Challenges for Broadband Deployment in India

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Outline

- Broadband deployment scenario in India
- Next Generation Access Technologies
- Optimal Access Architecture

Challenges to bridge Digital (Information !) Divide

- **Affordability**
  - Access devices.
  - Connectivity.
- **Human Capital (Digital skills and capacity)**
  - General cognitive sense and skills necessary to make sense of online information.
  - Basic reading and writing skills required
    - Most web information available only in text form.
    - Need audio/video interface.
  - Access Interface
    - Needs to be more intuitive, simple.
- **Language Skills**
  - Need for multi-lingual information access

Affordability

- In US, service provider can earn revenues to the extent of US$ 360 per year per household for 90% household.
- In India, 90% households may not afford more than US$ 100.
- In India, minimum data rate of 256 Kbps is considered as broadband.

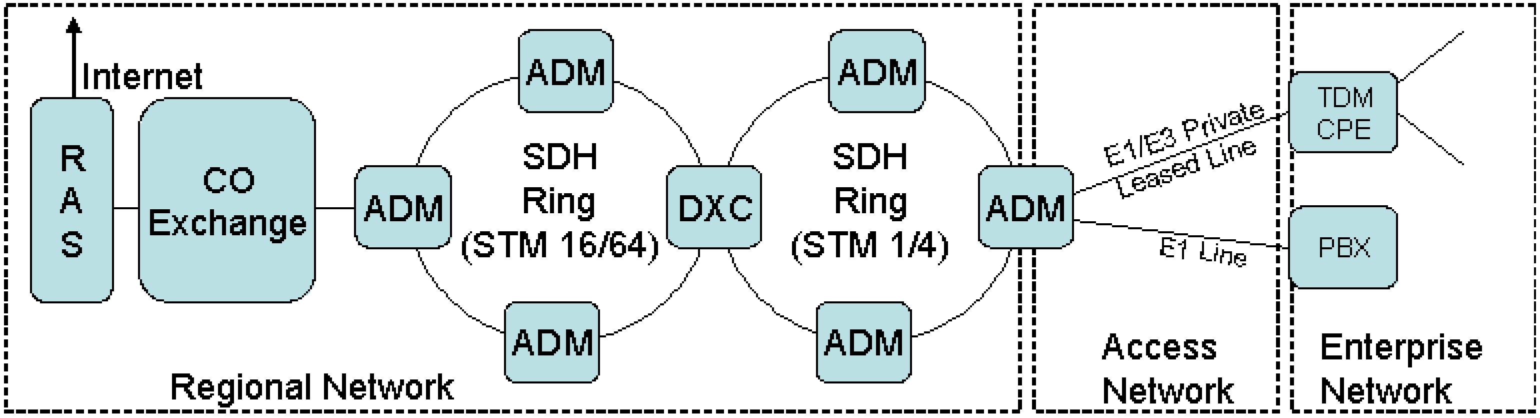
Broadband Scenario in India and other Asian countries

- **Number of Household**
  - Korea- 14.3 M
  - China-333M
  - India-192 M
- **Broadband Connections (Year 2005 end)**
  - Korea- 11M
  - China- 64.3 M
  - India- 0.9 M
- **Indian Target**
  - 9M (2006)
  - 30M (2007)
  - 50 M (2010)

Problems for Service Providers

- **Challenges**
  - Poor Infrastructure
  - Diverse demographics
  - High Capital costs
- **Technologies in use**
  - TDM Model
  - DSLAM Model
  - Cable TV and Local Service Provider Model

