Future-proofing the Wiring Closet with Resilient and Scalable Modular Switch/Routers

Introduction

Wiring closets in the enterprise LAN are undergoing a number of significant changes. Perhaps the most important transition stems from the emergence of the enterprise IP network and IP/Ethernet LAN as the converged infrastructure for both data networking applications and real-time communications applications. This convergence is driven not only by the cost reductions achievable through network consolidation, but also by the productivity gains that can be achieved through innovative linkages among communication and data applications, resulting in converged applications such as unified messaging. As application convergence gains further momentum, the LAN infrastructure must continue to evolve to support a widening range of real-time applications, including:

- *IP telephony*
- *IP videoconferencing (bi-directional or multi-directional)*
- *Wireless LAN mobility solutions*
- *IPTV (unidirectional)*
- *IP multimedia conferencing*
- *Instant messaging (IM) with presence determination*

While some of these applications are just beginning to appear on the LAN, IP telephony has entered a phase of mainstream adoption by enterprises of all sizes. IDC expects the number of VoIP phones to increase by 42 percent per year through 2008, and the Dell'Oro Group expects IP PBX revenues to exceed $7.5 billion in 2011. Also according to the Dell'Oro Group, 80 percent of new wiring closet ports installed in 2007 will be PoE-capable, and, by the end of the year, 20 percent of the installed base of wiring closet ports will be PoE-capable. These figures show that IT managers are future-proofing the wiring closet for VoIP phones and other devices that will powered over the LAN.

As the breadth of applications supported by the LAN continues to diversify, the wiring closet will need to accommodate a wider range of attached devices, including:

- *VoIP desk phones and video phones*
- *WiFi access points for connection of laptops, PDAs and wireless VoIP phones*
- *Digital surveillance cameras*
- *IP enabled badge readers*

Another major change for the wiring closet will come when desktop PCs and other edge devices are transitioned to Gigabit Ethernet connectivity. While there is no imminent "killer application" that absolutely requires GbE to the desktop, there are a number of potential benefits of increasing desktop bandwidth beyond 100 Mbps. In the near term, the primary benefit of GbE to the desktop will be improved response time for client/server and peer-to-peer data applications that involve bursty transfers of large blocks of data. The response time advantage of GbE is now achievable due to improvements in 10 GbE intelligent NICs that allow servers and network attached storage (NAS) devices to support numerous simultaneous, wire-rate GbE client/server streams at low levels of CPU utilization. Beyond improved response time, GbE provides the headroom that can accommodate the diverse bandwidth and latency requirements of the widening range of applications and edge devices.

- *VoIP: <100 Kbps per call, but tight latency/jitter requirements for small packets*
- *Video conferencing/telephony: <1 Mbps per endpoint, low latency required for variation for variable length packets*
- *Streaming video: ~1 Mbps for 1280 x 720 resolution at 30 frames/second, low latency variation for large packets*
- *IPTV: Up to 19 Mbps per channel for full HDTV with MPEG4 compression*
- *WiFi: Up to 540 Mbps is required for IEEE 802.11n*

In addition to convergence trends, new IP-enabled enterprise applications and the need for more edge bandwidth, enterprises are also shifting how new applications are deployed and provisioned to their users. Software-as-a-service (SaaS) is a software application delivery model where enterprises rely on web-based or Internet-based software applications that operate and host the application online and provide services to customers over the network. According to the IDC, the key characteristics of SaaS include:

- *One-to-many application model (single instance, multi-tenant architecture)*
- *Network-based access to commercially available software*
- *Managed from central locations rather than at each user site*
- *Centralized feature updating, which obviates the need for downloadable patches and upgrades*

SaaS architectures have new and significant impacts on the enterprise wiring closet. Most importantly, with remote, hosted applications, workers' productivity is specifically tied to network uptime. Many of these services, such as Salesforce.com CRM solutions, have limited to zero value to workers when those workers cannot access and maintain a reliable connection to the Internet. Whereas user productivity could be guaranteed with reliable client applications in the past, this blending of data center core to server edge reliability is considered a must have in the enterprise for SaaS.

