PERFORMANCE TECHNOLOGIES

Product Specification

PT-CPC441X

PICMG® 2.16
Gb Ethernet Switch

IPnexus™
Embedded Packet Products

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Features

- 24 10/100 TX + 2 Gb TX or Gb Fiber Ethernet Ports
- FlexLink™ PTMC Type 5 Slot on CPC4416 for NAT/LSNAT, IP Tunneling or Front Panel Uplinks
- Wire Speed, Non-blocking Layer 2 switching and Layer 3 Routing
- Low Latency, 9.6 Gbps Switched Fabric
- Support for 2.16 Fabric, 2.16 Node and non-2.16 modes
- Advanced Fast Filter Processor for Wire Speed Layer 2-7 Packet Classification and Filtering
- CompactPCI® CORE Spec (PICMG 2.0 R3.0) Compliant, 6U x 4HP
- CompactPCI® Hot Swap support (PICMG 2.1 Hardware Connection Layer)
- CompactPCI® System Management Bus (PICMG 2.9/IPMI) Compliant
- CompactPCI® Packet Switched Backplane (PICMG 2.16) Hot Swap Compliant
- Telco Style CompactPCI® Latching Handles
- Full Duplex 802.3x Flow Control
- 8K Layer 2 MAC Addresses, 2K Layer 3 IP Addresses
- Managed Learning of Attached Devices on a Per Port Basis for Enhanced Network Security
- Jumbo packet (9KB) Layer 2 switching for iSCSI Applications
- Tagged packet (802.3ac) Support
- Support for IEEE 802.1p class of service with 4 Priority Queues with traffic class management
- IEEE 802.1Q VLAN Support (16 VLANs)
- 802.3-2000 Link Aggregation, up to 12 Link Groups, 8 ports per Group
- Broadcast Storm detection and suppression
- Multi-Port Mirroring
- Front panel, Non-Switched 10/100 Ethernet Port for Out-Of-Band Management
- Front or Rear panel Console port (RS-232)
- Switched PICMG 2.16 Fabric-to-Fabric interconnect, auto-negotiating
- Protocols Supported:
    - GARP, GMRP, GVRP
    - RIP versions 1 and 2
    - OSPF, VRRP
    - 802.1D Spanning Tree Protocol w/Fast Port & Fast Uplink Enhancements
    - 802.1W Rapid Spanning Tree
- CLI Management Interface with Scripting Language for Value Added Applications
- Embedded HTTP Server for Management
- Telnet
- SNMP V1, V2c, V3
- MIBs
    - MIBII – RFC 1213, MIBII Bridge – RFC 1493
    - RMON MIB – RFC 1757 Groups 1, 2, 3, and 9
    - EtherLike MIB – RFC 1643
    - IEEE 802.1q MIB – RFC 2674
    - IEEE 802.3AD Link Aggregation MIB
    - PTI Enterprise MIB
- TFTP/FTP Based Firmware Upgrade and Configuration Upload and Download
- TFTP/FTP Client/Server2 MB User File system, minimumBootP/DHCP Client/Server with support for Port-based leasing
- DHCP/BootP Relay
- Partner Switch Configuration Replication, Cloning, Version Matching
- Power-On or Manager (CLI or SNMP) Invoked Diagnostics
- Online, Real-time Integrity Tests for Non-Stop Networking™ASCII Extraction of Current Configuration
- Multiple configuration, RTM and build options
- Compliant to the requirements of UL/EN 60950, CE, FCC Class A and ETSI EN 300 386
- Designed to meet the requirements of NEBs Level 3
- MTBF of 128,779 Hours per Telcordia TR-NWT-000332, Issue 5

General Description

The PT-CPC441x is the latest generation of PTI's 10/100 Ethernet switch family, the product line that started the PICMG™ 2.16 revolution. It fully complies with the PICMG CompactPCI® packet switched backplane standard, The CPC4411 offers 24 wire speed 10/100BaseT ports and 2 10/100/1000 TX ports while the CPC4416 has 24 10/100 ports and 2 multimode fiber Gb ports as well as a FlexLink ™ site for the addition of network processing or front panel interface options.

PTI originated the 2.16 extension to the PICMG 2.x family of specifications that overlays a packet- based switching architecture on top of CompactPCI® to create an Embedded System Area Network (ESAN). Other PICMG®2.16 based node cards may connect to the CPC441x via Ethernet over the mid-plane, removing the often confusing and unreliable mass of cabling found within most 'Rack Area Network' solutions. Alternatively, a rear panel I/O Transition Module (RTM) can bring some (or all) of the Ethernet interfaces out to RJ-45 connectors.

Disclaimer

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Table 1 – Revision History

Revision	Description	Affected Pages	Date
10	Initial Release	All	7/14/03

Applications

The CPC441x is an advanced switching platform, compatible with both standard and 2.16 CompactPCI® chassis. It can function as either a stand-alone device or be integrated into many types of high-availability (HA) as well as non-HA Ethernet system applications. These applications include:

- Integrated Server Farm
- VoIP Media Gateway
- Integrated Access Device (IAD)
- IP DSLAM Device

Integrated Server Farm

The Integrated Server Farm collapses an entire network of servers into a single chassis. See Figure 1. The CompactPCI® chassis is populated with Servers attached to their file systems. The CPC441x provides inter-connectivity between the servers as well gigabit uplinks to the Internet.

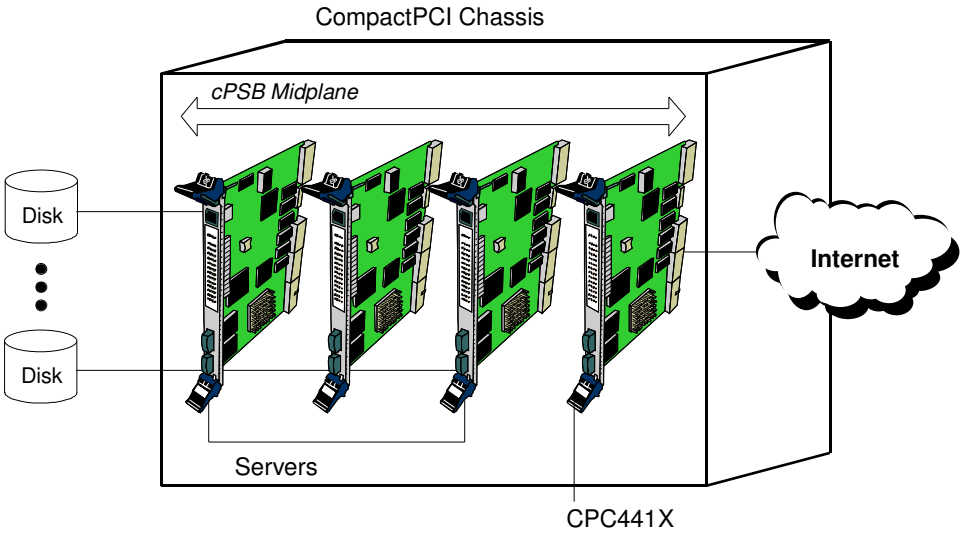

Figure 1

VoIP Media Gateway

The voice over IP media gateway application consists of three major functional blocks. The Allocate, Convert and Aggregate blocks make up the simplified bridge architecture between traditional PSTN voice circuits and the Internet.

