Cisco Systems

White paper

Equal Access Networks
for real broadband access

Contents

The importance of real broadband

Metropolitan economies are important to the national economy. To make a real contribution to national prosperity, cities need to increase levels of economic growth and become more competitive. They must also improve the way they are governed and managed.

Connecting real broadband to a city can change the way whole areas work, play and learn. That gives municipalities real opportunities to deliver better service to tax payers, attract more businesses to the area and improve overall prosperity and competitiveness.

Metro Ethernet from Cisco is an ideal foundation for real broadband. Today, almost all network traffic begins and ends as IP, and Ethernet and the Ethernet RJ-45 connector are seen as the most important form of access to public networks. The Ethernet to the x (ETTx) Solution is based on Metro Ethernet technology and utilises IP to provide intelligent network functions. It represents a unified network infrastructure providing end-to-end delivery of next-generation voice, video, storage and data services.

The availability of dark fibre and the economics of Ethernet in the local loop are radically changing access to metropolitan area networks. By developing Ethernet as the transport technology of choice in the first mile, service providers can quickly build real broadband networks that avoid the cost and complexity of protocol conversion and unnecessary layers while leveraging an installed base of 300 million low-cost Ethernet ports.

Cisco ETTx can accelerate the implementation of real broadband by allowing service providers to exploit the use of existing rights of way and civil infrastructures through strategic partnerships with utilities, private companies, municipalities and other local stakeholders.

New opportunities for service providers

Governments worldwide are making equal access mandatory for broadband access providers. In existing deregulated markets, a number of agreements are already in place:

- access-level agreements, with DSL unbundling and an obligation to provide a minimum number of leased lines to an alternate or second/third operator
- interconnect-level agreements, with interconnection charges and termination fees regulated country-by-country
- open access agreements for cable operators.

Market and regulatory forces are driving service providers to open up their networks so that subscribers can specify their own choice of ISP or content provider. Although this trend appears to open up networks to competitors, it actually helps service providers increase real broadband subscriber penetration and generate additional revenue.

The main source of revenue for real broadband service providers is subscribers - residential or business customers. To maximise revenue, it is essential that subscribers can enjoy a "real broadband experience" where they can access all available services and applications on demand, at any time from any connected content provider or ISP.

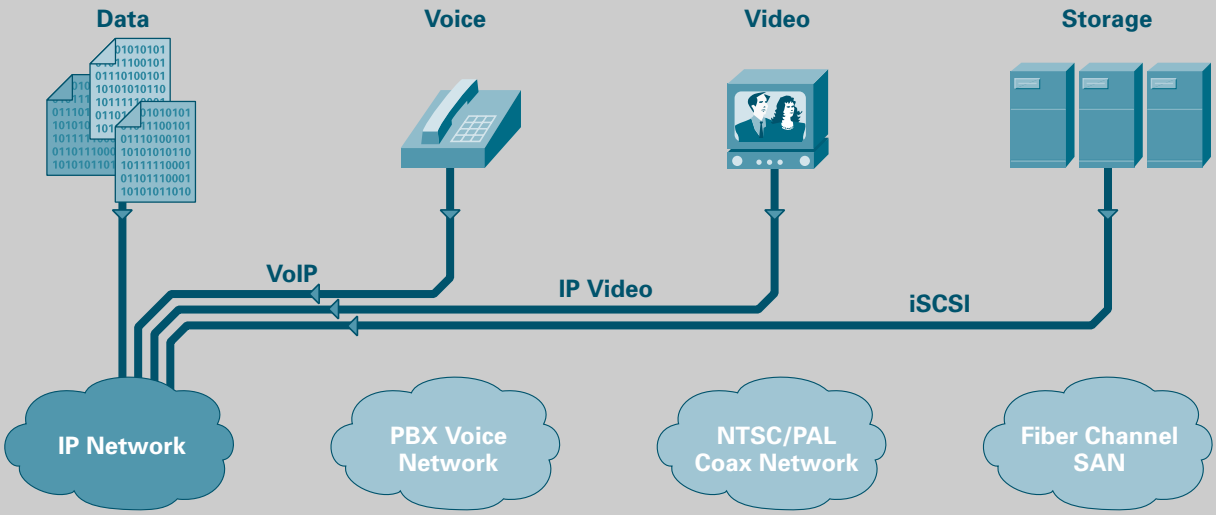
Equal Access Networks support this with a wide range of subscriber benefits:

- ability to select the content provider or ISP of choice
- service on demand
- broadband access with no or minimal delay for service activation
- choice of services rather than one standard package
- consolidated billing and service management.

Benefits of an Ethernet-based infrastructure

Bandwidth alone is becoming so heavily commoditised that margins are dwindling to near-zero. To differentiate themselves, service providers must move higher up the value chain, open new revenue streams and leverage maximum value from their existing

Benefits of an Ethernet based infrastructure



networks. Cisco ETTx offers a truly multi-dimensional opportunity for service providers, delivering expanded customer bases, reduced customer churn and a diversity of new revenue streams.

The financial case for ETTx is compelling considering the low cost of standards-based Ethernet ports and equipment. An Ethernet interface card can cost a much as 10 times less than a SDH interface and can compete with the cost of deploying DSL. The simplicity of provisioning ETTx means that staffing and operating costs are also lowered - while revenue opportunities are greatly increased.

Cisco ETTx installed directly over fibre enables service providers to offer customers a 10 or 100Mbps connection, far faster than other available broadband technologies and upgradeable to 1Gbps by simply changing the customer premise equipment.

