NexComm Systems White Paper

Utilizing Ethernet DSL as the Ultimate Access Solutions – for Business and Residential Customers.

March 2006, NexComm Systems, Inc.

Introductions

The recent economics around the globe is known to develop in directly proportional to the level of the Information & Communication Technology (ICT) infrastructure of each country.

This paper discusses the method how to build Next Generation Network easily, rapidly, and affordably using cutting edgy Ethernet DSL solution that can maximize subscription of recent sweep of Ethernet service at low cost. Until now broadband service platform worldwide has been driven by ATM technology that can support a variety of multi-media services by fully making use of Sonet/SDH network and its bandwidth scheme that have dominated telecom infrastructure all over the world.

Typical example for the above platform has been shown in recent ATM based ADSL and ADLS2+ deployment worldwide. However this platform is known to be vulnerable to Triple-play broadband service that has been discussed in the telecom industry. Since transportation of voice, data and video at the same time has already been converged to IP from legacy technology, considering investment in future-proof service platform it is thought to be non-sense

to realize this service by utilizing ATM or Sonet/SDH technology. Therefore in order to keep it in the right track, it is a necessary but tough mission to examine the network development road-maps of the advanced countries that have made a great effort to take the right direction in building infrastructures for Broadband Network Services.

Refer to the table 1 below for the comparison between the Ethernet based Next Generation Network and the existing Sonet/SDH Network.

Feature	Sonet/SDH	Ethernet Transport
OAM	SDH OAM framework	● IEEE 802.3ah ● ITU Y.17 ethoam PTP OAM ● IEEE 802.1ag e2e OAM ● MEF Service OAM & PM
Protection	UPSR, BLSR, SNCP, MSSPRing. MSP 1+1, LCAS	MPLS, Fast Reroute, RPR, Link Aggregation
Traffic Engineering Hierarchy & Scalability	Sonet VT/STSs, SDH VCs	● Q-in-Q (VLAN) ● MPLS Label Switched Paths(LSPs) ● Pseudowire (PWE3) ● Hierarchical VPLS (H-VPLS)
PDH, SDH Support	Inherent, deterministic	Circuit emulation over pseudowire
Multiprotocol Support	Escon, Ficon, Fibre Channel, etc. over GFP/VCAT	Multiple protocols over Pseudowire, mapped to Ethernet
Scalability	Nearly limitless number of endpoints Transport/Interface rates to 40 Gbit/s	Control plane and data plane limits data rates to 10 Gbit/s today
SLA Support, QoS	Deterministic	Difficult end-to-end; exacerbated in any-to-any topologies
Interoperability	Interface well standardized, with proven intercarrier interworking	● Many proprietary schemes today ● Standards looser than Sonet/SDH ● Demarcation devices new to market

(Source: Heavy Reading Webinar “Will Ethernet Devour Sonet/SDH?”)

Table 1

As described above, OAM, reliability, and other features once recognized as weaknesses of the current Ethernet Network have been greatly improved so that the Ethernet network can be considered as substitute for traditional legacy technologies. Especially, the Ethernet Network is known to have many advantages like economical efficiencies with various QoS and interoperability when it is connected via Metro Ethernet and the IP/MPLS network of the network core.

Roles of the Legacy TDM network (Sonet/SDH)

Sonet/SDH network, developed as the forthcoming of the worldwide communication mean along with the narrow-band PDH network over the last ages, has been growing as a powerful infrastructure that support low/mid speed data transmission and voice communications. In the phase of the development, the role of the legacy TDM network has been extended to transmit packets, IP data in other words, and various protocols have been developed. They specifically are Data over PSTN (64Kbps ~ 128Kbps), Frame Relay (mostly T1, E1, N x T1/E1), ATM (T1/E1/ DS3/ STM-1) and Leased Lines.

However, the network is required for expansion as the internet protocol has become more and more generalized, and services and applications demanding high bandwidth have become very common. So now Ethernet technology becomes the ultimate alternative solution that meets this explosive demand for higher bandwidth. For some countries that have not invested excessive investment in Frame Relay or ATM could take opportunity to leapfrog to the next generation network model by adapting Ethernet based Network and save tremendous investment cost in the network development phase.

