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Gaming Processor with up to 68 PCIe 3.0 Lanes

Chipmakers continue to play for high stakes.

By Lynnette Reese, Editor-in-Chief, Embedded Intel® Solutions

Gaming is serious business. Pro-gamers can compete for a total prize pool of $25.5 million. And a high-performance machine can make a huge difference in an online multi-player game. The new Intel® Core™ X-series processors feature up to 68 PCIe 3.0 lanes (44 from the CPU and 24 from the chipset), and are designed for highly demanding applications, with eight to 18 cores handling up to 36 threads. (The eight-core i7-9800X can be outfitted with up to 68 PCIe 3.0 lanes.) The new processors can perform a trillion floating point operations per second with 18 cores.

Intel touts its 9th Gen Intel® Core™ i9-9900K as “the world’s best gaming processor.” The desktop product line, with three 9th Gen Intel Core processors to choose from (i5-9600K, i7-9700K and i9-9900K), enables blazing fast and immersive experiences for gamers with as many as eight cores and 16 threads, 5.0 GHz single-core turbo frequency, a 16 MB Intel Smart Cache, and up to 40 platform PCIe 3.0 lanes for potential system expansion for gaming, advanced overclocking, and crafting videos and other digital creations. Intel reports a possible 11 percent increase in Frames per Second (FPS) over the last generation of processors and as much as a 41 percent increase in FPS over PCs that are three years old. These new processors can handle mega-tasking—4K gaming while recording, streaming, and encoding simultaneously. Adding to the performance is Intel Optane memory and SSD for faster access.

Intel is celebrating the new 9th Gen Intel Core processors by hosting the “Dreamstakes,” an event where Intel will give away nine trips to world-class, Intel-powered esports and gaming events. The company will also be awarding second place winners one of thousands of exclusive in-game codes.

Compare PC gaming processors for the Intel Core i9-9900K gaming processor vs. competitors at http://facts.pt/11u9e2.

Lynnette Reese is Editor-in-Chief, Embedded Intel® Solutions and Embedded Systems Engineering, and has been working in various roles as an electrical engineer for over two decades. She is interested in open source software and hardware, the maker movement, and in increasing the number of women working in STEM so she has a greater chance of talking about something other than football at the water cooler.
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Border security is an important topic these days, and many countries are leveraging technology to improve effectiveness and at the same time reduce inconvenience for travelers. This article includes a brief overview of the current state of applications, focusing on land border checkpoints (Figure 1) and the drivers for increased deployment of technology. It also outlines the attributes that are critical relative to the embedded computing solutions used to address those applications. It concludes with examples of Intel® processor-based embedded solutions with particular relevance to border checkpoint applications.

There is a constant tension between maximizing security and minimizing traveler inconvenience. Increasing international travel puts even more stress on our systems. A 2016 study by Visa Inc. estimated that the number of households taking at least one international trip would increase by 35 percent between 2015 and 2025. This represents a tremendous increase in the number of travelers who need to be screened.

Border security technology has evolved significantly since the events of September 11, 2001 and the need to tighten security at airports. Land border crossings add the movement of private cars as well as commercial trucks into the mix. Automated License Plate Reader (ALPR) technology has been deployed in both in-bound and outbound lanes at several US land border checkpoints. ALPR allows vehicles license plates to be automatically checked against law enforcement databases for outstanding warrants or other alerts. A Govtech Works article quoted Customs and Border Protection (CBP) as saying it can achieve 55 vehicles per lane per hour versus 46.5 per lane per hour for lanes without ALPR. This technology is also used to read truck license plates and match the truck with a manifest that has been pre-filed with CBP, again speeding processing. Over the years the technology has been enhanced. For example, upgrades have included using higher resolution day and night cameras, incorporating RFID technology to automatically identify trusted travelers, and adoption of machine learning/AI techniques to improve character recognition. This brings us to the attributes of the embedded computing solution.

Performance and Future Proofing
Performance is the first thing that comes to mind, not just that of the processor, but also that of the interface to peripherals. Earlier implementations of ALPR technology could exist on embedded solutions featuring single core processors with sub-500 MHz clocks, 256 MB of memory, and 100BaseT Ethernet ports. Now, solutions with multicore processors such as Intel’s 7th generation Core™ i7, featuring internal GPU capability, are required to cater for current needs and to provide a degree of future-proofing. These upgrades are required to allow for use of the latest operating systems as well as to handle the application load. Expanded memory capability, which supports 8 or 16 GB of RAM, enables higher camera resolutions and better algorithms to decode what is being seen. The desire to increase camera resolution, frame rate, and field of view has necessitated Ethernet connectivity at gigabit speeds.

Temperature range is also a critical requirement. Border crossings exist from the deep chill of the Arctic Circle to the sweltering heat of equatorial countries. This drives the need for embedded computing solutions to work over the full industrial temperature range of -40°C to +85°C.
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Reliability is of course critical as well. The consequence of a system going down is manual screening that leads to long lines, long waits, and reduced accuracy in checking license plate records.

