TEE 843 – Sistem Telekomunikasi

9. Sistem Komunikasi Nirkabel

universitas
MALIKUSSALEH

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Wireless Communications

- Introduction
- Cordless Telephones
- PMR (Professional/Private Mobile Radio)
- Radio Paging
- Microwave Relay Systems
- Satellite Communications
- Bluetooth
- WLAN
- Cellular Communications

Komunikasi Nirkabel
(Wireless Communication)

- **Sistem komunikasi nirkabel** atau **nirkawat *(wireless communication)*** adalah sistem komunikasi yang media transmisinya berupa non-fisik (**tanpa kabel/kawat**).
- Transmisinya menggunakan **gelombang elektromagnetik**.
- Terminologi **komunikasi nirkabel (*wireless*)** adalah pengganti terminologi **komunikasi radio**.
- ***Mobile communication*** adalah sistem komunikasi yg bersifat nirkabel dan memungkinkan pengguna *(user)* dpt **berkomunikasi sambil bergerak**.

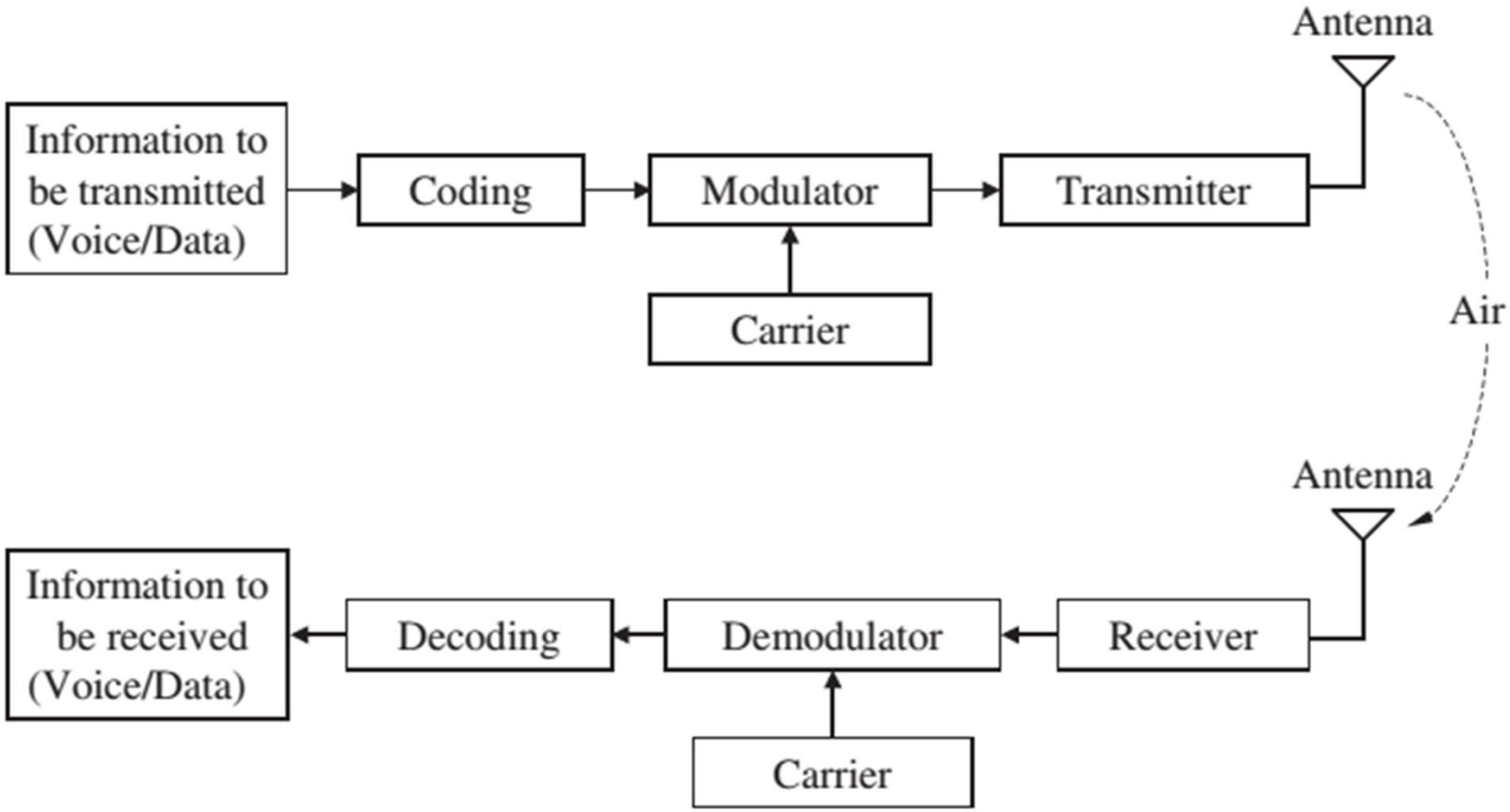
Komunikasi Nirkabel (2)