As a consequence, it will be a wise choice to invest in Ethernet Network while taking the most out of the Sonet/SDH network that have already been invested. Particularly, it is very advisable to minimize the excessive investment in Sonet/SDH network to expand PSTN voice services, which have been leveraged by mobile telephone services in some countries. Instead, investing in the future platforms, which is ideal for converged services with voice and multi-media data.

Desirable Network Investment Scenario

It is necessary to give it a second thought when determining the candidates in need of urgent investments in order to approach the subject more efficiently.

A. Service Provider's view point
   - High speed Internet service for the common; Internet, Gaming, VOD etc.
   - Communication services for SMB's or Enterprises; Internet, LAN extension, VoIP etc.

B. Government sector's view point
   - Delivering broadband service over each classroom in schools; e-learning, school management etc.
   - Delivering broadband service over each Government office; e-government, data exchange, etc.
   - Securing communication infrastructure for national welfare: health care, Internet café (free), municipal wireless mesh networks and etc.

It is interpreted that the investment systems can differ according to the purposes described in A and B above.

For the scenario A. the most effective investment will be FTTC + VDSL or FTTH, yet Wireless Broadband Service (WiMAX) or legacy ADSL/ADSL2+ can be the second best. To minimize investment, the fiber deployment has to be reached as near as possible to customer premise and technologies mentioned above have to be utilized. But eventually Service Providers have to get prepared for FTTH in which fiber connection is reached to every home. For business customer Symmetric DSL technology over existing copper infrastructure or Metro Ethernet solution over fiber will be desirable network build-out.

For the purpose B, investment for the Symmetric DSL utilizing fixed phone line and point-to-point WiMAX when there is no availability of the phone line will be alternatives. Optical fiber can also come into consideration afterwards.

Refer to the below Chart 1. regarding the access technologies for the business and home subscribers descried in the purpose A above:

DSL(VDSL & SHDSL)	Optical Ethernet	WiMAX
• Uses existing copper lines • Intelligent CPE can address upstream congestion control • New IP/Ethernet DSLAMs allow more cost effective Ethernet aggregation	• Last mile equipment perceived to be costly • Aggregation is over Cost-effective Ethernet • Requires a fiber strand per user • Future proof upgrade to GE	• Last mile equipment perceived to be costly for the initial investment • Aggregation is over cost-effective Ethernet • Requires no wireline infrastructure • Easy addition of new users

- DSL(VDSL & SHDSL) is the best choice for delivering high grade VoIP and Multi-media and data services without last mile changes or additional investment.

Chart 1

As descried above, it is clear that DSL technology is the most efficient and economic technology. So the current advisable investment for each class of network is as below:

A. Core Network: IP/MPLS network over Ethernet Optical Transport Network (EOTN)
   - Utilization of Ethernet over DWDM or Ethernet over Sonet/SDH in substitute for EOTN.

B. Edge or Regional Network: Metro Ethernet network is the most suitable.

C. Access Network: Ethernet based VDSL(10PassTS) or SHDSL(2BaseTL).

Ethernet DSL infrastructure for broadband solutions

As illustrated in the previous sections, now there is no doubt that the most important goal of investment in network infrastructure is to make each network element Ethernet-based which is best suited for All IP paradigm. Especially Ethernet based DSL access is able to make economic and full featured broadband services when working with Metro Ethernet network as a higher level network.

Integrating technologies, such as SHDSL ratified by ITU-T G.991.2 and VDSL ratified by G.993.2, together with Ethernet OAM ratified by IEEE 802.3ah, various kinds of present and future network service is available. Examples are shown below;

1) Providing business Internet Access services with a various service model utilizing Class of Service (CoS) of Ethernet network, previously with CSU/DSU and CPE Router.

2) Providing optimal Access Network for E-Line and E-LAN service of Metro Ethernet.

3) Provision of QoS (Layer 1/2/3) for VoIP, Multi-media conference.