For performance and reliability, even at temperature extremes, one embedded computer supplier has been filling the bill in border security applications for more than 10 years. VersaLogic Corp has seen four generations of its products leveraged for increasingly more powerful border security systems.

The company’s experience started with its Puma single board computer (SBC) in 2008. It featured a processor running at 366 MHz, 256 MB of RAM, and a single 100BaseT Ethernet.

This was replaced by another PC/104 embedded computer, the Ocelot, which was introduced in 2009 and phased out in 2016. It featured an Intel Atom® Z530P processor at 1.6 GHz, up to 2 GB RAM, and a gigabit Ethernet port (Figure 2).

The Bengal, which was introduced in 2015, took the PC/104 form-factor up in performance using an Intel Atom E3845 quad-core processor with 1.9 GHz clock, up to 8 GB of RAM, and dual gigabit Ethernet ports (Figure 3).

For emerging security requirements, such as facial recognition and cyber security threat management, the Lion was introduced in 2017. It includes a seventh generation Intel Core i7 running at 2.8 GHz, integral GPU, up to 16 GB of RAM, dual gigabit Ethernet ports, USB 3.0, and an on-board TPM 2.0 security chip (Figure 4).

In summary, the application of technology at checkpoints is a major contribution to border security and requires embedded computing solutions that not only keep pace, but also provide a transition to future platforms so that the application can evolve. The products illustrated are examples of one company’s success at utilizing Intel technology to satisfy the need for high reliability, increasing performance, and simplified migration from one generation to the next.

Bob Buxton brings more than twenty years of experience in both R&D and product management roles. He has worked within, and has provided products to, the mil/aero segment. His R&D experiences have been primarily in connection with radar and microwave sub-system design.

He is currently working in product management at VersaLogic Corporation, a leading provider of embedded computers which are designed for the most demanding applications. VersaLogic is located in Tualatin, Oregon.

Buxton holds a master’s degree in Microwaves and Modern Optics from University College, London and an MBA from George Fox University, Newberg Oregon. He is a Chartered Engineer and a Member of the Institution of Engineering and Technology.
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Linux-based Virtualization for IoT Edge Devices

Linux containers, which enable virtualization anywhere, are now a standard tool in cloud development and deployment workflows. One company, balena, has harnessed all that container goodness for the embedded world in IoT, greatly improving reliability, power efficiency, and security in Edge devices.

By Lynnette Reese, Editor-in-Chief Embedded Intel® Solutions, Embedded Systems Engineering

Editor’s Note: Embedded Systems Engineering Editor-in-Chief Lynnette Reese (LR) interviewed Alison Davis Riddell; Director, Product and Commercial Strategy at balena.io. (Note: balena recently changed its name from resin.io.)

At first glance, balena.io may seem like “just another company who works with IoT,” but balena provides a vital service for companies who want the benefits of the big data that IoT is driving but don’t have the time to mount the learning curve. By creating and managing the IoT infrastructure, balena.io lets developers concentrate on building IoT applications. The company’s expertise pays for itself as its customers avoid costly mistakes and the expense of building and maintaining an infrastructure while making it to market faster than the competition.

LR: What exactly does balena do?

Alison Davis Riddell (ADR):

We are an IoT infrastructure company. We provide tools for organizations to build, deploy and manage fleets of connected devices. The goal is to remove friction for fleet owners at every stage of their IoT projects.

Much of our offering is built around container technology, as we believe Linux containers are the best way to benefit from virtualization on embedded devices. We’ve adapted containers for the constrained operating environment of the edge, where users are faced with intermittent power, low-bandwidth connectivity, constrained memory and compute resources, heterogeneous device fleets, and so forth. The benefits of using containers are numerous, including portability across platforms, minimal overhead, and more control for developers over how their code runs.

balenaCloud is a container-based, hosted platform for developers to build and deploy code and remotely manage fleets of connected devices [Figure 1].

LR: How does Balena add value to connected Linux IoT devices?

ADR: Balena lets developers concentrate on building IoT applications, not creating and managing infrastructure. By using our platform, developers can get their projects to market faster and cheaper than if they had to build and maintain this infrastructure themselves. Once devices are deployed, IoT fleet owners can continue to grow and improve their project by seamlessly provisioning new devices, pushing frequent updates without fear of bricking their code, and monitoring the health of their fleet from anywhere in the world.

LR: Balena is known for widely contributing to open source tools. What are some of the open source projects balena has developed?

ADR: balena is the developer of:

- balena, which is a minimal Yocto Linux-based host operating system that’s packaged with balenaEngine;
- balenaEngine, which is a lightweight, Docker-compatible container engine for IoT;
- balenaEtcher is a tool we created to flash OS images to SD cards, device storage, and other media;
- openBalena, which provides the open source building blocks of balenaCloud that can be used to host your own device deployment and management server.
LR: A customer’s first 10 IoT devices are free and “full-featured.” What does “full-featured” mean?

