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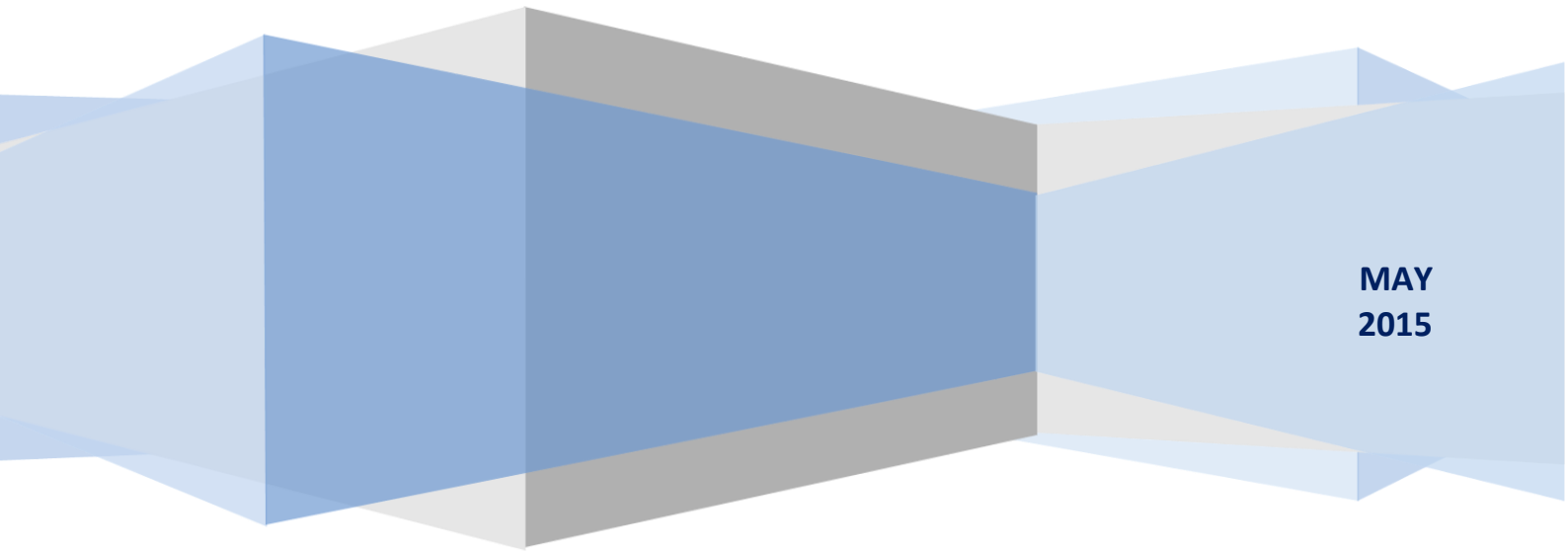
How to leverage on the High Speed Ethernet capability of existing copper cables

WHITE PAPER

Didier Ana



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Ethernet First Mile

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WHITE PAPER

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Forewords

Industry networks continue to converge to IP protocols and integrate various service traffics of control, video surveillance, information, management, etc. They require more bandwidth and scalability with best coverage to develop such services and anticipate future requirements.

Developing a new fiber infrastructure makes a huge investment with a lot of labor, delays, service interruption, organization and process changes such as engineering rules and maintenance, etc.

In many case though, existing copper cables are excellent opportunities to satisfy present and future requirements with suitable scalability and best cost savings.

This white paper brings a prospective vision with technical and economic criteria on DSL technologies and their ability to satisfy mission critical network expectations.

1. DSL Technologies

DSL = Digital Subscriber Loop

DSL technologies are aimed at supporting data communication and Internet access to subscribers through the existing twisted copper cable. ADSL was designed purely for Internet access. ADSL has asymmetrical speeds – a higher upstream and a lower downstream that suit typical Internet traffics, except peer to peer applications.

Two other technologies offer valuable characteristics for industrial networks : VDSL et SHDSL.