Used in conjunction with Internet Protocol (IP), ETTx gives network service providers a future proofed unified platform on which they can deliver a rich mix of voice, video, storage and Internet access services to both residential and business customers located in high-density buildings. This rich service portfolio gives the service provider a strong competitive advantage. It allows the creation of service bundles based on "triple play" services which are not feasible over first-generation broadband technologies like ADSL.

- Voice traffic is becoming packets on an IP network using VoIP technology
- IP video is bringing video onto PCs and IP networks, with video-on-demand, videoconferencing, company event broadcasting and video surveillance now used by companies around the world
- TV broadcasts, video-on-demand and network video recording are also available to a growing number of residential customers in European cities
- New technologies like iSCSI are allowing IP networks to connect computer systems to storage systems located anywhere in the world.

As the industry's only fibre-based metropolitan broadband solution supporting standards-based voice, video, data and storage network architecture, Cisco ETTx provides a roadmap for combining business and technology strategies into a single integrated model.

A service provider operating a Cisco ETTx solution has the opportunity to offer other providers specific network facilities with interconnection and provisioning capability. An ETTx network allows the operator to open the network to multiple ISPs, voice operators, video content providers and other providers, giving their subscribers the freedom to buy services from a provider of their own choice.

Cisco's ETTx solution

Cisco's Metro Ethernet infrastructure provides a foundation for integrated voice/video/data/storage solutions as well as MPLS VPN-based services.

Primary points of presence (PoPs) are installed in the metropolitan area network from which fibre is laid to secondary PoPs. More fibre is then laid from the secondary PoP to an Ethernet/IP switch in the building itself, often in the basement of an office or apartment block.

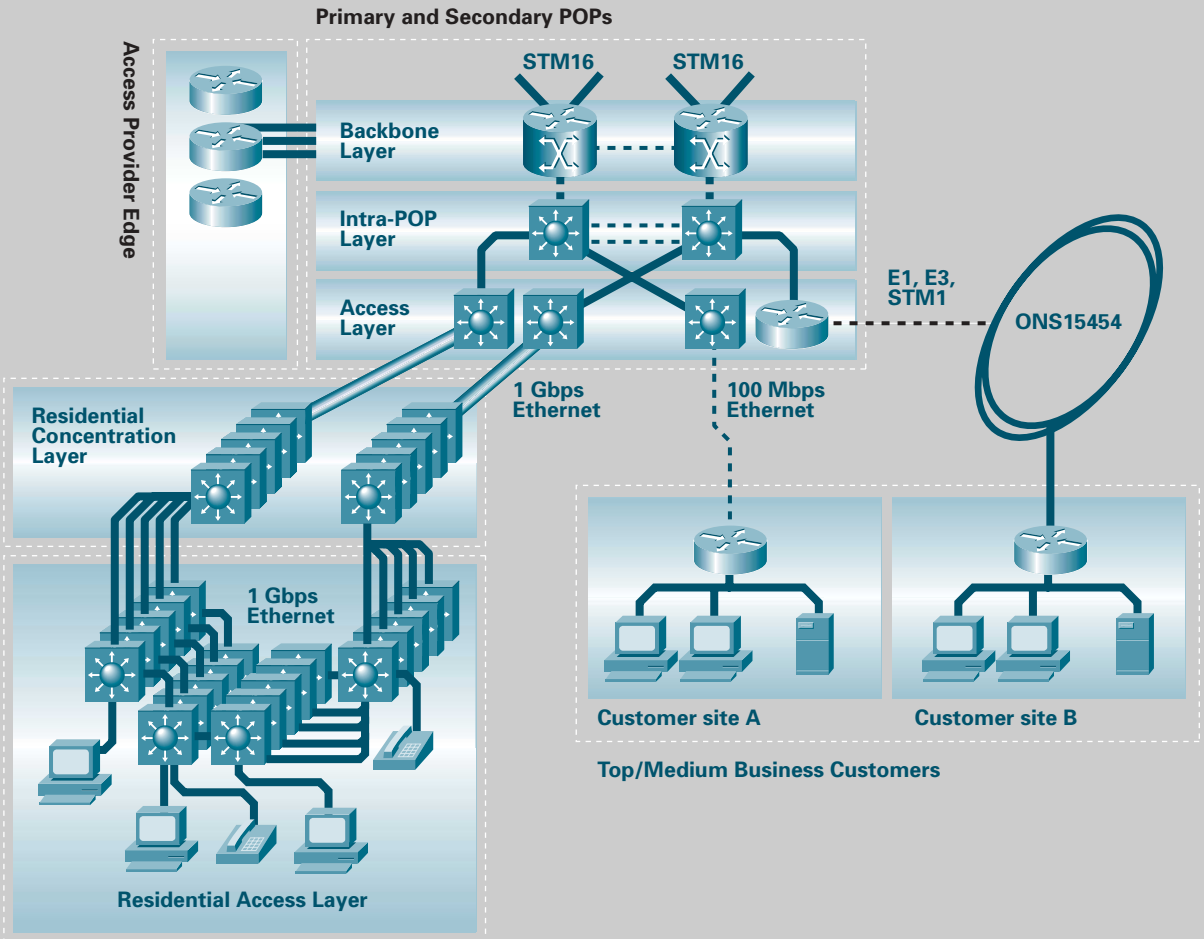
The fibre is usually laid using a ring-based topology to provide resilience. Robust Ethernet and Internet protocols and good network design ensure that there is no noticeable interruption to voice calls or video sessions if a link is lost.

A fibre-based LAN is then laid within the building which terminates in a network socket in each office or home. Ethernet optical/electrical converters are installed directly onto this fibre.