ADR: It’s important for us to maintain a low barrier to entry; to enable developers to try out our platform before committing as paying customers, or so they can use it for free for personal projects. So, every capability offered in balenaCloud is available at no cost on up to 10 devices, and there’s no limited trial period. To extend a project beyond 10 devices, a user simply moves up to a paid subscription plan. Otherwise, they can remain on a free plan for as long as they like.

LR: Zephyr is a small Linux OS intended for IoT. Does balena support any Linux-connected device, or just the Yocto-based distro that balena provides?

ADR: For devices to work with balenaCloud, those devices currently need to run balenaOS, our Yocto-based distro. That said, developers can run the operating system of their choice from within their application container(s). We also provide many base images with several common Linux distributions to make this easier. To investigate this further, you can find out more at https://hub.docker.com/u/resin/.

All the code for balenaOS is open source, and balenaOS currently supports more than 30 device types from a common layer called “meta-balena,” which can be found on GitHub at https://github.com/balena-os/meta-balena.

Support for each individual device type is then added in specific GitHub repos, such as https://github.com/balena-os/resin-intel for x86 devices.

More details can be found at balena.io/os/; a site that explains how our OS is designed to run Docker containers on embedded devices.

LR: How does balena use Docker containers?

ADR: We think virtualization is a great match for IoT devices. Virtualization enables features like isolating application failures and executing efficient updates, which are ideal for connected edge devices. Developers benefit from the friendliness and flexibility of cloud-native workflows, too.

LR: This sounds cloud-intensive, and containers are primarily associated with server-based applications. How does balena resolve the differences?

ADR: Since containers were originally designed for the datacenter, balena made required modifications for use in the IoT ecosystem. For example, we support a wide variety of devices compared to the relatively homogenous world of cloud servers and desktop machines. To make updates more efficient in the field, we also needed to reduce the size and build time of new images to deal with the less reliable and more bandwidth-sensitive connectivity common to remote devices. We also worked to build in resiliency to interruptions from network or power failure, which
isn’t a typical consideration in datacenters. You can learn more about how we use containers on our blog at https://www.balena.io/blog/why-linux-containers-matter-for-the-internet-of-things/.

LR: Security is a very large concern for IoT. How does balena.io assist with security?

ADR: Balena primarily assists with security of devices by offering reliable, fast, over-the-air updates of everything from the bootloader on up to the user application, defending from all issues that are patched upstream. Our fine-grained permission system allows developers, operators, and device administrators to have access to relevant information while making sure they can only do what they have permissions to do. One core means for implementing this security approach is through API access control. To effectively explain how we handle security, which gets deep, we would need a very long discussion indeed. For a more detailed explanation, read about how we handle device access, run time management with VPN, support access, building images, and how we handle backend security at https://www.balena.io/docs/learn/welcome/security/

LR: Do containers benefit security?

ADR: Containers benefit security by isolating applications from the rest of the system and making it easy to use the latest sandbox technology of the Linux kernel like namespaces, seccomp, etc.

LR: Does balena work with Intel products? If so, which ones?

ADR: Yes! balena supports x86 IoT devices such as the Intel NUC. The balenaOS image for the Intel NUC is actually a generic x86 image and will usually “just work” on any x86 device.

LR: What type of application or enterprise would best benefit from balena’s model?

ADR: Anybody building and managing an IoT project can benefit from balena. Our customers span verticals and industries, including start-ups and large enterprises, from farms to factories, from energy to medicine, from real estate to robotics. If you’re deploying fleets of connected Linux devices, then balena is for you.

For specific real-world examples, see https://www.balena.io/customers/ and https://www.balena.io/blog/tag/case-study/
Build Fast-Booting IoT Solutions with Ease

Slim Bootloader helps speed development with optimizations for the latest Intel®-based IoT platforms.

With the huge growth in the Internet of Things (IoT), there are more smart devices than ever before. Companies are innovating new ways for us to interact, work, and live by using new technological solutions. And the software underlying embedded systems is what makes it all happen. But most software uses system bootloaders that are not originally designed with IoT use cases in mind, which present their own unique requirements.

The Intel® Slim Bootloader is a new scalable firmware solution for IoT devices. Slim Bootloader brings simplicity to the IoT development process and is ideal for integrated industrial IoT solutions and Real-Time Operating Systems (RTOS) with minimal firmware requirements. Slim Bootloader addresses the need for a streamlined, easy-to-implement bootloader for a variety of IoT use cases spanning various markets, including:

- Industrial automation
- Public sector
- Digital security
- Healthcare
- Transportation

Slim Bootloader is ideal for IoT because of the following attributes:

- Small footprint: Slim Bootloader has a low memory footprint optimized for small form factors.
- Quick boot: Slim Bootloader is tailored for IoT usages and quick startup.
- Simple configuration: Speed up deployment with the included binary configuration tool that avoids the need to modify source code or recompile the code.
- Integrated, out-of-the-box use: With robust security and ready-to-use integrations, developers can download and start using Slim Bootloader from open source resources.
- Permissive licensing: Because of Slim Bootloader’s BSD licensing structure, which is more permissive regarding proprietary contents, device manufacturers are free to innovate and differentiate at the bootloader level.

