

Access Networks

- Introduction
- Cable television
- Digital subscriber lines
- UMTS
- Digital television
- Conclusions

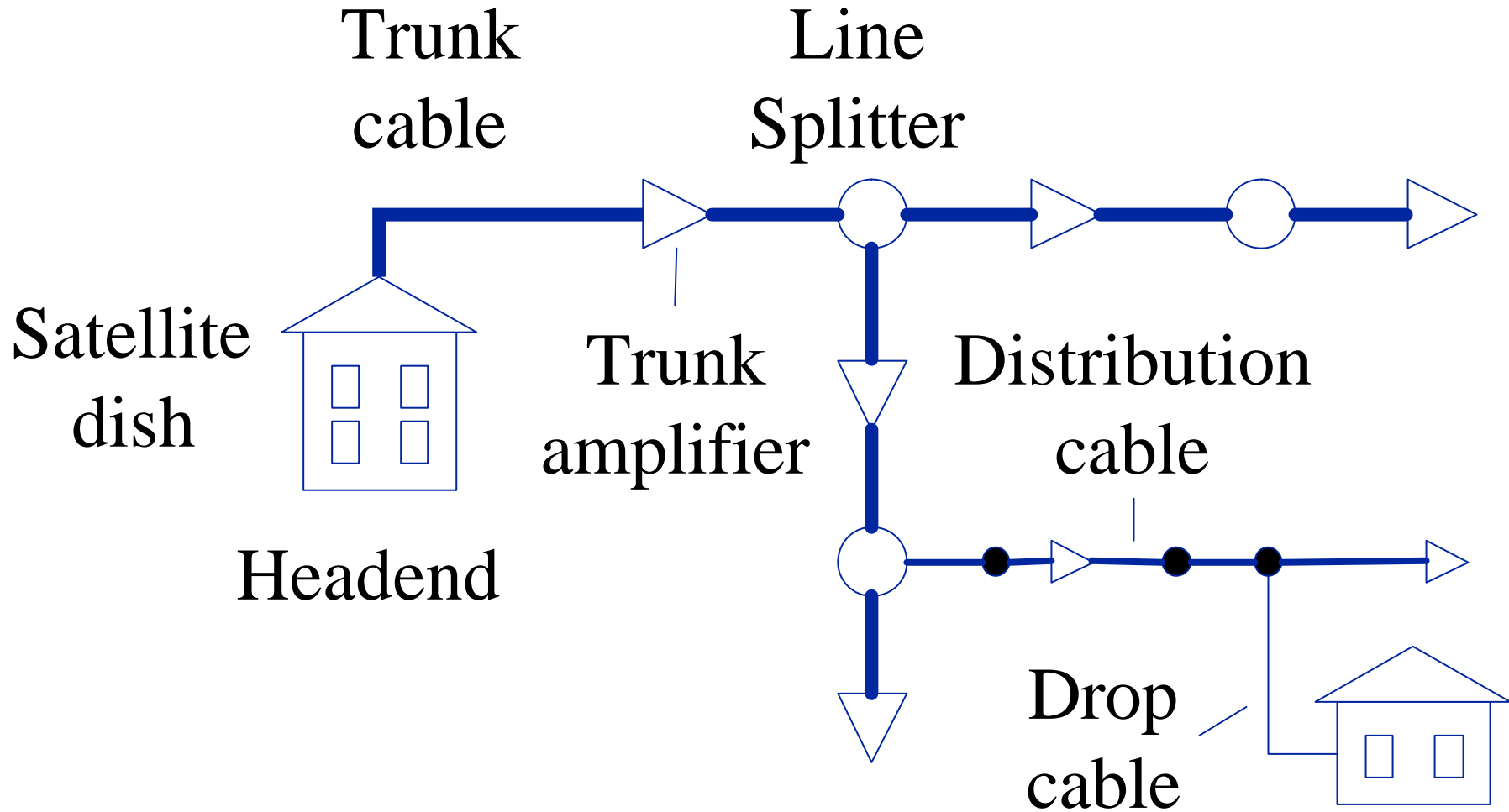
Introduction

- Wideband networks do not reach homes
- Fiber is too expensive to be installed everywhere
- Current networks have to be made wider
 - + cable, ADSL, digital TV, electric network
- Mobile users need a wireless network
 - + UMTS
- In addition, the home networks have to be renewed
 - + wireless local area networks (WLAN), Firewire

