

# Addressing Next-Generation CPE Challenges

The Role of the Intel® XScale™ Technology-based  
Intel® IXP425 Network Processor in CPE

Intel®  
Internet Exchange  
Architecture

White Paper

intel®

*February 2002*

## Abstract

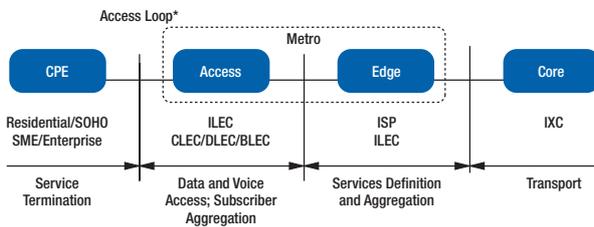
The use of the Internet has continued to expand despite the recent slowdown in the economy—It is yet another strong testimonial to the need of a ubiquitous wide area broadband network capable of carrying rich services, of which Internet access is one. However, the continuing explosion in traffic volume, and the demand to carry latency-sensitive content, such as voice and video, presents a major challenge moving forward. Equipment providers, carriers, and enterprise IT professionals face a new challenge in deploying bandwidth-intensive services, cost-effectively and in a timely manner. Not only do they need to preserve legacy networks and applications, but they also need to deploy new services on their current legacy networks, and on new network infrastructures. As a result, equipment providers are constantly under pressure to design flexible equipment in record time. This equipment needs to support both legacy and new network technologies. It also needs to be field upgradable to accommodate new standards and support for new services.

Consequently, network processors will continue to find widespread applications in equipment designed for the customer premises equipment (CPE), access, edge, and core market segments. Intel's three new families of network processors (IXP425, IXP2400, and IXP2800) target the requirements of the CPE, Access, Edge, and Core/Metro market segments, while providing OEMs with a consistent and cost-effective design environment, including software tools and development platforms.

This paper examines the challenges facing equipment providers, carriers, and the enterprise in the CPE segment. In the context of this paper, the CPE can reside in the residence, the small office/home office (SOHO), or the branch office in a small to medium enterprise (SME). It will further explain how the Intel® IXP425 network processor family has been designed from the ground-up to address these challenges. These new network processor offerings will enable network equipment vendors to offer their customers the best combination of customizable/upgradable services at wire-speed performance, while minimizing development time and costs.

## The New Network Landscape

The recent wave of deregulation resulting from the U.S. Telecommunications Act of 1996 dictates a new market model designed to take advantage of the unbundling of equipment from the local loop. With the separation of the access infrastructure from the services being offered, new access and service providers, with corresponding business models have emerged—Figure 1. While some of these new entrants have failed to construct profit-based business models, the fact that deregulation and unbundling is becoming a global phenomenon suggests that many new, profitable models will eventually emerge. Not only are the competitive carriers in Europe, Asia, and Japan learning from the U.S. experience, the U.S. itself is now re-evaluating some of the rulings, as broadband access has become a national priority.



CPE—Customer Premises Equipment  
 SOHO—Small Office/Home Office  
 SME—Small to Medium Enterprise  
 ILEC—Incumbent Local Exchange Carrier  
 CLEC—Competitive Local Exchange Carrier  
 DLEC—Data Local Exchange Carrier  
 BLEC—Building/Business Local Exchange Carrier  
 IXC—Inter Exchange Carrier  
 \* Also known as Local Loop, or Last Mile

Figure 1. The unbundled broadband network model—four market segments: CPE, Access, Edge, and Core. Also shown is the regional metro network connecting Access to Edge.

It should be understood that the primary objective of unbundling has been to enable carriers to compete on the basis of services, while remaining cost-effective. Instead of simply charging a flat fee for network access,

the new competitive environment allows service providers to capitalize on the content they deliver. A case in point is video-on-demand and gaming, where connect time is not as important as the value of the content. Service providers can charge more for delivering a first-run movie or the hottest interactive game. This model satisfies user demand for relevant content and the service provider's requirement for sustainable margins.

