# LMDS

## Wireless Broadband Communications

# Outline

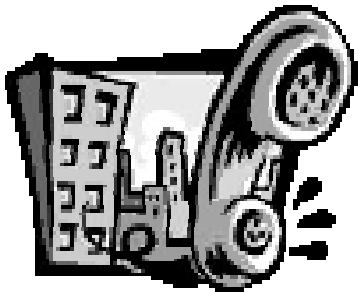- Class Schedule
- LMDS Specification
- Hughes Example

# Class Schedule

- 5.11 LMDS
- 5.18 Third Generation
- 5.25 (Preparation for your Midterm)
- 6.01 (Midterm)
- 6.08 IP Multi-Layer Switching
- 6.15 IP Multi-Layer Switching
  - 4 Page Final Report for Broadband Service
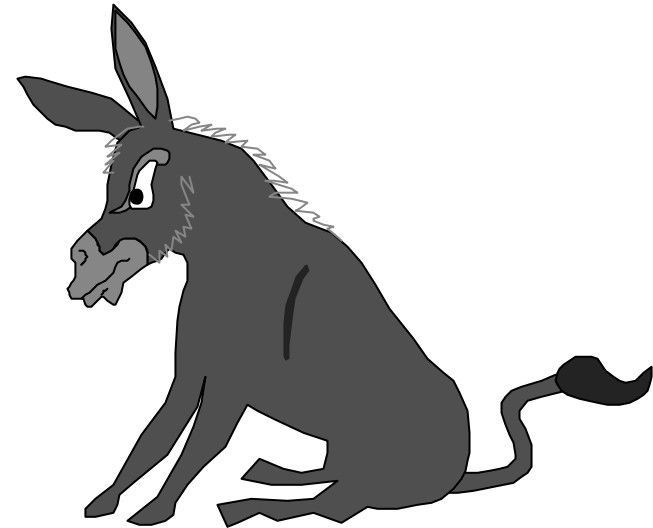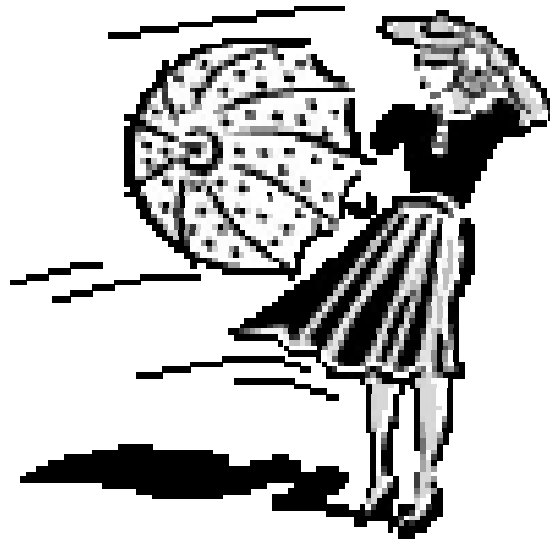
# Dark Horse of the broadband

Cable Modem

Wireless

ADSL

# LMDS could provide upstream

- LMDS could provide upstream bandwidth
- usually relies on telephone line return
- LMDS could provide QoS
  - Provide Point to Point Connection
  - Provide Point to Multi-Point Connections

# Wireless World is Coming?

# Wireless Broadband Communications

- Fixed Access Networks
  - Deployment Costs and Time
- Mobile Cellular Access
  - Mobile Users (Vehicular)
- Local Area Networks
  - Deployments
  - Tetherless

# DVB and DAVIC

- Digital TV Applications
  - Standard for digital Broadcasting over
    - 1994 release (DVB, Digital Video Broadcasting)
      - Satellite
      - Cable Networks
    - Radio
      - below 10 GHz microwave -(MMDS)
      - above 20 GHz LMDS millimeter-wave Radio
    - Digital AudioVisual Council
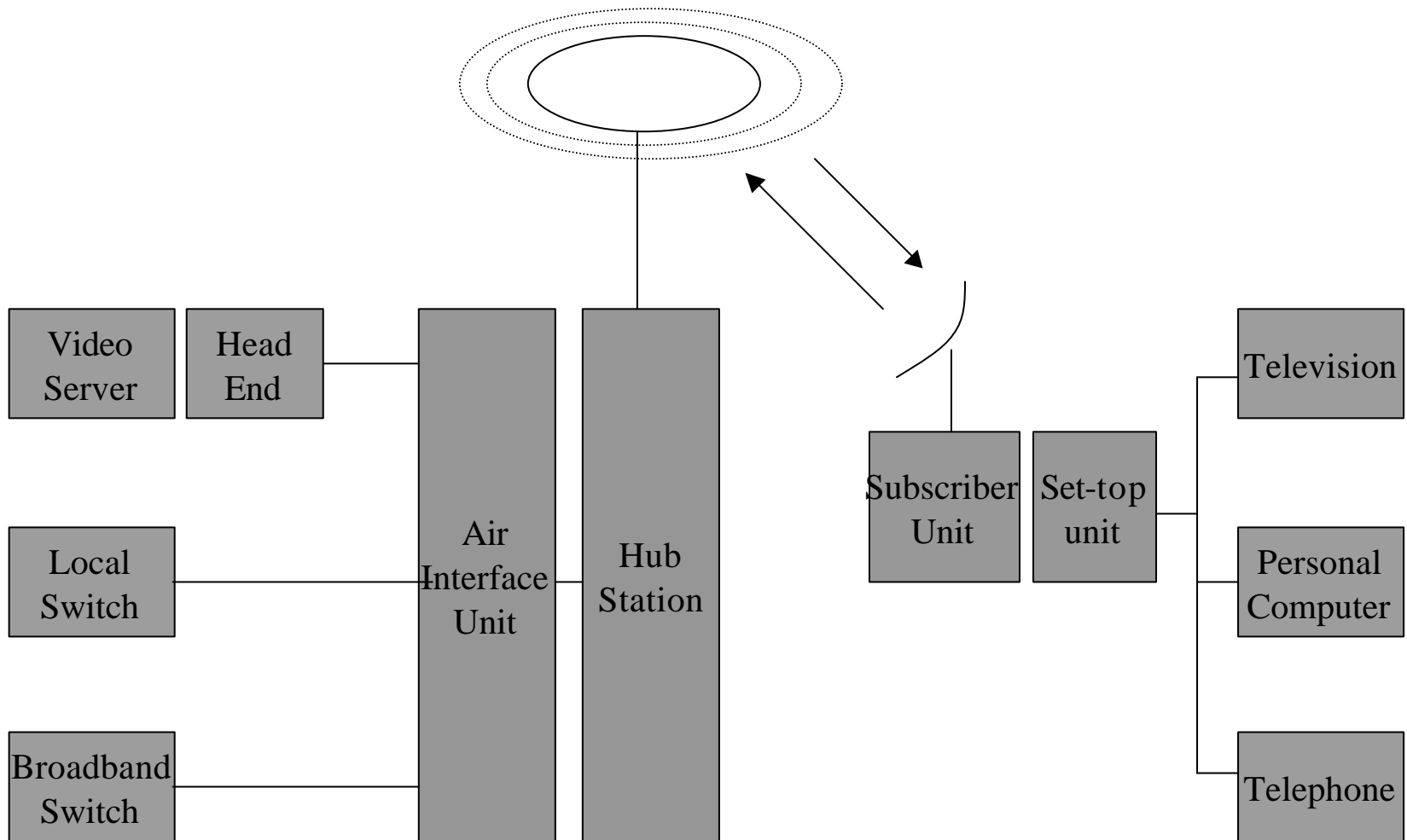      - interactive Service as well

# Providing More Services

- DVB/DAVIC Packet Format
  - e.g. 7 ATM cells onto 2 MPEG2
- Supply Broadband Service
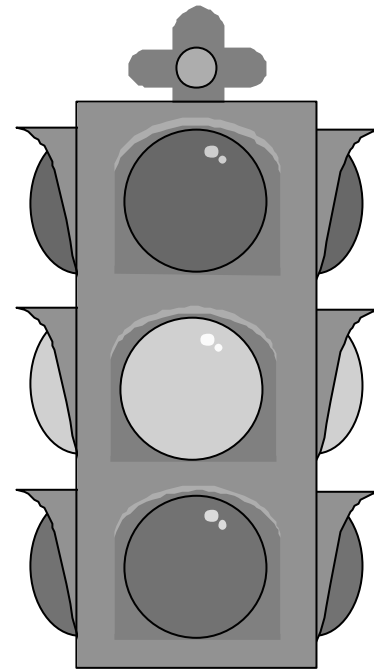  - Data
  - Telephony
- Quick Deployment

