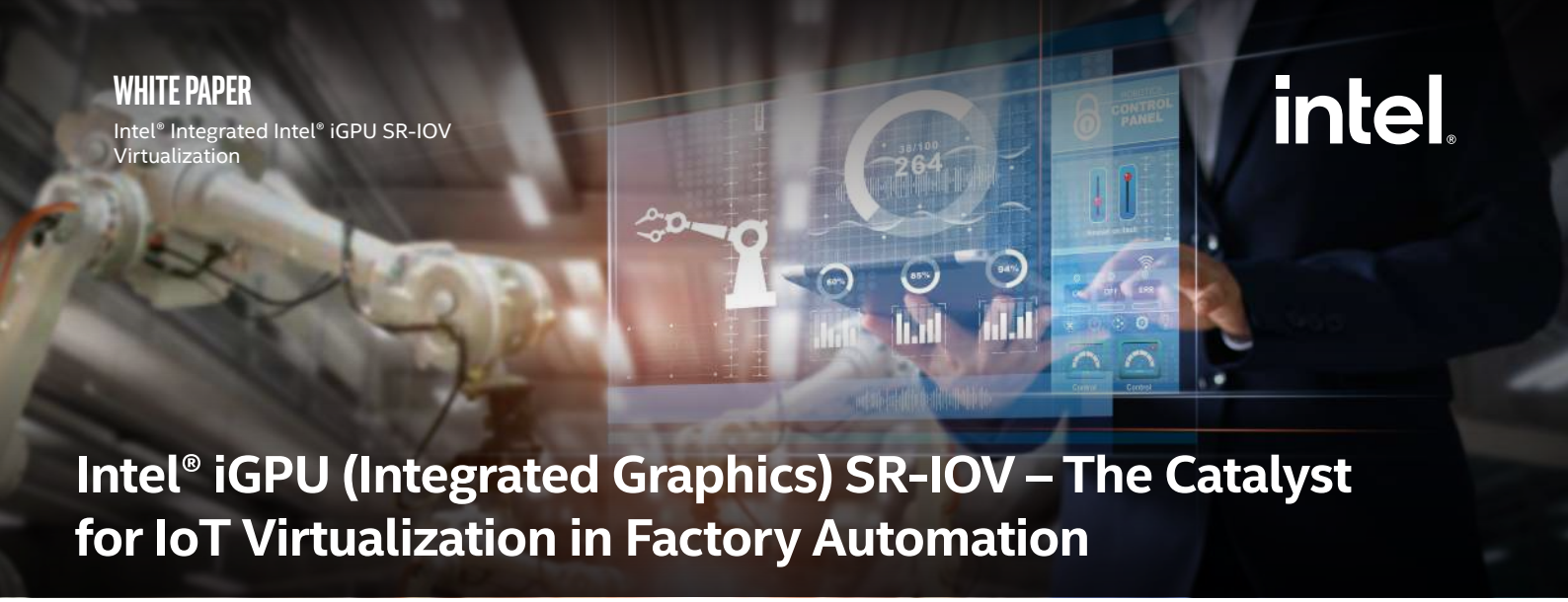

WHITE PAPER

Intel® Integrated Intel® iGPU SR-IOV Virtualization

Intel® iGPU (Integrated Graphics) SR-IOV – The Catalyst for IoT Virtualization in Factory Automation

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> Intel® iGPU SR-IOV greatly simplifies the application scenarios of virtualized infrastructure in industrial automation and can further improve availability and reduce costs.
>
> – Jarry Chang
> General Manager of Product Center, DFI

Introduction

Industrial processes are known to be complex to achieve high accuracy with precision industrial control and automation. It required various technologies, systems, hardware, foundational software, and applications to fulfil these requirements, as well as cost effective and reliable to operate in industrial environment. In order to achieve proper industrial control and automation, various technologies, systems, hardware, software, and applications are needed for different processes or product lines.

Traditionally, industrial or manufacturing factories have multiple sets of systems, hardware, and software to support the dedicated appliances for different functions, processes, and production lines. For example, visual processing system, displaying system, storage system and industrial control system.