Residential or business subscribers are provided with an IP home access gateway, an IP set-top box for the television, a network card for their computer, connection cables and set-up instructions. The gateway is connected either to existing analogue telephone handsets for voice services, or to IP phones for advanced services. Currently, most subscribers are offered a connection with a speed of 10Mbps.

Service providers set up gateways to the incumbent telecommunications operator for interconnection of voice calls and video gateways to video content providers or video servers for video-on-demand. Video delivery is achieved through the use of IP multicast technology, which allows multiple video streams to be transmitted across the network. This allows delivery of hundreds of digital TV channels to thousands of subscribers without overloading the network.

Structure of the inteligent network



Benefits of intelligent networks

Security

Service providers must protect ISPs, content providers and their networks from a rapidly-growing range of security threats. These can be classified as:

- Internal – either sabotage or accidental misconfiguration
- External – deliberate attacks launched against the system from an access point to the network
- Known – attacks against specific known system weaknesses
- Unknown – a new type of attack or disguised variant of a previous one.

To ensure full protection and business continuity, a layered approach to security must be implemented, rather than reliance on one particular defence. The first step is to define a security policy that outlines the risk areas and details the procedures to be followed to secure them. Areas to be considered are:

- Physical security – restricting access to areas that contain key network elements such as servers, power supplies etc
- Access – limiting access to the network for both internal and external devices/connections
- Identity – recognition, authorisation and auditing of devices/connections to the network
- End device protection – detection and prevention of exploits designed to attack operating systems and applications
- Management – comprehensive management of the security elements to maximise the overall security policy.

Cisco can offer end-to-end, integrated solutions to provide defence in depth against all of the risks listed above. These solutions can take the form of standalone devices, devices integrated into both the LAN switching and the routing layers, or a combination of both. Elements of a comprehensive security solution would include:

- VLAN functionality, including the Private VLAN Edge feature and the 802.1Q VLAN trunking between switches. Subscriber segregation within the VLAN is provided by private VLANs (PVLANs) which turn a broadcast segment into a non-broadcast multi-access segment. PVLANs allow multiple subscribers to be on the same VLAN at the same time, but prevent them from accessing each other's data
- Access Control Lists (ACL). Ring-to-ring security is achieved through ACL filtering and routing capabilities on the Catalyst 6500 modular switch.
- Port Security is provided on each access switch so that the Layer 2 forwarding table cannot be fully populated.
- Storm Control regulates the number of packets per second that can be received on all ports, eliminating broadcast and multicast storms
- Spanning Tree Protocol (STP) Root Guard: All Layer 2 topologies depend on STP to break loops within the network. A hacker can maliciously disrupt the stability of an STP topology by introducing a "new" STP Root into the topology, preventing subscribers on the access port from accessing their network services. The STP Root Guard feature eliminates this threat
- Firewalls provide access control from external sources to ensure only specified connections and data streams are allowed onto the network. This functionality can be enabled in Cisco IOS software on the routers, by PIX firewall appliances or blades within the Catalyst 6500/7600 LAN switch chassis
- Identity-Based Network Services using Access Control Server/Access Registrar, 802.1X and RADIUS can detect devices connecting to the network and either enable or disable access to VLANs
- Intrusion Detection/Prevention is provided by the IDS sensors – appliance, router Network Module or Catalyst blade based. These are deployed as Network Intrusion Detection Systems NIDS), the Cisco Secure Agent (CSA) provides Host Intrusion Detection (HIDS). CSA can be installed on both servers and desktops to prevent day zero attacks from worms and viruses by interpreting the behaviour rather than relying on a virus signature
- VPNs should be used to encrypt connections, especially remote management sessions.

A comprehensive set of management applications is available to configure, manage and monitor the elements of the overall solution as well as providing management reports, fault diagnosis and alerting.

Quality of Service (QoS)

Service providers must employ QoS mechanisms to ensure high-quality application performance, especially in multimedia environments. Cisco equipment features robust QoS via 802.1p CoS and DSCP at Layer 2 and Layer 3. The QoS-aware hardware prioritises applications to guarantee bandwidth to delay-sensitive applications. Service providers can choose either to deploy intelligent CPE devices that mark application-specific traffic with appropriate tags, or they can monitor and mark traffic by application type at the distribution layer.

Subscriber authentication, access control, and billing

VLAN Query Protocol (VQP) and Port Security allow service providers to build applications to track subscribers, control access and set up online billing on the network. VQP allows service providers to track MAC address and Ethernet port association within the network. With this tracking information, service providers can authenticate subscribers entering the network and assign the appropriate IP address information and access control. VQP lets service providers pinpoint the physical location of any customer within the network in the event of DoS attacks. Port Security also allows service providers to dynamically control the number of MAC addresses per Ethernet port. This enables them to limit the number of customers that can access the network using the same Ethernet port.

Network resiliency

Network resiliency is vital for robust fault tolerance on the network. Subscribers expect analogue telephony and television broadcasts or cable and data services to be continuously available. Ring-based topology enables service providers to achieve network resiliency through rapid Spanning Tree Protocol (STP) enhancements in the access layer and the Hot Standby Router Protocol (HSRP) in the distribution layer. This allows for termination of VLANs at the Layer 3 boundary and speeds up overall convergence times when a topology change occurs in the network. This mixture of STP and HSRP has been used successfully in large enterprise network designs and provides the same level of fault tolerance in the current design.