Figure 2 shows a block diagram of a simplified media gateway. In this example, the Allocate function allocates circuits from the PSTN through a TDM switch to H.110 based DSPs. The DSPs serve to convert the PSTN circuit into IP frames. The IP frames are collected and aggregated into a high speed uplink to be sent over the Internet. This uplink function could be provided via the FlexLink Module. Another PTI product, the PT-CPC396 Dual Channel T3/H.110 TDM Switch provides the allocation function in this example.

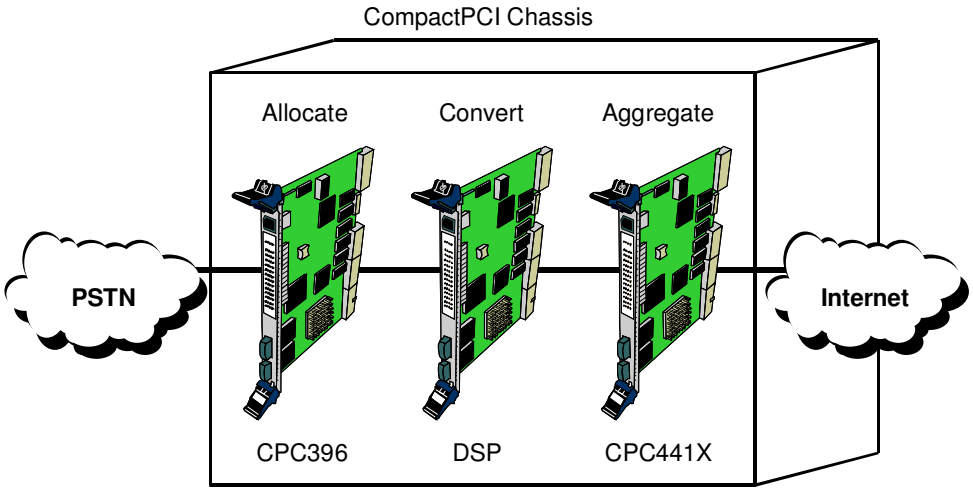

Figure 2

Integrated Access Device (IAD)

The Integrated Access Device consists of a gathering of different types of digital and analog interface boards that are commonly tied together through the cPSB Midplane. The CPC441x provides a common Ethernet interface for the assortment of devices. See Figure 3.

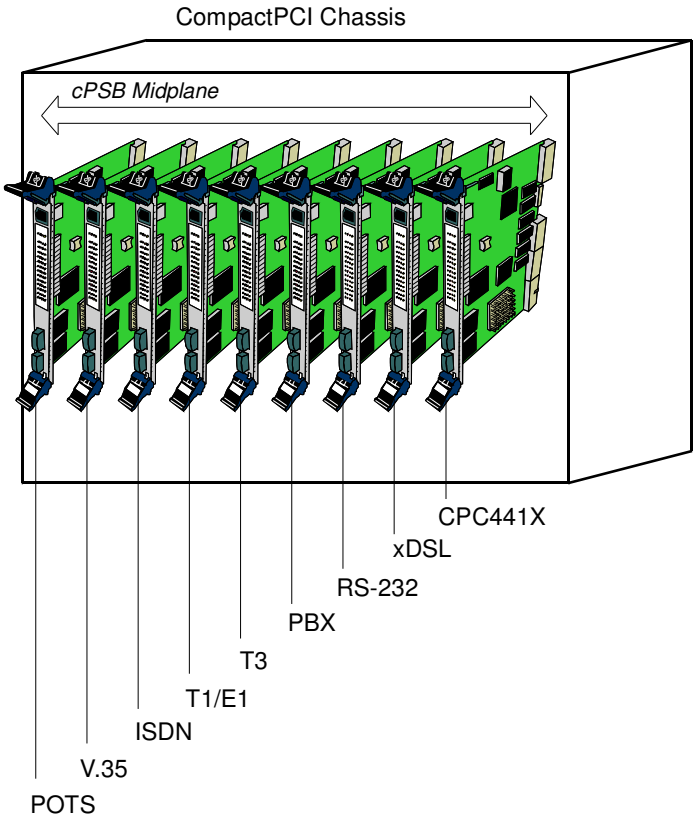

Figure 3

IP DSLAM Device

The IP DSLAM Device concentrates multiple xDSL interfaces onto an IP packet Ethernet interface. See Figure 4. The CPC441x aggregates the traffic from multiple xDSL line interface cards onto gigabit uplinks for transmission over the Internet.

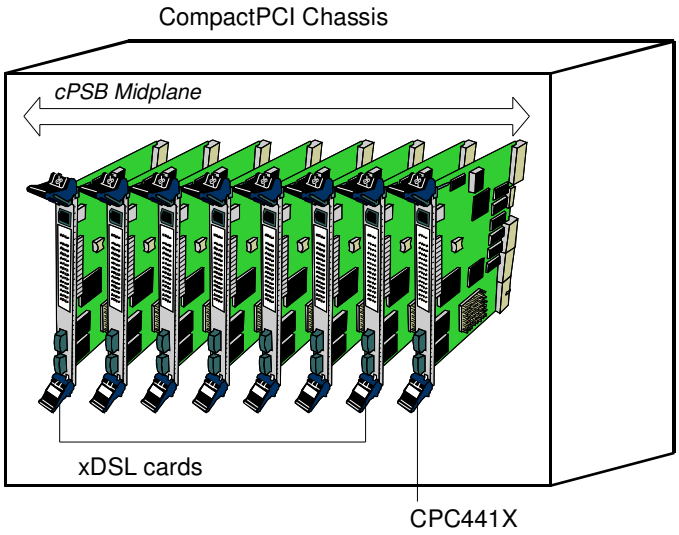

Figure 4

IPnexus™— Packet Switched Midplane

The IPnexus product line supports the PICMG®2.16 standard. PICMG®2.16 overlays an embedded Ethernet switching network fabric on the CompactPCI® midplane, thus extending CompactPCI's capabilities. It allows developers of next-generation packet-based systems to reduce design complexity and component costs while increasing overall system reliability, performance and scalability. Most importantly, adoption of 2.16 can radically decrease the time required to bring a product to market.

Two types of slots are defined under PICMG®2.16; Fabric Slots and Node Slots. A PICMG®2.16 chassis may support up to twenty-four dual port Node slots and up to two Fabric Slots. The midplane is wired so that each of the ports of the Node slots is wired to one of the two Fabric Slots. Node Slot port connections are provided via 16 pins specified on J3.

The PICMG®2.16 specification promotes the system-in-a-slot concept, where each card in a chassis operates as a discrete system or subsystem with its own processor, memory and operating system. The PICMG®2.16 specification enables creation of integrated systems in which any card can reside in any node slot and run any operating system, provided that each card supports standard Ethernet protocol communications interfaces. Because integration occurs at the system level, rather than at the driver level, development time is significantly decreased. As requirements change, individual cards or subsystems or both can be changed without affecting other components in the system.