Increasingly, many companies are going beyond point SaaS solutions delivered as services and are now using virtualization tools like Virtual Desktop Infrastructure (VDI) from VMware and other virtualization vendors. Virtualization of client services is additionally blurring the lines between the traditional data center compute "center" and the virtualized "campus," wherein all remote and edge clients are consuming data center services for their desktop "platform."

Whether a business is using one service, or committing to a more complete virtual client infrastructure, these solutions make similar demands on the campus LAN. Specifically, they require:

- *Massive bandwidth that provides a network without congestion*
- *High availability through a full suite of NIC teaming capabilities*
- *Network simplicity and agility to deploy new services without complex network traffic engineering*
- *Reliability is paramount*

Given the significant changes expected in the LAN over the rest of this decade, it makes sense to try to maximize the lifetime of any investments that are being made in wiring closet infrastructure. Future-proof investments will be based on Ethernet switching platforms that have the functionality and flexibility to accommodate the application-rich environment. According to IDC, the three primary concerns of IT managers deploying VoIP are: 1) network availability to meet expectations for "always on" communications applications, 2) latency/jitter, and 3) sufficient bandwidth to support the new application mix. As VoIP and other emerging applications and edge devices are deployed, the edge of the network will need to be capable of evolving to provide additional security, manageability, serviceability and power provisioning functionality.

Future-proofing the Wiring Closet

Investment protection is one of the most important factors in the selection of a wiring closet switch because the edge of the LAN represents a very large share of the overall LAN investment. While there are significant differences between individual networks and suites of applications, protecting the wiring closet investment against rapid obsolescence and possible "forklift upgrades" will, in general, include consideration of the following factors:

Resiliency and Reliability: For real-time communications applications such as IP telephony, the user expectation is for service availability in the range of 99.99% to 99.999%.

In order to achieve this level of "carrier class" availability wiring closet switches need resiliency and reliability, features that are comparable to those currently available in the most robust LAN core switches and service provider switches:

- Elimination of single points of failure through redundant subsystems
- Layer 2 and Layer 3 mechanisms that allow rapid fail over of traffic from primary to secondary paths whenever a hardware or software fault does occur
- Proactive fault discovery and diagnostics to reduce MTTR and maximize system uptime

Performance: The switch should support a sufficient number of 10 GbE uplinks to allow considerable control of the over subscription ratio even for high densities of 10/100/1000 Mbps desktop or access ports configured for GbE operation. At this point in the evolution of Ethernet switching, it is generally assumed that all packet processing and data forwarding is performed in hardware at full wire speed.

Port Density and Scalability: In many cases, space in the wiring closet is becoming a precious commodity. Therefore, the port density measured in terms of ports per rack unit (RU) and the maximum number of ports per device are important metrics that should be compatible with the growth projections for the wiring closet.

QoS and Bandwidth Management: Given the widely different characteristics of data, voice and video traffic, the wiring closet switch needs to support a comprehensive array of QoS features that ensure each class of traffic receives the level of service it requires without affecting other traffic types. In cases where the uplink ports are under subscribed (e.g., for 10 GbE uplinks and Fast Ethernet desktop connectivity), QoS queuing disciplines in the wiring closet switch will rarely come into play. As the uplinks become over subscribed, the probability of congestion increases, and QoS starts to play a more significant role.

Comprehensive Layer 2 and Layer 3 Functionality: With the traditional three-tier switched LAN architectural model (access, distribution, core), wiring closet switches generally require only Layer 2 functionality. As the scalability and resiliency of Ethernet switches continues to improve, two-tier architectural models (aggregation, core) are becoming more attractive because they can reduce TCO through switch consolidation, simplified network management and improved fault diagnostics. As shown in the two-tier model depicted in Figure 1, the aggregation switch is placed in the wiring closet and combines the comprehensive Layer 2 and Layer 3 functionality of the traditional distribution switches and access switches.

