate,

Efforts to protect IP and ensure a level playing field are pitting countries against high-tech companies, and everyone's at risk.

relying on each other to bridge innovation chasms and get products to market on time. Collaboration, with all of its benefits and downsides, is as essential as competition.

Today, the industry is embroiled in a different kind of quarrel — one that is pitting countries against high-tech companies. Regulators are concerned about IP theft and the exercise of predatory power by certain governments bent on improving their countries' economic and military positions. When such actions put a company at risk of shutting down over alleged actions that may be difficult to prove, the confrontation is concerning for the industry at large. The silence of rivals in such situations endangers the industry's intricate design and supply chains.

China's Huawei today feels like a company under siege as the United States and many other Western nations take steps to curb its growth. Maybe its Western rivals will gain some market share and reap other benefits as Huawei reels, but this blade can cut both ways.

Competitors deserve a level playing field. Regulators can help achieve it. But when regulatory fervor merely swings the pendulum of advantage from one player to another, everyone is at risk. ■

— Bolaji Ojo, global editor-in-chief at AspenCore Media

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OPINION

Can Tech Solve Its Own Counterfeit Electronics Problem?

By Barbara Jorgensen



THE ELECTRONICS INDUSTRY has developed some of the most groundbreaking technologies in human history. But the best minds in tech have been unable to overcome one of the industry's most insidious challenges: counterfeit electronics.

Technological advancements have only added to the problem. Electronic components can now be cloned so well that they cannot be distinguished from the genuine article. Counterfeiting is not just a technology issue, however. Procurement and supply chain practices also contribute to the proliferation of fake devices.

Currently, there is no silver-bullet solution for counterfeit electronics.

Most inauthentic components are recycled substandard devices or parts that have been modified to appear to be something they are not. Counterfeitors most often target high-value components, many of which are destined for the defense, aerospace, automotive, or medical industries, because that's the most profitable track for criminals. Just last month, for example, the owner of distributor PRB Logics pleaded guilty in a U.S. federal court to charges of selling counterfeit integrated circuits, some of which could have been used in military applications.

Sound supply chain practices provide some defense against the circulation of fake parts. Original component manufacturers (OCMs) try to restrict their distribution to authorized resellers that are audited for strict quality control practices. Distributors buy directly from OCM factories; trace the devices via part numbers, date codes or other identifiers; and pass through OCM warranties. Authorized channels are tantamount to buying directly from the OCM.

Industry associations and standards organizations have contributed to sound procurement practices. Commercial distributors use the SAE Aerospace 6496 standard for fraudulent and counterfeit components. U.S. Department of Defense sourcing rules, under the auspices of the National Defense Authorization Act (NDAA and DFARS), are wide-ranging and comprehensive.

Nevertheless, because of imperfect forecasting, there are always unused electronic components in the supply chain. If customers are unable to return inventory, they can sell components on the open market. Many of those devices are bought by distributors that are not authorized by brand owners and are not required to adhere to established quality-control practices.

Although many nonauthorized distributors strive to sell authentic products, less scrupulous brokers traffic in counterfeits or mix defective parts in with genuine devices.

Practices for identifying and eliminating suspect components within the electronics supply chain are inconsistent. NDAA and DFARS apply to all component sources but are largely self-policing. Other agencies, such as the U.S. National Aeronautics and Space Administration (NASA), have

no centralized systems for identifying and sharing information on suspect components or vendors.

Commercial manufacturers are encouraged to report counterfeits to organizations such as North America's Government Industry Data Exchange Program (GIDEP). But because GIDEP requires complete transparency — reporting parties and brand owners must be identified — companies worry that their reputations will be tarnished. Therefore, some simply handle counterfeit notifications themselves.

ERAI, an organization that monitors, investigates, and reports issues affecting the electronics supply chain, maintains the confidentiality of organizations that report suspect devices. ERAI arranges testing of components whose authenticity is disputed. However, there are no formal information-sharing agreements between ERAI, GIDEP, and other outlets that combat counterfeiting.

Anti-counterfeiting solutions have lately focused on component traceability. The authorized supply chain promotes buying and selling only through franchised distributors that can provide the provenance of any component, but tracking a component from the factory throughout its lifecycle remains problematic. RFID and devices such as microtags have been raised as possible solutions.

Other solutions are emerging. Applied DNA Sciences Inc. has developed a plant-DNA-based marker that can be used for tracking purposes. Solutions developer Battelle offers fast nondestructive authentication of electronic components, enabling separation of cloned or counterfeit components from authentic ones at a lower cost than for alternative methods. Optimal+ provides software for collecting, cleaning, and aggregating data from multiple chip-manufacturing locations. That data could then be applied to create unique identifiers for components to enable verification.

It is unlikely that a single solution will ever be adopted across the electronics industry. End markets have different tolerances for risk. The consumer electronics industry has had its share of horror stories, but the automotive, medical, military, and aerospace markets have zero tolerance for defective parts. Industry segments seek solutions that best meet their needs.

At the same time, the breadth of anti-counterfeiting systems and tools is extensive. Information remains a powerful means of thwarting criminal efforts. ■

Barbara Jorgensen is managing editor of EPS News.



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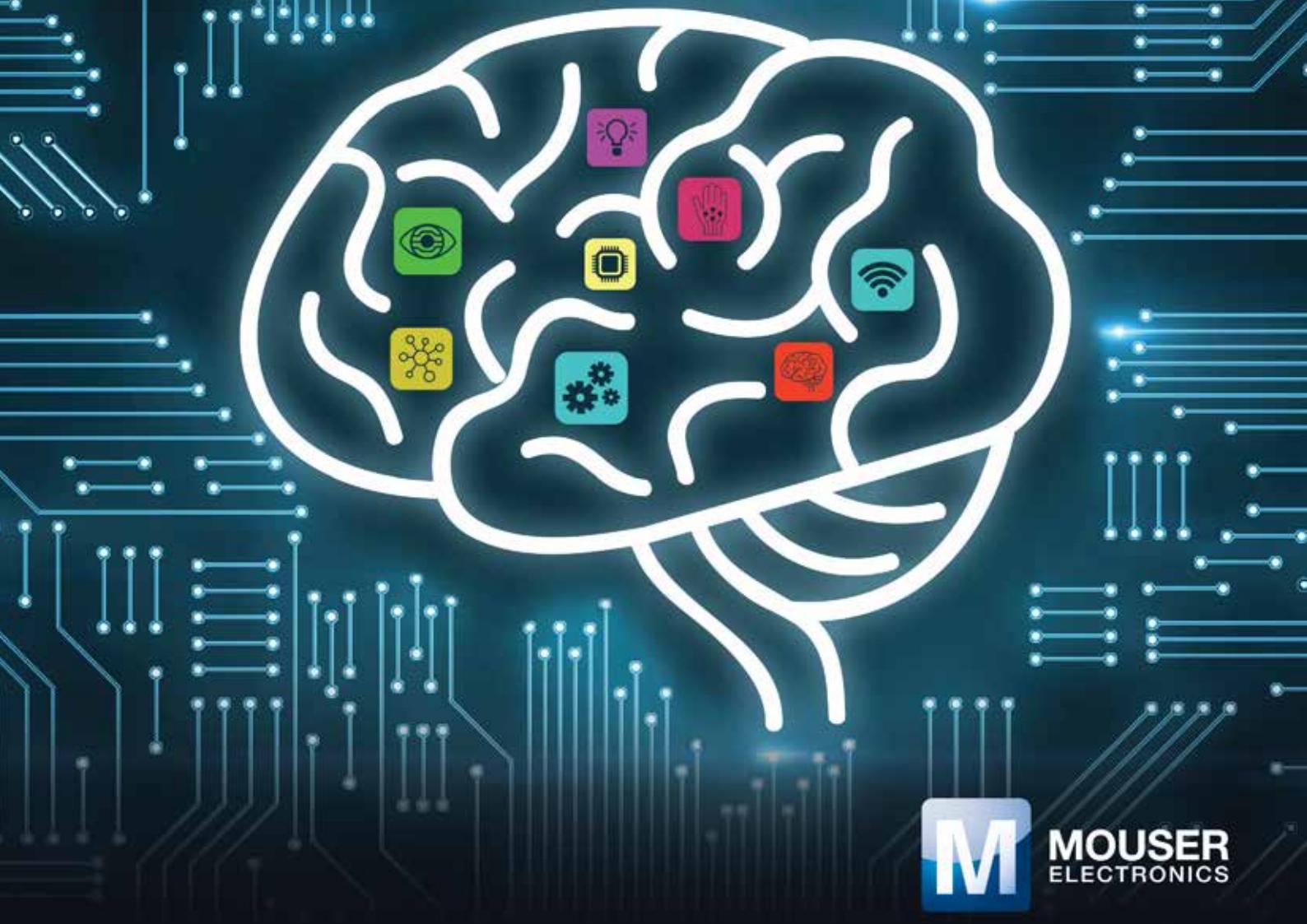


Virtual and Augmented Reality: Believe the Hype

Virtual and augmented reality technologies are finally living up to expectations and are supporting a host of innovative applications across a wide range of sectors

By Mark Patrick, Mouser Electronics

Rapid advances in electronics and data processing are blurring the boundaries between the digital and physical worlds. These days, radical technologies such as virtual and augmented reality (VR/AR), once limited to early adopters, are proving increasingly popular in consumer and business markets alike. The speed, clarity, and immersive quality of images and data delivered through headsets and glasses are now so good that new applications are being found almost on a daily basis.



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Virtual and Augmented Reality: Believe the Hype

In terms of history, the concepts of VR and AR have their origins quite a long way in the past. The first patent for a VR device was awarded in 1962, while AR emerged from U.S. military research in the early 1990s.

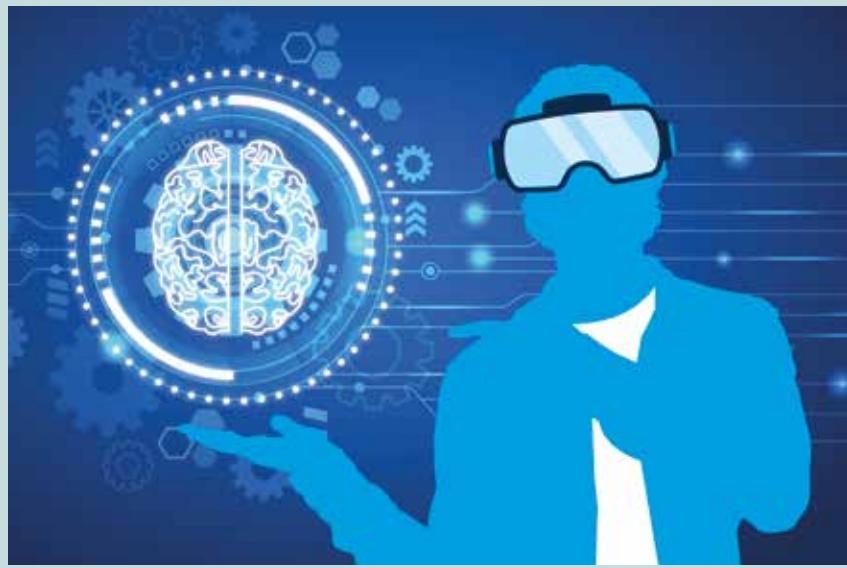
In both cases, technological progression has been hampered by the enormous computational resources required to deliver graphics of any meaningful quality.

But Moore's Law has changed all of that. Exponential improvement in the performance of integrated circuitry has led to the development of myriad new systems and components such as field-programmable gate arrays (FPGAs), graphics processing units (GPUs), and high-performance multicore processors. These advances, in combination with innovations in open-source vision-processing algorithms and seamless cloud integration, have led to a step-change in the performance of human-machine interfaces. Now, both VR and AR are finally set to deliver on their technological promise.

Before we take a look at some of the imaginative and disruptive applications of VR and AR in the consumer and business sectors, it is worth reiterating the clear delineation between the two technologies. VR is widely characterized as an interactive computer-generated experience taking place within a simulated environment, usually via a headset, creating a complete immersion experience that shuts out the physical world.

AR, meanwhile, builds digital elements such as graphics and data into a live real-world view, often by using the camera on a smartphone or tablet. More recently, next-generation AR systems have used interactive headsets and glasses, with virtual 3D objects inserted into a wearer's line of sight.

Out of the two distinct technologies, it is VR that has achieved greater market uptake, particularly in the gaming and creative sectors. Typically, VR headsets combine stereoscopic head-mounted displays, stereo sound, and head-motion and eye-tracking sensors, used in combination with a controller.



Perhaps the best-known VR device is Oculus Rift, produced by Facebook subsidiary Oculus VR, which was launched as the first consumer headset in 2016. But it has quickly become an extremely competitive market, with the likes of HTC Vive, Sony PlayStation VR, and Google Daydream View all vying for a slice of the action. And there's an awful lot to play for, according to research from global technology giant Nvidia, which predicts that about 50 million VR headsets will be sold by 2021.

While the majority of these devices will be sold into the gaming sector, VR has also found a growing niche in business and industry, with — arguably — training representing its killer application. The



Mark Patrick, Technical Marketing Manager, Mouser Electronics

ability of developers to create detailed, accurate, and consistent simulated environments offers huge value to organizations that need to coach and prepare employees for certain situations without putting them or anyone else at physical risk. This is particularly true in the military sector, with defense forces around the globe using VR for activities such as flight simulation and combat training.

Health care is another area in which VR holds enormous potential. Medical practitioners are already using the technol-

ogy to learn how biology works from within. This can include detailed models of DNA structures and body part functions. VR can bring such learning to life in a far more interactive manner than traditional training materials such as textbooks.

Training for surgical procedures is another area of medical application. Several organizations already have software-as-a-service platforms that offer low-cost and scalable simulation experiences for trainee and qualified surgeons, combining VR with haptic feedback. This enables medical practitioners to hone their skills over and over again in a safe environment and is widely claimed to represent a more cost-effective approach to training than the traditional use of cadavers.

There is also a growing area of research looking at how VR can be used to treat and manage severe pain. Patient-centric applications have been developed as a means of improving pain management, with simulated distraction experiences acting as alternatives to painkillers.

If VR has become a mature technology with a growing market acceptance, AR can be seen as the young upstart whose value and benefit have yet to be fully realized. That's not for want of trying. Google Glass, a brand of smart glasses comprising an optical head-mounted display, was launched to loud fanfare back in 2013 before being quietly dropped a couple of years later after concerns were raised about privacy and safety. Since then, AR adoption has been tentative at best, with technology firms taking a more pragmatic approach to commercialization.

But now, after several years of intense behind-the-scenes research and development efforts, a new wave of AR devices has started to come to the fore. In August this year, for example, U.S.-based startup Magic Leap released the first version of its hugely anticipated Magic Leap One wearable glasses, which superimpose 3D computer-generated imagery over real-world objects. According to Magic Leap, the \$2,200 headset combines natural light waves with synthetic lightfields to create an "unbelievably believable experience."

So how does the technology actually work? In the case of Magic Leap, the AR experience is delivered through the combination of three distinct, yet connected, pieces of hardware. First, the headset itself — referred to as lightwear — combines a package of cameras, sensors, speakers, and optical relay to provide vision and audio. The lightpack, meanwhile, is a small and portable processing unit comprising an integrated GPU and CPU that clips onto the user's pocket to provide total freedom of movement. And finally, there's a handheld controller, which provides six degrees of freedom and haptic feedback to deliver what Magic Leap claims is an intuitive and sensory experience.

Virtual and Augmented Reality: Believe the Hype



While most of the attention will inevitably focus on the look and feel of the headset, it is the processing unit that acts as the heartbeat of the system, delivering its powerful performance. Magic Leap tech sheets show that the GPU/CPU module contains three processors: a quad-core Arm A57 CPU, a dual-core Denver 2 CPU, and an Nvidia Pascal-based GPU with 256 CUDA cores. RAM is listed as 8 GB, with 4 GB of memory available to applications, while storage capacity is 128 GB. The package also contains a built-in rechargeable lithium-ion battery, which delivers up to three hours of continuous use, and connectivity is provided through Bluetooth and Wi-Fi.

There's no doubt that the launch of Magic Leap One has caught public attention, with numerous positive user reviews, and this has thrust AR firmly into the spotlight. Early applications have focused on gaming, with users able to create virtual battles in their own homes, seamlessly merging digital imagery with real-world environments. Going forward, Magic Leap says that it is targeting "creative professionals," who it says will be able to use the headsets to form their own visual experiences.

While that might sound somewhat esoteric, there are other examples of AR technology being applied in more definitive ways. In industry, for example, several use cases have recently emerged in the maintenance sector, with AR headsets being used to assist workers with the repair of complex pieces of equipment out in the field. The ability to access 3D technical information within line of sight means that maintenance work can be performed in a more effective and timely manner.

One early adopter of such technology is thyssenkrupp, the German industrial conglomerate, which has successfully applied AR in the installation and maintenance of its escalators and lifts. In this example, workers wearing Microsoft HoloLens headsets can familiar-

ize themselves with the particular lift or escalator that needs repair in advance of a site visit. Using the technology, it is possible to zoom in on a specific part, revealing technical data and drawings. This, says thyssenkrupp, means that technicians are fully prepared before they arrive for a job.

Then, once on-site, the worker can use the HoloLens headset to retrieve historical notes before using the system as a guide for the actual repairs. According to thyssenkrupp, the hands-free nature of AR means that its maintenance workers can go about their tasks in a far more effective manner than was previously possible using a laptop or printed manuals. The headset can also be used to trigger a call to a remote colleague, who can plug into the headset's line of sight, enabling them to assist.

The use of AR in this setting has delivered profound business benefits, says thyssenkrupp, particularly around speed and flexibility. Maintenance jobs that were typically taking one to two hours can now be completed with AR support within 20 minutes, it says. Such a dramatic improvement in performance has also underpinned a shift in the business model, enabling thyssenkrupp to move away from being a traditional supplier of products and toward a more profitable position of being a solutions provider. Commonly referred to as "servitization," this model sees the company shift from being a maker of things to a product-centric service supplier — essentially selling a guarantee of performance levels and uptime.

What is clear from these numerous examples, then, is that both VR and AR have moved from the margins to the mainstream and have found increased adoption across consumer and business markets. And as acceptance accelerates and new applications come to the fore, VR and AR are set to become ever more prominent in our daily lives. It might have been a long wait, but at last, these exciting technologies are living up to the hype. ■

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5G AND MORE

5G is Just Getting Started; Time for 6G

By Nitin Dahad

OULU, Finland — When officials in this innovation hub invited journalists to have a look at the work under way to initiate research on 6G wireless networks, I immediately thought, *But we don't even have commercial 5G yet. How can we be talking about 6G?* I've spoken to others who have confessed the same reaction.

Once you get there, you realize that for now, "6G" is just a marker. Most of the work going on in Oulu, as in the rest of the world, targets the 5G rollout: conducting trials, defining use cases, and figuring out business models. It's still early days. But Nokia is already shipping millions of its AirScale radio access platform for 5G installations in cities around the world, Erja Sankari, vice president of supply chain engineering, told EE Times in an interview.

As the 5G rollout gets under way, there needs to be a vision for what's next for mobile networks far beyond what is possible today. Will that next big thing be "5G Long-Term Evolution [LTE], or is it 6G?" said Ari Pouttu, professor for dependable wireless at the University of Oulu's Center for Wireless Communications. Looking to kick-start funding for their work on 5G's successor, university researchers opted for the moniker 6G to suggest the scope of the envisioned leap in capabilities and required rethinking of technologies and materials.

The university has since attracted more than €250 million in funding over the next eight years for its flagship 6Genesis project.

The 6G initiative is a vision for 2030. Over the next eight years, the 6Genesis program will consider the impact of a data-driven society enabled by nearly instantaneous, unlimited wireless connectivity.

6Genesis, or the 6G-Enabled Wireless Smart Society & Ecosystem, is focused on the implementation of 5G communications technology and the possible development of a 6G standard. It will help industry commercialize 5G by carrying out large pilots with a test network. At the same time, it will explore development of the essential technology components that would be needed for 6G, targeting wireless connectivity and distributed intelligent computing. The long-term research will focus not just on communications between people but also on communication between devices, processes, and objects. The University of Oulu is leading the project, collaborating with researchers from Nokia, the VTT Technical Research Center of Finland, Aalto University in Finland, BusinessOulu, and the Oulu University of Applied Sciences.

NEARLY INSTANTANEOUS CONNECTIVITY

How far into the future does this out-of-the-box thinking look? The 6G initiative is a vision for 2030.

Over the next eight years, the program will consider the impact of a data-driven society enabled by nearly instantaneous, unlimited wireless connectivity, Pouttu said. Researchers will explore the devices, circuits, and distributed-computing requirements that could satisfy expectations for artificial intelligence (AI)-inspired applications serving every aspect of society with ubiquitous wireless connectivity.

"Humans are already connected, so the promise of 5G or 6G will be to connect even more objects," said Pouttu. "Near-instant connectivity is still not fully solved in 5G in terms of latency. Millisecond latency is not good enough for some [time-critical] applications, so there is still a



The University of Oulu has attracted more than €250 million in funding for its flagship 6Genesis project. (Image: EE Times)

lot of potential to improve communications capability."

Handling the massive data volumes envisioned will require terabit/second communications, he said. And as data rates rise, so will frequency requirements — from 100-GHz all the way up to terahertz frequencies.

There is already a line of thinking that there will be 1,000 radios per person in the next 10 years, said Pouttu. "[Communications] distances will be short, with radios everywhere. We'll need to start looking at totally new ways of providing over-the-air communications. Could this mean the renaissance of ultra-wideband radio, or will it be OFDM [orthogonal frequency-division multiplexing]?"

Everything from device and circuit technologies to materials science may require a rethink, said Pouttu.

One research focus will be the mobile edge intelligence required for more data-driven, nearly instantaneous connectivity. Distributed computing, particularly multi-access mobile edge computing, will become even more important. "A lot of computing will be done at the edge, with a lot of modeling done in the handheld device itself," said Pouttu. Apple's September 2018 launch of three iPhones powered by the 7-nm A-12 Bionic system-on-chip, enabling up to 512 GBytes of memory, shows that the trend is already unfolding.

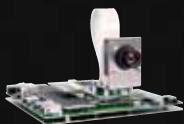
Aarno Parssinen, professor of radio engineering at the University of Oulu, said researchers need to take the long view because technology can take decades to mature. "Our timeline of development is not in quarters," he said. "For us, 10 years is really a short time frame.

"If you look at millimeter wave, the first fundamentals might have been done around the 2000 time frame, but industry has really only developed a level of maturity with this 10 to 15 years later," said Parssinen. "Even so, 5G millimeter wave is still 10 times more difficult to implement. The same fundamental principles might apply, but the dimensions are getting smaller. The antennas are getting tiny, with more electronics around [them], and this will get even more difficult in terahertz communications." Today's transistors can't cope with terahertz frequencies, he said.

The proposed terahertz frequencies will contain an absurd amount of data, increasing data intensity not only in information technology terms but also for wireless transport. "We must come up with a solution that makes this reasonable and physically possible in those frequencies," said Parssinen. "We need to do things that cannot really



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be done yet. But that is the purpose of science.

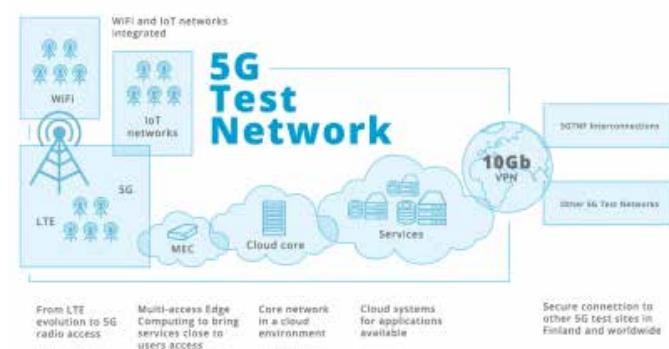
"The goal is to make new things in frequencies that have enabled significant advances in radio astronomy and other scientific or otherwise very demanding applications. The focus is on harnessing this for commercial use in reasonably priced, small devices, and [the challenge is] how to get the radio signal to travel in this environment."

5G TEST NETWORK

The more immediate challenge is the 5G rollout. Toward that end, the 6Genesis project includes a 5G test network (5GTN) based on Nokia's



The Oulu 5G test network partners range from technology to health and public service organizations. (Image: 5GTN Project)



The 5G test network in Oulu. (Image: 5GTN Project)



The LTE network on campus at the University of Oulu, operating in Band 7 at 2.6 GHZ, feeds into the 5G test network.

(Image: EE Times)



5GTN partners use a SIM card to access the University of Oulu's 5G test network. (Image: EE Times)

core network products and operated by the University of Oulu and VTT, with funding support from roughly 25 partners.

The 5GTN acts as a verification platform for theoretical 5G research and is a testbed for R&D and trials by the partners, which range from technology companies to health and public service organizations. The test network is centrally located at the university, and the partnering businesses connect to it using SIM cards. Product developers can test their technology prototypes, with access to all functions and interfaces on the network, and other businesses can run trials of potential services that would benefit from 5G connectivity.

The network architecture uses 3rd Generation Partnership Project (3GPP)-specified evolved packet core elements and LTE radio access technology, with an emphasis on small-cell-based solutions. The 5GTN project team can also grant frequency licenses. Active projects include care, wellbeing, and fitness; e-health at home; media production and distribution; and a Nokia automated factory that uses 5G technology.

'BETTER WAYS TO DO THINGS'

Given the work that remains to be done on 5G, it's easy to dismiss the 6G discussion as premature. "I think 6G is a red herring until it is really defined and not worth much effort before 2020 to 2022," said Mike Short, who spent 17 years at Telefonica and is now chief scientific adviser with the British government's international trade body. "We need to see real 5G customer demand and rollout first."

But scientists and researchers are already thinking about the challenges of next-generation networks, and work is under way to address them. According to some reports, China began researching 6G at the end of 2017. The International Telecommunication Union, looking toward 2030, established a focus group last year to investigate backbone technologies for next-generation networks. And Semiconductor Research Corp.'s Center for Converged Terahertz Communications and Sensing is looking at developing technologies for future cellular infrastructure using hubs with massive spatial multiplexing. The approach would provide 1 to 100 Gbits/second to the end user, with 100 to 1,000 simultaneous, independently modulated beams and with aggregate hub capacities in the tens of terabits/s.

Finding "even better ways to do things" is just a manifestation of human curiosity, said Oulu professor Pouttu. "Don't worry about applications or business. There are other guys to do that."

"We are engineers. We are curious." ■

Nitin Dahad is a European correspondent for EE Times.

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5G AND MORE

MWC in Barcelona: This Year's Focus is on 'Intelligent Connectivity'

This year's Mobile World Congress (which is now officially called MWC) will take place from Feb. 25 to 28 in Barcelona at the Fira Gran Via, Fira Montjuïc, and La Farga L'Hospitalet. Organizer GSMA expects that more than 107,000 professionals from over 200 countries and territories will attend.