Node scalability

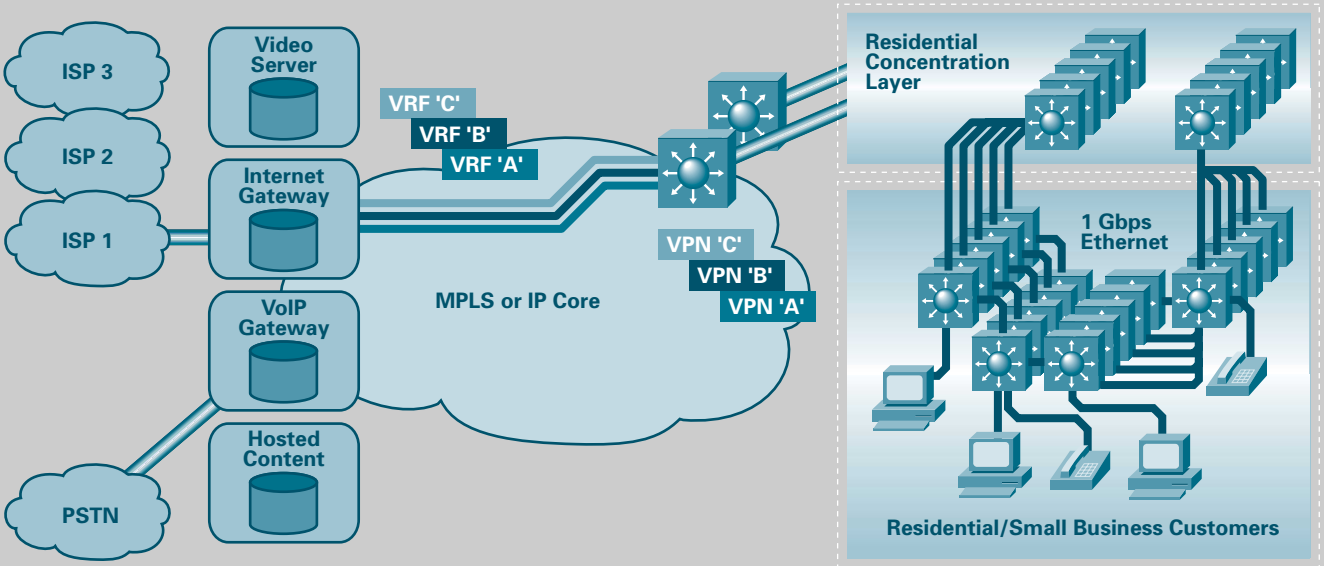
Ring-based topology allows service providers to scale their networking infrastructures quickly as more subscribers come online. Scalability and performance are assured through the following features:

- Flexibility - The size of the fibre ring and the number of access switches deployed per ring can vary greatly depending upon the targeted density of subscribers in a particular segment of the metro area. This flexibility allows service providers to maximise the dark fibre in the metro area and permits maximum coverage at a lower cost. As the Gigabit Ethernet ports use GBICs, service providers can easily overcome distance limitations by installing the appropriate GBIC interface for the desired distance between access switches on the ring
- Form factor and stackability - Catalyst switches come in 12-, 24- and 48-port configurations and are stackable allowing service providers to easily increase access port density per building.

Multicast media support

IP multicast services allow a service provider to replicate the broadcast television model in a large IP network. The access layer of ETTx provides support for multicast applications, such as

Multicast media support



broadcast video, via a multitude of features, such as Cisco Group Management Protocol (CGMP), which supports processing of IGMP join and leave messages. The number of members subscribed to a multicast stream can be easily controlled. In the distribution layer, dynamic multicast routing support is provided via Protocol Independent Multicast (PIM). This design also has built-in safeguards to allow multicast traffic to be distributed with minimum impact to the overall bandwidth available.

Infrastructure for Equal Access Networks

The simplest and most flexible design for implementing an Equal Access Network utilises a combination of rich VLANs at the access point, with managed L2/L3 VPNs, based on Multiprotocol Label Switching Virtual Private Networks (MPLS VPNs), in the aggregation and at the edge towards the ISPs. As an example of implementation, these are the most common design guidelines.

The access layer is based on 2950/3550 in ring or star topologies and connected to the aggregation layers through Gigabyte Ethernet (GE) uplinks, which can be configured to support:

- 1 VLAN per ISP
- multiple VLANs per MxU
- multiple VLANs per subscriber, if the customer subscribes to DIA, VPN and voice services
- private VLANs allowing traffic segregation.

Policy-Based Routing (PBR) enables the network administrator to provide equal-access and source-sensitive routing to incoming packets. All PBR- enabled packets received on an interface are considered for policy-based routing. The router passes the packets through enhanced filters called route maps. Based on the criteria defined in the route maps, packets are forwarded or routed to the next appropriate hop.

A Catalyst 6500 at the aggregation layer provides key PBR functionality which filters subscriber device IP addresses and ensures they are redirected properly into each content provider's Virtual Route Forwarding (VRF) table in the two network provider edge routers (Cisco 7400).

The Cisco 7401 ASR router plays a pivotal part in Cisco's EAN solution by ensuring that content providers have secure access to the access operator's infrastructure edge, where another 7401 manages the content provider's specific address space. The 7401 ASR is a compact route-processing platform that features two 10/100 or Gigabit interfaces as well as an additional port adapter module bay which can be populated with any supported port or trunk port adapter compatible with the Cisco 7000 series routing platform.

The content provider edge provides Virtual Private Network support which creates a virtual pipeline from each content provider edge router across the MPLS network. VPNs are terminated into a managed VRF service, which manages the address space assigned to each of the content providers. From here, packets destined for a subscriber are sent down a content provider-specific VLAN path, through a Cisco Catalyst 6500

multilayer switch and then onto the access ring for delivery to the addressed device.