This is more or less a linear relationship, i.e., when you have a new function, you add another new appliance as well as a new set of system, hardware, and software to support and manage it. However, things tend to get complex quickly with this approach. As a result, higher cost, lower efficiency, and loss of flexibility.

In this white paper, we will look into how **Intel® Virtualization Technology, Intel® iGPU SR-IOV enabled by 12th Gen Intel® Core™ processors (Alder Lake),** and **DFI's hardware** help you overcome these challenges and achieve real factory automation in a cost-effective, highly efficient, and flexible way.

Intel® Virtualization Technology

What is Virtualization?

Figure 1 (left) shows the traditional deployment architecture for factory hardware, software, and applications, which is considered a hardware-based architecture. In other words, applications for each function or process need dedicated hardware and operating software (OS) to host and run them. This type of architecture often results in high operational cost, low resource efficiency (i.e., high resource wastage), and low flexibility.

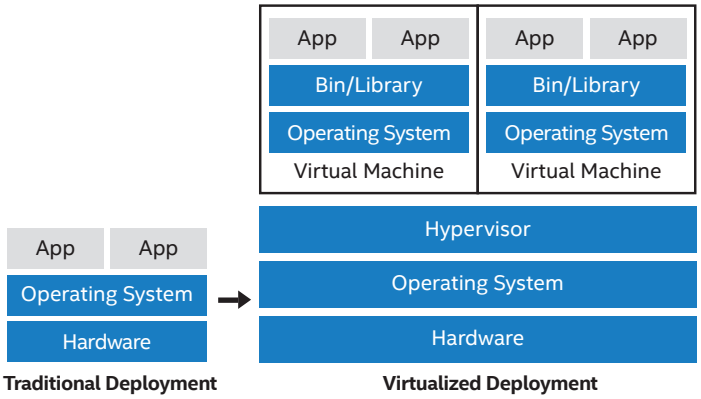

Figure 1: Comparison of hardware, software, and applications architecture between traditional deployment (left) and virtualized deployment (right)

In this regard, it is where virtualization comes in handy. Virtualization is used to break the strong connection between application, OS, and hardware. With virtualization technology, you can run multiple OSs (same or different types of OSs) and applications simultaneously, but separately, on one single physical host hardware, as shown in Figure 1 (right).

In simple words, virtualization uses software (i.e., Hypervisor, also known as virtual machine manager [VMM]) to simulate hardware functionality to create and manage multiple virtual machines (VMs). Each VM has its dedicated guest OS to run the applications hosted in it, as well as has an interface to the hypervisor that controls the physical hardware and assigns the resources concurrently to different VMs as if the VMs are run natively on their separate hardware.

Benefits of using Intel® Virtualization Technology

Owing to the unique virtualization architecture and characteristics of VM, deploying virtualization in your industrial processes can help you bring 5 key benefits as below.

1. **Low capital and operational costs on hardware.**
   This may be achieved by reducing the number of physical hardware required and optimizing the available hardware resources through workload consolidation. Besides, fewer physical hardware also means less maintenance, hence, lower operational costs as well.

2. **High management efficiency.**
   Since all applications are run on a minimum number of physical hardware and servers, managing them becomes easy. In terms of software maintenance, new software revisions or updates only need to be installed on one master VM, which then can be duplicated for the rest.

3. **High deployment and application flexibility.**
   Since VMs are software-defined or software-based, they can easily be cloned and replicated to a new production line or a new factory for expansion purposes, or can quickly be modified and tested for new products or functions. Moreover, the deployment of a new VM and modification of the existing VM would not affect other VMs on the same physical hardware, or even the physical hardware itself, as they are completely isolated from each other.

4. **Reduce downtime.**
   If the physical hardware or server is affected for any reason, affected VMs can be replicated to another physical hardware easily, and the whole recovery process would only take minutes, as compared to hours or even days it would take for fixing or setting up new physical hardware.

5. **Increase application longevity.**
   Virtualization enables users to dependably keep their legacy software running for years, even though it is virtually deployed on newer hardware. Also, existing hardware can be used for new application deployments over a longer period as long as its computing power remains sufficient for use.

