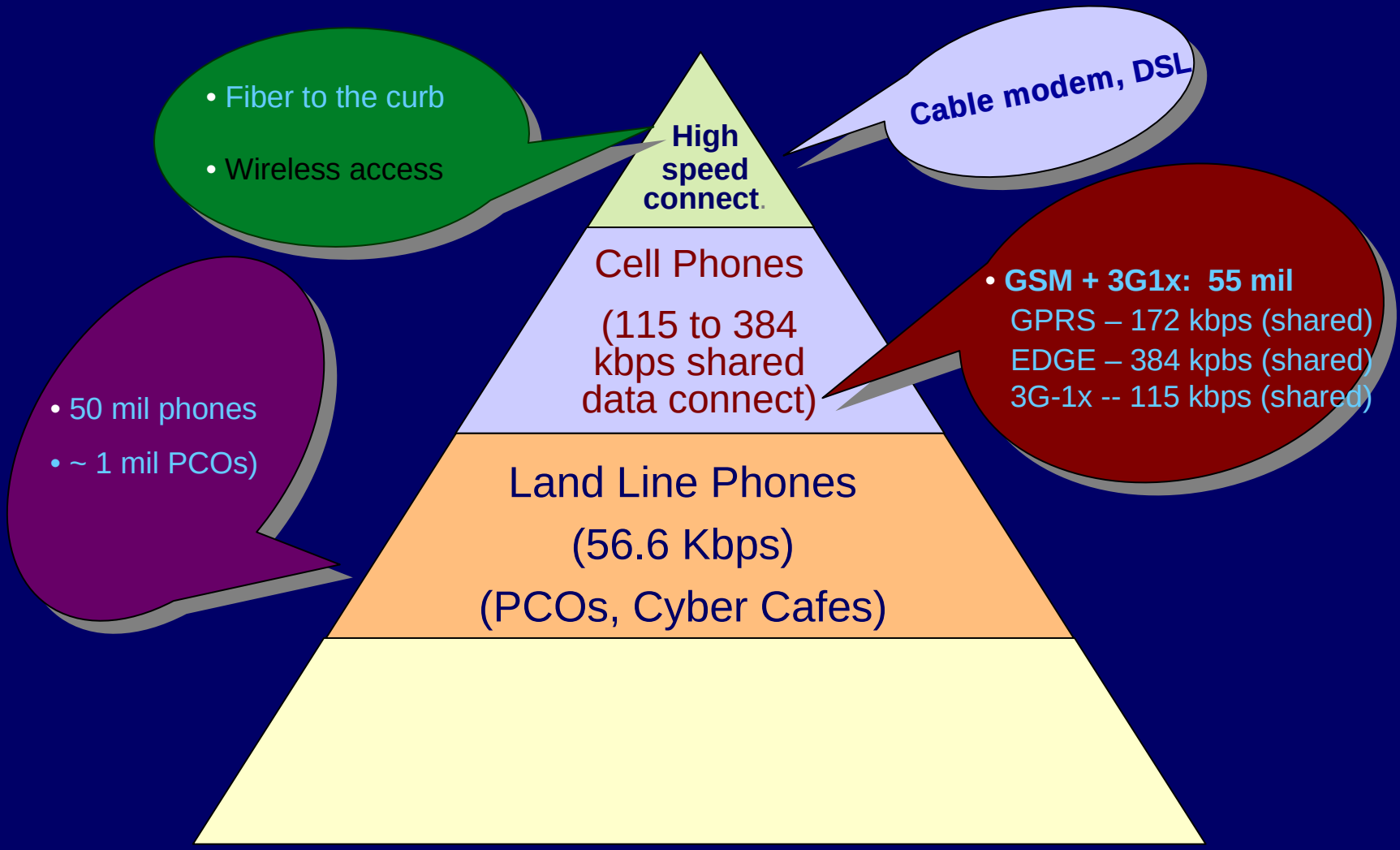
Telecom for Rural Areas

U. B. Desai

SPANN Lab
Department of Electrical Engineering
IIT-Bombay
ubdesai@ee.iitb.ac.in

Data Communication Pyramid in India



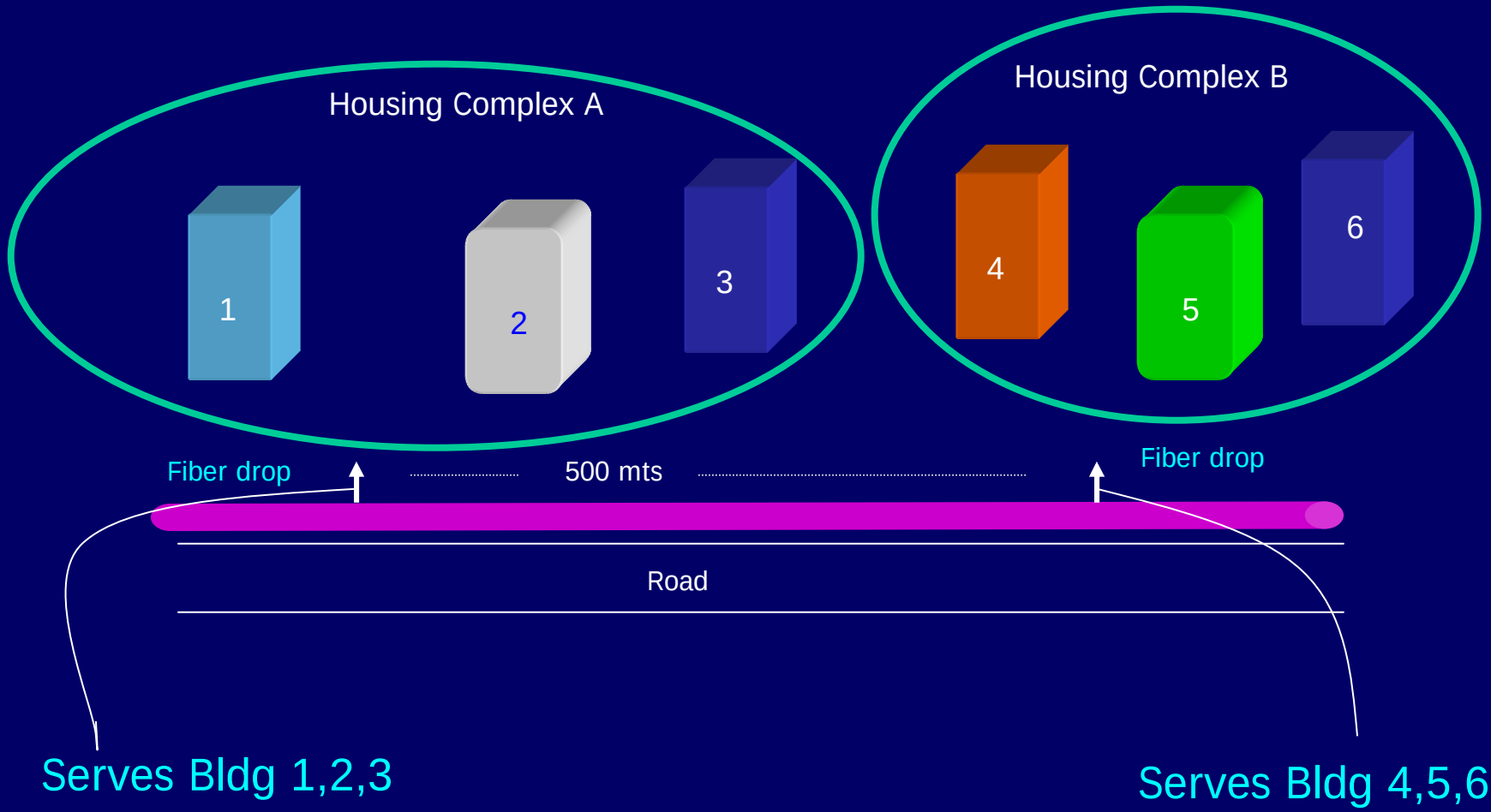
Back Bone: Fiber

- Back bone will be fiber
- Very cost effective (except for the last mile)
- Various industries are laying fiber across India

(BSNL, MTNL, Reliance, Bharati, Tata-Tele, Shyam Telecom, etc.):