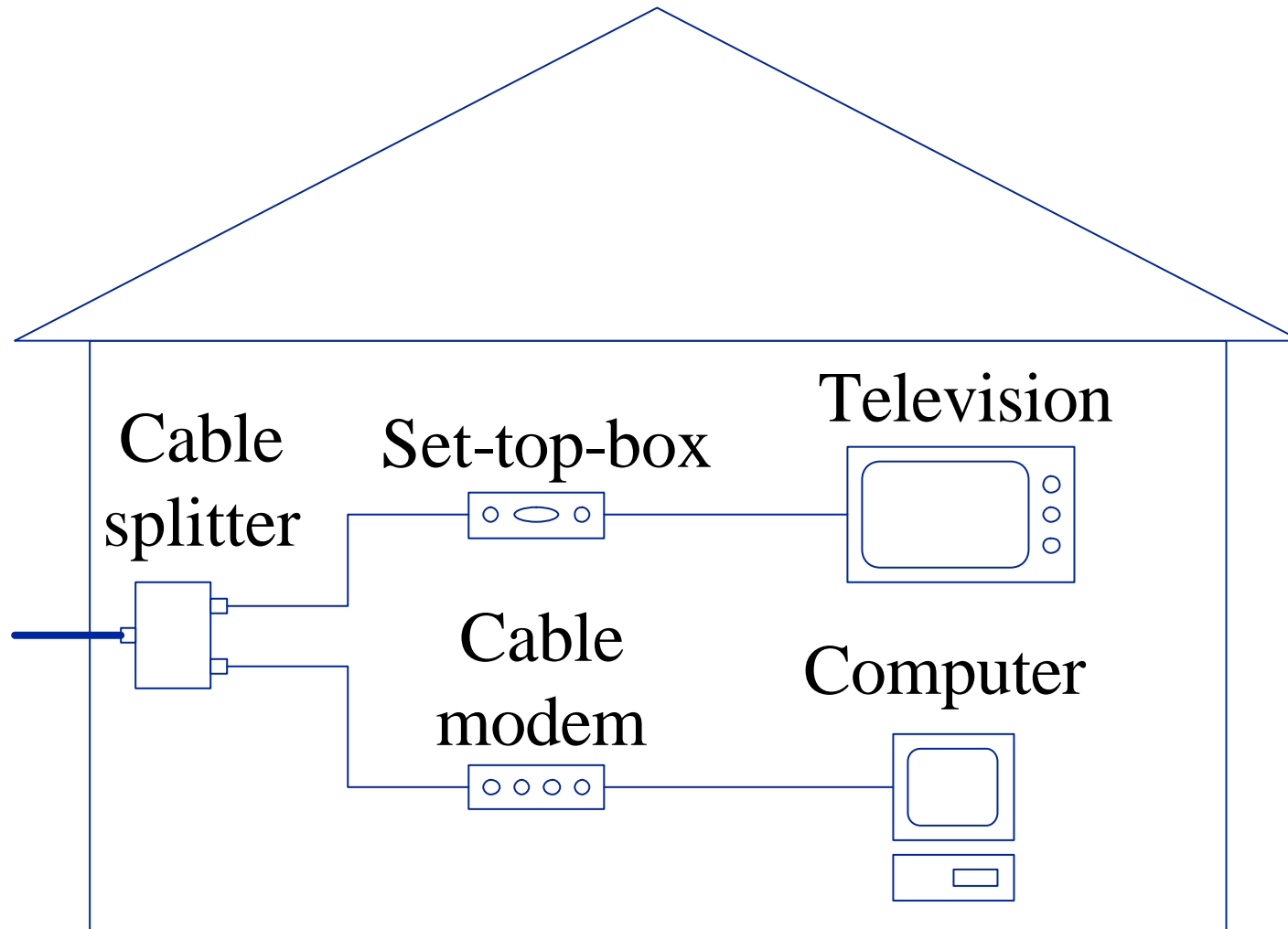
Cable television

- Community Antenna Television (CATV)
- In Finland, about 900 000 households are connected to cable TV system
- Several operators (e.g., local telephone operators)

Architecture



Home cable modem interface



Hybrid network

- Originally fully coaxial cable
- Since 80s also optical fiber
- Hybrid Fiber Coax (HFC)
- NTSC signal requires about 4.3 MHz
- To prevent overhearing 6 MHz per channel used
- Depending on the quality of the network different systems can be implemented

Different systems

Size	Band	Frequencies	Channels
Small	170 MHz	50 – 220 MHz	12 – 22
	220 MHz	50 – 270 MHz	30
Middle	280 MHz	50 – 330 MHz	40
	350 MHz	50 – 400 MHz	52 / 104
Large	400 MHz	50 – 450 MHz	60 / 120
	500 MHz	50 – 550 MHz	80
	700 MHz	50 – 750 MHz	110
	950 MHz	50 – 1000 MHz	150

Data service

- Cable network is originally unidirectional
- Data services requires bi-directional connection
- Amplifiers have to also bi-directional
- Optical fiber should come closer to consumer
- Fiber to the Home (FTTH)
- Fiber to the Neighborhood (FTTN)
 - + Fiber to the Curb (FTTC)
 - + Fiber to the Basement (FTTB)

New services

- A cable modem is required for bi-directional data services
- In addition cable network should be updated
 - + amplifiers bi-directional
 - + modem banks installed
- Allows the use of Internet, video-on-demand, etc.

Cable modems

- Most of the cable modems support bi-directional communication
 - + different speed downlink and uplink
- Some modems can be used also for telephony
- Some modems use telephone line for uplink
 - + cable network can remain unidirectional

Standards

- Compatibility between different manufacturers can be quarantined with standards
- Two standards in use:
 - + DVB (Europe)
 - + DOCSIS (USA); also EuroDOCSIS version
- Final decision about the standard in Finland has not yet been made

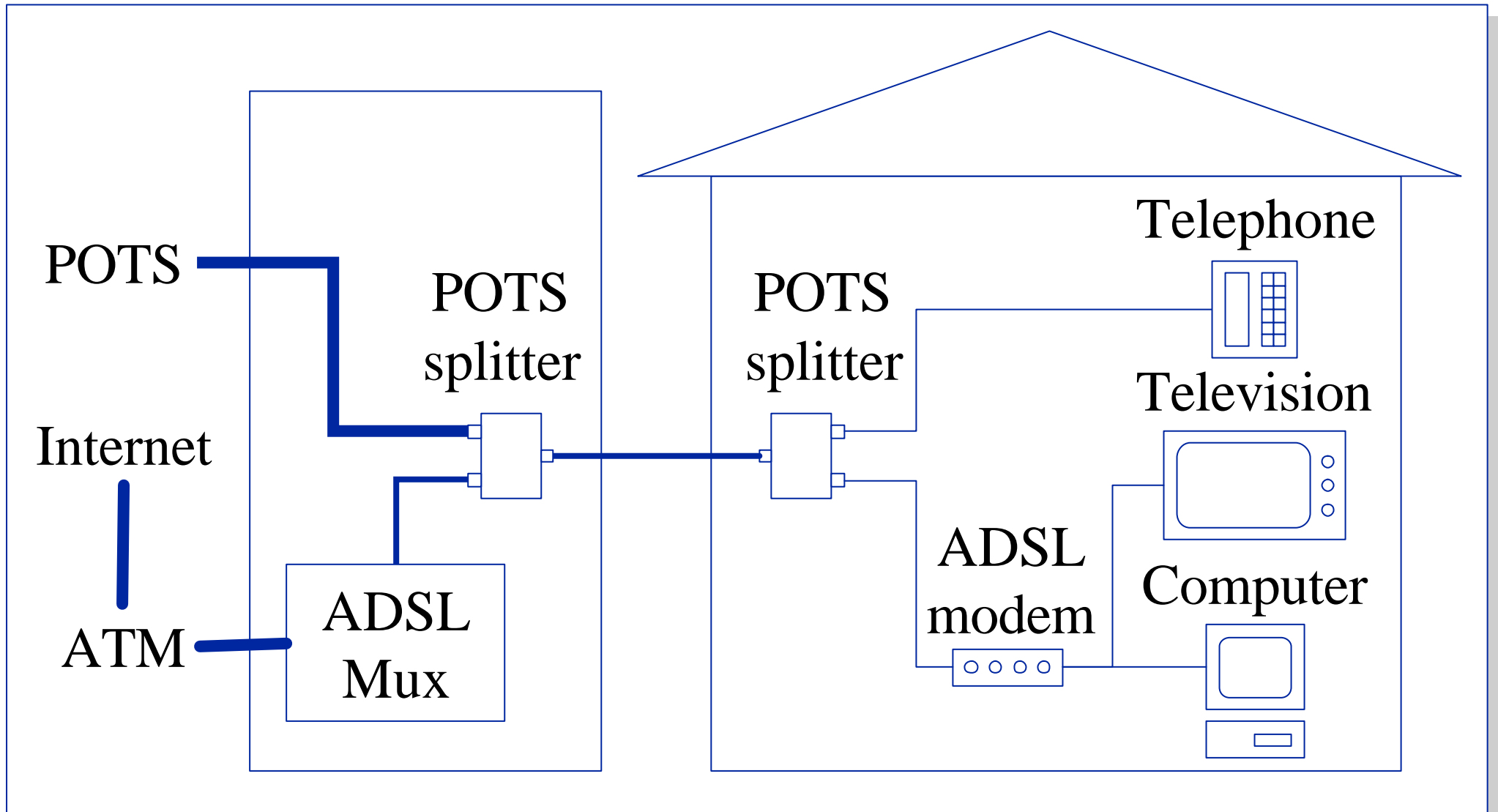
HTV cable modem service

- Welho 525:
 - + Subscription 30 €
 - + Monthly fee 25 €/month
 - + Cable modem rent 6 €/month
 - + Together 31 €/month