Enterprise TDM Model



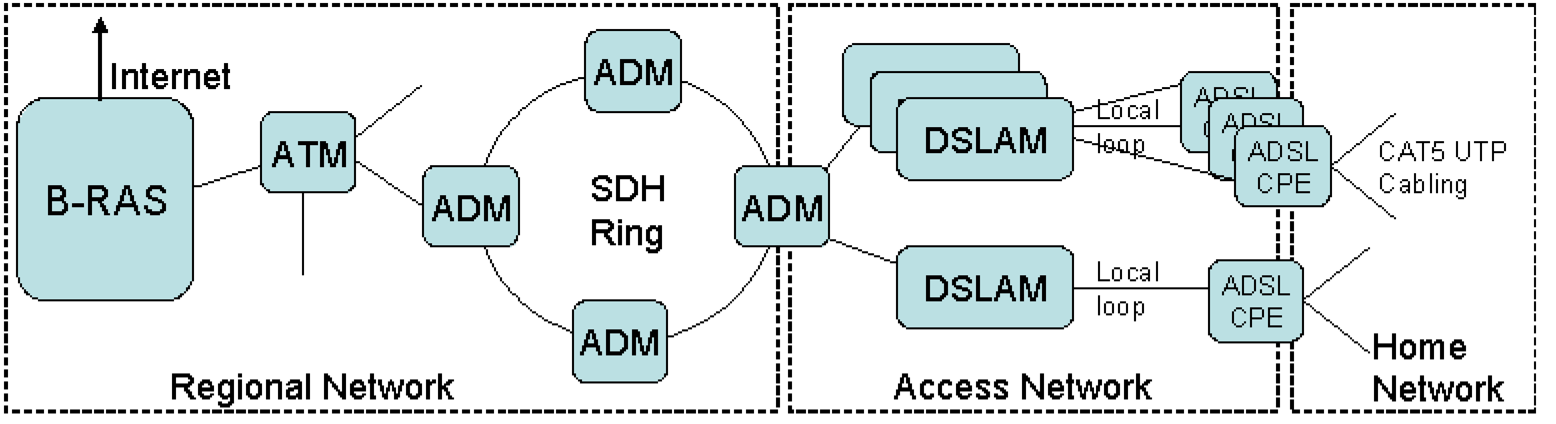
RAS: Remote Access Server
CO: Central Office
ADM: Add-Drop Multiplexer
SDH: Synchronous Digital Hierarchy
DXC: Digital Cross Connect

TDM: Time Domain Multiplexing
CPE: Customer Premises Equipment
PBX: Private Branch Exchange
STM: Synchronous Transport Mode

Issues

- **Advantages**
  - Offers Guaranteed Quality of Service
  - Fast protection and restoration
  - Reliability
- **Bottlenecks**
  - No flexibility to scale with the needs of the customer
  - High cost of installation and slow provisioning
  - Bandwidth does not grow linearly with customer demands
  - Low bandwidth

DSLAM Model



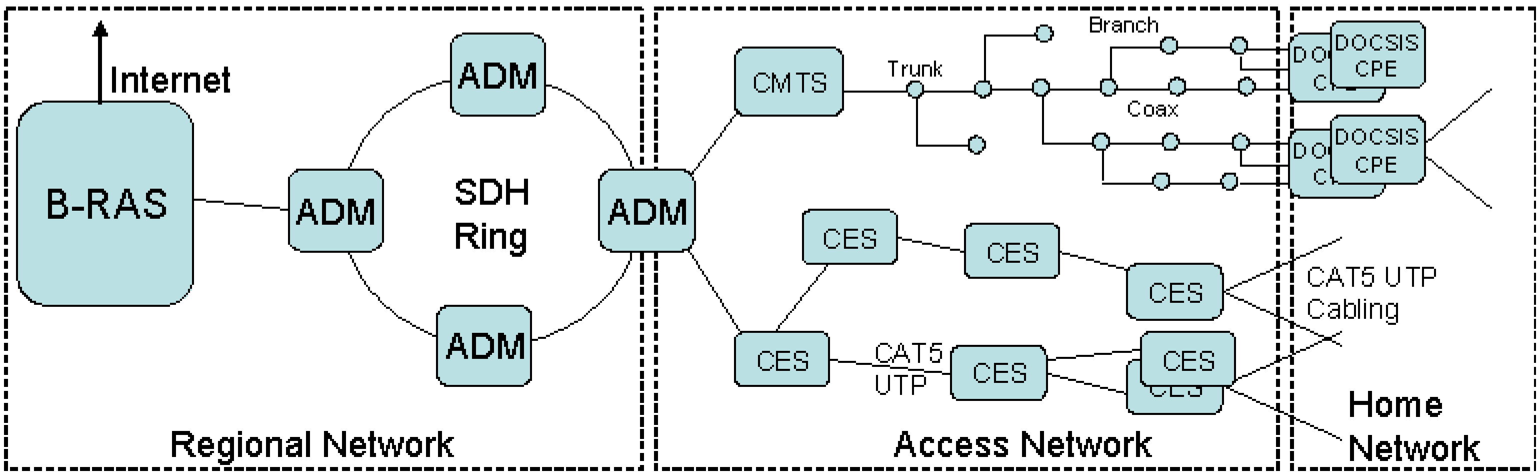
ATM: Asynchronous Transfer Mode
ADM: Add-Drop Multiplexer
SDH: Synchronous Digital Hierarchy
B-RAS: Broadband Remote Access Server

ADSL: Asymmetric Digital Subscriber Line
CPE: Customer Premises Equipment
DSLAM: DSL Access Multiplexer
CAT5 UTP: Category 5 Unshielded Twisted Pair

Bottlenecks

- Of 40 Million copper lines owned by state-owned Telco in India, only about 7 millions are technically fit for carrying DSL signals.
- Local loop unbundling has hardly happened.
- High cost of network elements in SDH and ATM backhaul network.

