Wireless Mobile Communication

Lecture 8, 9, 10

- Operation of Cellular System

Topics to be Covered

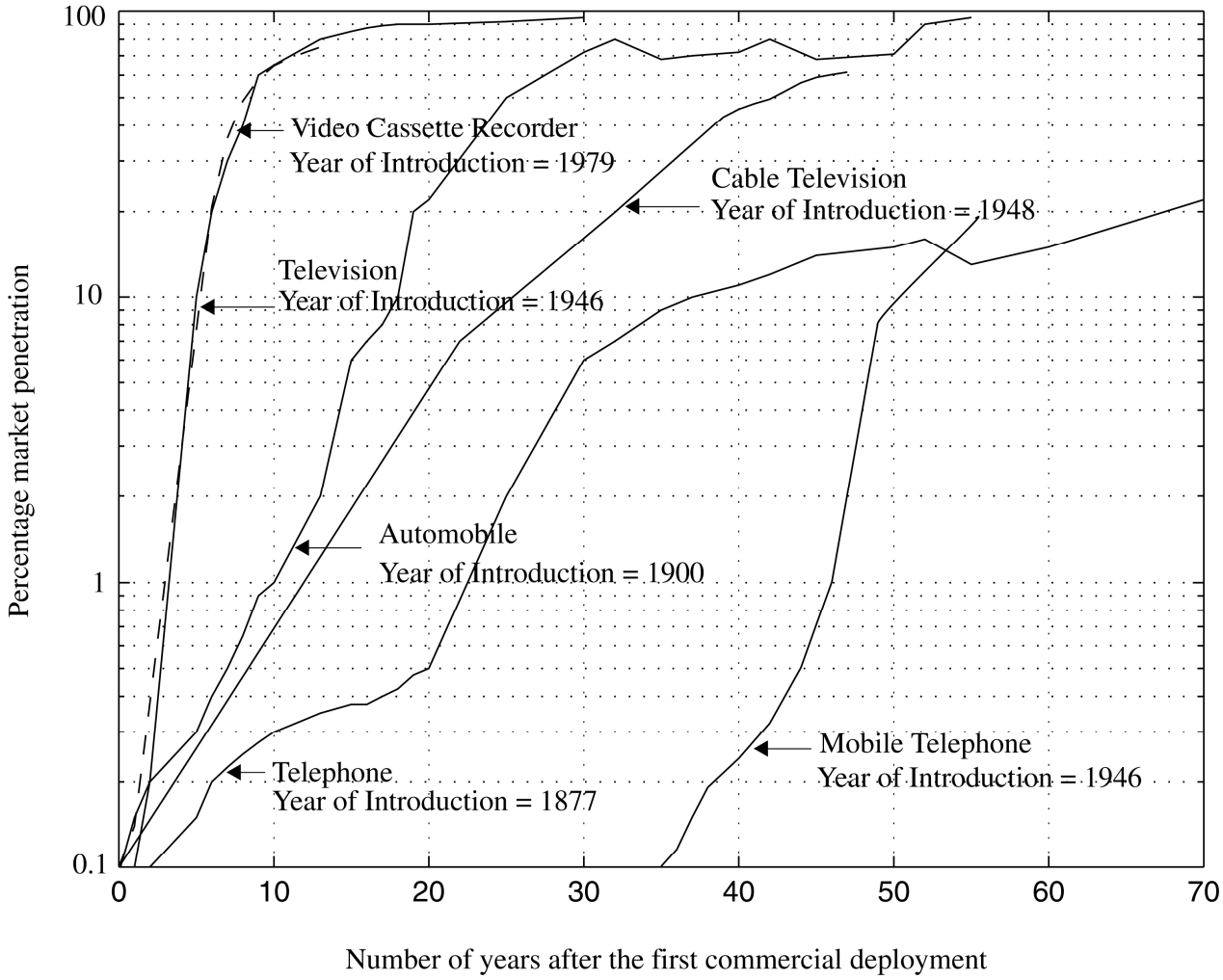
- Introduction to Cellular System

Introduction

- The target for mobile communications is to provide communications for anyone, from anywhere, at any time.
- A demanding task. Technological challenges include:
  - Time–varying, hostile communication channel.
  - Location and tracking complexities due to mobility.
  - Efficient use of scarce resources such as frequency spectrum ⇒ cellular structure. The amount of interference generated is critical.
  - Power restrictions due to health issues.