- Secara umum ***mobile*** diidentikkan dgn ***wireless***, sehingga istilah ***mobile communication*** sering dipertukarkan dgn ***wireless communication***.
- Meskipun sebenarnya ada ***fixed wireless communication*** dan ***mobile wireless communication***.
- Oleh karena sistem komunikasi bergerak yg paling dominan adalah sistem komunikasi seluler, maka ***mobile communication*** sering juga diidentikkan dengan ***cellular communication***.
- Padahal sebenarnya sistem komunikasi bergerak tdk hanya berupa sistem komunikasi seluler.

Klasifikasi Komunikasi Nirkabel

Wireless Communication	**Fixed Wireless**	**Non Cellular**	**contoh :** point to point communication, infra red communication, LMDS, Microwave communication
		Cellular	**contoh :** PHS, CT2, PACS, DCS1800, DECT
	Mobile Wireless	**Non Cellular**	**contoh :** paging system (ERMES, NTT, NEC) , dispatching system, PAMR (*Public Access Mobile Radio*) dsb
		Cellular	**contoh :** GSM, CDMA/IS-95, AMPS, UMTS, PHS, DCS1800, NMT450, TACS, C-450, dsb

Sistem Komunikasi Nirkabel
(disederhanakan)



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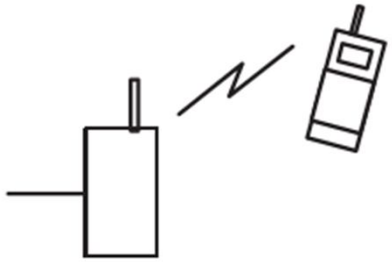
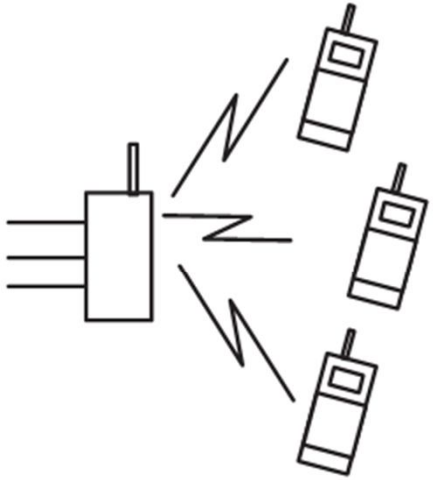
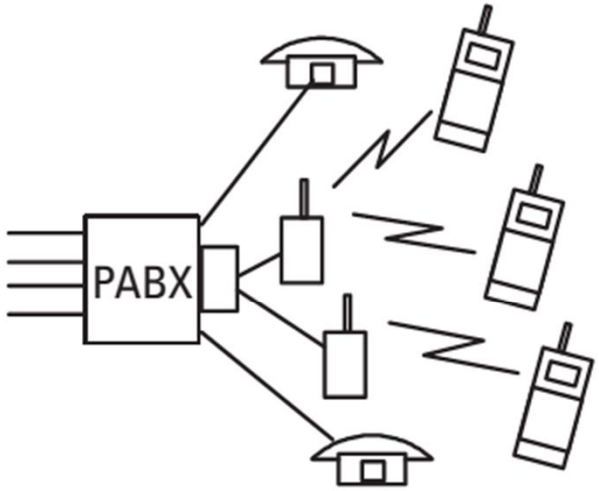
Cordless Telephones



