White Paper

myOPALE™ Cable connection concept for Remote Embedded Modular Computers

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myOPALE™ offers disruptive technology to multiply capabilities of your next Embedded Computers in a smaller foot print thanks to PCI Express® over Cable interconnect, standard 5.25" building blocks with mini-SAS HD connectors.

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For three decades, industrial PCs have used two types of internal architecture, motherboards and passive backplanes : ATX motherboards with slots for ISA, PCI and PCIe I/O extensions connected perpendicularly to the motherboard or smaller form factors like EBX/miniITX variants for 1U chassis and, since 1994, PICMG 1.0 and 1.3 passive backplanes, where a single board computer and its I/O cards are connected vertically to offer more I/O sites and better MTTR for industrial and test bench systems.

The major evolution during the last 25 years has essentially concerned the housing, which has shrunk from standard 4U/2U 19'' rackmounts to Box PC's, so-called fanless PCs. In all cases, the SBC and its I/O cards have remained physically and mechanically connected through Peripheral Component Interconnect direct linear connectors, nowadays PCI Express, a standard local bus developed by Intel Corporation in 2004 and now promoted by PCI-SIG® community. The PCI Special Interest Group is responsible for specifying the PCI, PCI-X and PCIe computer buses since 1992. This standard PC backplane interface is not optimal in many cases. In 1U/19'' chassis, only two I/O cards can be installed, while mechanical fixing and cards exchange are complex in 1U and 2U chassis due to riser or butterfly backplane interconnects. Reliability of the contacts is not secure and NRC customization will be necessary in most appliances. Furthermore, connectors of all I/O boards and SBC's are located at the same side of the chassis, usually at the rear panel. If specific connectors are needed (BNC, XLR,

SMA, RJ-FTV, MIL-DTL-38999...), all I/O cards and computer board have to be moved, as an entire block, inside the housing, and chassis depth will therefore increase drastically.

There is also no universal method to dissipate waste heat from hot spots, and in most of the cases, chassis customization will generate NRC and extra cost for systems. Customized appliances will usually require a complete mechanical and electronic redesign.

ECRIN's myOPALE concept is based on four major principles. It breaks the mechanical link between the computer mainboard and its I/O cards thanks to PCI Express over Cable interconnection. It uses building blocks in a standard half-height 5.25'' form factor. The re-use of universal deployed interconnect standards from SNIA (Storage Networking Industry Association) that encompass cables, connectors, form factor sizes and housing dimensions, is possible. These specifications enable multi-source products and solutions. And finally, it includes the cooling system into the building block.

Figure 1. Concept of myOPALE

PCI Express was introduced by Intel in 2004 as the new Peripheral Component Interconnect serial bus. Today, PCIe is very popular as the standard PC backplane interface, but it is still less known as a high-speed cabling interface. The serial technology and embedded clocking within each differential signal pair allow PCIe protocol to be used at full speed across a motherboard or over a cable with the benefits of high performance, low power and reduced costs. The cabled version of PCIe features the same high-speed differential line pairs as one that transfers data on PCB's, as well as a number of additional signals – known as Sideband signals. One PCIe lane consists of two pairs of cables individually shielded for EMI protection – one transmit-pair and one receive-pair. Sideband signals provide additional
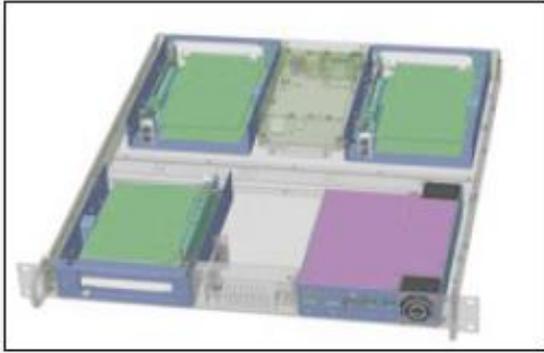
Figure 2. Configuration based on one myOPA-LE-CPU driving three myOPALE-IO, allowing to integrate up to five I/O cards in 1U/19" rackmount.

functionalities, but are not directly involved in the PCIe data transfer. The myOPALE concept integrates most advantages of PCI Express over Cable inside the rack. In this concept the PCIe backplane bus is conceptually stretched to operate over a cable from CPU to secondary I/O backplanes, physically located anywhere in the chassis. Thus, it offers many advantages in a small footprint 1U/19'' rackmount, but also very interesting capabilities for other integration formats beyond the limits of the previous IPC generation.