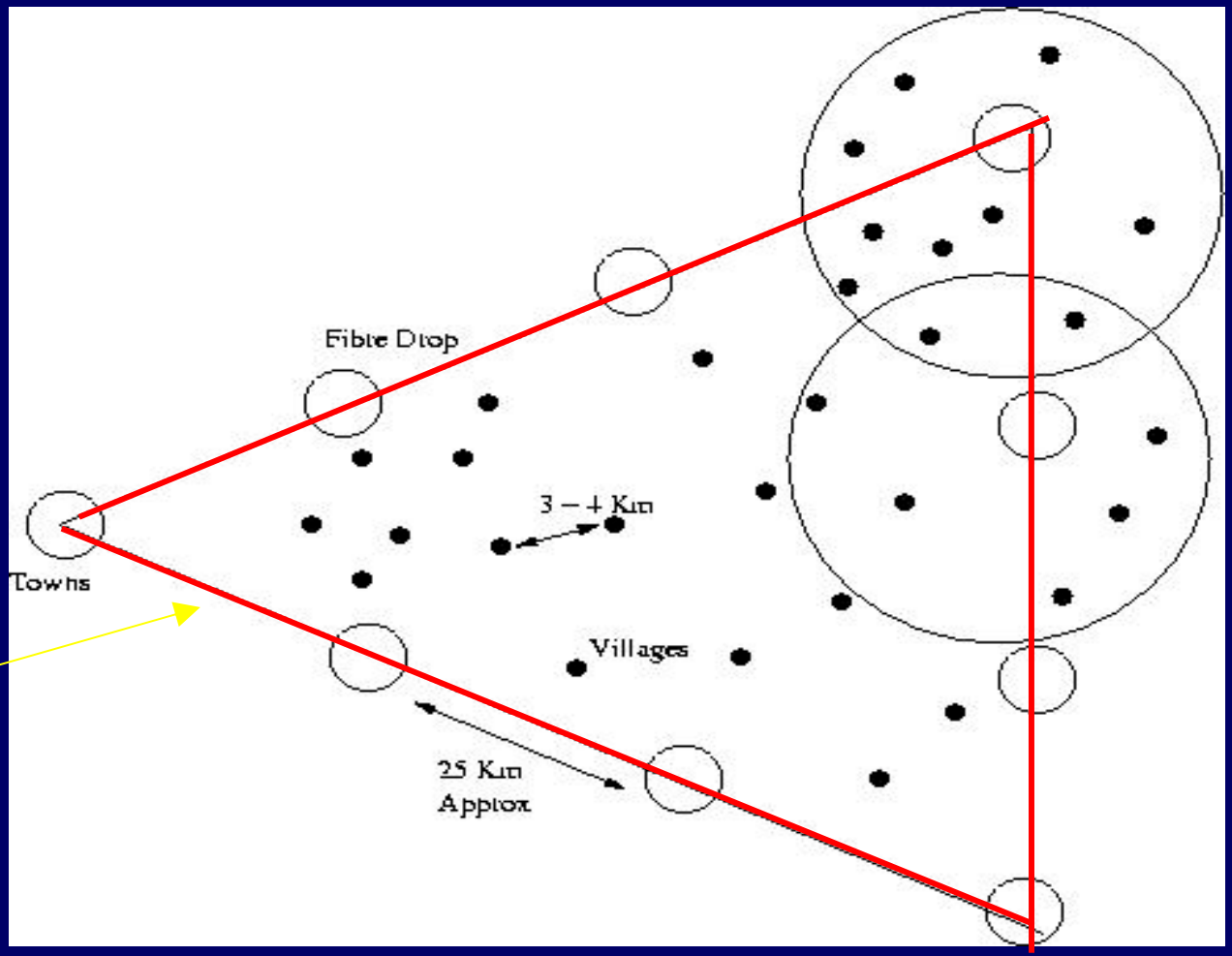
  - In cities there will be fiber drop every 500 mts.
    - in cities we expect fiber to the curb technology, already there in parts of several metros
    - thus last mile access will be from curb to building
    - There is talk of fiber to home, but at present this is not cost effective
  - In rural areas there will be fiber drop every 25 kms.
    - BSNL fiber is available at every taluk in the country

Urban Scenario for Fiber in the Loop Technology



Fiber Drop in India

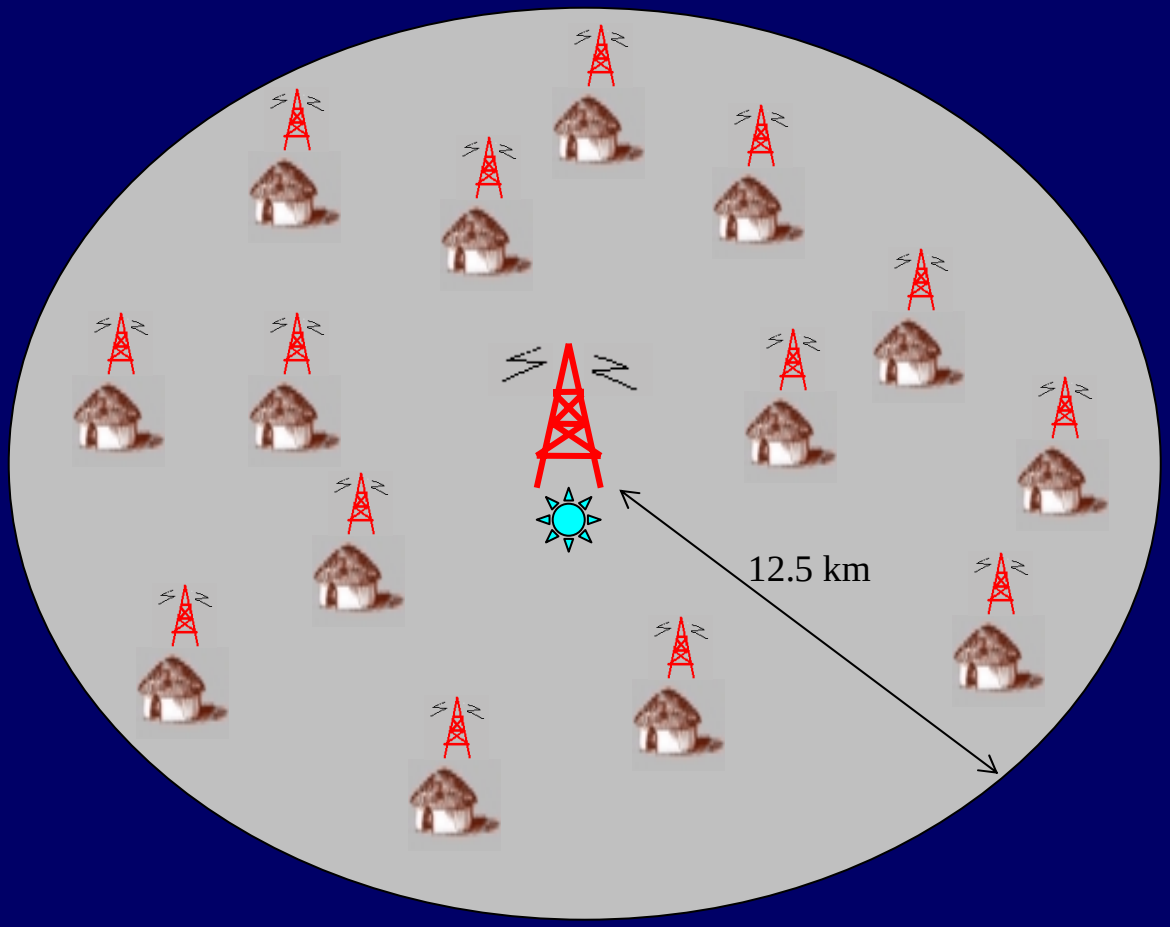
- Avg. Village Area ~ 6 sq. km.
- Total of 650,000 villages in India
- About 100 villages per fiber drop
- Population per village: 500 to 1000



Optical Fiber Backbone

Domestically, 30,000 of BSNL's exchanges are connected by fiber an average of one exchange for 20 villages, not including the contribution of other operators. Thus, almost unlimited bandwidth is already possible.