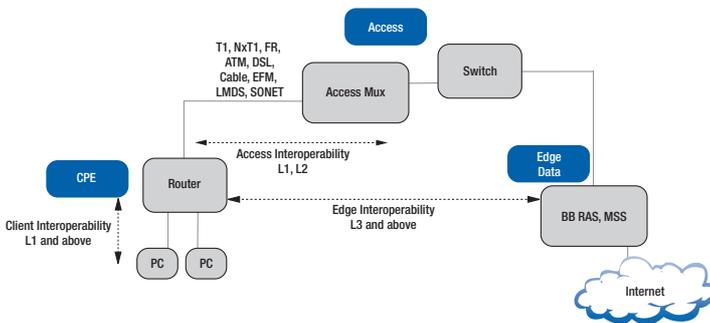
## Carriers, OEM Challenges, and The Role of The CPE

The challenge for the industry continues to be: How to minimize operational costs and to simultaneously offer new services that can support higher margins, and are profitable? For the incumbent carriers, such as the ILECs and the PTTs, voice traffic revenue continues to decline—this needs to be offset by new easy to deploy, profitable services that capitalize on their current infrastructure. For the multi service cable operators (MSOs), being confined to offering broadcast video service, and a flat-fee-based Internet access will no longer sustain their growth into the future. Enterprises, on the other hand, are constantly facing the challenge of upgrading their network to save operational cost, and to offer higher-level services such as a multi-national secure network, and broadband video conferencing capabilities.

In responding to these challenges, it is key for the carrier and the enterprise alike to continue to deploy broadband access capability, and to offer new services over this broadband infrastructure. For the carrier, bundling multiple services will enhance customer retention and higher margins. For the enterprise, IT professionals will be able to contribute to the corporate bottom line by saving operational expense and increasing employee's productivity.

The result is that service providers (carrier and enterprise) will demand networking equipment manufacturers to offer flexible as well as high-performance equipment, to allow them to add new, bundled, billable services,

accommodating new standards requirements. All of these requirements will make the contribution of network processors increasingly important.



Access Mux: DSLAM (DSL Access Multiplexer), or DLC (Digital Loop Carrier), or CMTS (Cable Modem Termination System), or BTS (Base Transceiver Station)

BB RAS: Broadband Remote Access Server

MSS: Multi Service Switch (FR, ATM, IP)

FR: Frame Relay

EFM: Ethernet in the first mile

*Figure 2. The CPE is the demarcation point between the customer-owned LAN and the carrier-owned public network, or enterprise-owned virtual private network (VPN). The CPE needs to interoperate with end-user PCs in the customer network, the access equipment in the access provider network, and the edge equipment in the service provider network.*

That brings us to the role of the CPE. The CPE can reside in the residence, the small office/home office (SOHO), or the branch office in a small to medium enterprise (SME). In addition, this paper defines the CPE as the demarcation point between the customer-owned private network, and the carrier-owned public network, or the enterprise virtual private network (VPN). The wide area connection between the customer network and the public network, or VPN, is increasingly becoming broadband-capable (in the order of 1 Mbps and above), enabling new services to be delivered to the end customer. This connection is, however, increasingly becoming an always-on connection, inviting unwanted intrusion, and hence presenting higher security risk to the customer, and to the enterprise.

Let us now examine the implications of the new broadband and service deployment on the role of the CPE—The CPE needs to:

- **Minimize operational cost**—The CPE should be able to support legacy networks and services. It should ensure interoperability with the client PC and voice terminals, the access equipment, and the edge equipment. In addition, the CPE should be able to be configured remotely.
- **Provision and deploy new, profitable broadband services**—The CPE should be able to be configured and managed remotely, for ease of service provisioning and deployment. As these new services need to run on existing networks, the CPE should seamlessly integrate with legacy networks, and interoperate with existing equipment.
- **Offer optimum performance**—To take full advantage of the underlying broadband network, the CPE needs to operate at wire-speed performance on the LAN, and on the WAN.
- **Provide VPN and network security capabilities**—The CPE needs to be able to implement an enterprise-based, or a carrier-based VPN. It should also be able to implement a firewall capability for intrusion detection, and protection.