Under the event theme of "Intelligent Connectivity," MWC19 Barcelona will highlight the intersection of "hyperconnectivity," enabled by 5G and the internet of things, and "intelligence," delivered by artificial intelligence and big data. In addition to the core elements of intelligent connectivity, MWC19 will explore the key topics of Content, Digital Trust, Digital Wellness, and The Future.

"Underpinned by 5G and AI, intelligent connectivity is a major technological force that will shape how the world communicates well into the future," said Michael O'Hara, Chief Marketing Officer, GSMA. "Attendees will get to experience the impact of intelligent connectivity firsthand across the conference and exhibition and the many programs and events taking place at MWC19 Barcelona."

The GSMA has rebranded its flagship event series, moving from

"Mobile World Congress" to "MWC," a refresh that will be applied across all three global MWC events. The 2019 events will be referred to as MWC19 Barcelona, MWC19 Shanghai, and MWC19 Los Angeles.

O'Hara commented: "We are rapidly moving to a world where mobile will connect everyone and everything, but at the same time, we are expanding our reach beyond mobile. The new brand retains the familiar acronym while placing less emphasis on 'mobile' to reflect the broadening scope of communications today."

MWC19 Barcelona will bring together leading players from across the mobile ecosystem, as well as adjacent industry sectors such as automotive and consumer electronics, showcasing the latest technologies, products, and services. More than 2,400 companies will participate at MWC19. The show floor will also include more than 40 country and regional pavilions.



CONTRIBUTED BY MWC

MWC in Barcelona: This Year's Focus is on 'Intelligent Connectivity'



One of the perennial favorites at MWC, the GSMA Innovation City, will put a spotlight on how intelligent connectivity — 5G, IoT, AI, and big data — is impacting and improving the lives of citizens, enterprises, and governments around the world. Visitors will experience intelligent connectivity across a range of sectors including entertainment, transportation, public services, and industry, among others, with demonstrations from partners Google, Huawei, KT Corporation, Sierra Wireless, and Turkcell, as well as GSMA industry and advocacy programs.

NEXTech Hall 8.0 is the destination for MWC19 attendees seek-

ing cutting-edge technology trends, including AI, IoT, drones, robotics, and virtual reality/augmented reality (AR/VR), among others. NEXTech will feature several specialized technology areas, including the Drone Zone, the Graphene Pavilion, and the IoT Pavilion, alongside the NEXTech Lab, an open theater where leading industry players will present their latest innovations.

New for 2019, the GSMA will introduce “Digital Planet: The Connected Experience” in Hall 8.1, an evolution of App Planet, which has been a mainstay of MWC since 2010. Digital Planet will include over 200 app, ad tech, e-commerce, and marketing communication solution providers and other organizations focused on creating connected experiences and solutions that will positively impact citizens’ daily lives. Digital Turbine, Infobip, MessageBird, and Toyota are among the companies that will be showcased in Digital Planet, and Generalitat de Catalunya has been confirmed as the official sponsor.

4YFN is the innovation platform for MWC19 Barcelona, enabling startups, investors, and companies to connect and launch new business ventures together. The three-day event, scheduled for Feb. 25–27 at Fira Montjuïc, is expected to attract 21,000 attendees who will have the opportunity to meet the growing global tech startup community, take inspiration from onstage talks and workshops, and develop their skills in the newly designed Discovery Area.

Over 600 companies will be exhibiting at 4YFN, including startup delegations from Colombia, France, Greece, Hungary, Japan, Jordan, South Korea, and the United Kingdom, among others. Sponsors for 4YFN include Banco Sabadell, Daimler, Intel, SEAT, and VISA, as well

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MWC in Barcelona: This Year's Focus is on 'Intelligent Connectivity'

as public institutions from countries and territories including Japan, South Korea, Spain, and Taiwan.

The Women4Tech Programme is back in Barcelona with an expanded set of activities and events in its third year. Running across all four days of MWC19 Barcelona, Women4Tech is designed to address and reduce the gender gap in the mobile industry. A central element of the program is the Women4Tech Summit, with keynote presentations and panel discussions exploring topics such as gender equality and career development; mentoring and youth education; women in communication and vertical sectors; and women as entrepreneurs and innovators. In addition to the Summit, the Women4Tech Programme includes the Women4Tech Speed Coaching and Networking session; specialized MWC Tours; Women4Tech GLOMO awards for "Outstanding Achievement in Mobile Industry Leadership"; a Women4Tech panel on Mobile World Live TV; and Women4Tech activities at 4YFN.

The Youth Mobile (YoMo) Festival returns to Barcelona for its third year and is expected to attract approximately 25,000 attendees, including 22,000 school group attendees – nearly 85% more students than in 2018. A dedicated program designed to inspire young people to pursue education and careers in science, technology, engineering, art/design, and math (STEAM), YoMo will offer an array of educational exhibits, live theater shows, interactive workshops, and hands-on activities, as well as educator-focused workshops, lectures, and more. The 2019 edition of YoMo also includes the Enhanced Teacher Track, which focuses on digital transformation of the classroom. YoMo will be held Tuesday, Feb. 26, through Friday, March 1, at La Farga L'Hospitalet. Energytruck, the new mobile exhibition of Foundation Naturgy, has been confirmed



as a corporate sponsor for the program.

The 2018 edition of MWC was officially certified as carbon-neutral by AENOR International, reiterating its position as the world's largest carbon-neutral tradeshow. In 2019, the GSMA is focused on further reducing the environmental impact and carbon footprint of the event, offsetting any outstanding emissions as necessary. It will also extend the "Donation Room" program, through which MWC exhibitors donate used materials to Barcelona citizens at the end of the event. At the conclusion of the 2018 event, the GSMA collected 21.5 tons of building materials and 10 tons of furniture items and worked with the city councils of Barcelona and Hospitalet to provide them to more than 20 local socially responsible entities. ■

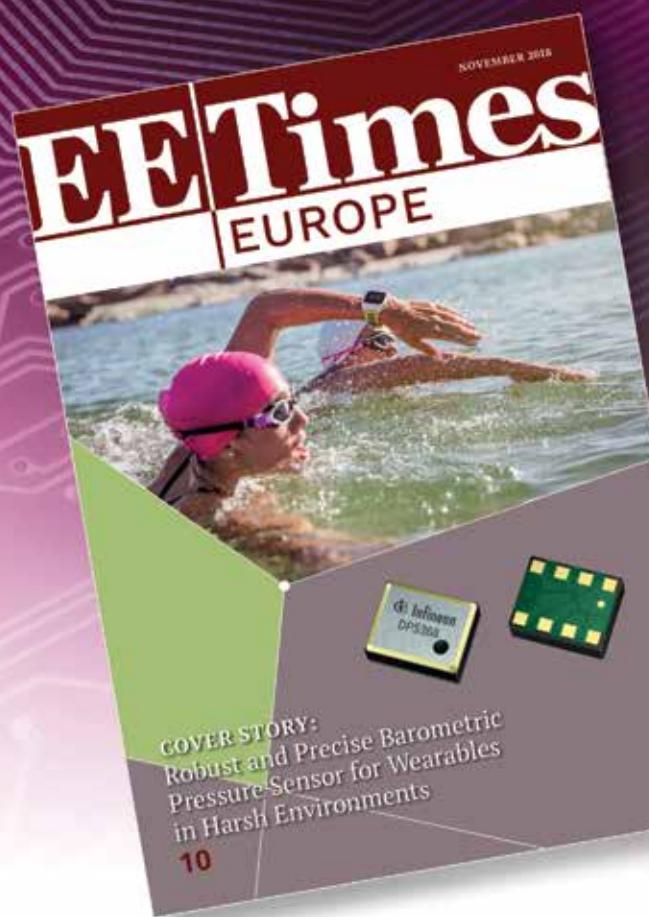
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5G AND MORE

Infrastructure Focus Clouds the Blue-Sky View for 6G

By Loring Wirbel

The 35-year history of digital cellular standards has followed a predictable trajectory since the 3G Partnership Project took the lead in standards development. As soon as one generation of standard reached draft form in 3GPP, it was time to speculate about the next generation, even if the barest framework of the next generation was still years away. The speculation has led to hype and nonsense in 4G and 5G, but for the still-nascent 6G, the decade of the 2020s may be too murky for even the best crystal balls to penetrate.

Uncertainty about 6G comes from two sources. First, with “handset fatigue” dampening end users’ enthusiasm for continual upgrades to new smartphone models, the standard will be defined almost solely by upgrades to infrastructure. The soft-function trends of software-defined networking (SDN) and network function virtualization (NFV) will drive base station and remote radio head development. That could make the feature sets of soft switches and SDN controllers seem downright squishy.

The second source is regional and political. China’s massive investments in backbone networks for 5G/6G could put engineers from Chinese OEMs and service providers solidly in the driver’s seat within international standards bodies like IEEE within the next decade. When engineers from Huawei, ZTE, and other Chinese companies accelerated involvement in 4G/5G, their practical contributions to areas such as narrowband internet of things (IoT) were benign, if not downright beneficial. But as China envisions a more centrally controlled wireless network for 6G, the protocols for ad-hoc subnets and “just right” bandwidth may look far different from what engineers at U.S. and European OEMs might propose.

Some trends in infrastructure look like no-brainers. The lower costs of soft functionality, for one, appear to make SDN/NFV a foregone conclusion for future network switches and base stations.

Yet foregone conclusions can turn out to be anything but. Scaled granularity from small cell to picocell to femtocell was the presumptive natural path for 5G, but the architectural model of widely proliferated femtocells hasn’t found the expected degree of market reality. Users and service providers tolerated a coarser granularity at the neighborhood and single-building levels because it was cheaper to deploy than a cell in every living room.

Similarly, ad hoc networks characterized by dial-up bandwidth on demand would seem to be a given for 6G, but unexpected market demands or shifts could change those expectations.

NOT SO FAST

The irony in launching a 6G discussion in 2018 is that only the first round of 5G standards, known to 3GPP as Release 15, is in draft stages of definition. At a minimum, additional standards packaged as Releases 16 and 17 will be debated through the middle of the next decade, and many analysts expect even more releases for 5G. That could push early implementations of 6G out to 2030 or beyond.

In the meantime, interest in 5G deployments is flagging for three reasons that should have been obvious.

First, the rise of 160-MHz channels and 4 × 4 multiple-input, multiple-output (MIMO) antennas promises theoretical data rates of up to 10 Gbits/second, translating to several hundred Mbits/s at the handset. Sounds great, but service providers have been polling users on the cost versus benefits of such upgrades, and their findings cast doubt on whether such speeds are necessary for traditional smartphones.

The second 5G goal is serving mission-critical applications requiring low latency, fault tolerance, fast failover, and ultra-high reliability. First-responder radio networks obviously can use such a feature set, but will the users of police and medical-radio subnets be willing to underwrite the primary costs of 5G deployment?

The final goal for 5G, IoT and autonomous-vehicle connectivity, has the opposite problem. Networks must support tens of thousands of low-data-rate nodes. Work on special networks such as Long-Term Evolution (LTE) Category 0 has been robust, but industrial and automotive networks cannot shoulder the deployment costs of 5G.

The deployment conundrum of 5G, seen from service providers’ perspective, is bad enough in bands below 3 GHz. For the most flexible sub-3-GHz services, carriers will need to provision a variety of small cells, including pico- and femtocells – an approach that attracted few users and lost money when it was tried in 2010–2015. Newer services, such as millimeter-wave long-distance offerings in the 11-GHz band, will require even more dedicated equipment, which might pull in new businesses – but only if the new commercial users emulate the diversity of military millimeter-wave users.

Some service providers have elected to focus on a subset of available bands. Verizon, for instance, has put most of its investment behind the 28-GHz and 39-GHz bands and called them 5G. But there have been no auctions yet for the 11 GHz of new spectrum that the U.S. Federal Communications Commission (FCC) defined two years ago for blocks at 28, 37, and 39 GHz. A new FCC-defined band at 64 to 71 GHz is even fuzzier, dwelling in a nascent state in which the blocks are not yet fully characterized.

It’s no wonder that users and carriers alike scratch their heads when network equipment vendors boast about the promises of 5G.

Even in markets that seem a sure bet, such as vehicle-to-vehicle (V2X) communications, existing LTE networks must compete with a slate of IEEE-based standards and proprietary offerings. Qualcomm and Huawei are promoting Cellular V2X (C-V2X) as a derivative of LTE Direct, the autonomous long-distance device-to-device (D2D) protocol introduced in 3GPP Release 12. But C-V2X must compete with automotive networks based on IEEE 802.11p, a Wi-Fi derivative for cars. The reality has deflated V2X cheerleaders’ early predictions of a \$40 billion market for V2X services in 2020 and a component and hardware market reaching \$36 billion in 2025. Such market fragmentation will likely repeat itself in other vertical domains.

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Infrastructure Focus Clouds the Blue-Sky View for 6G

BUILD IT AND THEY WILL COME?

Many broad areas were deliberately left out of 5G standards development, such as the integration of terrestrial cellular networks with satellite communications, the definition of ultra-dense cellular networks with ad-hoc joining features, more complex reconfigurable hardware following SDN/NFV models, and full immersion in wearable communication devices. From the standpoint of practical bandwidth, 6G proponents are talking about speeds of 1 to 100 Gbits/s for end users, along with multi-user MIMO element scaling to thousands of antenna nodes.

Those feature sets are of immediate interest in the infrastructure equipment and network testing segments because backbone networks will require new switching and

transmission. In virtually all instances, however, such services will need to be "sold" to both service providers and end users, as usage cases are still in their infancy.

Some proponents suggest that 6G will primarily serve the IoT/V2X market. While the number of nodes will dwarf those in traditional cellular communications, we are back to the problem of low-bandwidth users subsidizing a network defined for high-bandwidth advantage, which cannot be realized through a primarily IoT focus. If 5G Release 16 and beyond is still blue-sky territory, then 6G may well occupy the realm of speculative fiction.

Because nonsense never stops, blue-sky analysts already are talking about 7G networks, which would enable "space roaming" (central Internet Protocol nodes commu-

nicating with multiple satellite networks), and even 8G, which has not yet been defined beyond "ultra-high-fidelity" immersion networks. But it is important to remember that 3GPP just released the core 5G radio protocols and IP network-layer translations in October, and it has yet to define true 6G programs. As for 7G and 8G, those proposals exist only in some singularity-based world defined by followers of Ray Kurzweil. ■

Loring Wirbel is an independent communications analyst with more than 30 years' experience covering wireless and wireline communications. He has worked with such organizations as The Linley Group, Qual-comm Smartbook Blog, EE Times, and EDN's FPGA Gurus.

OPINION

CEO Viewpoint: Software Delivery Is Not an Assembly Line

By Mik Kersten



THE AGE OF MASS PRODUCTION began at the turn of the 20th century when engineering organizations mastered complex product delivery. Since that time, product complexity has continued to grow, fueled recently by an ever-growing number of electronic and software components.

In the 2000s, approximately 40% of a car's cost was in its electronic systems. We are now getting to the point where a modern car can have dozens of electronic control units and more than 200 million lines of code, with the cost of building that code exceeding the cost of the engine itself.

Most large organizations outside of the tech giants are much better at managing physical and electronic product delivery than they are at managing large code bases. The dramatic rise in software-related automotive recalls underscores the problem. In 2016, for the first time, software flaws were responsible for nearly as many recalls as electronic components were.

The irony is that even as cars become computers on wheels, the methods that the automotive industry developed to master the quality and consistency of automotive production in the last century have not been adequately applied to vehicle software.

What if we applied product development and lean manufacturing principles to software products? What if we structured our software organizations the way an automaker arranges and optimizes its assembly lines? And what if we used customer-centric product metrics such as lead time instead of the multitude of agile and DevOps metrics in use today?

The most innovative software companies already have such prac-

tices in place. It's time for the rest of the business world to catch up.

The challenge is in applying the key lessons of physical product development to software delivery. In his seminal book, "The Principles of Product Development Flow: Second Generation Lean Product Development," Donald G. Reinertsen outlines some of those key propositions. He also underscores the pitfalls of focusing solely on the manufacturing process and failing to understand the end-to-end process of product development.

If we look at software delivery or mixed software and hardware delivery in an end-to-end fashion, we see that some common principles apply. For example, delivery needs to be organized into product value streams that align with what customers value. The job of scaling delivery is all about ensuring that value can flow without interruptions.

It is only with this mind-set that we start seeing software delivery for what it is: a complex network that produces intangible assets through conversation, coding, and collaboration among numerous specialists. These lines of collaboration need to provide flow, feedback, and traceability.

Unlike physical production, there are no linear or batch processes here. All steps that correspond to production can now be automated through DevOps approaches.

What we have left is similar to the state of the art for product delivery that Reinertsen envisioned: a connected value stream network. It is this way of thinking that scaled how products are made, and that will soon define the future of software delivery. ■

Mik Kersten is the CEO of Tasktop and author of "Project to Product: How to Survive and Thrive in the Age of Digital Disruption with the Flow Framework."

MEMS & SENSORS

New Capacitive MEMS Design Boosts Audio Pickup Quality

By Marcel Knecht, Infineon Technologies

The latest generation of microelectromechanical system (MEMS) microphones based on Infineon's unique sealed dual membrane technology defines a new benchmark for high-end applications, enabling a whole new audio experience for a large range of consumer devices.

In theory, it's simple: Microphones convert sound pressure waves into electrical signals. In reality, microphones offer different levels of performance, and several parameters are key in determining the performance of dedicated features and applications. The potential of today's cutting-edge devices can be severely limited by poor quality of the provided audio raw data.

In recent years, microphones based on MEMS technology have been adopted in a wide range of applications. Downsizing and acoustic characteristic improvements have given rise to applications that allow us to share information and experiences with smartphone videos and FaceTime (**Figure 1**). Smartwatches can be used to make voice calls. We communicate with digital assistants, ask our smart speakers to play our favorite songs, or control smart home appliances via voice. Further-



Figure 3: Third-order Ambisonics audio recorder with 19 Infineon XENSIV MEMS microphones

more, MEMS microphones are used for active noise cancellation during long flights or while listening to music.

CREATE A TRULY IMMERSIVE EXPERIENCE WITH VIRTUAL REALITY

Imagine putting on virtual reality goggles and finding yourself on a sunny island in the Pacific Ocean. You are on a beautiful beach, admiring the scenery, walking among the palm trees and listening to the sounds of the waves. Colorful parrots are screeching over your head. The hardware required to create these 360° video experiences is here today and is exploding in popularity (**Figure 2**). However, the ability to easily create the accompanying 360° audio has lagged behind.

Zylia, a Polish recording technology developer, has enabled the world's first portable recording studio by using Infineon's class-leading 69-dB SNR digital XENSIV MEMS microphones. The third-order Ambisonics audio recorder Zylia ZM-1 microphone array can capture immersive 3D audio for virtual and augmented reality (VR/AR) (**Figure 3**). By using multiple devices, even six-degrees-of-freedom sound recordings are possible. To make virtual reality a truly immersive experience, high-fidelity audio pickup of Infineon's MEMS microphones combined with Zylia's advanced digital signal-processing algorithms and microphone array technology was key. Not missing any audio detail requires microphones close to studio microphone quality. MEMS microphones can not only provide this performance but also help to further miniaturize 360° audio recording devices.

AMPLIFY OR ATTENUATE SURROUNDING SOUNDS

Several headphones have been designed for an optimal 360° audio listening. With VR/AR goggles, users can transform their environment into an interactive audiovisual soundscape and capture, touch, and shape sounds. By integrating premium microphones in the headset, surrounding sounds can be attenuated or amplified. Active noise cancellation makes sure that the user hears only his favorite beats and no airplane noise for a comfortable sleep.

Transparent hearing modes have been developed so that the user can choose how much of the outside sound environment, captured through premium microphones, blends into the augmented audio experience. The headphones complement the AR experience by replicating spatial effects with incredible realism, helping the user perceive and locate virtual sounds with pinpoint accuracy. By mixing the right level of external acoustic environment with the specific virtual audio world, there is the option to create truly immersive and social experiences.



Figure 1: Sharing information and experiences via FaceTime



Figure 2: To make virtual reality a truly immersive experience, high-fidelity audio pickup is key.

New Capacitive MEMS Design Boosts Audio Pickup Quality



Figure 4: Today's video conference systems are fully integrated units including codec, display, camera microphones, and loudspeakers.

These headphones can shut out distracting external noise so that the listener can focus undisturbed on the audio content of interest. Combining active noise cancellation with active speech enhancement means that every word of a conversation can be heard even in a noisy environment.

COMMUNICATION SYSTEMS OF TOMORROW

Advanced audio features reduce the perceived distance between friends and colleagues. Teams all over the world are starting to use advanced video conference systems to increase the communication quality. To improve the performance of such devices, premium MEMS microphones are increasingly combined with advanced audio processing like blind source separation or beam forming (**Figure 4**). Today's video conference systems are fully integrated units including codec, display, camera microphones, and loudspeakers.

What works for companies might soon change people's social lives, too. For example, Facebook uses such technologies to enhance the communication between friends and family. In the future, devices will also include virtual and augmented audio and video features. The next generation of MEMS microphones will be the key to advanced communication features in even smaller form factors like smartphones.

POWERFUL AUDIO AND VIDEO EXPERIENCE WITH SMARTPHONES

What previously required a bulky video camera can now be captured with a hand-sized device. Smartphone video capturing has turned us all into storytellers, giving us the opportunity to share our experiences not only with family and friends but also with an audience of millions via social media.

While smartphone video recording has made remarkable progress and offers features like slow motion or time lapse, audio capture has not developed to the same extent. Even the most sophisticated smartphones are still capturing only mono audio, with only a few supporting stereo. No wonder the sound that smartphones produce is poor, flat, and uninspiring — not matching the superior visuals.

But change is happening: Premium MEMS microphones and advanced audio processing are bringing smartphone audio recording to a new level. Special sound recording options allow smartphone users to amplify sound in any direction they choose to focus. Audio zoom provides the option to record what the user wants to hear and suppress other sounds.

NEXT GENERATIONS OF VOICE USER INTERFACES

Voice commands and conversations with digital voice assistants are becoming more and more popular. Unfortunately, they still often require unnaturally loud voice commands or even shouting from a distance. Speech-recognition companies are improving their processors and algorithms for the next generations of voice user interfaces. In its latest incarnation, Alexa can now identify you talking with a low voice and answer you in a whisper to avoid disturbing your sleeping family members at night. It will soon be possible to use voice commands to turn off lights or TVs across different rooms.

Premium MEMS microphones and cutting-edge audio processing are the key elements for making voice-controlled devices truly ready for everyday situations. That is why Infineon and its voice user interface ecosystem partners — Aaware, CEVA, Creoir, SoundAI, Sugr, and XMOS — are leveraging their technological expertise to provide innovative reference platforms and ready-to-use next-generation voice user interface solutions (**Figure 5**).

BASIC TECHNOLOGY

MEMS microphones are fabricated in high volume using semiconductor production processes. The typical design combines a MEMS sensor and an ASIC. The sensor creates an electrical signal that is amplified for



Figure 5: Infineon and its voice user interface ecosystem partners — Creoir, XMOS, Sugr, CEVA, SoundAI, and Aaware (left to right, top to bottom) — provide innovative reference platforms and ready-to-use next-generation voice user interface solutions.

New Capacitive MEMS Design Boosts Audio Pickup Quality

analog microphones or processed by the ADC for digital microphones in the ASIC. The MEMS microphone, which converts the audio to an electrical signal, is basically a DC biased capacitor, in which movement of a membrane (or diaphragm) caused by audio pressure changes the voltage over a capacitor plate or plates.

The diaphragm and the backplate behave like a parallel plate capacitor. When the diaphragm vibrates due to incoming sound pressure, the gap and, therefore, the capacitance between diaphragm and backplate change. MEMS microphones extract these changes as electrical signals. The main challenge in handling the pressure level of loud sounds is the large mechanical movement of the membrane, which will cause distortion when the membrane is displaced to its extremes. The second challenge is to design the ASIC to handle the large signal that the MEMS element generates. As audio-processing algorithms assume a linear signal, any distortions above 1% can cause a significant reduction of the audio quality on which advanced audio processing relies.

One approach is to implement a MEMS sensor element that places the moving membrane between two capacitor plates (dual backplate). This produces a fully differential (compared to single-ended) output, which has several advantages. A dual backplate MEMS microphone minimizes distortion due to its symmetrical construction. The same effect is achieved by moving two membranes that sandwich the capacitor plate (dual membrane).

NEXT GENERATION OF PREMIUM MEMS MICROPHONES: SEALED DUAL MEMBRANE

Compared to MEMS microphones with a single backplate, the introduction of the dual backplate technology enabled a significant increase in linearity specifications. The next evolutionary step is capacitive MEMS

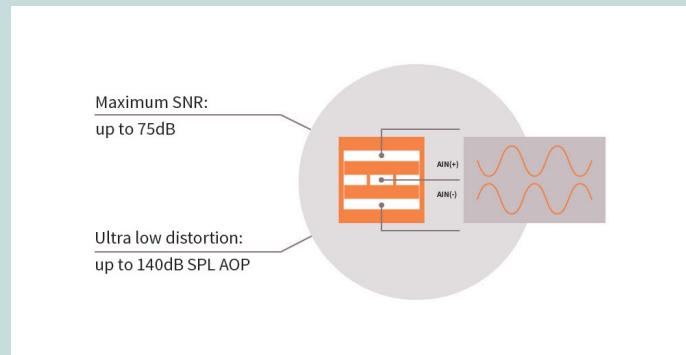


Figure 6: Infineon's new sealed dual membrane (SDM) technology

microphones with a sealed dual membrane (Figure 6). The sealing of the capacitance area enables practically noise-free audio signal capturing. The SNR is further increased from 70 dB up to 75 dB.

The first prototypes in 2018 have already achieved 75-dB SNR in a $4.0 \times 3.0 \times 1.2$ -mm package. The first premium MEMS microphones with the new sealed dual membrane design will be available by the end of 2019. The first devices of the new generation have already been used to demonstrate the advanced audio features discussed above. Engineering samples are already available for lead customers in the field for advanced audio recordings, active noise cancellation, communication, and voice user interfaces. In 2020 and 2021, Infineon will introduce further shrunk-sealed dual membrane microphones addressing devices with space constraints so that no matter where you are, you can be heard. ■

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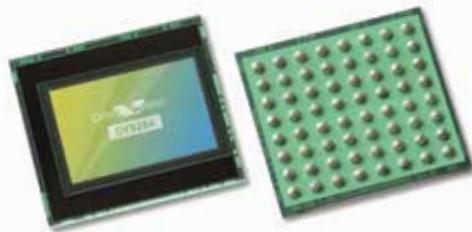
By Gina Roos

Vehicles are packed with sensors that measure pressure, temperature, position, speed, humidity, and occupancy, along with a growing number of sensors for advanced driver-assistance systems (ADAS) and cameras. Here, in no particular order, are 10 sensors for automotive applications that can help point you in the right direction for your next design.