Intel® iGPU SR-IOV Enabled by 12th Gen Intel® Core™ Processors

Even though virtualization technology has been continuously advancing and becoming more mature over the years, its deployment and application in factory automation are still limited. This is mainly because the Intel® Integrated Graphic Processing Unit (iGPU) is built-in within the CPU silicon die, and require specific virtualization implementation compare to standard I/O such as USB, network port, PCIe devices and etc, so iGPU resources can be shared across multiple VMs easily.

In order to attain desirable graphics performance, users can either install a dedicated GPU at an individual VM or emulate a virtual GPU to act as an intermediary between the physical GPU and the VM drivers. However, neither of these methods is practical in real scenarios as the former will incur an extremely high cost if multiple VMs require GPU support, whereas the latter causes high latency that most applications would not tolerate.

Hence, comes the solution for the industry-wide predicament – Intel® iGPU SR-IOV.

What is Intel® iGPU SR-IOV?

Intel® iGPU SR-IOV (in full: Single-Root Input/Output Virtualization) is a technology used to realize the full potential of virtual GPUs.

In 12th Gen Intel® Core™ processors (Alder Lake), rather than resolving the problem with complicated architecture or putting more graphics execution units than an edge system could possibly use, Intel® adds SR-IOV –support for a Peripheral Component Interconnect Special Interest Group (PCI-SIG) to Intel® Graphic Virtualization Technology, giving VMs direct access to the physical functions of a GPU's PCI Express port.

This allows the physical GPU in the physical host machine to be shared across multiple VMs at a near-native performance level. In other words, it allows resource sharing directly in hardware but not in software.

How does Intel® iGPU SR-IOV Enabled by 12th Gen Intel® Core™ Processors Contribute to Factory Automation?

As mentioned before, difficulty in virtualizing and sharing physical GPUs across multiple VMs is one of the reasons for low virtualization applications in factory automation deployment. This is especially true for factories that need VMs involving visual elements, such as human-machine interface (HMI) and machine vision.

Simply put, effective GPU access (technically and economically) needs to be made available to VMs to increase virtualization application in factory automation, and Intel® iGPU SR-IOV does precisely that. The benefits of Intel® iGPU SR-IOV in Intel® Alder Lake are as below.

1. **Support display virtualization up to 4 physical displays.** This feature is particularly useful for industrial machine usage where there is a need for consolidated workloads, for example, general-purpose display applications running in Windows OS, HMI applications for machine operation, Linux-based vision application display and data visualization dashboard.

2. **Support assignment of GPU virtual function (VF) to VMs.** GPU with SR-IOV capabilities can be configured to appear in the PCI address space as multiple VFs. By creating multiple VFs of the same physical GPU, one can assign individual VFs (such as AI inferencing) to different VMs (up to a maximum of 7 VMs) and share the physical GPU for hardware acceleration.

3. **Aims to improve VM's graphics performance** Without Intel® iGPU SR-IOV, VMs need to go through a hypervisor or VMM to access the physical GPU, as shown in Figure 2 (left); and, in our testing, graphics performance obtained by VM without SR-IOV was 28 fps (Figure 3 [left]). On the other hand, with Intel® iGPU SR-IOV, VMs can bypass the hypervisor or VMM layer and directly access the physical GPU, as shown in Figure 2 (right), achieving native-like graphics performance at a 60-fps frame rate, a common target for smooth graphics rendering (Figure 3).

**Intel does not control or audit third-party data. You should consult DFI to evaluate accuracy. Results have been estimated or simulated.*

4. **Lower costs in graphics cards.** With Intel® iGPU SR-IOV, one physical GPU can be shared directly with multiple VMs at a near-native performance level. In other words, it eliminates the need to install a dedicated highest-end professional graphics card at the individual VM level to support the graphics requirements of each VM and, therefore, significantly reduces the costs incurred.