Around Each Fiber Drop



- Approx. area covered by each fiber drop is 600 sq.kms.
- We assume each village occupies approx. 6 sq. kms.
- Approx. 100 villages covered by each fiber drop

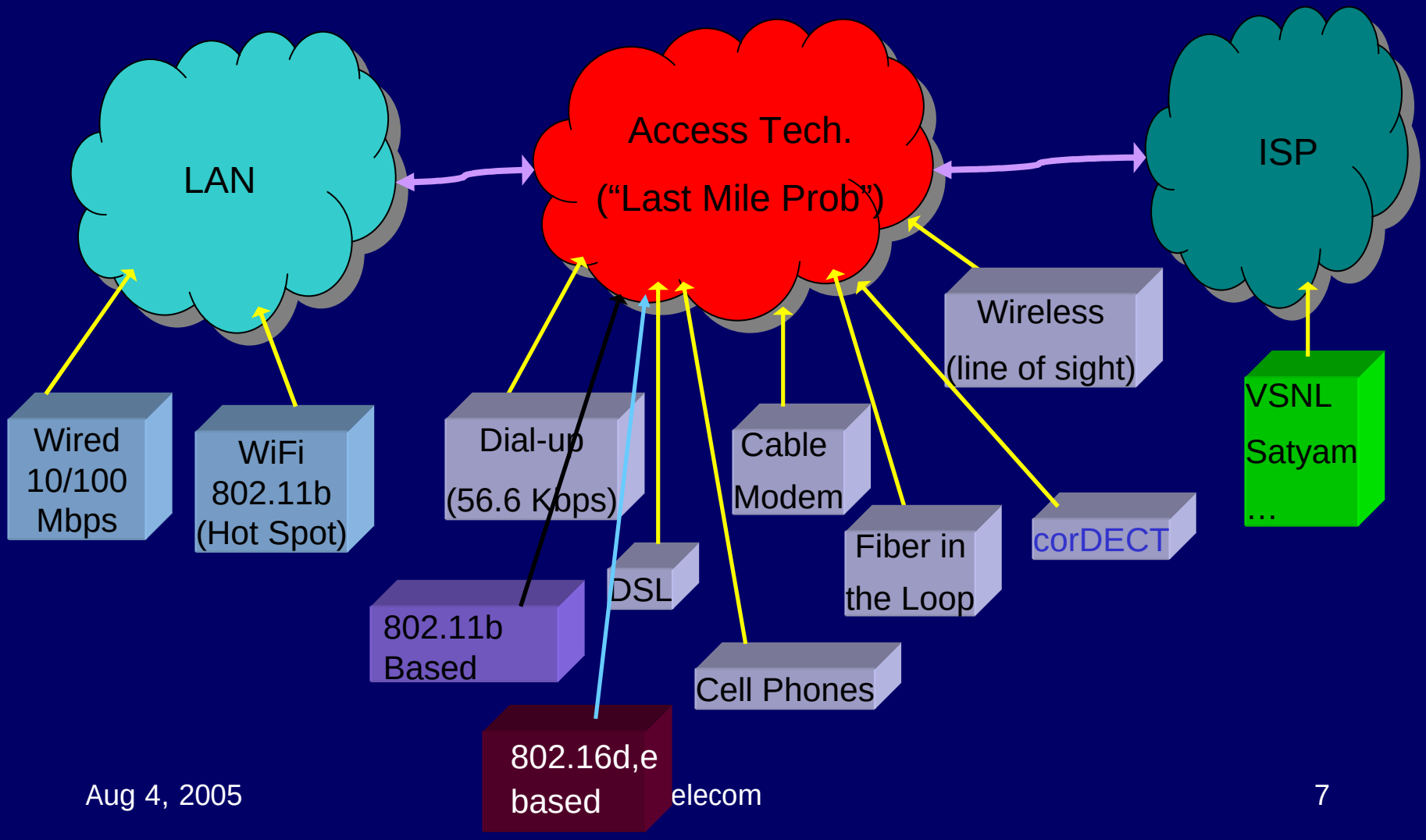
- **Objective:** Connect all villages to the Internet

Access Point connected to fiber drop

Village node with pole/tower antenna

Fiber Drop

A Look at Access Technologies



Data Rates for Copper based Last Mile Access

- DSL (Digital Subscriber Line)
  - Provided by BSNL using DIAS
  - 128 kbps always on connection on existing phone lines in 95 towns
- ADSL (Asynch. DSL)
  - 6 Mbps downlink, 512 kbps uplink for 4 Kms or less
- ADSL2+, VDSL (Very high data rate DSL)
  - 30 MBPS downlink, 1 Mbps uplink for 700m
- Most copper links in India are 3 to 4 kms (from MTNL or BSNL exchange)
  - thus ADSL only possibility
  - Problems due to poor copper links
  - Most operators put their own cables
- Cable Modem
  - 10 to 40 Mbps downlink and 512 to 1Mbps uplink (shared both ways)
  - Most operators put a separate cable since the TV coax is of poor quality to support data

Wireless: GPRS, Edge, CorDECT, ...

- CorDECT
  - 70 kbps; developed by TeNet Grp of IITM; deployed in rural India

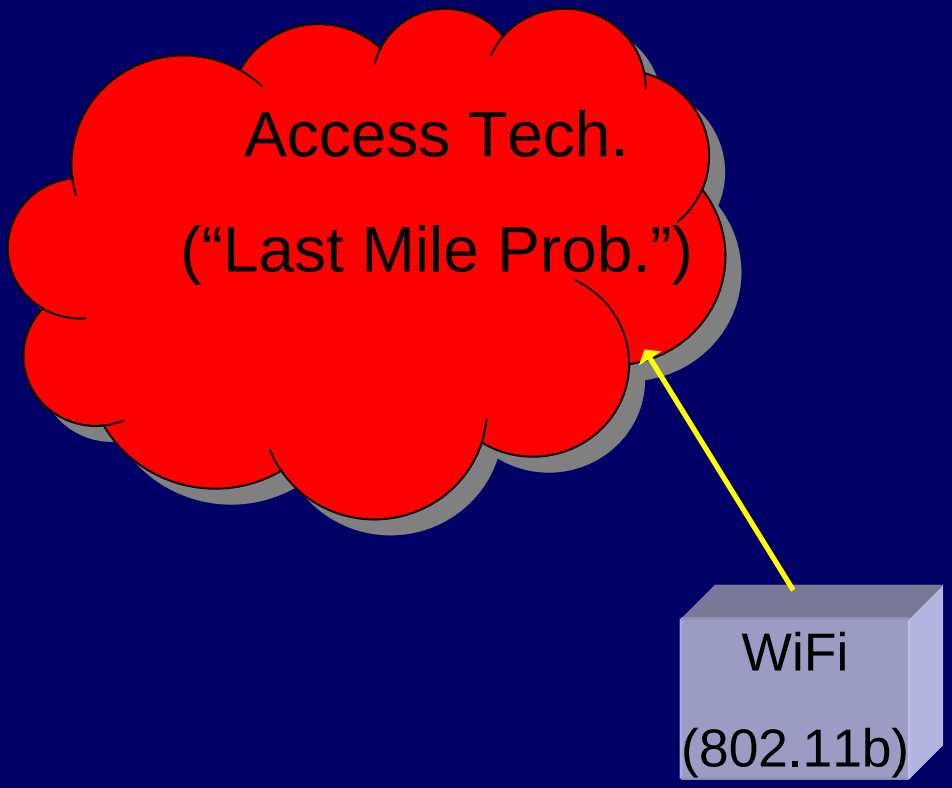
2.5G

- 3G-1x
  - 115 kbps shared to all subs per sector
- GPRS
  - 172 kbps shared to all subscribers per sector
- EDGE (Enhanced Data Rates for GSM Evolution)
- Maximum possible data rate – 384 kbps shared
  - Highest experienced download – 82 kbps
  - Highest experienced upload – 32 kbps
  - Vendor rated average speed – 130 kbps

Mobile Access: 3G - 3GPP in Europe (3rd Generation Partnership Program)