1. OMNIVISION OV9284

GLOBAL SHUTTER IMAGE SENSOR

Hitting the mark for in-cabin monitoring adoption, the OV9284 1-megapixel global shutter image sensor from OmniVision Technologies Inc. delivers small size, low power consumption, and high near-infrared (NIR) quantum efficiency (QE). Aimed at new safety regulations for Level 3 semiautonomous vehicles, in which driver state monitoring (DSM) is used to track the driver's gaze, the OV9284 offers NIR QE of 12% at 940 nanometers (nm). Power consumption is 90 mW at 60 frames/second, or 30% lower than that of the nearest competitor, according to the company. The global shutter sensor with OmniPixel 3-GS technology offers $1,280 \times 800$ resolution at video speeds of up to 120 frames/s and is housed in a 5.237×4.463 - μm chip-scale package.



The OV9284 delivers high NIR quantum efficiency. (Image: OmniVision)

2. TDK IAM-20680 AND IAM-20680HP IMUS

TDK Corp., through its InvenSense subsidiary, offers a line of automotive high-accuracy microelectromechanical system (MEMS) motion sensors that can get a bead on vehicles in GNSS- and GPS-poor environments, such as tunnels, parking garages, and urban canyons. The "motion tracking" automotive-qualified IAM-20680 and IAM-20680HP six-axis inertial measurement units (IMUs) can help pinpoint the position, direction, and speed of a vehicle when the satellite signal is poor or nonexistent, as well as improve the quality of the position estimation when the satellite signal is strong, according to TDK.

The company touts the IAM-20680 as the smallest available six-axis automotive-qualified sensor (combining a three-axis gyroscope and a three-axis accelerometer) and says it is



The six-axis IAM-20680HP and IAM-20680 enable navigational driving through challenging environments. (Image: TDK)

the only device featuring 16-bit accelerometers and 16-bit gyroscopes that's in use in a series-production car today. The operating temperature range is -40°C to 85°C . If you're looking for a beefier and higher-temperature-range IMU, the IAM-20680HP, a high-performance version of the IAM-20680, offers an extended operating temperature range of -40°C to 105°C and high gyroscope and offset thermal stability. It is pin-, package-, and register-compatible with the IAM-20680.

The IAM-20680 and IAM-20680HP are designed into the new InvenSense Coursa Drive solution, inertial-aided positioning software for autonomous vehicle (AV) platform developers. The Coursa Drive is a high-performance extension of the InvenSense Positioning Library (IPL) and improves inertial-only vehicle positioning to $<0.2\%$ of distance traveled. Such precision is required for maintaining decimeter lane-level vehicle positioning in GNSS/perception system environments.

3. VISHAY VCNL4030X01

OPTICAL SENSOR

The Vishay Semiconductors VCNL4030X01 combines photodetectors for proximity and ambient light, a signal-conditioning IC, a 16-bit analog-to-digital converter (ADC), and a high-power infrared-emitting diode (IRED) in a $4 \times 2.36 \times 0.75$ -mm surface-mount package, saving board space and increasing design flexibility in multi-sensor applications. The AEC-Q101-qualified proximity and

ambient light sensor can be used in applications including mobile devices, smart homes, industrial, and automotive.

Using the company's Filtron technology, the sensor allows ambient light spectral sensitivity close to that of the human eye while offering excellent background light cancellation capabilities, according to Vishay. A programmable interrupt function can set both high and low thresholds to reduce overall power consumption.

The VCNL4030X01's built-in ambient light photodiode offers detection from 0.004 lux (lx) to 4.2 klx, letting the device operate in dark or high-transparency lens designs. The unit's proximity sensor uses intelligent cancellation to eliminate crosstalk. A smart persistence scheme offers a fast response time and accuracy when an object is detected. The device can detect objects at distances up to 300 mm.



The VCNL4030X01 combines photodetectors for proximity and ambient light, a signal-conditioning IC, a 16-bit ADC, and a high-power IRED in a surface-mount package. (Image: Vishay Semiconductors)

4. STMICROELECTRONICS VG5661 AND VG5761 GLOBAL SHUTTER IMAGE SENSORS

ST's VG5661 and VG5761 global shutter image sensors capture scenes as illuminated from the camera, eliminating external effects such as sunlight or street lighting to enhance vehicle occupant monitoring and improve driver-monitoring systems, particularly under near-infrared illumination close to 940 nm. The sensors can also be used in new feature applications such as assessing driver attention, passenger comfort, or child behavior.

The VG5661 and VG5761 respectively deliver 1.6-megapixel and 2.3-megapixel resolution. ST's automotive global shutter pixel is designed with two memory cells and a pixel size of $3.2 \mu\text{m}$, offering both a small size and higher resolution for sharper images, even in challenging conditions. The two memory zones deliver double-image storage for a linear high dynamic range up to 98 dB or background removal without lag effects.

10 Hot Sensors for Automotive

Global shutter image sensors for automotive in-cabin camera



The VG5661 and VG5761 are available in standard BGA packages or as bare dice for direct integration in automotive OEM systems. (Image: STMicroelectronics)

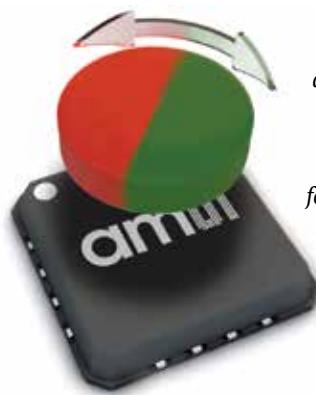
The architecture also eliminates the need for additional processing by the host system. A high dynamic range and high modulation transfer function at near-infrared wavelengths minimize interference from natural light sources. The sensors are qualified to the Automotive Electronics Council's AEC-Q100 grade 2 standard and include safety-integrity features required for an Automotive Safety Integrity Level ASIL-B camera system under International Organization for Standardization automotive safety standard ISO 26262.

5. AMS AS5200L POSITION SENSOR

Suited for safety-critical automotive applications that call for high accuracy, redundancy, and a small footprint, the AMS dual-die AS5200L magnetic rotary position sensor with an I²C interface is AEC-Q100 grade 1-qualified. Target applications include electrified powertrain drive-by-wire control functions, such as shift-by-wire for both traditional stick and rotary shifters and pedal applications.

The AS5200L offers inherent immunity to stray magnetic fields and thus delivers highly accurate and repeatable measurements in noisy magnetic environments, according to the company. The dice are in a stacked configuration, which means that they can be paired with a single small target magnet while providing identical measurement outputs from each die. Separate package pins for each die prevent an electrical fault in the device from affecting both dice.

The AS5200L automotive-grade sensor, housed in an MLF-16 package, is designed for shifter position detection in hybrid, battery-powered, and conventional vehicles. (Image: AMS)



6. TEXAS INSTRUMENTS AWR1642 MMWAVE SENSOR

Although introduced more than a year ago, automotive millimeter-wave sensors from Texas Instruments are still worthy of mention for ADAS applications that include long-, short-, and medium-range radar. The automotive-qualified and highly integrated, ultra-wideband AWR1642 mmWave sensors can also be used for detection of free space and obstacles near doors and trunks, occupancy detection inside the cabin, intruder alert, and smarter automated parking.

Operating over the 76- to 81-GHz band, the single-chip solution frequency-modulated continuous-wave (FMCW) radar sensor includes the DSP subsystem, which contains TI's C674x DSP for radar signal processing and an Arm R4F-based processor subsystem for radio configuration, control, and calibration. The chip is housed in a 0.65-mm pitch, 161-pin, 10.4 × 10.4-mm flip-chip BGA package. Software development kits, sample configurations, and other design resources are available to speed development time. A vehicle occupant detection reference design, for example, provides a system-level overview and software examples for using the AWR1642 sensor to detect vehicle occupants.

7. VELODYNE VELADOME, VELARRAY, AND VELLA

LiDAR sensors will be essential in ADAS and autonomous vehicles, but they pose some limitations, particularly in the areas of cost, range, and resolution. One company making significant headway in LiDAR sensor technologies for advanced driving safety systems is Velodyne LiDAR. Although product specs are lacking, it's worth looking at Velodyne's newest products: VelaDome, Velarray, and Vella.

Touted as the industry's first wide-field-of-view short-range sensor, the VelaDome is a small, embeddable LiDAR for near-object avoidance and blind-spot monitoring, providing an ultra-wide, 180° × 180° image and detecting objects as close as 0.1 m.

Vella, an ADAS solution powered by the directional view (day or night) Velarray LiDAR sensor, is expected to enable faster object identification and longer braking distance at highway speeds. Target applications include lane-keeping assist, automatic emergency braking (AEB), and adaptive cruise control.

8. ACEINNA IMU381ZA IMU

Integrated inertial sensing modules can deliver a number of sensing functions in one component, saving space and reducing the bill of materials as well as reducing cost and

development time. ACEINNA's six-degrees-of-freedom (with an optional, three-axis magnetic sensor) IMU381ZA can measure acceleration of up to 4 G, offers a 3-V to 5.5-V supply voltage, operates over a temperature range of -40°C to 85°C, and has a 24 × 37 × 9.5-mm footprint. Standard and high-range models are available. Evaluation kits are available for the IMUs.

9. QUANERGY S3 SOLID-STATE LIDARS

Quanergy Systems Inc. is betting that solid-state LiDAR will bring down the cost of LiDAR solutions. Because it has moving parts, Quanergy's S3-2 delivers high reliability while requiring less power, according to the company. Quanergy combines its S3 solid-state LiDAR sensor with its QORTEX object-profiling software to analyze 3D point cloud data for safety-critical functions such as object detection, tracking, and classification. The artificial intelligence software enables object detection based on data collected by one or more LiDAR sensors.



The 381ZA-200 delivers multiple sensing functions in a single, compact package.

(Image: ACEINNA)

10. VAYYAR 3D IMAGE SENSORS

Vayyar Imaging's 3D image sensors provide 360° sensing to know what's happening both inside and outside the car. The company's system-on-chip (SoC) for millimeter-wave 3D imaging integrates 72 transmitters and 72 receivers, plus an advanced DSP for high resolution and high accuracy. The SoC covers imaging and radar bands from 3 GHz to 81 GHz.

The chip doesn't require an external CPU for complex imaging algorithms. It can operate in every weather or light condition, which makes it suitable for automotive markets, according to Vayyar.

For 360° sensing in and around vehicles, the sensors can detect and monitor presence, location, posture, distance, vital signs, and obstacles. They can detect more than 150K points of interest per second. ■

Gina Roos is editor-in-chief of Electronic Products.

SECURITY

Japan to Hack 200 Million IoT Devices

By Junko Yoshida

The Japanese government this month is implementing a recently disclosed plan to hack more than 200 million internet of things (IoT) devices already installed in Japanese homes and elsewhere. Both proponents and critics of the plan acknowledge it is likely to expose the uncomfortable truth of the IoT's vulnerability to cyberattack.

Providers and users alike share some of the blame for that vulnerability. Too often, consumers don't bother to change the initial settings in an IoT device after purchase and installation. Peer-to-peer communication among IoT devices remains unchecked and unsupervised. And service providers aren't doing automated firmware updates frequently enough.

When it announced the plan late last month, the National Institute of Information and Communications Technology (NICT) said it would use default passwords and other tactics to attempt hacks of randomly selected IoT gear, seeking to compile a list of vulnerable devices. It plans to share its findings with internet service providers, which would be asked to alert consumers and secure the compromised devices. The government has not specified the targeted IoT equipment, but it will most likely start with routers and webcams. The NICT said the program could last for up to five years.

While security experts hail the Japanese government's plan as a necessary step, some Japanese media reports have called the approach heavy-handed. Critics say the hacks are a violation of citizens' privacy, and they don't trust the government to keep the collected data safe. Fearing that public-safety concerns are turning their country into a surveillance state, citizens are asking: Is Japan becoming China?

The government's rationale for its Orwellian escalation of public surveillance is that the world will soon be coming to Tokyo, host city for the 2020 Summer Olympics.

It is not unusual to see security experts and government agencies issue a flurry of cybersecurity alerts in the run-up to a major international event like the World Cup or the Olympics. The Mirai attack is also fresh in the national memory. In that case, malware turned networked devices running Linux into remotely controlled bots, which became a botnet for large-scale network attacks. Mirai's primary targets were online consumer devices such as internet protocol (IP)



With the Mirai malware attack fresh on their minds and the Summer Olympics headed to Tokyo in 2020, Japan's government and cybersecurity experts are on high alert.

(Image: tokyo2020.org)

cameras and home routers.

Tanner Johnson, a cybersecurity analyst focused on IoT and transformative technologies at IHS Markit, called the hacking plan "a simple proactive precaution." As Tokyo prepares for the Games, he said, the specter of an "influx of millions of individuals to the country raises some overall security concerns. Technologically naive or ignorant individuals can put tangential systems they may be connected to at risk if they are targeted."

"Hackers don't go after the strongest individuals within a connected group, as it is too much effort. They target the weakest members in order to infiltrate the entire herd."

Still, skeptics wonder whether the government has ulterior motives. "If this is to tighten security in the run-up to the Tokyo Olympics, I wonder why the government is saying that this program could last up to five years," Gaku Ogura, country manager of AnyConnect, told EE Times.

AnyConnect's platform lets device makers and service providers develop and manage IoT video devices, including connected and embedded cameras. Ogura acknowledged that in many cases Japanese consumers don't take the elementary steps to change the default passwords of their internet-connected devices.

Some critics have speculated that the real aim of the government project is to find out what's going on with the Huawei technologies used in network and network equipment.

While declining to predict all the contin-

gencies the hack might be intended to cover, Johnson said it would not be "not out of the question" for such a test to be designed "to collect data on specific devices or gaining in-depth analytics on the behavior of those devices."

David Uze, CEO of Trillium Secure Inc., told EE Times that his company "applauds the efforts and investment the Japanese government is making to protect its citizenry and audiences in preparation for the 2020 Olympics in Tokyo." Trillium, with a U.S. base in San Diego and operations in Japan, offers automotive cybersecurity and mobility solutions for connected and autonomous vehicles.

Uze believes other governments will mandate IoT device audits to safeguard connected and autonomous vehicles. "It is absolutely imperative that vehicles are certifiably safe and secure," he said.

IS JAPAN THE FIRST?

Indeed, Japan might not be the first nation to have undertaken random IoT device hacks, said cyber analyst Johnson. "I can think of dozens of nations that have likely already conducted similar tests," he said. "But they are unlikely to announce their efforts, as such acts are prone to result in backlash, and cries of government intrusion into personal privacy."

The Japanese government went so far as to change the law to ensure that the NCIT "survey" would not be illegal. But will the test be effective?

"If conducted properly — [if] the individuals with weak credentials are effectively notified and there is some measure of follow-up — a test such as this could be very effective at reducing the number of vulnerable devices in the region," said Johnson. But the "blowback" could extend beyond the "cries of intrusion of personal privacy," he said. "Additional concerns could be raised regarding the lack of 'consent' that is normally required for any type of penetration testing."

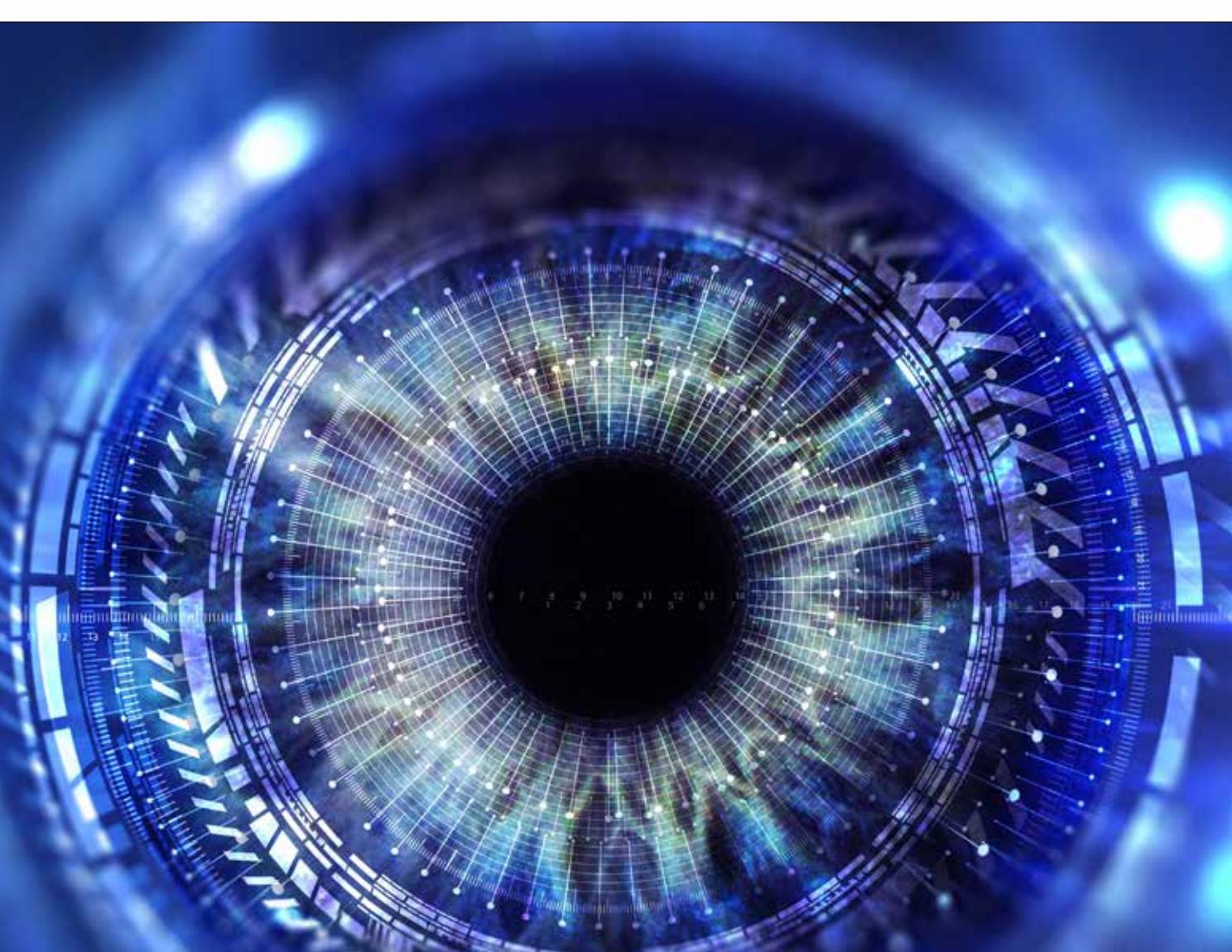
The impact on IoT chip and system suppliers will be negligible, said Johnson. "OEMs know many of their users have limited knowledge of security, with even less patience to maintain it, and so design their products to be connected as easily as possible," he said. "Even those manufacturers who have additional security measures installed on their devices ultimately require the end user to activate or utilize them."

If nothing else, the Japanese test is a good reminder that IoT users everywhere are sacrificing privacy for convenience. ■

Junko Yoshida is global co-editor-in-chief of AspenCore Media and chief international correspondent at EE Times.

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ARROW

COVER STORY:

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30

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VIEWPOINT

Embedded Intelligence: the New Frontier



IN THE 1990S, the annual global conference to go to for embedded systems was the Embedded Systems Conference in Silicon Valley, USA. How times have changed: The meeting point for the world's embedded community now, as it has been for a few years, is embedded world in Nuremberg, Germany, with over 32,000 visitors attending in 2018.

At last year's event, much of the focus was around concerns about internet of things (IoT) security and how that was pushing vendors to do more at the edge. The industry (or at least the suppliers) seems to have realized that any device or sensor with an IP address connected to a network may open the doors to a devastating security incident. In addition, latency issues mean that real-time or critical operations don't perform if they have to send data to the cloud and experience delays. That's why Vibhoosh Gupta, product management leader for GE Power's automation and controls business, told me at the show that they

were bringing intelligence as close to the machine as possible.

And that seems to have been an indicator of what was to come — in the last 12 months, there's been a huge progression in which everyone is now looking to address the need for embedded intelligence, which also happens to be the theme of this year's conference.

Like every tech trend we've seen over the years, embedded intelligence is the latest big thing that is supposed to

address all of industry's and society's problems: for automated driving functionality, predictive maintenance, and improved efficiency in factories and industrial equipment, intelligent buildings and homes, and more. While the marketing people try to push the hype and promise, the engineering world is more realistic and understands the real-world promise.

The keynotes at embedded world reflect this practicality: One will talk about developing game-changing embedded intelligence while the other will look at opportunities and challenges in developing embedded intelligence at the edge for the next wave of smart systems.

THE REALITY OF SMART EVERYTHING

As we move toward a world where we expect "smart everything," sensors and edge devices will have more embedded systems with integrated data processing, artificial intelligence, and analytics. Essentially, systems will have higher levels of sophistication, and how data is shared between the device and cloud will also evolve. At embedded world, the interplay of computing architectures, connectivity, intelligence, and security is likely to be a key focus.

It's this reality that we hope to understand more in the context of solving some of the grand challenges that the embedded systems design community will address.

See you in Nuremberg! ■

Nitin Dahad is a European correspondent for EE Times.

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COVER STORY

Smart Everything is Being Fueled by AI-Enabled Embedded Vision

By Nitin Dahad

The world is rapidly moving to a phase in which we expect “smart” everything. It started a few years ago with talk about smart cities, but more recently, there’s a finer granularity, with both technical and non-technical people exploring areas like smart mobility, smart energy, smart factories, smart agriculture, and smart homes.

Initially, the smart element was based on analyzing the sensor data for key parameters — whether it was temperature, humidity, vibration, or some other environmental factor. However, advances in computing power, especially at the

edge of networks, has meant that the vision element is also being added just because the images can now be interpreted using deep learning, one part of what is generally labeled as artificial intelligence (AI).

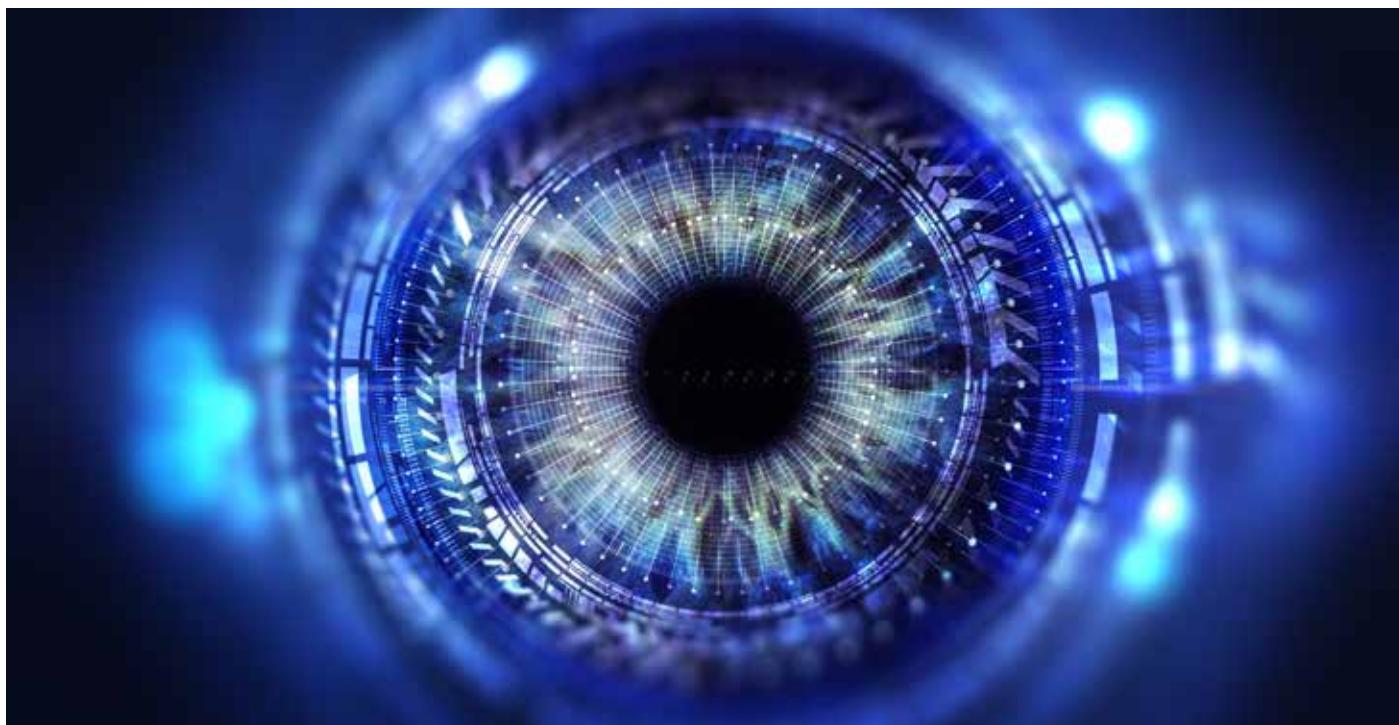
Not only that, but the huge progress that has been made in advanced driver-assistance systems (ADAS) and connected autonomous vehicles has meant that vision systems and

AI have made a huge impact in many other industries in addition to automotive. One example is Israeli startup VayaVision, which earlier this year launched a software-based autonomous vehicle environmental perception engine that upscales raw data from camera, LiDAR, and radar sensors to provide what it claims is a more accurate 3D model than object fusion-based platforms.

CEO Ronny Cohen told EE Times that today’s object-led fusion of sensor data is not reliable and can lead to objects being missed. Roads are full of unexpected objects that are absent from training data sets, even when those sets are captured while traveling millions of kilometers. He said that most current-generation autonomous driving solutions are based on object fusion, in which each sensor registers an independent object and then reconciles which data is correct. This can provide inaccurate detections and result in a high rate of false alarms and, ultimately, accidents.

EMBEDDED VISION IS MAJOR DRIVER OF AI

In a World Intellectual Property Organization (WIPO) technology trends report on artificial intelligence published in January 2019, among AI functional applications growing more rap-



Smart Everything is Being Fueled by AI-Enabled Embedded Vision



idly than others, it identified computer vision, which includes image recognition, as the most popular. Computer vision is mentioned in 49% of all AI-related patents (167,038 patent documents), growing annually by an average of 24% (21,011 patent applications filed in 2016). Those AI-functional applications with the highest growth rates in patent filings in the period 2013 to 2016 were AI for robotics and control methods, which both grew by an average of 55% a year.

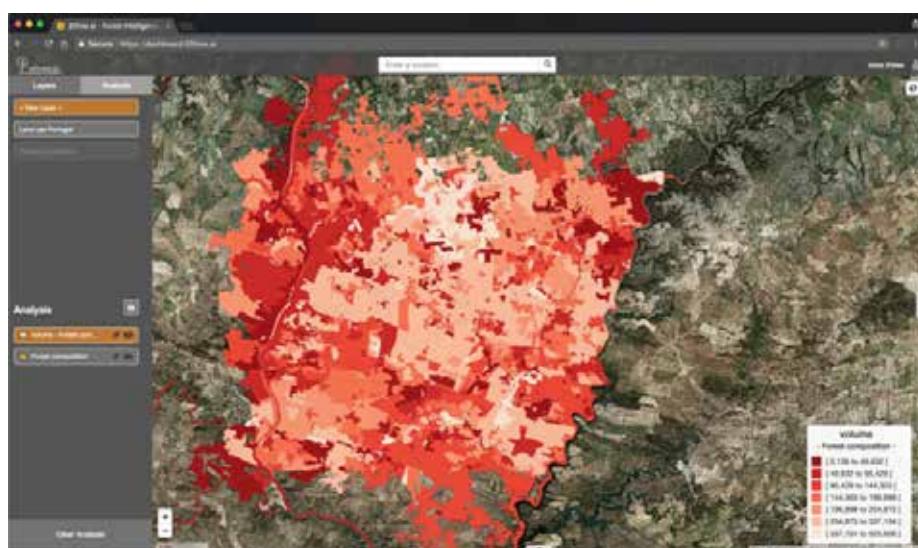
The combination of deep learning and computer vision is likely to have a huge impact in many application areas, including industrial, agriculture, medical imaging, and surveillance, to name just a few. The industrial machine vision systems market is projected to reach US\$14.11 billion by 2025, growing at a CAGR of 7.4% from 2018 to 2025, according to

an estimate from Verified Market Research.