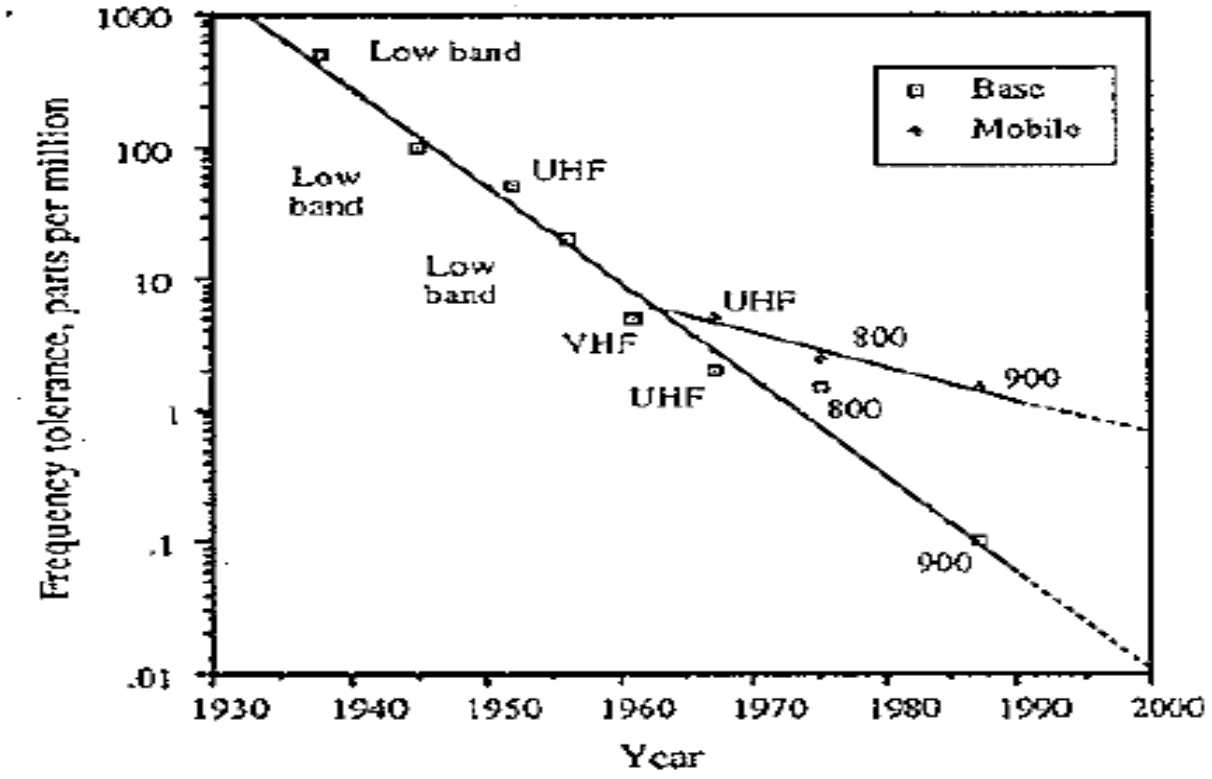
Introduction

- The exponential growth of mobile subscribers worldwide is due to the decreasing service charges and diminishing hardware costs. The continuous development of the enabling technologies is the key.



Introduction

RF technologies (such as improved frequency stability in electronics)



Introduction

- IC design (size)
- Battery technology (weight and size)
- Higher order modulation is made possible due to the use of more sophisticated advanced digital signal processing techniques.
- Speech coding techniques – reduces the required bandwidth per channel.