Each content provider can issue IP addresses to their subscribers' PCs. EANs support peer-to-peer traffic (file transfer, file sharing, chat and other services) between subscribers on the same network or subscribers on different networks and allows the availability of public network addresses. Peer-to-peer traffic can be measured and charged as a usage-based service.

A complete provisioning solution

Service provisioning is a critical element of service delivery. The use of Cisco Network Registrar integrates DNS and DHCP services into the IP infrastructure to improve control and service management. Combining industry-standard functionality with Cisco enhancements for higher performance, availability and configuration flexibility, Cisco Network Registrar product helps service providers reduce operating costs while providing greater functionality to subscribers and customers.

There are two approaches to provisioning:

- pre-provisioning
- self-provisioning.

In pre-provisioning environments, the service provider records the MAC address of the Home Access Gateway (HAG) and ships it to a subscriber. The information is then passed to the provisioning system for inclusion in its database. The system associates the information with a predetermined CoS appropriate for the subscriber. When the subscriber plugs in the HAG, it is immediately recognised by the provisioning system, provided with an IP address and configured for the predetermined level of service.

Self-provisioning represents a different workflow for service providers. Subscribers joining the network must register for service before getting properly configured and gaining access to the Internet. The provisioning system issues the PC as a temporary IP address and at that point the subscriber is temporarily provisioned. The subscriber then sees in their Web browser a form requesting information about their subscriber status, asking them to register for specific services and instructing them to reboot their PC.

Subscribers require high levels of security to prevent malicious users from spoofing their IP addresses and "tapping" into their communications. Many local government agencies require service providers to implement strict security and traceability techniques to monitor subscribers at all time.

Cisco Address and Name Registrar (ANR) overcomes the complexity of IP address management by allowing deployment-defined policies to drive intelligent IP block allocation and reclamation decisions. As well as managing their own IP address space, the ETTx service provider will need to allocate, maintain and track IP address spaces of their ISP partners. CPE devices should always have an IP address specific to the IP address space "owned" by the ISP selected by the subscriber.

In tracking the allocation and usage of IP address blocks, ANR can utilise complex IP utilisation data to drive efficient IP usage and distribution. Through ANR, an administrator can assign an owner to a particular address block, and then distribute that address block across the network in a customised way. ANR then monitors that IP address space, tracks utilisation and performs customisable actions based on specified utilisation triggers.

Supporting efficient network operation

Efficient network operation is essential to an ETTx service provider. FastWeb, a service provider in Italy, has added over 160,000 subscribers in 18 months and Bredband in Sweden more than 270,000 in the same timescale. Growing the subscriber base means:

- expanding the network at the core, distribution and access layers
- coping with hundreds of thousands of physical subscriber interfaces
- managing hundreds of thousands of subscriber HAGs
- delivering multiple simultaneous services
- managing frequent changes in subscriber data and subscribed services.

The Cisco Internet OSS solution provides service fulfillment, service assurance, and billing based on the Cisco Internet OSS Platform. Cisco has selected this as the method of building advanced, next-generation OSS solutions using the "ecosystem model".

The "ecosystem model" used by Cisco is built on partnerships between companies that share an open architecture based on industry standards. Each partner brings a unique capability and service providers can select from a range of potential solutions that fit their specific requirements. In this way, providers protect their investments and can rapidly deploy solutions. Because of the inherent openness of the architecture and focus on interoperability, it is easier to extend the system to address new services and technologies, such as advanced or value-added data services, managed access, security, H323 Voice, SIP-based voice, IP telephony, video-on-demand and interactive TV, compared to proprietary models.

Real broadband – the prospects for residential subscribers

High-speed, bi-directional Metro Ethernet networks support many different types of residential services. Initially, high-speed Internet access was the most popular service. Many residential subscribers had their first experience of broadband as

teleworkers and the "business to employee" model proved useful in supporting the introduction of real broadband at home. This model provides:

- Internet and intranet access
- high-quality multipoint videoconferencing
- e-learning on demand
- senior management business TV broadcasting
- VPN-based data security.

However, voice, broadcast television, video-on-demand and network recording have quickly taken over as the most popular services and are regularly included in a residential bundle. Broadcast television can be delivered over Ethernet with better definition and programme guides than terrestrial or cable. Voice is provided using VoIP through existing handsets connected to the home access gateway.

Voice subscriptions are usually sold at a flat rate that is competitive with existing telephone bills. It is important to generate revenues quickly and achieve critical mass and voice helps to achieve this.

Video-on-demand allows residential customers to pay a set fee to watch a chosen movie at any time within a 24 hour period. Customers can pause, stop, fast forward or rewind the movie. FastWeb, for example, is working with Universal Studios to provide content for this type of service and already have over 10,000 movies in their catalogue.

Real broadband

Network recording allows a customer to log on to the service provider's website to order a particular programme to be recorded. The recording is stored for up to 30 days and the subscriber can play it back at their convenience.

Gaming-on-demand is becoming increasingly popular, with on-line sites reporting more than 10 million players on 600,000 servers, generating millions of dollars per month in revenues. High-quality gaming is only possible on ETTx networks, which ensure very high volumes of symmetrical bandwidth with very low latencies to provide video quality for real-time gaming.

Internet-based video surveillance, using networked IP video cameras, can lower total cost of ownership and enable customers to access any camera via the Internet over secure connections. Service providers can also offer storage servers for recorded security images.