Industrial vision systems comprise automatic image capturing, evaluation, and processing capabilities based on digital cameras, back-end image-processing hardware, and software. Applications in industrial include positioning, identification, verification, vibration, and flaw detection. Integration of embedded-vision systems into robotics is especially gaining strength, not just in industrial and manufacturing but also consumer, military, health care, and government.

AI VISION TO GUIDE DEREPLICANT SATELLITES

There's no limit to the scope for embedded vision. Stanford University professor of aeronautics and astronautics Simone D'Amico is looking at developing an AI-powered navigation system to direct spaceborne "tow



20tree.ai uses AI and NVIDIA GPUs to analyze satellite images of forestry and other spaces. (Image: 20tree.ai)

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Smart Everything is Being Fueled by AI-Enabled Embedded Vision

“trucks” designed to restart or remove derelict satellites circling aimlessly in graveyard orbits. His Space Rendezvous Lab (SLAB) is working with the European Space Agency (ESA) to spur development of an AI system to direct the orbital equivalent of a tow truck. They launched a competition for an AI system that would identify a derelict satellite and, without any input from Earth’s assets, guide a repair vessel to navigate alongside to refuel, repair, or remove it.

The navigation system that D’Amico has in mind would be inexpensive, compact, and energy-efficient. To spot defunct satellites, the repair vehicle would rely on cameras that take simple gray-scale images, just 500×500 pixels, to reduce data storage and processing demand. Barebones processors and AI algorithms that come out of the competition would be integrated directly into the repair satellite. No ground communication would be required. The goal is simplicity: processors and algorithms that require low-resolution images and limited computation to navigate space. Essentially, the spacecraft would have to able to see and think for itself.

KEEPING FORESTRY IN CHECK

Bringing things back to Earth, forestry and agriculture is an area where embedded vision and AI comes into its own. Countries like New Zealand have long been utilizing IoT technology to improve agricultural operations and yield.

The addition of vision capability and the ability to analyze images adds a new dimension. Portugal-based 20tree.ai, part of NVIDIA’s Inception startup program, is combining AI and satellite imagery to analyze entire forests in a fraction of the time currently required. Using GPUs running in-house and in the cloud via AWS and Google, it feeds satellite data into its proprietary deep-learning algorithms to create highly accurate insights and reveal patterns not visible to the human eye. The total amount of satellite data that is captured on a daily basis exceeds tens of terabytes, so the ability to make sense of that data using massive computing power is essential if it is going to be of any use for

both non-governmental as well as commercial organizations.

CROWD COUNTING AND PEOPLE RECOGNITION

Part of the proposition of vision and AI systems in smart cities is people counting and crowd monitoring. Not even getting into the issues of privacy (which is another debate altogether), one of the challenges here is how to accurately count the number of people in still images — for example, with issues like occlusion, in which images contain only partially visible people, and handling different scale, wherein people in near and far field of sight need to be taken into account.

Arrow Electronics’ company eInfochips has developed a new 96Boards based on NXP’s latest i.MX8M Quad Arm Cortex A53 with Neon instructions and Arm Cortex M4 core; Arrow’s engineering solution center software team has ported and updated the development of its edge AI machine vision deep neural network that runs on this new board. It executes a multi-column deep neural network consisting of multiple convolutional neurons with pooling and ReLU activation functions. The network is trained using the ShanghaiTech dataset that is openly available.

This type of solution has application in multiple areas, such as human flow monitoring and traffic control as part of a smart city solution or at airports and for overcrowding avoidance to ensure safety for events. Another potential application is in smart retail to identify customer points of interest.

READY-MADE MODULES WITH WORKSTATION PERFORMANCE FOR THE EDGE

For deployment of advanced AI and computer vision to the edge, NVIDIA has an embedded module solution for developers, the Jetson AGX Xavier. This can enable robotic platforms in the field with workstation-level performance with the ability to operate fully autonomously without relying on human intervention and cloud connectivity. Intelligent machines using these modules can be developed to freely interact and navigate

safely in their environments, unencumbered by complex terrain and dynamic obstacles, accomplishing real-world tasks with complete autonomy.

This can include actions like package delivery and industrial inspection that require advanced levels of real-time perception and inferencing to perform. The Jetson AGX Xavier module delivers GPU workstation-class performance with 32 TeraOPS (TOPS) of peak compute and 750 Gbps of high-speed I/O in a compact 100×87 -mm form factor. Users can configure operating modes at 10 W, 15 W, and 30 W as needed for their applications. This gives it the performance to handle visual odometry, sensor fusion, localization and mapping, obstacle detection, and path-planning algorithms critical to next-generation robots.

This and other AI-enabled embedded-vision solutions will be in abundance at the embedded world conference in Nuremberg, Germany, and Arrow Electronics will be showing several of the solutions mentioned in this article. More details and products being showcased may be found online at arrow.com/ew2019. In addition, all of the products mentioned in this article are available at arrow.com. ■



The NVIDIA Jetson AGX Xavier embedded compute module with thermal transfer plate (Image: NVIDIA)

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EMBEDDED VISION

Embedded Vision, Edge AI Drive Smart Industry

By Nitin Dahad

Smart technology is taking hold in virtually every sphere, from public infrastructure and transportation to industry, agriculture, and the home environment. Smart systems rely on sensors to detect the data from which actionable intelligence is derived. Increasingly, these sensors include embedded vision to capture images for inspection, monitoring, and analysis — for example, to spot product defects on a manufacturing line, survey farmland via drone cameras, or enable autonomous vehicles.

The first deployments of the internet of things (IoT) sent the captured images and other data to the cloud for processing. But as concerns rise over security risks and latency, processing is moving to the network edge, where embedded computing systems provide the artificial intelligence (AI) needed to act on the data coming from embedded vision systems.

According to Yole Développement, the largest market for embedded vision is industrial vision systems. In the autonomous robotic vehicle segment alone, Yole expects 140% growth in embedded vision over the next four years. In the more fragmented market for PC- and board-based camera technologies, standardized commercial-off-the-shelf (COTS) offerings with guaranteed long-term availability open up additional market opportunities for embedded vision.

Here, we look at some recent releases that enable embedded vision and edge AI in smart industry systems.

PLUG-AND-PLAY MODULES

One company focusing on the fusion of embedded computing and embedded vision, including AI and deep learning, is congatec. The company's application-ready OEM components, which congatec says integrate into systems with the same ease as standard USB devices, offer unified application programming interfaces (APIs), general-purpose GPUs (GPGPUs), and AI compatibility. Offerings include an automotive infotainment platform, a vision-based AI platform, a facial recognition system, and industrial IoT (IIoT)-ready systems.

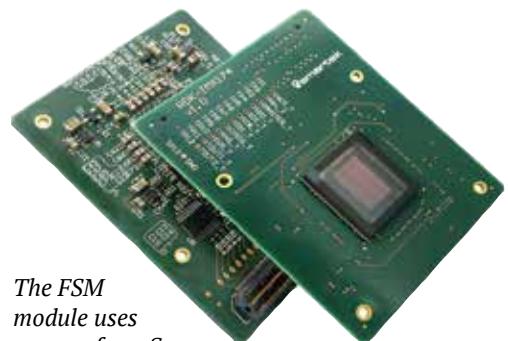
For automotive infotainment systems, congatec co-developed a platform with Intel and Luxoft that enables smart digital-cockpit designs for next-generation vehicles. The platform allows the clustering of functions that previously were managed separately, such as head unit display, cockpit occupant

monitoring, and advanced driver assistance systems (ADAS). Its conga-SA5 module uses a SMARC 2.0 computer-on-module that is scalable for designs ranging from low cost to premium performance, with a low non-recurring engineering (NRE) cost for the core. SMARC, or the Smart Mobility Architecture, is a Standardization Group for Embedded Technologies (SGET) standard.

A conga-TR4 module-based platform for AI-based vision systems targets the seamless integration of GPGPU technologies. The platform uses AMD Ryzen embedded V1000 processors and an open-source smart-vision ecosystem based on tools and frameworks such as TensorFlow, Caffe, and Keras, as well as the open-source ROCm platform for GPGPU applications. This enables knowledge-based AI and deep learning to be implemented using OpenCL 2.2, which simplifies writing parallel programs, according to the company.

For facial detection and recognition, congatec has teamed up with Basler to provide a smart embedded image recognition platform based on Basler's USB 3.0-compliant dart camera module and the conga-PA5 Pico-ITX board, with fifth-generation Intel Atom, Celeron, or Pentium processors.

For IIoT intelligence, smart cameras based on the Mobile Industry Processor Interface Alliance's Camera Serial Interface (MIPI CSI-2) bring video analytics and AI for decision-making to the network edge. Typical smart-camera applications at the IIoT edge include industrial and medical imaging, situational awareness and video surveillance systems, intelligent-vehicle functions, augmented reality for maintenance opera-



The FSM module uses sensors from Sony and ON Semiconductor. (Image: FRAMOS)

tions, gesture-based controls, and biometrics recognition.

A MIPI CSI-2 rugged smart-camera kit from congatec enables evaluation and deployment of MIPI-CSI-2-based camera analytics in harsh industrial, outdoor, and in-vehicle environments. Built with COTS components, the product includes the building blocks for a smart-camera solution and can be customized to support new applications and features. It is optimized to run Leopard Imaging's MIPI CSI-2 camera, based on ON Semiconductor's AR0237 HD sensor, together with a rugged conga-PA5 Pico-ITX single-board computer based on Intel Atom E3900 processors for extended temperature ranges.

IMAGE SENSOR MODULES AND FPGA CORES

FRAMOS Technologies pairs its own products with image sensors from Sony and ON Semiconductor to offer a modular approach to embedded vision development, providing elements ranging from sensor modules and processor adapters to field-programmable gate array (FPGA) intellectual-property cores. It offers ready-to-use solutions based on a variety of processors and platforms, including Nvidia's Jetson and Qualcomm's DragonBoard. And its SLVS-EC RX IP core for Xilinx FPGAs can be used with sensors based on the Scalable Low-Voltage Signaling Embedded Clock interface.

The company's FSM series sensor modules place Sony and ON Semiconductor sensors on a printed-circuit board with a standardized connector and the appropriate circuit conditioning to get the sensor up and running quickly. The modules have a 26.5 × 26.5-mm footprint, connect via a Hirose 60-pin connector on the bottom side, and have four mounting holes. The FSM series offers two M12 lens options as well as a broad range of sensor



The conga-TR4 module. (Image: congatec)

Embedded Vision, Edge AI Drive Smart Industry

Sony's new image sensors for high-end machine vision and intelligent transport systems. (Image: FRAMOS)

options, from VGA up to 12-megapixel resolution. The sensor modules are ready to be integrated with other mating ecosystem components and can capture images immediately.

FRAMOS also supports Sony Semiconductor Solutions' portfolio of image sensors for high-end machine vision and intelligent transport system (ITS) applications. Sony's IMX387, IMX367, and IMX342 are second-gen-

eration CMOS global shutter (GS) sensors based on Sony's Pregius GS technology. They provide a resolution range between 16 and 31 Mpixels, offer speeds up to 56 frames/second at full resolution, and are equipped with Sony's SLVS-EC high-speed interface running up to 19 Gbits/s. The three share a pixel pitch of 3.45 µm and provide high sensitivity.

The sensors support the need for imaging cameras with excellent resolution and image quality as well as high-speed bandwidth and flexible capture modes for automated production lines, speed detection/enforcement, and traffic monitoring. FRAMOS helps developers integrate the sensors in designs for specific applications and projects, including providing customization support.

MACHINE VISION SOFTWARE

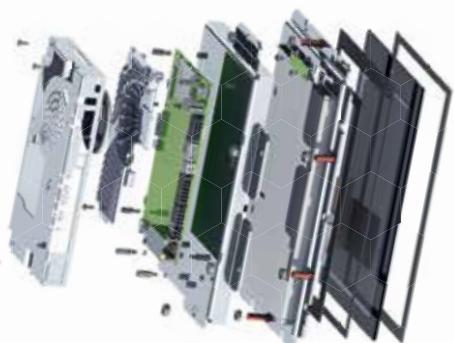
Software for building smart-camera machine vision applications includes MVTec Software's MERLIC 4, which allows different machine vision tasks to be performed in parallel on Windows-based PC and embedded platforms. The company says its user-friendly software allays industry concerns about the usability of



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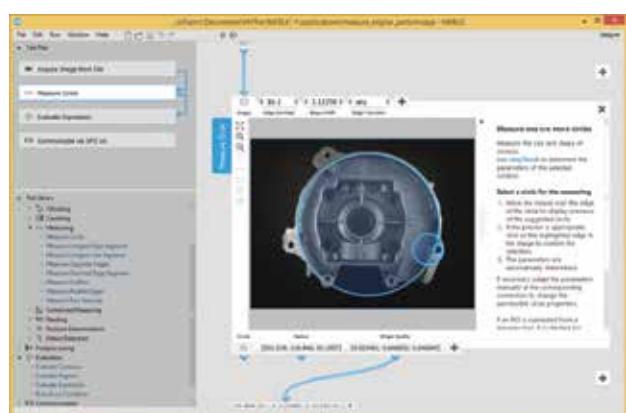
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MERLIC a product of MVTec

MERLIC communicates with common fieldbus and real-time Ethernet protocols for industrial control. (Image: MVTec)



MERLIC's image-centered user interface provides a tool library (left) for standard vision tools, such as acquisition, calibration, alignment, measuring, counting, checking, reading, position determination, and defect detection.

(Image: MVTec)

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Embedded Vision, Edge AI Drive Smart Industry

machine vision software in IIoT applications. Parallel processing and execution of different tools can simplify the implementation of multi-camera setups and enable more efficient use of a system's computing power, according to MVTEC. The software offers 3D vision tools to enable height imaging so that users can read embossed text, for example, and perform other 3D machine vision tasks. The MERLIC tools include the ability to prepare images from 3D sensors or 3D cameras so that subsequent inspections can be carried out using existing 2D tools. The software can communicate with common fieldbus and real-time Ethernet industrial protocols, such as PROFINET and Ethernet for Control Automation Technology (EtherCAT), via PC cards from Hilscher. This makes it possible to seamlessly integrate machine vision systems running MERLIC with a programmable logic controller (PLC).

READY-TO-GO SMART CAMERA

ADLINK Technology uses the MERLIC software in its NEON-1021-M Intel Atom processor-based ready-to-go smart camera. The quad-core smart camera for machine vision development features 2-megapixel global shutter image sensors and pulse-width modulation (PWM) lighting control support. High-speed multi-barcode capture via multiple-regions-of-interest (MROI) imaging

shortens image-processing cycle time. Optimized I/O includes an additional slave GigE Vision camera connection, 4x isolated input, 4x isolated output, and VGA output for maximized integration with external devices. With an IP67-rated housing and M12 connectors, the NEON-1021-M can withstand harsh industrial environments.

AI FOR DEPTH SENSING

Smart cameras with depth-sensing capabilities are critical for facial identification accuracy and precise object recognition, tracking, and measurement. Adding depth sensing to robots, drones, and autonomous vehicles dramatically improves the machines' ability to navigate, save, and reconstruct spaces in 3D, making them more autonomous.

VIA Technologies and AI vision startup Lucid have developed an integrated AI software and hardware solution to bring AI-based depth-sensing capability to dual- and multi-camera devices for security, retail, robotics, and autonomous-vehicle applications. The proprietary Lucid 3D fusion technology embedded in the VIA edge AI 3D developer kit enables the capture of accurate depth and 3D images while reducing costs, power requirements, and space consumption compared with emissions- and laser-based hardware depth solutions, according to the companies.

The AI depth solution in the VIA kit runs



The AI depth solution in the VIA kit runs Lucid's proprietary 3D fusion technology on a Qualcomm embedded processor.

(Image: VIA Technologies)

on the Qualcomm APQ8096SG embedded processor, which pairs the Qualcomm AI Engine with support for multiple cameras to deliver what the companies say is a unique, purely machine-learning-based software solution that speeds system scaling and deployment compared with previous approaches. ■

Nitin Dahad is a European correspondent for *EE Times*.

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embedded world PREVIEW

embedded world Preview: All Facets of Embedded Technologies on Show

From Feb. 26 to 28, embedded world Exhibition & Conference in Nuremberg will offer the opportunity to obtain information about new products and innovations, enter into an exchange, and maintain and develop valuable contacts.

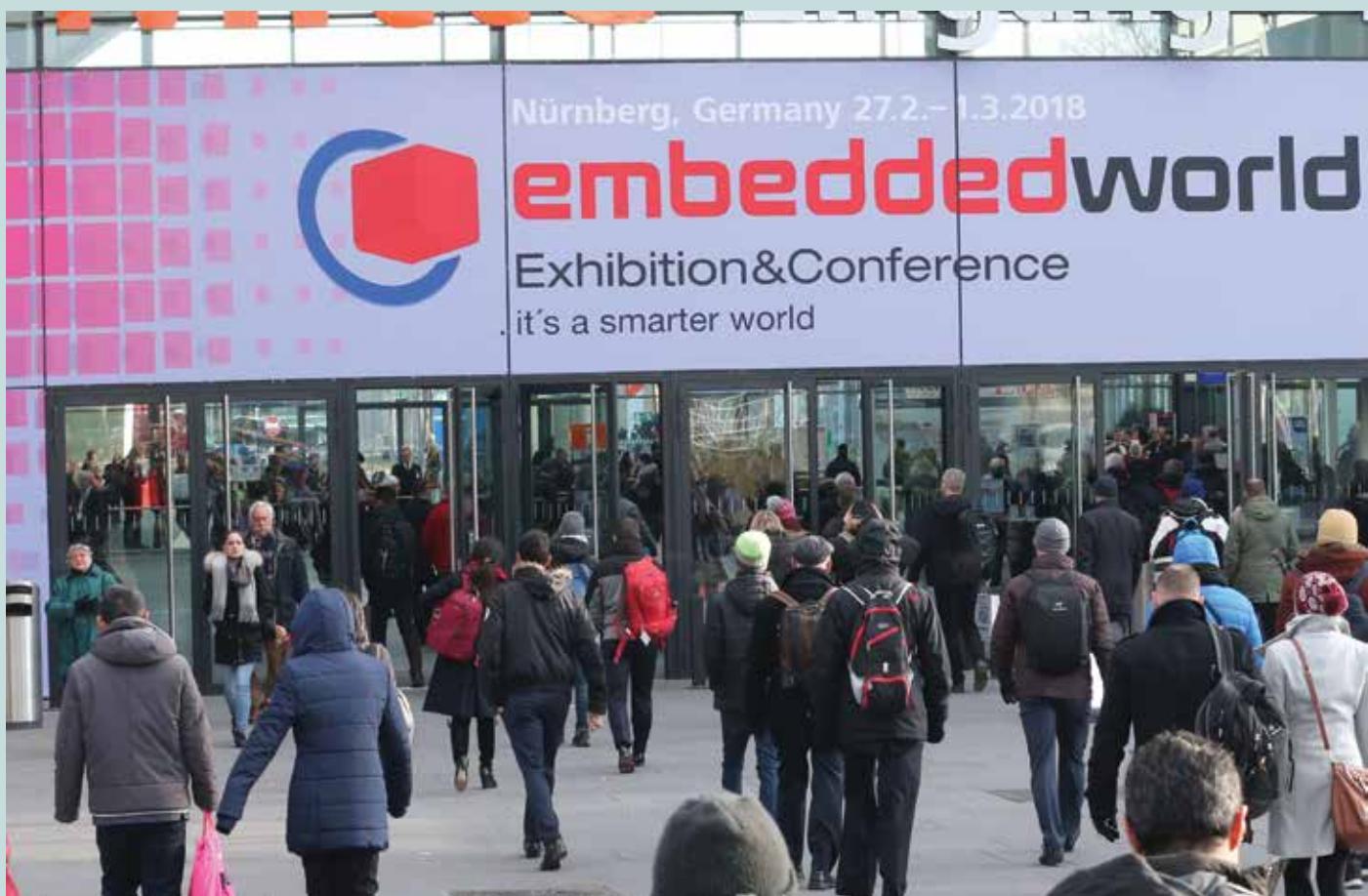
At embedded world 2019, more than 1,000 exhibitors will present state-of-the-art technology in all facets of embedded technologies from construction elements, modules, and complete systems to operating systems, hardware, and software tools to services covering all aspects of embedded systems. Last year, 32,217 embedded world visitors gathered information from a total of 1,021 exhibitors. Ninety-five percent of the exhibitors reached their most important target groups during embedded world.

There are some new features at this year's embedded world. "To make it even easier to get visitors to the exhibitors' stands, there will be an additional entrance to Hall 3A that is readily accessible from the

car parks and also one of the regular stops on the shuttle bus route," says Benedikt Weyerer, exhibition director of embedded world at NürnbergMesse. Moreover, in addition to the established discussion platforms "Safe for the Future" and "Embedded Vision," there will be two new panels on the topics "RISC-V" and "Embedded Intelligence." The discussions among high-caliber professionals take place in the exhibitor forums.

SAFE FOR THE FUTURE

The issues of safety and security do not just play a major role in the panel discussion and congress but are also at the heart of the trade fair





action. In the special "Safety & Security Area" in Hall 4A, visitors can find out how embedded systems can be protected from attack, how attack-proof hardware and software for embedded solutions are designed, and how attack routes are monitored in the embedded sector.

"Safe for the Future" is the theme of the panel discussion on Feb. 27. It will cover aspects of the safety and security of embedded systems and the protection of computers and communication channels. The key topic is the protection of networked embedded systems in the internet of things. A particular focus of the discussion will be how the differing requirements of data protection (security) and functional security (safety) can be combined with one another and the measures that can be taken to achieve both objectives.

The panel discussion on this topic, moderated by Professor Peter Fromm from the University of Darmstadt, will hear from three outstanding experts: Professor Peter Liggesmeyer, Scientific Director of the Fraunhofer Institute for Experimental Software Development (IESE) in Kaiserslautern; Thomas Pilz, Managing Partner of safety specialists Pilz GmbH & Co. KG in Ostfildern; and Nigel Stanley, Chief Technology Officer, Operational Technology and Industrial Cyber Security CoE at TÜV Rheinland.

PREMIERE: STARTUP AREA

For the first time, there will be a startup area at embedded world. The special presentation area at the heart of the trade fair offers young companies an opportunity to present themselves to the international embedded community. The startup area is located in Hall 3A, one of the newest halls at the Nuremberg exhibition venue.

"Our trade visitors want more fresh ideas from young innovative companies, and that's exactly what we are giving them by creating the startup area for the next embedded world," says Weyerer. "Already, we are more than satisfied by the number of young entrepreneurs who have registered. This clearly shows us that the already very innovative and agile embedded sector offers great potential to startup founders."

EMBEDDED INTELLIGENCE

The performance of processors and integrated circuits has improved so much and they have become so inexpensive that new technologies like machine learning and artificial intelligence are finding their way into an increasing number of applications. This opens up the possibility of totally new systems that independently perceive their environment, formulate conclusions, and make decisions. The embedded world conference reflects this trend with the motto "Embedded Intelligence," which takes up the title of one of its precursors from the 1990s. These technologies that were once only a dream have since become a reality.

The high points of the conference are always the two keynotes. This year's keynote speakers are two industry experts who approach embedded intelligence from very different angles: Jim Tung, MathWorks Fellow, and Jean-Marc Chery, President and CEO of STMicroelectronics. On Feb. 26, Jim Tung will speak about "Developing Game-Changing Embedded Intelligence." In particular, he'll focus on how algorithmic expertise and domain-specific knowledge must be combined to maximize the added value created by systems and products. This global approach, in conjunction with dynamic changes in the

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embedded world Preview

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market, presents developers with ever-greater challenges.

On the second day of the conference, Jean-Marc Chery's keynote will focus on "Embedded Intelligence for the Next Wave of Smart Systems — Opportunities and Challenges on the Edge." He will demonstrate the continued role of the embedded system in the field, on the edge. Not all data will be moved to the back end, to the cloud, but an optimal balance needs to be found between the computer, storage, and communication resources.

electronic displays CONFERENCE

"The electronic displays Conference is the most important European B2B platform for display technologies," explains Prof. Dr. Karlheinz Blankenbach, Pforzheim University and Chairman of the conference board. "It's the central dialog and sector platform for high-caliber expertise, presented by experts for experts. What makes this conference so special is the exchange of information on a high professional level. This is the place where innovations are presented and new projects launched." From Feb. 27 to 28, developers, scientists, and users of electronic displays will be able to learn about the latest display technologies, including LCD, touchscreens, optical bonding, display systems, and promising HDR technology.

Highlights in 2019 include keynotes on display trends and micro-LEDs, four sessions on automotive displays, and additional high-caliber sessions on measurement technology and e-signage as well as applications and optimizations. The author interviews have become a fine conference tradition. After each session, they provide an excellent opportunity to discuss the information just received in a small group. Displays are a central and important

topic not just at the conference but also in the exhibition halls. The electronic displays area in Halls 1 and 3A provide a platform for state-of-the-art technology relating to all aspects of LCDs, OLEDs, ePaper, touchscreens, interfaces, display solutions, and much more.

STUDENT DAY

Student Day is taking place for the 10th time. The crowning touch on the third day of the fair will be the presentation "Maps as Collective Brains for Vehicle Automation" by Dr. Ralf G. Herrtwich, Senior Vice President Automotive, HERE Technologies — SVP Services Group & Site Lead Berlin. His address will explore the development of navigation systems, which, as a result of automated driving, now need to be tailored to the vehicle's systems rather than the driver. This calls for highly accurate and consistently current data. Using their sensors, cars themselves can provide this detailed 3D information in real time. This process creates a "collective brain."

Yet again, more than 1,000 university students from embedded-related courses are expected in Nuremberg. As well as bus transfers, two lectures, and a visit to the trade fair, students also get the opportunity to get to know the embedded community and come into contact with potential employers.

The exclusive special program at Student Day brings together undergraduates and exhibiting companies. It's where future engineers will have the opportunity to get to know specialists from the sector. The students are brought to Nuremberg by bus free of charge by their respective universities. On arrival, they are welcomed by Professor Axel Sikora, who will introduce them to the embedded sector and the embedded world event. Fol-



Following Dr. Herrwich's lecture, the students can look forward to a foyer exhibition, where selected companies are waiting to chat to the next generation of experts. The visit to the trade fair in the afternoon is also free of charge for the students. A separate trade fair guide will ensure that the students find their way to the stands of the event's sponsors.