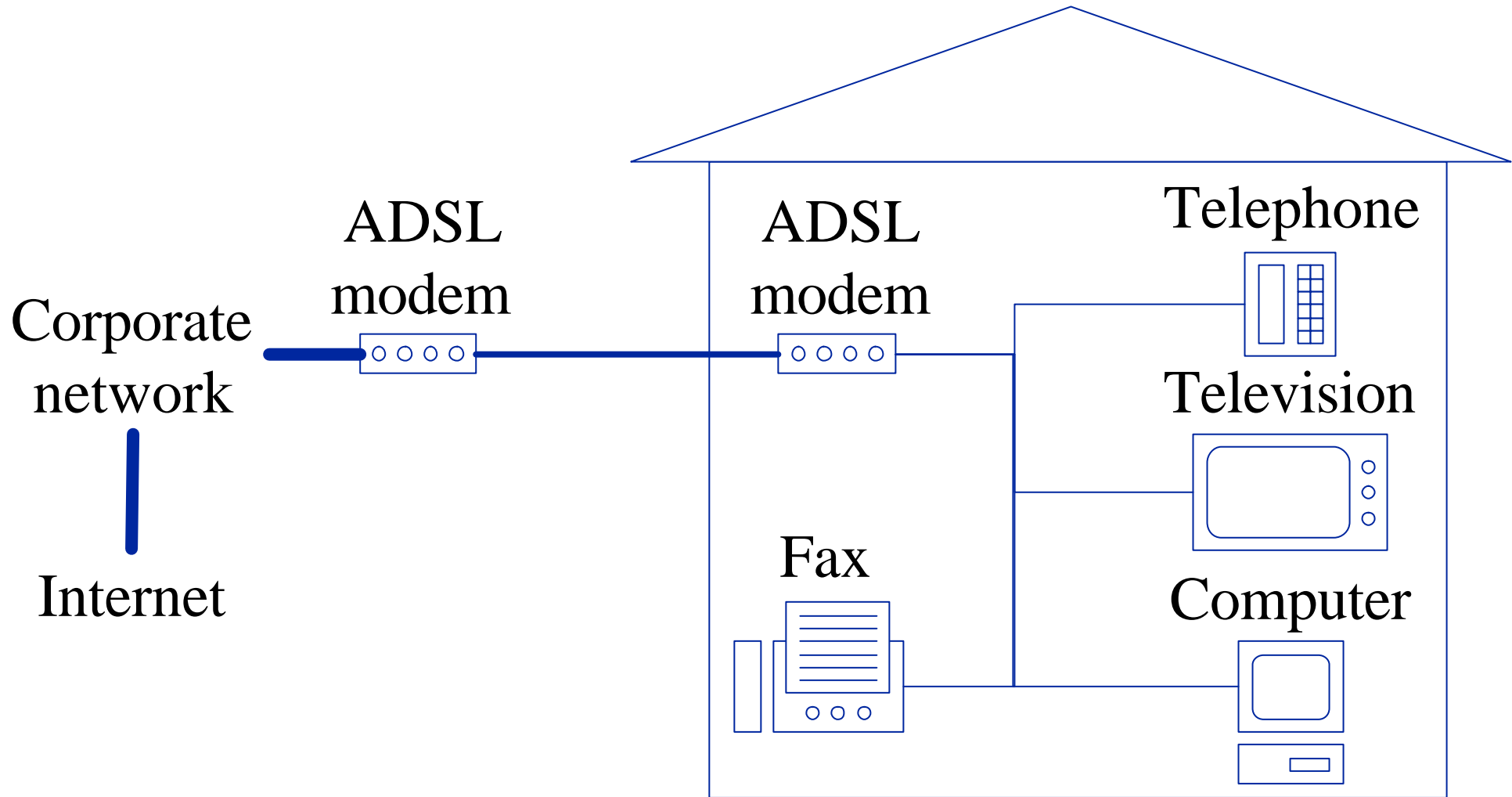
Digital subscriber lines

- Digital subscriber lines use existing telephone twisted pairs
- Modems are based on efficient signal processing
- Digital subscriber lines bring wideband connections to homes
- The technology can also be used in small offices / home offices (SOHO)

Home ADSL connection



SOHO ADSL connection



Different techniques

- IDSL = ISDN
- ADSL = Asymmetric DSL
- R-ADSL = Rate Adaptive ADSL
- HDSL = High Bit-Rate DSL
- SDSL = Symmetric DSL
- VDSL = Very High Bit-Rate DSL

Distance / Speed

Distance	Speed
5 500 m	1.544 Mbps
4 900 m	2.048 Mbps
3 700 m	6.312 Mbps
2 700 m	8.448 Mbps
1 400 m	12.960 Mbps
900 m	25.820 Mbps
300 m	51.840 Mbps

ADSL and R-ADSL

- ADSL has asymmetric connection
- 1.5 - 8 Mbps downlink
- 16 - 640 kbps uplink
- R-ADSL adjusts the used frequencies (i.e., rate) automatically

HDSL and SDSL

- HDSL is already in wide use (business)
- Symmetric connection
- Requires two (1.544 Mbps) or three (2.048 Mbps) twisted pairs
- SDSL uses only one twisted pair (i.e., single line)
- SDSL has shorter distance

VDSL

- Asymmetric connection
- 13 - 52 Mbps downlink
- 1.5 - 2.3 Mbps uplink
- Speed depends heavily on distance