Personalised portals provide customers with a gateway to important information such as online billing, communities, promotions, content mirrored within the urban network for optimised performance, personal storage areas, availability of new services or changes in subscribed services, as well as Internet access to an always-on home IP camera.

Metro Ethernet allows service providers to deliver a higher standard of customer service than competitors because of the flexibility of the bandwidth available. For example, B2, an innovative Swedish service provider, has achieved penetration rates of between 33 and 37 per cent, very high compared to traditional take-up rates for DSL services.

Customising local content is just one of the reasons the service is so appealing. ETTx and video over IP allows easy insertion of local content to create localised programme baskets at costs that were not even conceivable a few years ago. Lyse Tele, a Norwegian Metro Ethernet provider, is working with local newspaper and TV stations to deliver tailored local news content direct to subscribers on a pay-per-view basis. In Bologna, basketball is a bigger sport than football and service provider Acantho has signed a deal with two local basketball teams. Subscribers can get up-to-date information on their local team and see all away games.

Real broadband – the prospects for business subscribers

Business enterprises need to reduce operational costs and improve employee productivity and efficiency. They are therefore implementing Internet business solutions, such as workforce automation, electronic commerce and electronic supply chain management by putting internal processes on the web.

This requires considerable bandwidth and quality of service at an affordable price. However, bandwidth bottlenecks in the access network are limiting potential productivity increases for businesses of all sizes.

Businesses need a cheaper and more flexible broadband service to support Internet business solutions and realise value and savings. Flexible bandwidth allocation enables businesses to react in real time to specific events, such as data back-up or video broadcasts, that require temporary additional bandwidth. Businesses may also need different levels of bandwidth to support new applications or additional sites. Bandwidth-on-demand is a software-based service that allows a business subscriber to log onto a service provider's web page and alter the amount of bandwidth available to them, either immediately or for a specific period.

ETTx supports wide-ranging business applications, including:

- voice over IP
- secure inter-office networks
- links to operational sites, retail outlets, suppliers or customers
- disaster recovery
- managed services
- remote data centres
- distribution channels for television, print or other media
- data mirroring
- distance training
- videoconferencing.

Business models for implementing real broadband Equal Access Networks

Equal Access Networks (EANs) represent a solution for operating a real broadband access network without worrying about content availability. Offering a wide range of services is vital to attracting subscribers to the real broadband experience. Involving different content providers helps to enhance the overall experience for both residential and business customers. Equal Access operators must therefore attract more content and service providers and allow them to offer their service exclusively (wholesale model) or selectively (service selection model).

Wholesale model

In this model, the access operator allows other content providers and ISPs to offer services through its own IP network, typically a layer 2 offer. This offers third party providers significant benefits:

- immediate entry to the real broadband market
- no investment in equipment or technical skills to design and run broadband access
- reduced financial risk
- faster time to market for services requiring real broadband access
- opportunity to roll out new services with minimal investment.

The third party provider manages the installation of the customer router or gateway or provides a self-install version. The third party provider owns the customer relationship, bills the customer and pays the access operator for access.

Service selection model

A service selection model is the most flexible way to build a real broadband access network and retain the value of the infrastructure. Subscribers are given the choice of many different content providers and ISPs, with a basic package of free services included. This model can take a number of forms:

- Walled garden. A branded service or content environment available only to authorised subscribers. Walled gardens allow a service provider to differentiate its offering and retain subscribers within the network.
- Open garden. An opening in a walled garden, called an open garden, is used to attract service subscription by offering free content such as Internet access, television, telephony, radio or video surveillance.
- Web-based service. This supports subscriber authentication, service authorisation and service connection, eliminating the need for client software.
- Captive portal. By redirecting a subscriber to a captive portal, content providers can communicate with subscribers using account or service messages, such as blocked access to a service or payment requests.
- Peer-to-peer broadband traffic. All subscribers on the network can communicate on a peer-to-peer basis.

- Service advertisements. This combines personalised web portals with branding to provide a unique subscriber interface and reach subscribers with targeted messages.
- Retail pages. Content providers can offer web pages with their own customised look and feel - the equivalent of a branded portal - while the access operator benefits from the incremental revenue that differentiated services can provide.
- Device and locality awareness. This model recognises language and regional differences, allowing content providers to offer a web portal that serves multiple locations and devices with a customised subscriber experience.

Community network model

Here a community group builds, owns and operates everything from the passive infrastructure (trenches and ducts) to the broadband network and the services provided to local residents and businesses. This is also known as the vertical model and has been implemented successfully by many local communities.

Property developer model

A property developer can invest in a real broadband network to connect apartments or offices with, for example, 10 Mbit/s fibre-based Ethernet broadband. Offering residents high-speed connectivity and a choice of services from multiple providers makes the property more attractive. Developers can also implement their own network-based services, such as online booking of facilities, management of fire, burglar and safety alarms and electronic communication. Services like these increase the value of the property and help keep occupancy levels high.

Carrier-class voice

One of the most important areas of revenue opportunity for real broadband service providers is voice services. Service providers can challenge the incumbent telecoms providers with a range of Cisco carrier-class voice solutions, including:

- Basic H.323 VoIP. Based on the mature and established H.323 protocol, the H.323 solution provides a simple, flexible rate-based, second-line service for subscribers. It is particularly suitable for small deployments in countries with minimal regulatory requirements and trials.
- V5.2/GR303 VoIP. This is a hybrid VoIP/TDM solution based on a Bellcore standard interface specification. The GR-303 standard is used in the United States and Hong Kong while the V5.2 standard is used in most other areas of the world. It is ideal for ETTx service providers who already offer telephony services via a traditional TDM Class 5 switch and want to take advantage of the operational economies of VoIP.
- Session Initiated Protocol (SIP). This is a popular VoIP solution for enterprise customers and service providers, particularly those using ETTx access methods. The solution is based on a soft switch, the Cisco BTS 10200 for residential applications, that includes such functionality as DQoS, event messaging, additional security and lawful intercept.