# LMDS system functional blocks

# LMDS Applications

- Local Multi-point Distribution Systems
  - TV Broadcasting
  - Telephone
  - Data Network
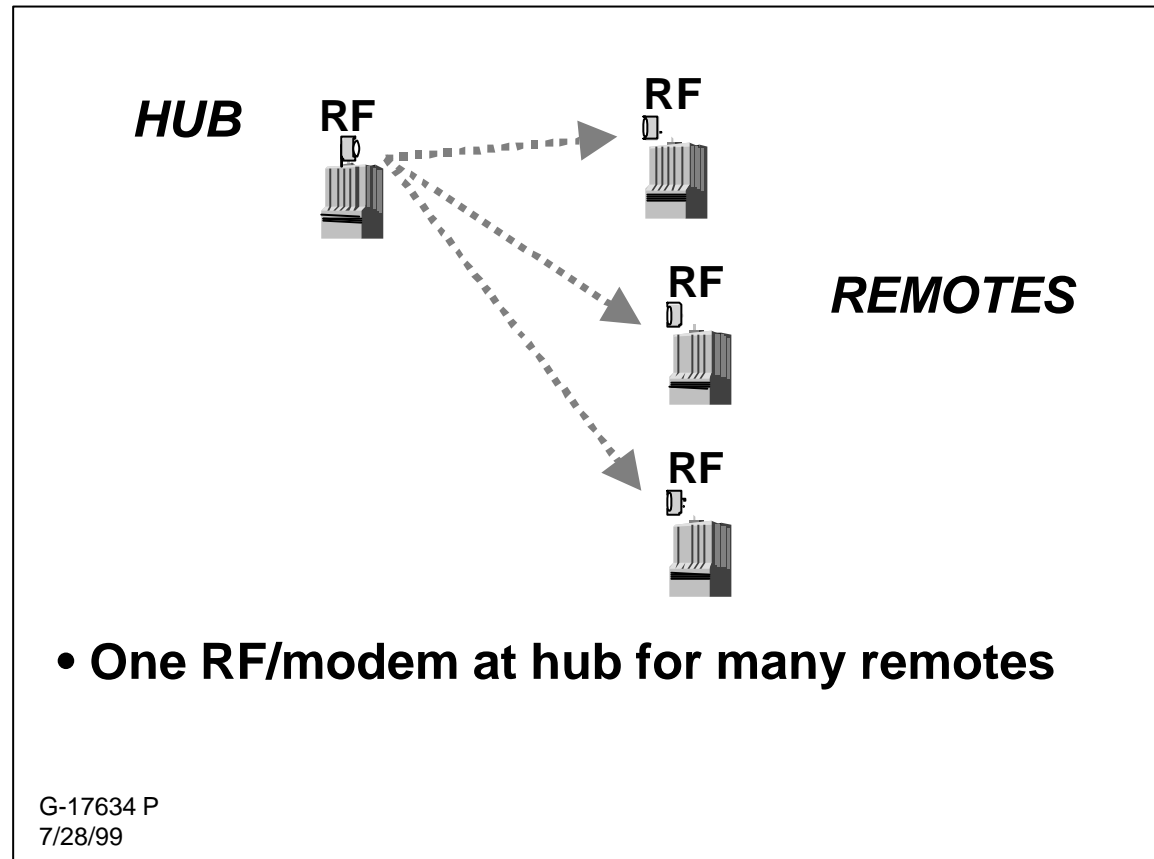
# LMDS Characteristics

- above 20 GHz (20-40 GHz)
- Based on Cellular architecture
- fixed links between a multidirectional hub and a number of of fixed subcribers
- line-of-sight
  - unobstructed path
- 2-6 km diameter
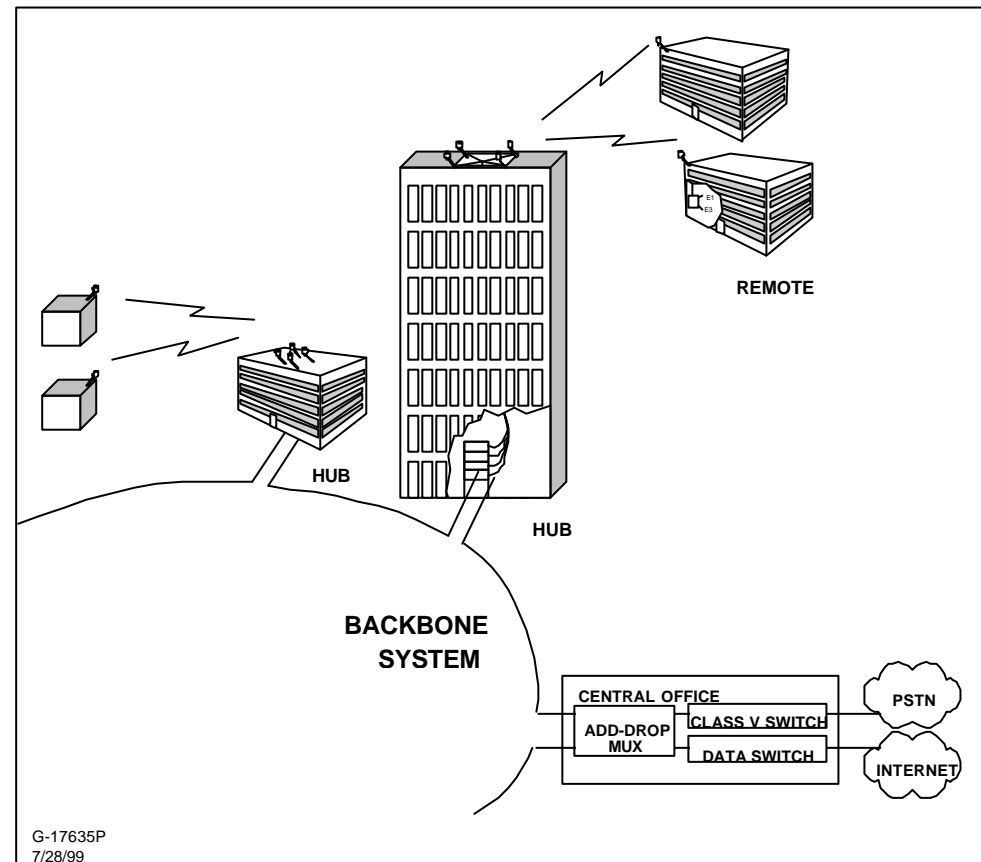
# Channel Modeling
# (Physical Layer)

- Propagation Measurements and Modeling

- Path Loss Characteristics

- Delay Characteristics

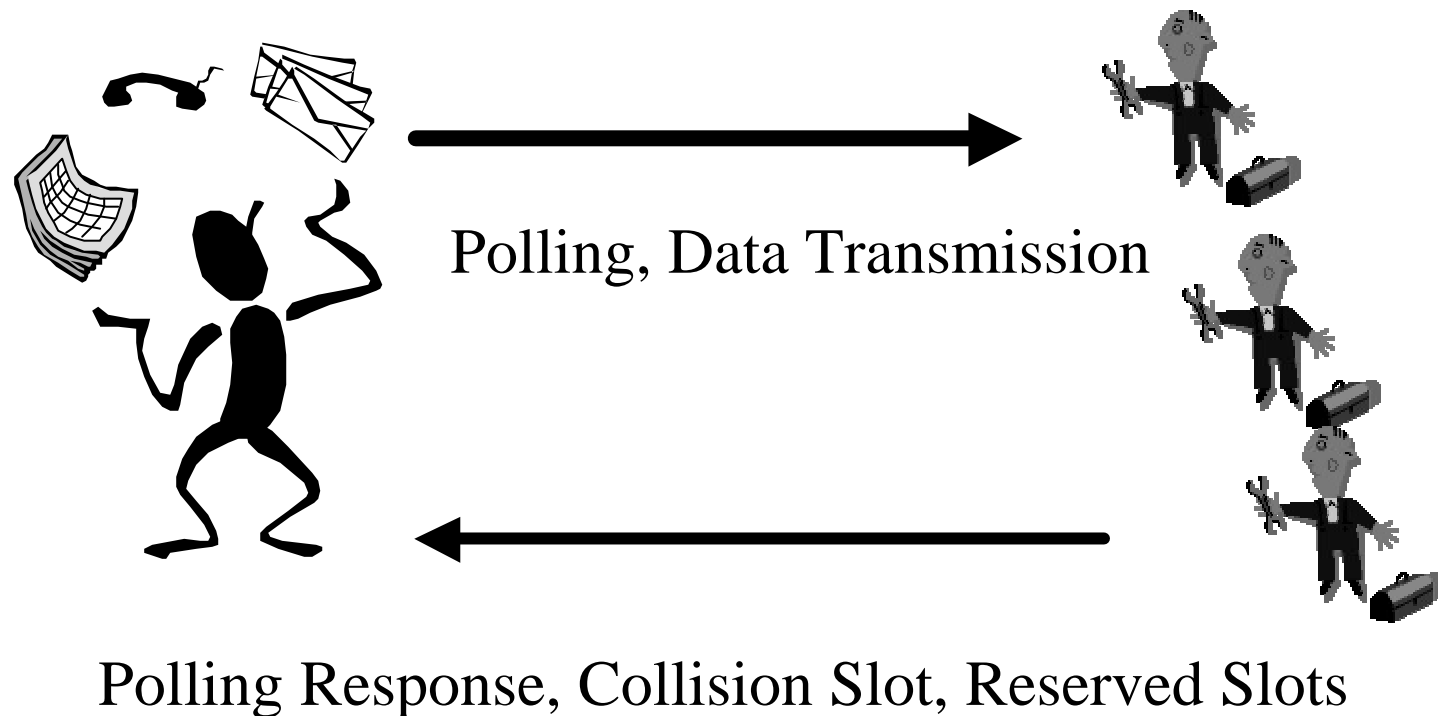- Channel Coding

# Point to Multiple Point System



HUB    RF          RF

RF    REMOTES

RF

- **One RF/modem at hub for many remotes**

G-17634 P
7/28/99

# Combined Multiple Network System with LMDS System



REMOTE

HUB

HUB

BACKBONE
SYSTEM

CENTRAL OFFICE

ADD-DROP
MUX

CLASS V SWITCH

DATA SWITCH

PSTN

INTERNET

G-17635P
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# MAC Protocol (ATM Solution)

- Time Slots (For each ATM Cell)
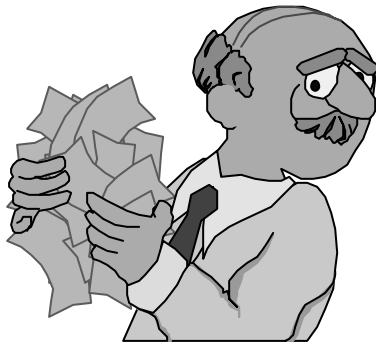
Polling, Data Transmission