FREE EXHIBITION TICKETS

Using the voucher code *ew19web*, trade fair visitors can already secure their free ticket to embedded world 2019. The code can be redeemed at www.embedded-world.de/gutschein. After registering, you will immediately receive an electronic ticket for fast, direct access to embedded world. ■

embedded world NEWS

DATA MODUL to Showcase Everything about Embedded

DATA MODUL presents a wide range of Arm- and x86-based embedded solutions in all form factors and performance classes at embedded world: from the computer-on-module itself to a pre-configured kit consisting of embedded board, display, adjusted cable set, and specific OS image. Within a very short time, the development team was able to realize customer-specific baseboards or operating units with integrated CPU board, display, and touchscreen solutions. Their own developed "eMotion" LCD controller boards and display control kits cover the complete range of embedded visual solutions and can also be seen in Nuremberg.

DATA MODUL increases its commitment in the field of embedded computing and expands its modular embedded PC solutions portfolio. The growing demand in the market also plays a decisive role. The in-house developed products enable DATA MODUL to define its own standards and to implement individual, customer-oriented embedded solutions flexibly and promptly.

At embedded world, DATA MODUL will be showing the i.MX6 CPU-based eDM-SBC-i. MX6-PPC board, with which extremely slim Panel PC solutions can be realized. The portfolio of the eMotion series includes LCD controller boards and display control kits as well as the latest UHD II, NT2:3, and NT1:3. It covers the complete requirements of embedded solutions and was developed especially for the industrial sector. In addition, DATA MODUL will present various COM Express modules based on current Intel Apollo Lake and Coffee Lake platforms. ■

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New Release of Parasoft C/C++test — Most Comprehensive C/C++ Development Testing Solution for Safety and Security

At embedded world in Hall 4, Booth 378, Parasoft will be demonstrating the new release of Parasoft C/C++test, which now offers the most comprehensive C/C++ development testing solution on the market for safety and security, including support for CERT C/C++, CWE, MISRA, JSF, AUTOSAR, and UL 2900. Along with its unparalleled coverage for industry coding standards, Parasoft will be showcasing its innovative approach to compliance reporting and risk assessment. Their unique approach saves development time and helps organizations establish a sustainable compliance process with dynamic, industry-specific compliance dashboards and reporting widgets that automatically generate compliance documentation adhering to the categorizations of the specific coding standards required for code audits. With Parasoft C/C++test, organizations can now benefit from a single tool for development testing best practices, security and safety compliance, and conformance documentation and reporting.

The solution addresses various markets such as aerospace and defense (with support for DO 178 B/C), automotive (with support for ISO 26262), industrial automation (with support for IEC 61508), medical devices, rail (with support for EN 50128), and security.

Its highlight features are:

- The best coverage for industry coding standards. Parasoft provides the most comprehensive compliance solution that supports all import-

ant industry coding standards like MISRA, AUTOSAR, JSF, UL2900, and HIS, including security standards like CERT C, CERT C++, or UL2900.

- Compliance packs with dedicated compliance reporting. Compliance packs enhance the core functionality of C/C++test by enabling users with industry-specific rule sets and provide dedicated compliance reporting. Interactive dashboards and widgets designed for specific industry guidelines help in managing compliance processes and automatically generate compliance documentation.

- Support for functional-safety software development. Parasoft's C/C++test is TUV-certified for ISO26262, IEC61508, and IEC 62304 and supported with an automated qualification kit, which streamlines all of the steps required for the qualification procedure, including automatic generation of qualification documentation.

LEARN MORE AT THE EMBEDDED WORLD EXHIBITION

In addition to the booth (Hall 4, Booth 378), Parasoft will showcase its expertise in navigating the world of security and compliance at the session "Navigating the Jungle of the Secure Coding Standards" at Embedded World Conference (Tuesday, Feb. 26, 10 a.m.) and at the vendor session "Accelerating MISRA and CERT coding standards compliance with dedicated reporting and workflow management" (Tuesday, Feb. 26, 1:00–1:30 p.m.). ■

CONTRIBUTED BY PARASOFT

Identify the Perfect Memory Solution for Your Requirements

At embedded world 2019, the 100% memory-specialized distributor MEMPHIS Electronic will be focusing on products from its wide line card with over 20 manufacturers. Visitors of Booth 441 in Hall 1 can benefit from the extensive expert knowledge of the MEMPHIS team to identify the perfect memory solution for their requirements. Beyond an expert knowledge in memory and technically versed support, customers benefit from design-in and cross-reference expertise as well as obsolescence management and global supply chain/inventory management service offerings.

The company has a longstanding history in memory distribution and expert knowledge in memory module manufacturing. MEMPHIS designs and manufactures high-quality industrial memory modules using fixed and fully traceable BOMs. Sourcing and manufacturing are backed by certified Quality and Environmental Management processes (ISO 9001 and ISO 14001). This combination produces high-reliability, superior-quality modules for extremely demanding applications including industrial, networking, aerospace, defense, and test/measurement.

OWN NAND FLASH PRODUCT LINE LAUNCHED

This manufacturing expertise has been leveraged for starting NAND flash business: At the end of 2018, MEMPHIS Electronic launched its own NAND flash product line. The product portfolio includes SSD in various form factors, CF and CFast Cards, SD/uSD, and USB drives. All are available in both commercial and industrial temperature ranges and



WE KNOW MEMORY

in all standard densities.

The new line of MEMPHIS NAND flash provides a solution to customers who would prefer to maintain current designed-in density products. The MEMPHIS SLC and MLC NAND-based products are available in traditional densities and form factors. This expanded spectrum of products delivers fail-safe industrial-grade flash memory solutions for safety-critical and highly demanding applications.

MEMPHIS's philosophy is to ensure on-time volume deliveries of technology based on the solution qualified by the customer, not as dictated by the major flash manufacturers' business models. MEMPHIS has longstanding relationships with suppliers and has delivered value through many market cycles.

Whatever product interest or memory need you bring along, come and talk to us at embedded world 2019 in Nuremberg, Germany. ■

CONTRIBUTED BY MEMPHIS

Creating High-Quality PCB Prototypes with the Technology of the Future

With its new product generation, LPKF Laser & Electronics AG makes the development and production of sophisticated PCB prototypes even faster and easier. LPKF's new products will be shown for the first time at embedded world 2019 in Hall 3A, Stand 238. Electronics developers who implement complex applications or use new materials will benefit from both the two new ProtoMat circuit board plotters and the new ProtoLaser ST laser machine. All systems are fully automatic, precise, and quick and do not require elaborate etching technology.

FULLY AUTOMATED CIRCUIT BOARD PLOTTERS

Whether it's the standard "all-rounder" LPKF ProtoMat S64 or the LPKF ProtoMat S104 for HF applications, the fully automatically operated circuit board plotters with high milling spindle speeds guarantee production of fine structures up to 100 µm. Easy operation is a key feature and operating times are reduced through automatic tool change, camera-controlled fiducial recognition, and integrated milling width control. The system software enables fast and flexible layout adjustments. Thin laminates and substrates with sensitive surfaces may be processed by



the LPKF ProtoMat S104 thanks to its vacuum table and high-performance spindle with up to 100,000 rpm. The system software covers the special requirements of HF materials.

LASER OPERATION FOR GENTLE MATERIAL PROCESSING

The LPKF ProtoLaser ST processes precisely and at high speeds standard FR4 PCBs as well as PCBs made of sensitive HF materials and with sensitive surfaces. Compact as it is, this tabletop system fits through any laboratory door and requires only a power socket and compressed air for operation. The highly specialized laser system with optimally programmed software realizes exact geometries, secures process results, and enables a short time to market. The laser system is ideal for structuring single- or double-sided PCBs, antennas, filters, and many applications in which sharp edges are required. Desired layout changes and associated iteration steps can be implemented flexibly and quickly. Accurate positioning for processing the pre-drilled and cut-out PCBs ensures exact results.

To find out which of the LPKF machines is best suited for a special application, contact LPKF at the trade fair or at www.lpkf.com. ■

embedded world NEWS

Würth Elektronik eiSos to Present New Components for Smart Systems

Würth Elektronik eiSos presents a wide variety of new electronic and electromechanical components at embedded world and provides the first insights and outlooks on its new product family sensors: temperature sensors, absolute and differential pressure sensors, and three-axis acceleration sensors. Moreover, the proprietary module Thebe II, the Wi-Fi module Calypso, and the Bluetooth module Proteus II represent the next step toward digital communication.



The wide bandwidth and high performance of the MagI³C power modules from Würth Elektronik eiSos are represented by MagI³C-VDRM (Variable Step-Down Regulator Module). The compact step-down converter scores with integrated inductor and capacitors. Capacitors themselves are represented with no fewer than four different product series of H-Chip aluminum-polymer capacitors.

Miniaturization is an important topic for Würth Elektronik eiSos: With WE-CBF HF, the SMT ferrite for high-frequency applications, tiny components make a huge impact on suppression. Further product highlights from the EMC specialists' portfolio: WE-MAPI, one of the world's small-

est metal alloy power inductors, and WE-MCRI, an innovative, molded double choke. USB-3.1 Type-C connectors with SuperSpeed technology are presented from the field of electromechanical components.

The Wireless Power Congress has been integrated into embedded world and Würth Elektronik eiSos is also very strongly represented in the new form of the congress. Experts from Würth Elektronik eiSos provide information with the following specialist presentations: Market and Future of the Global Wireless Power Transfer Industry; 15-W Inductive Wireless Power Transfer with Integrated Data Communication; Wireless Power Transfer in Rotating Assemblies. ■

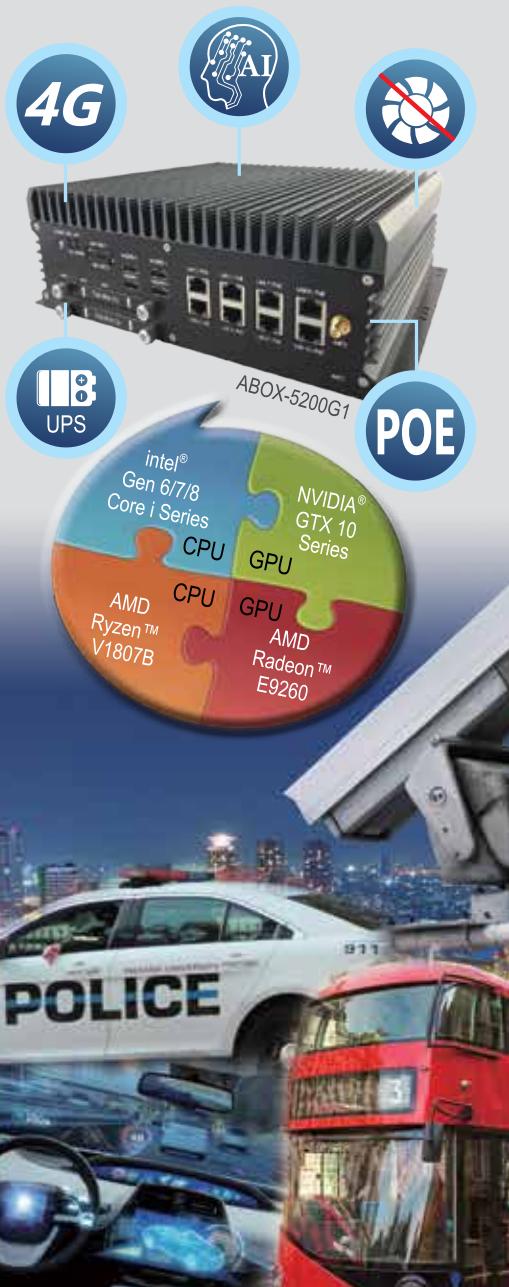
EKF: Low-Power CompactPCI Serial CPU Board Suitable as Standalone Solution

At embedded world, EKF will introduce the SC6-TANGO, a low-power CompactPCI Serial CPU board, based on an Intel Atom E39xxseries System-on-Chip processor (Apollo Lake API-I). The front panel is provided with two Gigabit Ethernet jacks (option M12 X-coded), two USB 3.0 Type-A receptacles, and two DisplayPort monitor connectors. The board is equipped with 8-GB directly soldered DDR3L ECC RAM and a CFast card socket for use as removable SATA SSD.

Optionally available is an on-board 64-GB e•MMC flash memory chip. Furthermore, a low-profile dual M.2 SATA SSD mezzanine module

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is available as an additional mass storage solution (4HP assembly) and also a multifunction side card (8HP front width). The SC6-TANGO backplane connectors provide a CompactPCI Serial system with 4 × PCIe and optionally 2 × GbE. Due to its robustness and very low power consumption, the card is also suitable as a standalone solution (IoT and edge computing). ■

ROHM: Advanced Power Management and Sensor Technologies



ROHM Semiconductor will again be exhibiting at embedded world 2019, where it will showcase new solutions for power management and sensor technologies in the automotive and industrial sectors. Highlights include ultra-low power management ICs for battery applications, timing controller ICs for automotive applications, sensor solutions for machine health monitoring, power semiconductors, updates to the discrete products in the RASMD product range, which feature an unprecedented degree of miniaturization, and much more. Visitors have the opportunity to experience state-of-the-art semiconductor demos and application examples. ■

ept: 16-Gbps Colibri High-Speed Connectors Now Available

ept's Colibri high-speed connector is now available as a 16-Gbps and 10-Gbps version. This new board-to-board connector was developed by connector manufacturer ept in response to the ever-increasing market demand for connectors suitable for sophisticated high-speed transmission applications such as USB 3.1 Gen2 and PCI Express 4.0. The Colibri COM-Express boasts a compact design with a 0.5-mm pitch.

Like the 10-Gbps version, the new high-speed version is available for a board-to-board distance of 5 or 8 mm. Both the plugs and receptacles are available for pin counts of 40, 80, 120, 160, 200, and 220. There also is a 440-pin version, which is made up of two 220-pin plugs or receptacles held together by a soldering frame. The 16-Gbps version is compatible with the Colibri standard version in terms of layout and mating.

Samples and S-parameters for simulating data transfer rates of up to 16 Gbps will be available for interested parties at embedded world 2019 in Nuremberg. The Colibri Plug 16+ will be available as of March. ■

PEAK-System with Innovations at embedded world

PEAK-System will present its latest products at embedded world 2019. Exhibition visitors can take a look at the PCAN-MiniDiag FD, which was released at the end of January 2019, and the new PCAN-MicroMod FD product series, which will be released after the exhibition. The plug-in module PCAN-MicroMod FD, the development board PCAN-MicroMod FD Evaluation Board, and the PCAN-MicroMod FD motherboards Analog 1, Digital 1, and Digital 2 will be available. In addition, the first product of a CANopen series will be shown, which will be launched in the second half of the year.

Access to CAN FD buses via the LAN interface of a computer is to be made possible by the PCAN-Gateway FD DR at the end of 2019. A first prototype of this Linux-based module in a DIN rail housing will also be shown. Last but not least, exhibition visitors can take a closer look at the PCAN-Router Pro FD announced for the third quarter, which is equipped with six CAN FD channels, I/Os, and data logger and can be configured with Windows software. ■

PLS: UDE 5.0 Supports Development of Virtualized Applications

PLS Programmierbare Logik & Systeme provides developers with the latest version 5.0 of its Universal Debug Engine that offers a wide range of completely new and significantly enhanced functions for professional debugging and testing of embedded systems. The UDE 5.0, presented for the first time at

embedded world NEWS

embedded world 2019, now supports the development of virtualized applications for Arm Cortex-A53 by providing hypervisor awareness for the LynxSecure hypervisor from Lynx Software Technologies.

With the hypervisor awareness, the developer can now use the extensive debug capabilities of the UDE for the development of virtualized applications too. Specific features of the Arm Cortex-A53, such as two-stage address translation or the support of virtual interrupts, are handled transparently for the users. The hypervisor awareness of UDE enables the user to debug a bare-metal application as usual and as if it was running on real hardware instead of being encapsulated within a virtual machine (VM). If required, UDE also provides support for debugging and system analysis of the hypervisor itself. For each individual VM, both the state and the contexts can be displayed. In addition, information about the memory layout of the individual VMs as well as the mapping of the virtual memory addresses to physical memory addresses is provided by UDE. ■

Kontron: IoT Solutions for Digital Transformation

Kontron will be presenting numerous highlights to its visitors at embedded world 2019, where among other things, Kontron will be showing Computer-on-Modules based on standards with the latest processors from leading manufacturers. The current portfolio of scalable IoT edge computers and gateways as well as the latest HMIs and Panel PCs with the latest x86 and Arm processors will also be presented. A new 1U Short Rackmount Industrial Server of the KISS family and a Box PC with an Intel processor of the eighth generation complete the range of novelties at the booth. For the Industry 4.0 and digitization strategies of its customers, Kontron will demonstrate the IoT software framework SUSIETec as well as machine learning with object recognition using artificial intelligence.

Kontron will be presenting Computer-on-Modules of all leading standards such as COM Express, SMARC 2.0, and Qseven as well as motherboards and single-board computers in various price and performance classes with the latest processors from the chip manufacturers Intel, AMD, and NXP.

For the first time, Kontron presents a Qseven module with the latest NXP iMX8X processor. The module is characterized by its low power consumption and, thanks to the powerful NXP i.MX8X processor in dual- or quad-core configuration, provides an ideal basis for networked terminals in industrial applications. Kontron is thus expanding its COM line based on the Qseven standard, which is particularly distinguished by its low power consumption and was first introduced in early 2018. Kontron supports the Qseven form factor in order to offer customers who already use it the opportunity to opt for new CPU technologies with Kontron products.

Kontron will also be presenting new products and development services for Raspberry Pi. The developer kit based on a single-board computer expands the Raspberry Pi's compute module with a variety of industry-typical interfaces, not only including USB, Ethernet 10/100 Mbit, RS 232, and RS 485 but also a CAN fieldbus interface. In addition to the developer kit, Kontron also offers customer-specific developments of carrier modules and systems for Raspberry Pi. ■



Silicon Labs to Showcase Smart Home and Building Automation Connectivity Solutions

Silicon Labs will showcase its latest Wireless Gecko connectivity solutions for smart home, lighting, and building automation applications at embedded world 2019. Hands-on demonstrations at Silicon Labs' Booth 4A-128 highlight easy-to-deploy Bluetooth mesh and Bluetooth 5 solutions, device-to-cloud connectivity with low-power Wi-Fi, Zigbee home automation and control, and next-generation Z-Wave 700 smart home solutions.

Silicon Labs demos at embedded world include:

Bluetooth Xpress Solutions: Discover how to add Bluetooth 5 connectivity to end-node designs with zero programming and no Bluetooth expertise. Pre-certified BGX13 Bluetooth Xpress PCB and SiP modules provide the easiest wireless development path.

Bluetooth Mesh Networking: Create secure, reliable, large-scale Bluetooth mesh networks based on Silicon Labs' Wireless Gecko devices, Bluetooth mesh software, SDKs, and tools. See how easy it is to implement a Bluetooth mesh for smart lighting.

Low-Power Wi-Fi: Add low-power, cloud-connected Wi-Fi to your IoT designs with little to no programming. Silicon Labs' Wi-Fi devices — including the world's smallest Wi-Fi SiP module

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Z-Wave 700: Unlock the potential of the smart home with Z-Wave 700 based on the Wireless Gecko platform. Z-Wave 700 builds on industry-leading S2 security and interoperability and adds major improvements in energy efficiency, battery life, and wireless range, enabling developers to create new classes of smaller, more intelligent smart home products. ■

Conrad Introduces its Digital Platform

Conrad Electronic will once again be exhibiting at embedded world in Nuremberg, where it will present its operational and technical expertise in sourcing B2B product ranges. This will include a focus on the areas of 3D printing, single-board computers, high-quality measurement and power supplies, and soldering technology, as well as new and practical service offerings to embedded systems designers. Therefore, the platforms Conrad Business Supplies, Conrad Marketplace, SOS electronic, and Conrad Connect, as well as innovative offers for the Maker & Education sector are now united in one digital platform. Cus-

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tomers can benefit from the individual services at any time and from anywhere.

The strong expansion of the product range, the expansion of the sales force, and the logistics center with ESD handling geared to the needs of B2B customers, as well as a cable warehouse with more than 32,000 different cables, made a major contribution to this positive business development. In addition, Conrad Business Supplies supports its business customers with first-class professional services such as 3D printing, calibration, 24-hour standard delivery, PCB service, re-reeling service, and many more. ■

Wibu-Systems at embedded world with Lineup of Solution Partners

Wibu-Systems will once again exhibit at embedded world. The journey starts at Wibu-Systems' principal booth and continues at the Open Source Automation Development Lab (OSADL), SD Association, Trusted Computing Group, and Wind River spaces for a fully engaging experience of the world of secure license management applied to electronic systems, distributed intelligence, the industrial internet of things, e-mobility, and energy efficiency.

At Wibu-Systems' main space, the company security experts will be focusing specifically on IP protection as a way to prevent attempts to pirate or reverse-engineer crucial code and to ultimately ensure the lasting commercial success for businesses everywhere. They will also be sharing several case studies in which IP protection was skillfully integrated into modern business models to multiply revenue streams.

At the collective exhibit of OSADL, embedded software developers will be laying out the importance of monetizing digital know-how and raising the quality of their code. Wibu-Systems, who affiliated with OSADL a couple of years ago, will join forces with them to provide their combined expertise and services to the entire OSADL community.

Together with ATP, Delkin, GRL, Hagiwara, JMicron, Micron, Phison, Swissbit, Toshiba, and WD, Wibu-Systems will also present some of its many hardware secure elements at the SD Association's group exhibit. ■

POLYRACK: Case and System Applications for Individual Requirements on Show

The POLYRACK TECH-GROUP will be presenting their wide range of case and system solutions at embedded world 2019. Customer-specific system applications from various branches and application fields including integration of electronics and a range of HMI and MMI applications will be displayed.

For the embedded market, particularly for industrial environments, POLYRACK presents its PanelPC 2-series. These Panel-PC-solutions satisfy the protection class IP54 and are available in sizes from 10.1 inches to 21.5 inches and in different materials such as milled aluminium or sheet-metal-bending solutions. Resistive single-touch or multi-touch capable touchscreens (PCAP) in different glass thicknesses are options for the user interface. Customer-specific printing and anti-fingerprint coating are available on request. In order to use the advantages of different materials, other technologies are available for customers to realize individual requirements in materials, such as plastics and castings — also in a material combination mix. ■



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OPEN STANDARDS

Are Open Architectures the Way Forward?

By Nitin Dahad



From left: Kevin McDermott, Imperas; Ted Marena, Western Digital; Diptesh Nandi, Microsemi; Loic Lietar, Greenwaves Technologies; Rupert Baines, UltraSoC; Tim Whitfield, Arm. (Image: EE Times)

MUNICH — With forecasts of exponential growth for connected devices and the demand for more compute power to support intelligence processing at the network edge, device and system developers are under mounting pressure to speed the appropriate solutions to market. That means that design cycles must come down dramatically.

The instruction set architecture (ISA) provides the clearest opportunity to innovate because the ISA is where the hardware meets the software. From the operating systems through the applications, all of the software ultimately has to work on the instructions. The ISA defines the hardware. It is the fundamental specification that drives everything.

Open-source ISAs, based on core intellectual property (IP) that is license-free, have emerged to help developers create and rapidly commercialize differentiated designs that are optimized for the target application's critical parameters. One such hardware architecture is the RISC-V ISA, developed as part of a university project that began in 2010. Today, an ecosystem of more than 100 hardware and software companies supports the ISA under the not-for-profit RISC-V Foundation.

Given the growth of RISC-V adoption and the pressure on developers to shrink design cycles, EE Times assembled a panel of experts at electronica 2018 and posed a question: Are open architectures the way forward?

Our panelists were Rupert Baines, CEO of UltraSoC; Loic Lietar, CEO of Greenwaves Technologies; Tim Whitfield, vice presi-

dent of competitive strategy at Arm; Kevin McDermott, vice president of marketing at Imperas; Diptesh Nandi, marketing manager for the programmable solutions business unit at Microsemi, a wholly owned subsidiary of Microchip Technology; and Ted Marena, RISC-V ecosystem director for Western Digital. They were forthcoming about the benefits as well as the caveats of open-source ISAs.

LICENSE TO OPTIMIZE

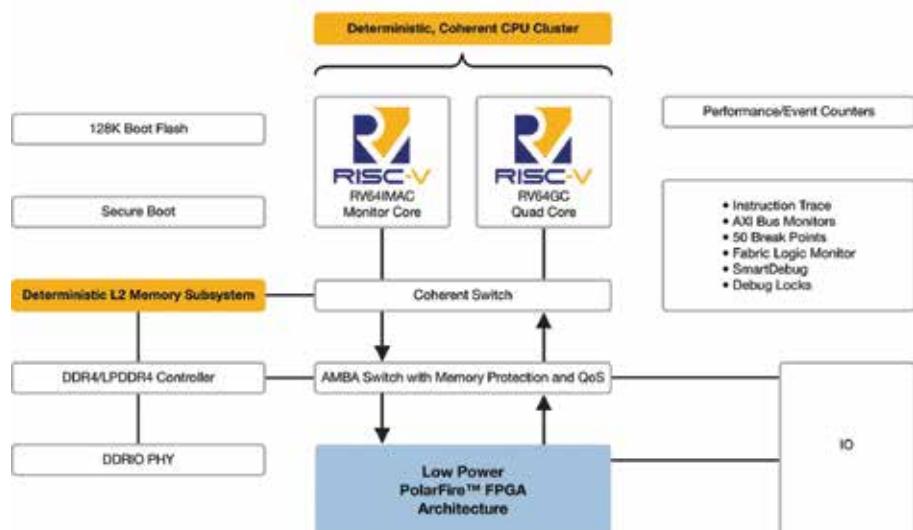
A key benefit of the RISC-V ISA is that "it's a frozen instruction set," said Western Digital's Marena. "It's the equivalent of everybody having a microarchitecture license to design the processor and controller that is absolutely optimized for your design and your requirements. The frozen instruction set means software developers can write code today and be assured it will continue to run in the processor in the future."

McDermott of Imperas said that RISC-V is a candidate for use in heterogeneous multicore devices executing different key functions. "It lends itself to custom instructions, enabling a new wave of innovation in SoCs [systems-on-chip] and semiconductors," he said. "A few years ago, people would just buy a standard chip off the shelf and do everything in software. But now you can actually do things in the custom chip yourself."

Lietar of Greenwaves Technologies, a startup developing application processors for the internet of things (IoT), said that open-source IP helps level the playing field for smaller companies, letting them tap the accumulated knowledge base and explore their architectural options before committing. "If you are a \$20 billion company and you want to drop [a processor core like] Arm, this is a political decision," he said. "It could take forever because you have to take into account many, many other dimensions that have nothing to do with the product."