1.1. VDSL : Very high speed Digital Subscriber Loop

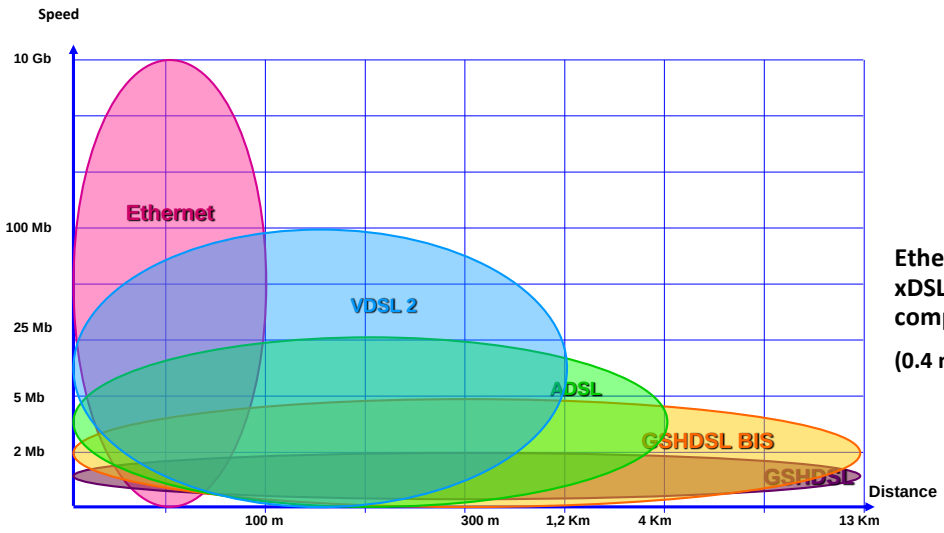
VDSL provides subscribers with very high speed Internet on a telephone copper pair but on quite short distances and usually less than 1 km. VDSL2 is the most current standard today with throughput in the range of 20 to 100 Mbps. Several classes of operation adapt to the line length with different options of symmetrical and asymmetrical rates. The VDSL standard still evolves to increase the bandwidth (Vectoring, G.Fast) but still on short distances.

Industry networks may benefit from the high bandwidth of VDSL when distances remain in the range of a few tens or hundreds meters. Point to point communication are established between a master CO modem and a slave CPE one.

1.2. SHDSL : Symmetrical high speed Digital Subscriber Loop

SHDSL is an exceptional technology in several aspects :

- No other technology could deliver such a high speed symmetrical bandwidth when distances increase above 1 km or 2 km. Also no other technology could reach distances of up to 8 or 15 km or even more with cables thicker than 0.9 mm. SHDSL can connect on line longer than 10 km on cable of 1 mm and more, and repeaters can be inserted on the line to increase distances.
- SHDSL inherited a broad standardization and stable maturity since many years. SHDSL was first ratified as ITU-T G.991.2 standard then as the ETSI TS-101 524 one. A new version of the standard was released in 2004 for native transport of Ethernet frames over SHDSL. The IEEE issued the 802.3ah standard that is also called Ethernet First Mile. EFM brings strong improvements Ethernet communications such as standardization and operability between vendors, low latency of Ethernet frame transmission, and multiple pair bandwidth aggregation through the PME Aggregation Function that produces higher speed Ethernet throughput. 100 Mbps Ethernet transmission can be achieved over few copper pairs which competes with 100FX optical performance. SHDSL – EFM mature standardization and technology as well as flexibility to serve the ubiquity of Ethernet throughout the industry, are great guaranties of future-proof investments.
- SHDSL is an adaptive transmission technique over copper lines. This raises three interesting facts that are impedance adaptation, speed / distance ratio and transmission quality control. SHDSL was initially designed for Subscriber Lines that have quite standard characteristics worldwide based on 0.4 mm twisted pairs. Many industries have been interested in SHDSL which incited developers to broaden the SHDSL characteristics so it is suitable for any kind of copper gauge while other DSL techniques remained dedicated to the 0.4 mm Subscriber Lines. SHDSL connection starts with a standardized G.HS handshake procedure that determines best connection speed according to the line conditions – mainly its attenuation and level of noise. This results in selecting a higher speed of 15 Mbps on a short line down to 192 kbps on a several km long line. Finally SHDSL enables control of the Signal to Noise Ration to reach performance and quality targets and best serve application requirements. A SHDSL communication is in good conditions when its SNR ratio is higher than 6 dB and it is absolutely perfect above 10 dB.
- The native PAF Aggregation Function of SHDSL provides a high speed and low latency Ethernet stream over several copper pairs to reach 30 Mbps over 2 pairs or 60 Mbps over 4 pairs. This gives many opportunities for industrial networks with flexibility and scalability to higher bandwidth when new applications and requirements arise.



Ethernet and xDSL speed comparison

(0.4 mm cable)

2. Industrial networks

VDSL and SHDSL are well suited to replace old point to point and point to multipoint modems over copper cables. They have native Ethernet support and a number of equipment are aimed at transporting legacy communications over Ethernet such as RS232/RS485 asynchronous communications, digital inputs and outputs, etc.