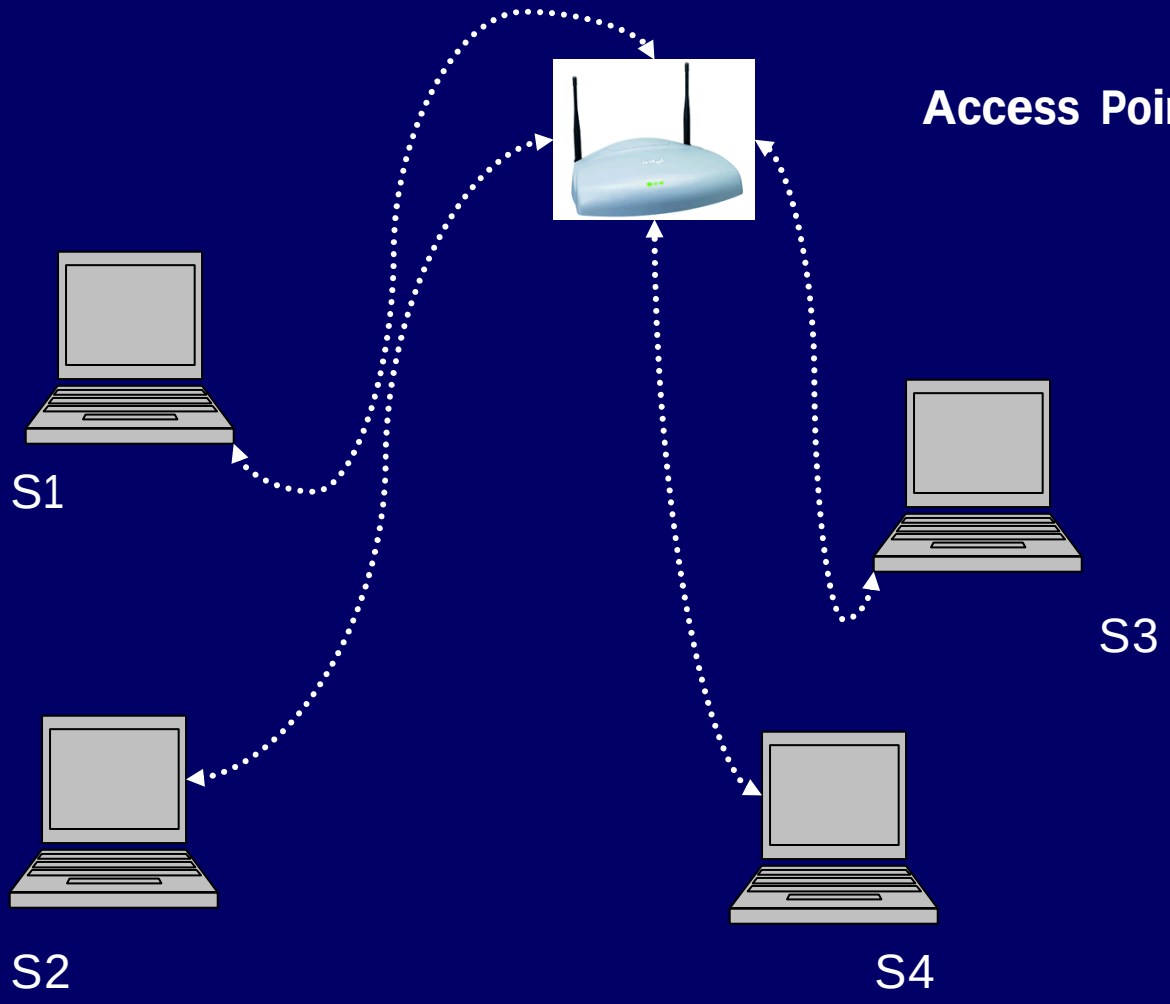
- WCDMA
  - Recently deployed by Vodaphone in 13 countries in Europe.
  - 5 MHz+5 MHz BW
  - Approx. 2 Mbps shared by all users per sector
  - Data rates drops drastically when you are at the periphery of the sector
- HSDPA (High Speed Downlink Packet Access)
  - Data rates expected to go up to 8-10 Mbps (spectral efficiency of 1 bits/sec/Hz
  - With MIMO, data rates can go up to 20 Mbps
- In US – 1xEVDO, data rate of 300-500 kbps, expected to go up to 2 Mbps

WiFi for Access

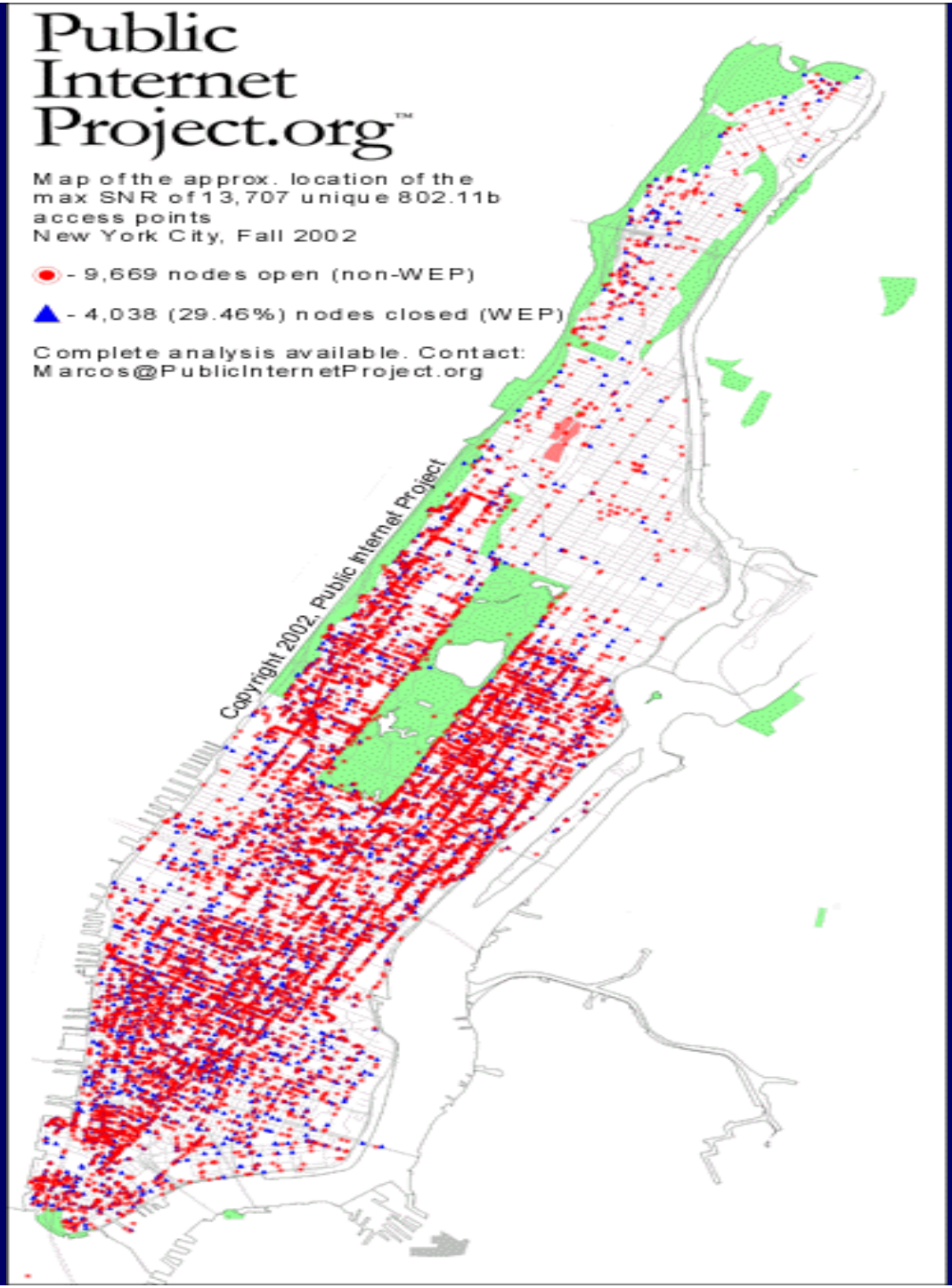


- 802.11b (WiFi, WLAN) ideally suited for hot spots
- Of late extensive R and D to see if 802.11b can be used for access.
- Motivation: Expect 802.11b access to be cheaper, easy to deploy, and obviously broadband
- Operates in the unlicensed band
- Some believe it is not a good access technology since the data spectral efficiency is 0.15/bits/sec/Hz

HOTSPOT: Typical use of WiFi typically (Infrastructure Based)



