Use of Optical Fibers Towards Global Village

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Paradigm Shift of People

- Revolution
  - **Agriculture**
    - Green Revolution
      Transformation of agriculture in many developing countries that led to significant increases in agricultural production between 1940 to 1960
  - **Industrial Revolution**
    A major shift of technological, socioeconomic, and cultural conditions in the late 18th century and early 19th century. The economy based on manual labour was replaced by one dominated by industry and the manufacture of machinery.
  - **Communication Revolution?**
What is Communication Revolution?

- Technological breakthroughs have revolutionized communications and the spread of information.

Yesterday

- In 1875, for example, the invention of the telephone breached distance through sound. Between 1910 and 1920, the first AM radio stations began to broadcast sound. By the 1940s television was broadcasting both sound and visuals to a vast public. In 1943, the world’s first electronic computer was created. However, it was only with the invention of the microprocessor in the 1970s that computers became accessible to the public. In the 1990s, the Internet migrated from universities and research institutions to corporate headquarters and homes.
- All the above technological changes related with information storage and transmission.

Today & Tomorrow

- Today we are in year 2007, observe vast information storage with quick access time independent of the distance. Voice communication is becoming a essential commodity for human beings. In future certain operators may opt to provide free telephones for the people with marketing advertisements becoming the sustainable revenue to operate the network
- Due to advances in computation, storage, scientific data generation, and communication, we are getting close to crossing, or are crossing the Peta ($10^{15}$) line in storage size, communication speed and computation rate. Early optica transmission experiments are in the range of 0.01-0.1 Petabits/s, and by the end of this decade, they will cross the Petabits/s line!!
Global Experience

- Saturation of Traditional Markets (e.g. Traditional Voice, TV)
- Explosive Growth of Internet
- Broadband demand – From Dialup to BB Broad Band To The Home (BTTH)
- Growth in Mobile (2G ➔ 3G)
- Rapid developments in Asia
Saturation of Traditional Market

- In Sri Lanka even towards end of Year 2000 there was a serious demand for Traditional Voice Telephone though at that time there were three operators to provide telephones.
  - SLT (Copper Network)
  - SunTel, LankaBell (Radio Network)
- In 1989 Mobile Telephone was introduced to Sri Lanka. Towards end of year 2000 there was a demand for Mobile Telephones though there were four Operators
  - Dialogue, Mobitel, Celltel (Tigo), Hutch
- In 2005 the provision of CDMA licenses to fixed Operators and rapid expansions carried out by the Mobile Operator resulted in relieving the demand upto a certain level.
- With respect to TV & Radio there are many operators in Sri Lanka traditionally using radio access whereas a few operators uses Cable and Satellite TV provision. Most of households having electricity is having access to the TV in Sri Lanka
- What is going to be the NEXT? Evolution of Traditional Market to a data oriented Market
The Internet is the Universal Source of Information. In a matter of very few years, the Internet has consolidated itself as a very powerful platform that has changed the way the life pattern of human beings. It changes the way we do business, and the way we communicate. The Internet, as no other medium, has given an International or, if you prefer, a "Globalized" dimension to the world.
# World Internet Usage and Population Statistics