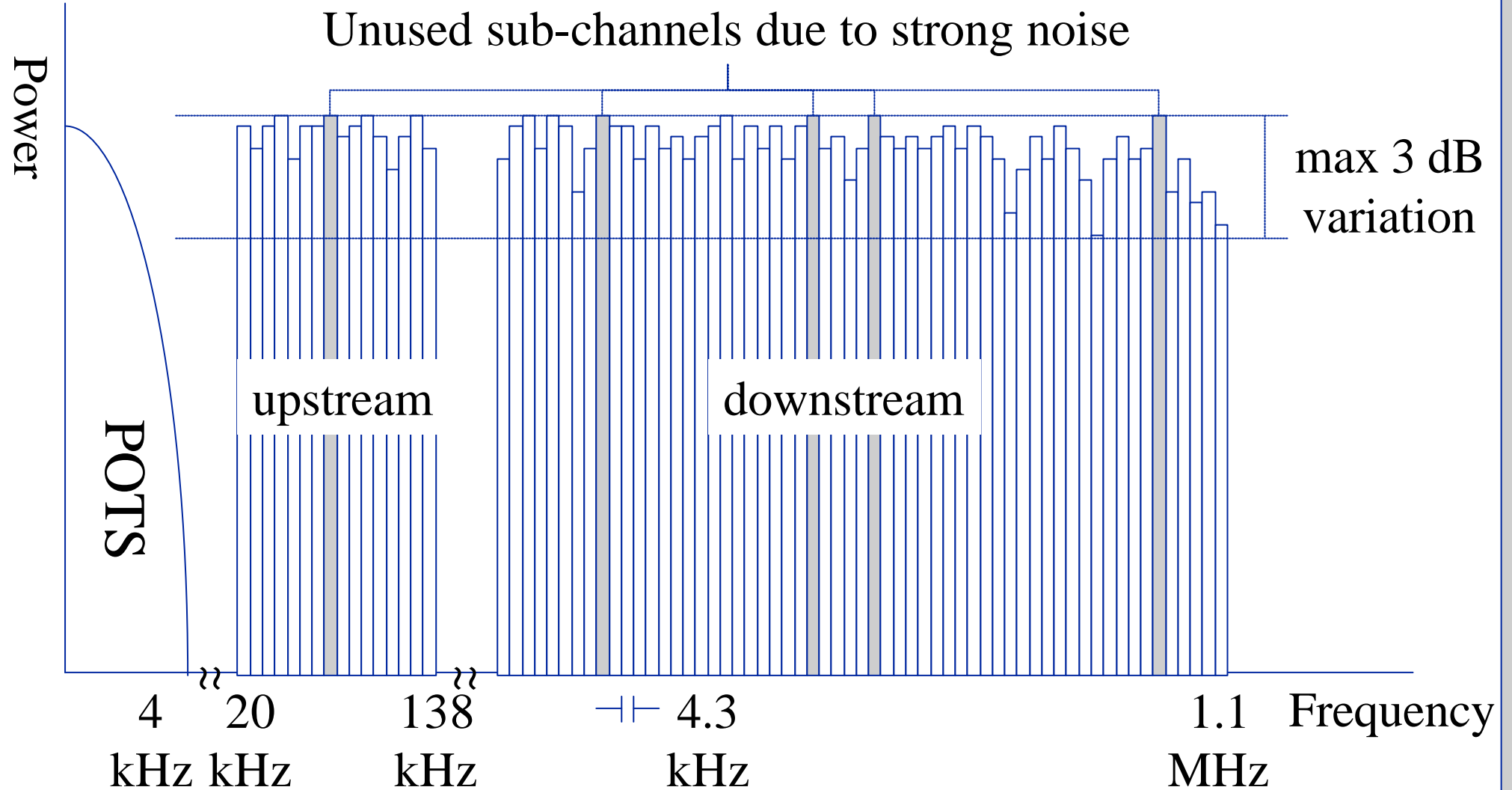
xDSL modems

- Two competing technologies
 - + Discrete Multitone (DMT)
 - + Carrierless Amplitude Phase (CAP) Modulation
- Both are based on Quadrature Amplitude Modulation (QAM)
- DMT is much more efficient, but also harder to implement

xDSL modems (cont.)

- In DMT, the frequency band is divided into 256 sub frequencies (4.3 kHz)
- Each sub frequency has its own transfer rate
- The frequency band can be divided into telephone, downlink, and uplink traffic

Discrete multitone modulation



Elisa Communications ADSL

- Subscription 78 €(offer 8 €)
- Monthly fee

Speed	Fee
256/256k	19.90 €/month
512k/512k	24.90 €/month
1M/512k	36.00 €/month
2M/512k	49.00 €/month
8M/1M	59.00 €/month

HomePNA

- With HomePNA different apartments can share the same broadband connection
- Based on Ethernet technology
- Physical layer is telephone cable (4-10 MHz)
- HomePNA 1.0: 1 Mbps (150 m)
- HomePNA 2.0: 10 Mbps (350 m)
- Separate adapter or converter required per each apartment