## CPE Requirements

One of the primary goals of the CPE is to enable carriers and enterprises to increase their revenue by deploying new services to homes and businesses. To be a fully functional part of this infrastructure, the CPE must be compliant with current and planned services, and interoperable with other parts of the network. A flexible approach, in which the CPE can be configured and optimized for a variety of WAN technologies and services, provides the most effective approach to address this challenge.

Equipment OEMs need to address a variety of requirements when developing a CPE:

- Devices must support easy configuration and remote management by the service provider, with headroom to accommodate new standards and upgrades
- Service-compliant protocols must operate at wire-speed performance on the attached LAN and the attached WAN
- CPE must interoperate with the access equipment at Layers 1 and 2, and with the edge equipment at Layer 3 and above in the service provider's network
- The CPE must be able to support customer-based, and carrier-based VPN implementations
- The equipment must support low-cost implementation.

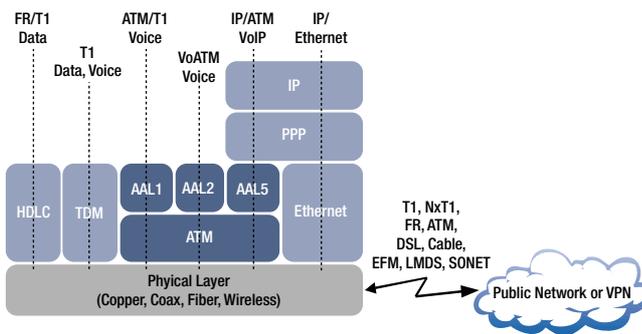


Figure 3. SME CPE needs to support numerous layer 2 technologies in the WAN, including TDM, Frame Relay, ATM, and Ethernet. This will enable the CPE to support legacy, and new data and voice services.

With the potential deployment of millions of CPE devices, remote configuration and management becomes a critical system requirement. Service providers and equipment providers must be able to remotely monitor, control, trouble-shoot, perform routine maintenance, and provide software upgrades that support new features or standards. Finally, the CPU at the heart of the CPE should have enough processing headroom to handle current applications and accommodate new applications and services.

## The Intel® IXP425 Network Processor Family—Meeting the CPE Challenge

The new Intel IXP425 network processor family is designed to meet the needs of next-generation broadband CPE applications such as high-end residential gateways, small to medium enterprise routers, voice/data routers, integrated access devices, cable modems, and wireless access points with VPN and broadband connection capabilities. In addition, the Intel IXP425 can be used in remote terminals (RT) such as remote DSLAMs and MxU concentrators.

The Intel IXP425 network processor integrates data plane, control plane, and management and application planes processing on-chip. Specialized on-chip micro-coded network processor engines (NPEs), optimized for packet payload processing, handle data plane functionality. These include ATM segmentation and reassembly (SAR), voice TDM framing, HDLC bit-level manipulation, and hardware security acceleration. The benefit of such architecture is manifold:

- Optimize system performance toward meeting wire-speed requirement on the LAN and on the WAN
- The hardware security accelerator makes the introduction of IP security an economically viable option to adding necessary security functionality for always-on WAN connections
- Relieves the main on-chip CPU from such tasks that a general-purpose CPU is not optimized for—leaving CPU headroom for equipment designers to differentiate their products
- The micro-coded network processors engines are software-controlled, and hence their functionality can be upgraded in the field.
- The on-chip Intel® XScale™ microarchitecture offers a broad range of tools, together with support for two widely adopted operating systems: VxWorks\* and Linux\*.

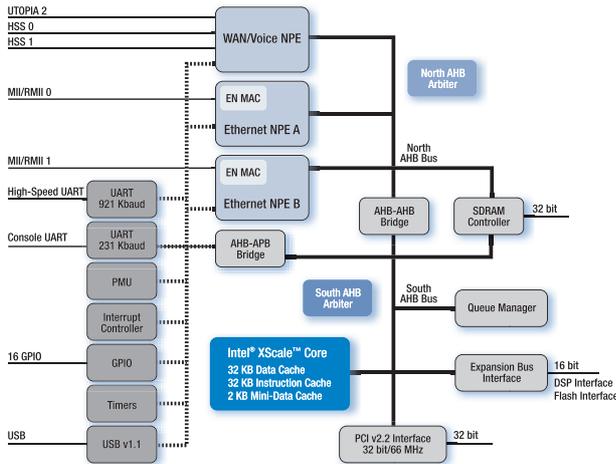


Figure 4. The IXP425 network processor integrates data plane, control plane, management and application plane processors on-chip. In addition, it provides the necessary interfaces for legacy and emerging networking technologies in the LAN and in the WAN.