FastWeb in Milan offers carrier-class voice quality using H.323, one of the most common protocols. Acantho in Italy is delivering a mix of business and residential voice. BT Ignite in the United Kingdom and Dubai Internet City are both offering managed business voice. Here the service provider not only provides connectivity, but also hosts software-based IP-PBX functionality. This relieves the business of the effort and cost of installing, managing and maintaining a traditional PBX.

There are two sources of voice traffic:

- Voice is converted from TDM to IP through customer premises equipment. For the last four or five years it has been possible to interface an existing PBX to an IP connection without modification, using its standard ISDN interface.
- Voice traffic can also be native VoIP coming directly from an IP-PBX and originated using IP handsets. This does not require any conversion, but it does require quality of service, reliability and network availability to meet planned service level agreements.

Transporting voice and data across the same pipe requires good design, as well as specific functionality in the access, aggregation and core levels of the network. The most important functionality includes:

- quality of service, both in the customer premises equipment and in the access switch
- classification of traffic, so that equipment in the network can understand whether each packet it receives contains voice, data or video and can route it accordingly
- management of different types of traffic across an IP pipe at either end. Technologies need to be implemented at each layer of the network to make voice traffic flow consistently and flawlessly
- security – voice traffic must be encrypted and individuals who connect to the network must be authenticated as legitimate customers
- resilience, which depends on good network design.

Most service providers deploy fibre into a ring topology, because sharing fibre between customers allows them to lay less fibre than would be required with dedicated fibre to each customer or building. In order to make a ring as reliable as point-to-point connections and therefore suitable to transport voice, protocols like Fast Spanning Tree (802.1w) or the more robust RPR can be adopted. If a ring is accidentally cut during civil works, intelligent devices are able to reconfigure themselves and divert traffic to the other side of the ring. Fast Spanning Tree takes fractions of a second and RPR takes less than 50ms, which are both fast enough to deliver business voice.

TV and video solutions

Video applications enable service providers to test the residential market for interactive TV services. Video applications include:

Interactive programme guide – provides an on-screen listing of all programming and content available to a subscriber. Service providers can display advertising for specific programmes or commercials.

TV broadcasting applications – ideal for delivering news or live events such as sport or concerts using IP multicast and application layer multicast techniques. Current interactive satellite applications are very limited by the absence of a return channel.

Pay TV applications – use the same infrastructure as TV broadcasting, but access to content is on an individual programme basis using an access key system unique to a subscriber or household. Access is controlled by the service provider's management system.

Near video-on-demand – identical streams are delivered via IP multicast every few minutes for each piece of content. Subscribers wait for the next available stream, sharing it with other subscribers.

True video-on-demand – as soon as a subscriber requests content, a new individual stream is created and played without delay using unicast transmission.

Interactive video-on-demand – unlike true video on demand, subscribers can control the video stream with functions such as Stop, Play, Rewind, Fast Forward.

Virtual VCR – allows subscribers to record live video streams on network storage for later playback with interactive video-on-demand functionality.

Interactive advertising – enables service providers to profile and target subscribers with personalised advertising.

E-learning applications – allow service providers to develop specific e-learning offers at a lower price point than other content.

With Cisco real broadband access solutions, all of those applications share a common IP format. Apart from video services and the interactive programme guide, the services will also run on a PC with the appropriate plug-in.

The service provider business opportunity

Real broadband over Ethernet gives service providers an opportunity to build a successful new business stream within a very short time by leveraging existing infrastructures to provide a multi-service network that meets the rapid growth in demand. A single infrastructure for integrated voice, data and video means lower costs and an opportunity to future proof the network and roll out an unlimited array of high-value services that deliver real growth and real profits.

In deciding whether an area is suitable for ETTx, the most important factor is demographics. The cost of laying fibre cables to each building is economically viable where there is the greatest density of buildings. In many cases, the business case for residential and business subscribers customers is based on partnership with a local utility who provides access to subscribers' premises over existing ducts and rights of way, while the service provider operates the network.

The service provider may be able to lease existing backbone or metropolitan area network fibre from a utility at competitive prices and complete the network by laying fibre through existing utility ducts and rights of way. The service provider can also supply in-building cabling and customer premises equipment, such as a home access gateway or set-top box for the video service. This model allows a service provider to build a metropolitan area network relatively easily, quickly and at reasonable cost, while overcoming the problem of the last mile.

ETTx fibre infrastructure maximises return on investment when it is used to support a voice, video and data offering in an integrated subscriber package. A broad range of value-added services allows the service provider to tailor service bundles for specific market segments. By providing turnkey, bundled or managed services, service providers can position their portfolio as offering value-added solutions rather than commodity network transport.

Experience has shown that a flat rate voice over IP offer is an essential part of the solution because the cost is very appealing compared with the rigid pricing or complex tariffs available from incumbent operators.

Television over IP then becomes a way to attract more subscribers and increase ETTx penetration: voice, video and data are delivered over the same Ethernet wire, minimising the complexity of cabling in a building and simplifying administration for subscribers. Video-on-demand will also play a key role in building real broadband business. ETTx bandwidth meets studio-quality requirements and subscriber expectations.