The PICMG®2.16 specification dramatically improves the performance, scalability and reliability of CompactPCI® while preserving its mechanical, power and hot-swap attributes. It also leaves the H.110 telephony bus intact for systems that support that standard.

Components that support the PICMG®2.16 specification can be mixed with units that still rely on the CompactPCI® bus for communication within the same chassis. Developers will be able to scale system capabilities onto the PICMG®2.16 framework over time, since there is no need to change subsystems built around legacy CompactPCI® elements. Systems can evolve over time in response to changing needs, without scrapping prior design work.

The PICMG®2.16 specification significantly increases the performance of subsystems in a CompactPCI® chassis by moving data traffic off the shared CompactPCI® bus and onto an embedded, switched 10/100/1000-Mbit/s Ethernet network. To improve reliability, two fully independent packet paths are defined, providing theoretical midplane throughput rates up to 5 Gbytes/s-an improvement of an order of magnitude over current CompactPCI® implementations. The adoption of PICMG®2.16 also allows for the construction of much larger systems than are possible with the PCI bus.

In the PICMG®2.16 specification, up to 20 link slots can be supported using a single fabric (packet-switching) slot in a 19-inch CompactPCI® chassis. Redundant hot-”swappable” fabric slots can support up to 19 link slots. Midplane performance can range from 250 Mbytes/s (with a single 100-Mbit/s fabric) up to 5 Gbytes/sec (with dual-switched Gigabit Ethernet fabrics). System expansion can easily be accomplished by running CAT5 Ethernet cables to external connections

to extend the packet-switched bus. This technique can be used to expand the system to one or more CompactPCI® or even non-CompactPCI® systems, creating a “virtual midplane.”

This lets designers pick the best-of-class CompactPCI® solution for their design without regard to operating system support. Integrators can choose the best solution for any given application. Ethernet connects all units in the chassis so system-integration tasks are greatly simplified. As features are added to the Ethernet standard, systems based on the PICMG®2.16 specification can capitalize on the improvements.

Different members of the CPC441x family are available as non-2.16 or PICMG® 2.16 compliant Fabric or Node cards. See Port Connections section for specific options.

Electrical

The CPC441x meets the electrical requirements specified in the PICMG® 2.16 R1.0 CompactPCI® Packet Switching Backplane specification.

Power Requirements

The power consumption of the CPC4411 is shown in Table 2.

Table 2 – CPC4411 Power Consumption

Model and Total Power Consumption	Voltage	Current	Power
PT-CPC4411 29 W max. 22 W typical	3.3 V	3 A	9.9 W
	5 V	3.5 A	17.5 W
	+ 12 V	.1 A	1.2 W
	- 12 V	0 A	0 W

The typical power consumption of the CPC4416 is shown in Table 3.

Table 3 – CPC4416F/N Power Consumption

Model and Total Power Consumption	Voltage	Current	Power
PT-CPC4416 25.4 W max. 18.5 W typical shown without FlexLink™	3.3 V	1.45 A	4.8 W
	5 V	2.47 A	12.4 W
	+ 12 V	.1 A	1.2 W
	- 12 V	.01 A	.12 W

The worst-case power consumption figures are for all ports, running full wire speed, simultaneously. Half wire-speed represents the typical power consumption.

Voltage Requirements

Table 4 shows the minimum and maximum acceptable voltages.

Table 4 – Voltage Requirements			
	Nominal Voltage	**Minimum**	**Maximum**
PT-CPC441x	3.3 V	3.14 V	3.47 V
	5 V	4.75 V	5.25 V
	+12 V	10.8	13.2
	-12 V	-13.2	-10.8

Port Connections

The CPC441x family provides connectivity of all switched 10/100 Ethernet ports to the ® mid-plane per the PICMG®2.16 Specification. Additionally, the console port is presented to the midplane pins so that rear access to the console port may be provided. Some, or all, of the TX ports can be brought out to RJ-45 connectors on a rear panel RTM (Rear Transition Module). The remaining ports may be connected to other slots in the system via the midplane. The CPC441x supports 24 switched 10/100Base-T ports, 2 Gb TX or MM SC fiber ports, and one out-of-band 10Base-T/100 Base-TX port.

The CPC441x family has several models. The CPC4411 has 24 10/100 TX ports and 2 Gb fiber ports, while the CPC4416 has 24 10/100 TX ports and 2 10/100/1000 TX ports. The both the CPC4411 and CPC4416 may be ordered as either a Node Board or a Fabric Board. Node versions may also be used in non-2.16 applications. The following tables describe the various port configurations that are supported by members of the CPC441x family.

Table 5 – Port Connections, CPC4411		
Port and Function	**Speed**	**Connection**
1–24 Switched 10/100 TX	10/100 Mbit	Midplane or Rear panel (TX)
25-26 Switched Gigabit	1000 Mbit	Multimode SC Front Panel Connections
Out-of-band Management	10/100 Mbit	Front Panel (TX)
Console	RS-232	RJ-11 on rear panel RTM and/or front panel

The CPC4411 can be configured to support 100Mb fabric to fabric connections over a 2.16 midplane by setting the micro-switches on the appropriate RTM.

The CPC4416F is usually installed in a fabric slot of a 2.16 compatible chassis. The Gb ports typically are presented to the RTM to link the switch (and the chassis it resides in) to the outside world.

The following port usage options are available:

Table 6 – Port Connections, CPC4416F		
Port and Function	**Speed**	**Connection**
1 –24 Switched 10/100 TX	10/100 Mbit	Midplane or Rear panel (TX)
25-26 Switched 10/100/1000 TX	10/100/1000 Mbit	FlexLink Module, Midplane or Rear panel (TX)
Out-of-band Management	10/100 Mbit	Front Panel
Console	RS-232	RJ-11 on rear panel RTM and/or front panel

When installed in a 2.16 chassis, the CPC4416F can be connected to another fabric slot (fabric-to-fabric) at 1000Mb by setting the appropriate jumpers on the switch. Alternatively, it can support a 100Mb fabric-to-fabric connection by configuring the appropriate RTM.

The CPC4416N can be installed either in a node slot of the 2.16 compatible chassis or in any slot of a non-2.16 CompactPCI chassis. When used in a 2.16 chassis, the two Gb uplinks are typically routed to the redundant Ethernet fabric switches that reside in the fabric slots and the 24 10/100 TX ports are delivered to the RJ-45 ports on the RTM or breakout panel. (see RTM options).