Cellular system

Example :

- *Consider a system allocated total bandwidth of 12.5MHz and each voice channel requires a 10kHz slot. We can only support 12.5MHz/10kHz or 1250 simultaneous conversations.*
- *Supposing the penetration rate in Singapore is 10%, for a population of 3M+, this is equivalent to 300k users. What happen if 1% of the users making call at the same time? Channels need to be in someway reused or shared?*

Cellular system

What can we do?

- Frequency bands are reused at different locations. With this, higher user capacity in the same frequency spectrum can be achieved.
- Technical challenge: interference issue, location tracking, etc., needs to be overcome.

Cellular system

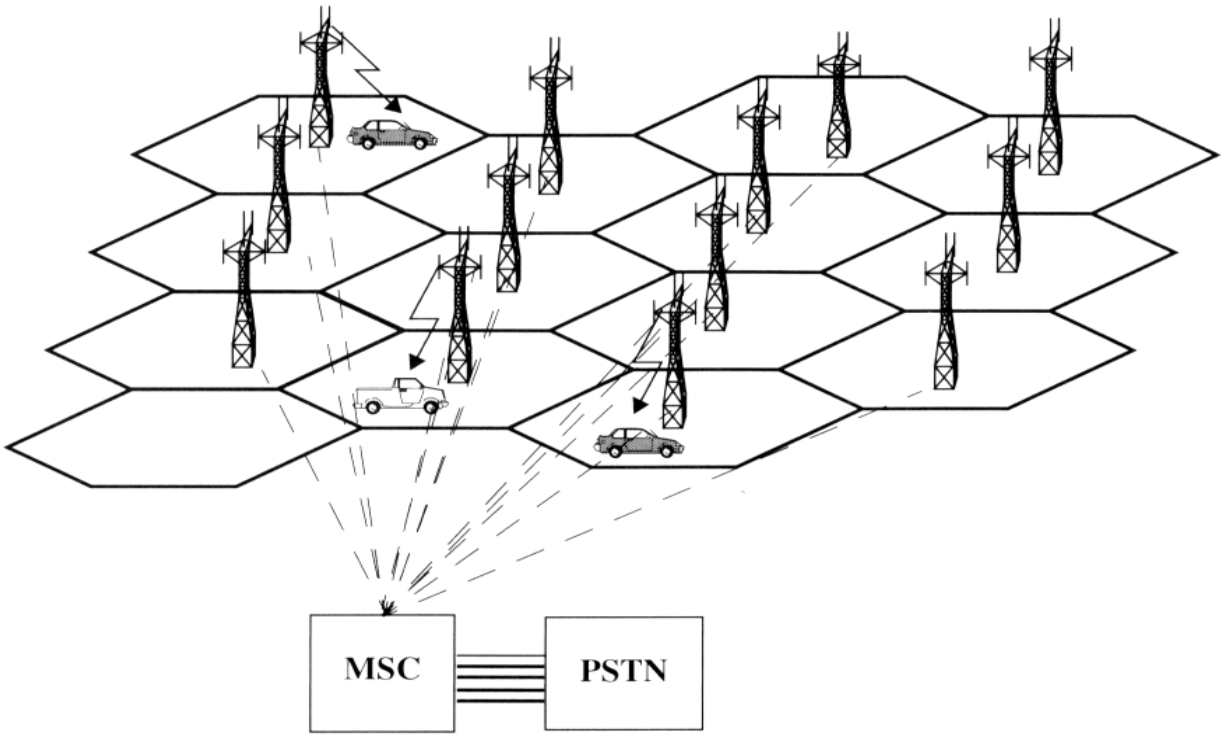


Figure 1.5 A cellular system. The towers represent base stations which provide radio access between mobile users and the mobile switching center (MSC).