Control, management and applications are handled by a powerful, on-chip Intel XScale core running at up to 533 MHz. This core exhibits optimum power consumption per MIPS ratio, necessary for CPE applications powered through the supplied phone line.

### Distributed Processing Architecture—Intel® XScale™ Core + Three Network Processor Engines:

The Intel IXP425 network processor family meets next-generation broadband CPE requirements with a distributed processing architecture that allows the right processing capabilities to be matched with specific functional requirements. Each Intel IXP425 network processor utilizes the power and programmability of the Intel XScale core, plus three network processor engines (NPEs) to deliver wire-speed performance while ensuring sufficient “processor headroom” for equipment providers to add a variety of rich services to their broadband applications, such as VPN, voice, and video capabilities. The Intel XScale core is used for application and control processing, while the three network processor engines offload high number crunching, and bit-level tasks for packet pro-

cessing, such as packet filtering, and co-processor functions, such as packet payload encryption. The result is, a highly integrated network processor family that support multiple LAN and WAN technologies giving the equipment designer the flexibility to use the Intel IXP425 network processor family in multiple applications.

### Support for Multiple Data Link Technologies:

The Intel IXP425 family is designed to support legacy and new network infrastructures. These include T1, Frame Relay (FR), and ATM legacy networks, and new networks based on DSL, cable, and fiber access technologies. In addition, the Intel IXP425 family is designed to support various services that can be carried over these network technologies. These services include voice and video over broadband access, and security over the always-on broadband access networks.

### Support for Multiple Physical Interfaces—LAN and WAN:

The Intel IXP425 family provides a plethora of interfaces to connect to a variety of LAN and WAN networks. On the LAN side, a 10/100 Mbps repeater or Ethernet switch can be easily connected to one of the MII/RMII ports. In addition, the on-chip PCI enables the implementation of an IEEE802.11b access point. On the WAN side, a serial interface is provided for T1, and Frame Relay networks, a UTOPIA level 2 interface is provided for ATM and ADSL networks, and an Ethernet interface is provided for a long reach, VDSL-based connection in high-rise applications, or in the wide area in support of the emerging Ethernet in the First Mile (EFM) IEEE standards.

### Wire-speed Performance—LAN and WAN:

The Intel IXP425 family is designed to ensure wire-speed performance on the attached LAN and on the attached WAN. For example, CPE based on the Intel IXP425 network processor will be able to filter Ethernet traffic on the attached 100 Mbps LAN segment at up to 148,881 packets per second (PPS) for 64-byte packets. The same would apply on the WAN side: the Intel IXP425-based CPE will be able to forward 9,888 ATM cells per second when connected to four E1 (2 Mbps) WAN lines in an inverse multiplexed mode connection.

## Security Acceleration Engine:

One of the key features of the Intel IXP425 family is a hardware security accelerator for enabling the deployment of secure connections in always-on networks. For example, the security acceleration engine implements, in hardware, DES, and 3DES data encryption standards, as well as SHA-1 and MD5 hashing algorithms, typically used in VPN applications.

## The IXP425 Family is Ideal for Multitude of CPE Applications

Many of the features described in this paper make the Intel IXP425 network processor family ideal for various CPE applications. Figure 5 depicts some of these applications.

### VPN CPE

This application is ideal for small offices and branch offices. On the LAN side, the Intel IXP425-based CPE supports two 10/100 routed Ethernet segments. One such segment can house customer resources that need to be directly accessible over the public wide area network, such as the customer Web server. This segment is referred to as the DMZ segment. The second 10/100 Ethernet segment houses the customer private LAN. Public access to the DMZ is then filtered before allowing access to the second segment. This is done through the firewall functionality provided by the IXP425-based CPE. On the wide area side, support for legacy networks such as T1, Frame Relay, and ATM, as well for emerging networks such as multiple ATM/T1 with inverse multiplex ATM (IMA) capability can be supported. In addition, the Intel IXP425 hardware security accelerator is used to enable the implementation of IPSec standard required to support the wide area VPN connection.