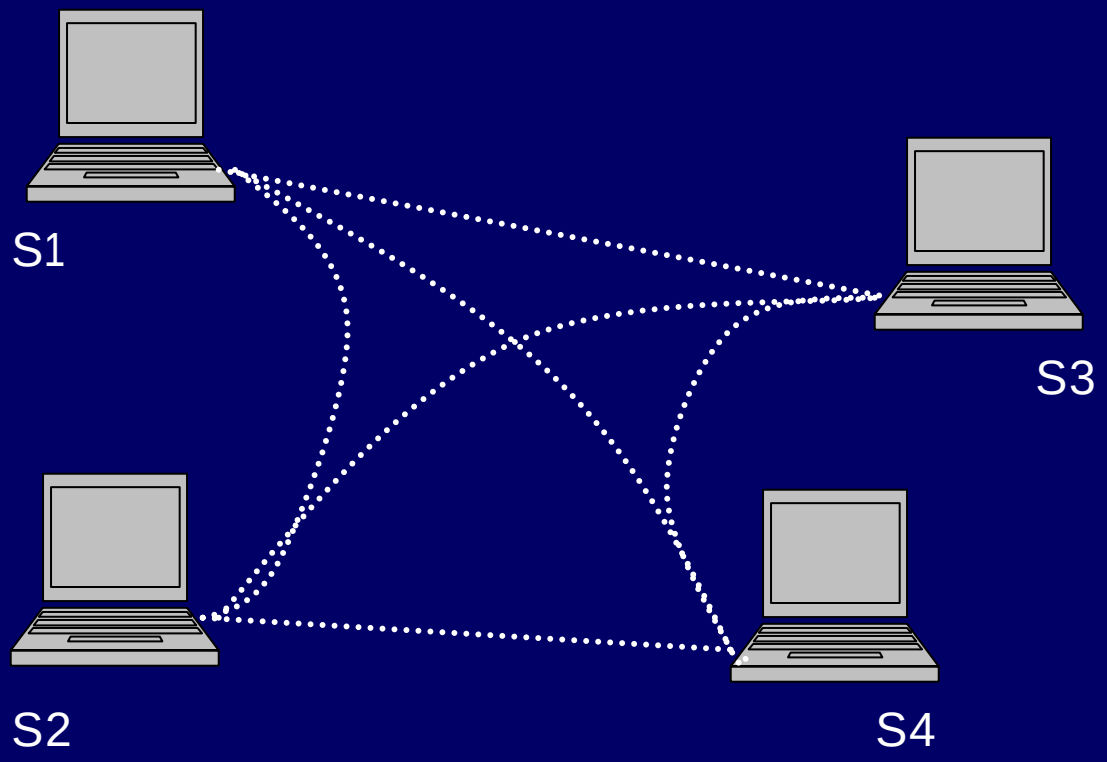
- An AP acts like a bridge
- Si communicates to Sj via AP.
- All comm. via AP
- Every Si must be within the range of AP. Si need not be within the range of Sj



- Manhattan area in NY
- 13707 unique nodes
- 9669 nodes not secure protected
- 4038 secured
- Nodes identified by probing using a 802.11b card from a car with GPS capability
- Case of Bryant Park community network

802.11b based Ad Hoc Network

Basic Service Set (BSS): Stations communicate directly with each other.



Sometimes referred to as IBSS (Independent BSS)

station si must be in the range of station sj

Key Advantages

- Open IEEE Standard
- Unlicensed Band:
  - 802.11 operates in the unlicensed band (ISM – Industrial Scientific and Medical band) ~ 3 such bands
    - Cordless Telephony: 902 to 928 MHz
    - 802.11b: 2.4 to 2.483 GHz (opened up in India for indoor use and recently for outdoor use)
    - 3rd ISM Band: 5.725 to 5.875 GHz
    - 802.11a: 5.15 to 5.825 GHz (occupies part of 3rd ISM band)
    - 802.16d: 2 to 11 GHz

Salient Features of 802.11a, b, g, n

802.11a

- Operates in 5.15-5.35 GHz, and 5.725-5.825 GHz
- 54 Mbps max data rate,
- 50mt range
- Total band of 240MHz
- 12 non-overlapping channels, each of 20 MHz BW
- OFDM (54 subcarriers) for the physical layer
- Same MAC layer for 802.11a b, and g
- Not (yet) unlicensed in India

802.11b

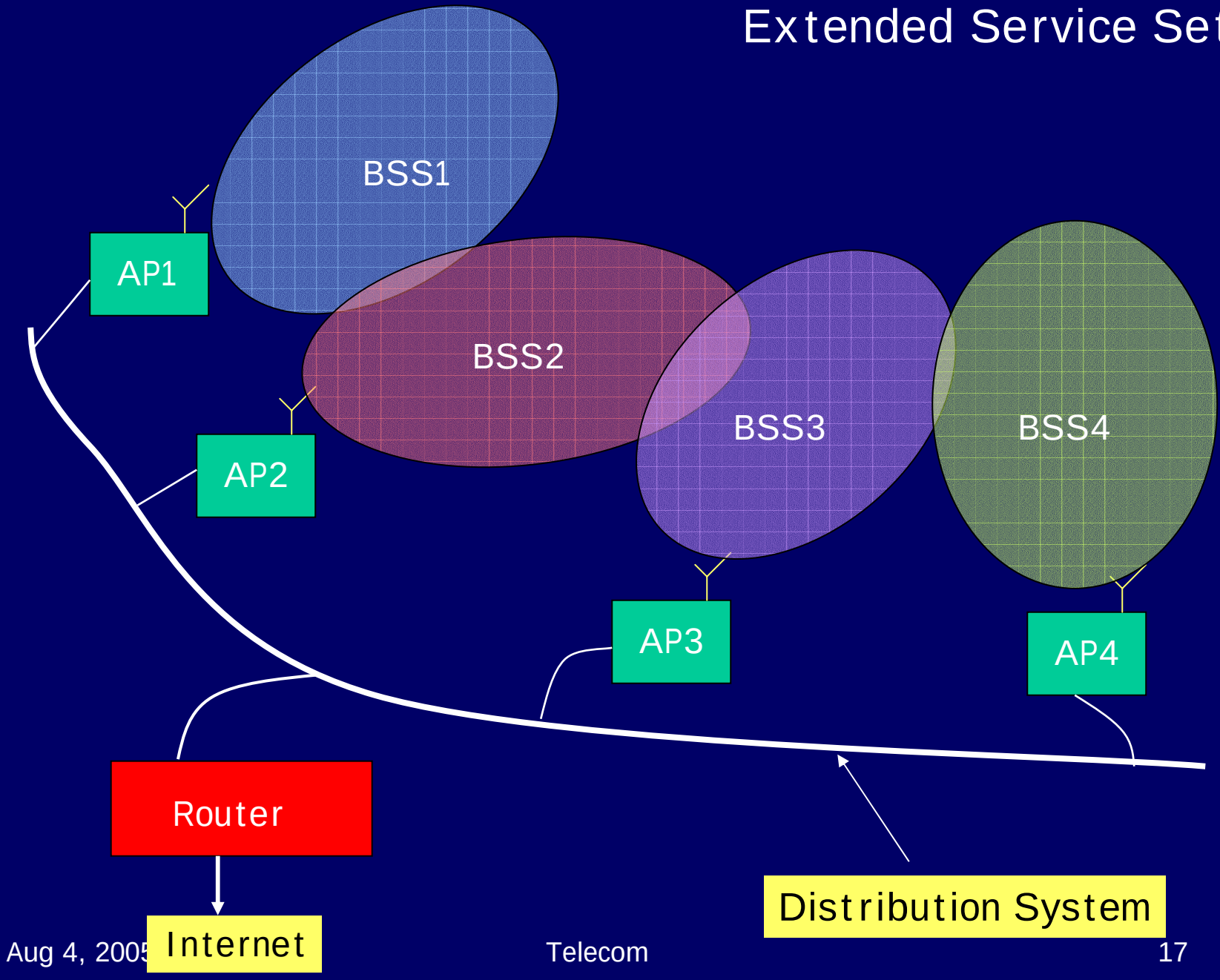
- Operates in 2.4-2.483 GHz
- 11 Mbps max data rate
- Total band of 83 MHz
- 3 non-overlapping channels, each of 20 MHz
- DSSS for the physical layer
- Same MAC layer for 802.11a and b