Table 7 – Port Connections, CPC4416N		
Port and Function	**Speed**	**Connection**
1 – 24 Switched 10/100 TX	10/100 Mbit	Rear panel (TX)
25-26 Switched Gigabit	10/100/1000 Mbit	FlexLink™, Midplane or Rear panel (TX)
Out-of-band Management	10/100 Mbit	Front Panel
Console	RS-232	RJ-11 on rear panel RTM and/or front panel

FlexLink™ Module

The CPC4416F/N provides support for one FlexLink™ module. The The FlexLink™ site is compatible with PICMG 2.15, PTMC Type 5 specification – also known as PT5MC. FlexLink™ module can provide an alternate LAN or WAN interface to the board such as 1000Base-SX, 1000Base-LX, IP over SONET, ATM over SONET, NAT Server, etc, or additional processing capability. The CPC4416 provides the 32-bit 33MHz local PCI bus to the FlexLink module.

The module interface also provides support for passing up to two of the switched gigabit and two of the switched 10/100 Ethernet ports to the FlexLink module through connections on the user-defined pins of P4. This allows the module to directly interface to the switch fabric at gigabit rates for high-speed packet processing applications.

Several PTI designed FlexLink modules are available to take advantage of these port connections. They include: the FlexNAT™ NAT/Load Sharing NAT module, the FlexTunnel™ Secure Access module. The FlexConnect™ module brings two 10/100 and two 10/100/1000 TX ports to the front panel. Consult your PTI sales representative for more detail on these products and the availability of other FlexLink™ Modules.

Rear Transition Module Options

The CPC441x family supports a number of options for rear panel connectivity. The Rear Transition Modules (RTMs) provide all required signals through J3, J4 and/or J5. Since no active components reside on the RTMs, custom configurations are easy to develop. Please talk to your PTI representative for further information and new configurations that may have been developed.

CPC4411F

2 + 0 Port RTM – This is a single slot RTM that brings 2 Switched 10/100Base-TX Ethernet ports and an RJ11 serial console port to the rear panel. Ports 23 and 24 are presented to the rear panel via RJ-45 connectors, ports 1-22 are routed to the 2.16 midplane for extended fabric applications and the two fiber Gigabit ports are presented to the front panel using SC connectors.

5 + 0 Port RTM - This single slot RTM, intended for 2.16 fabric position applications, offers 5 Switched 10/100Base-TX Ethernet ports and an RJ11 serial console port. Ports 20-24 are presented to the rear panel via RJ-45 connectors. Ports 1-19 are presented to the PICMG 2.16 midplane.

CPC4411N

24 + 0 Port RTM - is a dual slot RTM, intended for non-2.16 applications, that brings all 24 Switched 10/100Base-TX Ethernet ports to the rear panel. Ports 1-24 are presented to the rear panel via RJ-45 connectors.

24 + 0 Port RTM - is a single slot RTM, intended for non-2.16 applications, that breaks out all 24 Switched 10/100Base-TX Ethernet ports to a separate breakout panel that can be mounted to the front or the rear of a standard 19" cabinet. Ports 1-24 are presented to the single slot RTM and 2 meter cables are supplied to connect the RTM to the breakout panel and its 24 RJ-45 connectors.

CPC4416F

5 + 2 Port RTM – Meant for 2.16 solutions, this is a single slot 2.16 fabric RTM that brings 5 Switched 10/100Base-TX Ethernet ports, 2 switched 10/100/1000BaseTX and an RJ11 serial console port to the rear panel. Ports 20-26 are presented to the rear panel via RJ-45 connectors. Ports 1-19 (10/100 TX) are presented to the PICMG 2.16 midplane.

24 + 2 Port RTM – A dual slot non-2.16 RTM that brings all Switched Ethernet ports to the rear panel. Ports 1-26 are presented to the rear panel via RJ-45 connectors. No console port is provided on this RTM. However, it is accessible via the front panel of the CPC4416F.

24 + 2 Port RTM, single slot – This option is intended to be used in a non-2.16 application. A single slot RTM brings all 24 switched 10/100Base-TX Ethernet ports to a pair of 2 meter transition cables. The transition cables terminate ports 1-24 in a breakout panel that can be mounted on the front or rear of a 19 inch rack using RJ-45 connectors. The 2 switched 10/100/100BaseTX ports are presented to the rear panel of the RTM via RJ-45 connectors. The RJ11 serial console port goes to the rear panel of the RTM.

CPC4416N

24 + 0 Port RTM – Designed to be used in a 2.16 node position, this single slot RTM brings all 24 switched 10/100Base-TX Ethernet ports to a pair of 2 meter transition cables. The transition cables terminate ports 1-24 in a breakout panel that can be mounted on the front or rear of a 19 inch rack using RJ-45 connectors. The 2 switched 10/100/1000BaseTX ports are presented to the fabric slots via the 2.16 midplane. The RJ11 serial console port goes to the rear panel of the RTM.

24 + 0 Dual Slot RTM – Designed to be used in 2.16 node applications, this RTM brings all 24 switched 10/100Base-TX Ethernet ports to the rear panel via RJ-45 connectors. The 2 switched 10/100/1000BaseTX ports are presented to the fabric slots via the 2.16 midplane. The RJ11 serial console port goes to the rear panel of the RTM.

24 + 2 Port RTM – Intended for a non-2.16 application, this is a dual slot RTM that brings all Switched Ethernet ports to the rear panel. Ports 1-26 are presented to the rear panel via RJ-45 connectors.

Mechanical

The CPC441x meets the mechanical requirements specified in the PICMG® 2.16 R1.0 CompactPCI® Packet Switching Backplane and the IEEE 1101.11 specifications.

Form Factor

The main board is a 6U (233.35 mm by 160 mm) board size. All Rear Panel I/O RTMs (Rear Transition Modules) are also 6U size (233.35 mm). RTMs are 80 mm in depth for standard applications. RTMs are available with up to 26 switched Ethernet ports and a console port.

CompactPCI® Connectors

The main board uses standard 2 mm CompactPCI® connectors as follows:

J1	Type A
J2	Type B
J3	Type B
J4	Type A
J5	Type B

The RTMs use the following:

rJ3	Type AB
rJ4	Type A
rJ5	Type AB.

Front Panel

The CPC441x front panel is compliant with IEEE 1101.10. The CPC441x front panel provides an RJ-11 console port connection and all LEDs for ports and system status. The LEDs are individually identified. The CPC441x front panel also provides access to the (out-of-band) management port

Agency Certifications

The CPC441x family adheres to the following certifications:

- UL/EN 60950
- CSA-C22.2 No. 950 93
- FCC Class A (Part 15, Subpart J)
- CE
- ETSI EN 300 386

The CPC441x is designed to NEBS Level 3 standards, but, as a system component, is not certified by PTI for standalone use. NEBS certification has many system level dependencies, requiring the system integrator's involvement. PTI will provide any necessary assistance to aid the integrator in this task.

Switched Ethernet Ports

The CPC441x provides 24 10/100Base-T plus 2 Gb Ethernet ports interconnected in a full mesh by 802.1D MAC Relay Entities. That is, a bridge function exists between any given switched port and any or all of the remaining switched ports. The switched Ethernet ports offer low latency, wire-speed, Layer 2 and Layer 3 IP switching performance on all ports simultaneously.