<table>
<thead>
<tr>
<th>World Regions</th>
<th>Population (2006 Est.)</th>
<th>Population % of World</th>
<th>Internet Usage, Latest Data</th>
<th>% Population (Penetration)</th>
<th>Usage % of World</th>
<th>Usage Growth 2000-2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa</td>
<td>915,210,928</td>
<td>14.1%</td>
<td>23,649,000</td>
<td>2.6%</td>
<td>2.3%</td>
<td>423.9%</td>
</tr>
<tr>
<td>Asia</td>
<td>3,667,774,066</td>
<td>56.4%</td>
<td>364,270,713</td>
<td>9.9%</td>
<td>35.6%</td>
<td>218.7%</td>
</tr>
<tr>
<td>Europe</td>
<td>807,289,020</td>
<td>12.4%</td>
<td>291,600,898</td>
<td>36.1%</td>
<td>28.5%</td>
<td>177.5%</td>
</tr>
<tr>
<td>Middle East</td>
<td>190,084,161</td>
<td>2.9%</td>
<td>18,203,500</td>
<td>9.6%</td>
<td>1.8%</td>
<td>454.2%</td>
</tr>
<tr>
<td>North America</td>
<td>331,473,276</td>
<td>5.1%</td>
<td>227,303,680</td>
<td>68.6%</td>
<td>22.2%</td>
<td>110.3%</td>
</tr>
<tr>
<td>Latin America/Caribbean</td>
<td>553,908,632</td>
<td>8.5%</td>
<td>79,962,809</td>
<td>14.4%</td>
<td>7.8%</td>
<td>342.5%</td>
</tr>
<tr>
<td>Oceania / Australia</td>
<td>33,956,977</td>
<td>0.5%</td>
<td>17,872,707</td>
<td>52.6%</td>
<td>1.7%</td>
<td>134.6%</td>
</tr>
<tr>
<td><strong>WORLD TOTAL</strong></td>
<td>6,499,697,060</td>
<td>100.0%</td>
<td>1,022,863,307</td>
<td>15.7%</td>
<td>100.0%</td>
<td>183.4%</td>
</tr>
</tbody>
</table>

**NOTES:**
1. Internet Usage and World Population Statistics were updated for March 31, 2006.  
2. CLICK on each world region for detailed regional information.  
3. Demographic (Population) numbers are based on data contained in the [world-gazetteer](http://www.world-gazetteer.com) website.  
4. Internet usage information comes from data published by [Nielsen/NetRatings](http://www.nielsen-netratings.com), and the [International Telecommunications Union](http://www.itu.int), by local NICs, and other other reliable sources.  
5. For definitions, disclaimer, and navigation help, see the [Site Surfing Guide](http://www.isc.org).  
6. Information from this site may be cited, giving due credit and establishing an active link back to [www.internetworldstats.com](http://www.internetworldstats.com). ©Copyright 2006, Miniwatts Marketing Group. All rights reserved.
Major Observations of Shift towards Data

- The Trend in Africa, Middle-East and Asia is very much higher than Europe and North America
- Though the trend is more the penetration of Data Usage of these continents are very much lower than Europe and America
- ¾ of the population in the world lives in these continents where ¼ lives in Europe & America
World population, 6.2 billion (2003)

Distribution by region

- **Northern America**: 322.5 million
- **Latin America and the Caribbean**: 535.6 million
- **Europe**: 727 million
- **Asia-Pacific**: 3.8 billion
- **Africa**: 832 million

Importance of Asia, Africa and Middle-East

- Higher Population
- Lower Penetration as at now
- Higher Trend
- Technological Advancement can be easily implemented with low cost
- More Traffic will be generated in uplifting the social standards of the people with comparable returns
Experience of Sri Lanka

- Change in Customer needs
- Change of Government Policies – Open markets
- Change of Domestic Networks
- International Connectivity
- Global Involvements
Trend in Data Traffic in Sri Lanka

International Circuit Activations

Year

No. of E1 Equivalent
Trend in Exponential
Trend in Linear

Present Trend is exponential

Number of E1 Circuits
The Comparison of Traffic Volumes from Data to Voice for Sri Lanka

This diagrams indicate the growth of Data Traffic (exponential) while the Voice Traffic appears to be constant.
Cost shift towards in achieving Paradigm change

• Up to now Main Revenues expected from Voice but not from Data
• Now this has changed to Data
• Earlier Major Cost attributed to Copper Access. This has changed to low cost wireless access
• Earlier Transport Network utilizing Circuit Switching and Radio Networks. This has now shifted to low cost Near Generation switch with optical fiber networks
Government Policies