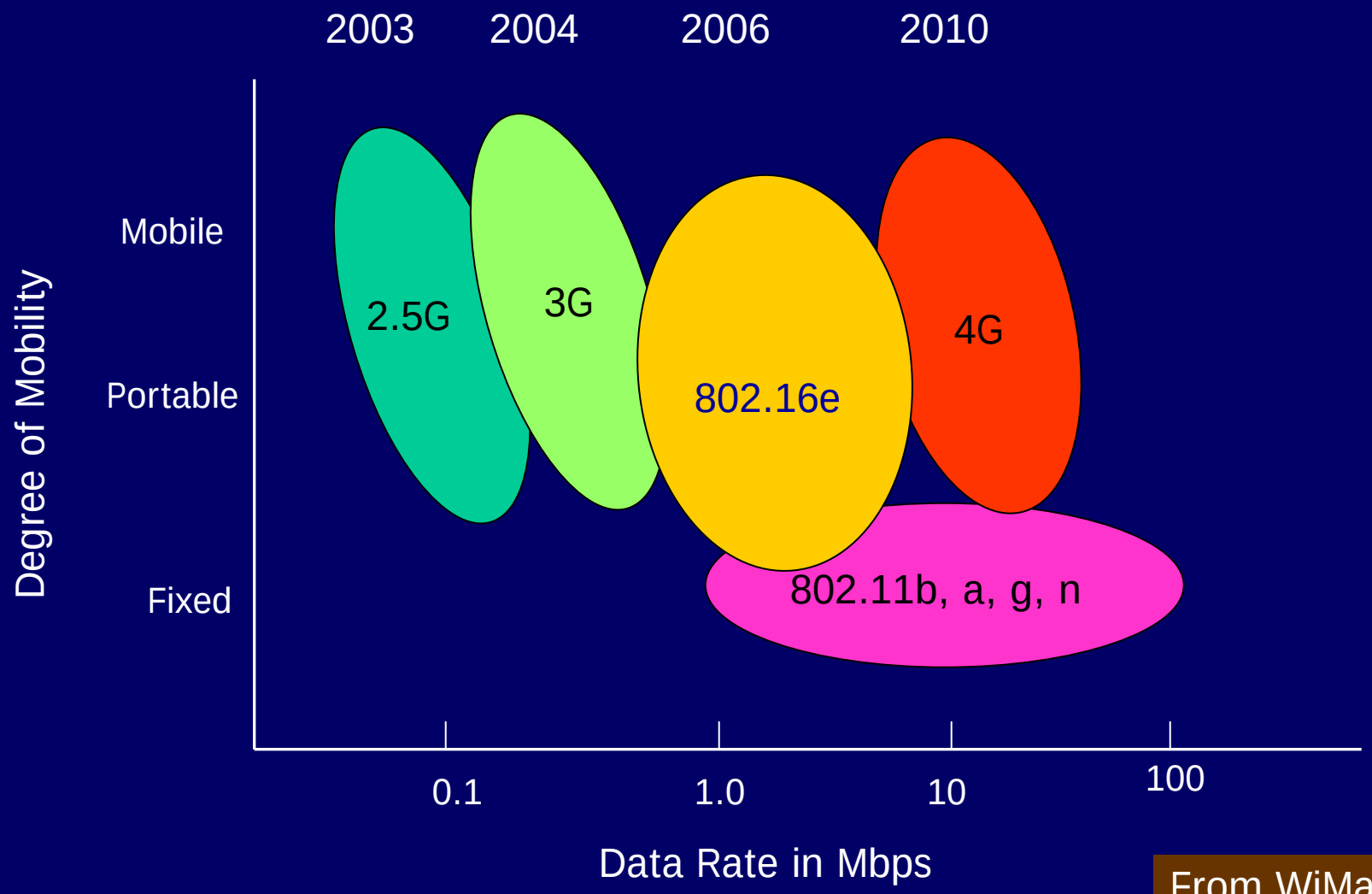
802.11g

- 54 Mbps at 10mts range
- upto 100 mts at lower data rate
- OFDM, and 802.11b MAC

802.11n: 100 Mbps WiFi expected sometime in 2005

Extended Service Set





From WiMax Forum

802.16d --- WiMax – Fixed Wireless

Physical Layer: (Does not use CDMA)

- Designed to operate in the 2-11 GHz band
  - NLOS: 10 km; LOS: 80 km
- Physical Layer:
  - Single Carrier
  - OFDM (256 carriers)
  - OFDMA (2048 carries; subset of this allotted to different users)
    - OFDM helps to better combat multipath interference
    - Higher data rates via higher level modulation (QPSK, 64QAM, etc.)
- Optional: performance enhancement using MIMO (multi-input, multi-output) system and sophisticated equalization
- Uses various channel coding schemes: convolutional codes, Reed-Solomon Codes, Turbo Codes (optional)
- Channel BW: 1.5MHz to 20 MHz, (802.11b has only 20MHz)
- Data rates at 20MHz can vary from 5 Mbps to 70Mbps

802.16e
Mobile Wireless Data Access

- 802.16e standard to be frozen by mid 2005
- At present, several flavors of 802.16e
- Ahead in the race is the Korean standard – WiBro – deployment in 2006
- Right behind is Intel's 802.16e version
- Unlike GSM or CDMA (which are primarily for voice), 802.16e is primarily for data under mobile conditions. Voice will be using VoIP

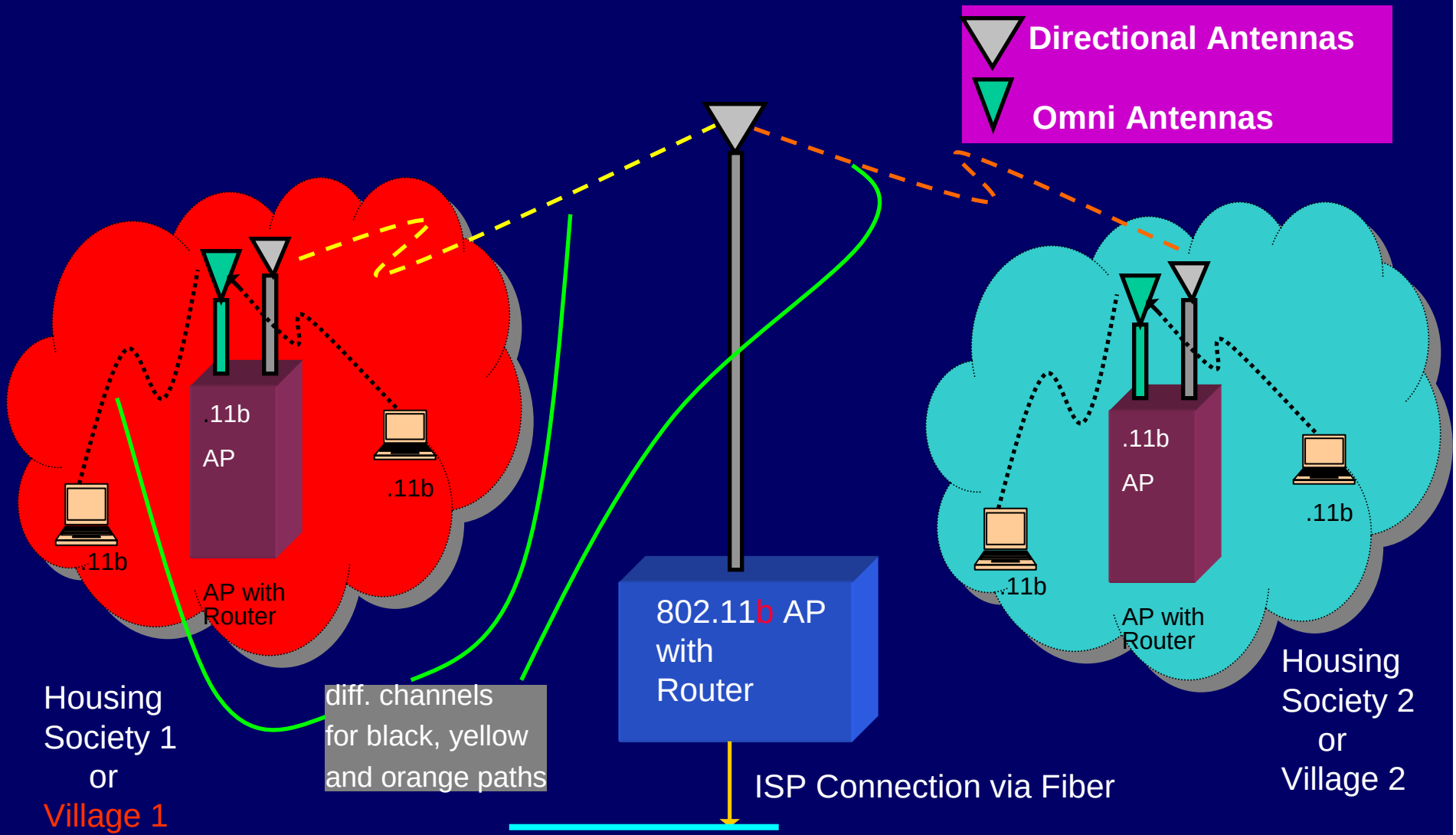
- WiBro
  - Downlink: 18.4 Mbps
  - Uplink: 6.1 Mbps
  - At 60 Km/h: downlink - 512 kbps and uplink – 128 kbps
  - BW: 10 MHz
  - Carrier at 2.3 GHz
  - OFDMA
  - Modulation: QPSK, 16QAM, 64QAM
  - Mobility: Midrange (less than 3G)
  - Cell Coverage ~ 1 Km in urban areas
  - Frequency reuse of 1