Industrial networks are facing new challenges not only with technical but also with economical and security requirements that communication infrastructures must provide support for. Networks shall not only transport a single application communication, but many different communications:

- Control and monitoring : usually low bandwidth but latency, availability and security constraints,
- Information and video surveillance : potentially high bandwidth, but lower priority

Several responsibility domains may fall to different services or entities depending on the organization and legal requirements which in turn has several impacts on network security functions and VLAN traffic isolation.

2.1. Intelligent Transport Systems - ITS

Intelligent Transport Systems are facing many challenges especially to optimize traffic flows, to prioritize public transportation (buses, tramway) and emergency vehicles, to improve public safety ant to better respond to urgency situations. It is not only a concern with upgrading legacy Traffic Light Controllers to Ethernet and IP based models, but rather a global approach to develop more efficient city commuting and to support multiple application communications and video surveillance services.

Most cities own a copper cable network that was before connected with multi-drop modems for asynchronous communications of legacy controllers. DSL equipment deliver several Mega-bit capacity on such copper networks and support native Ethernet services for such multimedia and secured Intelligent Transport applications. The Return on Invest is very high in most cases as it leverages on existing copper cables and it avoids heavy investments in fiber deployment and roadwork.

2.2. Smart Grid and Utility Transport - Distribution networks

Oil and gas, water and electric utility networks have some copper cables along transport and distribution lines for telemetry, control and protection communications that are transferred through FSK/PSK modems. A Pilot Cable is made of a multi-pair copper cable with 0.9 mm wire gauge on which SHDSL equipment can deliver Ethernet communication over several km between substations.

Although such environment have potentially high levels of electromagnetic noise and cable connections are subject to strong environmental constraints, many developments have demonstrated that SHDSL is a very robust and performing technology to deliver Mega-bit communications and up to 2 Mbps bandwidth over 9 or 10 km on such cables.

2.3. Smart Cities

The advent of Smart Cities is subject to several innovative concepts that tend to optimize our global commutes, to reduce energy consumption and to protect natural resources, to raise good and people security, to promote easier access to culture and education, to improve health care and emergency response, to maintain living and natural environment, to develop tourism, etc. These concepts require access to broader information that must be accessed globally and securely. Networking equipment shall guaranty perfect performance and Quality of Service, network and data security, application traffic classification and prioritization, scalability and flexibility.

Various copper cable networks are already available in these cities and Ethernet First Mile SHDSL technology provides these smart networks with dozen of Mega-Bit Ethernet bandwidth for very low investment cost and effort. The EFM transmission enables high speed Ethernet communications for WIFI hot-spots, video cameras, traffic controllers, emergency services, voice over IP, smart metering and control stations, etc.

3. Conclusion and Prospective

VDSL and SHDSL Ethernet First Mile solutions enable obvious cost savings on investments in comparison with heavier fiber installation and roadwork. Optical communications are required to reach Gigabit bandwidth or more.

VDSL throughput is close to Gigabit on short distances and below one km.

SHDSL, Ethernet First Mile supports much broader distances over several kilometers and bandwidth up to 15 Mbps per pair. Multi-pair SHDSL equipment produce high speed Ethernet communications from the aggregation of several coper pairs. The Ethernet bandwidth can be increased in adding another copper pair in the aggregation group to scale up the network capacity as new requirements arise.

4. CXR solutions overview

CXR has produced VDSL and SHDSL equipment for more than 15 years. In the early 90's, CXR designed the first SDSL product to deliver Ethernet communication on a copper pair with a 5 Mbps bandwidth. CXR solutions bring very high speed Ethernet communications with up to 8 pair aggregation and 120 Mbps bandwidth.

CXR is the first company to deliver a complete range of Ethernet First Mile SHDSL products dedicated to Mission Critical Networks. CXR developed innovative solutions that raise the levels of performance, quality, resilience and fault immunity that have no equivalent on the market. Products are qualified around the world in many electricity production plants, utility transport and distribution networks, in water, oil and gas infrastructures, in Defense sites, hospitalities, telecom networks, and in many smart cities. They have demonstrated long term performance with industry specific standards such as Modbus, DNP-3, IEC-850, Diazer, NTCIP, etc

CXR offers a global networking and communication equipment portfolio aimed at serving a whole network requirement. CXR also offers products and services for measurement and diagnostics. Our engineering team can contribute to successful project through architecture design, training, installation, expertise and maintenance services.