Support for Industry Standards: Network design based primarily on industry standards (rather than proprietary features) is an important aspect of investment protection. Industry standards generally have the advantages of providing good backward compatibility with previous generations of standards, while also enabling multi-vendor interoperability and protection from excessive reliance on a single vendor. Some vendors of LAN switches try to maximize profit margins by offering a

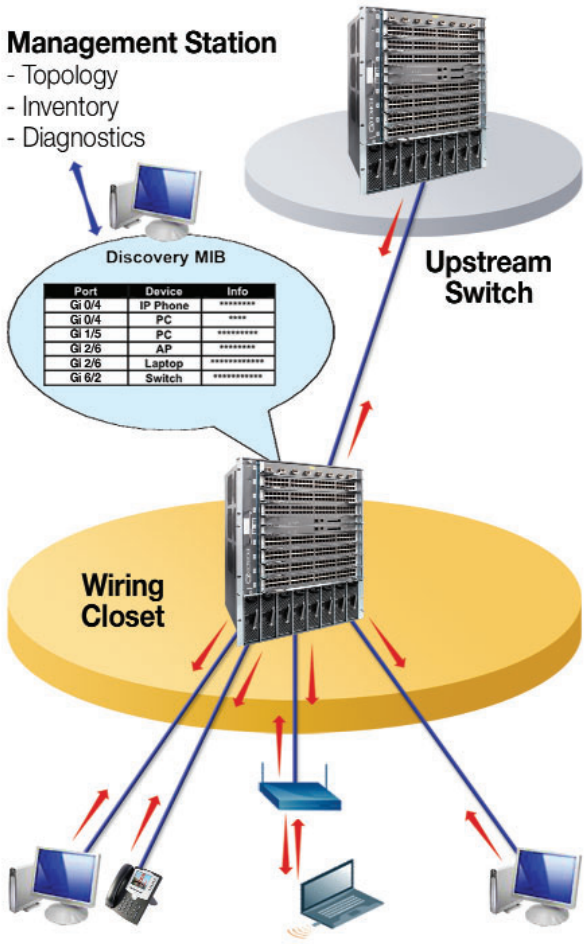

Figure 1. Wired closet with collapsed distribution and access tiers

number of proprietary features aimed at adding value and differentiating their products from competition. These features are often quite attractive and frequently provide the stimulus for industry standardization of similar functionality. However, proprietary features also involve the significant hidden costs of an eventual transition to adopt equivalent (and often superior) industry standards, as they become available. The remainder of this section of the white paper deals with the aspects of future-proofing the wiring closet that are affected by key industry standards that are continuing to evolve.

Power Provisioning and Management: Power over Ethernet (PoE) based on the IEEE 802.3af standard is a highly convenient means of providing power to VoIP phones, WiFi access points, and other small Ethernet-attached devices, such as surveillance cameras and office hubs. As a result, PoE line cards, together with switch-based utilities to manage the delivery of power to attached devices, have become basic requirements for extending the service lifetimes of wiring closet switches. IEEE's PoE Plus Study Group is investigating an enhanced