Possible Access Model using 802.11b, or 802.11a or 802.16d

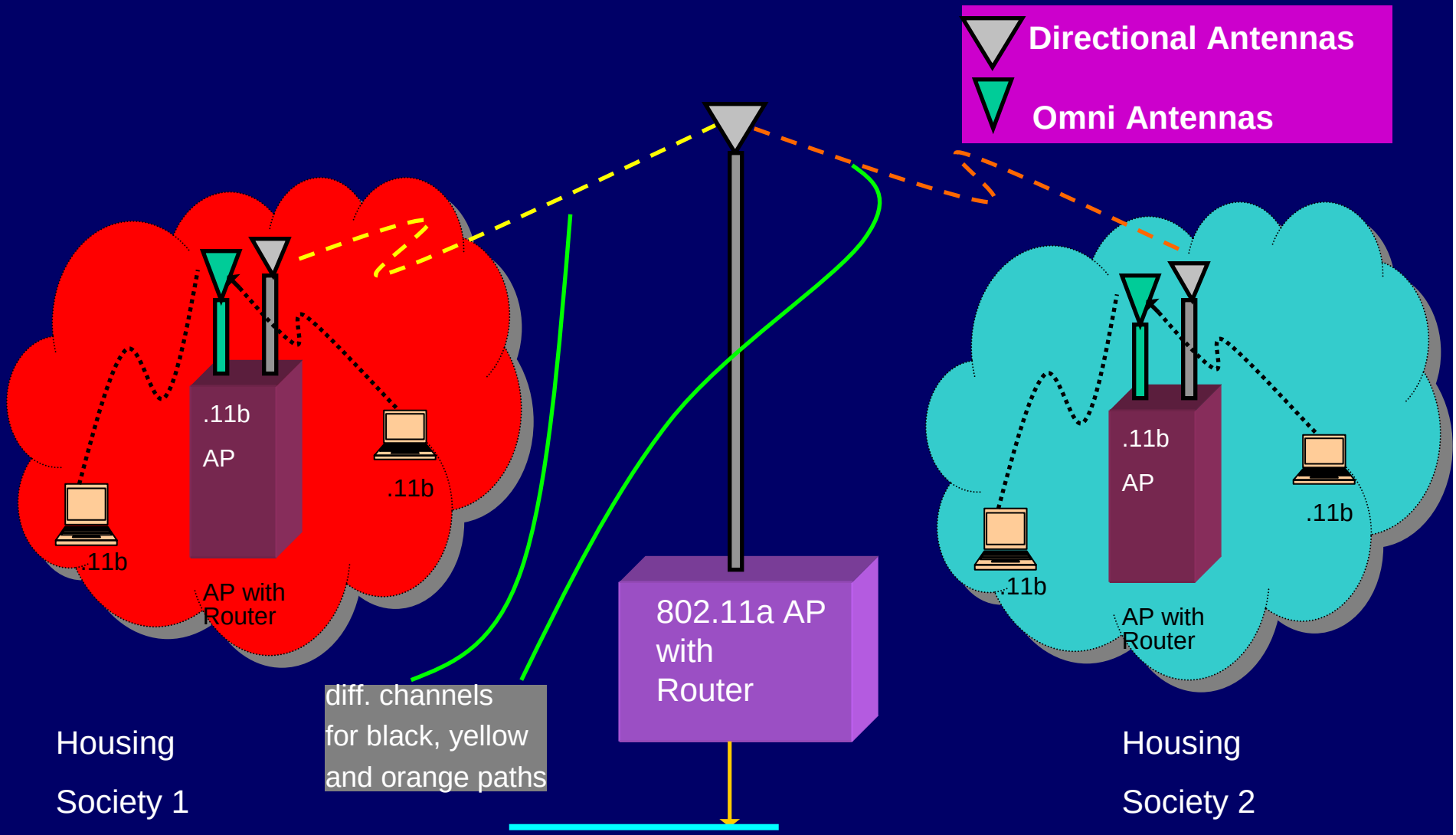
CorDECT (IIT-M, TeNeT Group)

- Earlier version
  - guaranteed 70 kbps
- New version
  - BB CorDECT
  - 2 Mbps
- Always on, supports telephony