4) Enabling Managed service using smart demarcation functions of the Business Gateway. (e.g, network security service, tiered services etc)

Refer to the below diagram 1 in the next page describing the service model mentioned above:

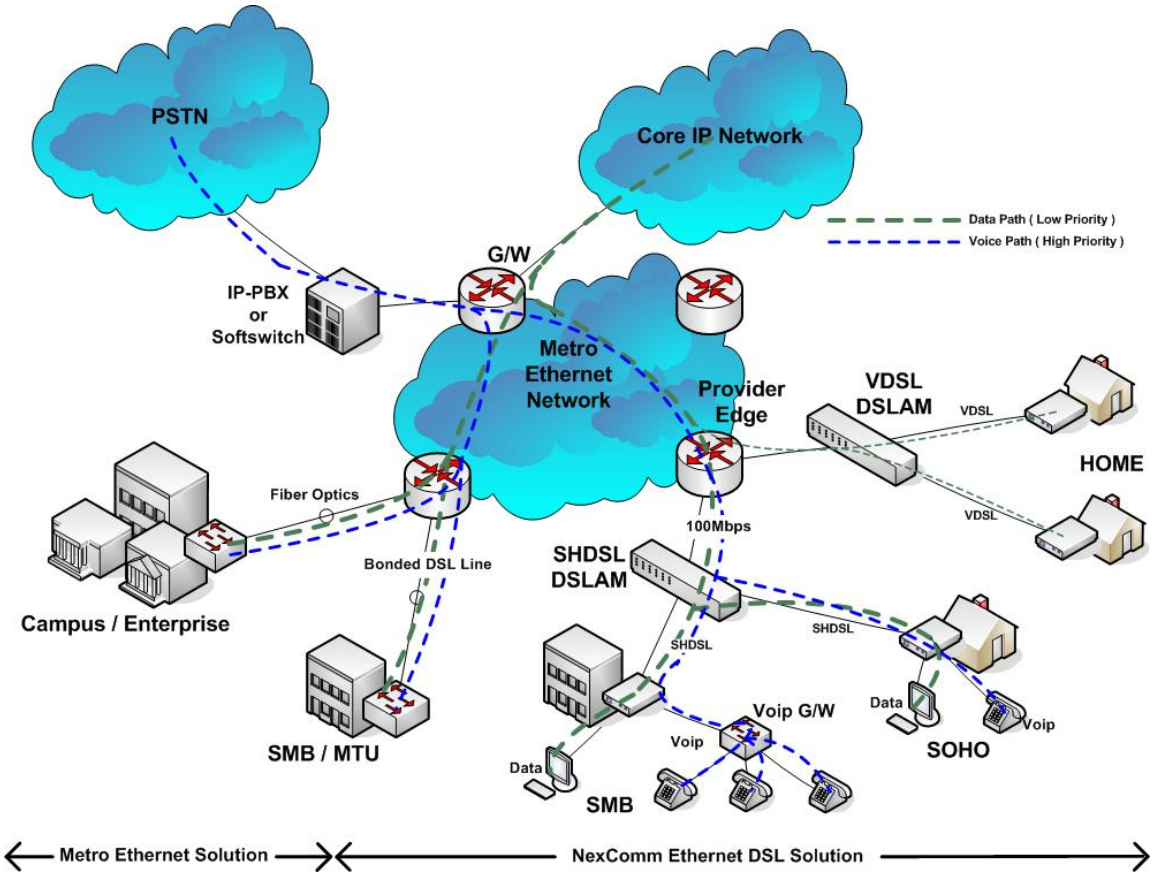

Diagram 1

As easily noted in the above picture, simple Metro Ethernet solution and together with SHDSL & VDSL solution enable almost all home users, enterprises and schools to have broadband service so that Internet access, VoIP service can be available. What's interesting is the fact that SHDSL & VDSL are naturally adapting the service system blended with the devices consisting Metro Ethernet, and service providers are able to constitute service networks with most economical efficiency according to clients' needs.

As you can see in the above example, regional Ethernet network can be utilized and applied to many cases as below even before a large scale network like nationwide or worldwide Ethernet network is built.

1) Regional networking including VoIP service of Local council
   - Schools, government offices, healthcare centers
2) Large enterprise campus networking with VoIP.
3) Military campus broadband networking
4) Regional network for railway system, highway system and etc.