Figure 1 provides a high-level overview of Slim Bootloader. The Slim Bootloader consists of both the initialization code and a payload. The initialization code consists of the Intel® Firmware Support Package (Intel® FSP) as well as board-specific code. The initialization code includes the board and silicon initialization and determines resource allocation, General Purpose Input/Output (GPIO) assignments, Advanced Configuration and Power Interface (ACPI) tables, etc.

The Payload in Figure 1 consists of any standard media drivers (eMMC, UFS, etc.), custom features, OS-specific loading protocols, and so forth. The Payload can be the Operating System (OS) loader, u-boot, a Unified Extensible Firmware Interface (UEFI) payload, or a custom payload.

The OS loader is a versatile Linux loader implementation that boots Linux, a hypervisor, Android, or ELF executables / PE executables, and supports the MultiBoot specification. The OS loader is also an optimized reference payload specifically developed for IoT use cases and is the default Slim Bootloader payload.

Figure 1: Overview of Slim Bootloader. (Image: Intel® Corporation)
Slim Bootloader supports verified boot, measured boot, and secure firmware updates. The Firmware Update is a power fail-safe, fault tolerant, and secure firmware update tool that is also included in Slim Bootloader.

**Benefits of Slim Bootloader**

Slim Bootloader is designed to enable new experiences and customer-centric innovation for IoT with the following benefits:

- **Fast boot**: Compared to previous bootloader solutions. Boot up of 420ms¹ on Apollo Lake.
- **Strong security**: Features verified boot, measured boot and firmware update support.
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- **Optimized for Intel® architecture**: Intel® FSP integration.

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1. Up to 420ms fast claim based on APL Leaf Hill REV D board running on Intel Atom™ Processor E3950 at 1.6GHz with HT enabled and Turbo enabled, LPDDR4 8GB, 64G eMMC 5.1. FSP version MR5 from github.com/IntelFsp/FSP.git, revision a57c6616e-78b471515a1e1862f96b1d3824d8. Compiler: Microsoft Visual Studio*, Measured from CPU Reset vector to OS entry point.
New Wheel Chair Kit Powered by AI Uses Facial Expressions for User Control

Instead of invasive body sensors, HOOBOX Robotics’ kit, powered by Intel® AI technologies, uses a 3D Intel RealSense camera mounted on the wheelchair to stream data that AI algorithms process in real time to control the chair.

Everyday, most people use artificial intelligence (AI) for tasks like photo tagging, talk-to-text, online searches, handwriting recognition for mobile check deposits, and ride-sharing apps. Other examples of AI in common use include email spam filters, credit card protection, and autopilot in commercial airlines. However, we continually see AI and machine learning contribute to cutting-edge innovations such as autonomous cars, precision medicine, and preliminary diagnoses.

AI is also helping quadriplegics control their motorized wheelchairs using facial expressions. The HOOBOX Robotics’ Wheelie 7 kit, powered by Intel® artificial intelligence technologies, is an aftermarket add-on that allows the user to pick from ten simple facial expressions to control their motorized wheelchair. Facial expressions such as kissing, wrinkling the nose, smiling, and raising the eyebrows are translated into commands to go forward, turn right, turn left, and halt. The HOOBOX system accurately detects expressions and manipulates the wheelchair in real-time without the need for body sensors or machine training ahead of time.

Figure 1: HOOBOX Robotics’ Wheelie 7 kit allows users to pick from 10 facial expressions to control their motorized wheelchair. Instead of invasive body sensors, the Wheelie 7 uses a 3D Intel RealSense Depth Camera SR300 mounted on the wheelchair to stream data that AI algorithms process in real time to control the chair. (Credit: HOOBOX Robotics)

Figure 2: HOOBOX Robotics’ Wheelie 7 kit allows users to pick from 10 facial expressions to control their motorized wheelchair moving forward, turning and stopping. Instead of invasive body sensors, the Wheelie 7 uses a 3D Intel RealSense Depth Camera SR300 mounted on the wheelchair to stream data that AI algorithms process in real time to control the chair. (Credit: HOOBOX Robotics)

By Lynnette Reese, Editor-in-Chief, Embedded Intel Solutions
Figure 3: Mobility is often enabled through caregivers or through a motorized wheelchair with complex sensors placed on the body that require special education to operate. HOOBOX Robotics’ Wheelie 7 uses AI and a 3D Intel RealSense Depth Camera SR300, without invasive body sensors, providing users with independence and control over their location. (Credit: HOOBOX Robotics)

HOOBOX web site claims that there are in excess of 60 people in the United States who are presently testing the kit, the majority of whom are people with amyotrophic lateral sclerosis, quadriplegics, or the elderly. The HOOBOX Wheelie 7 kit takes about seven minutes to install and employs a 3D Intel® RealSense™ Depth Camera SR300 to stream data to on-board AI processors. The system can process, in real-time, the AI algorithms that control the wheelchair.