Residential use



Telepoint or wireless
local loop, WLL



Cordless corporate network

Aplikasi Cordless Telephones

- Residential Use
  - First generation cordless phones (CT1)
  - Cakupan hanya seluas rumah dan halaman.
- Telepoint dan Wireless local loop (WLL)
  - Second generation cordless telephone technology (CT2)
  - Misalnya pada stasiun kereta dan bandara.
  - Pemakaiannya berkurang dgn semakin murahnya biaya telepon seluler.
- Cordless Corporate Network
  - Digital European Telecommunications (DECT).
  - Personal access communication system (PACS) di Amerika.

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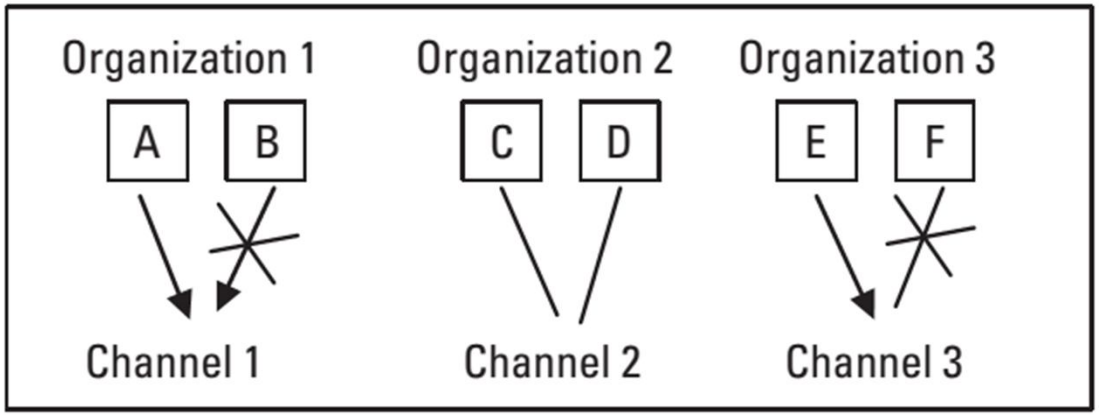
PMR

(Professional or Private Mobile Radio)

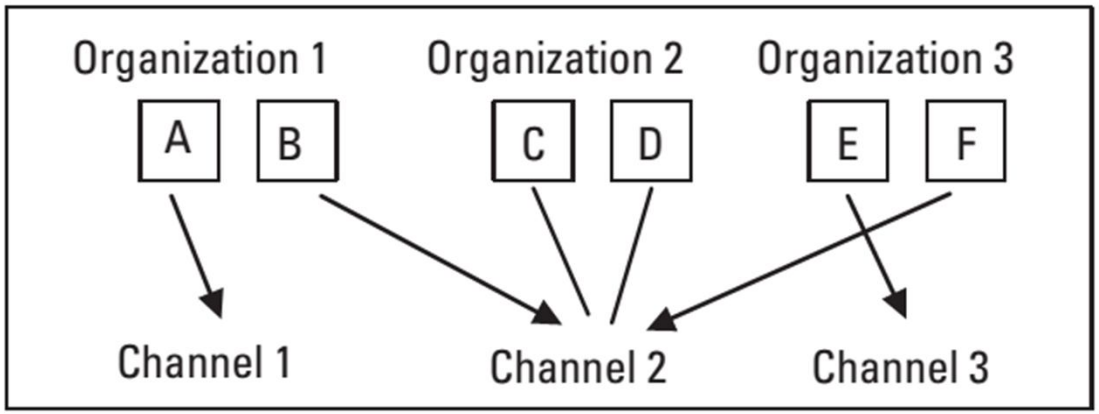
- The PMR systems are dedicated and independent mobile radio systems.
- Some of them are just simple “walkie-talkie” type radios, others are complex networks that use a technology similar to that of public cellular mobile radio systems.
- One typical PMR is owned by a taxi operator.
- Standar PMR digital modern: Terrestrial Trunked Radio (TETRA).