The choice of the Mini-SAS HD (SFF-8643) connector for PCIe over Cable was also electrically the best solution thanks to its multisource and price/quality ratio. It is COTS ready and able to use standard cables from 30cm to 1m and lockable connectors to protect against shock and vibration in harsh environments. The high bandwidth of 12Gbps for PCI Express Gen3 protocol and 8 differential pairs for x4 PCIe Gen3 lanes enable high data throughput. Eight Sideband signals for the control plane between myOPALE-CPU and myOPALE-IO building blocks are available. Compatibility with new NVM Express storage media and networks, availability of standard adapter cable from Mini-SAS HD (SFF-8643) to U.2 (SFF-8639) is ensured. Availability of M.2 and PCIe x4 form factor boards to Mini-SAS HD will allow to integrate myOPALE-IO modules into standard desktop or tower PC's.

Mechanically, ECRIN Systems has adopted the SNIA SFF-8500 specification that defines the configuration characteristics associated with 5.25" drive bay for the following reasons: ideal format for 1U/19'' rack mount (41.3mm x 146.1mm), well adapted to full-height PCIe I/O cards, compliant form factor with custom COM Express carrier board easy integration into rack, desktop or tower chassis. The set of specifications includes external dimensions, connectors, connector placement, mounting holes and interface pinouts to assist manufacturers for system integration.

Figure 3. myOPALE-CPU building block in half-height 5.25" form factor with its own monitored cooling system mixing conduction cooled and push-pull airflow technologies.

The CPU module incorporates all features of Embedded Computer into an SFF 5.25'' site with 200mm depth only. These are: 6th or 7th Gen Intel Core, Intel Xeon E3-1500 series; up to 32GB Dual Channel DDR4 with ECC for Intel Xeon SKUs; I/O on front panel with 2 DisplayPort, 1 GbE, 4 USB 3.0; legacy I/O on rear panel with 2 SATA3 and 3 USB 2.0 (on Micro-Fit 24-pin connector). Internal site for one 2.5" SSD SATA3, 12VDC power supply (+5Vstb for ATX mode) and the most disruptive technology point with 24 PCIe Gen3 lanes through six Mini-SAS HD connectors (4x PCIe lanes per Mini-SAS HD connector) that offer lot of benefits for embedded Industrial IoT systems.

The design is based on COM Express Type 6 that integrates Embedded Low Power SKU's with 10 years life support. In Skylake and Kaby Lake versions, Intel Core i7 or Xeon E3-1500 CPU with Chipset platforms are selected, which directly drive 24 PCIe Gen3 lanes as their expansion bus. They can be grouped by 8/8/4/4 or 8/4/4/4/4 which allows to drive up to five I/O cards per processor. PCIe cable adapter on the carrier card is quite simple by routing to the connector, and provides some signal conditioning to guarantee the signal integrity is met at the other end of the cable. Because these adapters are simple, they are inexpensive. Because they don't convert the PCIe protocol into anything else, they provide higher performance and don't require any software drivers (as do such others as thunderbolt, InfiniBand, firewire, USB, Fiber channel…). Throughput and latency, offered by PCIe over Cable in myOPALE system, are the best of any other protocol or I/O adapter.

Power supply may be used in AT or ATX-mode. In AT-mode, 12V input is fine. +5VStb is generated internally to support Wake-on-LAN function and AMT Remote Power-on. In ATX-mode, +5VStb signal input is provided via a 6-pin power connector to myOPALE-CPU which monitors PS-ON to drive the power supply unit. The cooling system is based on an aluminum mono-block composed of two areas: one conduction-cooled cold plate that takes away heat from its CPU hot spot up to fins cooled by a forced air-flow system (2x 40mm fans in push-pull mode). Temperature and fan speed are monitored by the Embedded CPU.