The CPC441x provides its Gigabit Switched Ethernet ports in one of two configurations, either as multimode SC connections to the front panel or as 10/100/1000Base-T Twisted Pair Ethernet physical connections. These TX connections are either supplied to the CompactPCI® Midplane as defined in the PICMG® 2.16 Specification or supplied to a rear transition module for external connectivity.

Switched Ethernet Status Indicators

Two visible displays (LEDs) are provided for each port. One visible display (green LED) is provided for each port to indicate link and receive activity, and a second visible display (yellow LED) is provided for each port to indicate speed. On the Gb TX ports, an illuminated Speed LED indicates 1000Mbit. If the Gb Speed LED is off, this indicates 10Mbit or 100Mbit. On the 10/100 TX ports a lit Speed LED indicates 100Mbit while a dark LED indicates operation at 10Mbit. The fiber ports on the CPC4411 only operate at 1000Mbit.

Switched Ethernet Ports LLC Interface

The CPC441x provides an LLC interface between the IP Stack of the embedded onboard operating system and the switched ports. This interface allows for sending and receiving frames to and from the onboard CPU and any of the switched Ethernet ports.

This capability allows the onboard CPU to be a presence on the attached network and allows external clients to manage the operation of the switch via any of the switched Ethernet ports.

Out-Of-Band (Management) Ethernet Port

One 10Base-T/100Base-T Non-Switched Ethernet port is provided on the CPC441x for switch management purposes. This port conforms to all requirements of the IEEE 802.3 (CSMA/CD) MAC interface. This port supports symmetric flow control using the MAC Control Client interface (Pause) specified in IEEE 802.3u. The MAC Address of the management port is one of the PTI-allocated MAC Addresses assigned to the CPC441x.

This port does *not* have a MAC Relay Entity between itself and any of the Switched Ethernet Ports. This separation offers the ability to allocate all switched ports to users and to always have a secure and available path to manage the switch.

Out-Of-Band Ethernet Status Indicators

A visible display (green LED) is provided for the management port to indicate Link and Activity (transmit or receive). A second visible display (yellow LED) is provided for the management port to indicate speed. When the Speed LED is illuminated, this indicates 100Mbit. If the Speed LED is off, this indicates 10Mbit.

Out-Of-Band Ethernet LLC Interface

The CPC441x provides an LLC interface between the IP Stack of the embedded onboard operating system and the Out-of-Band Ethernet port. This interface allows sending and receiving frames from the onboard CPU and the Out-of-Band Ethernet port. This capability allows the onboard CPU to be a presence on the attached network and allows external clients to manage the operation of the switch via the Out-of-Band Ethernet port.

The Out-of-Band Management port provides access to a subnet separate from that of the Switched Ports. The CPC441x must be provided with an IP address for each LLC Interface that is to be enabled. If the Out-of-Band Ethernet interface is to be used, it must be assigned an IP address and subnet mask combination that place the interface in a separate subnet than that of the switched ports.

Spanning Tree Extensions

The CPC441x family supports both standards for Spanning Tree, 802.1D and the newly approved 802.1W Rapid Spanning Tree for speedier network re-convergence in case of a network failure or other topology change.

PTI also provides several extensions to the standard Spanning Tree protocol for networks that cannot support Rapid Spanning Tree. These extensions enhance the switch's utility in building fault tolerant networks. The standard Spanning Tree protocol supports redundant links for resiliency, but the algorithm that selects the active link can take anywhere between 30 and 50 seconds to converge. This delay often causes Application time outs. The CPC441x addresses this problem with two extensions to the Spanning Tree protocol; Fast Uplink and Fast Port.

Fast Uplink

Allows a blocked, redundant pathway towards the Root Bridge to be quickly opened upon failure of the current path to the Root Bridge. The switchover time is less than 1 second on the TX ports and 3 seconds on the fiber ports.

Fast Port

Allows the user to select ports that do not need to participate in the Spanning Tree protocol. These ports must have simple client stations attached to them and must not create a loop or provide a path to any device that might act as a bridge between sub-networks. That is, the user must ensure that no Bridges or Routers can be accessed through a port that has Fast Port turned on. When Fast Port is turned on, the port will not participate in Spanning Tree and will not undergo or cause any Spanning Tree topology changes.

Filtering Database

The CPC441x supports up to 8K Unicast MAC Addresses and up to 255 Multicast MAC Addresses in its Filtering Database. MAC entries can be statically configured or automatically learned from traffic seen on attached networks.

Multicast Registration

The CPC441x supports static and dynamic multicast filtering.

Static Unicast/Multicast MAC – Forwarding database entries can be made that dictate where a frame addressed to a particular MAC address should be sent. A Static Multicast MAC entry can direct Multicast frames to a fixed set of destination ports. A Static Unicast entry can direct frames to a single destination port.

Dynamic Multicast MAC Registration - is supported via IGMP (Internet Group Management Protocol) snooping and/or GMRP (GARP Multicast Registration Protocol).

IGMP Snooping - The CPC441x will inspect IGMP multicast registration packets and determine which ports have clients 'interested' in becoming members of a multicast group. The switch will dynamically add and remove ports to the member group and only send multicast frames to those ports that have members. This frees up bandwidth on those ports that have no members interested in joining a multicast group.

GMRP Registration - Through the operation of the GMRP protocol, clients interested in being members of a multicast group, make registration requests. The switch dynamically maintains a list of the member ports and only sends multicast frames to those ports that have members. This frees up bandwidth on those ports that have no members in a group. The switch also announces to other inter-networking devices that support GMRP, that the switch is a pathway to member stations. This allows member stations to 'find' each other across a bridged LAN.

Managed Learning

The user may also manage the learning mode of the switch on a per-port basis. The modes supported are;

- Learn - This is the default mode of operation. It allows the switch to automatically learn addresses seen on its ingress ports.
- Flood - This mode causes all packets received on the ingress port to be flooded to all ports in the VLAN of the ingress port, if no entry for the Source MAC is found in the FDB. The switch does not automatically learn the Source MAC Addresses seen on the port.
- Drop - This mode causes all packets received on the ingress port to be dropped, if no entry for the Source MAC is found in the FDB. The switch does not automatically learn the Source MAC Addresses seen on the port.

The **Drop** mode along with the ability to add Static Unicast addresses allows for the configuration of a secure switch that only forwards packets that are sourced from a set of pre-determined MAC Addresses. Any packet sourced from an unknown MAC will be dropped. Note that simply setting this mode on a port does not prevent frames DESTINED to unknown MAC Addresses from being flooded. In order to prevent this, you can set the Threshold Limit to zero and enable Flood Threshold. Details can be found in the user manual.

The **Flood** mode allows for the configuration of a switch that acts like a Hub. The switch can be configured into multiple 'logical' hubs through the definition of VLANs.

VLAN Registration

The CPC441x supports dynamic VLAN registration through the operation of GVRP (GARP VLAN Registration Protocol). The switch automatically learns which ports have clients interested in being members of the established VLANs, and frames destined to those VLANs are restricted to only the ports that have members. The switch also announces, to other inter-networking devices that support GVRP, that the switch is a pathway to member stations. This allows member stations to 'find' each other across a bridged LAN.