"If you want to innovate, though, what open platforms bring to the table is the freedom to explore before making a decision. You don't have to call your lawyer, your purchas-

PolarFire™ SoC Architecture



Microsemi has added a class of SoC field-programmable gate arrays that combine the low-power, midrange-density PolarFire FPGA family with a complete microprocessor subsystem based on the RISC-V ISA. (Image: Microsemi)

Are Open Architectures the Way Forward?

ing manager, and everybody that is involved in purchasing something before exploring. This brings a lot of freedom."

The RISC-V ISA helped Greenwaves get to market quickly because its designers were able to leverage an open-source project that already reflected some 100 man-years of effort, Lietar said.

Nandi of Microsemi said that a customer's requirements had steered the company to the RISC-V open platform. The customer wanted certain features that were not readily available from a commercial solution, so Microsemi used the RISC-V ISA to develop a soft core. The approach proved easier than using a standard microcontroller in this case, and the customer did not have to pay upfront license fees.

"We also see customers who might come to us and say, 'We need two, three, or four instantiations of some code in the data path, and we really want a really small-value or small-feature-set core,'" Nandi said. In such cases, "RISC-V is a perfect solution."

Our panel also cited the trend to drive more intelligence and compute power to the edge of IoT systems. Many current solutions for artificial-intelligence (AI) and machine-learning (ML) processors use proprietary architectures with a GPU heritage. But Baines of UltraSoC sees a shift toward "using open architectures in an AI context."

"You are starting to see others coming out that are using more open-architecture building blocks," Baines said. "Wave Computing acquired MIPS and is going to be carrying forward with using the MIPS architecture, [which it is also making open-source]. You've got Esperanto Technologies, which is using a sea of RISC-V processors. There's another [group] I was talking to in China that's re-inventing some of the Sparc processor for an AI application."

BEWARE OF FREE

The panelists dispelled the notion that an open-source ISA is completely free to use. "[It's] free as in freedom, not free as in free beer," said McDermott. "Yes, it might be an open ISA, but to build a pipeline, to build a microarchitecture, somebody somewhere will have to do an awful lot of work, and that will need to be validated and verified.... None of that is free."

While there might no upfront fee, there are costs involved in developing a product and getting it to market. "Tape-out cost is very, very high, and the cost of an error or late-found bug will kill any deadline, will kill any time to market," said Imperas' McDermott. "It may be free going in. But if you want to make sure you hit your milestones, hit your schedule, deliver a working product, you need a professional ecosystem."

"There are a number of professional companies delivering IP cores based on an open ISA because they can add value."

UltraSoC is one such provider. "[Because] I'm CEO of an IP licensing company, I'm really quite motivated about making money out of it, and I'm not interested in free," said Baines. "We are making very good money out of licensing IP into the RISC-V community. And there are a number of other companies that are doing likewise, whether it's building blocks or support systems, up to and including the actual paid-for and supported commercial RISC-V course."

Microsemi's Nandi said that open source lends itself to low volumes and cost-sensitive territory. "As far as future designs are concerned, we're not really into high volumes," he said. "Typical high volume is about 10K or 20K. So I don't think cost or royalty is something that our customers care for, and they are generally agnostic about the processors they choose. However, we've seen a definite shift of them choosing RISC-V now more than ever."

The need for an established ecosystem and support applies whether you're designing with a fixed architecture or an open-hardware platform, said Arm's Whitfield. "If you look at where the real value is in licensing IP from someone like Arm, you quickly get to things like legal indemnification, and there's an awful lot of that that goes on in the IP world. You get to things like support. There is a real cost [in building that ecosystem]."

"What I do think is perhaps changing is that there is a shift in some of the economics around SoC design," said Whitfield. "The economics that work for mobile are very different from the economics that we perhaps are going to come across in a trillion connected devices, with different kinds of people developing silicon."

Western Digital's move to RISC-V wasn't cost-driven, said Marena. Rather, the company wanted to achieve a specific aim that available general-purpose processors could not address: monetizing the data on its drives. Western Digital leveraged RISC-V to develop and customize a purpose-built solution.

Open-source collaboration is well-advanced in the software world, and Linux has demonstrated the power behind that movement, said Marena. "I believe that hardware will start to ride a similar wave, and you'll see organizations start sharing. They may not share everything, but as they incrementally offer up more and more solutions into the ecosystem, there's going to be a broader benefit." ■

Nitin Dahad is a European correspondent for EE Times.



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OPEN STANDARDS

Ruggedized Hardware Brings IoT to Harsh Environments

By Nitin Dahad

Designing for internet of things (IoT) connectivity can be a challenge when the electronics need to perform in industrial environments or under harsh conditions. Extreme temperatures, high humidity, and exposure to shocks, vibration, and contaminants can cause components to fail or operate less effectively. Neither outcome is an option in mission-critical operations.

Applications requiring ruggedized electronics range from military and factory systems to transportation and the oil and gas industries. Here's a look some recent releases that target rugged IoT systems for these and similar environments.

TRANSPORTATION SOLUTIONS

DIN rail box PC: MEN Mikro Elektronik has developed a modular DIN rail box PC for embedded transportation applications. Based on Intel's Atom E3900 CPU series, the MC50M can be used as the basis for functions such as IoT, security gateways, predictive maintenance, CCTV, and ticketing. It can be used standalone or in combination with prefabricated extension modules that provide additional features.

Extension modules can add application-specific connectivity for wireless communications, including Long-Term Evolution (LTE) Advanced, wireless LAN, and Global

Navigation Satellite System (GNSS) systems, and for I/Os such as the Multifunctional Vehicle Bus (MVB) and Controller Area Network (CAN) bus. The wide-range power supply unit (PSU) provides isolated power supply from 24 VDC to 110 VDC nominal in compliance with EN 50155.

Embedded rugged PC: Axiomtek offers an embedded rugged PC for vehicle and railway markets. The UST500-517-FL is powered by LGA1151-socket 7th/6th-generation Intel Core and Pentium processors up to 65 W with the Intel Q170 chipset. The 16 integrated Power over Ethernet (PoE) ports are available in RJ-45 or M12 connectors for Internet Protocol cameras. Power protection includes intelligent vehicle power management technology for accessory (ACC) on/off delay, shutdown delay, and over/undervoltage protection.

The PC can withstand an operating temperature range of -40°C to 70°C and vibration to 3 Grms. Communications capability includes two full-sized and two half-sized PCI Express Mini Card slots and two SIM card slots for 3G/4G, GPS, Wi-Fi, and Bluetooth applications. The transportation embedded box complies with e-Mark and EN 50155 specifications for mobile surveillance applications.

IoT gateway: Syslogic offers industrial computers and human-machine interface (HMI) systems that were designed for railway

applications, but because they support GPS, LTE, GSM, and UMTS broadband, they can also serve as IoT gateways. The railway computers operate from -40°C to 85°C at the component level, meeting EN 50155 class TX requirements. They support dead-reckoning navigation and motion sensing; offer power failure bypass up to 10 ms, compliant with EN 50155 class S2; and have a DC input voltage range of 16.8 to 154 V. The devices can be equipped with a Trusted Platform Module (TPM) to guard against hardware attacks.

Fanless box PCs: Syslogic also offers the Compact M series of fanless box PCs for off-train applications such as traffic and tunnel monitoring and train detection. Based on Intel Atom E3825 or E3845 processors, the embedded PCs support continuous, 24/7 operation; include CAN, USB, RS-232, and RS-485 interfaces; and can be equipped with up to five Ethernet interfaces. Syslogic says that it can also integrate Ethernet for Control Automation Technology (EtherCAT) master stacks into the Linux operating system so that customers can use the Compact M computer directly as an EtherCAT controller.

LoRa gateways for trains: LoRa (short for long range) is a low-power wide-area wireless network that's finding use in IoT systems for long-range wireless communications in remote locations where long battery life is required. Franco-Belgian railway company Thalys, for example, is using the TRACe LoRa-MQTT, an EN 50155-certified IoT LoRa gateway from Kontron. The gateway delivers a private, train-accompanying LoRa communications network in which a simple 10-cm antenna enables coverage for up to 10 railcars. Whereas traditional communications systems with a ground-based LoRa infrastructure work only inside stations, Kontron's LoRa network is not dependent on sensor positioning or on the train's location or speed.

The TRACe LoRa-MQTT combines a secure LoRa network server with an IoT gateway that streams the Message Queuing Telemetry Transport (MQTT) messaging protocol to the cloud, enabling data collection from different sensors as well as remote analysis. EN 50155 certification enables Kontron to guarantee the network's resistance to temperature, shock, and vibration, meeting Thalys' requirements.

An 18-month pilot phase used the system to link up with maintenance sensors as well as with client satisfaction terminals used for large-scale collection of client feedback.

Cellular gateway: For areas where cellular networks can be used, Kontron's EvoTRAC-G103 gateway leverages the Intel Atom processor on Kontron's hardened Type 6 COM Express CPU module, coupled with a ruggedized carrier board. All are packaged in



The MC50M DIN rail enclosure is based on Intel's Atom E3900. (Image: MEN Mikro Elektronik)

Ruggedized Hardware Brings IoT to Harsh Environments

a natural-convection, sealed IP67 enclosure to survive rigorous environmental conditions for on- and off-road vehicle use. The system includes a 64-GByte embedded multimedia card (eMMC) for onboard storage and a Wi-Fi and 4G LTE module for wireless connectivity. It has been tested for use at -40°C to 80°C and under other demanding environmental conditions, including shock, vibration, humidity, salt, and fog. The conduction-cooled IP67 sealed chassis prevents water and dust ingress, meets International Special Committee on Radio Interference CISPR 25 emissions standards, and meets the International Standards Organization's ISO 11452-2 susceptibility requirements.

INDUSTRIAL IOT SINGLE-BOARD COMPUTER

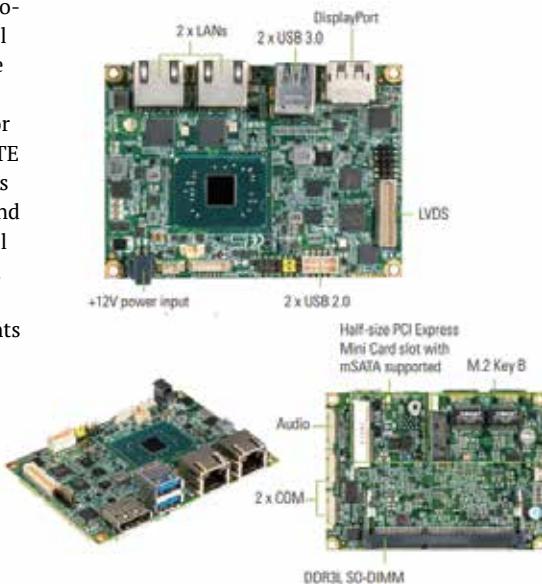
Axiomtek has released the PICO318, a palm-sized fanless Pico-ITX motherboard powered by Intel's Pentium N4200 or Celeron N3350 processor. The 2.5-inch expandable embedded board has a low-power-consumption, rugged design for deployment in applications such as factory automation, industrial IoT gateway systems, and machine vision.

The fanless embedded motherboard supports various expansion interfaces and wireless communication capabilities with an internal PCI Express Mini Card slot. The board comes with two Gigabit Ethernet ports for customers who need mass data transmission or LAN port teaming functions for each virtual machine. The PICO318 is designed for industrial environments with an operating temperature range of -20°C to 60°C.

ULTRA-COMPACT IOT BOARD

Portwell's RICH-61D0 is another fanless embedded system for applications with space limitations, such as industrial automation, medical equipment, communications devices, and IoT. The rugged system is equipped with the Portwell WUX-N series, a Next Unit of Computing (NUC) form factor, 4 x 4-inch embedded board based on the Intel Atom processor N series, which integrates the low-power Intel Gen9 graphics engine with up to 18 execution units to optimize 3D graphics performance and support faster 4K encode and decode operations.

The compact, 113 x 41 x 135-mm chassis integrates the M.2 interface for wireless



The PICO318 single-board computer is designed for industrial environments.

(Image: Axiomtek)

connectivity such as Wi-Fi and Bluetooth, making the RICH-61D0 suitable for use as an embedded computer or IoT gateway, according to Portwell. With a product lifespan up to 10 years, it operates with thermal design power (TDP) of 6 or 10 W for fanless applications and supports power direct-voltage input from 12 V to 19 V for industrial applications.

RUGGED AI COMPUTERS

A new embedded computer from Syslogic addresses the need for incorporating artificial intelligence (AI) within edge computing. Target applications include machine vision, intelligent control, and deep learning. The design is based on Nvidia's Jetson TX2i module, which features an economical but powerful quad-core processor platform. The core of the Jetson TX2 is Nvidia's Parker system-on-chip (SoC), which combines two computation modules based on Nvidia's proprietary Denver 2 microarchitecture with four Arm Cortex-A57 cores and a Pascal GPU. The latter has 256 shader cores.

The AI computer features a flexible interface layout for system connection. Wi-Fi, GPS, and LTE functions can be added.

In addition to the processor platform,

Nvidia has provided the JetPack development kit, which contains CUDA libraries, programming interfaces, and examples. Syslogic's AI embedded computer is delivered preinstalled with an Ubuntu board support package for AI applications development. The embedded computers are fanless, maintenance-free, and suitable for operation at -40°C to 70°C.

ENTRY-LEVEL EDGE COMPUTING

Cincoze, a developer of embedded computing platforms, has fielded a fanless embedded computer for entry-level edge computing applications. The DA-1100 series supports wireless modules for IoT systems. Based on the Intel Pentium N4200/Celeron N3350 processor with integrated Gen9 Intel HD Graphics 500 series functionality, the system lets users expand functions and I/Os through ready-to-use modules, such as triple display support, PoE, serial ports, optical isolated digital I/O, and LPT and PS2 parallel ports.

The system can provide a maximum of 25.5 W per port, suiting it for use in applications such as machine vision and video surveillance. It withstands an operating temperature range of -40°C to 70°C, provides a DC power input range of 9 to 48 V, and exhibits high vibration/shock tolerance (5 G/50 G). ■

Nitin Dahad is a European correspondent for EE Times.



Syslogic's railway computers can be deployed as IoT gateways, as well as data loggers, passenger information system (PIS) computers, and rail control units.

(Image: Syslogic)

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Boot, Log, and Update Securely with Removable Memory Devices

By Hubertus Grobbel, Head of the Security Products Division, Swissbit



When devices need to be networked — think IIoT — embedded system developers are faced with numerous security challenges. Flash memory producer Swissbit offers an innovative approach: Security features are integrated into removable industrial-grade memory devices such as memory cards or USB sticks. The benefits are clear: easy upgradeability and high flexibility.

Boot, Log, and Update Securely with Removable Industrial-Grade Memory Devices

Protecting data from unauthorized access or subsequent tampering, stopping data communication from being spied upon and tampered with, and creating a secure environment are all possible requirements for the development of electronic systems. One component that is required virtually everywhere is memory – whether for booting, as firmware memory, or for logging data. In industrial environments, robust flash memory media is commonly used. Swissbit specializes in particularly durable storage media with long availability for industrial, medical technology, or telecommunications markets, for example. The industrial memory specialist's latest innovation is to combine memory and security features.

COUNTERFEIT PROTECTION AND SECURE BOOT

Flash memory modules used in important devices must comply with minimum standards. Unique identification as well as counterfeit and integrity protection are required. Counterfeit devices pose not only an economic threat for producers but also a risk for users – for example, in medical technologies. Using uniquely identifiable data memory ensures that the hardware and software combination in one device complies with the producer's specification. Furthermore, its function in the field needs to remain constant and defined throughout its entire lifecycle. It is important to be able to trigger test functions to find out whether the firmware in the memory controller is the one expected. Real-time protection that can be read cryptographically is particularly important. This allows for identical storage media to be made uniquely identifiable, enabling a device manufacturer to control their spare parts business.

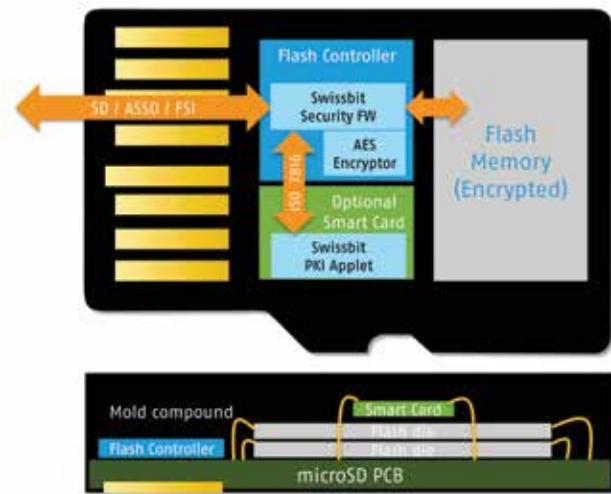
Another device-specific application is trusted boot. This concept ensures that software can only be run on specific hardware or hardware classes. The boot loader uses an authentication protocol that is available only within the boot environment. As soon as the first phase is started, a hash calculation is applied in the next phases for each subsequent phase. If the hash calculation is correct, the decryption key for the next phase is provided. As soon as this cascade is interrupted due to tampering or an error, the system is deemed unreliable and will not even start up. This way, the quality of a device can be strictly defined whilst benefitting from full flexibility. A secure flash memory card can be used to manage software licensing and feature activation. Access control, code encryption, or digital signatures enable definition and management of different software configurations for products.

DATA ENCRYPTION

Even in its core function as pure data storage, a flash card gains additional application options with additional security features. Audit trails, for example, require a reliable logging mechanism. Each event that needs to be logged is stored permanently and is unmodifiable. Hash-chains of data sets in write-once, read-many (WORM) memories ensure the detection of any tampering or deletion of data elements. Exported data is sealed using a digital signature. It is a perfect solution for securing fiscal applications in cash registers. Asymmetric encryption with secure elements can also be simply used for data protection. The application saves password-protected data so that it can only be read by authorized personnel or a specific system – for example, images from surveillance cameras or bodycams.

DESIGNATING AN ID TO "THINGS"

If the storage medium allocates a unique identity to applications and systems, this identity can be used in other ways as well. More and more devices are connected within the industrial internet of things and are accessible from the internet. Thus, remotely serviced systems such as industrial controls or IIoT gateways become vulnerable. In the future, networked systems need to be protected from misuse and "identity theft." Data access must be restricted. The neatest solutions are data encryption and clearly identifiable M2M communication participants.



Integrated smart card – setup of a secure microSD memory card

Similar to the protection of online communications in IT, wherein users identify themselves as part of a two-factor authentication using a smartcard token, the memory modules with secure element provide the option to give M2M communication participants a unique ID. This way, a "thing" knows that the data or data queries received from another "thing" are correct and that the source is truly the system component that it claims to be. Integrating smartcards on memory cards allows non-clonable identities to be allocated to the systems. These systems are then able to authenticate themselves and send and receive cryptographically heavily secured data.

A PROVEN SOLUTION

The secure flash media offered by Swissbit for the described tasks are extensions of proven SD and microSD memory cards for industrial requirements. These are available with extremely durable SLC flash or with the more cost-effective "durabit" MLC – a Swissbit brand that encompasses special firmware features that prolong endurance and retention of the MLC NAND chips far beyond what is commonly feasible.

The firmware also includes many security features such as an integrated AES encryptor or the option to apply the WORM mode to the medium. For applications that require a unique, non-forgeable identity, the memory card includes an additional smartcard as secure element. It assumes the function of a trusted platform module (TPM). These security options have already proven themselves: in tap-proof mobile phones, in bodycams for security authorities, or in fraud-resistant cash registers. The integration of the cards and their security features is very simple (see box).

The cryptographic tasks are delegated to the memory cards with secure element using Public-Key Cryptography Standard (PKCS) #11 programming. To use the API of the secure memory cards, Swissbit offers a PKCS #11 library. The API defines the functions required for creating, modifying, using, and deleting cryptographic objects on secure flash cards. These objects can be X.509 certificates, RSA private/public key pairs, elliptical key pairs, symmetrical keys, or data objects.

A PKCS #11 application program is also supplied, which allows all security features to be easily retraced. It uses the PKCS#11-API and implements a command line interface (CLI) to the PKCS #11 library. As a key and certificate management program, an existing PKCS#11-compatible tool or, alternatively, the open-source tool xca, an

Boot, Log, and Update Securely with Removable Industrial-Grade Memory Devices

application with GUI for handling X509 certificates, can be used. Xca creates via the PKCS-#11-API requests for certificate signatures based on prepared key material on the Swissbit card and copies the certificates onto the card. Additionally, RSA and ECDSA key pairs can be created on the card.

A very practical aspect for using PKCS #11 is that even Mozilla Firefox uses PKCS-#11-API. The Swissbit-PKCS-#11 library integrates with Firefox and uses X509 certificates for the SSL-Client authentication. These are stored on the Swissbit flash card and secure access to and communication with websites. Furthermore, PKCS-#11-API offers OpenSSL engine support, meaning that OpenSSL can access objects on the card directly. This way, regularly used security mechanisms can be implemented highly securely using memory cards. The integration in a host of open-source applications demonstrates the standard conformity of the PKCS #11 interface.

SECURITY ON A USB STICK

At embedded world 2018, Swissbit presented the latest addition to its secure flash memories: the USB 3.1 stick PU-50n DP (data protection) — a logical development as, since the introduction of USB 3.1, this interface has gained increasing popularity for use in industrial applications.

The USB is very user-friendly, particularly as an interface for maintenance tasks such as data transfer or copying updates to devices. However, in IT security, USB thus far has had a rather dubious reputation, but precisely these negative experiences make a good argument for using the new Swissbit USB flash drives. A simple security routine on devices equipped with a USB interface blocks access through the interface should the USB stick not follow the requested authentication protocol.

The USB stick offers additional options for memory usage that is not possible in this manner on SD memory cards. It is, for example, possible to divide the memory of the USB stick into different logical areas, wherein every section provides separate mass storage with a freely configurable data security policy. Thus, data protection for each section can be controlled flexibly. As access policies for each partition CD-ROM emulation, private partition, public partition, and hidden WORM memory are available. The CD-ROM function can provide read-only data such as boot media, software installer, or other data that must not be overwritten. The private partition encrypts and protects data — it is unlocked using a PIN login. In the WORM area, data can be logged and protected from manipulation. The public partition can be used the same as any commercially available USB stick.

The USB standard offers many possibilities but is also susceptible to risks that are referred to as bad USB attacks. In this case, the USB stick



Write once, read many — Flash memory cards as WORM storage for signed audit trails and fiscal data

has hidden features that, following an unauthorized firmware update, result in a compromised user host. Authenticity, counterfeit, and integrity protection are an efficient solution to protect against these attacks.

CONCLUSION

The combination of security and memory in a removable storage medium makes perfect sense:

1. Read-only applications in industrial applications with a long life-cycle need to be replaceable.
2. Replaceable storage media are better-suited for solutions in which security features are added to existing systems — for retro-fit and future-proof concepts.
3. Cybersecurity is a constant race. Modules for a security solution should be replaceable when upgrades are necessary (think post-quantum cryptography). ■



A solution with a secure USB 3.1 stick such as Swissbit's PU-50n ensures that the USB as an interface for maintenance tasks can't be misused.

COMPANY FOCUS

Nokia Bets it All on 5G

By Bolaji Ojo

Watch Nokia Corp. The communications and networking equipment manufacturer is for the umpteenth time on a bold but perilous redemption journey. Years from now, industry analysts, academics, and competitors will look back at this time and see a company that either burnished its reputation as a master of reinvention or failed to find its way out of the fog.

What's clear today is that Nokia is taking radical steps to reposition itself in the business world, as it has already done several times in its 150-year history. Having jettisoned the mobile handset business and undertaken a series of strategic acquisitions, including the purchase of Alcatel-Lucent, Nokia is betting the farm on 5G, a nascent technology with the potential to serve a larger customer base, create new revenue streams, and afford the company the stability it has sought for a decade.

"I have absolutely no doubt that a fast and meaningful shift to 5G is under way," said Rajeev Suri, CEO of Nokia, during a conference call to discuss the company's fourth-quarter 2018 financial results. "5G will drive a virtuous investment cycle that plays to Nokia's full-portfolio strengths. It begins with radio access networks being upgraded to 5G in key early markets like the U.S., Japan, and [South] Korea. Those upgrades then drive the need for higher-capacity transport connectivity to data centers. And that means more backhaul networks using IP [Internet Protocol] routing and optical infrastructure."

The potential market for 5G is indeed huge, but it faces strong geopolitical headwinds. Governments are erecting regulatory and other roadblocks in a sometimes futile effort to prevent data breaches. In the United States and other Western nations, efforts to thwart the transfer of dual-use technologies to adversarial powers, such as China and Russia, have hampered tech companies' ability to operate in their preferred freewheeling mode. Sanctions on rivals such as China's Huawei create opportunities for companies like Nokia in the West but have negative implications for Western companies in the fast-growing Chinese market.

Nokia operates in a tough competitive environment and faces deep-pocketed rivals in North America and China. All are jostling to supply next-generation equipment to traditional telecommunications service providers and myriad new players, including web-based companies that emerged in the past two

decades and now dominate the data and information markets. The targeted customer base includes mammoth enterprises such as Alibaba, Amazon, Facebook, Google, and Microsoft, which have positioned themselves as purveyors and facilitators of the still-evolving information revolution.

Nokia's vision extends even beyond those companies, however. Waves of new players are barreling into the global information-processing and data-mining market. Many of these "newcomers" are established players in disparate sectors of the economy — aviation, banking and finance, energy, industrial, insurance, manufacturing, military, and transportation — but the thread that binds them is the desire to control the collection, curating, and utilization of data critical to their industries. Toward that end, they are investing in their own high-end networks and shopping for technologies that will ensure not just access to information, but the ability to protect it from digital stealth invaders.

That's where companies like Nokia come in, said Suri. Nokia has refocused its operations on the enterprise market, preferring it to the rambunctious consumer electronics sector, where contract manufacturers, fabless IC makers, and independent design firms have



5G "plays to Nokia's full-portfolio strengths," says CEO Rajeev Suri.

"We see growth of 5G in 2020," said Suri. "Every major customer is thinking and talking about 5G. It is going to happen. Private wireless is also going to happen in the enterprise side. I have talked to many enterprise customers in recent months, [and] those conversations strengthen my conviction that as organizations of all kinds seek to digitalize their operations, there is strong demand for Nokia's products and services."

REALITY CHECK

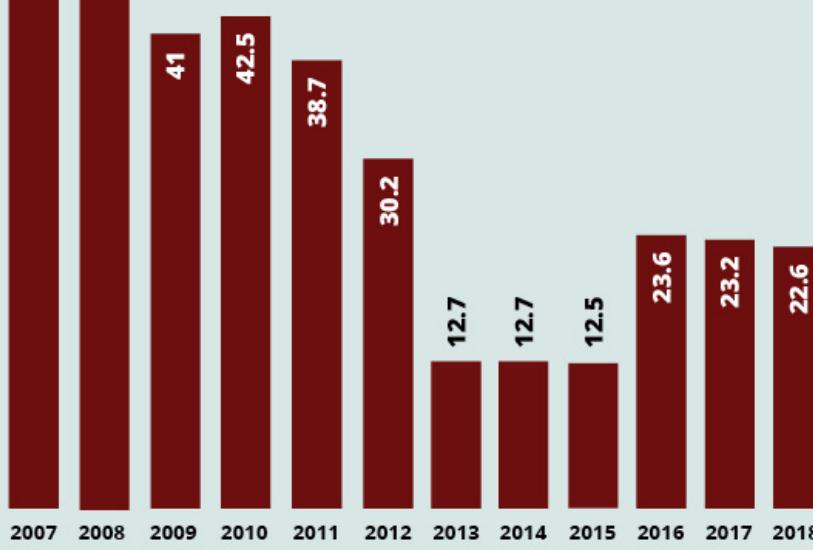
As Nokia steamrolls toward 5G, however, there is a harsh reality checkpoint ahead. Nokia is still a deeply troubled company in the throes of a transformation. It is undergoing probably the most difficult reorganization in its history and has had mixed results thus far.

