What is ATCA?

Rob Pettigrew, Marketing Director and Rob Persons, Senior Field Applications Engineer
Embedded Computing
Emerson Network Power
Emerson.com/EmbeddedComputing

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The Advanced Telecom Computing Architecture (AdvancedTCA® or ATCA®) is a series of open standard computing platform specifications originally developed to meet the needs of carrier grade communications equipment. It has recently expanded its reach into scientific research, more ruggedized applications geared toward the military and aerospace industries and other industries that require high performance embedded computing.

This white paper gives an introduction to the standard covering mechanical characteristics, hardware platform management, and data transport. It goes on to discuss open system management standards that have developed on top of the ATCA specification and concludes with a view to the future for ATCA.
The Advanced Telecom Computing Architecture (AdvancedTCA® or ATCA®) is a series of specifications originally developed to support carrier grade communications equipment.

It was designed to incorporate the latest trends in high speed interconnect technologies, next generation processors and improved reliability, manageability and serviceability.

One objective of the effort was to create a specification for applications requiring more performance than the bus architecture standards commonly deployed at the time for telecom applications: CompactPCI® and VMEbus®.

Another significant objective was to provide a technology platform that would enable network equipment providers to move from their closed, proprietary computing platforms to one based upon open standards and supported by a large ecosystem of vendors.

The ATCA specification was developed by the PCI Industrial Computers Manufacturers Group (PICMG) www.picmg.org, a consortium of end users, equipment makers, blade and system vendors, and component suppliers, which continues to manage its evolution as market demands and technologies change.

The ATCA specification continued the bladed system concept of CompactPCI but replaced the PCI parallel bus with an interconnect scheme focusing on high speed serial interfaces.

It also increased the total surface area of a blade by 2.5 times, increased total power consumption to 200W per blade (subsequently increased again to 400W per blade), and added an advanced management infrastructure which can be used to develop highly available system architectures.

These features in totality define a managed high performance computer system designed to process a large amount of high speed packet data, but that could also be applied to other industries including intelligent military applications and scientific research.

PICMG 3.0 is the base standard for ATCA that defines:
- Mechanical characteristics
- Hardware platform management
- Power distribution
- Power connector zone
- Rear I/O access zone
- Data transport connector zone
- Shelf thermal dissipation
- Regulatory guidelines

**Mechanical Characteristics**

The definition of the size of the enclosure and placement of the components in the chassis are not defined in the standard and are dependent on the vendors producing this type of equipment.

A typical large ATCA system is 13U (rack units) high with vertically mounted blades. Variants are available to suit 19-inch or 600mm ETSI rack mounting, usually accommodating 14 or 16 blades respectively. Smaller chassis are also available with typically 2 or 6 slots, in which blades are mounted horizontally.

The large ATCA shelves are targeted to the telecom market so the airflow goes in the front of the shelf, across the boards from bottom to top, and out the rear of the shelf.
Smaller shelves with fewer slots typically have horizontal side-to-side air flow, however smaller units designed for the front-to-rear cooling requirements of a telecom central office are also available.

The ATCA blade size is defined as 280 mm deep and 322 mm high. The blades have a metal front panel and a metal cover on the bottom of the printed circuit board to limit electromagnetic interference and to limit the spread of fire.

Boards are spaced at a 1.2 inch (30.48 mm or 6HP) pitch. This accommodates components such as the latest CPUs with integral heat sinks, off-the-shelf memory modules, and high power dc-dc converters. The pitch also improves cooling as more air volume can be circulated over a card.

Serviceability is a key attribute of ATCA, as well as being able to replace blades in the field - other shelf field replaceable units (FRUs) include power entry modules (PEMs), fan trays and thermal sensors.

### Switched Fabric Backplane

ATCA chassis include a backplane, which is a printed circuit board with slots into which other cards are plugged. Active backplanes contain, in addition to the sockets, logical circuitry that performs computing functions.

In contrast, passive backplanes contain almost no computing circuitry. The ATCA backplane provides point-to-point connections between the blades and does not use a data bus. The backplane definition is divided into three sections: Zone 1, Zone 2, and Zone 3.

The foundation of the standard is the high-speed switched fabric, which provides a peak throughput of 40Gbps per link (originally defined at 1Gbps, upgraded to 10Gbps and subsequently increased again to the higher bandwidth), and definition of the blade envelope and interconnects.