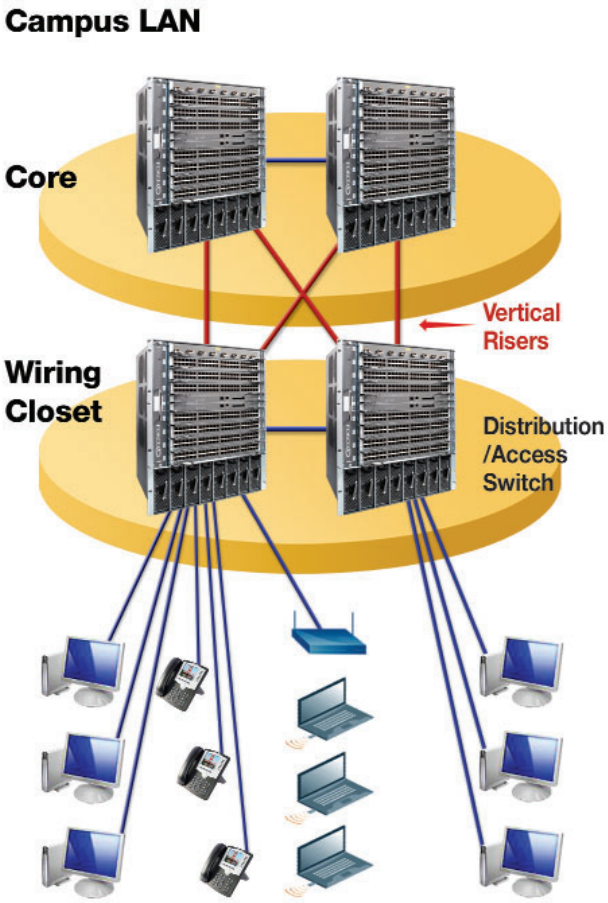

Figure 2. Neighbor discovery and data exchanges with LLDP

PoE standard that will provide increased power (of at least 30 Watts per port) to Ethernet-powered devices. Power conversion efficiency and power efficiency measured in Gbps/Watt are additional aspects of managing power and cooling resources within the wiring closet. Power efficiency is already a major concern in the data center and will become more of an issue in the wiring closet as port densities increase and more ancillary devices are powered from the wiring closet via PoE.

Link Level Discovery: The Link Level Discovery Protocol (LLDP) specified in the IEEE standard, 802.1AB is an extensible Layer 2 mechanism that allows network elements to discover and exchange information with neighboring devices. LLDP is a critical element in the converged wiring closet because it can be used to discover and support "plug-and-play" operation of any LLDP-enabled device connected to an access port, including IP telephones, WLAN access points, network cameras, etc.

As shown in Figure 2, each device stores received information in a neighbor database, accessible via the CLI or an LLDP SNMP MIB. Management applications can access the database in each device to build topologies, locate devices (e.g., for 911 lifelines), take device inventories, etc. Therefore, LLDP has the flexibility and extensibility to support a very wide range of management functions, including automated configuration management, fault diagnostics, and power management.

LLDP-MED defines a set of organizationally-specific IEEE 802.1AB TLV extensions and a related MIB module for the purpose of improved deployment properties and multi-vendor interoperability between VoIP endpoint devices and IEEE 802 networking infrastructure elements.

LAN Access Security: Security of the access portion of the network is becoming more of a concern due to the possibility of viruses and other threats entering the LAN via infected or unauthorized computers. In this scenario, malicious software can spread behind the firewalls and intrusion-detection systems that protect against Internet intrusions. Over the long term, the best security solution for the wiring closet is likely to be a standards-based network access control (NAC) system that screens and authenticates edge devices and users. A number of components of such a system are already standardized, including IEEE 802.1X in the wiring closet switch and RADIUS servers that support the Extensible Authentication Protocol (EAP) over 802.1X. The most important missing piece of a complete solution is a standard security agent that would be installed on the PC to track security information such as whether the most current version of anti-virus software is installed and when the last security scan was performed. Requiring that wiring closet switches support 802.1X provides assurance that the switching infrastructure can support any future form of standardized access control.

Manageability and Serviceability: Managing the edge of the LAN will become more challenging as more of the traffic becomes real-time vs. best effort, and the diversity of devices attached to wiring closet increases significantly. These changes will have an impact on virtually all aspects of the traditional FCAPS management model. In order to cope with these changes, the network management systems for wiring closet switches will need two basic attributes:

- ***Ease of Integration:*** By leveraging industry standards, management of the wiring closet can be readily integrated with other management frameworks, applications and node management systems to provide seamless end-to-end management of the LAN to ensure high availability, predictable QoS and effective security measures. Another aspect of integration involves the

interaction between fault management system and the serviceability (diagnostics and debugging) features of a switch/router. Fault management isolates the fault to a root cause network element, while the switch/router diagnostics perform the complementary task of quickly isolating the root cause to a particular field replaceable unit (FRU) within the device.