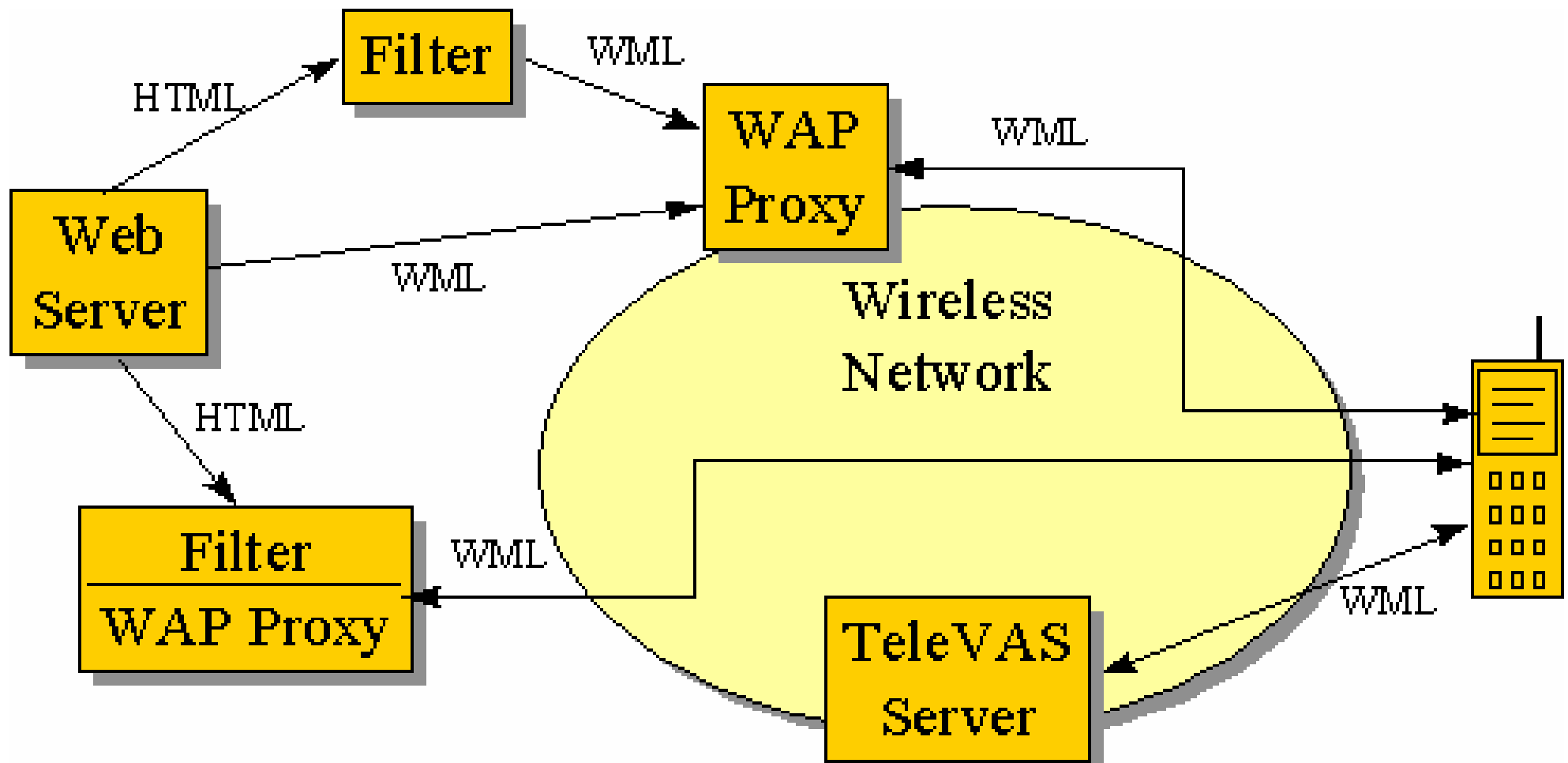
UMTS

- UMTS is the 3rd generation mobile phone system
- There should be enough bandwidth for multimedia services
- Transfer to UMTS systems is commonly seen as evolution
 - + GSM 2+, WAP, HSCSD, GPRS, EDGE
 - + WCDMA, UMTS

GSM phase 2+

- **ASCI**: group and broadcast calls
- **GPRS**: packet radio
- **HSCSD**: several data channels (max 64 kbps)
- **CAMEL**: central services
- **EFR**: better voice quality
- multifrequency phones (GSM/DCS1800)
- multistandard phones (GSM/DECT)

WAP



HSCSD

- High Speed Circuit Switched Data
- Allows the use of more than one GSM data channel at the same time
- In Finland, the service is offered by Sonera
- Requires support from mobile phone
- E.g., Nokia Card Phone 2.0
 - + standard speed 14.4 kbps
 - + triple speed even 43.2 kbps

GPRS

- General Packet Radio System
- Based on packets - not switched circuits
- Connection is always on and switching is faster
- GPRS uses one GSM radio channel (200 kHz)
 - + Capacity of radio channel is 271 kbps, which is divided into eight 34 kbps data channels
 - + After protocol and error correction speed is 14.4 kbps
 - + GPRS can use all data channel at the same time
 - + capacity is over 100 kbps

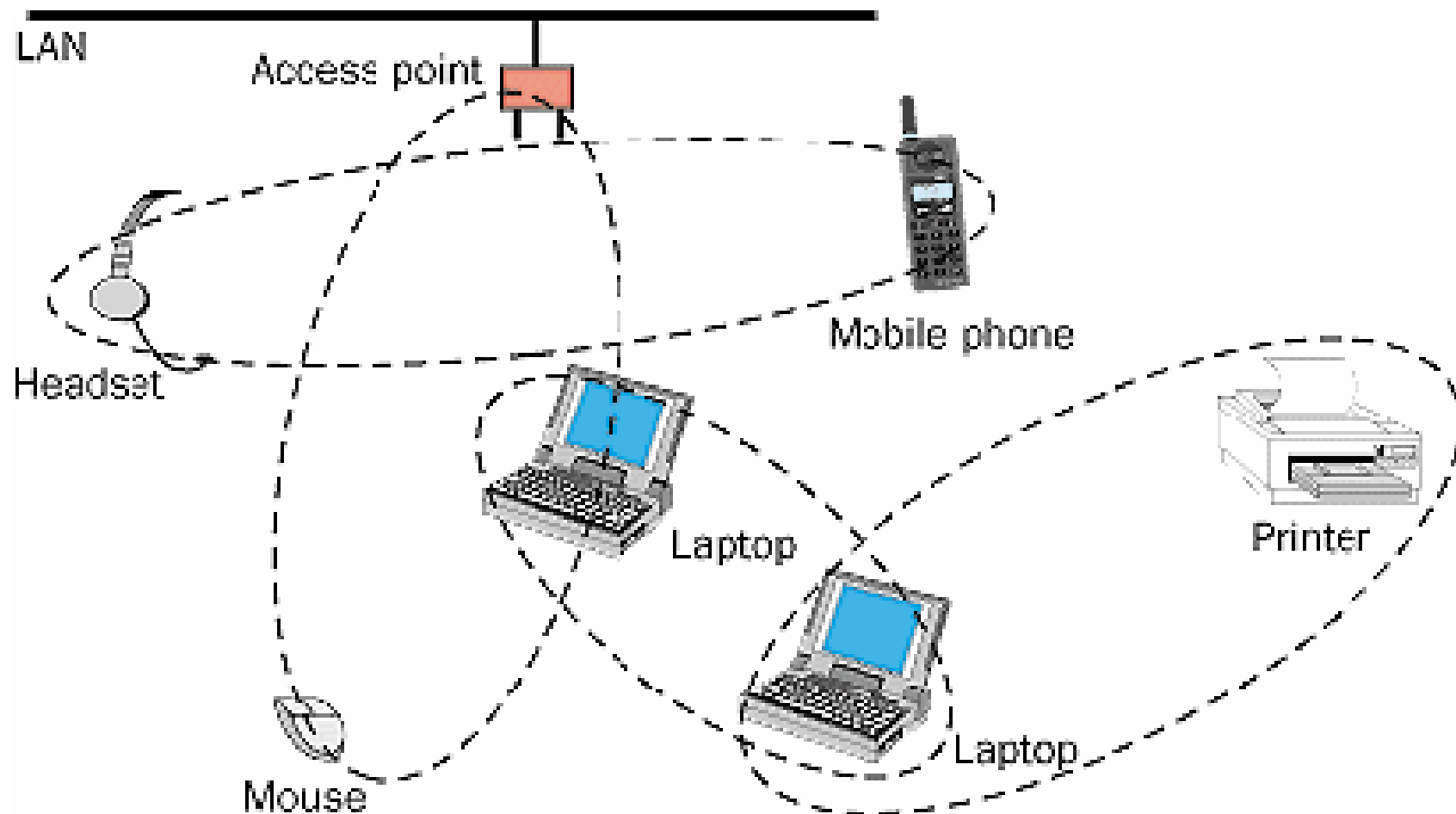
EDGE

- Enhanced Data Rates for Global Evolution
- Packet traffic max 473 kbps
- Circuit switched traffic max 64 kbps

Bluetooth

- Close range (10-100m) wireless communication
- Radio frequency 2.4 GHz and frequency hopping
- Two data channels
 - + synchronous 64 kbps (max. 3)
 - + asynchronous 721/57.6 kbps (asymmetric) or 432.6 kbps (symmetric)
- Different devices can be connected as piconet
- More than one piconet make scatternet

Scatternet



3rd generation mobile phones

- ETSI: Universal Mobile Telecommunications System (UMTS)
- ITU: International Mobile Telecommunication 2000 (ITM-2000 / previously FPLMTS)
- ARIB: Association of Radio Industry Business

UMTS (technology)