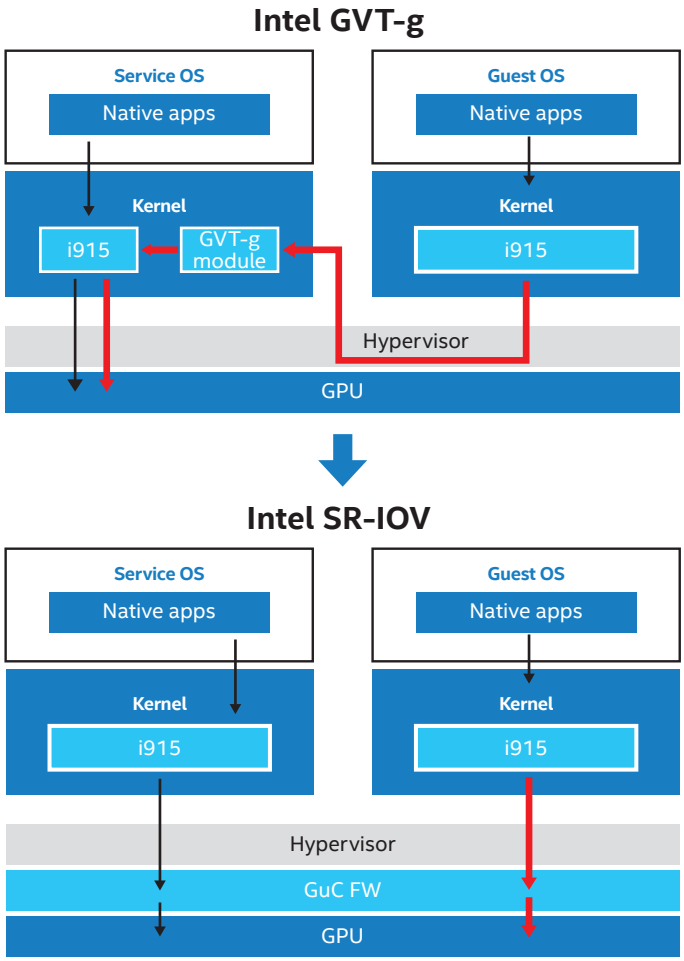

Figure 2: With SR-IOV, Intel's new generation graphics can achieve advanced graphics virtualization, helping greatly improve the industrial automation.

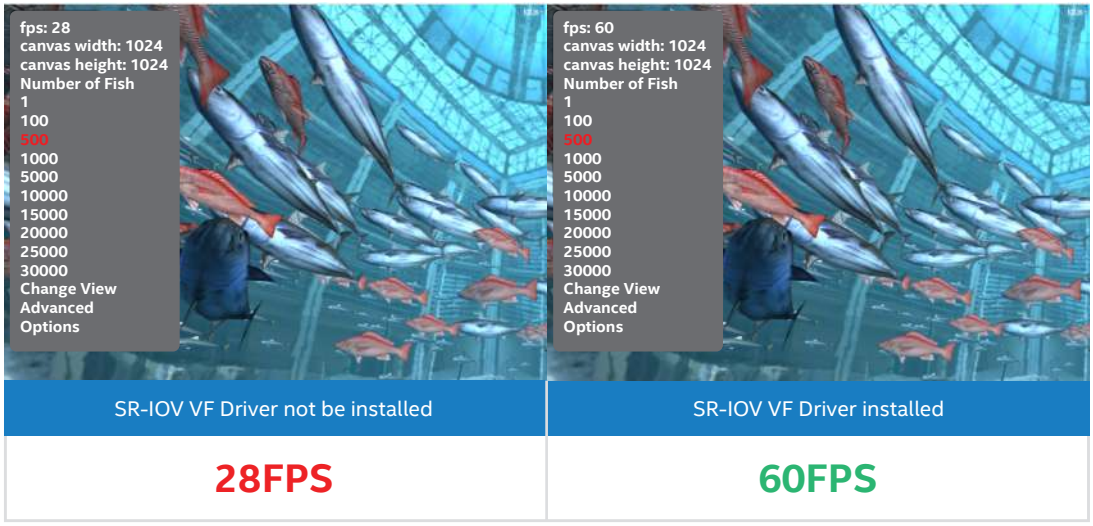

Figure 3: In the performance test of the WebGL aquarium, when 500 fish were swimming, the performance jumped from 28 FPS to 60 FPS when Intel® iGPU SR-IOV was activated.

DFI Hardware

Who is DFI?