The benefits of offering service bundles is even more pronounced when service providers target businesses. Service providers who can offer managed or bundled solutions will have greater appeal to organisations that don't have dedicated network staff.

The role of the dark fibre provider

There are a number of different business models with different economic implications. However, using existing ducts or leasing fibre reduces time to market and payback cycles and improves overall profitability for the service provider.

For service providers considering building new networks from scratch, negotiating rights of way, civil works and deploying fibre, any profitability would depend on the right demographics and careful targeting of the best districts in a city. This model is much more challenging in terms of optimisation, while partnership with a utility has proved to be key to winning.

National and local government policy influences consents for rights of way and regulation of fibre leased in the metropolitan area. Municipally-owned fibre which is locally controlled enhances the local economy, quickly meets the specific needs of the municipality and causes less disruption as roads do not have to be dug up repeatedly for installation or maintenance.

Municipalities with their own urban network can optimise their IT infrastructure and their costs by linking their own operations with education, administrative organisations and local companies, providing cost-effective communications and increasing network capacity without new investment in infrastructure.

Stokab, the only company allowed to deploy fibre in Stockholm, is an example. It leases fibre to:

- telecom operators, Internet operators, cable TV companies, mobile telephony operators, and network operators as an alternative to building their own networks
- local hospitals and medical centres who share a common infrastructure for data, voice, video, storage and communications
- banks, insurance companies, retailers, media companies, university colleges, urban networks, property developers and IT companies who depend on high-capacity data transfer and efficient, secure communications.

Emerging business models

Many different players are involved in a successful metropolitan network: residents and business customers, service providers, municipalities, dark fibre providers, utilities and property developers.

According to service providers, customer acquisition is more expensive and complicated in multiple occupancy buildings than in traditional single-occupier units and requires a tailored marketing approach. However, communicating with just one prospect – the property developer or landord - is simpler than contacting 200 single-occupancy units individually.

The relationship with property developers is likely to be long term, as developers will be an important main point of contact between the service provider and the subscriber. Many successful service providers have allocated significant resources to training property developers in service packages, selling techniques, and marketing collateral such as kiosks, door hangers and business reply cards.

Property developers can offer exciting new facilities to their residential and business customers by connecting them to real broadband. Residents and businesses are now demanding high-speed Internet access and value-added services available anytime, anywhere as well as the established services such as air-conditioning, security and fire alarms.

Many other players, including utilities, telcos and service aggregation companies are targeting the lucrative high-density building market. ETTx service providers can leverage their real broadband value proposition to penetrate this sector and deliver a growing stream of enhanced services

Proving the business case

Despite 20 years of discussion about digital networks, convergence and integrated networks, Ethernet to the residential and small and medium business sector is currently the only practical, proven technical solution for integrating voice, data, Internet access, video storage and other services.

Although it may be some years before it is economically viable to deploy Ethernet on a national basis, the business case is extremely attractive when the right conditions exist in terms of population density, demographics, service mix, availability of existing fibre and the opportunity to partner with a utility to complete fibre deployment.

Cisco has researched the business case for service providers delivering real broadband over Ethernet to residential or business customers. Feedback indicates:

- service providers can achieve positive EBITDA within three to five years if the model is set up correctly
- net present value is maximised when the service provider is able to combine services to subscribers in the same building
- net present value is maximised when subscribers are offered the "triple play" of voice, Internet access and video
- play maximises average revenue per user, although it requires more investment than voice and data alone
- video alone, without voice or data, is only marginally profitable but helps to increase penetration into each building and can encourage take-up of other services.

The typical cost of the infrastructure per subscriber varies. However, if the service provider achieves a 30 per cent penetration of the units within a building in a densely-populated area with the right demographics, the capital expenditure per subscriber is comparable with other technologies. ETTx has a very clear cost structure with no hidden surprises during deployment and operation.

Why Cisco?

Cisco is the world leader in IP networking. The infrastructure of the Internet is made up largely of Cisco products and there are more enterprise LANs based on Cisco solutions than any other current vendor's equipment. Cisco's expertise extends to voice and video as well as data, for example, it is the world's number 1 provider of pure IP telephony systems.

Cisco is well placed to offer service providers a highly-functional, yet commercially-viable Metro Ethernet solution that consists of a comprehensive range of products and price points together with exceptional manageability for controlling costs on a converged platform that is optimised to carry multiservice traffic. Cisco's solution offers service providers a wealth of benefits, including:

- unrivalled expertise in the Metro market. Cisco has more years of experience in Metro Ethernet than any other vendor
- professional services. Cisco is the only vendor that can provide high-level training and consultancy in this area. Cisco's expertise has, in some cases, reduced network deployment time from nine months to just four, giving service providers a real competitive advantage
- technology leadership. Cisco's Metro Ethernet solutions are extremely scalable, ensuring future proofing for both service providers and customers. They deliver high levels of availability, reducing maintenance costs, and comply with open standards for integration with existing infrastructures or software compatibility
- comprehensive product range and price points. Service providers can build customised networks that match their own, as well as their customers', requirements. The solutions cover central office and CPE equipment and area easily upgradeable for future technology advances
- ecosystem of partners. A growing range of applications and content from partners enables service providers to retain customers and maximise return on investment for each connected building
- proven solution. More than 80,000 buildings are connected to Cisco or service provider-operated real broadband networks in Europe.+

To find out more about Cisco's Metro Ethernet product range and other Cisco solutions for service providers, visit **http://newsroom.cisco.com** or **http://www.cisco.com/go/metro**

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