The user interfaces of the CPC441x provide all of the tools needed to register the switch as a member of up to 16 VLANs at a time. Users can associate an IP subnet address to sixteen of these VLANs. The switch can then route between, or be managed by, clients located on any of the sixteen possible subnets that interface with the CPC441x.

The registration protocol also allows for the dynamic creation of new VLANs that the CPC441x might not belong to. These VLANs will be instantiated and frames will be restricted to those ports with members, as usual, but the CPC441x does not provide routing services to VLANs that it does not belong to.

Mirroring

Port Mirroring allows the user to monitor the traffic on any port at an analyzer connected to the "mirrored-to" port. The CPC441x offers the ability to monitor frames transmitted to a port, received from a port, or both.

This feature is a very useful tool for network administrators to detect and correct network malfunctions, or can be used by developers to aid in debugging network applications and protocols.

Broadcast Storm Suppression

The CPC441x offers the ability to limit forwarding of Broadcasts, Multicasts, and frames with unknown Destination MAC Addresses. The user may establish a maximum frame rate on per port basis for these types of traffic.

This feature prevents malfunctioning network equipment from flooding the network.

Link Aggregation

The CPC441x supports Link Aggregation by which up to eight ports of the same speed can be bundled together, point-to-point, to provide a high-speed interface. Link Aggregation provides for higher throughput, incremental bandwidth, active link redundancy and load balancing.

A Link Aggregate appears as a single logical link to VLANs, Multicast Groups, and Spanning Tree. The CPC441x supports multiple frame distribution algorithms based on; Source or Destination MAC Address, and Source or Destination IP Addresses. The CPC441x is fully 802.3AD compliant.

Layer 2-7 Packet Filtering

The CPC441x supports a Layer 2-7 packet classification and filtering mechanism that allows the user to define special handling actions for packets based on the content of any field within the first 64 bytes of the packet. The switch supports eight different filters at a time. That is, you can define one filter to be the Destination IP Address and the 32nd byte of the frame, and then you can define another filter to be the Source IP Address and the 16th byte of the frame, etc.

After you have defined the filters, you may then create up to 127 different rules. Each rule defines what to do if the packet value is equal to a particular pattern. For instance, if the filter is based on Destination IP and the 32nd byte of the frame, then you can define what to do for up to 127 different values of these two fields.

Based on the classification, the switch can do any of the following:

- Change the 802.1Q packet Priority.
- Forward the packet with a specific priority without changing the 802.1Q packet Priority.
- Change the IP Header TOS Precedence value.
- Send a copy of the packet to the local processor.
- Discard the packet.
- Forward the packet to a specific Egress port.
- Send a copy of the packet to a “mirrored-to” port in addition to sending it to its normal destination.

Quality/Class of Service

The CPC441x supports four traffic priority queues per egress port. Each queue provides a different class of service by allowing those frames queued to the higher priority queues, to be transmitted ahead of those on the lower priority queues.

The CPC441x may assign frames to the egress port queues on the basis of the priority field carried with the 802.1Q tag header. The 802.1Q specification allows for eight traffic classes to be specified in the tag header field of the frame. The CPC441x supports modification of the standard priority mapping through the management of traffic classes.

The CPC441x also supports mapping a packet to one of the four COS queues based on the TOS field in the IP header. This is accomplished by using the Layer 2-7 Packet Filtering feature.

Once packets have been mapped to the four COS queues, the queues are drained at the egress port based on a user programmable scheduling algorithm. The possible scheduling algorithms include; Strict Priority, Weighted Round Robin and Weighted Round Robin with Bounded Delay.

Jumbo Frames

The CPC 441x switches jumbo frames (9 Kb packets), at Layer 2, between attached devices at full wire speed, making ideal for network attached storage (NAS) applications. Any jumbo frame packets that are directed at the switch itself, i.e., the on-board CPU, will be discarded.

Layer 3 IP Switching

The CPC441x supports wire-speed routing of IP packets between subnets. Each VLAN attached to the CPC441x provides access to a different IP subnet. The CPC441x can act as a gateway for clients on these subnets and will route packets between the VLANs (subnets) for them. The CPC441x allows for up to 2K Host IP addresses on a maximum of 16 subnets in its Layer 3 routing table.

Routing Protocols - The CPC441x runs RIP-I, RIP-II, and OSPF to maintain routing table information. Static routes, stored in NVRAM, are also supported.

VRRP – To further the role of the CPC441x as a key component in fault tolerant networks, the CPC441x also supports Virtual Router Redundancy Protocol (VRRP) as described in RFC 2338. This feature allows multiple CPC441x's to act as a single 'virtual router'. One CPC441x in the group acts as the active router and the others remain in stand-by mode until a failure is detected. If the active router fails, the surviving CPC441x(s) will elect a new active router, which will take over both the gateway IP address and its underlying MAC Address. This provides attached clients with a seamless, fault-tolerant, internetworking pathway.

IPMI Management Bus

Performance Technologies 2.16/IPnexus products support version 1.5 of the PICMG 2.9 implementation of the Intelligent Platform Management Interface (IPMI). IPMI is typically used by a system controller or alarm card to monitor house-keeping items in the chassis, such as cooling fans, power supplies and internal system temperature(s) as well as checking on the proper operation of every IPMI-capable element installed in the chassis. The IPMI management system can, many times, also control the remote operation of the chassis elements, including the ability to reset them, read Field Replaceable Unit (FRU) information and manage hot swap operations.

Each connection to the IPMB (Intelligent Platform Management Bus) is via a specialized, dedicated micro-controller, known as the Peripheral Management Controller (PM). PTI's PICMG 2.16 compatible products each come equipped with a PM, which respond to requests from the IPMB controller, also known as the Baseboard Management Controller (BMC). Note that this IPMB bus is separate from the Ethernet channels provided by the switches and provides an out-of-band means of talking to the switch or I/O card, albeit in a limited fashion.

The IPMB is a two wire, serial bus running a standard request/response protocol. Using this protocol, PTI's IPnexus products are able to interact with hot-swap activities, report board ID, status and control information. IPMI includes a common format, and use, of Field Replaceable Unit (FRU) information. This information is primarily used to provide inventory data about the board. The CPC441x FRU storage includes Board and Product Inventory Areas. In addition to being managed by the BMC, the FRU information can be configured through the CPC441x CLI or via SNMP.

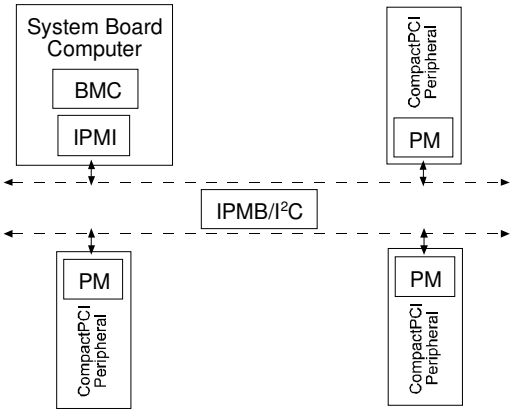

Figure 5

Embedded Diagnostics

The In-System verification Power-On Confidence (POC) tests and On-line Integrity Checks.