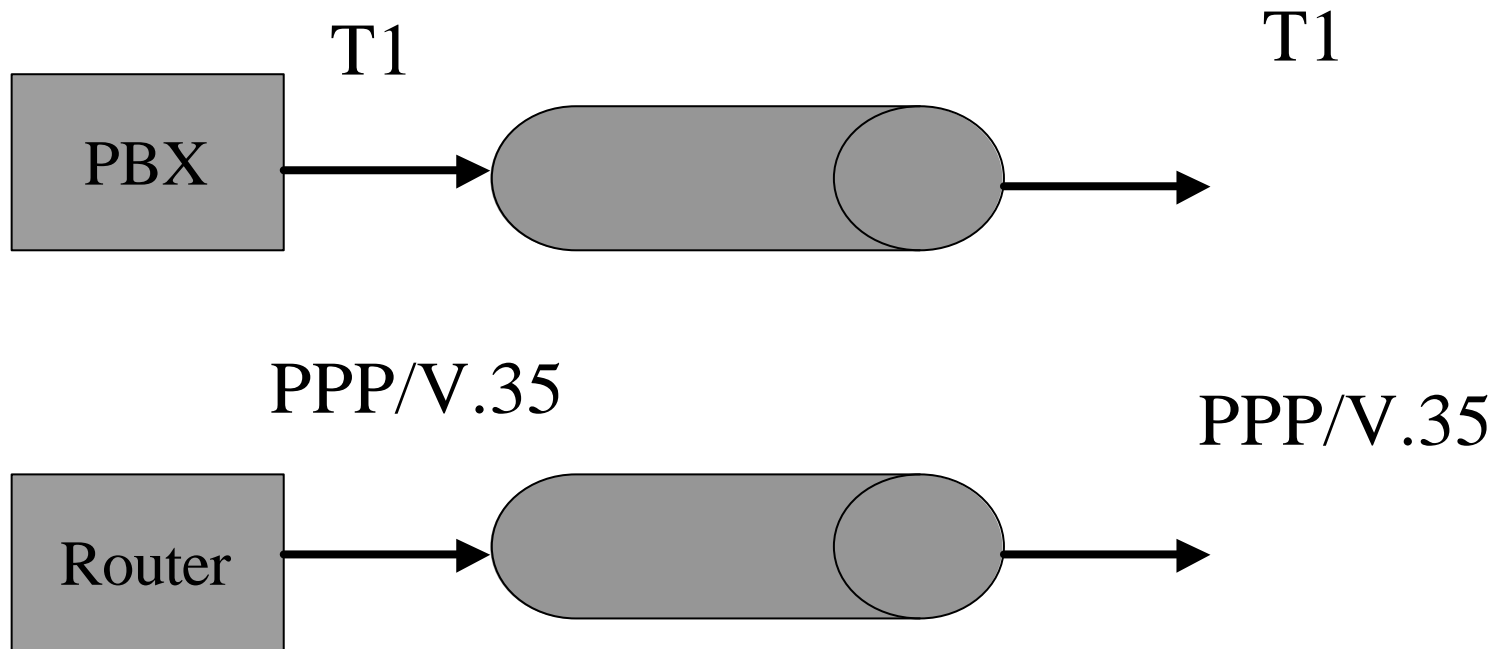Polling Response, Collision Slot, Reserved Slots

# Polling Signal

- Establishments, Maintain, Terminate Connection, (e.g. Power Control, carrier frequency control )

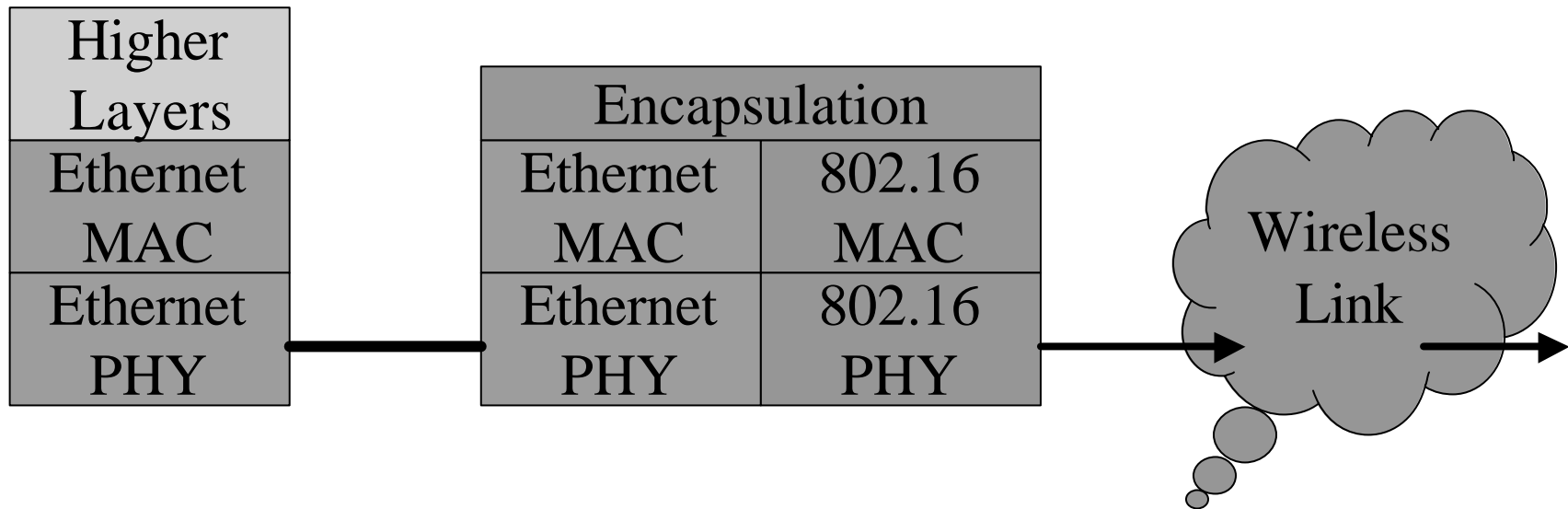- Synchronization (terminal enter the network)

# Tunneling Protocols
# 802.16 Broadband Wireless

T1                           T1

**PBX**

PPP/V.35                PPP/V.35

**Router**

# Wireless Connections Protocol Spec

| Higher Layers |
|---|
| Ethernet MAC |
| Ethernet PHY |

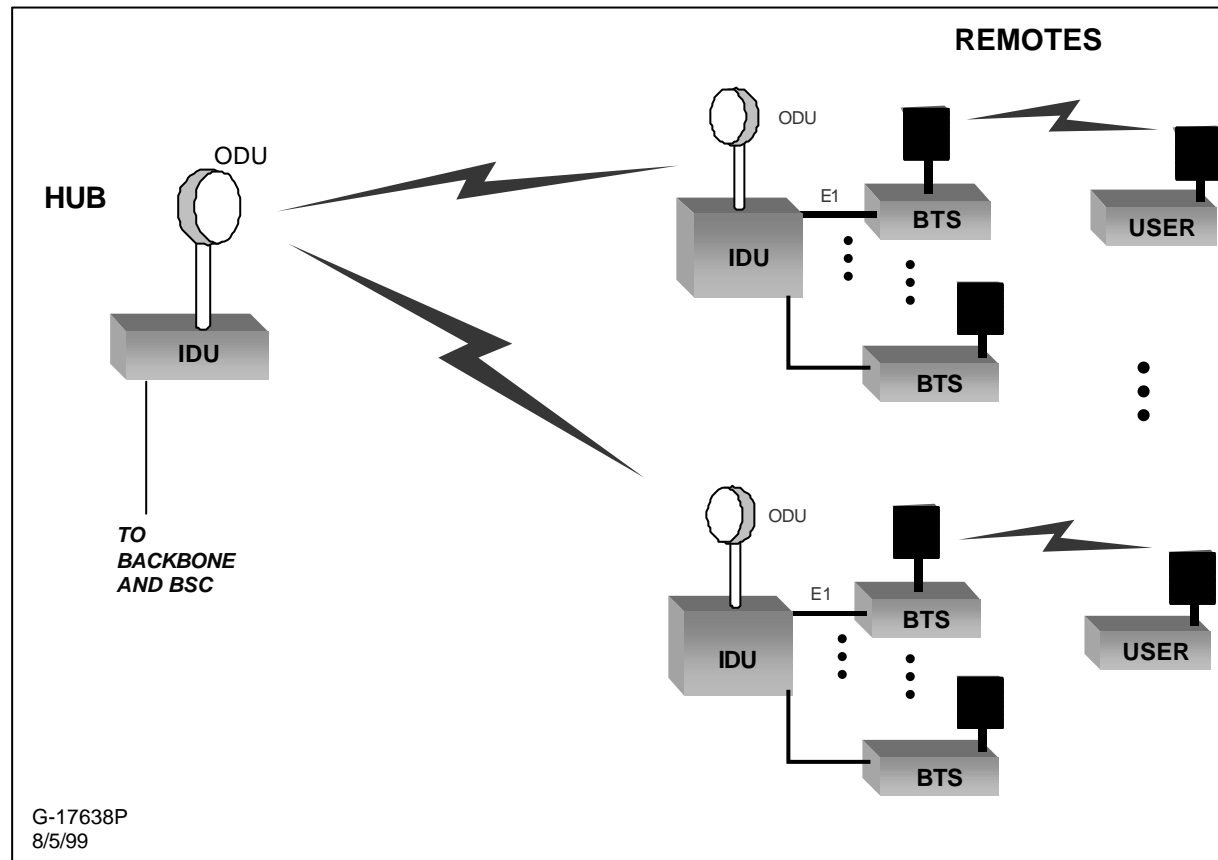| Encapsulation | |
|---|---|
| Ethernet MAC | 802.16 MAC |
| Ethernet PHY | 802.16 PHY |