- ***Broad Extensibility:*** Support for industry standards, such as LLDP, will also play a significant role in determining the ability of the management system to continue to evolve to support new edge devices and the new functionality that may be required for efficiently provisioning, configuring and troubleshooting.

Modular vs. Stackable Wiring Closet Switches

Any remaining debate regarding the relative merits of modular vs. stackable wiring closet switches is primarily driven by vendors who have a vested interest in one form factor vs. the other. In fact, the two form factors are quite complementary, as evidenced by the fact that most medium to large networks employ a mix of modular and stackable products in both wiring closets and data centers.

As shown in Table 1, stackable switches offer advantages for smaller wiring closets, where the growth rate in the number of user ports required is fairly low, and where there may be a considerable degree of sensitivity to the capital equipment component of TCO. Because of these advantages, fixed configuration and stackable switches have tended to be preferred by the majority of small-to-medium sized enterprises.

Relative Advantages
Stackable
• Better low-end scalability (fewer desktops/closet)
• Lower entry price
• Lower price per port
• Less rack space consumed per user port
Modular
• Greater resiliency/redundancy
• Better high-end scalability
• Better control of subscription ratio
• More bandwidth for local switching
• Better power efficiency (Gbps/Watt)
• Greater flexibility and upgrade ability
• Better ability to assimilate new technologies
• Longer service life

Table 1. **Relative advantages of modular vs. stackable switch/routers**

On the other hand, modular switches are generally preferred for larger wiring closets where the emphasis is on future-proofing the wiring closet investment as described in the previous section of this document. Modular devices have the advantage of superior flexibility to accommodate rapid growth, assimilate new technologies or industry standards, and minimize TCO measured over a longer service lifetime. The service lifetime of the modular switch can often be extended a number of times through a series of backward-compatible upgrades to the various subsystems, including the switch fabric, route processors, line cards, and power and cooling systems.

Force10 C-Series: A Foundation for the Resilient Wiring Closet

Since its introduction in 2002, the Force10 E-Series switch/router has consistently demonstrated an unparalleled level of resiliency and scalability for the most demanding applications in the network data center and LAN core. Now, with the C-Series modular switch, Force10 Networks is introducing a similar level of resiliency and scalability for wiring closet applications that require carrier class reliability together with low TCO and future-proof investment protection in the face of continuing technology evolution. The E-Series heritage is clearly reflected in the design of the C-Series switch/router. The C-Series makes extensive use of redundant subsystems, draws on the E-Series technology base for the switch fabric and passive backplane, performs all data path packet processing in line card hardware, and restricts all control functions to redundant route processor modules running the FTOS modular operating system, which uses the industry standard CLI.

The C-Series supports an extensive list of future-proof features and functions that will maximize its service lifetime while minimizing life cycle TCO:

Resiliency, Reliability and Stability: The system's mission MTBF is maximized through extensive use of redundancy in the major subsystems: dual redundant (1+1) route processor/switch fabric modules, redundant system power supplies, redundant PoE power supplies, and redundant cooling fans. System stability is maximized by the maturity and modularity of the FTOS operating system and by the clear demarcation between data plane and control plane components. This demarcation means that all GbE or 10 GbE uplink ports are located on dedicated line cards rather than included as ports on the route processor modules where forwarding stability and connectivity to the core could be compromised during hot-swapping route processor cards. Rapid traffic fail-over among


```
Force10#show power inline
Interface     Admin   Oper   Inline Power Allocated (Watts)   Inline Power Consumed (Watts)   Class
--------      -------  -----  ------------                     --------------                  ----
Gi 1/0        auto     on     15.40                            3.30                            2
Gi 1/1        auto     on     15.40                            3.42                            2
Gi 1/2        auto     on     15.40                            7.19                            3
Gi 1/3        auto     on     15.40                            6.60                            3
Gi 1/4        auto     on     15.40                            0.00                            NO_DEVICE
Gi 1/5        auto     on     15.40                            3.61                            2
Gi 1/6        auto     on     15.40                            3.42                            2
Gi 1/7        auto     on     15.40                            0.00                            NO_DEVICE
Gi 1/8        auto     on     15.40                            3.43                            2
Gi 1/9        auto     on     15.40                            0.00                            NO_DEVICE
Gi 1/10       auto     on     15.40                            3.50                            2
```