DFI is a global leader in industrial computer solutions, that is committed to offering various high-technology, high-quality products to their clients worldwide, from modules and boards to integrated systems and embedded solutions.

DFI has recently formed a strategic alliance with Intel® in developing computer and monitor hardware powered by 12th Gen Intel® Core™ processors with Intel® iGPU SR-IOV. In this strategic collaboration, the ADS310 is the motherboard with graphics virtualization fully enabled by Intel® iGPU SR-IOV, as well as supporting OpenVINO™ AI algorithms containerized workload in an Ubuntu VM to analyze images using iGPU resources.

Figure 4: DFI ADS310 Micro-ATX Industrial Motherboard

Testing was conducted to evaluate the graphics performance of the ADS310 that has Intel® iGPU SR-IOV enabled. In the testing, the video in local storage were passed to a local monitor through HDMI. Besides, the same video file was also fed into two Windows 10 OSes, partitioned by KVM* hypervisor. Then, the images were relayed to remote displays via Wi-Fi and HDBaseT Ethernet. The graphics performance observed from Windows 10 VMs without SR-IOV enabled was at around 28-fps frame rate, whereas the frame rate increased to 60 fps in Windows 10 VMs with SR-IOV, which is a common target for smooth graphics rendering.

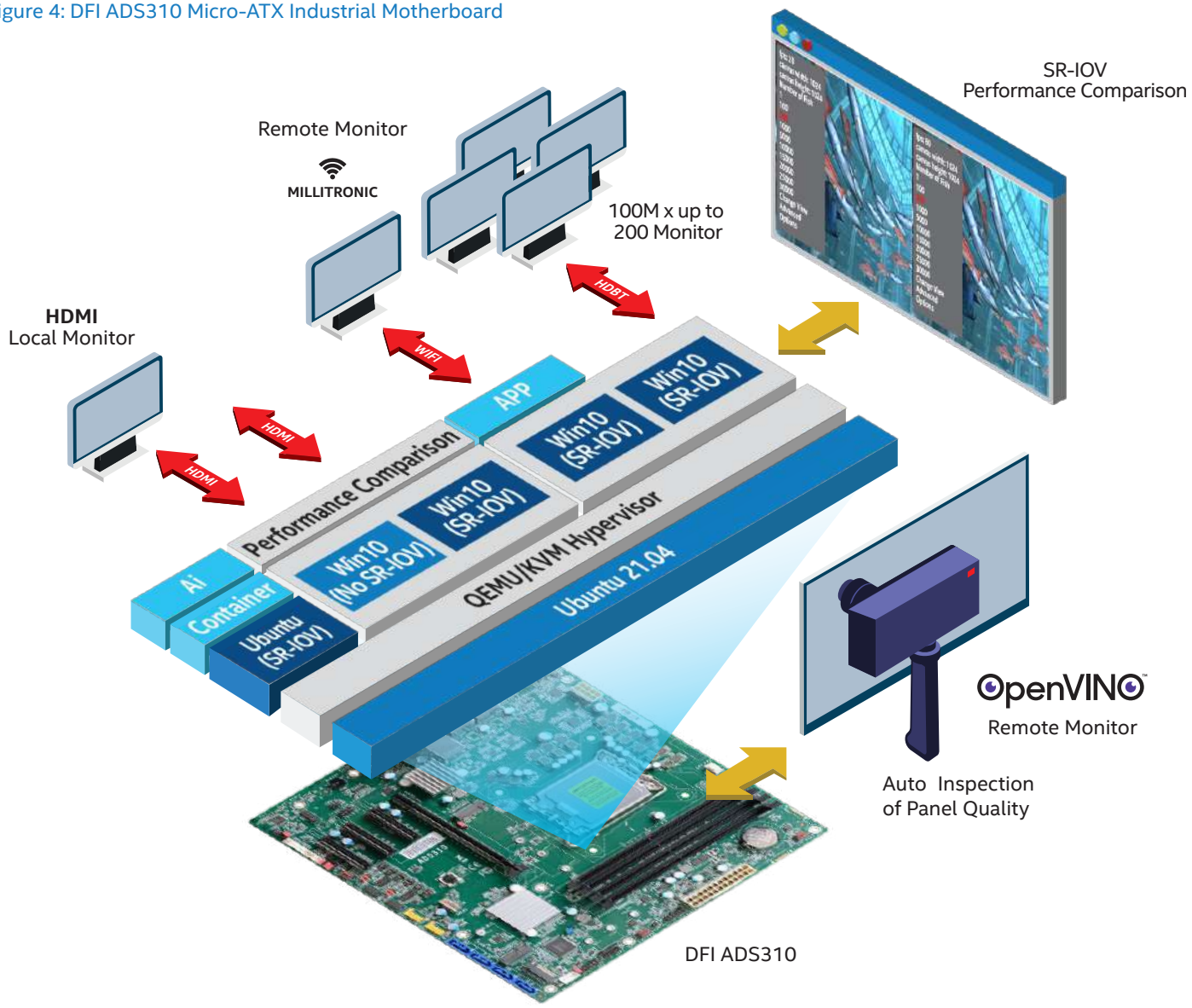

Figure 5: Auto Inspection of Panel Quality, Powered by OpenVINO.

DFI Display Devices with Wireless and HDBaseT Connectivity – Enabler for Industrial Visualization and Automation

Display device with high-quality, stable connection and graphics performance is one of the critical components in automating industrial processes. For instance, automated industrial processes would require multiple HMI screens for control, machine vision would need display screens for analyzing and monitoring images or videos collected from machine vision sensors, screens for production line monitoring, etc. For any of these, unstable connectivity and/or insufficient graphics performance will affect product quality and user experience. To meet the industrial needs, especially the productivity of production line operators, all DFI industrial panel computers, displays and applications that connect to a large number of screens are equipped with wireless and HDBaseT connectivity.