Since immediate responsiveness to the user’s facial expressions is critical to the success of the system, the Wheelie 7 incorporates Intel® Core™ processors using the Intel® OpenVINO™ Toolkit to accelerate the facial recognition software’s inference activity. The fact that AI training of each individual is not necessary speaks to a universal-ness of human facial expression.

A HOOBOX video demonstrates the Wheelie translating facial expressions into commands to control a motorized wheelchair. “The mission scenario is to drive from the room A, passing through the corridor, overcoming its obstacles (that require precise turns and displacements) and getting back to the room A. In this round, the user took 18 expressions to complete the course in 2 minutes.”

Dr. Paulo Pinheiro, co-founder and CEO of HOOBOX Robotics, states, “The Wheelie 7 is the first product to use facial expressions to control a wheelchair. This requires incredible precision and accuracy, and it would not be possible without Intel technology. We are helping people regain their autonomy.”

According to the National Spinal Cord Injury Statistical Center, there are over 280,000 people in the United States who have spinal cord injuries. The center also claims that there are approximately 17,700 new cases each year. Physical mobility has the most impact on the quality of life for those with spinal cord injuries.

As of this writing, The Wheelie 7 kit includes a 30-day trial and is available in a subscription plan at $300/month on a 12-month subscription plan.

The HOOBOX team. HOOBOX partners are Albert Einstein Hospital, JLABS@TMC, Intel® Software Innovator program, and FAPESP.

HOOBOX Robotics, a São Paulo–based company, was founded in May 2016 after the postdoctoral research of Dr. Paulo Gurgel Pinheiro (Co-Founder and CEO) at School of Electrical and Computer Engineering, State University of Campinas (FEES / Unicamp). The focus was to study and develop innovative solutions to control a wheelchair. In 2016, along with Cláudio Pinheiro (co-founder) and Prof. Eleri Cardozo (mentor), HOOBOX Robotics began developing technologies for monitoring people’s facial expressions to detect human behaviours, that allows users to control a wheelchair with simple facial expressions.

Lynnette Reese is Editor-in-Chief, Embedded Intel® Solutions and Embedded Systems Engineering, and has been working in various roles as an electrical engineer for over two decades. She is interested in open source software and hardware, the maker movement, and in increasing the number of women working in STEM so she has a greater chance of talking about something other than football at the water cooler.
Microcontamination, Despite High Yield, Can Cause Long-term Reliability Issues

For 7 nm node chips, any contaminant can make a chip fail. Microcontamination control is the last line of defense for chipmakers, as even a lot yield in the high 90s percent range can bear chips with long-term reliability issues.

By Lynnette Reese, Editor-in-Chief, Embedded Intel® Solutions

According to SEMI (semi.org), the global semiconductor revenue forecast for the second half of 2018 was doubled from 7.5 to 15 percent, a substantial growth. The semiconductor industry has seen cycles of growth and stagnation before, as innovative new products peak and decline before new technologies come out to drive growth from another direction. The wide adoption of personal computers marked great growth in semiconductors; a market that has been dominated by Intel for decades. When the PC market began to mature, a period of stagnation was followed by the mobile computing era. Companies like Qualcomm and MediaTek emerged as key players in the mobile industry. However, both computer and mobile sectors are now sustainable, but not growing appreciably.

Recently, multiple growth engines have kicked in for semiconductors, driving a new era of growth. Growth drivers include data centers, a growing “economy of data,” artificial intelligence, virtual reality, autonomous vehicles, and increasing automation in industrial applications, particularly in the Internet of Things (IoT) and robotics. The concurrent emergence of several new markets and applications has prompted a high demand; from leading edge chips on down to some of the legacy nodes. In turn, growth in semiconductors is driving the need for materials and better technologies for Integrated Circuits (ICs).

Companies feeding the boom with materials and chemicals for making ICs are seeing growth that shows no signs of

Figure 1: Entegris works with automakers and mainstream fabs to investigate reducing contaminants and particles that don’t affect yield yet cause critical problems in long-term reliability. (Image courtesy of Entegris, ©2018).
abating. One materials company, Entegris (ENTG), has recently expanded its Kulim manufacturing capacity and capabilities, adding new tooling, molding machines, and numerous updates to the assembly area so that Entegris can meet the demand for wafer handling products. Entegris is a 52-year-old company that, for context, was founded two years before Intel® Corporation. Entegris provides materials and material solutions to semiconductor companies (semis). Currently, the company has about 4,000 employees with sales revenue of approximately $1.5 billion. Entegris has been expanding rapidly in recent years, achieving growth by about two to three percent above the market. The company is now viewed by most investors more as a growth company than as an industrial, “cyclical business” type of company. Entegris is assisting the semiconductor industry in two ways: by helping the semis realize more advanced technologies and by providing materials for making chips.