Cable TV and Local Service Provider Model



ADM: Add-Drop Multiplexer
SDH: Synchronous Digital Hierarchy
B-RAS: Broadband Remote Access Server

CMTS: Cable Modem Termination System
DOCSIS: Data Over Cable Service Interface Specification
CPE: Customer Premises Equipment
Coax: Television grade Coaxial Cable
CES: Consumer grade Ethernet Switch
CAT5 UTP: Category 5 Unshielded Twisted Pair

Bottlenecks

- Deployment and maintenance operationally challenging
- Cable infrastructure in most cities does not have bi-directional support
- In local service provider model, enterprise grade switch is used
  - No security or user isolation.
  - No proactive network management
  - No traffic policing or rate shaping
  - No Quality of Service Guarantees
  - No built-in-redundancy

Next Generation Access Technologies

- Next Generation SDH
- Optical Ethernet or Ethernet over Fiber

Comments on Next Gen SDH

- Very popular in those carriers who already have installed base of SDH rings.
- Good choice of deployment when the predominant traffic is circuit switched.
- May be inefficient if the predominant traffic is bursty packet switched data.
  - Ethernet over Fiber and Copper is the solution.

Ethernet in Access

- **Reduces the cost of per user provisioning**
  - Relative technical simplicity
  - Due to large installed base
- **Efficient and Flexible transport**
  - Can offer a wide range of speeds from 128 Kbps to 10 Gbps.
- **Ease of Interworking**
  - Plug and play feature
- **Ubiquitous adoption**
  - Ethernet is the dominant technology of choice in enterprise and campus LAN

Ethernet Deployment in Access

- **Hub and Spoke Configuration**
  - Dedicated fiber/wavelength/copper is used for connectivity.
- **Gigabit Ethernet Ring**
- **Fully meshed architecture**

But what are the limitations with native mode Ethernet ?

- **How to identify different customers?**
  - Notion of Ethernet virtual circuit like ATM VC that connects two or more UNI.
- **How to enforce QoS?**
  - Guaranteed SLA and QoS Attributes
    - Committed Information Rate (CIR)
    - Committed Burst Size (CBS)
    - Peak Information Rate (PIR)
    - Maximum Burst Size (MBS)
- **Protection Mechanism**
- **In-service performance monitoring**
- **How to scale the number of customers?**

Ethernet as Transport Mechanism in native mode

- **VLAN Tagging**
  - Point to point VLAN can be used to establish virtual circuit
- **VLAN Stacking**
  - An already tagged frame can be tagged again to create a hierarchy.
  - 802.1Q in 802.1Q (Q-in-Q)
- **Protection and Restoration**
  - Spanning Tree and Rapid Spanning Tree protocol (IEEE 802.1s)
- **QoS**
  - Using 802.1p priority mechanism
- **OAM**
  - IEEE 802.1ag

Challenges with an All Ethernet Access

- **Scalability**
  - Limited VLAN tag space allows only 4096 VC to be set up
- **Traffic Engineering bottlenecks**
  - Spanning Tree allows only one loop free path which can result in uneven load distribution
- **Service Provisioning**
  - VLAN assignment and provisioning
- **Limited protection and restoration available only through rapid spanning tree**
  - 50 ms resiliency not possible.
- **TDM voice over Ethernet**