High Speed Copper Ethernet

Ethernet First Mile

Smart solutions for smart networks

CXR VDSL & SHDSL Ethernet Extender Solutions

	VDP2-2TTX (-POE)	VDD2-H-4TP	CopperLan-Bis	SpeederLanBis-GE	CopperWay-Bis	CopperWay-Bis-2TTX	CopperWay-Bis-HV
							
VDSL / SHDSL	**VDSL2**	**VDSL2**	**SHDSL-Bis**	**SHDSL-Bis**	**SHDSL-Bis**	**SHDSL-Bis**	**SHDSL-Bis**
Type	**Bridge**	**Bridge**	**Bridge**	**Aggregation bridge**	**Drop & Insert Bridge**	**Drop & Insert Bridge**	**Drop & Insert Bridge 20 kV Sub-Station**
Typical Use Cases	**1x DSL pair, 20-100 Mbps, short distance low noise environment, point to point**		**1/2 DSL pairs, long distance, point to point**		**2x 1/2 DSL pairs, 15 - 30 Mbps, ruggedize DIN Bus / Ring Transport / Utility network**		**2x 1 pairs, 15 Mbps 10 kV-50 Hz isolation**
WAN interface	1 copper pair	1 copper pair	2 copper pairs	1- 8 copper pairs 1 to 1 / 1 to 2 / 1 to 4 / 1 to 8	2x optical SFP 2x 2 copper pairs	2 copper pairs	2 copper pairs 1x optical SFP
Ethernet interface	2x 10/100 BaseT POE PSE	4x 10/100 BaseT POE PSE	4x 10/100 BaseT 1x POE PSE	4x 10/100/1000 BaseT 1x SFP 1000FX	4x 10/100 BaseT 1x POE PSE 2x SFP / 100FX	4x 10/100 BaseT 1x POE PSE	4x 10/100 BaseT 1x SFP 100/1000 FX
Other interfaces	Version POE	Version POL	1x RS232	1x USB H/D *(2x RS232)*	4x RS232 / RS485 6+2x Digital in / out	1x RS232 1x USB H/D	1x RS232 1x USB H/D 1+1 Digital in / out
Max WAN throughput	100 Mbps	100 Mbps	30 Mbps	120 Mbps over copper 1,000 Mbps over fiber	22 Mbps over copper 100 Mbps over fiber	2x 15 Mbps	2x 15 Mbps over copper 1,000 Mbps over fiber
WAN Protocol	VDSL2, G.993.2	VDSL2, G.993.2	802,3ah, EFM	802,3ah, EFM	802,3ah, EFM	802,3ah, EFM	802,3ah, EFM
Link Aggregation			802.3ah, PAF	802.3ah, PAF	802.3ah, PAF		
Protocols	802.1D	802.1D	802.3X 802.1D VLAN 802.1q Q-in-Q 802.1ad QoS, 802.1p, DSCP STP	802.3X 802.1D VLAN 802.1q Q-in-Q 802.1ad QoS, 802.1p, DSCP STP, RSTP 802.1X	802.3X 802.1D VLAN 802.1q QoS, 802.1p, DSCP STP, RSTP 802.1X	802.3X 802.1D VLAN 802.1q 802.1ad QoS, 802.1p, DSCP STP, RSTP 802.1X	802.3X 802.1D VLAN 802.1q 802.1ad QoS, 802.1p, DSCP STP, RSTP 802.1X
Management	Dip switch CO / CPE	Dip switch: Profile 30a / 17a	CLI http, https ssh snmp ftp Syslog	CLI http, https ssh snmp ftp Syslog USB memory card	CLI http, https ssh snmp ftp Syslog	CLI http, https ssh snmp ftp Syslog USB memory card	CLI http, https ssh snmp ftp Syslog USB memory card
Power supply	48 Vdc and AC adaptor	48 Vdc and AC adaptor	AC / 5 Vdc adaptor 24/48 Vdc	1x AC or 1 or 2x 48 Vdc	9 - 55 Vdc	12/24 Vdc	24/48 Vdc 12/24 Vdc
Format	Compact	Compact	Compact	Desktop or rackmount	Compact, DIN	Compact, DIN	Compact, DIN
Size - WxDxH mm	95x110x27	152x133x53	170x120x41	287x175x41	260x160x35	155x140x45	280x150x70
Dimensions - WxDxH "			6.7x4.7x1.6"	11.3x6.9x1.6"	10.2x6.3x1.4"		

CXR Anderson Jacobson - Rue de l'Ornette - 28410 Abondant – France
T +33 (0) 237 62 87 90 - @mail contact@cxr.com
www.cxr.com