• As at now Government of Sri Lanka has launched many projects to develop the ICT infrastructure especially in the rural areas of the country.
• SLT as the facilitator for these Government initiatives provides Data Services to the following projects, those are certainly moving in line with the global trend.
• SchoolNet
  – Under SchoolNet project 1140 schools/institutions have to be provided with 64Kbps/256 Kbps data connection and the schools have to be connected to university of Moratuwa via IP-VPN.
• Nenasala
  – Nanasala is a Multi-service Community Information Centers established especially in rural areas. 200 Nanasalas have to be provided with 128 kbps of data connection and have to be connected via IP-VPN.
• LakGove Net
  – Under this project 325 government sites to be provided with guaranteed 128 Kbps/ 1024 Kbps connectivity
In Summary - Paradigm Shift of People

**Yesterday**

- Information from TV, News papers and Books
- High price for voice communications
- Exponential growth of mobile applications

**Today**

- Information from Internet
- Paradigm shift using Skype, MSN etc. with low price of Video calls along with data transfers
- Almost all applications are integrated to a single terminal

Moving towards easy and quick information access (Online or retrieval) to a single terminal where ever you live in the globe.
Disparity Between Haves and Have Not

- Telecommunication has become a basic needs such as Water, Sunlight and Air
- Earlier people were deprived about communication due to lack of finances
- Today this scenario evolving to provide a telephone free of charge, but the operators will earn their returns through advertisements on the telephones
- Today paradigm is shifting from Voice to Data. Present network predominantly catering for voice will evolve to accommodate all unified services such as voice, video and data. Operators will invest for the viable converged network to provide unified service.
- Hence disparity between Haves and Have Not going to be reduced to make this world as a Global Village similar to water, sunlight and air
In Summary - Today’s Need

Any TIME Connection
- Night
- Daytime
- On the Move
- Indoors & Outdoors

Any PLACE Connection
- Indoors
- Outdoors
- On the Move

Any THING Connection
- PC to PC
- Human to Human (H2H)
- Human to Thing (H2T)
- Thing to Thing (T2T)

Supportive Stuff: ITU Internet Reports 2005
Basic demarcation of Transport Network

- Local Exchange
- Domestic Transport Network
- International Gateway
- International Transport Network
- Other country Domestic Transport Network
- Access Network
- Geographical Location of the customer
Accommodation of Paradigm Shift In the Telecom Network

CGN – Current Generation Networks
Near GN – Near Generation Networks
NGN – Next Generation Networks

Convergence of all the services

Source: ITU Workshop on Tomorrow’s Networks Today 2005
Technological development of Access Networks

- Wired Line:
  - Twist Pair
  - Coaxial
  - Fiber

- Wireless:
  - GSM
  - CDMA
  - Wi-Fi
  - WiMAX

- Fiber Access

- Copper Access

- Wireless Access

BW: Bandwidth

Time
Technological development of Transport Networks

Source: Presentation of ALCATEL
Summarizing the Evolution in Stages

- Presently Various Services will reach Customers with various Access and terminal networks
- In the Near Future, Fixed Mobile Convergence with BB convergence can be experienced (Near GN) resulting the provisioning of services guaranteeing the end to end quality with ensuring required security
- The Real Next GN (NGN) networks will converged all the services and can be received by the Customer through one Access Network with One Unified Terminal at Home
- Network construction cost will be reduced with the use of general purpose routers, which are much more cost effective than conventional switching systems having been developed exclusively for telecommunications
Accommodation of Paradigm Shift In the Telecom Network Elements…