Resource sharing dan Trunked network pada PMR

Conventional PMR (dispatch) network:
One channel for each organization



Trunked network:
Radio channels (spectrum) are shared by all users who may belong to separate networks



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Paging Networks

- Paging networks merupakan komunikasi unidirectional saja.
- Pager merupakan sistem komunikasi wireless (nirkabel/nirkawat) yg low-cost.
- Pager sederhana hanya dpt menyampaikan “beep”, tetapi yg lbh maju dpt menyampaikan pesan (message) yg cukup panjang.
- Keberadaannya telah dikalahkan oleh munculnya sistem selular.

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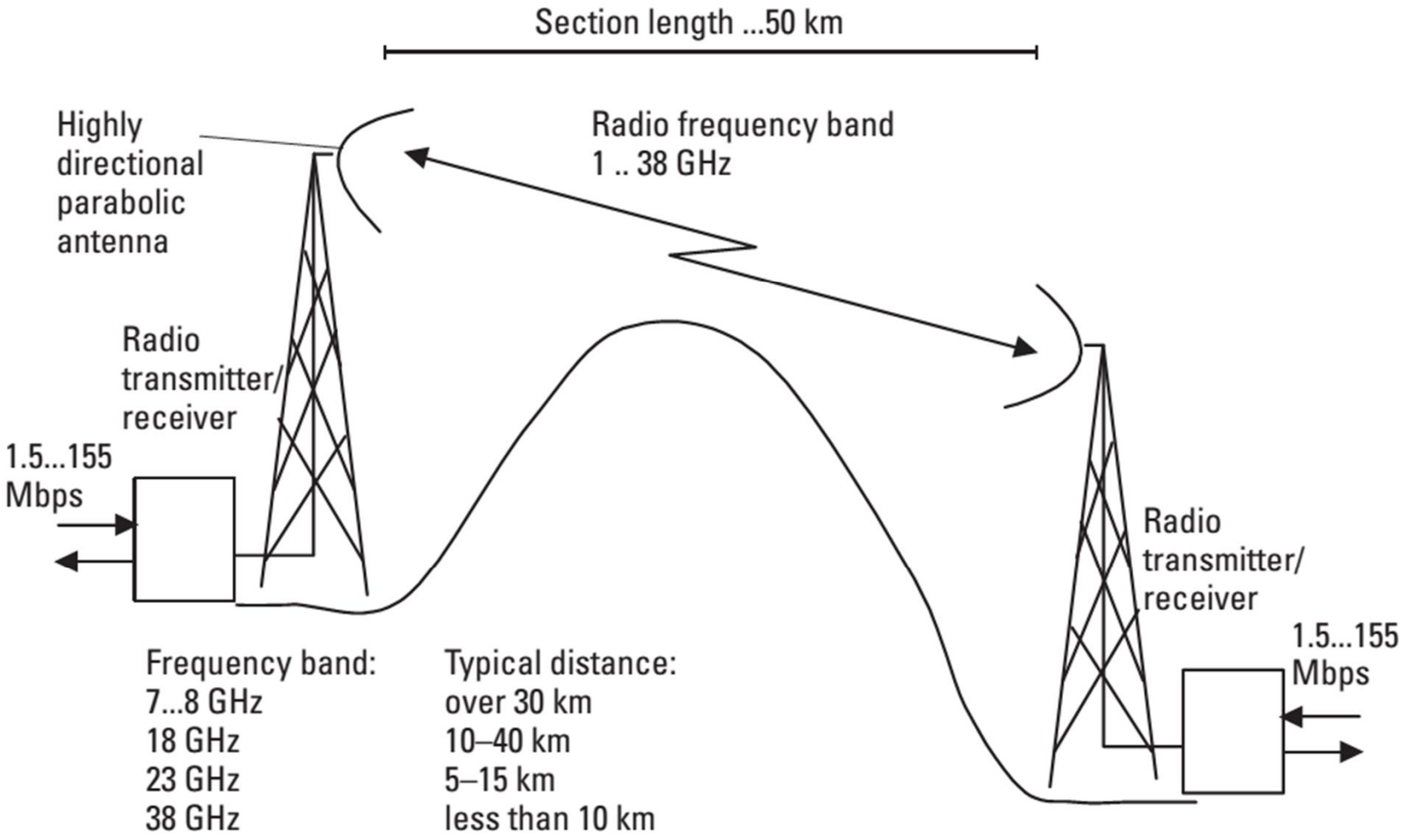
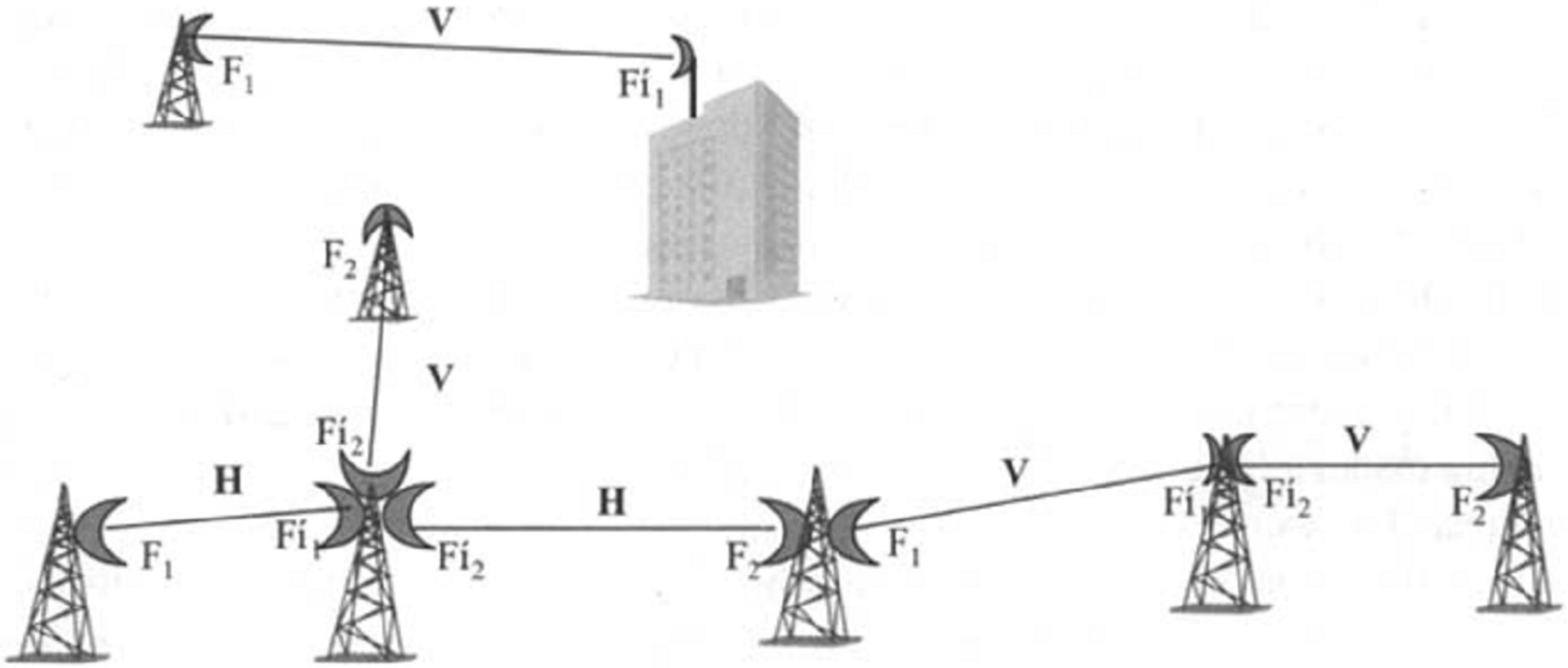
Microwave Relay Systems