LLDP-MED will help customers in the following ways:

- Simplified troubleshooting of end-devices
- Inventory management of end-devices (i.e. IP phones etc.)
- Discovering and maintaining network topologies
- Multi-vendor interoperability and management
- Rapid startup and emergency call service location, identification and discovery of endpoints to assist in E911 emergency call situations
- Managing unplanned user moves and security policy violations with endpoint move detection notification

Figure 3. FTOS inline power management

redundant subsystems and network elements is assured through a comprehensive suite of software resiliency features including Layer 2 and Layer 3 networking protocols that support load-sharing redundancy (MSTP, RSTP, PVST+, VRRP, and OSPF ECMP). The independence of the software modules within FTOS significantly improves system stability because it isolates the effects of any fault within a single module, allowing uninterrupted operation of the remaining modules.

Performance, Port Density and Scalability: The switching fabric provides each of the line card slots with 96 Gbps of switching fabric capacity. This provides ample line-rate fabric capacity for 48-port GbE line cards and 8-port 10 GbE line cards, plus sufficient latent capacity to support a future increase in port density beyond the current maximums of up to 384 10/100/1000 ports and up to 64 10 GbE ports in a 13 RU chassis. The 802.3af-compliant PoE system scales to provide 15.4 Watts of in-line power per port for up to 384 PoE ports.

QoS Support for Real-time Traffic: Extensive support for traffic classification and policing helps ensure traffic differentiation and deterministic delivery of data, voice, and video traffic. A full suite of IP multicast protocols facilitates the delivery of point-to-multipoint video application traffic.

Comprehensive Layer 2 and Layer 3 Functionality for Configuration Flexibility: The C-Series has the resiliency, scalability and Layer 2 and Layer 3 functionality needed to support migration from the traditional wiring closet networking model to a consolidated model based on a single collapsed tier of L2/L3 distribution and access switching, as shown previously in Figure 1. The benefits of a single layer of aggregation switch/routing within the wiring closet include reduced switch count, simplified traffic flow patterns, elimination of potential Layer 2 loops and STP scalability issues, and improved overall reliability.

Support for Industry Standards: The functionality of the C-Series is based on comprehensive support for industry standards, including those standards that are expected to play a significant role in the future evolution of LAN edge and wiring closet networking, including LLDP, LLDP-MED, 802.3af PoE, and 802.1X. From a product perspective, focusing on industry standards significantly simplifies the design of hardware and software, reduces product costs and improves operational stability.

Power Control and Efficiency: The C-Series uses an intelligent power management system to monitor and control the provisioning of power both for the chassis and for inline PoE. The power utility monitors both allocated and consumed power for chassis subsystems, line cards and PoE ports. The redundancy design ensures maintaining full system power in the event of a chassis power supply failure. Using the PoE Management LLDP TLV, endpoints can advertise the required power level and the desired power priority.

Manageability and Serviceability: The Force10 Management System (FTMS) is a highly customizable, flexible and extensible management system designed to deliver fault, configuration, accounting, performance and security (FCAPS) management of Force10 products. FTMS supports both a web-based client for universal access as well as a standalone Java application client. The FTMS platform is based on the latest emerging industry standard technologies including Java Beans, JFC, XML, HTTP, JSP, JDBC, CORBA and SNMP (v1, v2c, v3). The wide variety of northbound and southbound interfaces (plus the support for industry standard SNMP MIBs) facilitates integration with popular network management frameworks (such as HP OpenView) and OSS/BSS platforms. Examples of the extensibility of FTMS include the capability to use LLDP and its extensions to discover network elements to build topology maps or perform real-time network inventories.