Its redundant fabric, redundant power, and hot swap features reduce susceptibility to point failures and enable individual blades to be serviced and upgraded without disrupting overall service. And its Intelligent Platform Management Interface (IPMI) system control framework enhances availability by facilitating active monitoring of and control over individual ATCA blades.

This common system and element management structure is also designed to improve the interoperability between vendors.

The PICMG 3.0 standard defines two different types of blades that are possible in a system configuration:

- A payload blade, which can be used for a variety of functions
- A hub/switch blade which can be used to interconnect the payload blades in a system
Zone 1
Power distribution, geographic address pins, and dual system management buses through IPMI over an I2C bus are all defined in the Zone 1 connector.

Since ATCA was originally developed to operate in a telecom central office, an internal -48V power bus on Zone 1 powers the ATCA blades. Smaller ATCA systems typically have options for internal AC to DC power supplies. Larger systems typically need some sort of AC inverter to supply -48V.

Emerson offers AC power in smaller configurations and can supply a -48V 1U high rack mountable power inverter for larger systems.

Zone 2
The final connector of the blade is used for control and data plane communications and distribution of telco stratum clocks. PICMG 3.0 supports dual control plane interfaces known as the Base Interfaces which are gigabit Ethernet channels routed to a pair of centralized switch/hub slots.

Dual channels allow for redundant control paths in the chassis and are configured as dual stars. The data plane, known as the Fabric Interface, is really defined as a set of differential signal pairs in the Zone 2 connector.

At a minimum, a redundant pair of four bidirectional differential pairs, known as a channel, is routed to the same pair of switch/hub slots for redundant Fabric channels in the chassis.

The standard supports up to 15 channels to be defined in the chassis, which could implement a full meshed backplane with point-to-point interconnects between every blade in the system.

Though some applications have used this special type of backplane, a majority simply use a pair of channels per payload blade that are routed to a pair of centralized fabric switches.

Zone 3
The connectors in Zone 3 are user defined and are usually used to connect a front blade to a rear transition module (RTM). RTMs plug into the back of the shelf in slot locations that match the front boards.

You can see from Figure 2 (page 3) that the front blade and rear blade have direct connections. The Zone 3 area can also hold a special backplane to interconnect blades with signals that are not defined in the ATCA specification.

Cooling
One of the key driving factors to develop the ATCA standard was support for higher performance processor blades that also increased the amount of power those processor blades would require. The power/cooling envelope for a payload blade in the original PICMG 3.0 standard defines support for 200W per front payload blade and 50W for the RTM.

The goal was to support a pair of Intel® Xeon™ class processor blades without active cooling on the payload blade. Removing processor fans eliminates a component with one of the greatest rates of failure.

Centralized redundant cooling provides the cooling for the entire chassis and, if designed correctly, consistently cools all payload blades even with fan tray failures at the extremes of the central office operating environment, which is 55°C. Redundant fans in the chassis should also allow for unlimited mean-time-to-repair if a failure of one of the fan trays occurs.

Mission critical computing should not be in jeopardy if a fan tray in the system has not been fixed within a certain amount of time. Though the original standard defines 200W per payload blade, early chassis designs were less than consistent when cooling the 14 slots available in a 19 inch chassis.
An organization known as Communications Platforms Trade Association (CP-TA), was initiated by Emerson Network Power and Intel to bring some consistency for customers evaluating ATCA platforms.

CP-TA defined a set of requirements, tests and certifications so that ATCA equipment manufacturers could test their equipment and define a cooling performance level, while network equipment providers purchasing this equipment could immediately understand what level of cooling performance the ATCA equipment can provide. CP-TA has since merged its activities with those of PICMG.

The strictest level of consistent cooling in all slots, including cooling during fan failures, is classified as CP-TA B.4. PICMG is considering higher classification levels because of a desire to create payload blades that support ever higher performing server class processors and packet processors.

Many vendors produce payload blades that exceed the 200W envelope but proper design should throttle back the processor performance if the chassis cannot support anything above the standard 200W envelope.

Many newer enclosures are now supporting these higher powered blades at full speed but care must be taken when specifying chassis and payload products.

System integrators that have limitations imposed on them for power and cooling can feel confident that an ATCA platform will not exceed the initial power/cooling provided to them for the system even during refresh cycles with the program because of the ability to force compliance of the payload blades to the total power defined in the original system.

In a military context for example, this will reduce the need to add generators or open holes in the hulls of ships to upgrade power and cooling to a mission computer.