Microwave Relay Systems (2)



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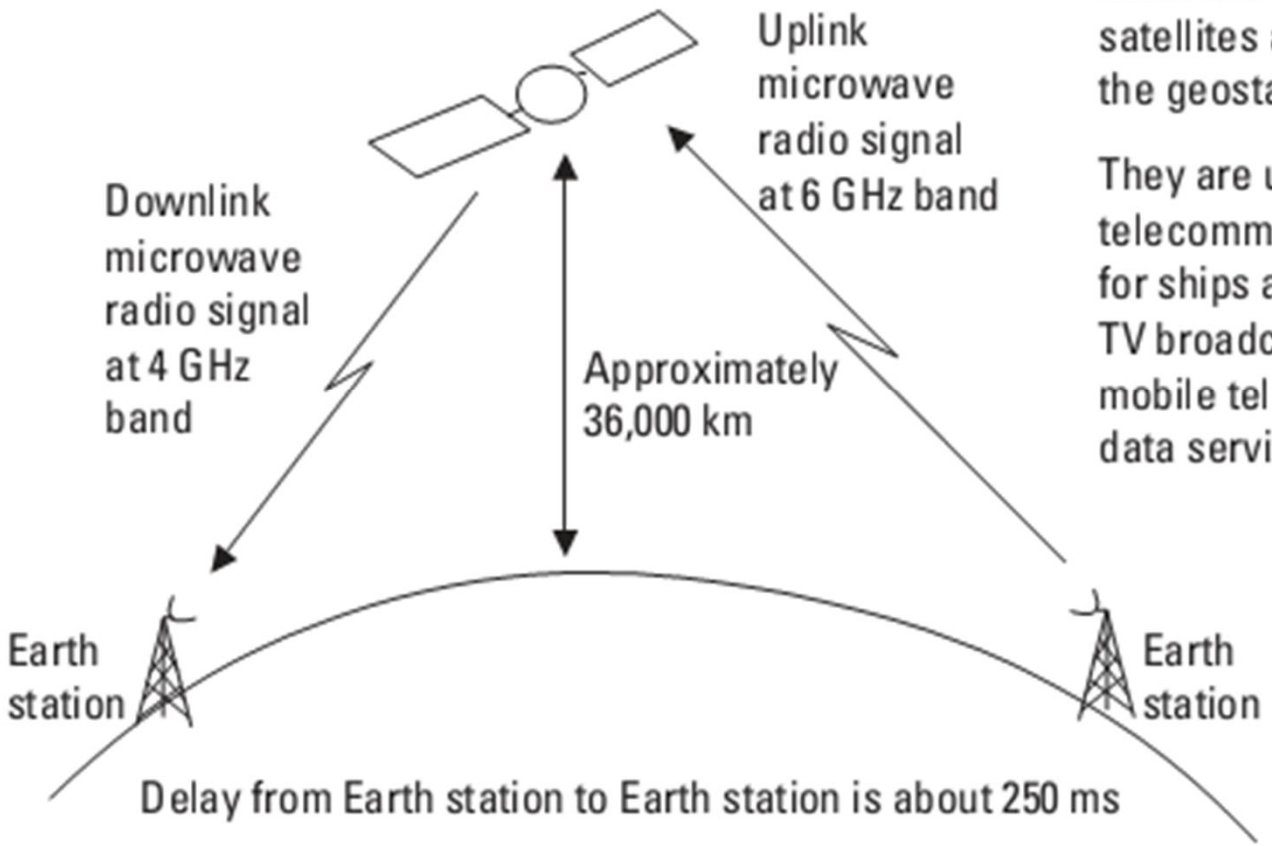
Sistem Komunikasi Satelit

- Pada dasarnya, aplikasi dari sistem komunikasi satelit adlh utk komunikasi point-to-point.
- Namun, satelit jg menyediakan layanan komunikasi bergerak utk kapal dan pesawat terbang, sbg sistem komunikasi cadangan. Satelit yg digunakan adlh satelit geostasioner pd ketinggian 36.000 km.
- Lalu, satelit jg menyediakan layanan utk handy MS, menggunakan satelit-satelit yg berorbit pd ketinggian 700 – 10.000 km. Misalnya: Iridium dan Globalstar.