Indeed, the restructuring has entered one

Nokia Peak, Valley and Bounceback?

Sales in € Billions

Source: Company Reports



Nokia Bets it All on 5G

of its more crucial phases, and Nokia will likely tweak its strategy for several more years. In October, for example, the company announced the layoff of “thousands” of employees following the posting of less-than-stellar financial results. Revenue slipped in 2018 from the prior year, and the company expects the first half of 2019 to be somewhat damp before a pickup in the second half, followed by a stronger 2020.

Kristian Pullola, Nokia’s chief financial officer, told analysts and reporters during the conference call that the company expects “full-year 2019 to follow a similar pattern as 2018: a soft first half with a particularly weak first quarter, followed by a robust second half, supported by a meaningful 5G acceleration.”

Nokia was operating at a much higher altitude a mere 12 years ago. In 2007, the company had a commanding share of the mobile handset market, including the burgeoning smartphone segment. Its sales shot to a record €51.1 billion (US\$70.6 billion) that year, up more than 24%, from €41.1 billion, in 2006.

Just one year later, however, Apple launched the iPhone and began to claw at Nokia’s market share. Within a few years, Apple had supplanted Nokia as the market’s leading smartphone vendor. The Finnish company never recovered from the assault, and in September 2013 Microsoft acquired the Nokia Mobile Devices unit.

The numbers show why Nokia had to exit the handset market. What they don’t show is what Nokia meant to do to rejuvenate its business and avoid following the likes of Alcatel, Lucent, Motorola, and Nortel Networks into the dustbin of corporate history. Having peaked in 2007, Nokia’s revenue started declining the next year, dropping steadily until it crashed to a low of €30.2 billion in 2012, the year before the company sold its handset business to Microsoft. The 2012 revenue number represented a drop of 41% from the peak only five years before. Following the sale of the handset business, Nokia’s sales sank to €12.7 billion.

Sales have zigzagged since and remain under pressure. The purchase of Alcatel-Lucent boosted the two entities’ combined revenue to €23.6 billion in 2016, but the tally slipped to €23.2 billion in 2017. Sales in 2018 came in at €22.6 billion, down 3% from the prior year. Sales are forecast to rise about 2% in 2019.

PRESIDENT MOVE

Nokia today is a shadow of the enterprise that once ruled its market segment. Could it have opted to hang on in the mobile device business? Yes, but it didn’t.

The iPhone’s ascendancy and the com-

pany’s own blunders might have forced its hand, but Nokia’s management shifted gears abruptly and aggressively to capitalize on what it bet would be a broader market dynamic. And it is beginning to look like Nokia was prescient in making that move.

The smartphone market is generally agreed to have peaked, mere years after phones took over from PCs as the sales volume drivers in consumer and enterprise electronics. Apple drove home that point when it announced that revenue had declined in its fiscal 2019 first quarter. CEO Timothy Cook pinned the drop in part on a 15% decrease in iPhone revenue, citing “weak macro conditions in some emerging markets [that were] more severe than we originally foresaw, especially in Greater China ... compounded by quarterly iPhone upgrades that were lower than we anticipated.”

Smartphone sales will continue to rise in the years ahead but at a much slower pace, market watchers now believe. And as suppliers compete for shares of a smaller pie, pricing pressure will drive down revenues, just as it did in the PC market.

In other words, the dreaded product commoditization that has long plagued consumer electronics is creeping into the smartphone business, and the remaining players could be powerless to stop its advance. In that light Nokia’s hasty retreat from the handset market might have given it a strategic advantage over former rivals Apple and Samsung.

That doesn’t mean its gambit is sure to succeed. Internal challenges persist, including the upheavals of reorganization. In its efforts to become a nimbler enterprise, Nokia confronts an urgent need to change its corporate culture, making it more proactive and less reactive to market developments.

“We are making structural changes that will enable us to execute quicker on our strategy and to enhance our customer focus,” CFO Pullola told analysts. “We are also taking cost actions. We have gone through one phase of cost optimization after the Alcatel-Lucent integration, and we are now moving into the next phase.”

Nokia and its competitors also face external challenges, which will be more difficult to resolve. The tussle for political and military dominance among the world’s leading nations has seeped into the corporate world, boosting some enterprises in their home countries but crippling their competitiveness in foreign markets. Nokia and its rivals operate in such an increasingly sensitive segment of the technology world that every step they take to expand market share, introduce products, and establish critical partnerships will require approvals from multiple regulatory

authorities and governments. That regulatory burden will slow down sales expansion.

Nokia’s bet on 5G will also be dogged by technology innovations, supply/demand challenges, and constraints on capital and R&D expenditures. Already, imbalances in the supply chain are forcing companies to rethink their strategies for planning and building out 5G infrastructure, even as the industry is beginning to talk about shifting 6G — the next-generation of communications technology — out of the labs and into product development. That’s not a problem Nokia can resolve alone, and Suri acknowledges the impact on the company’s financial performance.

“There are several factors that point to 2019 being very second-half loaded. The first is the staggered nature of 5G rollouts,” Suri said. “The second is that the 5G ecosystem, standards, chipsets, and devices are still in the early days. We expect that to stabilize in the coming months, but it means that development and testing are operating under considerable time pressure.”

This isn’t the first time Nokia has had to accept it must completely retool operations and shift its focus to a completely new market. The company was founded as a pulp mill and dabbled in electricity generation, rubber, military equipment, and cable before jumping headlong into electronics, consumer electronics, and now networking and communications equipment.

The new Nokia hasn’t strayed very far from its more recent interest in high tech, but this evolution has already proved to be more fundamentally disruptive for the company, its suppliers, and consumers. The decline in Nokia’s position in the wireless handset market severely crimped growth at chip manufacturers and other suppliers and helped move the center of communications equipment innovation to North America and, eventually, Asia.

At the peak of its success, though, Nokia gave the world much more than a distinct ringtone. It helped to spur growth across the world and laid the foundation on which other enterprises built an industry. Is it destined again to play a similar role, or will the new Nokia become another footnote in the long history of once-dominant enterprises that aimed for the next big thing and missed the mark?

Either way, the tech world should keep an eye on Nokia. When it succeeded in the past, the company ruled unchallenged for a time and left its imprint on the industry. And when it failed, it left quite a dent. ■

Bolaji Ojo is global editor-in-chief of Aspen-Core Media.

COMPANY FOCUS

Nokia's Bumpy Ride Toward Redemption

By John Walko

LONDON — Few technology companies in recent years have experienced a fall as precipitous — or acted as aggressively to right the ship — as Nokia. At the height of its success as the global mobile handset leader, Nokia's value was about US\$285 billion. Today, it is hovering at about US\$33 billion as the company tries to consolidate its position as the second-largest global supplier of networking infrastructure to operators.

Nokia's recent history sheds light on how the combination of external technological disruption and internal management shortcomings can sink corporations. Indeed, academics and management consultants often use the saga of Nokia's fall — and, we believe, its gradual redemption — to illustrate how corporations can lose their way and bounce back.

It has helped, of course, that Nokia (Espoo, Finland) has morphed many times since its founding in 1865 as a wood pulp mill. (One of the mill's products was paper, so it could be argued that Nokia has been in the "communications business" from its inception.) Over its history, it has entered and then abandoned the markets for bicycle tires, gas masks, electric cables, and television set-top boxes, among other high- and low-tech devices.

The company's continual reinvention came up in an impromptu meeting with Willem Verbiest, head of Nokia's Fixed-Wireless Access business, at the recent Telecom Infra Project (TIP) Summit here. TIP is the Facebook-inspired and -led initiative that aims to overhaul the way carriers design and implement mobile infrastructure. The project takes a disruptive, open-ecosystem and open-architecture approach to equipment design in a bid to improve cost efficiencies for both operators and equipment suppliers.

"We pride ourselves in the way we push forward boundaries and are able to approach problems from a different perspective, which is why we've joined the initiative," Verbiest told EE Times. "To date, we are the only major infrastructure equipment supplier to have the foresight to become a [TIP] member."

TRANSFORMING NOKIA

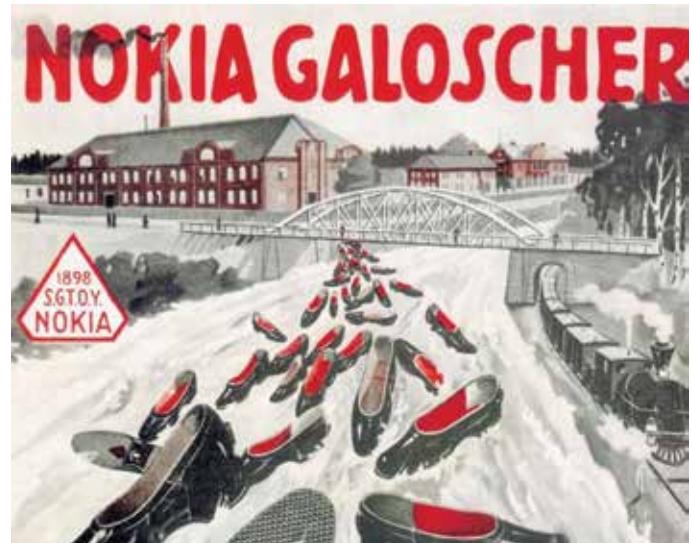
Of course, Nokia might have averted its near-death experience had it adopted such a strategy a decade ago.

Risto Siilasmaa, chairman of Nokia, painstakingly makes that case in his book, "Transforming Nokia: The Power of Paranoid Optimism to Lead Through Colossal Change," published late last year. As the co-founder of cybersecurity software company F-Secure, Siilasmaa grew familiar with Nokia's software strategy when his company became a supplier of security software to the handset maker. According to Siilasmaa's account, soon after he joined Nokia as an independent director in 2008, he suggested that the company seriously consider using the nascent Google Android operating system for its next-generation devices rather than stick with its own Symbian platform, which by then was past its prime.

The board never discussed the proposal. Siilasmaa blames then-chairman Jorma Ollila, writing that Ollila's autocratic style had infected the management structure with the "toxicity of success" and an air of paranoia. Middle management was afraid of relaying bad news or potential problems up the ladder, leaving the upper echelons of management largely ignorant of internal weaknesses and threats from outside, Siilasmaa writes.

As one of the few at the very top who really understood software, Siilasmaa recognized the severity of the threat the company faced. But as an independent director at Nokia, Siilasmaa could not discuss issues with operational managers — an edict that he claims Ollila strictly enforced.

Former chairman Ollila dismisses many of his successor's assertions, and a lively debate, if not a spat,



Nokia has transformed its business model many times since its 1865 founding as a wood pulp mill, including forays into tires and galoscher (boots). (Image: Nokia)

persists between the executives. But the reality is that Nokia failed to grasp the gradual ascendance of software and apps over hardware as the crucial competitive differentiators.

In 2011, Nokia sought to right itself through a doomed collaboration with Microsoft that made Windows Phone the primary platform for Nokia smartphones. Nokia caught a major break in 2013 when the software giant agreed to pay an amazingly generous US\$7.3 billion for the flailing handset division. Unburdened of that business, Nokia was freed to push forward in infrastructure, which remains its focus.

In the book, Siilasmaa suggests that the money from Microsoft, together with the US\$2.8 billion Nokia raised by selling its profitable HERE mapping operations to a consortium of German automakers, basically saved the company. Analysts largely concur.

The deal didn't work out nearly as well for Microsoft, which sold off the Nokia assets in 2016 and had largely exited the phone business by the end of 2017.

ACQUISITION TRAIL

Nokia's first post-Microsoft move was to buy out Siemens from the Nokia Siemens Networks merger in 2013 for US\$2.2 billion. Three years later came the game-changing acquisition of Alcatel-Lucent — one of

Nokia's largest competitors at the time — for US\$17 billion in shares. And the consolidations keep on coming.

Late last year, Nokia split its Customer Operations business into two geographic regions: one covering the Americas and the Western Hemisphere, the other focusing on Europe, the Middle East, Africa, and Asia. It then announced in November that it would merge its mobile and fixed units to create an Access Networks division, valued at US\$7 billion, that would "fully exploit the opportunities in 5G."

Marc Rouanne, president of the Mobile Networks division and a longtime executive in the Alcatel-Lucent organization, resigned in the wake of the surprise November announcement. Rouanne



The iconic Nokia 6110 GSM phone launched in 1998.

(Image: Nokia)

Nokia's Bumpy Ride Toward Redemption



Telia's 5G demonstration network in Oulu uses Nokia's AirScale radio access platform. (Image: Nokia)

had headed the mobile network group since 2017, when he took over from Samih Elhage in a previous round of consolidation that had split the mobile division into separate product and global service operations.

This latest reorganization underscores Nokia's assertion that its primary advantage when bidding for major infrastructure projects is its ability to offer a portfolio of fixed, mobile, and core network gear as a one-stop supplier.

But Nokia is not the only supplier positioned to make that claim. Its major competitor in the global market, Chinese group Huawei, has the same "end to end" capabilities, and reports suggest Huawei has been able to underbid the Finnish company and other competitors in numerous close contests. Nokia and others nonetheless have the advantage in the United States, where Huawei is prohibited from selling equipment to large carriers because of security concerns and charges that its chief financial officer did business with Iran in violation of U.S. sanctions.

The Chinese group's subsequent ostracism from less significant 5G markets, including Australia and New Zealand, has further opened up opportunities for Nokia and its other main competitor, Ericsson.

In the United Kingdom, Huawei's gear is at the heart of BT's phone and broadband network, and the Chinese group recently won the contract to upgrade Three UK's mobile network to 5G capabilities. Nokia supplies Three UK's core mobile network and had hoped the existing arrangement would open the door to the 5G radio deal.

But in a surprising and controversial development late last year, the Chinese group's increasing influence in the U.K.'s fixed and mobile network infrastructure came under the scrutiny of the country's most senior military intelligence officer. Alex Younger, the head of MI6, suggested the U.K. needed to decide to what extent it should "feel comfortable" with a Chinese company supplying so much of its communications infrastructure.

Huawei disputes the criminal allegations and insists that Chinese authorities have never asked it to install a "back door" to any network gear sold to another country. The diplomatic rows and court filings don't help Huawei's prospects, but whether they ultimately benefit Nokia and other competitors remains to be seen. Industry watchers suggest Huawei has won several major contracts for its 5G gear since November 2018.

THE ROAD TO 5G

Other deals and reorganizations, smaller but potentially significant, have further changed the strategic landscape for Nokia. Nonetheless, in its most recent quarter, the company's networks division was responsible for fully 88% of Nokia's revenue, and it will take some time for that to change.

The emergence of 5G networks will be crucial to Nokia's fortunes—and, to be fair, to those of its main competitors in the infrastructure

business. (For more on the opportunities and challenges for 5G and its blue-sky follow-on, 6G, see pages 12 and 19.)

Nokia has made some important technical and tactical bets that it believes will give it a clear advantage as network operators embark on the 5G rollout.

Speaking to EE Times, Phil Twist, vice president of network marketing, said network slicing would be critical to operators' ability to exploit 5G's higher data rates and low latency. Slicing lets operators target parts of the core access network for specific use cases and functions. Different slices can be programmed to carry different protocols, and thus differentiated services, depending on the application. Nokia sees slicing as a way for operators to rationalize their networks and enter new business areas.

The company has been testing network slicing in an industrial environment since early 2018 with the Hamburg Port Authority in collaboration with Deutsche Telekom. The 5G testbed is analyzing the performance of use cases such as traffic light management, data processing from mobile sensors, and virtual reality (VR) applications.

Twist also referenced Nokia's decision to develop the ReefShark family of systems-on-chip (SoCs). "They are being designed specifically for the kind of performance parameters 5G networking will [enable] and will offer us differentiation in size, throughput, and speed," he said. Intel is already making the devices for Nokia on its most advanced process lines.

The chipset range comprises digital front ends, radio-frequency ICs, transceivers for base station front ends, and integrated transceivers. The parts were designed to boost cell site throughput threefold, slash the size and power consumption of massive multiple-input/multiple-output (MIMO) antennas, use embedded AI capabilities to optimize radio resource usage, and support network slicing.

Twist said the United States and China would be the initial markets for 5G because operators there have adopted a bolder position than their counterparts in Europe and elsewhere. He said that Nokia Bell Labs had identified 110 use cases but that mobile broadband would likely be the first commercial use, emerging by mid-year 2019.

Most analysts concur with that assessment. "Verizon and AT&T in the U.S. are set to be the pacesetters, with fixed wireless access positioned as a complementary service to fixed-line broadband," said Kester Mann, principal analyst at CCS Insight. 5G will account for relatively few connections in the much touted internet of things (IoT), he added, because 4G and Long-Term Evolution (LTE) can support most of the performance requirements there and because the supposed killer application for 5G, autonomous driving, is unlikely to be a commercial reality until well into the 2020s.



Nokia's Cloud RAN centralized radio access network solution, part of the AirScale range, can automatically scale network capacity as demand changes. (Image: Nokia)

"There is not that much to choose between the three global infrastructure vendors as of now in terms of technology," said Bengt Nordstrom, founder and CEO of Swedish telecom consultancy North-stream. But he believes the European duo of Nokia and Ericsson will need to be on top of their game, as "Huawei is significantly larger than both, has been and will continue to be hugely aggressive in terms of pricing, and enjoys an R&D budget that dwarfs the large amounts Nokia and Ericsson can spend on infrastructure research for the next few years."

There is some consensus that Huawei has raced ahead of its competitors in massive MIMO technology, which uses huge numbers of active antennas to boost mobile network performance. Ericsson appears to have the edge in radio access networks, and Nokia holds the advantage in core and transport networks.

ENTERPRISE FOCUS

Nokia hasn't shied from shaking up its operations as it shifts resources to the 5G opportunity. Last year, it sold the bulk of its video business to Canada's Volaris Group. In 2016, it spent a reported US\$190 million to acquire French startup Withings, a developer of sleek digital health trackers and baby monitors, and merged the operation with its small, in-house wearables and health technologies business under the Nokia Digital Healthcare brand. Just two years later, however, the founder of Withings bought back the health-tracking operation for an undisclosed sum. Not long after that, Nokia abruptly abandoned the sector.

Set against those two negatives are a couple of promising strategic initiatives: Nokia's creation of a standalone Software Business unit and, arguably more significant, its push to sell a complete range of gear to enterprises.

The new Enterprise Business unit, headed by Nokia Chief Strategy Officer Kathrin Buvac, will target a host of organizations and markets outside of, but adjacent to, its traditional communications sector. The focus will be on enterprises such as energy, transportation/public sector, and what Nokia terms "technological extra-large enterprises." The latter includes the huge web-scale players.

Twist confirmed that Nokia has been targeting such opportunities for a while, but the global push will now be on a much larger scale. He acknowledged that while the opportunity is huge, Nokia will be up against some competitive established companies, notably Cisco, IBM, and Juniper Networks.

Industry revenues from those enterprise sectors are expected to increase at a rate of 13% over the next few years, Twist said. That contrasts with a forecast CAGR of just 1% over the same period from the traditional telecom players. Of course, the latter industry is valued globally at US\$129 billion, while the anticipated total available market for the former is estimated at US\$20 billion.

Asked whether the new division would have a dedicated product development operation, Twist said that all of the equipment sold to enterprises to date, including private LTE networks, had been adaptations of existing products, though by no means off-the-shelf designs. "However, this could change over time," he said.

One thing is clear, said analyst Peter Jarich, head of GSMA Intelligence: If Nokia is to succeed in this enterprise, "it will need to invest in new sales and marketing efforts, along with new ways of working with partners in an open way while guarding against competitive complexities the likes of which Nokia has not had to deal with in the past." He believes Nokia will solve the intricate issues involved, but not necessarily with technology. "They are fundamentally sales issues."

SOFTWARE MATTERS

Another element of the growth strategy is Nokia's dedicated, stand-alone software business, which the company is betting will achieve the kind of margins enjoyed by many of the large software-focused companies.

4G's Moon Shot

Whether infrastructure equipment providers and operators will benefit from the next giant leap for mobile communications remains to be seen, but this year, 4G coverage is coming to the moon. Supporting a mission led by Berlin-based PTScientists, Nokia and Vodafone will supply the 4G network, which will provide communications between Audi lunar rovers as they approach the rover that the Apollo 17 mission left on the lunar surface. Nokia Bell Labs is creating a space-grade "Ultra Compact Network" weighing about 1 kilogram. The partners are targeting the 1,800-MHz band for the network, which will transmit data and high-definition video from the moon back to a "mission control" of servers back in Berlin. The project is yet another small step in Nokia's bid for redemption.

— John Walko

It has become clear to everyone in the infrastructure business that software — and thus the business models around it — is crucial to winning the big contracts. Nokia Software is an obvious response to the emergence of cloud-based technologies in the network infrastructure business.

By leveraging technologies such as software-defined networks and network function virtualization, service providers want — need — to be able to run increasingly complex network functions and software programs on any cheap server in the future. Selling expensive boxes to support specific functions is no longer enough.

The two focus areas for Nokia Software are expected to be enterprise software and IoT platforms, building on Nokia's existing, relatively small applications and analysis operation. The company's May 2018 acquisition of California-based SpaceTime Insight brought machine-powered capabilities to Nokia's existing IoT applications.

But the first significant show of intent, and an indication that Nokia is on the hunt for relatively small but innovative companies in this area, was Nokia's US\$317 million acquisition of Comptel in 2017. The Helsinki startup, a long-term partner and specialist in service orchestration and intelligent data products, has proved a good fit with Nokia's existing operational support systems.

"The Comptel portfolio has been completely and successfully integrated into the Nokia Software portfolio," said Josh Aroner, a vice president at Nokia Software.

Once the various operational shifts have been completed (expected early this year), Nokia Software will take over responsibility for the development of core network products, as these are increasingly reliant on software, Aroner said. The move will allow the Mobile Networks group to focus on radio technologies, an important consideration as 5G deployment ramps up.

PATENTS GALORE

Another important pillar of Nokia's strategy is to generate even more revenue from its vast licensing opportunities. It is difficult to estimate how much the company earns from its 20,000-plus patents because that figure is embedded in the results for the entire Nokia Technologies business unit. But patent licenses likely accounted for a significant percentage of the unit's €1.6 billion in sales and €1.1 billion operating profit in 2017.

The company also receives royalties from HMD Global, the Finnish company that now makes and markets the latest generation of Nokia-branded phones, for use of the brand name and the devices' look and feel.

Nokia's Bumpy Ride Toward Redemption

Significant additional revenue is expected once 5G services and devices emerge. The company predicts that it will receive US\$3.50 per mobile phone but declines to estimate licensing revenue for the unprecedented variety of other end-user devices being developed using Nokia's intellectual property in the 5G era.

Strategy Analytics posits in a recent report that handsets alone will generate US\$20 billion annually by 2025 in global royalties for all IP holders, with three companies — Nokia, Ericsson, and Qualcomm — grabbing the lion's share of royalties. The two Scandinavian companies will collectively account for 35% of the total, while Qualcomm will take more than half, the report predicts.

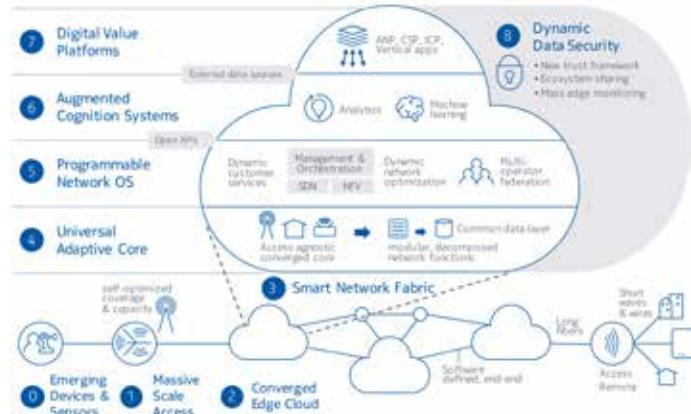
THE FUTURE IS X

The newest element of Nokia's next-generation strategy is the Future X for Industries architecture, which aims to drive dramatic productivity improvements across myriad sectors. Bell Labs developed the concept under the direction of Executive Director Marcus Weldon, who is also Nokia's chief technology officer.

Future X for Industries incorporates four core technology layers: applications, platforms, distributed cloud computing, and networking. Those layers will variously cover technologies such as edge computing, augmented intelligence and VR, and advanced LTE and 5G, providing strict security solutions.

Early this year, the company plans to open a Future X Lab at a New Jersey, U.S., Bell Labs facility to demonstrate 4G and 5G industrial and enterprise opportunities. Third parties will be able to develop their own network simulations to suit their specific targets, choosing 4G or 5G access layers.

Nokia appears to be doing the right things, but its work isn't done.



The Future X architecture. (Image: Nokia)

Through some brave and ambitious consolidation, the company has lined up a great technology portfolio. Whether that will be enough in an industry sector that faces huge price competition remains to be seen.

Even with the prospect of the next mobile generation on the horizon, operators' total spend on global infrastructure is not in good shape, and more painful cost reduction measures cannot be ruled out. ■

John Walko, a London-based contributor to EE Times, is a technology writer and editor who has been covering the electronics industry since the 1980s.

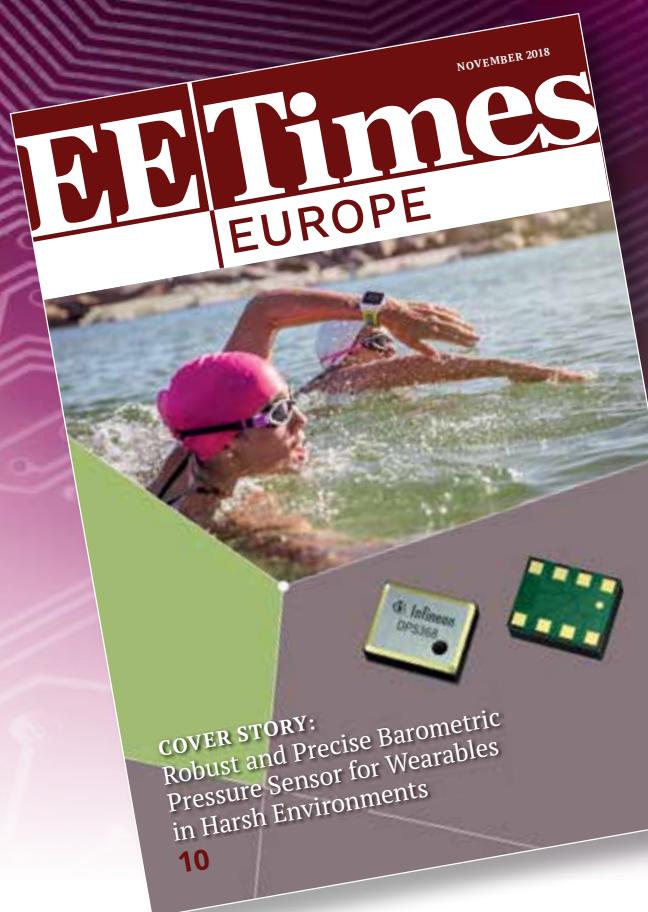
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ARTIFICIAL INTELLIGENCE

AI Tradeoff: Accuracy or Robustness?