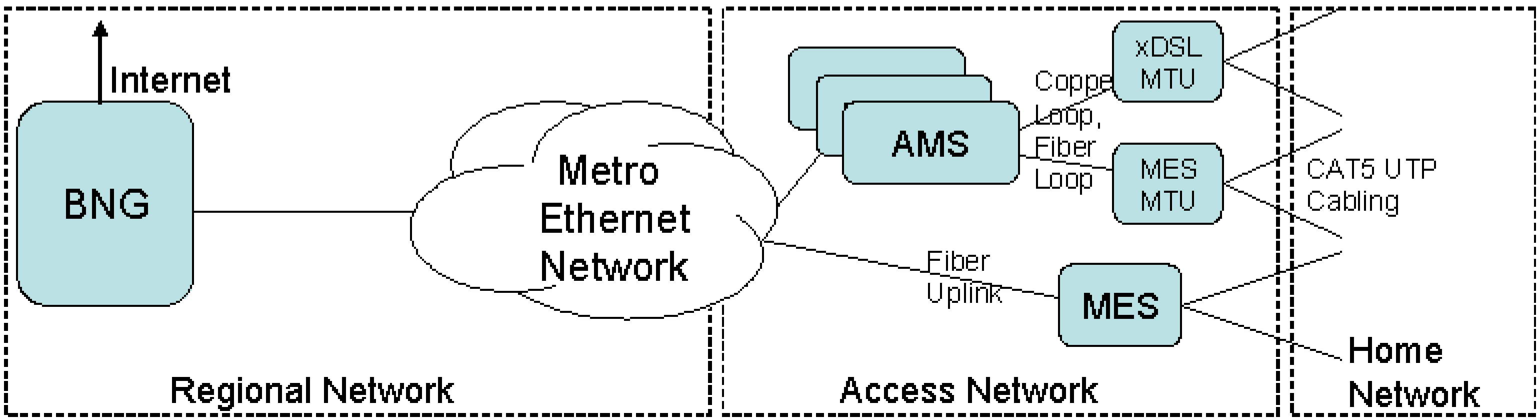
MPLS bridges the gap

- MPLS can address the limitations of VLAN space, scaling with spanning tree, carrying VLAN information within network.
- Hybrid L2 Ethernet in access and IP/MPLS based core network is proposed for deploying Ethernet services.

MPLS as the transport mechanism in Core

- Scalability in terms of aggregation
- End to End QoS
  - Guaranteed Bandwidth LSP
- Offers circuit setup and traffic engineering capabilities
- Protection and Restoration
  - MPLS-TE (Backup LSP/LSP Preemption, Fast Reroute Option)
- Support of TDM voice
  - Circuit emulation

Towards An Optimal Access Architecture



BNG: Broadband Network Gateway

xDSL: Any Digital Subscriber Line
AMS: Access Multiplexer/Switch
CPE: Customer Premises Equipment
MES: Metro Ethernet Switch
MTU: Multi-Tenant Unit
CAT5 UTP: Category 5 Unshielded Twisted Pair

Optimal Access architectures

- **MES architecture**
  - MES with carrier class features and fiber uplink.
  - Suffers from low port-fill rate leading to higher cost per port.
  - While fiber to every building is ultimate goal, deployment scenarios in the field are very complex.
- **MTU architecture**
  - Multi-tenant unit
    - First level of aggregation.
    - 4-8 port for optimal utilization.
    - Uplink- Fiber or VDSL
  - Access Multiplexer-Switch
    - Second level of aggregation.
    - Flexible Physical interfaces (VDSL, Ethernet over CAT5, Ethernet over Fiber)

Cost Comparisons

Parameter	DSLAM	LSP	MES	DSL MTU	MES MTU
Port Density	384	512	24	384	384
DSLAM Port	$20	-	-	-	-
CPE	$16	-	-	-	-
MTU Port	-	-	-	$20	$20
CES Port	-	$2	-	-	-
MES Port	-	-	$20	-	-
AMS Port	-	-	-	$8	$12
Copper Loop	$40	-	-	$5	-
Fiber Loop	-	-	-	-	$8
CAT5 cabling	$2	$40	$30	$20	$20
Fiber Uplink	$2	$2	$10	$2	$2
Total per port	**$80**	**$44**	**$60**	**$55**	**$62**

Comparisons

- **LSP Model**
  - Least expensive
  - Residential subscribers tend to overlook problems in favor of cost factor.
- **MES Model**
  - Low-port fill rate leading to higher cost per port.
  - Low device port density results in higher cost for upstream devices.
- **MES/MTU Model**
  - Suits best for providing affordable access in countries like India.

Technology Development

- Eisodus Networks company incubated at IIT Bombay has developed solution based on MES-MTU architecture.
- www.eisodus.com

Conclusions

- **Cost competitive access infrastructure key to bridge information divide.**
- **Discussed various technology options.**
- **Ethernet over Fiber with VDSL in last few hundred meters based MES-MTU architecture seems promising.**
- **We also need**
  - Affordable computing platforms
  - Rich information environment
    - Content, language, interface, information retrieval