Satellites for Fixed Communications



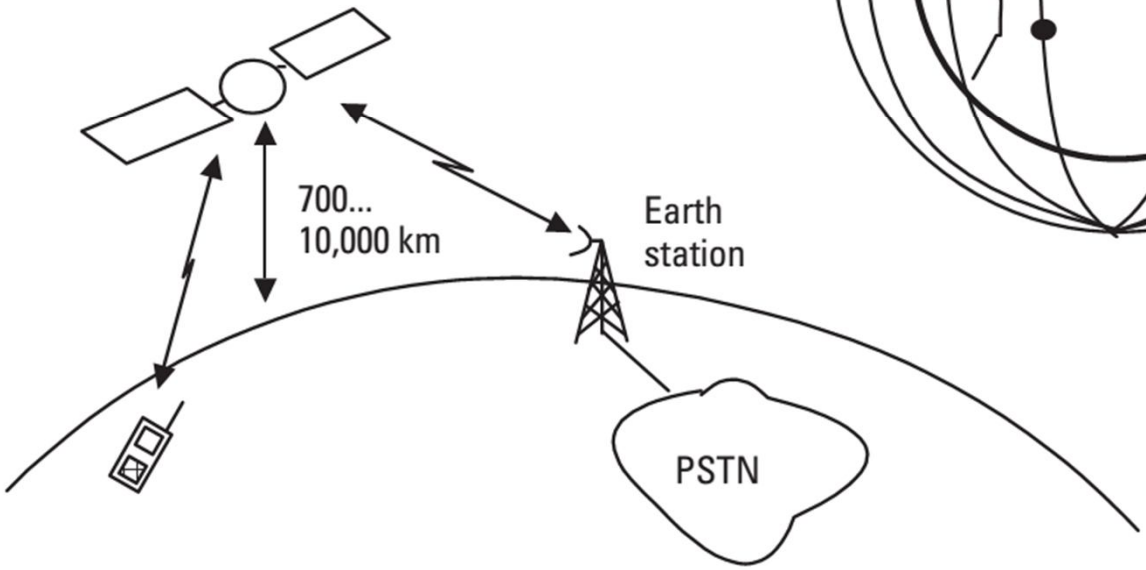
Most telecommunication satellites are placed in the geostationary orbit.

They are used to provide telecommunication services for ships and aircrafts, TV broadcasting, and mobile telephone and data services.