### Access Point CPE

This application is also ideal for small offices and branch offices. On the LAN side, the Intel IXP425-based CPE supports a local 10/100 Ethernet segment and 802.11b access point functionality. This enables simultaneous support for desktop and mobile clients at the customer

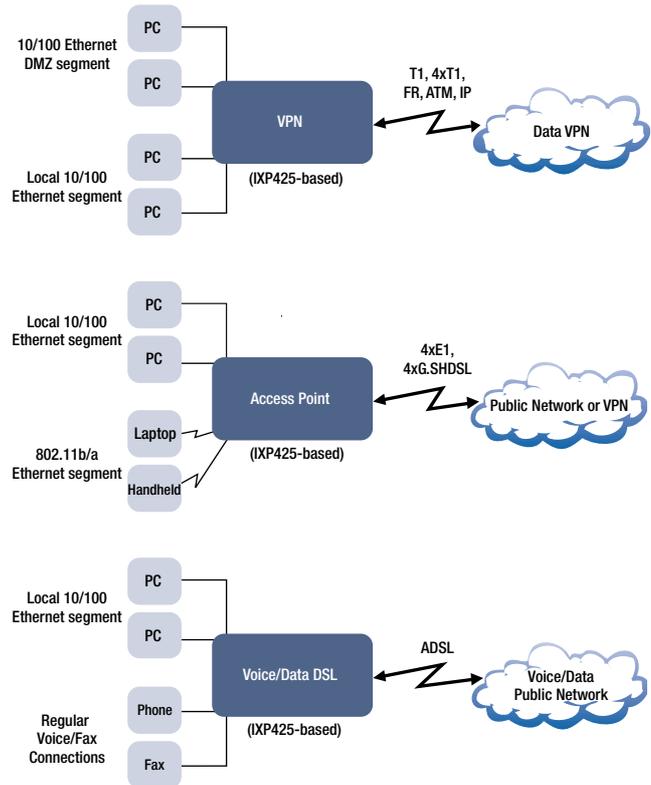


Figure 5. IXP425-based CPE applications include a CPE with VPN capability, and support for two 10/100 routed Ethernet segments. A wireless access point CPE with up to 8 Mbps wide area connection, and a voice/data CPE supporting up to four compressed voice channels.

site. The wide area connection depicted supports four E1 legacy connections, or four emerging G.SHDSL connections, totaling 8 Mbps in each direction. It should be noted that a version of this application is also ideal for hot spots such as airport lounges, restaurants, and coffee shops.

### Voice/Data DSL CPE

This application is ideal for the home office and small office, requiring up to four simultaneous voice connections. The Intel IXP425-based CPE supports regular analog phones and fax machines, and is capable of compressing voice channels using G.72x algorithms. This design is capable of detecting a modem, or a fax call, and as a result revert back to G.711, no compression mode.

## Residential Network Interface Device (NID)

Carriers are promoting the network interface device (NID) concept to support voice/data convergence in the local loop, while ensuring a demarcation point outside the house—the same way a gas or water meter is supported on the side of the house. The NID is a special CPE device that has requirements that are not typical of an average CPE, such as:

- Low power consumption—as the NID power is supplied over the carrier line feed
- Extended temperature support (-40° to 85° C)
- Integration of voice support, including voice compression.

The above NID requirements are ideal for an IXP425-based design as they can all be met very effectively. This is especially true when the voice compression is executed on the Intel XScale core, and no external DSP circuitry is required.

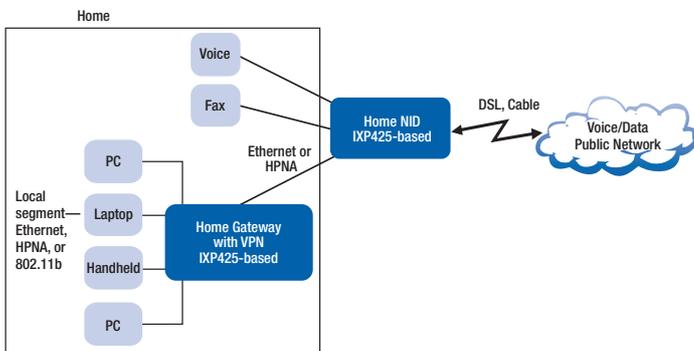


Figure 6. The Intel® IXP425 is ideal for implementing the NID concept—its low power consumption, extended temperature support, and voice integration makes it ideal for this application.