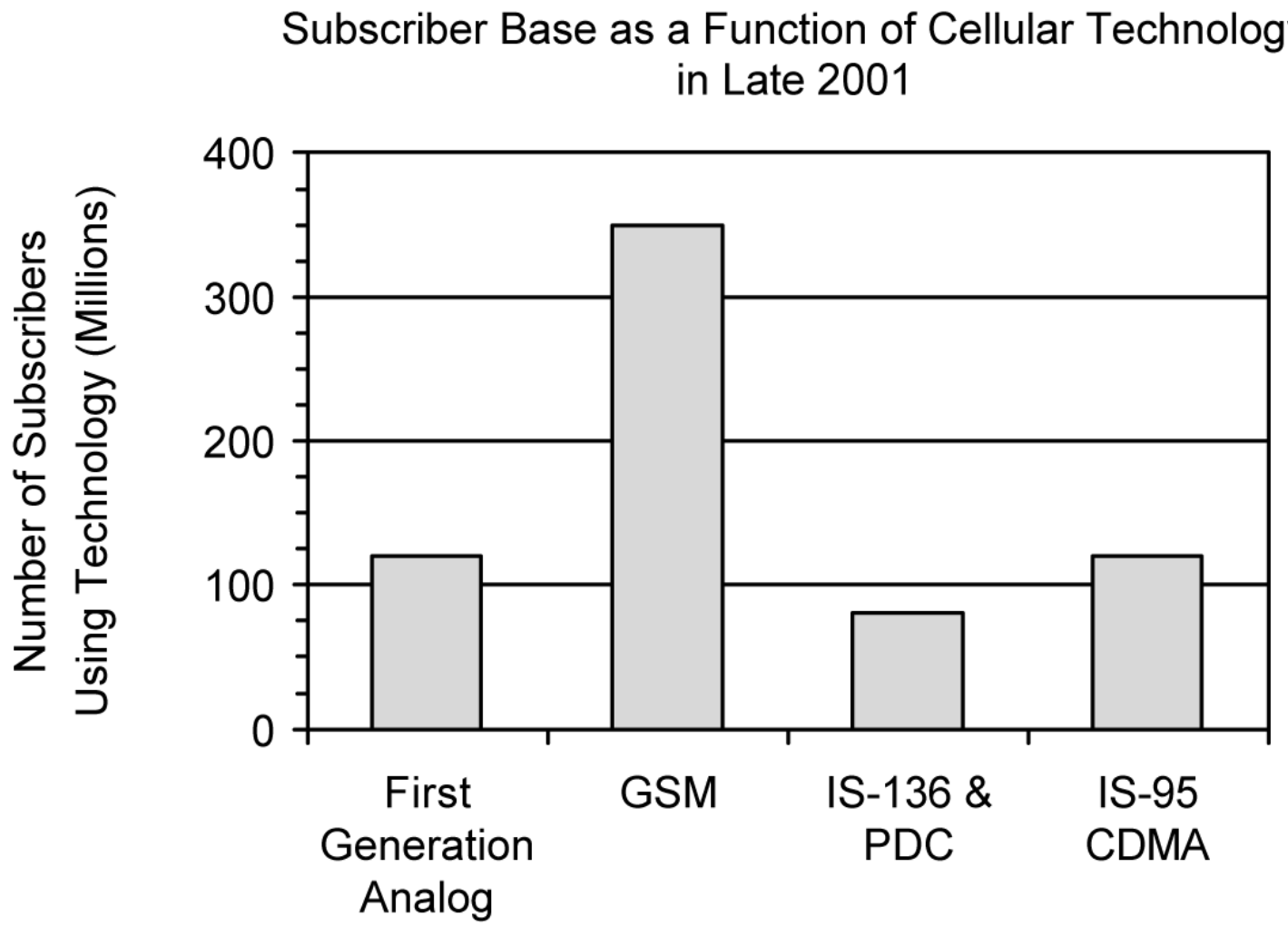
Cellular system

- Each cell has a *base station* (BS), providing the radio interface to the *mobile station* (MS).
- A sophisticated switching technique called a *handover* enables a call to proceed uninterrupted across cell boundaries.
- All the BS's are connected to a *mobile switching center* (MSC) which is responsible for connection users to the public switched telephone network (PSTN).
- Control channels transmit and receive data messages that carry call initiation and service requests, and are monitored by mobiles when they do not have a call in progress. ~5% of total available channels.