• Presently Services such as Telephone, Internet, TV are having separate access networks to the Home. This paradigm will be shifted to a unified equipment to provide all the services through one access network to be delivered to home.
• Hence Integration of all services through access network will be a global experience in time to come.
• Technological development of Access Networks
  – Copper ➔ wireless (3G, CDMA, Wi-Fi, Wi-MAX)
  – Copper➔ FTTH➔ IPTV – for provisioning of high bandwidth
• Technological development of Transport Networks
  – PDH➔ SDH,
  – Reliability – Self healing Rings, ASON (Automatically Switched Optical networks), OTN (Optical Transport Network)
• Technological developments in inter-oceanic networks
  – Coaxial ➔ Fiber
  – Repeaters➔ Optically Repeated Systems➔ Repeater-less Systems
  – Single Channel➔ Multi-Channel (DWDM)
  – 2.5Gbps➔ 10Gbps➔ 40Gbps
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Accommodating Global Experiences in Sri Lanka by SLT

Global Connectivity
- Invest in SEA-ME-WE 4 & SEA-ME-WE 3 Cable Systems
- Invest in BL Cable System
- Invest in DL Cable System

Inland Transport Networks
- Optical Rings island wide

Access Networks
- CDMA rollout
  - Introduction of EvDO
- Launching WiMAX (Yet to arrive)
- VoIP

Data Services
- IP Backbone Network
- Establishment of data wear houses – SLT iDC
SEA-ME-WE 3 Cable System
### SEA-ME-WE 3 Optical Fiber Cable System

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total length of the system</td>
<td>39,000km</td>
</tr>
<tr>
<td>Bit Rate of a channel ((\lambda))</td>
<td>10 Gbps</td>
</tr>
<tr>
<td>Number of possible channels (Optical Colors, (\lambda)) per fiber pair</td>
<td>8</td>
</tr>
<tr>
<td>Number of Fiber pairs</td>
<td>2</td>
</tr>
<tr>
<td>Total Capacity</td>
<td>10 x 8 x 2 Gbps</td>
</tr>
<tr>
<td></td>
<td>= 160 Gbps</td>
</tr>
<tr>
<td>Possible telephone channels</td>
<td>160,000,000/64</td>
</tr>
<tr>
<td></td>
<td>= 2,500,000!</td>
</tr>
</tbody>
</table>
SEA-ME-WE 4 Optical Fiber Cable System

Total length of the system = 20,000km

Bit Rate of a channel (λ) = 10Gbps

Number of possible channels (Optical Colors, λ) per fiber pair = 64

Number of Fiber pairs = 2
  Omnibus Fiber – between Branch Cable Stations
  Express Fiber – Between Full Fiber Cable Stations

Total Capacity = 10 x 64 x 2 Gbps
= 1,280 Gbps
= 1.28 Tbps

Possible telephone channels = 1,280,000,000/64
= 20,000,000!
Bharat Lanka (BL) & Diraagu
Lanka DL Cables

BL Cable

DL Cable
BL & DL Cables

• BL
  – Two Parties, 230 km, 6 fiber pairs, 20 Gbps (2 Fiber pairs), Repeater less DWDM System

• DL
  – Two Parties, 700 km, 8 fiber pairs, Repeated (7 Repeaters) DWDM System
Global Connectivity of Optical Fiber in Sri Lanka

Four Optical Fiber Cable Systems

- SEA-ME-WE 4
- SEA-ME-WE 3
- BL Cable
- DL Cable
Fiber Optic Super Highway Network Connecting Any Province of Sri Lanka

Existing Fiber Network

Proposed Fiber Network

Shifts from Microwave to Optical
CDMA Network (SLT CityLink)

Present CDMA Coverage with 201 BTSs.
SLT IP/MPLS Backbone Network

- **IP/MPLS Provider**
  - Edge Network (PE) #4
    - PE Ring (STM1)
  - Edge Network (PE) #1
    - PE Rings + Linear Links (STM1)
  - Edge Network (PE) #2
    - PE Ring (STM1)
  - Edge Network (PE) #3
    - PE Ring (STM1)

- **IP/MPLS Provider Network (P)**
  - 2*P Rings (GBE & STM4)
SLT IP/MPLS Backbone Network