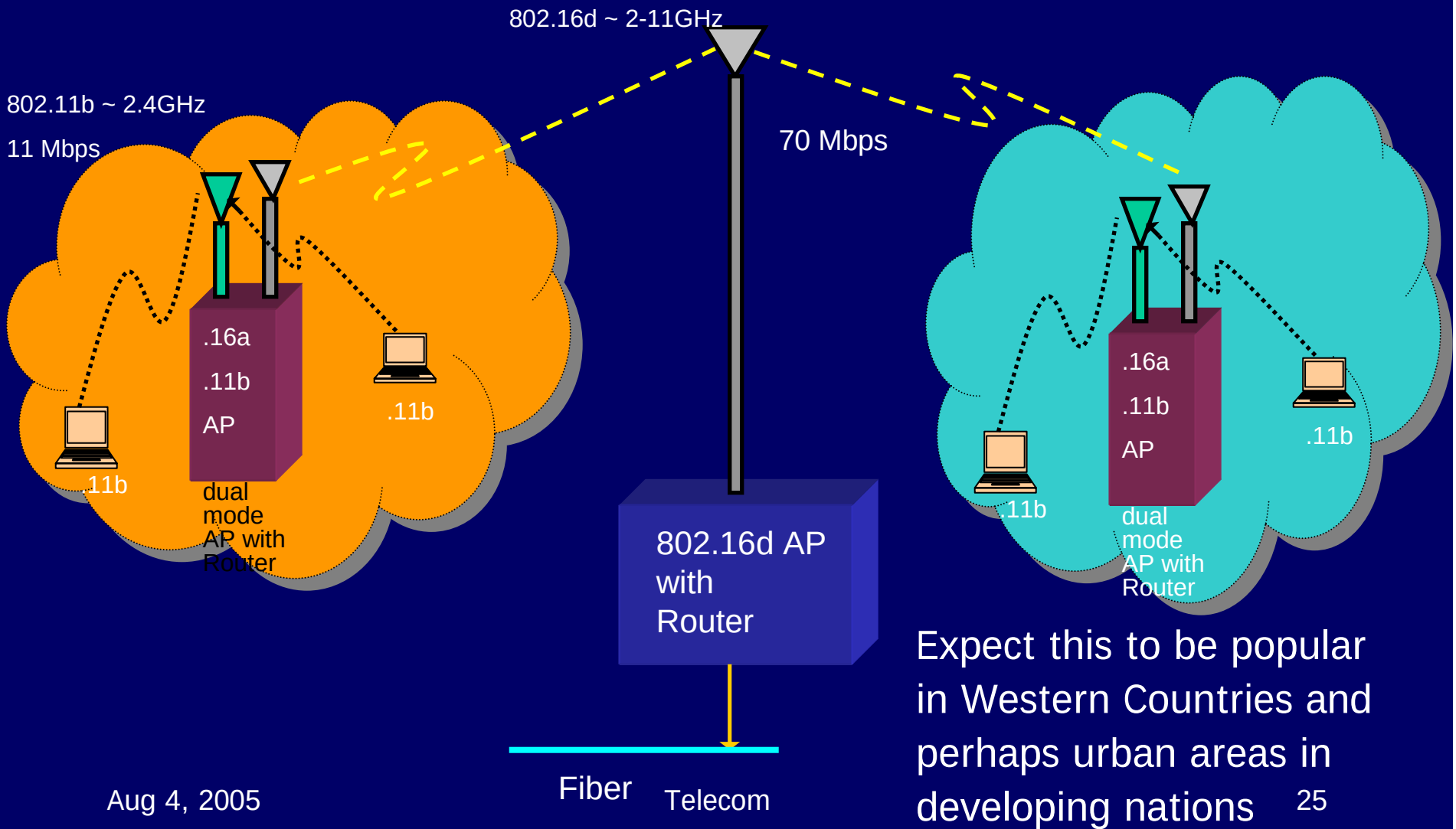
802.11b based Access



802.11a based Access

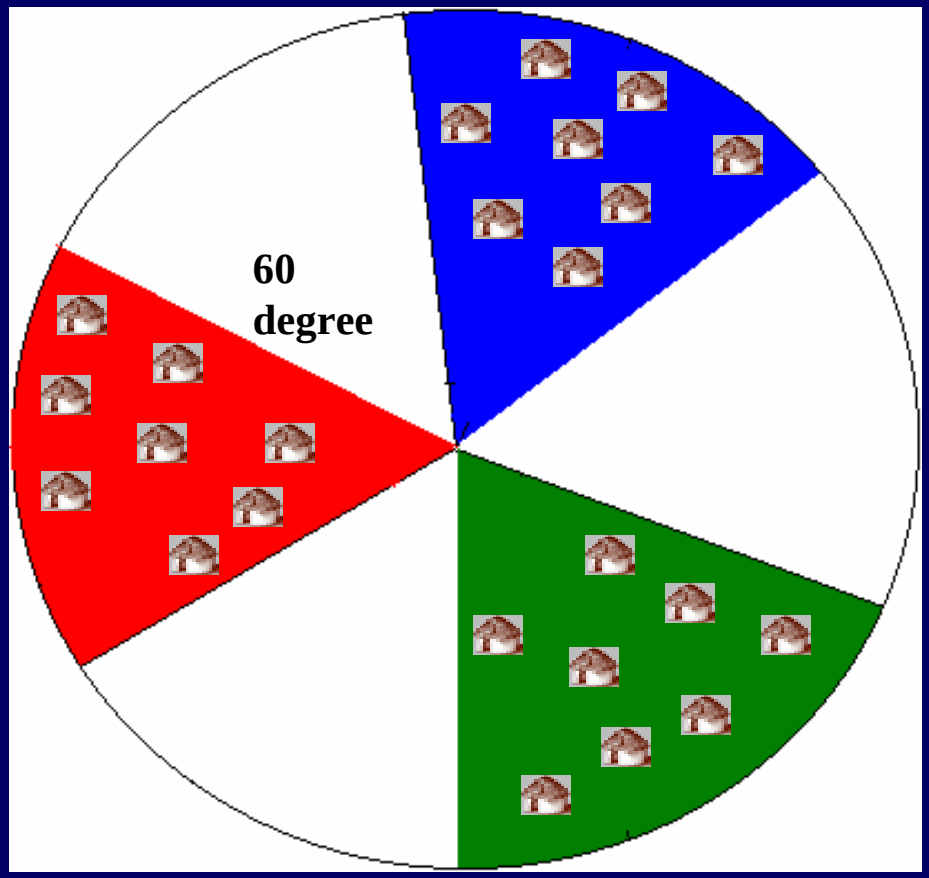


Could use IEEE 802.16d (WiMax) for long links



Expect this to be popular in Western Countries and perhaps urban areas in developing nations

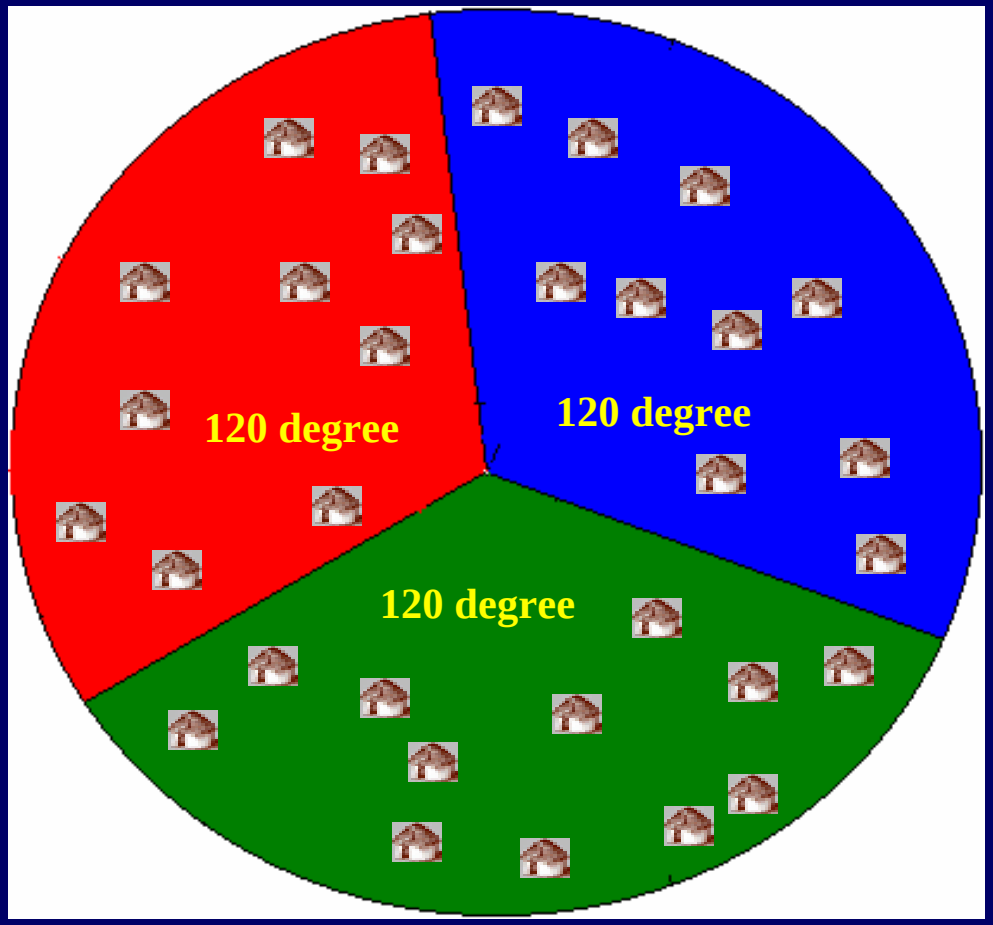
60° Sectoring



- Coverage Area ~ 300 sq. km. (50%)
- No. of villages in each sector ~ 15
- Cost of 60° antenna ~ $1400

Channel1
Channel2
Channel3

120° Sectoring



- Coverage Area ~ 600 sq. km.
- No. of villages in each sector ~ 30
- Cost of 120° antenna ~ $1500

Channel1
Channel2
Channel3

Antenna Assembly

Requirements:

Weather proof

Line of sight

Tower (at base station) - for installing directional antennas at about **50 m** height

Pole (at village node) - for installing directional antennas at about **5 m** height.

May require a small tower at the village node depending on the terrain

Cost

Antenna (16 dBi directivity gain):

20° ~ **$400**, 60° ~ **$1400**, 120° ~ **$1550**

Antenna Connectors and cables ~ $150

Tower ~ **$4000**

Pole ~ **$200**

Amortized cost over 45 villages

- Cost per village kiosk for connectivity. Amortization includes cost for the base station, tower, antenna assembly, poles, and 802.11b solution. Does not include cost of PC, printer, battery back up, since these remain the same irrespective of the access technology.

	1x for imported component	2x for imported components
802.11b Solution	$776	$1,102
Cisco Aironet Bridge	$1,729	$3,290

Some Remarks

- Power consideration will make WiMax system heavy duty, and expensive
- WiMax has a complex physical layer (compared to .11b):
  - Needs to support single carrier, OFDM, and OFDMA
- Multiple mandatory modulation options:
  - QPSK, 16QAM on uplink as well as downlink
  - BPSK for uplink
  - 64 QAM for downlink
- QOS a must in WiMax
- Much more complex MAC
- **Bet is on 802.16e as the future**