Wireless Link

# BS/CPE Communications

- BS- Base Station
  - Access Control
  - Authentication
- CPE (Customer Premise Equipment)
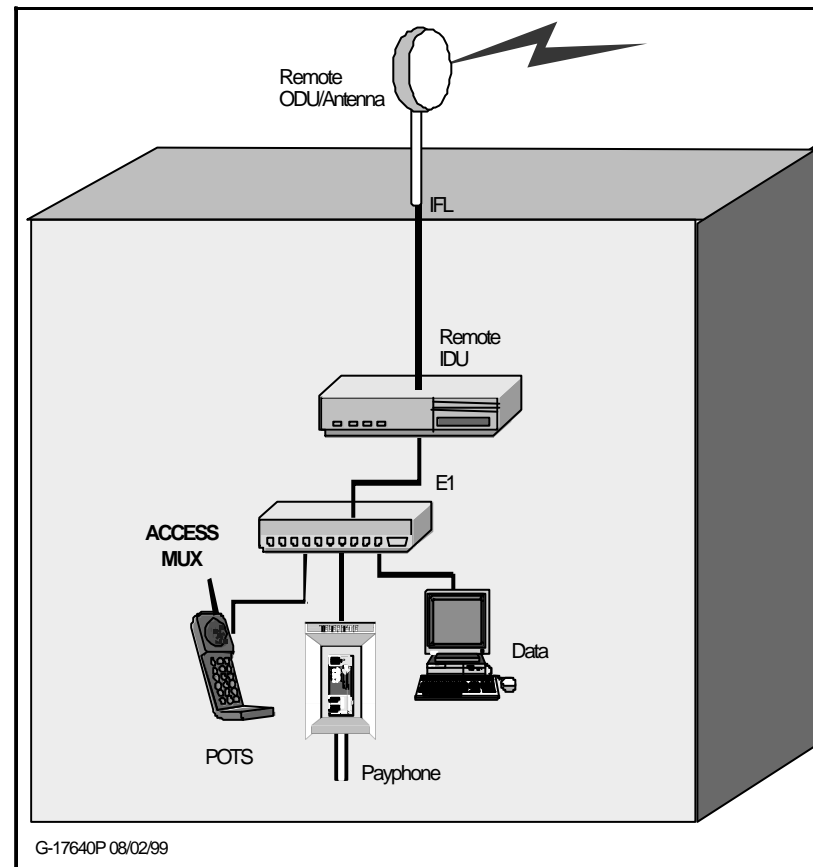  - must achieve down

# Uplink Subframe structure

| Registration Contention Slots (QPSK) | Bandwidth Request Contention Slots (QPSK) | CPE Schedule Data (QAM) | CPE Schedule Data (QAM) |
|---|---|---|---|

# Mobile cellular and WLL application

REMOTES

ODU

HUB

ODU

E1

BTS

USER

ODU

IDU

BTS

IDU

TO
BACKBONE
AND BSC

ODU

E1

BTS

USER

IDU

BTS

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# Typical Architecture of Remote Terminal



Remote
ODU/Antenna

IFL

Remote
IDU

E1

ACCESS
MUX

Data

POTS

Payphone

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# Typical Architecture of Hub Terminal
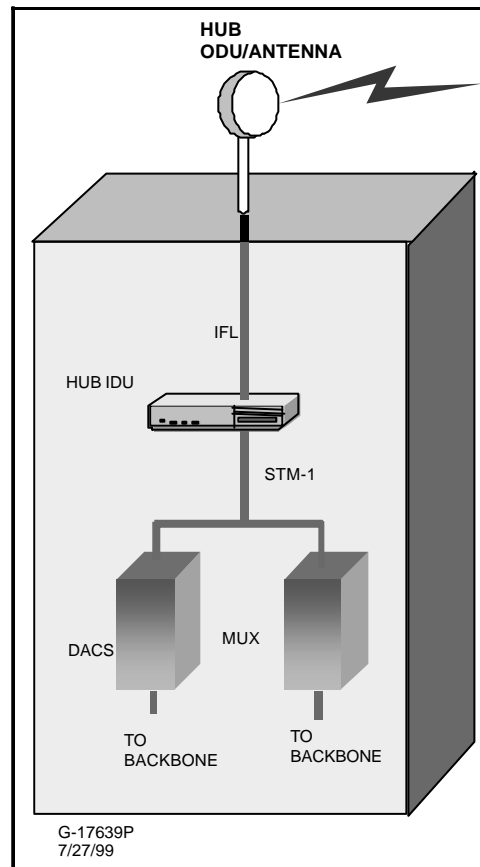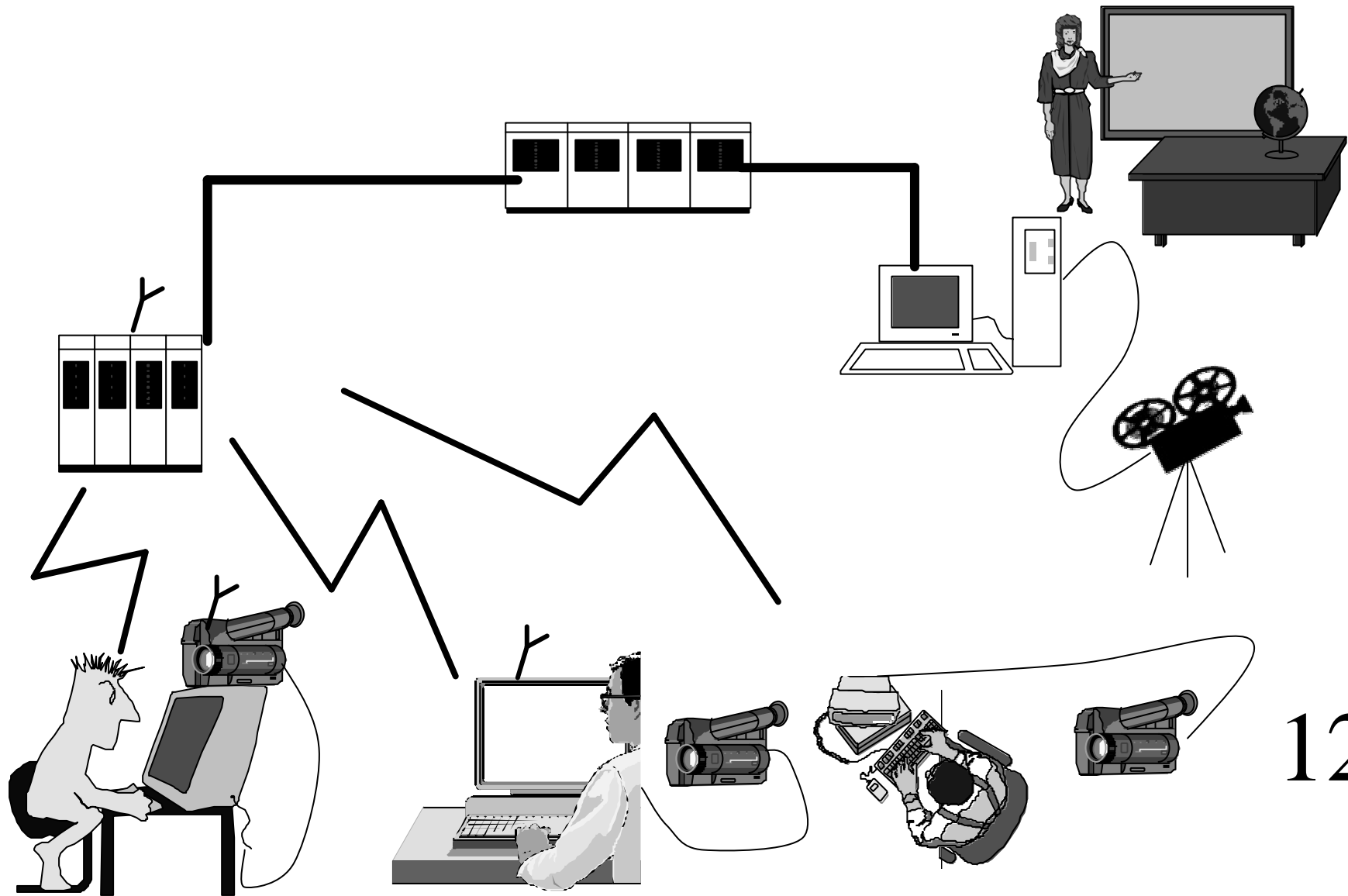
**HUB
ODU/ANTENNA**

IFL

HUB IDU

STM-1

DACS

MUX

TO
BACKBONE

TO
BACKBONE

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# Wireless ATM

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# Scheduling question
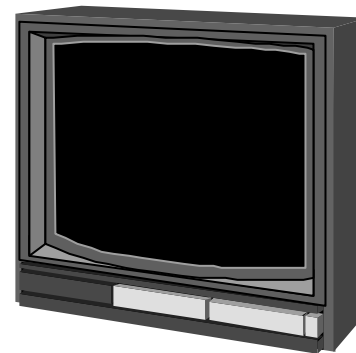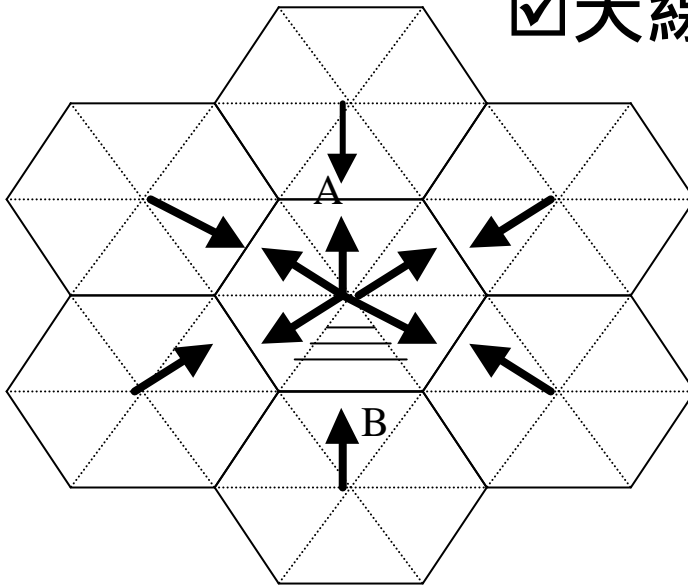
☑