HDBaseT is the global connectivity standard for the distribution of ultra-high-definition audio and video, Ethernet, controls, USB and up to 100 W of power over a single cable, for up to 100 m/328 ft. Simply put, devices with HDBaseT connectivity eliminate cable clutter without compromising performance or quality.

Millitronic, the subsidiary of Innodisk as long-term partner of DFI for industrial embedded flash and DRAM storage, its Wi-Fi 6 Media Server module is tailor-made for establishing high-speed, stable wireless connectivity for USB devices, interactive touch screen to connect with a Windows computer. Empowered by virtualization technology and the industry's latest Wi-Fi 6 (802.11 ax) standard, the Wi-Fi 6 Media Server (WMS) module enables interactive contact between users possible. Users can access, share, annotate or edit interactive content directly on the secondary screen in real time, without latency. The Wi-Fi 6 Media Server module is recommended to be deployed in a wide range of in-door environments, such as meeting rooms, digital classrooms, healthcare facilities or wherever requires a stable wireless connection, interactiveness and collaboration.

Therefore, the sky's the limit as to where you want to install the screens, be it at a high location or a distanced location for remote control or monitoring, because no wiring is required for the installation and the wireless technology used in our devices would allow you to install up to 200 monitors within 100 m (Figure 6).

Moreover, DFI's industrial displays adopt the latest LCD flat-panel display and are available in not only projected-capacitive multi-touch but also resistive touchscreen. Therefore, they are suitable in rugged environments and applications, for instance, working as monitoring displays with touch functionality in factory control rooms.