MTTR is minimized by a wide range of FTOS diagnostic and debugging features, including runtime monitoring of hardware and software components, advanced in-service diagnostic fault tracing and troubleshooting, and enhanced SNMP MIBs for status monitoring. The system includes proactive health monitoring functions that send real-time alerts via syslog messages or SNMP traps when out-of-range conditions are detected that can potentially lead to failures. In some cases, health monitoring functions can take automated remedial action in real time to minimize the impact of any error. When an error does occur, advanced debug commands are available to isolate the cause of the fault condition.

LAN Core to Wiring Closet Solutions with C-Series and E-Series Switches/Routers

With the introduction of the C-Series modular wiring closet switch/router, it is now possible to build very large scale, end-to-end campus LANs that feature the same resiliency, scalability, stability and future-proof investment protection that the Force10 Networks E-Series switch/routers have brought to the data center and network core.

End-to-end campus LAN switched networks based on the E-Series and C-Series provide a number of unique benefits:

- Ultra-high, carrier-class availability achieved through end-to-end resiliency features and extensive device-level redundancy resulting in extremely high MTBF and availability at both the device and network levels
- Enhanced stability and manageability through end-to-end consistency of the network control plane. End-to-end support for the FTOS modular switch/router operating system span feature sets, protocol implementations, the CLI, and enhanced FTOS diagnostics to help reduce MTTR. As shown in Figure 4, FTOS uses a hardware abstraction layer to compile hardware agnostic software modules to run on specific hardware platforms. This allows a single code base to support a range of hardware platforms, ensuring consistent features/functionality, interoperability and network stability.
- End-to-end network consolidation leveraging resiliency and scalability to reduce switch-count throughout the LAN core and aggregation tiers and to minimize the complexity of the network. In the data center, the collapsed model of distribution/access aggregation based on E-Series switch/routers has enabled network consolidations, frequently resulting in >3:1 reduction in the number of data center switches. With the C-Series switch/routers, similar benefits of network consolidation can be extended to the wiring closet and the entire campus LAN.

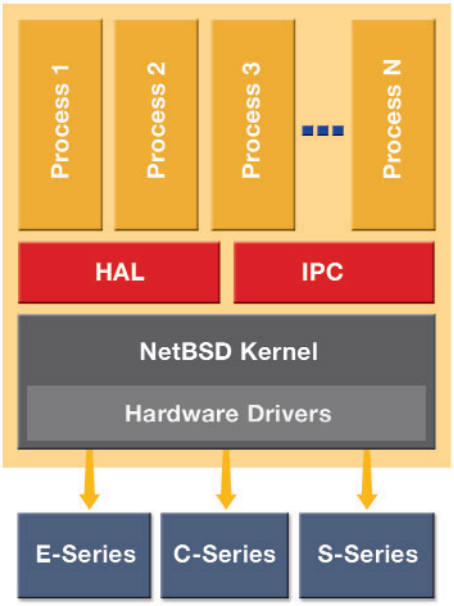

Figure 4. FTOS modularity and hardware abstraction

Conclusion

Networks are evolving quite rapidly to support both converged applications as well as new styles of data applications such as cluster computing, peer-to-peer and SOA. In the face of these changes and the resulting increase in application complexity, the challenge will be to make future-proof investments in the LAN infrastructure that will improve its availability and stability while also simplifying the task of administering and managing a network that supports a wider range of traffic types and edge devices. The C-Series wiring closet switch/routers have been designed from the ground up in the E-Series tradition of providing the ultimate in resiliency, scalability and flexibility to support the highest levels of availability, network consolidation and management simplification.

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