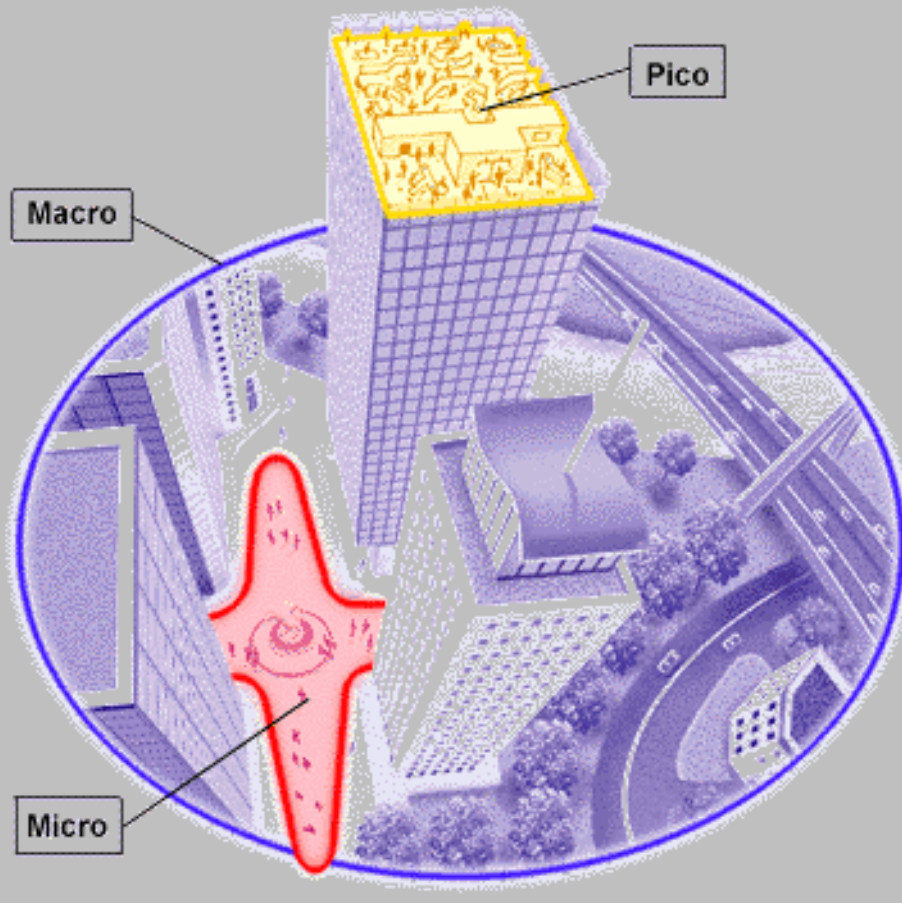
- 3rd generation services and system
- Open standard for operators and manufacturers
- Evolution path from current systems (GSM, DCS1800, and DECT)
- Speed up to 2 Mbps
- Restricted use in 2002-3
- Full service 2005

UMTS (services)

- Mobile: good speech quality and wide range
- PMR: private radiophone systems
- Peeper: small receiver and global use
- Wireless phone: excellent capacity in limited area
- Satellite: Global use everywhere
- Airplane: possible

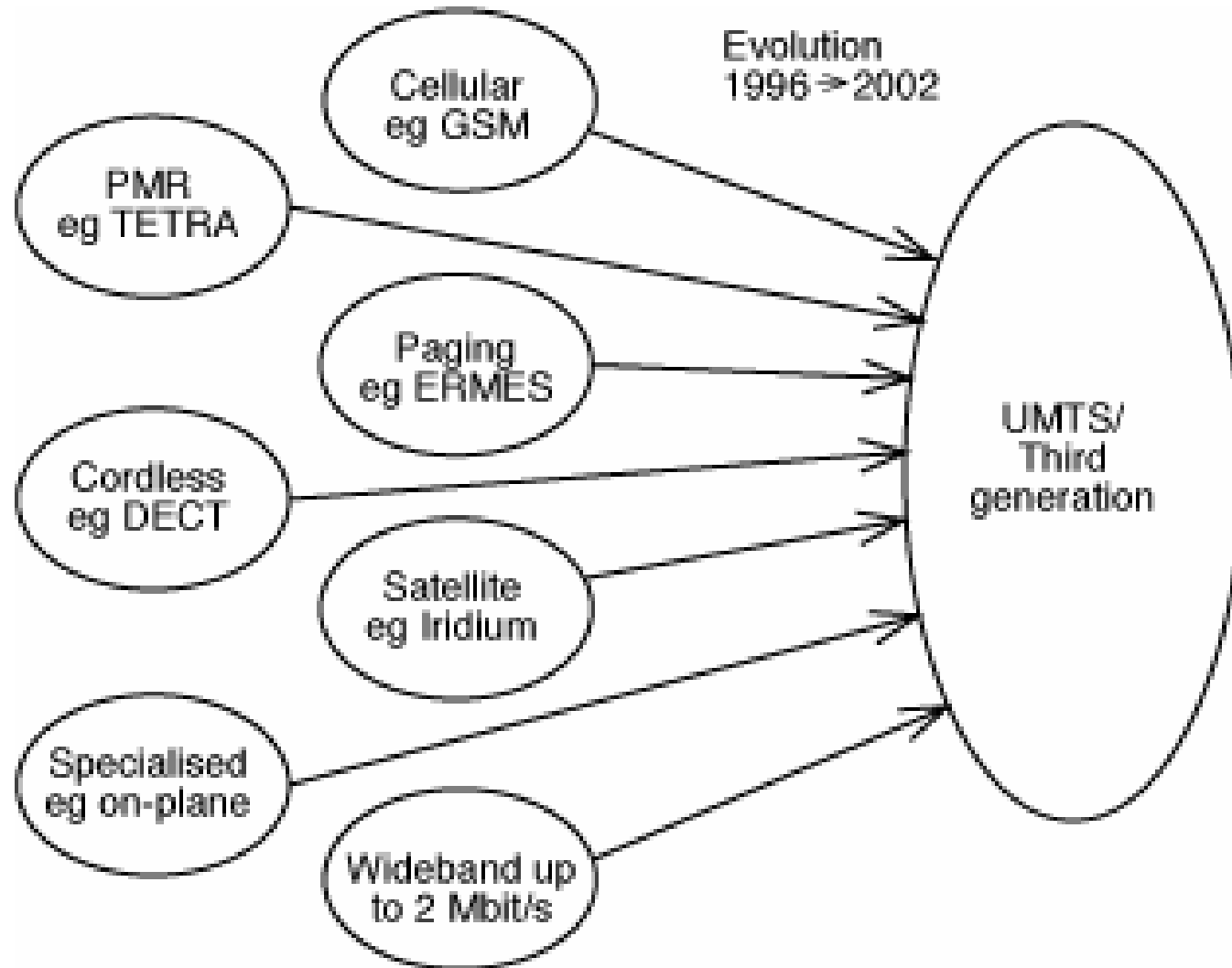
UMTS (cells)