Power-On Confidence (POC)

POC tests are a diagnostic suite that is run whenever the CPC441x is booted. POC tests are enabled by default, but the CPC441x also provides a method to disable them. The POC test suite includes only those diagnostic tests that do not affect externally attached devices. When running POC tests, the CPC441x becomes available to the user within 60 seconds of a power-on or reset. All subsystems are included in the POC suite.

On-line Integrity Checks

These are tests that are run on a continuous basis while the CPC441x is in service. On-line Integrity Tests are enabled by default, but the CPC441x also provides a method to disable them. Upon detection of a fault, the CPC441x may be configured to;

- Ignore the failure
- Log a message to the console or remote log server
- Send an SNMP Trap
- Reboot the switch
- Go offline (drop links, but remain accessible via CLI)
- Halt (drops links and requires manual intervention)

Network Services

The CPC441x provides a variety of network services to attached clients. Services offered include; File Transfer Protocol (FTP) and Trivial File Transfer Protocol (TFTP) access to the Flash based file-system and Dynamic Host Configuration Protocol (DHCP) IP Address allocation services.

FTP/TFTP Server

The CPC441x offers an on-board Flash based file system of 2MB. The file system is available to attached Ethernet clients and allows them to store and retrieve configuration files using FTP or TFTP.

DHCP Server

The CPC441x provides a basic set of DHCP services to attached clients. The DHCP server is capable of supplying permanent IP addresses to clients. In environments where static allocation is desired, IP Addresses may be provided based upon one of three keysMAC Address, Port, or Client ID.

The DHCP server settings (timeouts, IP "database", etc) are established by the contents of the DHCP configuration file. This file may be managed via the CLI or SNMP.

DHCP Configuration File - The DHCP configuration file is an ASCII file that is used by DHCP to manage the services that are provided. The user can create or edit this file. The format of the DHCP Configuration file is described in detail in the CPC441x User Manual.

Command Line Interface (CLI)

The CPC441x CLI serves these purposes:

- An initial configuration interface
- A simple and efficient management user interface
- A command interpreter for scripting
- A framework for adding user-defined diagnostic and configuration utilities
- A debugging tool for development and testing

Sessions

The CLI allows six concurrent sessions via telnet.

Command Set

The CPC441x's command set is optimized for embedded switching applications. The command set is based on conformance to industry-wide standards (published MIB definitions).

Command line editing, history, file name completion, and context-sensitive help are available.

Online Help

The CLI provides context sensitive command syntax help.

The detailed command list and user information is in the User's manual.

Configuration Management

The specific features provided on the CPC441x that support Configuration Management include;

- Flash File System
- Programmable Boot Sequence
- DHCP/TFTP Client
- DHCP/TFTP Server
- Scriptable CLI

Flash File System - The CPC441x supports a File System based on Flash memory. The file system supports a total of 8M bytes of Flash memory on the CPC4411, and a total of 32 MB on the CPC4416. At least 2M byte of this is available to the user. The Flash file system supports creating, copying, removing, and renaming files. Files may be copied to and from a remote system.

Programmable Boot Sequence -The CPC441x supports a programmable mechanism to determine the source of configuration information during the boot process. The CPC441x can either get its runtime configuration locally from a Flash based file, or remotely via DHCP. The CPC441x can also be configured to attempt to load its configuration via DHCP, but if that fails after a specified time, it will resort to a locally stored configuration. The CPC441x provides an ASCII configuration file that is processed at boot time. This file may be set at the factory based on user specifications to allow the CPC441x to be placed into immediate service.

DHCP/TFTP Client - The CPC441x may be set up to use DHCP to acquire its runtime configuration. The interface used for this purpose is programmable and any available IP interface can be enabled to use DHCP.

Whichever IP interface is selected will be automatically attached to during the boot process. The DHCP server could be configured to map the identity of the CPC441x to an IP address, subnet mask, default gateway, file server IP Address and the path to a script file located on the file server. The script file will direct the CPC441x to establish its runtime configuration. The CPC441x uses the IP address provided for further communication and will use TFTP to download any files needed by the setup script. This mechanism is useful for replicating configurations among switches and for cloning the configuration of a failed unit onto its replacement.

DHCP/TFTP/FTP Server - The CPC441x also provides DHCP, TFTP and FTP services to attached clients. The CPC441x may be configured to provide a predetermined configuration to the client based on the physical port that received the DHCP request, or based upon an Identifier provided by the client in the DHCP request frame. Using the receiving port number has advantages when all ports are connected point to point and the administrator knows all client/port pairings ahead of time.

Configuration Cloning Example

This example illustrates the use of the configuration features of the CPC441x to allow a replacement board to acquire the settings of the failed board automatically.

In this example, each CPC441x switch backs up the other. Each client has dual Ethernet interfaces, with one connected to the primary switch and the other to the secondary switch. The client's Ethernet driver software supports the ability to switch over to the secondary link upon loss of the primary link. See Figure 6.

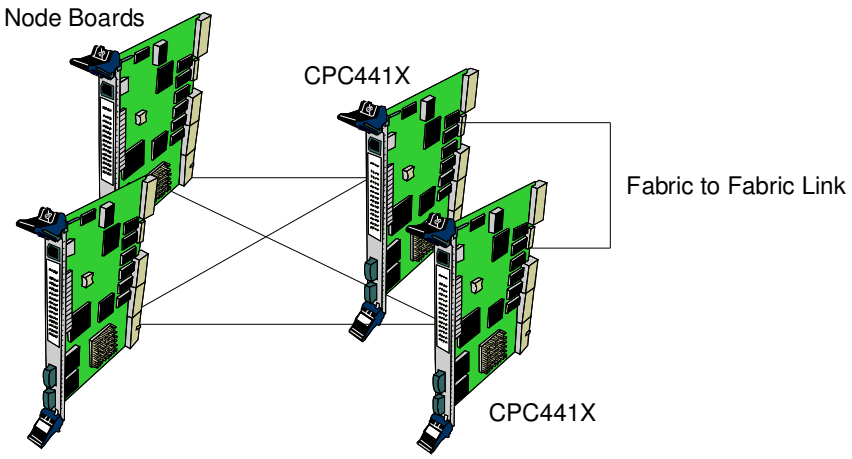

Figure 6

When the two switches are installed, they are configured to use each other as their DHCP and TFTP Server. That is, when a switch powers up, it will get its configuration from the other switch, using the Fabric-to-Fabric Link.

As part of the original installation process, all configuration files for each switch are stored in the Flash File System of the peer switch. A script file is created for each switch that will copy the appropriate files from the peer and instantiate them. For discussion purposes, call this file, ***clone.*** DHCP is configured on both units to provide this script file when a DHCP request from a CPC441x is seen on the Fabric-to-Fabric Link.

When the CPC441x is swapped out and a new one installed in its place, the new CPC441x will connect to the surviving peer over the Fabric-to-Fabric link and use DHCP to acquire an IP address and the name and location of a script file to execute. The ***clone*** script file will be provided via TFTP and the new CPC441x will execute it, thus replicating the configuration of the failed card.