By Junko Yoshida

ANYONE POISED TO CHOOSE an artificial intelligence (AI) model solely based on its accuracy might want to think again. Another critical parameter, according to IBM Research, is how resistant the AI model is to adversarial-example attacks. And research suggests that AI models might grow more vulnerable as their prediction accuracy rises.

IBM researchers presented the results of two collaborative research projects on AI vulnerability at the Association for the Advancement of Artificial Intelligence (AAAI) 2019 Conference on Artificial Intelligence, held last month in Honolulu. One study focused on how to certify the robustness of AI against adversarial attacks. The other examined an efficient way to test the resilience of AI models that are already deployed.

Of course, accuracy is the holy grail of AI. If computers can't beat humans, why bother using artificial intelligence? And indeed, the ImageNet competition results from 2010 to 2017 show that computer vision can already outperform humans. AI's accuracy in classifying objects in a dataset jumped from 71.8% to 97.3% in just seven years.

Companies big and small have used ImageNet as a benchmark for their image classification algorithms against the dataset. ImageNet competition winners earn bragging rights for AI algorithm superiority.

ROBUSTNESS GAP

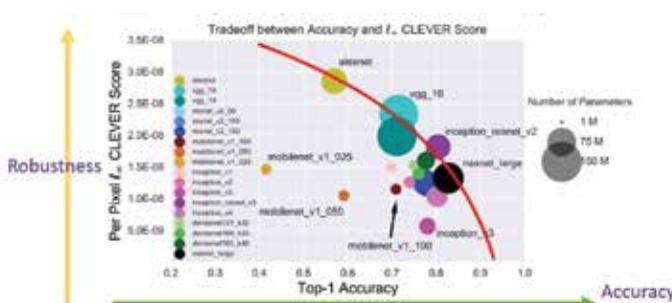
Recent studies, however, highlight a robustness deficit in well-trained deep neural networks versus adversarial examples.

Last summer, a team of researchers from institutions including IBM Research, the University of California at Davis, MIT, and JD AI Research published a study titled "Is Robustness the Cost of Accuracy? A Comprehensive Study on the Robustness of 18 Deep Image Classification Models." Co-author Pin-Yu Chen, a research staff member on the AI Foundations team at IBM's Thomas J. Watson Research Center, said the study cautions that "solely pursuing for a high-accuracy AI model may get us in trouble."

The team's benchmark on 18 ImageNet models "revealed a tradeoff in accuracy and robustness," Chen told EE Times.

Alarmed by the vulnerability of AI models, researchers at the MIT-IBM Watson AI Lab, including Chen, last month presented a paper focused on the certification of AI robustness. "Just like a watch that comes with a water resistance number, we wanted to provide an effective method for certifying an attack-resistance level of convolutional neural networks [CNNs]," said Chen.

Why does this matter? Visually unnoticeable perturbations to natural images can mislead image classifiers, resulting in misclassification, say researchers.



The IBM AI Foundations team's benchmark on 18 ImageNet models "revealed a tradeoff in accuracy and robustness."
(Image: IBM Research)

Growing concerns about safety-critical settings with AI

Autonomous cars that deploy AI model for traffic signs recognition



But with adversarial examples...



Visually unnoticeable perturbations to natural images can mislead image classifiers toward misclassification. (Source: IBM Research)

"Think about safety-critical settings with AI," said Chen. An autonomous car that uses AI should readily recognize a stop sign. Yet when a minor optical illusion is cast on the sign from a nearby light source, the autonomous car sees the stop sign as a speed limit sign, Chen said. "The light source, in this case, has become a classic adversarial example."

As a neural network is taught more images, it memorizes what it needs to classify. "But we don't necessarily expect it to be robust," said Chen. "The higher the accuracy is, the more fragile it could get."

For autonomous vehicles, in which safety is paramount, verifying classification robustness is critical.

Techniques available today have been generally limited to certifying small-scale and simple neural-network models. In contrast, the joint IBM-MIT team found a way to certify robustness on the widely popular general CNNs.

The team's proposed framework can "handle various architectures including convolutional layers, max-pooling layers, batch normalization layers, and residual blocks, as well as general activation functions," said Chen. By allowing perturbation in each pixel with confined magnitude, "we have created verification tools optimized for CNNs," he said. The team's goal is "to assure you that adversarial attacks can't alter AI's prediction."

Adversarial examples can come from anywhere, Chen added. They exist in the physical world and the digital space, in domains ranging from images and video to speech and data analysis. The new certification framework is applicable to a variety of situations and is designed to provide "attack-independent and model-agnostic" metrics, he said.

AI Tradeoff: Accuracy or Robustness?

The team says that its CNN certification framework is computationally efficient. The framework exploits the special structure of convolutional layers, reporting “more than 10x speedup compared to state-of-the-art certification algorithms,” according to IBM Research.

Chen told us, “We’ve evaluated the input and output relations of each layer to create a matrix that is fast, certifiable, and general.”

BLACK-BOX ATTACKS?

Chen also co-authored a paper focused on a much more efficient way to test for AI robustness, especially in “black box” neural networks.

It’s not hard to imagine how an actor with malicious intent and high familiarity with a particular AI model can find and exploit the system’s vulnerabilities to create an attack. This is the classic “white box” scenario for creating adversarial examples.

Now consider a “black box” scenario. A service provider is about to deploy a self-trained AI/machine-learning system. Very few actors have had access to the underlying AI model, and even fewer understand how it works. This can breed a false sense of security based on the assumption that manipulating an AI model in a black-box setting would require too many time-consuming model queries to generate a successful attack.

But that assumption is wrong, said Chen. He pointed to a recent project at IBM Research and the University of Michigan that developed a method for testing AI systems — including ones that are already deployed — to determine their vulnerability to attack. Called the Auto-encoder-based Zeroth-Order Optimization Method (AutoZOOM), the method posits a “practical scenario” for attacking AI models by creating adversarial examples in a black-box setting, said Chen.

In a white-box world, he said, an attacker can leverage knowledge of the AI model architecture and the model weights for inference to develop adversarial examples. But in a black-box setting, an attacker’s options are limited. Would-be attackers are at the same disadvantage as non-adversarial users in that they can only access the input/output responses of the deployed AI model (for example, uploading an image and receiving the prediction from an online image classification application programming interface [API]). An attacker must resort to a brute-force approach, sending a huge number of model queries to craft an adversarial example.

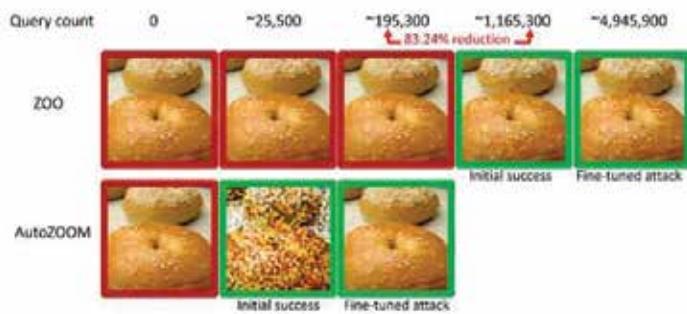
When the researchers used an existing method, Zeroth Order Optimization (ZOO), more than 1 million model queries were needed to find an adversarial bagel image, said Chen. With the newly designed AutoZOOM framework, only tens of thousands of queries were necessary, he said.

Two new techniques used in AutoZOOM include a way to “lessen the complexity of finding adversarial examples and reduce the number of queries to the black-box AI model” and a technique that “guides the generation of adversarial examples using only a few model queries in each iteration of the attack process,” according to IBM Research. You can use “an autoencoder that is either trained offline with unlabeled data or [trained with] a bilinear resizing operation for acceleration.”

Chen called the AutoZOOM a practical way to test robustness in AI models, adding, “You can apply this method to deployed AI systems.”

Indeed, evaluating AI robustness will be increasingly necessary as “machine learning as a service,” which brings powerful machine-learning tools to a broader community of users, becomes more widespread.

Commercially available services that offer well-trained image classifiers to the public include Google Cloud Vision API and Clarifai.com. Users can upload images and obtain the class prediction results for a low fee. “However, the existing and emerging machine-learning platforms and their low model-access costs raise ever-increasing security concerns as they offer an ideal environment for testing malicious attempts,” the authors of the AutoZOOM paper caution. “Even worse, the risks can be amplified when these services are used to build derived products such that the inherent security vulnerability could be leveraged by attacks.”



In testing, AutoZOOM slashed the number of queries required to generate a successful bagel image from the black-box Inception-v3 model. (Image: IBM Research)

In his keynote speech at last summer’s Design Automation Conference, Dario Gil, vice president of AI and quantum-computing initiative IBM Q at IBM Research, said that the horizon between narrow AI and broader AI (and, ultimately, general AI) is “still quite far away.” Critical research areas include fairness, explainability, and lineage, said Gil.

AI robustness is the fourth pillar, Chen told EE Times.

The two papers offer a reminder that AI training data can be noisy and biased. No one fully understands how neural nets learn to predict. Neural-network architecture can be redundant and pockmarked with vulnerabilities. The black-box system can be powerful, but that doesn’t mean it’s impermeable to an adversarial-example attack. ■

Junko Yoshida is global co-editor-in-chief of AspenCore Media and chief international correspondent at EE Times.

NEWS

Improve Airline Maintenance with AI & Analytics

Historically, some of the worst aircraft disasters have been attributed to faulty or overlooked maintenance — and as recently as last year, maintenance was still factoring into the top five causes of domestic aircraft delays. It’s prompted aerospace companies to take a hard look at implementing analytics and artificial intelligence (AI) to predict potential maintenance failures on aircraft before the failures happen.

As an aerospace manufacturer, Airbus is taking proactive steps to improve performance and reliability in aircraft maintenance. It is doing this by migrating historical maintenance information from aircraft and fleets to a cloud-based data repository known as Skywise. Airbus is also installing systems on each aircraft in an airline’s fleet to collate and record thousands of data parameters in real time. After each flight, this data is uploaded to Skywise to be analyzed and to enable maintenance predictions for the future.

“As an example, this data can record how the pressure of a certain type of hydraulic pump is gradually reducing over time,” said Norman Baker, senior vice president, Digital Solutions, at Airbus. “The Skywise analytics engine could then interpolate and ‘flag’ to the airline that the pump will likely be fine for the next five flights, but that failure is very likely to occur within 10 more flights.” ■

Deploying AI in Your Industrial Environment is Not as Hard as You Might Think

By Nitin Dahad

Artificial intelligence (AI) and the internet of things (IoT) have become such broad industry buzzwords today that the nebulous nature of the topic can make it very difficult to understand the relevance of it for your specific needs. The immediate thought when you read about these topics is that it's for the big companies with big budgets.

However, that's not entirely the case — while we only hear and read about the big impact stories, there are indeed many “use cases” for more basic tasks that can significantly benefit from some level of AI capability within their system. One such area is in industrial applications, where we often hear about the benefits of predictive maintenance.

A McKinsey Global Institute report from last year, “Notes from the AI frontier: Applications and value of deep learning,” analyzed more than 400 use cases across 19 industries highlighting the broad use and significant economic potential of advanced AI techniques. Predictive maintenance was one of those identified, wherein the power of machine learning can be used to detect anomalies.

It said that the capacity of AI, and particularly deep learning, to analyze very large amounts of high-dimensional data can take existing preventive maintenance systems to a new level. By adding additional data layers such as audio and image data from other sensors — including relatively cheap ones such as microphones and cameras — neural networks can enhance and even replace more traditional methods. Hence, AI can be used to predict failures and allow planned interventions, helping reduce downtime and operating costs while improving production yield.

The use of AI relies on having relevant data. In a factory or on a production line, the combination and analysis of maintenance history, live data such as vibration, temperature, humidity, or any other critical parameter for the machine using IoT sensors, and video images can not only help with failure prevention but also prolong the life of a machine.

ENABLING PREDICTIVE MAINTENANCE

One solution for enabling predictive maintenance is the Intelligent Condition Monitoring Box, or ICOMOX, which is an open development platform for condition-based monitoring (CBM) of industrial equipment, assets, and structures. It monitors operating conditions from the surface of the equipment to identify potential faults and reduce risks associated with equipment operation and maintenance.

Provided as a complete solution in a box, it can be used to sense



The ICOMOX solution provides an open embedded sensor-to-cloud platform plus embedded analytics for early detection of machine failures in condition-based monitoring applications.

vibration, magnetic field, temperature, and sound. Hence, it can sense a motor, whether it is functioning properly, and arm production managers with vital information that can alert them to any potential issues with the motor that might cause the machine to fail and commission other systems to compensate in case the failure is inevitable.

It provides an open embedded sensor-to-cloud platform but also features embedded software and analytics for early detection of machine failures in condition-based monitoring applications. Hence, everything is included to do a level of analytics, enabling a better understanding of the system, machine, or plant.

A key feature is its multi-sensing capability. This is enabled with a number of off-the-shelf components providing high-quality data for IoT applications and enabling intelligent sensing from the edge of the network. The individual sensors are the ADXL 356, a low-noise, low-power three-axis MEMS accelerometer from Analog Devices; the BMM150 low-power, low-noise three-axis magnetic field sensor from Bosch; the IMD69D130 high-performance microphone with dual backplane MEMS technology from Infineon; and the ADT7410 temperature sensor from Analog Devices.

The ADXL 356 MEMS accelerometer provides accurate and reliable tilt measurements for environments high in shock and vibration without saturating the sensor, an important requirement for tilt measurement applications on heavy equipment, as well as airborne platforms such as unmanned aerial vehicles (UAVs).

The IM69D130 delivers low self-noise (high SNR), wide dynamic range, low distortion, and a high acoustic overload point. It uses Infineon’s dual backplate MEMS technology based on a miniaturized symmetrical microphone design similar to studio condenser microphones and results in high linearity of the output signal within a dynamic range of 105 dB. The microphone distortion does not exceed 1% even at sound pressure levels of 128 dB SPL.

The flat-frequency response (28 Hz low-frequency roll-off) and tight manufacturing tolerance result in close phase matching of the microphones, which is important for multi-microphone (array) applications.

Each of the sensors can be configured for warning and alarm levels and timestamp events.

ULTRA-RELIABLE COMMUNICATIONS

Another key feature of the ICOMOX solution is its ability to transmit vital data in tough industrial environments in which the sensor data might be critical. It operates using Smart-Mesh, which is a network technology consisting of a scalable self-forming multi-hop mesh of



Block diagram of the intelligent condition monitoring box (ICOMOX) from Shiratech Solutions

Deploying AI in Your Industrial Environment is Not as Hard as You Might Think

nodes, known as motes, which collect and relay data, and a network manager that monitors and manages network performance and security and exchanges data with a host application. The motes and managers enable a complete wireless sensor network solution.

In the ICOMOX, the Analog Devices LTC5800-IPM SmartMesh IP 2.4-GHz, 802.15.4e system-on-chip (SoC) communications device provides a complete radio transceiver, embedded processor, and networking software for forming a self-healing mesh network. The chip can be utilized as either a wireless mote, e-manager, or access point in a smart mesh network, and the solution claims to ensure greater than 99.999% network reliability in even the most challenging RF environments.

The box is CE- and FCC-certified with IP66 enclosure and is available in a very compact form factor for external and under-hood mounting. It also features various mounting adapters to accommodate a wide range of monitored equipment.

The ICOMOX illustrates an example of how it is possible to bring the benefits of AI, complete with embedded software and analytics, into an industrial environment and implement a technology solution that can withstand tough environments, measure key critical parameters all in

one system, and provide data reliably, even in tough RF environments.

Amir Sherman, director of engineering solutions and embedded technology at Arrow Electronics, said that the cooperation between Analog Devices, Shiratech (the company that developed ICOMOX), and Microsoft is helping drive state-of-the-art solutions such as this. This is supported by the new engineering solution center software team in Gdańsk, Poland, available as a complementary service from Arrow in its role as a technology solutions provider.

Arrow Electronics will be showcasing this and other solutions at embedded world that enable developers to harness the power of AI in their applications. The company is evolving beyond its traditional role to offer more of a systems and solutions approach to provide technology, guidance, and support to help implement AI functionality across a wide range of sectors including industrial, health care, and transportation. Arrow provides solutions and services for many AI applications, including smart cities (street lighting, parking, public safety), industrial, robotics, autonomous machines, and agriculture.

More details and products being showcased may be found online at arrow.com/ew2019. In addition, the products mentioned in this article are available at arrow.com. ■

NEWS

Smart Cars Drive 200-mm Fabs

By Michelle Bourke

The industry that learned its trade making PC microprocessors and memory has been transformed. Today, it supplies chips for cloud computing, artificial intelligence, machine learning, virtual reality, robotics, medical, mobile, internet of things, and automotive applications. Automotive, though currently dwarfed by PCs and mobile in market share, shows the highest potential for growth, with an estimated compound annual growth rate of nearly 14% for the five-year period ending in 2021, according to IC Insights.

The endgame for automotive manufacturers is self-driving cars, though there is general agreement that widespread adoption of fully autonomous driving is still at least 10 years away. That adoption will be paced by the panoply of technologies and infrastructure that must be developed to support self-driving vehicles. The diversity of those requirements will make collaboration between automotive manufacturers and new industry players, including semiconductor equipment manufacturers, an essential ingredient for success.

Automotive ICs span a range of device types, with microprocessors/controllers, analog devices, and sensors accounting for more than 75% of the total. Those same segments, plus memory, also show the highest potential for growth. The trends are driving demand for 200-mm manufacturing, which is

more accommodating of diversity than leading-edge manufacturing processes developed primarily for purely digital microprocessors and memory.

Automakers also are tightening their requirements for reliability. According to one analysis, a failure rate of one per million at the component level translates to seven failures for every thousand cars. For a company making 4,000 cars per day, that's one failure every hour.

With the global forecast for light-vehicle sales in 2018 at 95.9 million units, according to IHS Markit, a 1% recall would involve nearly a million vehicles. Small wonder the industry is at the forefront of the drive for parts-per-billion failure rates.

Automotive ICs differ in many ways from planar CMOS and memory devices. They often incorporate multiple technologies and, in many cases, are most economically produced in 200-mm fabs.

New sensing and actuating technologies for cars will make use of new materials such as wide-bandgap semiconductors and piezoelectrics. Novel shapes and deep features will need tightly controlled etch capability. Advanced packaging processes that connect systems in a package or stacked dice will rely on through-silicon vias to achieve smaller footprints.

To address such challenges, capital-equip-

ment makers are releasing a new generation of 200-mm tools that incorporate the lessons learned for leading-edge 300-mm systems. For example, etch tools used to create the varying shapes and deep features often found in microelectromechanical systems (MEMS) and power devices now incorporate higher power capability, improved software, additional control features, tunable gas delivery, advanced edge uniformity features, and enhanced wafer-cooling options.

Automotive demand also is putting pressure on existing 200-mm fabs to improve productivity, performance, automation, and lifetime. Upgrading installed systems with capabilities drawn from 300-mm advancements can address those requirements. In addition to enhancing their performance, upgrading installed systems extends their useful lifetimes and reduces the risk of obsolescence.

Equipment makers must leverage lessons learned from 300-mm processes to solve the most difficult challenges ahead in MEMS and power devices for cars and other systems. They also must provide comprehensive solutions to address the diversity of technologies needed for both CMOS and mixed-signal ICs. These improvements for both new and installed systems will allow component makers to extend 200-mm fab lifetimes and optimize capital efficiency. ■

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INDUSTRIAL

The State of Machine Vision

By Alix Paultre

Technology development is being driven by market pressure from the creation of functionalities enabled by technology development. From smart facilities and buildings to smart vehicles and roads, solutions based on the latest core technologies are empowering designers in the creation of advanced industrial products.

There is no precision in any system without some kind of observation and feedback. That input can be from something as simple as a pressure switch or as complex as a LIDAR sensor. The ability to see something and gain information from it is a powerful enabler in a system, and machine vision provides that functionality in advanced automated systems.

A machine vision system is made up of task-related subsystems. Their number and function will vary depending on the system's targeted image resolution, speed, memory, and functionality. In general, however, machine vision requires subsystems for capture, processing, and communication. One must have an image, turn it into data, and send that data to the network. Points added if you can accept commands and adjust your operating parameters on the fly.

CAMERAS

Highly integrated cameras are available that incorporate the necessary electronics for the desired functionality. Not only do they have to deliver in the area of resolution and speed, but they also have to perform in a potentially harsh industrial environment.

The Cognex In-Sight 9000 family of ultra-high-resolution vision systems can acquire detailed images for high-accuracy parts location, measurement, and inspection, even when mounted at a distance. The 9902L is a 2K line scan camera; the 9912 does a 12-megapixel area scan. Both are IP67-rated for use in demanding factory envi-



ronments. The company's In-Sight Explorer EasyBuilder interface provides an integrated solution to simplify application design and setup. Cognex's vision tools and technologies include PatMax RedLine pattern matching and High Dynamic Range Plus (HDR+) technology.

Allied Vision's Alvium camera series offers a selection of current sensors, intelligent power management, and cost-optimized design to address limitations associated with legacy camera modules. The Alvium 1500 offers a Mobile Industry Processor Interface Alliance (MIPI) CSI-2 camera serial interface, with software integration realized via Video4Linux2 or GStreamer. Image-preprocessing functionality can be configured directly on the image, and depending on the application requirements, a Direct Register Access is available to enable full control of the camera.

The Alvium 1800, with an advanced feature set for image correction and optimization, can be used for industrial embedded vision or machine vision applications. Designers can choose advanced image-processing functionalities for their embedded vision application



The Alvium Camera Series addresses limitations associated with legacy camera modules.

(Image: Allied Vision)

The State of Machine Vision



Cognex's In-Sight 9000 family of ultra-high-resolution vision systems perform high-accuracy part location, measurement, and inspection.
(Image: Cognex)

that can be operated directly on the camera. For camera control, the series supports Video4Linux2 (V4L2), direct register access, and the Generic Interface for Cameras (GenICam).

The newest interface available for connecting cameras to systems for machine vision applications is 10 Gigabit Ethernet (10GigE). The touted benefits of 10GigE cameras are excellent speed and distance performance, quick and simple setup, reliability, backward compatibility with Gigabit Ethernet, efficient CPU usage, and GigE Vision compliance. Companies such as Imperx have recently added 10GigE cameras, with models that can deliver 31- and 25-Mpixel resolution.

For cost-sensitive applications, Imperx offers the Cheetah 3MP, which has a tiny form factor but packs a Sony IMX265 CMOS. Available in color or monochrome, the camera offers excellent sensitivity, a wide dynamic range, and an upgradable feature set for ease of integration, according to Imperx. The Imperx CMOS Cheetah 5MP, with a SONY IMX250 sensor, has polarization features to minimize glare from reflective surfaces as well as help visualize internal tensions and stresses within transparent materials.

BOARDS AND MODULES

The board your camera plugs into is another important part of the system with implications for the final product's performance. Among the companies addressing advanced computing is congatec, which released new versions of its NXP i.MX 8-based Smart Mobility Architecture (SMARC) 2.0 and Qseven modules last fall at electronica (Figure 3). The small-form-factor modules are particularly suited for ultralow-power, high-reliability industrial applications, according to congatec.

Leveraging the power-efficient Arm Cortex-A35 architecture, the i.MX 8X modules offer advanced processing and graphics performance, scaling from two to four cores. Features of the 2- to 4-W embedded computer modules include an extended temperature range from -40°C to +85°C; domain resource partitioning; high-bandwidth, low-power double-da-

ta-rate LPDDR4 memory; and real-time, IEEE 1588-compliant Ethernet support for devices connected to the internet of things (IoT).

Axiomtek supports factory automation, Industrial IoT (IIoT) gateway systems, and machine vision with the PICO318, a palm-sized fanless Pico-ITX motherboard powered by the Intel Pentium N4200 or Apollo Lake N3350 Celeron processor. The low-power, 2.5-inch embedded board is equipped with a 204-pin, DDR3L-1867 small-outline dual-in-line memory module (SO-DIMM) for up to 8 Gbytes of system memory. A dual-display capability is available through 18/24-bit single/dual-channel low-voltage differential signaling (LVDS) and DisplayPort. The modules have a M.2 key B slot for a Serial ATA (SATA) or PCI Express x2 SSD card, as well as a half-size Mini PCIe slot with support for Mini-SATA, and a 12-volt DC power input with AT auto power-on.

I/O connectivity includes two USB 3.0 ports, two USB 2.0 ports, one RS-232/422/485 port, one RS-232 port, two Gigabit LAN ports with Intel i211AT Ethernet controller, one HD Codec audio, and four-channel digital I/O. Features include a watchdog timer and hardware monitoring as well as support for AXView 2.0, intelligent remote management software for industrial IoT applications, and an I2C interface with smart battery support.

COMMS IS KEY

Of course, no matter how sophisticated your vision system is, if it can't communicate well with the rest of the process, it loses value. Once a machine vision camera is connected to a communicating network or the cloud, it becomes a critical sensing tool that not only allows you to control a process, but also can help you draw insight from the captured images. Interfaces such as Camera Link, GigE Vision and USB 3.0 continue to offer an affordable value proposition in low-end applications. But alternatives are emerging to deliver the bandwidth and latency performance required for transmitting decision-triggering data in advanced industrial IoT applications.

Among them is CoaX-Press (CXP), a high-speed, high-capacity interface that makes it possible to transmit data-laden live images that can help systems identify patterns and make decisions on the spot. CXP allows video, camera control for triggering, and power to be delivered via a single coaxial cable at high speeds, with CoaXPress V2.0 offering 10-Gbit/second (CXP-10) and 12.5-Gbit/s (CXP-12) communications.

The Cyton-CXP4 four-channel frame grabber from BitFlow incorporates a Gen 2.0 x8 PCI Express bus interface on its back end while supporting CoaXPress on its front end for capture speeds of up to 6.250 Gbits/s in applications deploying up to four CXP-6 cameras. It supports not only simple triggering modes but also complicated, application-specific triggering and control interactions within any hardware environment.

Vision is a critical enabler in any automated system and adds critical value on the manufacturing floor. Proper vision subsystem selection and integration are key to creating an optimal solution for industrial vision systems. ■



NXP i.MX 8-based SMARC 2.0 and Qseven modules from congatec serve ultralow-power and high-reliability industrial applications.
(Image: congatec)

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