• The network has the coverage in following main cities that covers most of the important areas
  - Edge network #1
    • Colombo Central, Ratnapura, Awissawella, Nuwara Eliya, Badulla, Kalutara, Galle, Matara, Hambantota, Kandy, Chilaw, Negombo, Gampaha, Kurunegala, Anuradhapura
  - Edge network #2
    • Havelock Town, Ratmalana, Kotte, Nugegoda
  - Edge network #3
    • Maradana, Liberty Plaza, Slave Island, Welikada, Angoda
  - Edge network #4
    • Wattala, Katunayake, Kelaniya
SLT iDC

• Sri Lanka Telecom Internet Data Center provides advanced Web and Mail hosting services.
• Data Center has two 1GB connection to Internet for providing faster connectivity and redundancy.
• The Data Centre is housed in a structure which provides completely weatherproof, dust prevention features and its doors are 2 hours fire rated.
• Data center is also equipped with a Facility Environment Control System and a Building Management System.
Current Transport Projects

Total Length is 174.4 km

Metro Super High Way – STM-64 (10G)
Immediate Achievement

- The Shift has resulted low cost Near Unified services to the customers even within a country or globally.
- Face of achieving the shift is gradual with a careful transformation of old equipment to the latest new equipment.
- Next three years will be experienced to reach the network with Near GN switches, Optical fiber transmission for transport networks while ADSL, EvDO or FTTH will carry the unified services to the customers.
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Use of Optical Fiber

- A long history of Optical Communication Systems
  - Ancient man signaled with smoke and fire, often relaying messages from mountain top to mountain top.
  - Since the end of the eighteenth century messages have been passed by semaphore – the use of flags to indicate the transmission of one letter at a time.
  - Another historical use of optical communication involved the heliograph -- a device to reflect the sun's rays from a transmitting to receiving station using a code.
To find a reliable, inexpensive, and that could be used over long distances, preferably at high rates of data transmission. The fundamental physical phenomenon that makes this possible is called *total internal reflection*. This phenomenon causes light to *reflect*, rather than *refract*, when it attempts to cross the boundary from one transparent optical medium to another of lower optical density, at a sufficiently large angle. As early as 1854, in London, John Tyndall demonstrated that light could be guided inside a transparent medium with such a density discontinuity with its surroundings. He did this by showing light being guided along a stream of water flowing from a container. His simple demonstration proves that in the right circumstances *light need not travel in straight lines*. 
Optical fibers use total internal reflection to keep a light ray trapped within the denser glass of the center of a composite cylindrical glass fiber, the core. It is as if light rays are guided down the core of the fiber in a zigzag path by a succession of total internal reflections at the boundary between the core glass and the less dense glass surrounding it – the cladding, as shown in Figure.
Why Optical Fibers so good for Communications?

• The information-carrying capacity of an optical fiber is far greater than to its competitors: wires, coaxial cables, Satellite and microwave links.
• In addition, optical fibers are inexpensive to produce.
• Do not conduct electricity (which makes them immune to disturbance by lightning storms, and other electromagnetic signals – except nuclear radiation).
• Do not corrode, and are of small size.
Next Generation Fiber

• Target bit rate x distance (20 Pbs x km)
  – Short Fat 20 Tbs x 1000 km
  – Long Thin 7 Tbs x 3000 km or longer
• Bit rates
  – 40 Gbs, 80 Gbs, 160 Gbs, 320 Gbs
• 160 to 240 Wavelengths
• Current bit rate x distance (5 Pbs x km)
Emerging Optical Amplifier Operations Window

- 4-6 more WDM capacity than current technology
- Supports 40Gbps+ and new fiber types
- All band Amplifier (1285nm – 1625nm)
DWDM
Dense Wavelength Division Multiplexing

Transmitting multiple data channels on different wavelengths (colors) of light within the same fiber.

Suitable Transmission Window of spectrum for long distance communication: 1500-1600nm
How to increase capacity of a trunk?