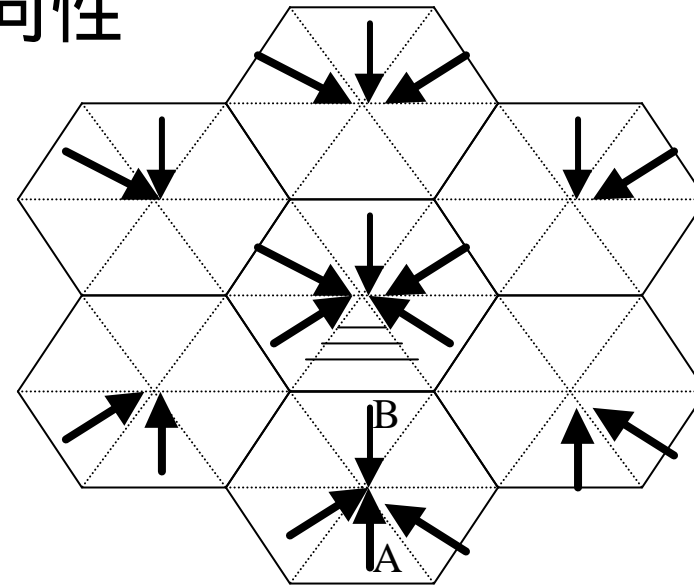☑



VOICE          DATA          VIDEO

5
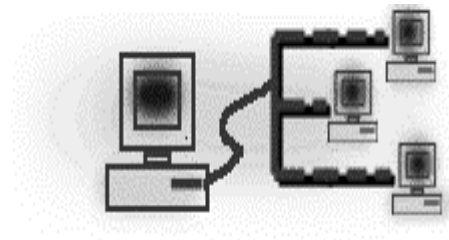
# Frequency Reuse

- 4 Sectors
  - rectangular cells with 90 sector antenna
- 3 Sectors
  - Hexagonal cell pattern with 120 sectors

# Base station placement

☑ assignment,
    reuse    ex:cross-
    polarization

☑Power control

☑

Major Sources of Interference for downlink    Major Sources of Interference for uplink
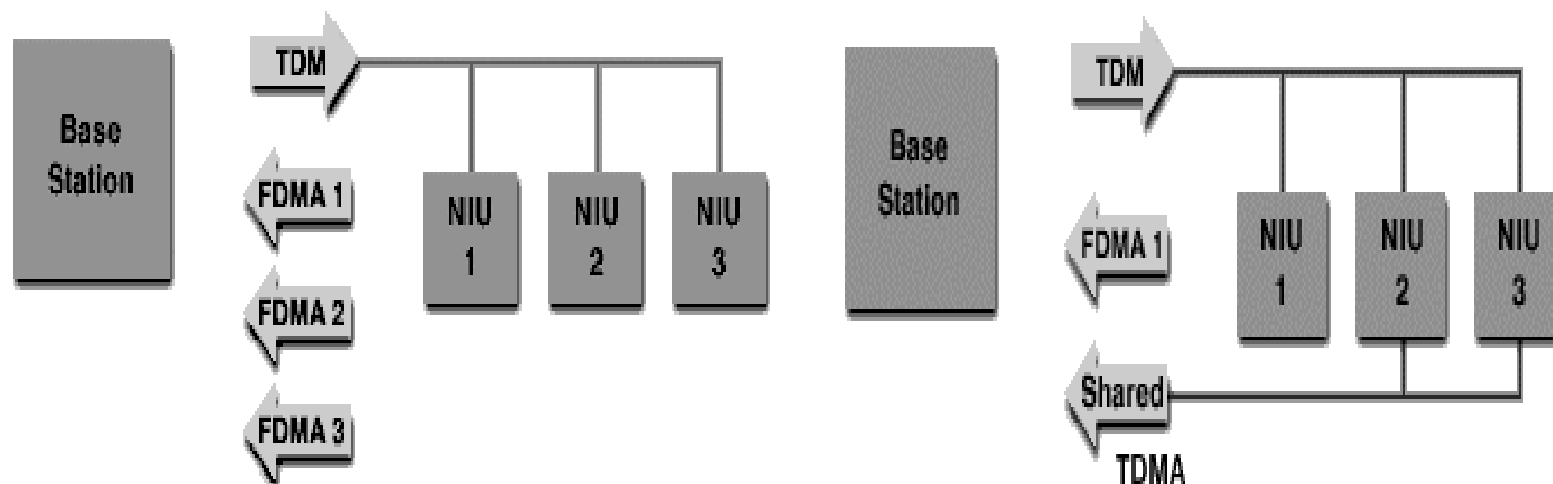
# Higher-Level Modulations

- QAM
- QPSK

# multiple access technology
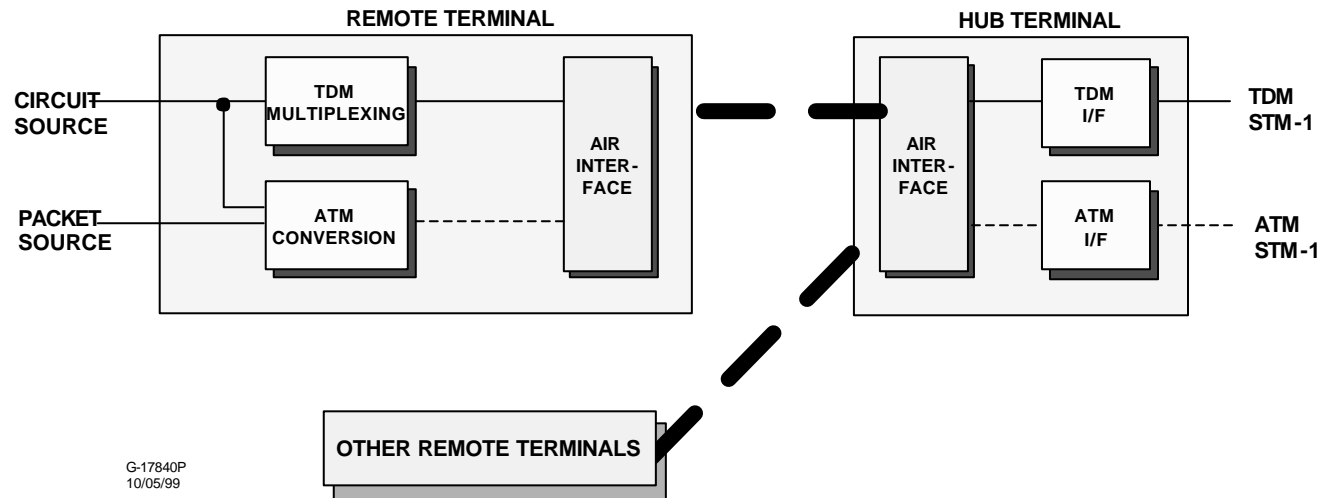
☑

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☑



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# AIReach™ Broadband Dual-Modulation Capability

- Ultra-high capacity with 64-QAM (60 Mbps gross)
    - 4.8 b/Hz spectral efficiency
- Greater range with QPSK (20 Mbps gross)
    - 1.6 b/Hz spectral efficiency
- AIReach™ Broadband supports both modes (slot by slot) simultaneously, optimizing system capacity and range



RT

RT

QPSK

64-QAM

HUB

G-17838P 8/18/99
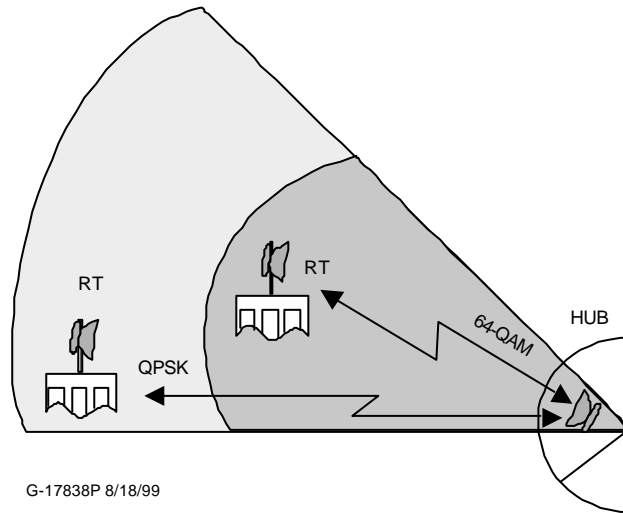
# AIReach™ Broadband Dual-Mode Transport Capability



REMOTE TERMINAL

HUB TERMINAL

CIRCUIT SOURCE

TDM MULTIPLEXING

PACKET SOURCE

ATM CONVERSION

AIR INTER-FACE

AIR INTER-FACE

TDM I/F

TDM STM-1

ATM I/F

ATM STM-1
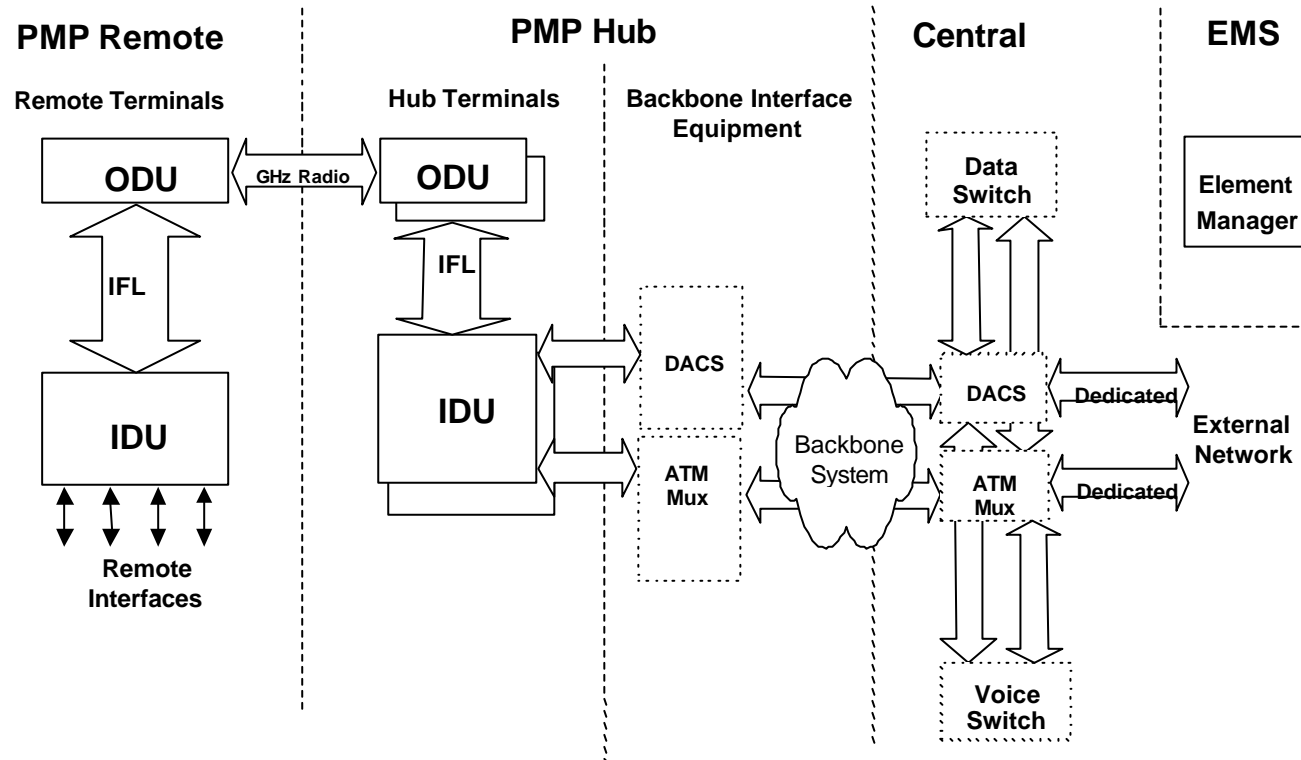
OTHER REMOTE TERMINALS

G-17840P
10/05/99

- **AIReach™ supports existing infrastructure through TDM and future migration through ATM (future proof system!)**