Entegris has three divisions that address three different elements of semiconductor manufacturing. The first division provides advanced materials such as specialty chemicals, specialty gas mixtures, cleaning chemicals, deposition chemicals, specialty coatings, graphite, silicon carbide (SiC), and many other materials that fabrication plants (fabs) use to make chips. The second group at Entegris is involved in benefiting materials handling with carriers for handling wafers and photomasks, wafer and reticle handling, fluid management, sensing, control, and supply and delivery of chemicals to fabs. It is chip growth that primarily drives the growth of all Entegris’ divisions, with some growth influenced by advances in technology. The third division focuses on microcontamination control and primarily handles leading edge filtration and purification (at levels measured in parts per trillion). Microcontamination control is presently the fastest growing division at Entegris. Anything that touches the semiconductor wafer must go through a filter and purifier, whether gas, liquid, photo-resist, slurries, or other chemicals.

Why is microcontamination control important?
Technologies continue to improve such that the industry is now producing Systems-on-chip (SoCs) at the 7 nm node and is headed to 5 nm. At such a scale, any particle or contaminants can make a chip fail. Enterprises like Entegris’ microcontamination control group are the last line of defense against contaminants for all chipmakers. Entegris works with automakers and mainstream fabs to investigate reducing some of the contaminants and particles that are not affecting yield yet are causing critical problems in long-term chip reliability.

According to Wenge Yang, Vice President of Marketing Strategy at Entegris, “Many existing and mainstream fabs are yielding high 90 percent range. However, we recently found that particles that are small enough to not cause a reduction in chip yield - can still cause reliability issues down the road. This has triggered Entegris to become an industry advocate on a new effort to reduce contaminants even further than has been practiced up to now.”

A Hot Topic
Entegris spotted a trend emerging about a year or two ago as semis began rooting out causes affecting long-term chip reliability that included microcontamination that did not affect yield but could affect a chips’ long-term reliability.

“Recently, multiple growth engines have kicked in for semiconductors, driving a new era of growth. Growth drivers include data centers, a growing ‘economy of data,’ artificial intelligence, virtual reality, autonomous vehicles, and increasing automation in industrial applications, particularly in the Internet of Things (IoT) and robotics.”
There's no greater concern for reliability than in autonomous cars; it's become a hot topic.

The Society of Automotive Engineers (SAE) International issued a standard (J3016) that defines six levels of automation for self-driving cars. Level zero has no automation whatsoever. Adaptive cruise control is a Level One feature. Level Two specifies partial automation. Level Three defines conditional automation, such as Tesla's Autopilot. Level Four demonstrates a high level of automation where the car can operate without human oversight under certain conditions. Level Five is full automation with no human involvement.

"One of the most interesting things we have seen is that with the growth of some specific sectors, the design and manufacturing challenge is changing," Wenge affirms. "One example is in the automotive industry. If an automobile used only 200 or 300 chips total, the failure rate is not causing that much of a headache as it does if you have 10,000 chips in one car."

Level Five autonomous cars may have as many as 10 LiDAR systems around the car, gathering data and processing signals and images in real-time, with low latencies. A fully autonomous car might have 10,000 ICs with 50 percent of the cost of the car sunk into the electronics. With that many chips in one autonomous vehicle, automakers begin to parallel NASA-level care in design and manufacturing, but without the added safety of redundant systems due to cost and size constraints. Add to this pressurized scenario the

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**Figure 4:** Autonomous Waymo Chrysler Pacifica Hybrid minivan undergoing testing in Los Altos, California, November 2017. Credit: Dllu, CC BY-SA 4.0.

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**Figure 3:** Entegris provides solutions to eliminate some of the random inferences impacting reliability. (Image courtesy of Entegris, © 2018)
harsh automotive environment with extreme temperatures and constant, heavy vibration.

“With these many chips in each car, if you have a failure rate of one chip out of one million, then several hundred cars might fail on the roads every single day,” states Wenge. The resulting repairs, medical bills, and lawsuits would be costlier than fixing the reliability issue at the outset. “For Entegris, the intrinsic need for increased reliability is an excellent opportunity.”

The military, aerospace, and avionics industries commonly employ redundant systems. However, the automotive industry cannot afford redundant systems, which means that we must improve the single systems’ reliability. The Level Five autonomous car sends processed data feeds into a central computer that decides whether the car should brake, slow down, accelerate, and so forth. If any component in any autonomous automotive systems fails, the car may not collect crucial data. If the car has made a decision, it may be unable to execute on it. The possibility for failure is multiplied as automakers load thousands of ICs in a single car.

As Wenge points out, “Autonomous car makers start to realize, ‘If I put that many chips into the car, I run the risk of reliability everywhere.’ Of greater concern are chips that have passed on down the line as ‘good’ in a 100 percent yield batch...but can still fail in the field. This is how the topic of detailed reliability gets triggered.” The design process for automotive applications must be accompanied by very high awareness of the reliability consequences. States Wenge, “Entegris is providing solutions to eliminate some of the random inferences impacting reliability.