Cellular system

- Communication between the BS and the mobiles is defined by a standard common air interface that specifies 4 different physical channels
  - Forward (Downlink) voice/data channel : BS to MS
  - Reverse (Uplink) voice/data channel : MS to BS
  - Forward (Downlink) control channel : BS to MS
  - Reverse (Uplink) control channel : MS to BS
- A MS contains a transceiver, an antenna and control circuitry. A BS consists of several transmitters and receivers.

1G 2G Distributions



2G Standard

Table 2.1 Key Specifications of Leading 2G Technologies (adapted from [Lib99])

	cdmaOne, IS-95, ANSI J-STD-008	GSM, DCS-1900, ANSI J-STD-007	NADC, IS-54/IS-136, ANSI J-STD-011, PDC
Uplink Frequencies	824-849 MHz (US Cellular) 1850-1910 MHz (US PCS)	890-915 MHz (Europe) 1850-1910 MHz (US PCS)	800 MHz, 1500 MHz (Japan) 1850-1910 MHz (US PCS)
Downlink Frequencies	869-894 MHz (US Cellular) 1930-1990 MHz (US PCS)	935-960 MHz (Europe) 1930-1990 MHz (US PCS)	869-894 MHz (US Cellular) 1930-1990 MHz (US PCS) 800 MHz, 1500 MHz (Japan)
Duplexing	FDD	FDD	FDD
Multiple Access Technology	CDMA	TDMA	TDMA
Modulation	BPSK with Quadrature Spreading	GMSK with $BT = 0.3$	$\pi/4$ DQPSK
Carrier Separation	1.25 MHz	200 kHz	30 kHz (IS-136) (25 kHz for PDC)
Channel Data Rate	1.2288 Mchips/sec	270.833 kbps	48.6 kbps (IS-136) (42 kbps for PDC)
Voice channels per carrier	64	8	3
Speech Coding	Code Excited Linear Prediction (CELP) @ 13 kbps, Enhanced Variable Rate Codec (EVRC) @ 8 kbps	Residual Pulse Excited Long Term Prediction (RPE-LTP) @ 13 kbps	Vector Sum Excited Linear Predictive Coder (VSELP) @ 7.95 kbps