- **TDM source is multiplexed to hub interface**
  - **TDM can be processed as TDM or ATM on air interface**
  - **ATM source can be multiplexed to air interface directly**

# Multiple Access Techniques

- TDMA

- FDMA

- CDMA
  - Walsh-Hadamard Sequence (Orthogonal)
  - Nonorthogonal CDMA (PN-CDMA)

# PMP System Elements



**PMP Remote**

Remote Terminals

ODU

GHz Radio

IFL

IDU

Remote
Interfaces

**PMP Hub**

Hub Terminals

ODU

IFL

IDU

Backbone Interface
Equipment

DACS

ATM
Mux

Backbone
System

**Central**

Data
Switch

DACS

Dedicated

ATM
Mux

Dedicated

External
Network

Voice
Switch

**EMS**

Element
Manager

G-17659 P
07/29/99

# Goal of the project

- IP Multimedia Application through LMDS
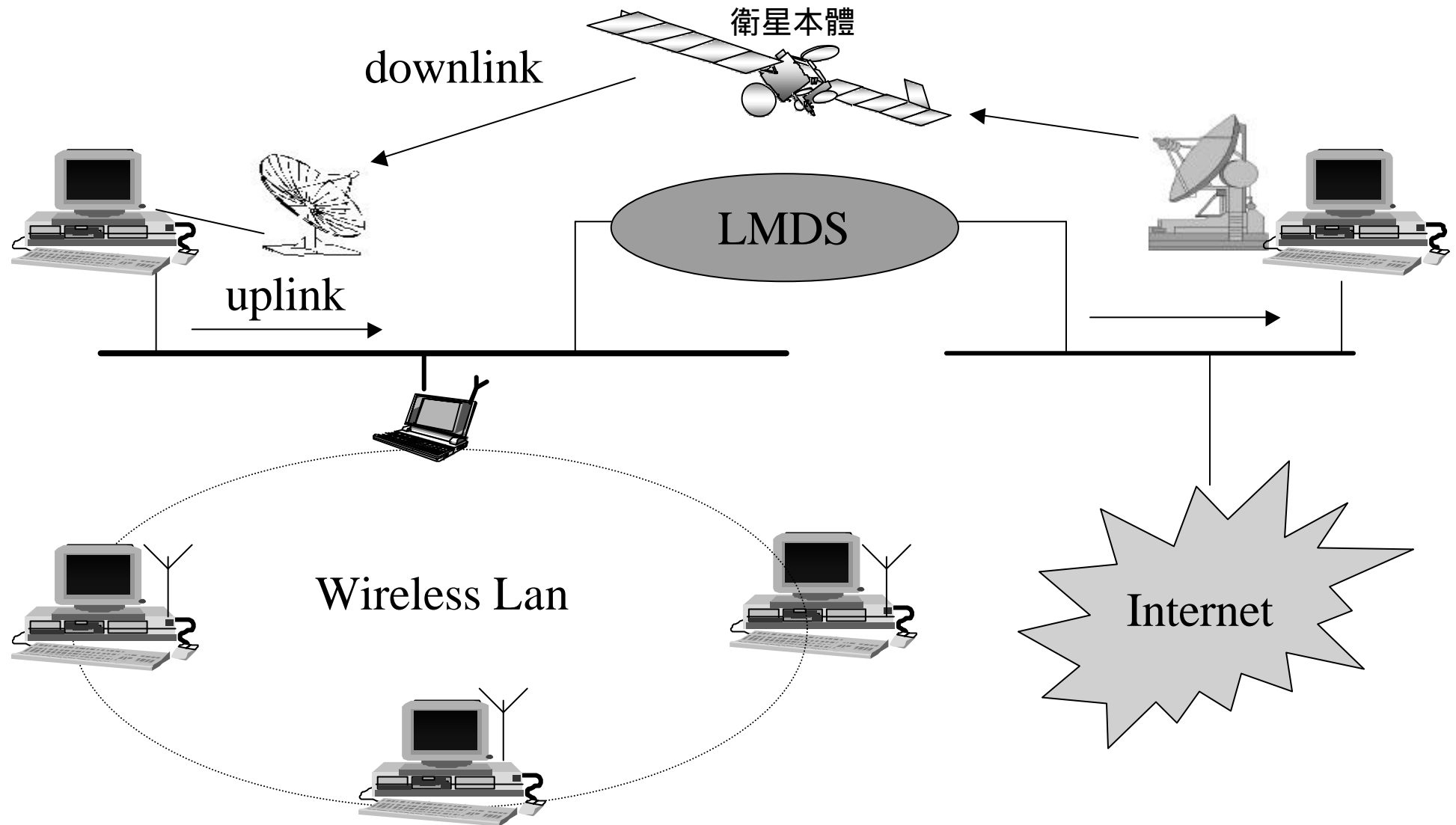  - ex:Voice over Ip , Video conference

- The first demo site in Taiwan: study the utilization of LMDS in Taiwan
- Extend the broadband network into wireless (Internet II)
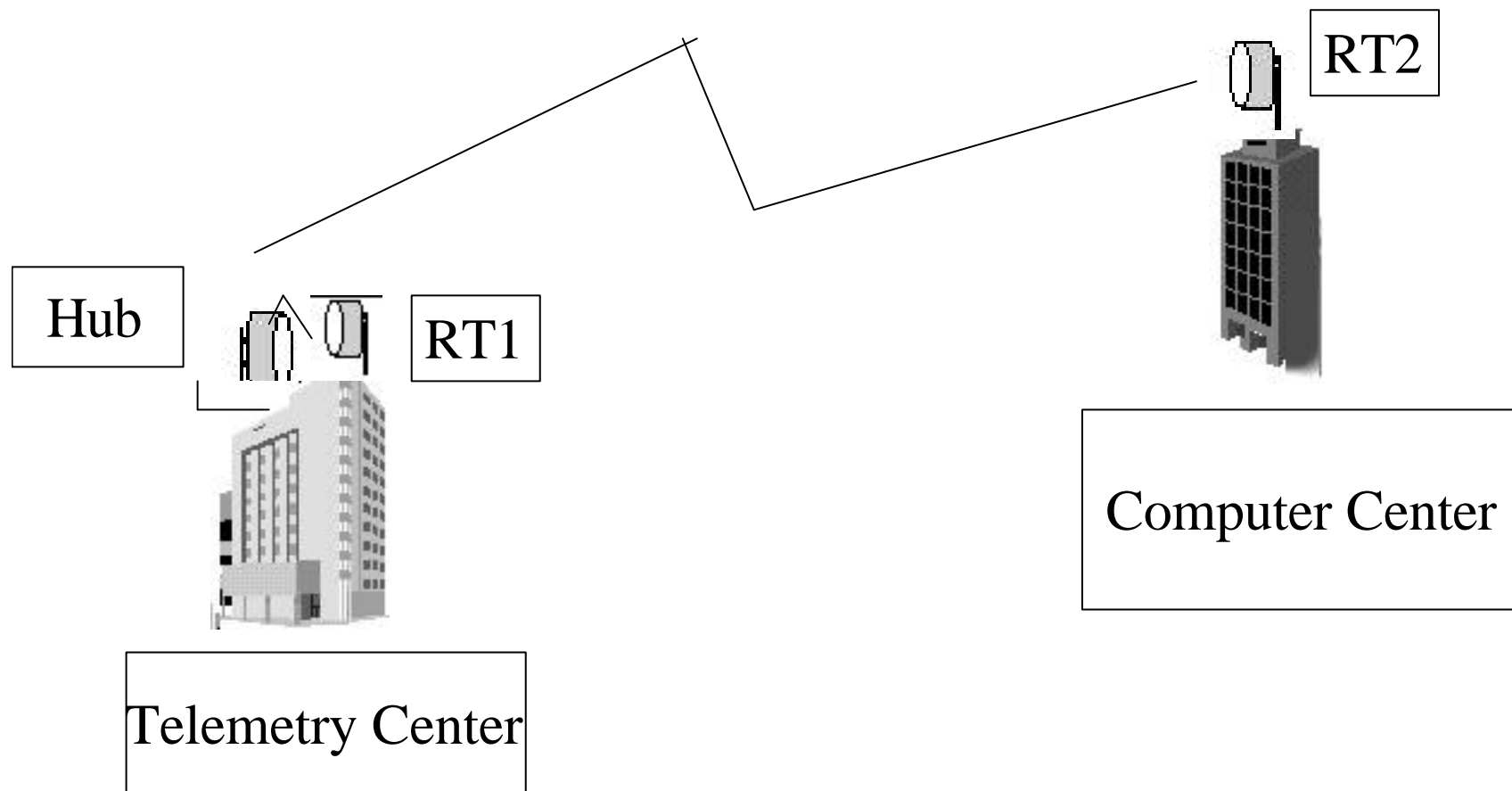
# Experiments and Research