## VDSL CPE and Access Concentrator for MxU

The Intel IXP425 is designed to support up to VDSL speed (51 Mbps) wide area connections. This makes it

ideal to support the emerging IEEE standard referred to as EFM, or Ethernet in the first mile. One of the first emerging applications for EFM is in MxU-environments, including multi-tenant units (MTU), multi dwelling units (MDU) and multi hospitality units (MHU). In these applications, an access concentrator resides in the basement, and communicates with the office, or apartment CPE over the copper in the riser. As many buildings are wired with cat3 grade cables, and as the distance exceeds 100 mt, the limit for Ethernet on copper, VDSL is used instead. This application requires the CPE to support Ethernet over VDSL at up to 51 Mbps—something that the Intel IXP425 is designed to support.

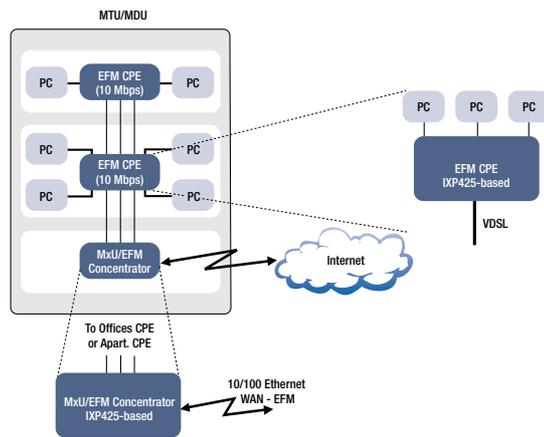


Figure 7. The Intel® IXP425 network processor can be used in MxU applications to support the new IEEE EFM standard. In this configuration, the CPE communicates with the access concentrator over an Ethernet/VDSL connection.

In addition, the Intel IXP425 network processor can be used in the implementation of the MxU access concentrator. In this application the Intel IXP425 based on Intel XScale technology is used to control the concentrator's Ethernet switch and the wide area connection.

## Summary

There are many challenges facing equipment providers, carriers, and the enterprise in the CPE segment. The new Intel IXP425 network processor family has been designed from the ground-up to address these challenges. These new network processor offerings will enable network equipment vendors to offer their customers the best combination of customizable/upgradable services at wire-speed performance, while minimizing development time and costs.

## INTEL AROUND THE WORLD

### UNITED STATES AND CANADA

Intel Corporation  
Robert Noyce Building  
2200 Mission College Boulevard  
P.O. Box 58119  
Santa Clara, CA 95052-8119  
USA  
Phone: (800) 628-8686

### EUROPE

Intel Corporation (UK) Ltd.  
Pipers Way  
Swindon  
Wiltshire SN3 1RJ  
UK

Phone:  
England (44) 1793 403 000  
Germany (49) 89 99143 0  
France (33) 1 4571 7171  
Italy (39) 2 575 441  
Israel (972) 2 589 7111  
Netherlands (31) 10 286 6111  
Sweden (46) 8 705 5600

### ASIA-PACIFIC

Intel Semiconductor Ltd.  
32/F Two Pacific Place  
88 Queensway, Central  
Hong Kong, SAR  
Phone: (852) 2844 4555

### JAPAN

Intel Kabushiki Kaisha  
P.O. Box 115 Tsukuba-gakuen  
5-6 Tokodai, Tsukuba-shi  
Ibaraki-ken 305  
Japan  
Phone: (81) 298 47 8522

### SOUTH AMERICA

Intel Semicondutores do Brazil  
Rue Florida, 1703-2 and CJ22  
CEP 04565-001 Sao Paulo-SP  
Brazil  
Phone: (55) 11 5505 2296

### For more information

To learn more about Intel Corporation, visit our site on the World Wide Web at [www.intel.com](http://www.intel.com)