**Fabric Interface**

The PICMG 3.0 base standard does not define a specific protocol used on the Fabric channels defined in the chassis. A separate “dot” standard is used to define this. The most prevalent protocol used for the fabric interface is Ethernet and the use of it is defined in the PICMG 3.1 standard.

PICMG 3.1 defines a number of uses of the fabric interface including the use of Fibre Channel along with Ethernet. Although there are some applications that have integrated Fibre Channel into a chassis, a majority of them focus just on Ethernet. There are a variety of options allowed for in the standard.

Figure 3 shows some of the options that were found on early systems. They all represent anywhere from 1 to 4 Gigabit Ethernet interfaces connected as BX type connections.
As the availability of 10G Ethernet switch parts became more economical, Option 9 with 10G Ethernet replaced the 1G Ethernet options in most deployments (see Figure 4).

The IEEE has developed a standard around KR over differential signals in a backplane. PICMG has leveraged this in an update called PICMG 3.1R2 that incorporates the new transport into the standard.

With the availability of 40G switch blades such as Emerson Network Power’s ATCA-F140, support for 40G, 10G as KR interfaces, 10G as stripped lanes or a single 1G interface are all supported in the standard chassis.

Emerson anticipated the incorporation of KR levels of performance and designed its current portfolio of 14-slot, 6-slot, and 2-slot Centellis™ platforms to support this KR rate. It is critical that the ATCA chassis chosen has a backplane that can support KR level performance.

This will ensure that a “forklift” upgrade won’t be necessary if a future refresh of the chassis requires moving to a 40G chassis fabric.

With the upgrade to 40GBaseKR switch/hub blades, older style Option 1 and Option 9 blades can continue to operate in the chassis along with newer 40G payload blades, protecting the system investment.

### Figure 4: Option 9

PICMG 3.0/3.1 can support all these options at the same time, though in reality today most system switch/hub blades support Option 9 and Option 1 and blades can be mixed in a system.

A new protocol has been added to a revision of the PICMG 3.1 standard to integrate KR Fabric interfaces into the chassis supported by some new switches. KR Fabrics operate at 10.3125Gb/sec and use a encoding method of 64B/66B (see Figure 5).

### Figure 5: KR Fabric interface options added to the PICMG 3.1 specification

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Switch/hub blades also can serve as the network access to the chassis. A variety of physical interfaces are available to both the Base and Fabric Interfaces of each switch.

These physical interfaces can be traditional RJ45 for terminating standard Ethernet to 1GB, CX4 (10Gb), SFP (1G), SFPP (10G), and QSFP (40G). In the case of the SFP, SFPP and QSFP interfaces, fiber termination can be supplied to the chassis through front panel interfaces or RTM panel interfaces. See Figure 6 for an RTM example.

Switch/hub blades can be simple layer 2 switches or, processors embedded on the blades running an operating system, can add more sophisticated layer 2 and layer 3 protocols such as Internet Group Management Protocol (IGMPv3), Open Shortest Path First (OSPFv2), Routing Information Protocol (RIPv2), and others which can be configured directly on the switch/hub through a set of configuration utilities or through an external network management protocol such as SNMP.

Most switch/hub blades persistently preserve the configuration between blade resets. In addition to the switch management software additional network management tasks can also be supported on these intelligent switch blades such as DHCP, tftpboot support, etc. The switch/hub blade can act as the network management device for the entire chassis.

Some switch/hub blades also support an additional Advanced Mezzanine Card (AdvancedMC™ or AMC) site to host a system management processor and a supplemental hard disk.

System Management

The standard also defines a pair of I2C buses that are integrated into Zone 1 and use IPMI protocol as mentioned above. This system management interface is routed to each blade and to components in the chassis such as power entry modules, fan trays, etc, and finally to a pair of centralized system management controllers called shelf managers.

The shelf managers perform a variety of functions, from controlling the operation of blades that are added or removed from the system to managing the fan speed to maintain proper cooling. ATCA systems are designed for continuous operation and allow blades to be added and removed while the system continues running. The shelf managers control the operation of the blades and other components in the chassis and use data on field replaceable units (FRU) stored in the chassis and on each of the components to determine what components are allowed to operate in the chassis.

This is known as electronic keying or e-keying and can be used to protect against the incorrect insertion of a blade with an incompatible type of fabric interface or to refuse to power a blade that takes the system beyond its total available power or cooling. For mission critical applications, this is very important. Even in situations where the payload blades won’t be dynamically added or removed from a system, sophisticated scenarios where spare payload blades could be left in a power down situation until they are required to operate due to a failure help conserve the total amount of power a system uses.