- **Two way video conference experiments**
- **IP network experiments**
- **Network Interconnection**
  - **Wireless LAN**
  - **Eithernet Experiments**
  - **Direct PC**
- **ATM interface experiments** (will be planned for the next LMDS with ATM interface delivery)
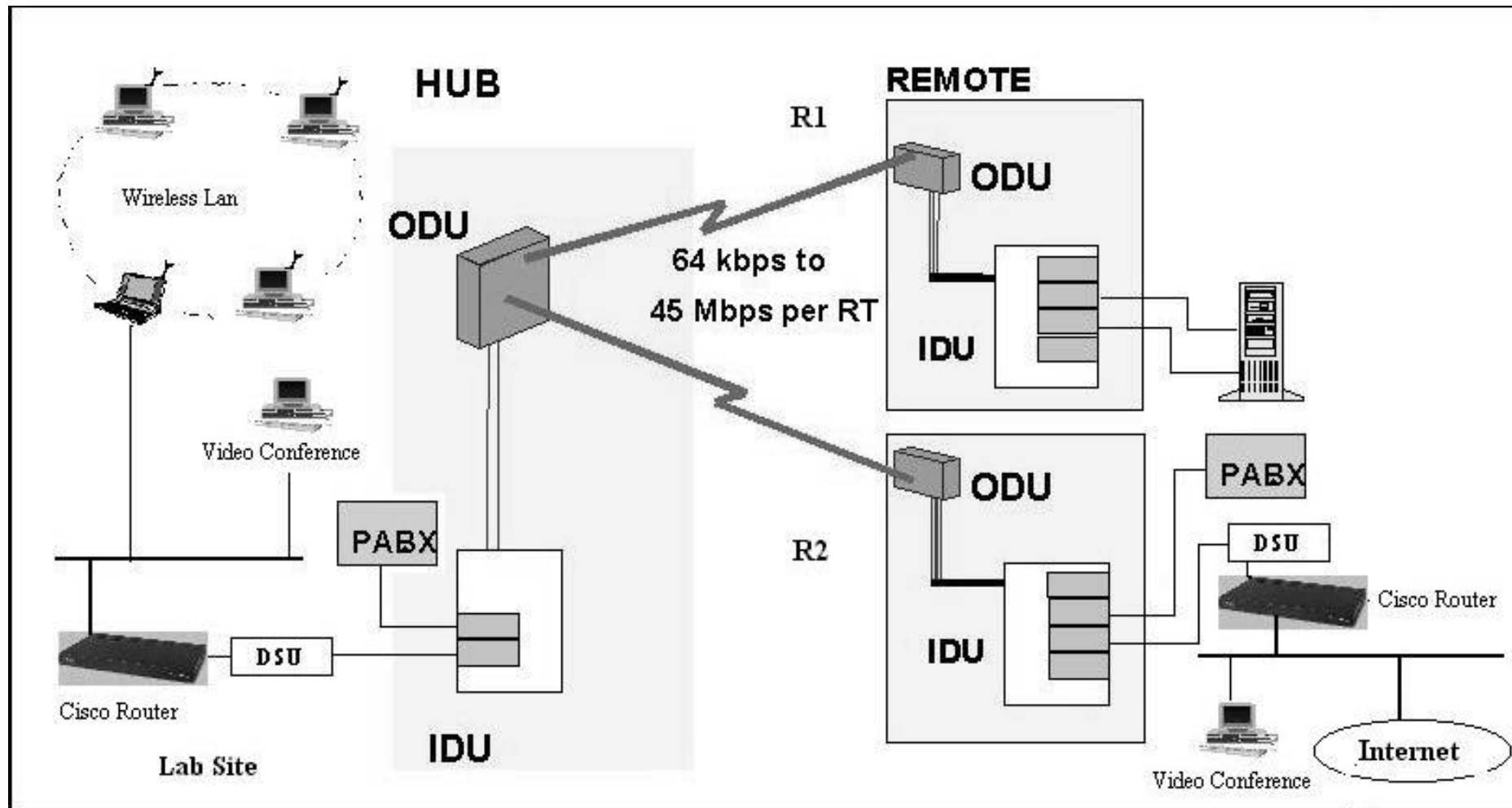
# Network Interconnection

downlink

uplink

LMDS

Wireless Lan

Internet

# LMDS Deployment Graph

Hub

RT1

RT2

Telemetry Center

Computer Center
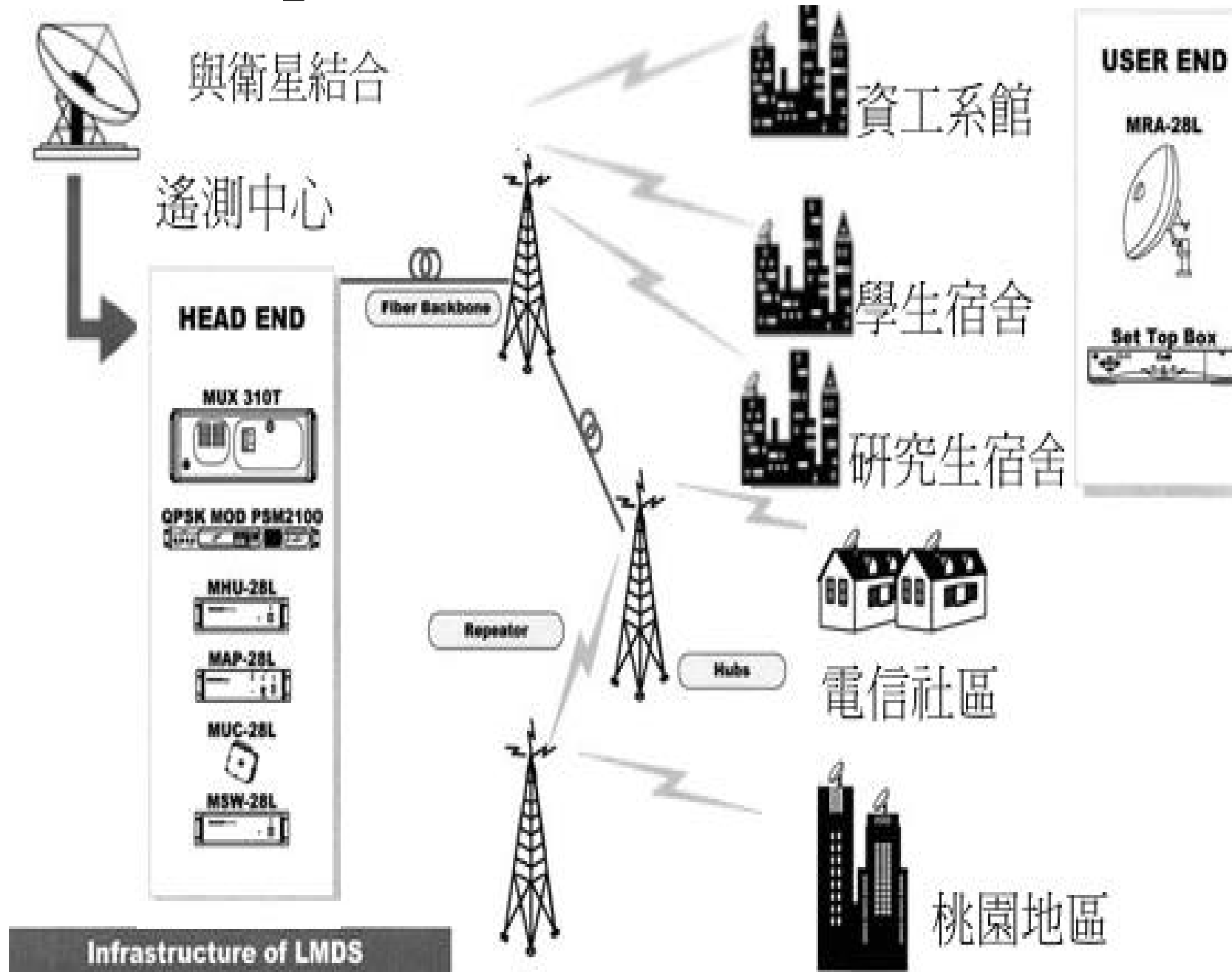
# Architechture of the Demo