Sideband control signals selected from Mini-SAS HD cable allow myOPALE-CPU to manage and monitor each myOPALE-IO without extra cabling. Power and Reset buttons, storage activity and default LED's are available on the front panel and simultaneously on a rear Micro-Fit 24-pin connector for remote control. The myOPALE-IO module can integrate up to two full-height I/O cards in a standard 5.25'' drive bay with 200mm depth.

Figure 5. Just by integrating one COTS PCIe or M.2 adaptor to miniSAS-HD card, you can add myOPALE-IO on the front panel of your PC for audio, broadcast, communication extensions.

Half-length I/O cards will be completely enclosed in the housing, while full-length cards can protrude from the back without any inconvenience. A retaining bracket system for card lock will protect low profile and full-height I/O modules against shocks and vibrations stress. Two versions of myOPALE-IO exist with different passive backplanes: two PCIe Gen3 x4 I/O sites and one PCIe Gen3 x8 I/O site. For both versions, PCIe connectors are mechanically in PCIe x16 format to accept all types of I/O boards in PCI Express (x1, x4, x8 and x16) formats. The myOPALE-IO backplane converts Mini-SAS HD connectors to standard PCIe direct linear connectors, ready to accept any type of COTS or Custom PCIe I/O cards. ECRIN Systems integrates also two other functions: a DC/DC converter from 12VDC to 3.3VDC and an automatic 2-fan control system from a Look Up table. Sideband control signals from Mini-SAS HD connector allow the control of the power supply, and monitor local temperature and fan speeds.

The ability to run PCIe over Cable at full performance with software transparency opens up a range of new applications for CPU and I/O system re-positioning in a rack. myOPALE extends the PCIe bus structure to dedicated PCIe I/O hardware. PCIe over Cable provides a simple method for extending applications that need more I/O boards than could be fitted in a standard Industrial PC based on legacy backplanes. Designing compatible end-points is straightforward because the PCIe interface is available as a gate array library.

Having backplane performance available over a cable expands the myOPALE usage model to encompass many high-end mono- and multi-chassis applications including more I/O expansion with different system integration capabilities, disk array subsystems based on NVMe interface, high speed video and audio editing equipment, quick trading with many pairs of CPU/FPGA in one system, medical imaging systems, etc.

About ECRIN Systems

Founded in 1976, ECRIN Systems has built its development around three main activities to become nowadays one of the major Embedded electronics players for Mil/Aero, Transport, Info-com and Industry markets:

• Subcontracting with Computer-on-Demand products and services based on Embedded Open Standards like COM Express®, SMARC, SHB Express™, MicroTCA®, VPX™, XMC™, FMC™, PCI Express®

• Design and manufacturing of Qualified COTS systems with Modified services:
- *ONYX™ & TOPAZE™ series for multi-mission computing and HPEC applications in extreme environment;*
- *OPALE™ V2 SMART series with 1U/2U/4U 19'' Rackmount Trusted Servers & IPC's for Mil/Navy/Cybersecurity, Info-com, transport and Industry applications;*
- *CRYSTAL™, a Control-Command Console for Navy and Ground Mobile Control Station;*
- *myOPALE™, a new line of Embedded Modular Computers based on PCI Express over Cable Inside to offer high density and extreme flexibility*

• COTS modules with associated systems integration services

This triple competency makes ECRIN Systems a unique partner in the Embedded market, with high innovation potential and strong expertise.

ECRIN Systems is an active member of PICMG®, VITA® and PCI-SIG® organizations and community

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High-resolution digital images attached
- myOPALE_Concept, see above picture into PR (1Mo),
- myOPALE-CPU rear face with its 6 Mini-SAS HD ((2.8Mo),
- myOPALE-IO (0.8Mo)
- *other High Def Use Cases pictures on demand*