The principle behind hierarchical cell structure

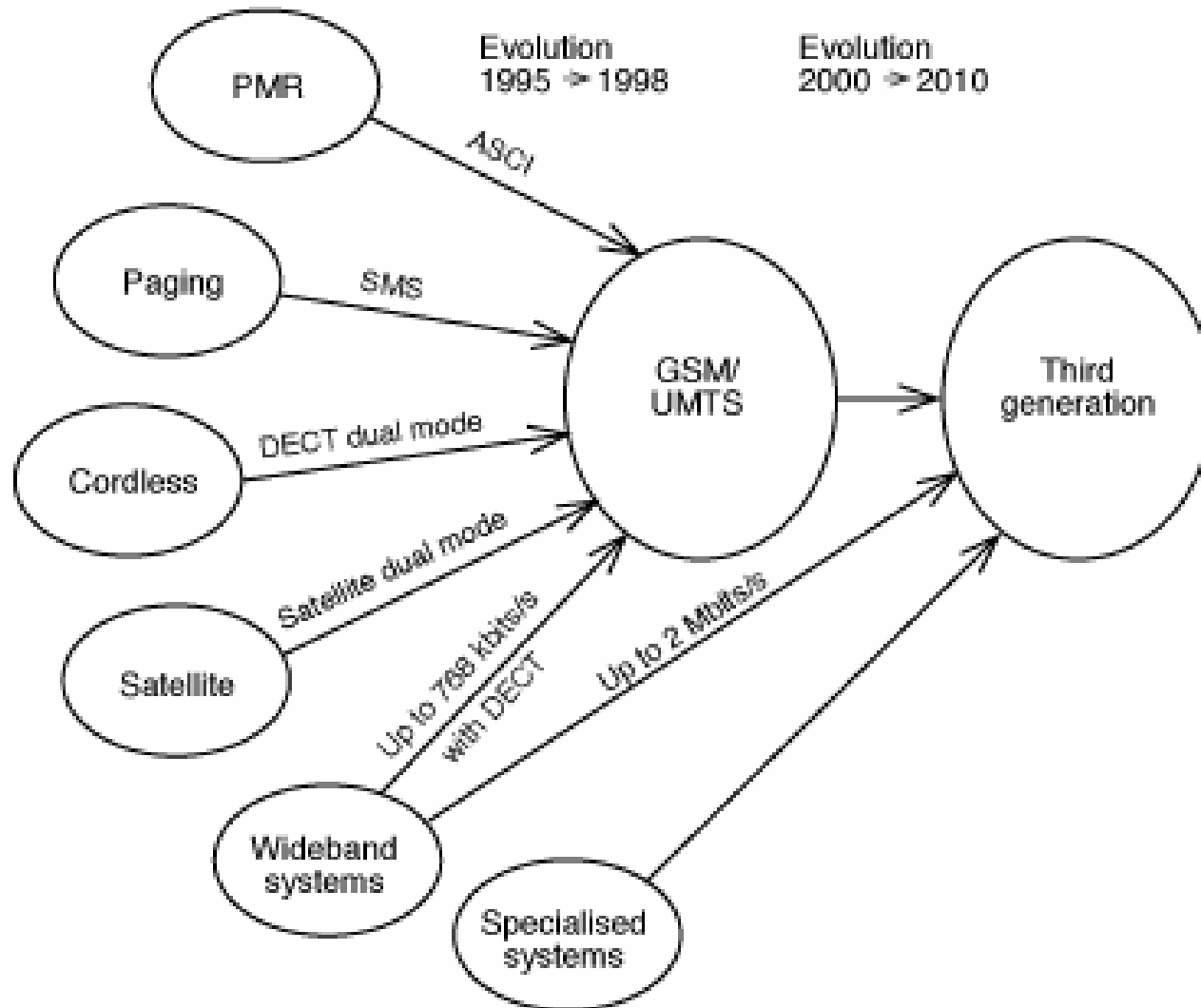


- satellite: country
- macro: < 30 km
- mini: < 3 km
- micro: few streets
- pico: office room, train, airplane, etc.

UMTS (development)



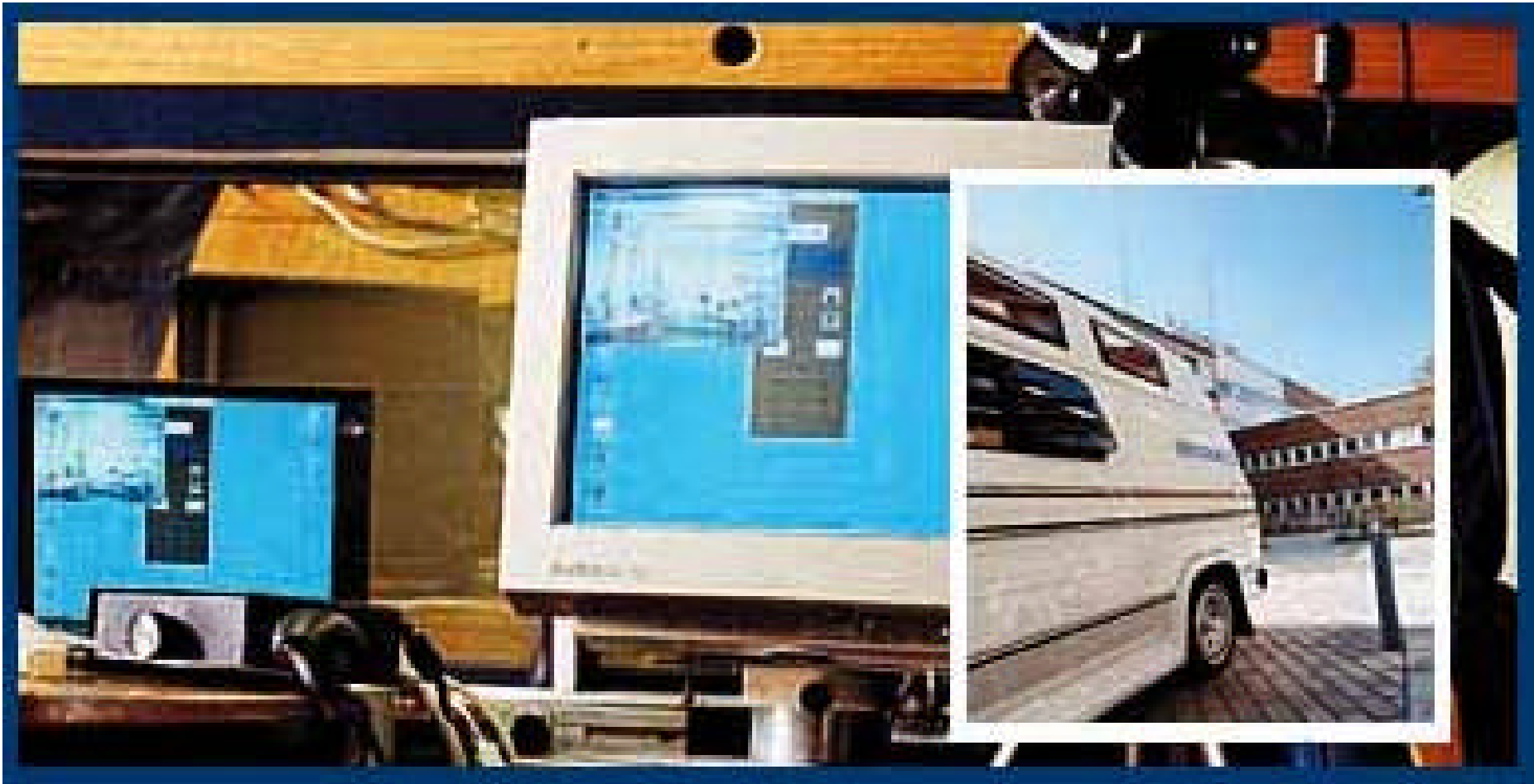
UMTS (evolution)