1. Increase number of paths (many physical paths in a same cable structure. E.g 32, 48 cores per fiber cable)
2. Increase Bit Rate over a path (2.5Gbps to 10Gbps/40Gps)
3. Traditional TDMA
4. Increase number of channels (wavelengths or colors) in a same physical path (WDM)

Today there are systems with 128 and 160 wavelengths are in operation. Limits for this technology are unpredictable!
## Analog vs. Digital Transmission

<table>
<thead>
<tr>
<th>Analog Transmission</th>
<th>Digital Transmission (As at today or immediate future)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BW of Traditional Voice Channel = 4kHz</td>
<td>BW of Traditional Voice Channel = 64kbps</td>
</tr>
<tr>
<td>Multiple Access Method: FDMA</td>
<td>Multiple Access Method: TDMA</td>
</tr>
<tr>
<td>Maximum Possible = 540MHz</td>
<td>Maximum Possible speed/wavelength = 40Gbps (STM-256)</td>
</tr>
<tr>
<td>BW through Copper</td>
<td>No. of wavelength deployed in a fiber = 128</td>
</tr>
<tr>
<td>Maximum Capacity = 540,000/4 = 135,000</td>
<td>Bit rate through Fiber = 40x128 = 5120Gbps</td>
</tr>
<tr>
<td>Ex: SEA-ME-WE 1 Cable System (Currently decommissioned)</td>
<td>Maximum Capacity = 5,120,000,000/64 = 80,000,000 (80 million telephone channels!)</td>
</tr>
</tbody>
</table>
WDM Carrying multiple clients

Coloured Emitters

Multiplexer (Combine)

Demultiplexer (Split)

Receivers

These detect the incoming electrical signal and transmit at the correct optical colour

These recover the signal for onward transmission
What makes a submarine Cable Network?

For more information on submarine cable laying please visit http://www.christiealwis.com/Knowledge%20Sharing/Submarine.pdf
Repeated Network Functional Overview

SLTE: Submarine Line Terminal Equipment
PFE: Power Feeding Equipment
Regenerated systems…

▲ Previous systems

- Regenerated systems (3R):

▲ Current systems

- Optically amplified systems (1R):

Line optical amplifiers only compensate for signal loss in the optical fibre generic repeater design, simpler and more reliable enhanced system capacity and network connectivity (WDM...).
Works in progress for the Ocean Ground Bed (Earth System)

October 2005, Sri Lanka
SEA-ME-WE 2 Cable in the sea bed....

Just before Tsunami, 26th December
2005, Galle Face, Colombo, Sri Lanka
Surveying Ship Bodo Mariner…

26th December 2005, Sri Lankan Waters
Cable Ship Tyco Durable in Sri Lankan Waters...
Cable Laying in Progress at Colombo...
DL Cable Landing Moment in Sri Lanka…
January 2006
Landing continues in Galle Face Beach…
Detailed Summary of Submarine Cable Systems in Sri Lanka

Source: www.underseacable.net
Conclusion

- SLT has pioneered in providing optical fiber connectivity globally as well as domestic network
- Sri Lanka too experience the global trend of transition from voice to data
- The domestic network of Sri Lanka is evolving to provide high bandwidth to the customers
- The high bandwidth needed for Sri Lankans will be made available to satisfy the modern trend
- Sri Lanka will experience the convergence of the services in time to come
- If carefully handled Sri Lanka can be facilitator for converged services to our giant neighboring countries like India. This may be a similar situation to Hong Kong compared to China.
- The BB Network available in Sri Lanka can be made useful to extend the BPO operations similar to garment factories concept of free trade zone and many middle level jobs can be created
- Most promising infrastructure development needed to provide the latest bandwidth requirement is only by Optical Fibers
- Sri Lanka is moving toward Global village with the heavy use of optical fibers
Questions?
Thank you

You can view this presentation at
www.christiealwis.com
(http://www.christiealwis.com/Papers/IET%20Presenta.pdf)