Wenge Yang, Ph.D. Vice President, Market Strategy

Dr. Yang joined Entegris in 2012 to serve as the Vice President of Market Strategy. In his role, he is responsible for Entegris product and market strategy, market research and market trend analysis, strategic marketing, and the company’s strategic technology roadmap. Before joining Entegris, Dr. Yang was an equity research analyst at Citigroup covering the semiconductor equipment and materials sector. He also served in various executive roles at Advanced Micro Devices, Tokyo Electron, and two start-up companies. Dr. Yang received a Ph.D. in Materials Science and Engineering and an MBA from Rensselaer Polytechnic Institute. Master of Science degree in Mechanical Engineering from the New Jersey Institute of Technology, and a Bachelor of Science degree in Materials Science and Engineering from Shanghai Jiao Tong University.

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Two Are Better Than One: Dual Technology Architectures Leverage Flexibility to Facilitate Exciting Casino Games

What it takes to achieve a cohesive, certified and highly reliable gaming platform

By Ron Mazza, EFCO

Creative casino gaming developers both large and small are continually looking for advanced technologies that will enable them to keep their competitive edge. OEMs understand the value technology adds in delivering immersive and entertaining experiences that provide the incentive players demand to keep them playing longer and more frequently.

For the most part, this is easier said than done. Video-rich, interactive games rely on the fastest multicore processors, extensive I/O, and screaming graphics performance in highly dense enclosures where proven reliability matters. Getting all this technology to work together isn’t always cost-effective or easily integrated to meet an OEM’s time-to-market goals. Another hurdle is that no developer wants to be slowed-down from getting to market quickly by continual regional certifications and recertifications if any modification to the system takes place. So, what is the best approach that offers long-term technology scalability? Recently some developers have discovered that gaming logic box platforms provide a building block solution. The developers get the latest features and capabilities for easily accommodating multiple game designs and future upgrades. However, there is still room for improvement in helping OEMs streamline the development process.

Achieving a cohesive, certified and highly reliable gaming platform requires developers to significantly change the technology architecture they integrate. The change is in
Gaming Machine Design Overview

Gaming machine designs are typically divided into two major functional areas: The media section has the hardware and software used to run the game, while the I/O portion connects the hardware peripherals and includes the security features required to pass GLI and BMM. A development challenge for OEMs is to seek out a gaming logic platform that comes closest to meeting their specific design, processor and graphics performance, and I/O needs.

The I/O part of the design is an important consideration, as it has a bearing on time-to-market and on the direction future upgrades or additional games development will take. That is because the I/O board needs to be certified by the GLI and BMM gaming laboratories.

There seems to be no lack of creativity when it comes to developing casino games. The intense graphics and interactive nature of today’s games calls for ever-increasing design complexity. In turn, their gaming hardware choices must deliver the performance, connectivity, and features that simultaneously support broad I/O needs while sufficiently handling advanced gaming software architectures. This makes size and power a real concern, so the most optimal hardware platforms need to support multiple independent display outputs simultaneously from a single gaming controller.

A dual architecture gaming logic box solution (Figure 1) can be the facilitating foundation that stimulates innovative games without being tied to a static feature set.

This level of complexity and desired performance calls for multicore processors that integrate high-speed graphics cores. Taking games to new levels of entertainment are where the latest quad-core processing architectures are true multimedia enablers, capable of driving multiple full HD or 4K screens with very low latency in terms of frames-per-second performance during video decode. High resolution graphics, supported with HD multimedia processing and simultaneous encode/decode video capabilities, as well as 3D acceleration, offer the most ideal gaming logic box features for multi-screen games. Hardware platforms for the gaming market need to be optimized to accommodate the full feature set of gaming I/O, pin outs, and removable storage including PCI Express (PCIe), high-speed Ethernet, RS-232 and USB ports, and SATA SSDs. These types of building block solutions essentially multiply the I/O options developers can access for everything from speakers and lights to card readers, printers, bill readers, and player tracking applications.

Architectural Shift Rationale

An architectural shift that took place several years ago giving gaming developers considerable design efficiencies is in the use of a common hardware platform that offers scalability, upgradeability, and backward compatibility. Innovation can take priority when a designer is working with a proven, open-architecture platform that can be leveraged across an OEM’s entire portfolio. The flexibility to scale application features per a given game’s specifications becomes much easier when hardware platforms can offer a number of multicore processor options with integrated high-speed graphics cores and a range of power profiles that meet expanded functionality in smaller form factors.
Today’s dual-architecture gaming logic box solutions make an even greater argument for a gaming hardware shift. Separate media and I/O architectures designed to work together provide a breakthrough platform for continued gaming innovation, scalability, and application flexibility. Of primary importance is that this approach solves a major time-to-market issue for OEMs. Any change at all to the I/O section of the game system requires all new regional certifications. By separating all the I/O functions onto their own dedicated board and keeping that portion of the system the same, developers will only be required to certify the system once. The certification process can be cumbersome as even slight gaming hardware alterations have typically required recertification of every part of the game’s design all over again. A boon for developers is that new gaming designs can now be streamlined. Taking a dual-architecture gaming box approach eliminates this costly and time-consuming requirement. Developers today have more freedom to change or upgrade the media platform without the need to recertify each and every machine design.