The above Access Network will be the best alternative investment, because it enables to manage end to end QoS service in tight connection with investment in IP/MPLS of the Core network afterwards. Below diagram 2. describes the end to end QoS enabled Broad-band Network.

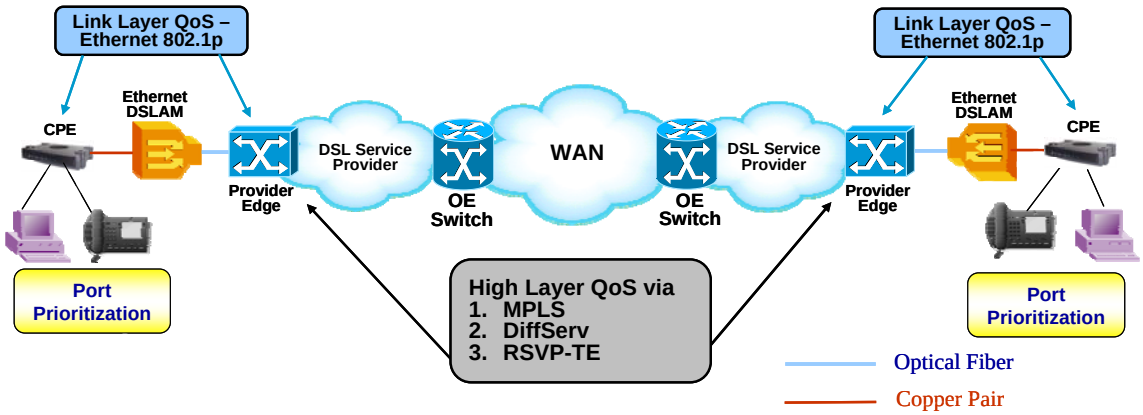

Diagram 2.

As you can see the above diagram, the Ethernet based DSL access solution is a perfect service platform with the Ethernet core network and can provides the End-to-End QoS service. Occasionally, MPLS network of the Core will lead the actual broadband network as being evolved to Ethernet Optical Transport Network (EOTN) according to the advancement of networks.

Ethernet DSL Technologies

1. Symmetric DSL Technologies

There are various technologies of Symmetric DSL, including HDSL (High bit rate DSL), FDSL (Single Pair HDSL), SDSL (Single Pair, 2B1Q based) for legacy TDM transmission. However, the global standard has become the HDSL (Two Pair solution, ITU-T G.991.1) using 2B1Q and SHDSL (ITU-T G.991.2 Annex A/B) using a single pair. SHDSL (G.SHDSL.bis), standardized by the ITUT-T G.991.2, Annex F/G, improved the bandwidth by changing the line coding from TC-PAM16, accepted by Annex A/B, to TC-PAM32. Currently, several service providers are testing for interferences with other services when applied of new coding methods, and there is a possibility that it will be chosen selectively according to the policy of each country.

Bandwidth capacities of SHDSL (Annex A/B)

The symmetric bandwidth, currently classified as 2Base-TL by IEEE802.3ah, transmitted by SHDSL is as below:

2.3Mbps(Annex A/B)/ 5.7Mbps(Annex F/G) using one pair(two wires) of copper cable
4.6Mbps(Annex A/B)/ 11.8Mbps(Annex F/G) using two pair (four wires) of copper cables

2. VDSL Technology

As Very High Speed DSL (VDSL) is designed for the purpose of maximizing the bandwidth via copper lines, VDSL2+, which has been decided by the ITUT-T G.993.2, as a standard, recently realized the transmission speed of 100Mbps with seamless connection to the upcoming Ethernet Network. It appears that each service provider will adjust the bandwidth variously depending on desired services and level of quality within the maximum potential speed.

This new VDSL2 standard delivers up to 100 Mbps both up and downstream, a ten times increase over ADSL technology. By doing so, it provides for so-called 'fibre-extension', bringing fibre-like bandwidth to premises not directly connected to the fibre optic segment of a telecom company's network. VDSL2 is seen by many operators as the ideal accompaniment to a fibre-to-the-premises (FTTP) rollout, where fibre optic lines are used to link large premises like office or apartment blocks to the PSTN, and ordinary copper cables used within the building to connect tenants or residents to high-speed services.