Competing proposals

- USA:
 - + CDMA and IS-41 (AMPS)
- Nokia, Ericsson, and NTT-DoCoMo:
 - + WCDMA and GSM
- Alcatel and Siemens:
 - + TCDMA and GSM

WCDMA



Ericsson's WCDMA Test Bed in Sweden

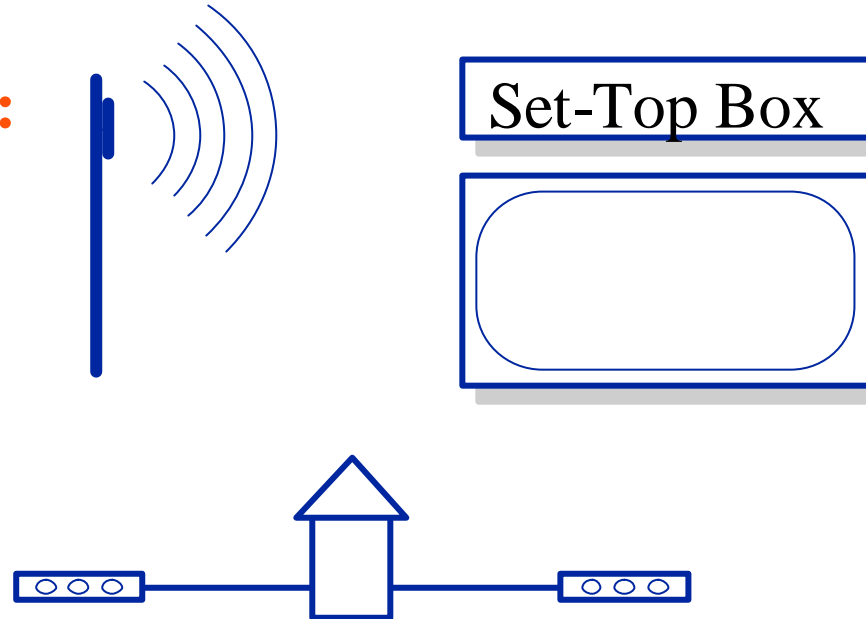
WCDMA (technology)

- Frequency 2 GHz and band 5 Mhz
- 8 - 384 kbps outside and max 2 Mbps indoors
- 50 packet data users or 100 calls
- Transport ATM Adaptation layer 2 (AAL.2)
- Adaptive Antenna Arrays
- Hierarchical cells

Digital television

Digital broadcasts:

- more channels
- better quality



Set-top box:

- cheap computer
- multimedia

Return channel:

- Interactive services
- Internet

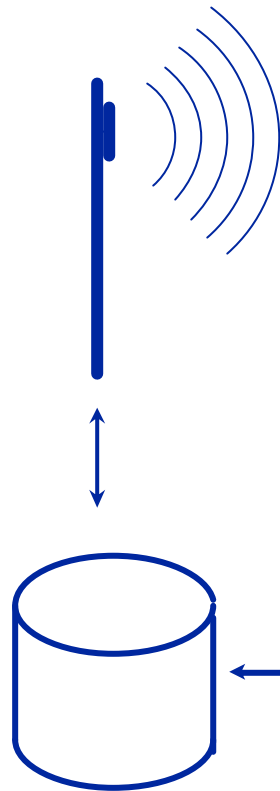
Technology

Broadcast:

- terrestrial
- cable
- satellite

Databases:

- content
- services
- users
- billing



Network

- Internet
- ATM

Set-Top Box



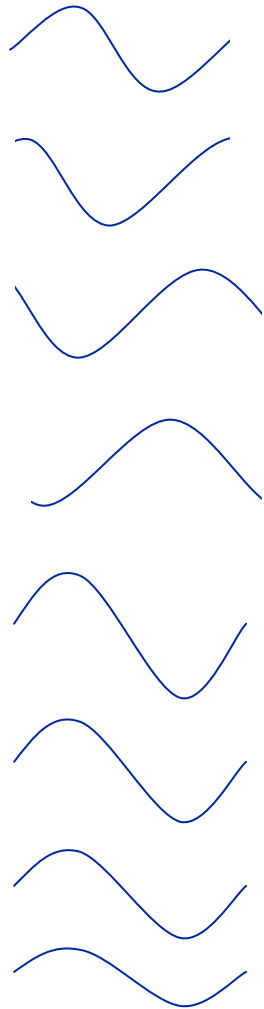
Return channel

- analog modem
- xDSL
- cable modem

Transmission technology

- Digital television uses MPEG2 encoded video signal
- Transmissions use several technologies
 - + modulation
 - + error protection
 - + multi carrier
 - + one or multi frequency network
- Depending on chosen parameters the capacity is 4.98 - 31.67 Mbps

Modulation



- Based on advanced modulation
 - + QPSK
 - + 16-QAM
 - + 64-QAM
- By changing both signal phase and amplitude 4, 16, or 64 bits can be sent at once

Multi carrier

- Multi carrier transmissions use several adjacent frequencies at the same time
 - + 2 K
 - + 8 K
- Transmission is composed of bursts (i.e., symbols) and protection zones
- Because of this reflection do not cause problems

Transmission capacity

- In practice the capacity of one transmitter (i.e., mux) is over 20 Mbps
- One “television channel” requires 4-5 Mbps and “high definition TV” 10-15 Mbps
- In Finland, 3 transmission networks (i.e., 12 “digital” channels) will be build
- Same frequency can be used (SFN/MFN)
- Satellite and cable transmissions use wider frequency band and have more capacity

Receivers

- At least in the beginning, the receivers will be separate set-top boxes
- The terminal demodulates the digital transmission and encoded video, audio, and data
- For encrypted transmissions there is a separate smart card
- Return channel requires a modem (analog, xDSL, or cable)

Conclusions

	Cable	ADSL	UMTS	DigiTV
Prize	++	--	---	+++
Capacity	+	++	+	+++
Return capacity	+	+	+	--
Mobility	---	---	+++	---

Future

Digital television