For example, with the media and I/O separate, OEMs can select from any of the highest performing AMD or Intel processor architectures for the media board. That means the developer can concentrate on optimizing the game’s software performance without worrying about the I/O needed. In addition, a two-architecture hardware solution that offers a PCIe slot also makes it easier to integrate a variety of higher performance graphics add-in cards such as those from NVIDIA or AMD. This results in faster development of both the media and peripheral connection areas of the game, allowing designers to meet both high-performance and low-power goals, and lets the OEM be in full control of selecting the exact combination of technologies to fit a particular game’s specs.

This new architectural approach can also help improve security with the inclusion of secure boot capabilities on the I/O board. Secure boot functionality ensures that only trusted game software is operating by preventing malicious software applications and “unauthorized” operating systems from loading during the system start-up process. By including this extra level of security, secure boot also aids in the ability to meet the security requirements needed to pass GLI and BMM.

Figure 3: EFCO’s latest EGL50X5 gaming logic box offers unprecedented versatility for the development of casino games from its dual architecture design. As one of its media board options, OEMs can select the AMD Embedded R-Series SOC for designs that need the highest performing graphics and HD multimedia processing. Its I/O board is fully GLI/BMM-compliant and supports the complete feature set of gaming I/O and pin out requirements, which satisfy current and future I/O application needs.

Gaming Features that Make Sense
Dual architecture platforms also need to offer state-of-the-art features that meet the advanced technology required for increasingly entertaining casino games. Processor performance with built-in graphics top the list of feature requirements for the media board. A prime example is illustrated in gaming logic box solutions based on the AMD R-Series quad-core SoC that integrates AMD Radeon™ graphics and an I/O controller. Its programmable cores make high-speed parallel processing possible, offering a performance-rich environment that capably supports complex casino gaming systems. Delivering amazing HD multimedia/video graphics with true 4K decode and encode, the AMD R-Series also presents a highly power efficient compact form factor solution. Plus, its Heterogeneous System Architecture (HSA) technology lets designers balance workloads between the CPU and GPU to optimize processing performance, reduce latencies, and maximize access to cache memory. The bottom-line is design complexity can be simplified through a reduction in board layers and power supply needs.

A key benefit in separating the media and I/O portions in gaming hardware solutions is that developers get increased CPU options that can help them take multiple streaming of 4K content, 360-degree videos, and virtual and augmented reality game creativity to the next level. Illustrated with the EFCO EGL50X5 gaming logic box, there is a broad range of processor choices that include Intel® (Skylake) and Intel® Xeon® or Core™ i9 or (Kaby Lake) CPUs as well as three different AMD R-Series options and the latest AMD Ryzen™ V1000. All four available CPU choices all can use the same fixed I/O board.
Features on the I/O board are equally important where the CPU selected can make a difference. Logic box solutions that, for instance, offer the Intel® Atom™ E3800 processor family as an option provide energy-efficient high performance. The feature benefits include exceptional I/O connectivity, an integrated memory controller, plus virtualization, error correcting code (ECC), and built-in security capabilities that are in addition to the approving gaming standards houses’ security requirements.

On the media board broad port interface support is a given, too. Considerations for the media portion of next-generation casino games must accommodate display and audio output, GPIO, and LAN connections as well as necessary gaming interfaces that include PCI Express, high-speed Ethernet, RS-232 and USB.

**Double the Flexibility**

Demonstrating the value of using a dual-architecture gaming logic box as the platform for new game designs, is how development flexibility is enhanced giving OEMs full control. With two intelligent computer boards that communicate via Ethernet ports as the foundation, OEMs have the freedom to select the right complement of components to meet their game’s functionality and graphics requirements and as well as their cost goals. For today’s complex games, the selection of the optimum and latest AMD or Intel processors, possibly with quad-core parallel compute capabilities, can be a vital consideration that ensures performance-per-watt advantages can be gained.

Flexibility for future games is also achieved from dual architecture gaming logic box solutions, such as the EFCO EGL50X5, that provide a one-time pre-certified I/O board. While every customer must have their own new slot machine system certified as well, they gain peace-of-mind that the I/O has gone through the process, so they know it can pass. A viable case in point would be a casino game system that has been certified with a new dual architecture pre-certified I/O board with an Intel® Atom™ that offers a 10-year lifecycle. Not having to recertify again for 10 years extrapolates into a considerable benefit in time and requalification costs.

These time and cost-saving advantages allow OEMs to further speed time-to-market on same-platform designs or upgrades. When an exciting new game trend takes hold, OEMs can keep their competitive advantage by migrating to any higher performance media board. By delivering the facilitating foundation that stimulates innovative games without being tied to a static feature set, separate media and I/O architectures are the versatile platforms developers can rely on to leverage the highest performance while meeting connectivity and security requirements for many years to come.

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**Ron Mazza** is CEO, EFCOtec Corporation. Mazza drives EFCoTec’s business strategy, tapping more than 40 years of leadership in embedded business development, sales, marketing, and operations management. Connect with Ron on LinkedIn or via email at ron.mazza@efcotec.com.
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