# LMDS Leaning Community

Cooperation among NCU School,
Telecommunication Lab and Neighboring
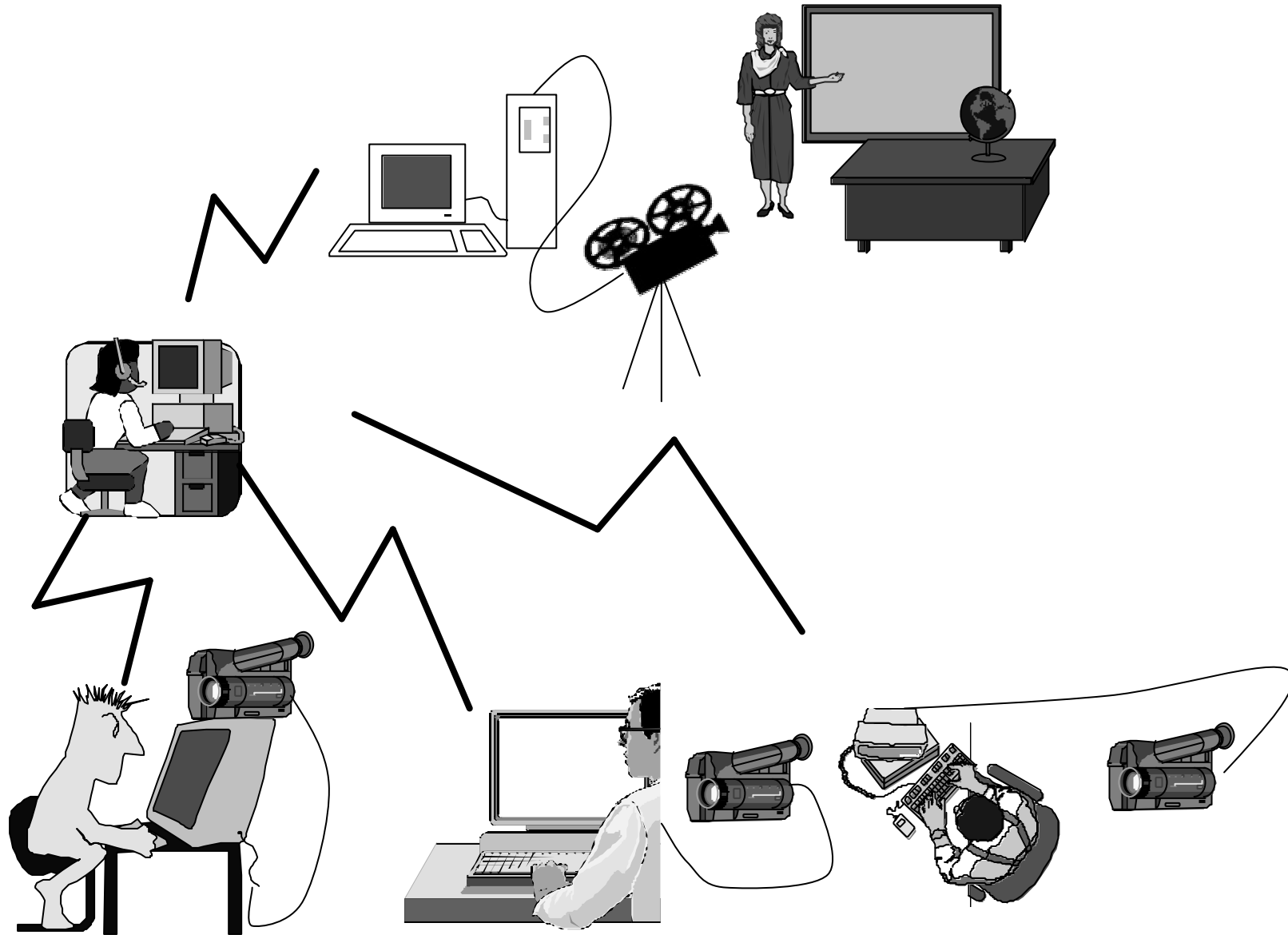Community

## National Central University

2000/2/11

# Step.1  LMDS Architecture



與衛星結合

遙測中心

HEAD END

Fiber Backbone

資工系館

學生宿舍

研究生宿舍

電信社區

桃園地區

USER END

MRA-28L

Set Top Box

MUX 310T

QPSK MOD PSM210O

MHU-28L

MAP-28L

MUC-28L

MSW-28L

Repeater

Hubs

Infrastructure of LMDS

11

# Step2.

real-time                    :



12

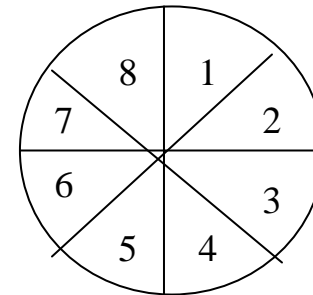# Research Issues
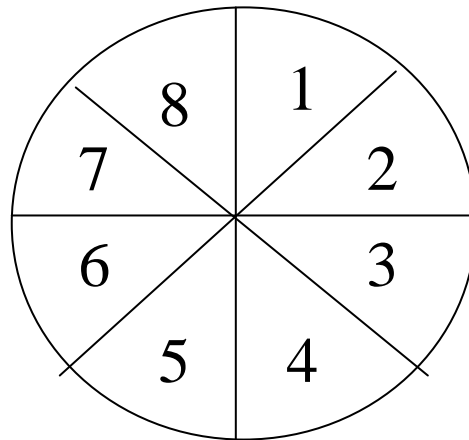# LMDS for Distant Learning

- Scheduling question
- multiple access technology
- Transmission impact
- Base station placement

4

2000/2/11

# Transmission impact

- Atmospheric attenuation

- Dynamic data rate

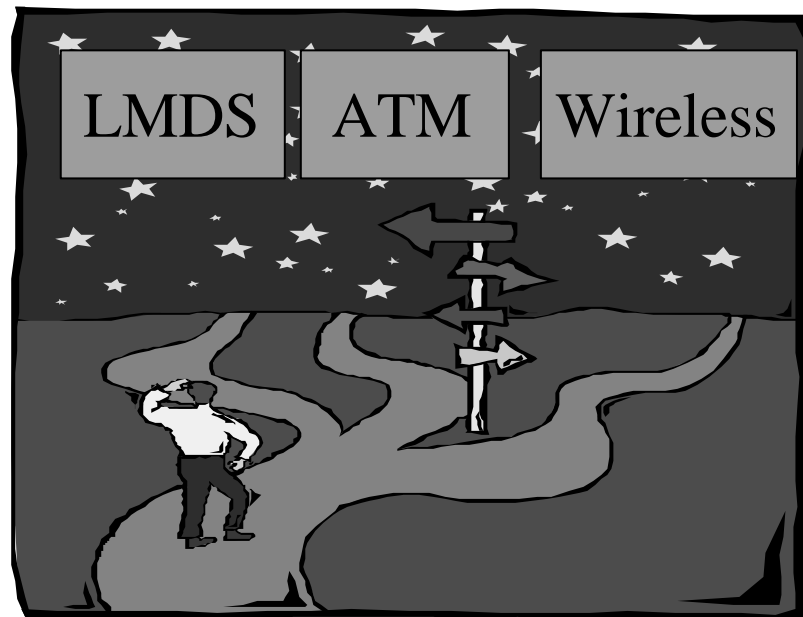- TCP/IP            ex: window size

- higher power,reduce cell size
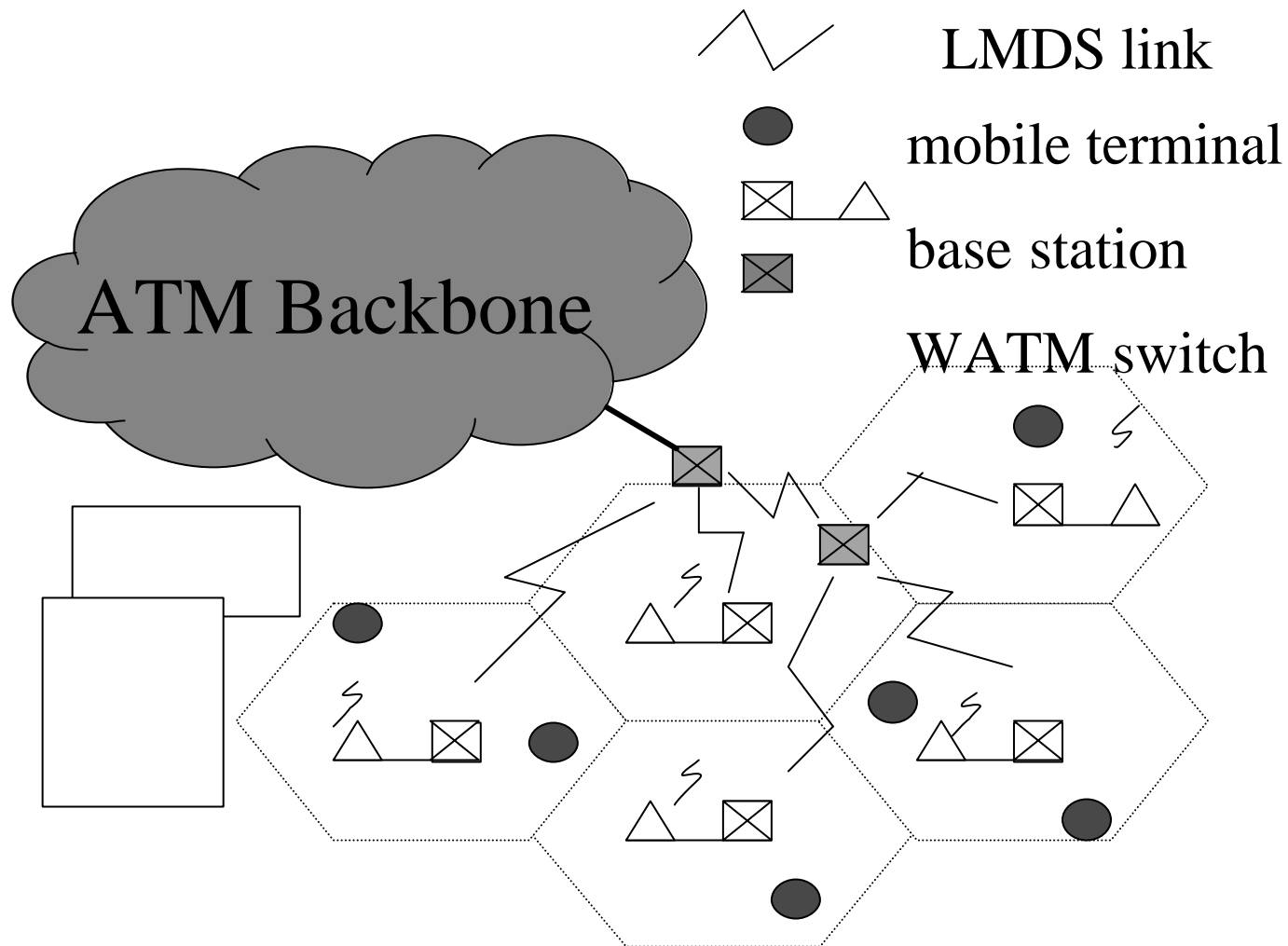
| Application |
|---|
| TCP |
| IP |
| Data Link |
| Physical |

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# Future Works

- **Intelligent Routing**
  - – Select the best one way to transmit data

# How to do multicast over ATM in LMDS?



LMDS link

mobile terminal

base station

WATM switch

ATM Backbone

# Guaranty of QoS in LMDS

Ex:Different rate based on different data type

**Data**

**Voice**

**Video**

Different rate

| |
|---|
| 30% |
| 20% |
| 50% |