The CPC441x may also be programmed to automatically save its configuration settings file to its peer whenever a configuration change is made.

If one of the CPC441xs were to fail, all clients would fail over to the surviving switch and the network would remain available. An alarm can be sent to a management entity triggering a service call to replace the failed unit.

These features allow the CPC441x to be used in a wide variety of applications without developing specific software to support each of these applications. The user has complete control over the configuration and operation of the CPC441x.

More detail on this example and several more example configurations are provided in the CPC441x user manual.

SNMP Agent

An SNMP manager, using version 1, 2c or 3 can be used to interface with the CPC441x SNMP agent. The agent can also generate SNMPv1/2c/3-style traps in response to CPC441x events. The user may define which events should cause a trap to occur, and may also specify the client or clients that are to receive specific traps.

All mandatory parameters for the following MIBs are provided

. RFC 768 . UDP
. RFC 783 - TFTP
. RFC 791 . Internet Protocol
. RFC 792 . Internet Control Message Protocol
. RFC 793 . Transmission Control Protocol
. RFC 826 - Addresses Resolution Protocol (ARP)
. RFC 854 - Telnet
. RFC 919 . Broadcasting Internet Datagrams
. RFC 922 - Broadcasting Internet Datagrams In The Presence of Sub-networks
. RFC 950 . Internet Standard Sub-netting Procedures
. RFC 959 . File Transfer Protocol
. RFC 1058 . RIP v1
. RFC 1122 . Requirements for Internet Hosts . Communication Layers
. RFC 1157 . SNMP
. RFC 1213 - Management Information Base For Network Management of TCP/IP based Internets (MIB_II)
. RFC 1215 . Traps for use with SNMP
. RFC 1256 - ICMP
. RFC 1493 - MIBII Bridge
. RFC 1517 - Applicability Statement For The Implementation of Classless Inter-Domain Routing (CIDR)
. RFC 1518 - An Architecture For IP Address Allocation With CIDR
. RFC 1519 - Classless Inter-Domain Routing (CIDR).
. RFC 1542 . BootP (relay)
. RFC 1583 . OSPF v2
. RFC 1643 - Ether Like MIB
. RFC 1700 . Assigned Numbers
. RFC 1723 . RIP v2
. RFC 1724 . RIP v2 MIB
. RFC 1757 . RMON MIB Groups 1, 2, 3, and 9 (statistics, history, alarm, events)
. RFC 1812 . IP v4 Routers
. RFC 1850 . OSPF v2 MIB
. RFC 1902 . MIB Structure
. RFC 1903 . SNMP v2
. RFC 1904 . SNMP v2
. RFC 1905 - Protocol Operations For v2 Of The Simple Network Management Protocol (SNMPv2)
. RFC 1906 - Transport Mappings for v2 Of SNMPv2
. RFC 1907 - Management Information Base for v2 of the SNMPv2
. RFC 2131 - Dynamic Host Configuration Protocol (DHCP)
. RFC 2233 . Interfaces MIB
. RFC 2338 - VRRP
. RFC 2453 - Routing Information Protocol v2 (RIP v2)
. RFC 2571 - An Architecture for Describing SNMP Management Frameworks
. RFC 2572 - Message Processing And Dispatching For The SNMP

. RFC 2573 - SNMP Applications and MIB
. RFC 2574 - User Based Security Model (USM) for v3 of SNMP (SNMPv3).
. RFC 2575 - View Based Access Control Model (VACM) For The SNMP.
. RFC 2576 - Coexistence Between Version 1, Version 2, and Version 3 Of the Internet Standard Network Management Framework.
. RFC 2578 - Structure of Management Information v2 (SIM v2)
. RFC 2579 - Textual Conventions for SIM v2
. RFC 2580 - Conformance Statements for SIMv2
. RFC 2665 . EtherLike MIB
. RFC 2668 . Ethernet MAU MIB
. RFC 2674 - 802.1q MIB
dot1dExtBase
dot1qBase
dot3Tests
dot1dPriority
dot1qStatic
dot3Errors
dot1dGarp
dot1qVlan
dot3ChipSets
dot1dGmrp
dot1qTpFdbTable
dot3adAgg
dot3adAggPort
. RFC 2787 VRRP MIB
. IEEE 802.3AD Link Aggregation MIB

PTI Enterprise CPC441x Switch MIB
PTI Enterprise IPMI PM MIB
PTI Enterprise IPMI FRU MIB

The PTI Enterprise MIB is used for CPC441x specific parameters that are not supported by the standard MIBs. An ASN.1 document is available that defines the PTI Enterprise MIB support, allowing SNMP clients to have complete access to the parameters supported by this MIB.

HTTP Server

The CPC441x provides an onboard HTTP Server that offers a management interface through a standard web browser. Simply point your web browser at the IP address of the CPC441x and the switch will serve HTTP pages that provide status and allow you to configure management options

Details on the support provided by the HTTP management interface are provided in the CPC441x user manual.

Security

CLI Security - Access to CLI, either via the serial console or telnet, is restricted by a username and password combination. If the combination is entered incorrectly, there is a 3 second delay prior to the login prompt reappearing. This hampers others from attempting to hack into the system.

HTTP Server Security - When managing the switch via a web browser, the user will be presented with a login window before allowing management access to the CPC441x.

Switch Security - The switch has a main login and password that are required when accessing the switch via the management port, a telnet session, or the switch Web pages. The login name cannot be changed. To change the password, use the CLI 'password'.

The switch also has eight possible SNMP community access passwords. By default, only one is enabled for read/write permissions as 'public'. The Switch administrator can change these passwords with the CLI command 'snmp community set'.

Non-Volatile Memory

Non-Volatile Storage (NVS) allows the CPC441x to begin functioning with user specified settings without having to retrieve these settings from a server. Non-Volatile storage is also used to store the Boot Loader, Application, MAC addresses, and boot flags.

Types of NVS - The CPC441x uses multiple NVS technologies, but the end user interface is isolated from underlying technology. Regardless of the technology, the system retains information between reboots and power cycles.

NVS Data - The NVS supports storage for the following types of information:

- System Boot Loader
- Application Code
- User Settings
- Boot parameters (method, interface, timeouts, etc.)
- Date and time
- System Settings (MAC addresses)
- Service Support Data/Files (DHCP, BOOTP, TFTP)

NVS Access - The NVS sub-system provides a means to select what data is used by the system. The user can retrieve data from a server and put it into NVS, as well as save NVS data to a server.

NVS File System - The NVS sub-system supplies a file system interface to the user allowing file manipulation tasks such as copy, rename, and delete. The NVS file system also supports a directory system, allowing users to create and use subdirectories.

NVS Management - The NVS is manageable from both the CLI and SNMP. There are commands and variables to save and load data, with options indicating where the data is placed. Where a file system is implemented, it is also manageable via the CLI and SNMP. Management of the NVS is performed through the PTI Enterprise MIB.