There is ATM, IP and recent Ethernet based equipments as an access solution that DSL technology is applied. Such confusion is caused by the competitions between each equipment vendor and service providers. The recent trend is that Ethernet as the layer 2 basic network and developed with various protocols over it.

1) ATM based Equipments: provided by most of DSLAM vendors and CPE vendors.
2) IP based Equipments: DSLAMs and CPEs, developed for end to end service of the past ATM, are used with the remaining ATM protocol in the DSL segment and Ethernet conversion is made in the uplink module, this solution was designed in order to adapt to IP/Ethernet based network which is economic and easy to handle. Therefore, there are many weaknesses when providing Ethernet services to enterprises. In other words, it is disadvantageous to apply Layer 2 QoS.
3) Ethernet based Equipments: There are equipments being introduced with Ethernet DSL technology and Ethernet backplane in the DSLAMs, applied to reinforce the weaknesses of the standardized equipments mentioned above and currently it's the most suitable SME service platform together with Optical Fiber solutions of Metro Ethernet.

The appropriate equipments are being developed adapting the recently broadband standard (ITU-T G.991.2 Annex G) and OAM, IEEE802.3h for service provisioning.

Comparison of various DSL equipment and technologies

As mentioned in the previous paragraph, DSL technology distributed globally is being commoditized complicatedly according to the applied technologies. Such confusion causes service providers not to be profitable from the redundant repeated investment and excessive investment in succession. Moreover, manufacturers suffer from the huge cost of development and stock keeping due to having to develop equipments with many versions. Refer to the below comparison table 2.

	Traditional ATM DSLAM	IP DSLAM	Ethernet DSLAM
Subscriber I/F cost	low (ATM)	low (ATM)	low (Ethernet)
Uplink I/F cost	high (ATM)	low (Ethernet)	low (Ethernet)
OAM	mid (F5 loopback)	mid (F5 loopback)	rich (802.3ah OAM)
OPEX	high	mid	low
seamless connectivity	yes (ATM switching)	no (ATM-to-Ethernet conversion required)	yes (no protocol conversion required)
Interoperability with Metro-Ethernet	bad	not good	good

Table 2

Evolution Roadmap of Ethernet DSL Technologies

A. Convergence of Voice and Data

As the limitation of VoIP service, which is provided by using IP DSLAM rolled out in the past, has been emerged, the industry starts to consider VoIP as one of the premium services based on QoS and SLA. For the method to enable this VoIP service, they took an approach of converting ATM QoS scheme to IP QoS or Ethernet Layer 2 CoS feature with existing IP DSLAM. However, this method has fundamental drawbacks of inefficiency when converting and remapping QoS marked ATM cells to the according IP packets or Ethernet frames. So Ethernet solution based on QoS and CoS (Class of Service) function came across as strong alternatives. This solution, so called Next Generation Network, is comprised with IP/MPSL, Metro Ethernet, fiber optic access, SHDSL and VDLS access solution. It seems that the future network takes full advantage of the existing DSL solution based on ADLS2+

or VDSL and try new value added services in the residential market. But for the business market Ethernet based SHDSL and VDSL solutions will be the main investment to be made

B. Rollout of IP/MPLS and realization of End to End QoS

Up until now many challenges of Metro Ethernet network comparing to the Sonet/SDH network has been addressed significantly for the criteria such as security, reliability, and supportability of legacy TDM service. The challenges coped with are as follows;

① Network Reliabilities: Fast rerouting of IP/MPLS, RPR of Metro Ethernet
② Network Securities: safety against DOS etc.
③ TDM supports: Pseudo wire emulation, end to end (PWE3) of IP/MPLS TDM over IP (TDMoIP)
④ Class of Service (CoS): Until now Metro Ethernet camp has defined and offered 8 levels of CoS. This kind of CoS delivers necessary service according to the access method

Conclusions

Ethernet Network will be continuously developed in a same way with the other Network that has been developed and evolved so far. Taking it for granted that the network is evolved as mentioned in the above sections, a variety of Ethernet access network solution supporting QoS/CoS should give a longevity that compensates its investment independent of core/metro network change to come.

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