Shelf managers have Ethernet interfaces to the Base interface in the chassis where external system management software can access inventory information of the chassis and blades and can be used to notify when critical events occur in the chassis such as blade failures, and potentially control what components are
operating in the chassis. Redundant Ethernet links between shelf managers are used to synchronize chassis status information and are used to activate the standby shelf manager in case the active one fails.

Events that occur on the various components in the system, whether it is from a blade overheating to a fan failing in a fan tray, are logged in the shelf managers and can be used to notify higher level management software of these events and to save those events in case a post mortem is performed.

The shelf managers are also responsible for maintaining the speed of the fans in the fan tray to maintain a good operating temperature for the components in the system while attempting to reduce the total noise of the chassis as it operates.

Over temperature events from a sensor on a payload blade will cause fans to increase in speed. If the payload blade continues to overheat, additional events occur until the blade shuts down due to the overheating. The shelf manager can collect each of those events and upper level management software can react to the different stages of overheating by preparing a backup to take over.

System Management Software
Along with the definition of the PICMG 3.0 standard, additional organizations were formed to define higher level system management software standards that could be used to create highly available systems. Bred from the telecom industry, which requires systems that will be unattended for long periods of time, these software standards define a framework and a layered software environment that can be used to create software that has different levels of sophistication - from a simple management module up to an application layer which can create a redundancy system model through scripting.

SA Forum
The Service Availability Form (SA Forum) [www.saforum.org](http://www.saforum.org) was formed to create this management infrastructure. Members had a variety of needs when the standard was created. Some had many years of experience in management software and wanted a consistent abstraction layer to the hardware. Others anticipated the need for a much higher level of sophistication for users who may not have much experience with system management but want to add the capability. Figure 7 graphically represents the various conceptual layers of the SA Forum software model.

Hardware vendors must add a baseboard management controller (BMC) and sensors on their payload blades and on various managed components in the chassis. The centralized shelf managers in the system communicate to these BMCs through the I2C management bus defined in the PICMG 3.0 standard and use the IPMC protocol to communicate. This defines the hardware platform layer.

The hardware vendor then marries a carrier grade operating system with additional features that support the IPMI interface with hardware platform interface (HPI) software layer to form the next layer.
The HPI layer, with the high availability (HA) middleware, defines a set of libraries that can be used to monitor and manage the hardware platform. The standard defines a hierarchical definition of a system made up of domains, which - when mapped to ATCA - represents a chassis.

Within that domain there are multiple resources (which are the hardware components in the chassis) that in turn have a variety of management instruments associated with the resource.

Examples of management instruments might be sensors, watchdog timers and inventory data repositories (FRU data). The HA middleware is the communications path for collecting the system information and is used to communicate events to the upper level applications from the resources in the system and to perform actions on those resources based on instructions from the upper level management software.

The standard defines a set of required features that a hardware vendor must implement so that upper level management software can manage these resources without caring what company produced the hardware, though the standard also allows for OEM extensions to enhance the basic functionality.

The Application Interface Specification (AIS) creates an even higher level of sophistication and abstraction from the underlying hardware. The AIS layer defines a set of services and an API which are used by system designers to create highly available applications. The AIS layer also defines an overall framework for an HA application that manages clusters of resources and potentially clusters of applications running on resources so that there is no single point of failure.

The services also monitor the health of all components and determine what to do in the event of a failure. An open source project, OpenSAF (www.opensaf.org), created an implementation of the AIS standard and can be adapted for a variety of hardware platforms. Commercial implementations of OpenSAF are also available from a variety of vendors.

**Now and Next**

The ATCA specification is not standing still. New working groups are being established to evolve and adapt the standard to better fit markets beyond telecom.

For more information about the current state of the ATCA market and where the technology is going, please download the Emerson white paper ATCA: Now and Next. [new paper, link to be added]

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Worldwide HQ
Tempe, AZ U.S.A.
1 800 759 1107 or +1 602 438 5720

Global Offices
EMEA
Munich, Germany +49 89 9608 2564
Paris, France +33 1 60 92 31 20
Tel Aviv, Israel +972 9 956 0361

Hong Kong +852 2176 3540
Seoul, Korea +82 2 3483 1500
Shanghai, China +86 21 3395 0289
Tokyo, Japan +81 3 5403 2730