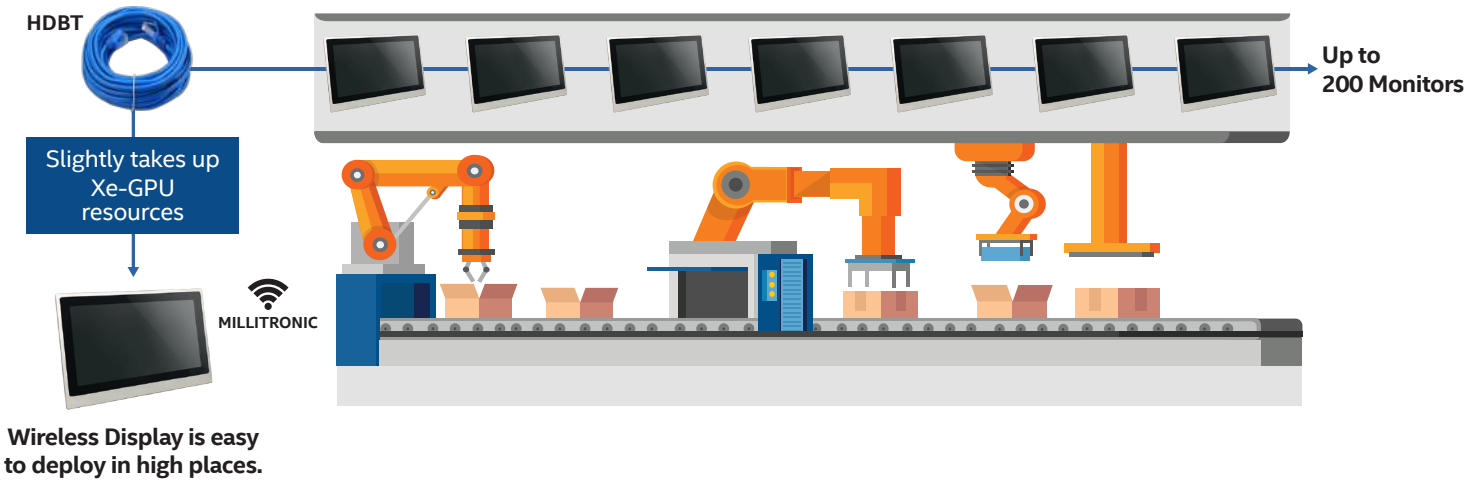

Figure 6: HDBaseT and wireless connectivity in DFI display devices enable the use of a single category cable to meet all industrial computer requirements, offering distribution of audio and video, Ethernet, controls, USB 2.0 and 100 W power over 100 m/324 ft

IDP070 and IDP156 are among the various industrial touch monitors produced by DFI.

Figure 7: IDP070 (supporting Millitronic Wi-Fi 6 Media Server) and IDP156 (supporting HDBaseT)

Conclusion

The cost has always been one of the major concerns when it comes to industrial automation considering the equipment value involved. Fortunately, as shown in this white paper, virtualization is a feasible, practical, and cost-effective way to automate industrial processes through workload consolidation.

The Proof-of-Concept exercise carried out between Intel® and DFI has proven that the latest 12th Gen Intel® Core™ processors (Alder Lake) with Intel® iGPU SR-IOV enabled are able to resolve the long-time concern regarding graphics performance in a virtualized environment.

In a nutshell, DFI industrial panel computers and displays powered by 12th Gen Intel® Core with Intel® iGPU SR-IOV could become the catalyst in speeding Industrial automation wide scale deployment in times to come.

For more information, contact your Intel/ DFI sales representative.

Appendix – Test Configuration

DFI motherboard model name: ADS310
CPU SKU: Intel® Core™ i9-12900E (16 Cores, 30M Cache, up to 5.0 GHz); 65W
Memory: 4x DDR4-2666 (Transcend TS1GLH64V6B)
Storage: 1x M.2 2280 PCIe Gen4x4 NVMe 1TB (Micron MTFDKBA1T0TFH-1BC1AABYY)
Operating System: Ubuntu 20.04

Graphic Test application: WebGL aquarium (https://webglsamples.org/aquarium/aquarium.html?canvasWidth=3840&canvasHeight=2160)

Support Contact

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Intel Sherman Chen (sherman.chen@intel.com)

Learn More

To know more about Intel® iGPU SR-IOV and DFI's hardware:

- Intel® Virtualization Technology
  https://www.intel.com/content/www/us/en/virtualization/virtualization-technology/intel-virtualization-technology.html
- DFI
  https://www.dfi.com/
- ADS310 Micro-ATX Motherboard
  https://www.dfi.com/product/index/1566
- IDP070 Industrial Display & Touch Display
  https://www.dfi.com/product/index/1518
- IDP156 Industrial Display & Touch Display
  https://www.dfi.com/product/index/1520
- HDBaseT
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- Innodisk
  https://www.innodisk.com/
- Millitronic
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