2G to 3G evolution

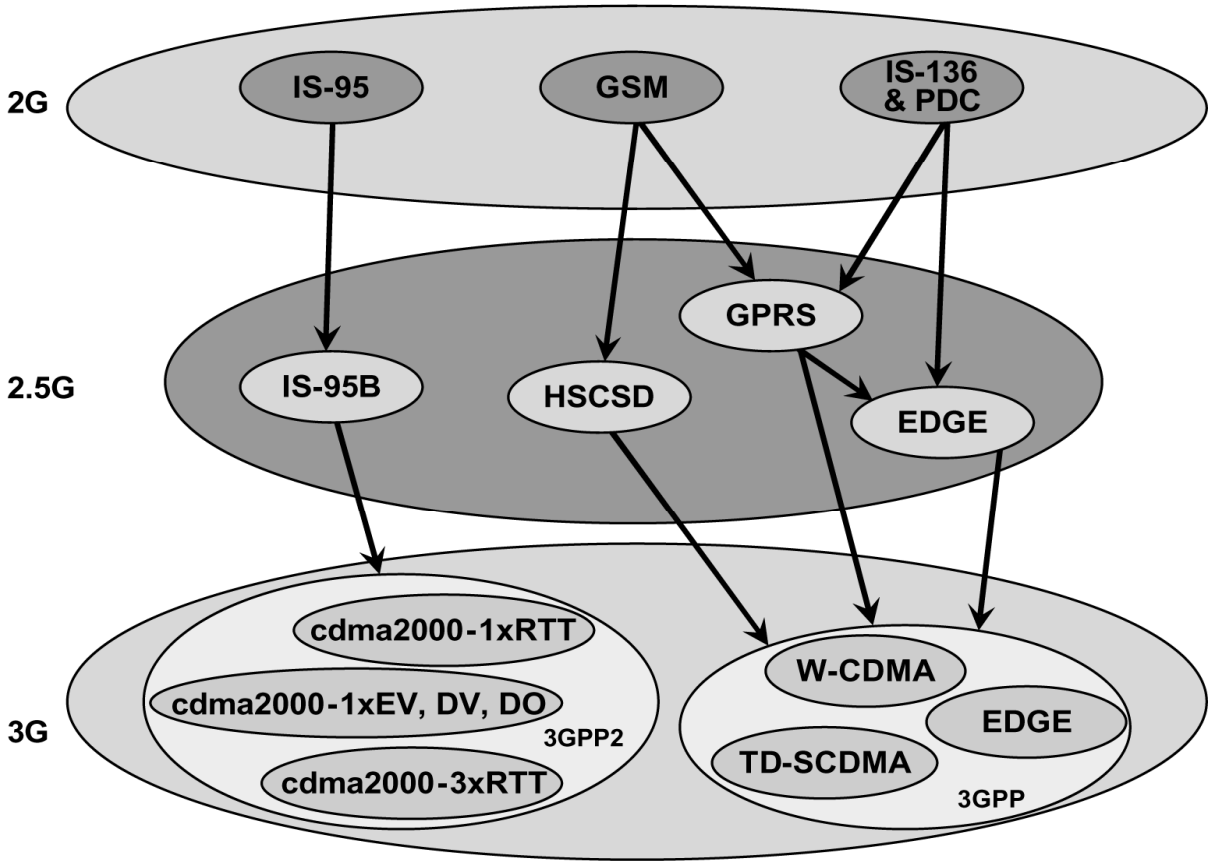


Table 2.2 Current and Emerging 2.5G and 3G Data Communication Standards

Wireless Data Technologies	Channel BW	Duplex	Infrastructure change	Requires New Spectrum	Requires New Handsets
HSCSD	200 KHz	FDD	Requires software upgrade at base station.	No	Yes New HSCSD handsets provide 57.6 Kbps on HSCSD networks, and 9.6 Kbps on GSM networks with dual mode phones. GSM-only phones will not work in HSCSD networks.
GPRS	200 KHz	FDD	Requires new packet overlay including routers and gateways.	No	Yes New GPRS handsets work on GPRS networks at 171.2 Kbps, 9.6 Kbps on GSM networks with dual mode phones. GSM-only phones will not work in GPRS networks.
EDGE	200 KHz	FDD	Requires new transceiver at base station. Also, software upgrades to the base station controller and base station.	No	Yes New handsets work on EDGE networks at 384 Kbps, GPRS networks at 144 Kbps, and GSM networks at 9.6 Kbps with tri-mode phones. GSM and GPRS-only phones will not work in EDGE networks.
W-CDMA	5 MHz	FDD	Requires completely new base stations.	Yes	Yes New W-CDMA handsets will work on W-CDMA at 2 Mbps, EDGE networks at 384 Kbps, GPRS networks at 144 Kbps, GSM networks at 9.6 Kbps. Older handsets will not work in W-CDMA.
IS-95B	1.25 MHz	FDD	Requires new software in base station controller.	No	Yes New handsets will work on IS-95B at 64 Kbps and IS-95A at 14.4 Kbps. CdmaOne phones can work in IS-95B at 14.4 Kbps.
cdma2000 1xRTT	1.25 MHz	FDD	Requires new software in backbone and new channel cards at base station. Also need to build a new packet service node.	No	Yes New handsets will work on 1xRTT at 144 Kbps, IS-95B at 64 Kbps, IS-95A at 14.4 Kbps. Older handsets can work in 1xRTT but at lower speeds.
cdma2000 IxEV (DO and DV)	1.25 MHz	FDD	Requires software and digital card upgrade on 1xRTT networks.	No	Yes New handsets will work on 1xEV at 2.4 Mbps, 1xRTT at 144 Kbps, IS-95B at 64 Kbps, IS-95A at 14.4 Kbps. Older handsets can work in 1xEV but at lower speeds.
cdma2000 3xRTT	3.75 MHz	FDD	Requires backbone modifications and new channel cards at base station.	Maybe	Yes New handsets will work on 95A at 14.4 Kbps, 95B at 64 Kbps, 1xRTT at 144 Kbps, 3xRTT at 2 Mbps. Older handsets can work in 3X but at lower speeds.