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### Glossary

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<tr>
<th>Term</th>
<th>Description</th>
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<tbody>
<tr>
<td>AdvancedTCA</td>
<td>Advanced Telecom Computing Architecture</td>
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<tr>
<td>AIS</td>
<td>Application interface specification</td>
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<td>AMC</td>
<td>Advanced Mezzanine Card or AdvancedMC™</td>
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<tr>
<td>ATCA</td>
<td>Advanced Telecom Computing Architecture</td>
</tr>
<tr>
<td>Base Interface</td>
<td>The primary fabric on the Zone-2 connectors and allocates 4 differential pairs per base channel. Wired as a dual-star with redundant fabric hub slots at the core.</td>
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<tr>
<td>BMC</td>
<td>Baseboard Management Controller</td>
</tr>
<tr>
<td>CompactPCI</td>
<td>Open standard for PCI-based industrial computers, electrically a superset of desktop PCI with a Eurocard form factor</td>
</tr>
<tr>
<td>CP-TA</td>
<td>Communications Platforms Trade Association. Has merged its activities with those of PICMG.</td>
</tr>
<tr>
<td>E-Keying</td>
<td>Electronic Keying: Protocol used to describe the compatibility between the Base Interface, Fabric Interface, Update Channel Interface, and Synchronization Clocks connections of Front Boards.</td>
</tr>
<tr>
<td>ETSI</td>
<td>European Telecommunications Standards Institute</td>
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<tr>
<td>Fabric Interface</td>
<td>Communications channel based on LVDS (Low Voltage Differential Signaling) differential pairs. Allocates 8 differential pairs per fabric channel and each channel can be divided into four 2-pair ports. Can be wired as a dual-star, dual-dual-star, mesh, replicated-mesh or other architectures. It allocates 8 differential pairs per Fabric Channel and each Channel can be divided into four 2-pair Ports. The Fabric Interface is typically used to move data between the boards and the outside network.</td>
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<tr>
<td>FRU</td>
<td>Field replaceable unit</td>
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<td>HA</td>
<td>High availability</td>
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<tr>
<td>HP</td>
<td>Horizontal pitch. A unit of length defined by the Eurocard printed circuit board standard used to measure the horizontal width of rack mounted electronic equipment. One HP is 0.2 inches (5.08 mm) wide.</td>
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<tr>
<td>HPEC</td>
<td>High performance embedded computing</td>
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<td>HPI</td>
<td>Hardware platform interface</td>
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<tr>
<td>I2C</td>
<td>Referred to as I-squared-C, inter-IC or I-two-C. A multimaster serial single-ended computer bus used for attaching low-speed peripherals to an electronic device.</td>
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<tr>
<td>IPMC</td>
<td>Intelligent Platform Management Controller</td>
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<tr>
<td>IPMI</td>
<td>Intelligent Platform Management Interface</td>
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<tr>
<td>NEBS</td>
<td>Network Equipment-Building System</td>
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<tr>
<td>OpenSAF</td>
<td>An open source project focused on service availability that goes beyond high availability requirements</td>
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<tr>
<td>PICMG</td>
<td>PCI Industrial Computer Manufacturers Group</td>
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<tr>
<td>RTM</td>
<td>Rear transition module: An 8U x 70 mm x 6 HP assembly installed into the rear portion of a Shelf and mated with a front board through Zone 3 connectors to provide I/O connectivity.</td>
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<tr>
<td>SA Forum</td>
<td>Service Availability Forum</td>
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<tr>
<td>SMI</td>
<td>Systems management interface</td>
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<tr>
<td>U</td>
<td>Rack unit, U or RU. A unit of measure that describes the height of equipment designed to mount in a rack. One rack unit is 1.75 inches (44.45 mm) high.</td>
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<tr>
<td>VMEbus</td>
<td>VERSAmodule Eurocard bus</td>
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<tr>
<td>Zone 1</td>
<td>The linear space along the height dimension of an ATCA slot allocated for power, management, and other ancillary functions.</td>
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<tr>
<td>Zone 2</td>
<td>The linear space along the height dimension of an ATCA slot allocated to the data transport interface.</td>
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<tr>
<td>Zone 3</td>
<td>The linear space along the height dimension of an ATCA slot reserved for user defined connections.</td>
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About Emerson Network Power

Emerson Network Power is a business of Emerson (NYSE:EMR) and, through its Embedded Computing & Power business, is the trusted partner for scalable embedded computing technology and power supplies for the aerospace, defense, computing, healthcare, industrial and telecom markets.

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