Satellites for Mobile Communications

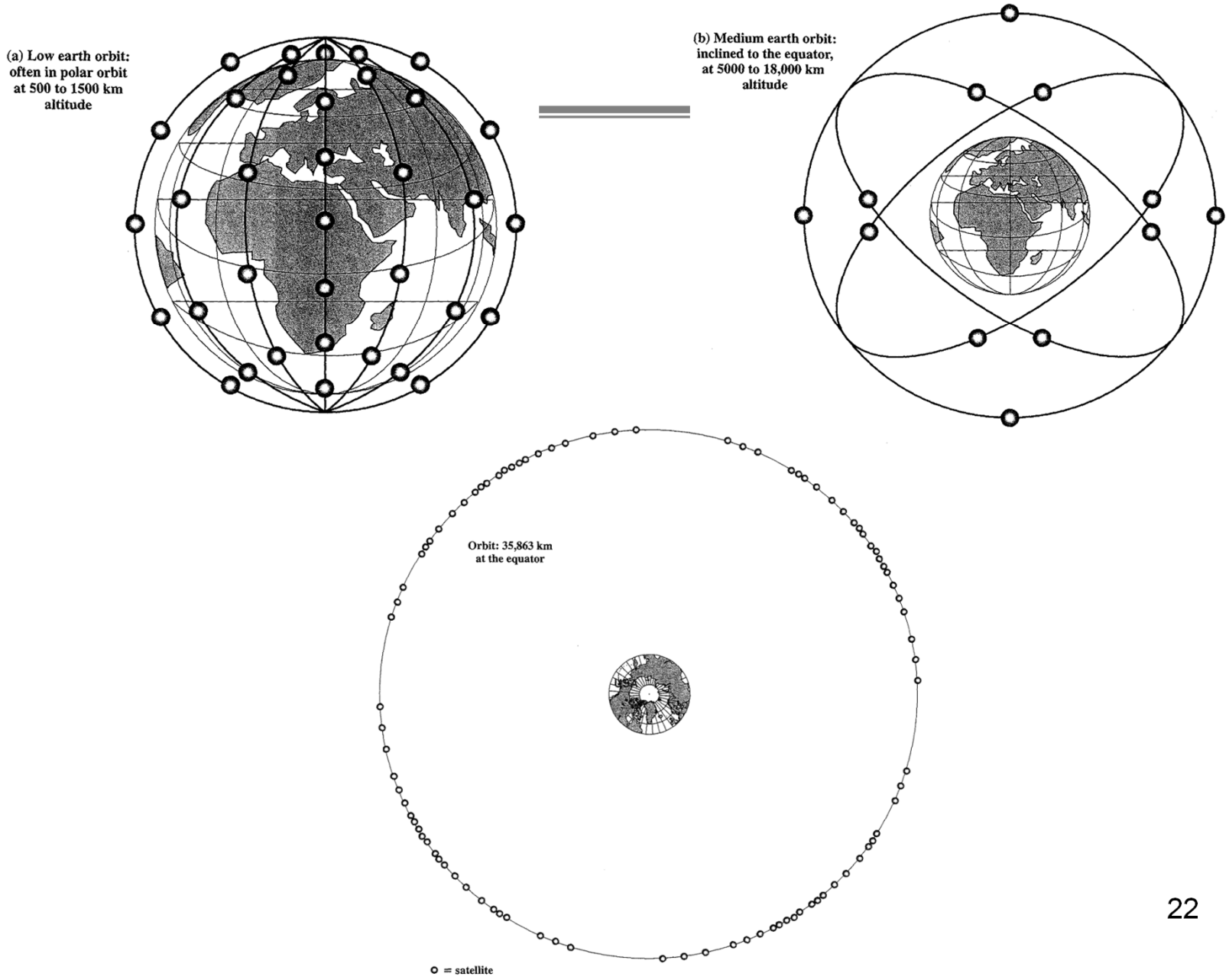
Mobile satellite systems use many low or medium orbit satellites that move around the Earth

Multimode terminals use satellite service if land mobile network is not available



A satellite that operates as a base station of a public land mobile network, PLMN.

Orbit Satelit: LEO, MEO, GEO



Aplikasi Satelit

Traditionally	-Weather satellites -Radio and TV broadcast satellites -Military satellites -Satellites for navigation and localization (e.g., GPS)
Telecommunication	-Global telephone connections -Backbone for global networks -Connections for communication in remote places or underdeveloped areas -Global mobile communication

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Bluetooth

- **Bluetooth technology** allows for the replacement of proprietary cables that connect one digital device to another with a universal short-haul radio link.
- Mobile computers, cellular handsets, printers, keyboards, and many other devices can be embedded with Bluetooth radios.
- Bluetooth was developed by the Bluetooth Special Interest Group (SIG, http://www.bluetooth.com), founded by Ericsson, IBM, Intel, Nokia, and Toshiba.
- A small wireless Bluetooth network connecting, for example, a user's computer to its peripherals is called a **personal area network (PAN)**
- Bluetooth systems use the same 2.4-GHz license free frequency band as WLANs and they can coexist in the same area.
- Bluetooth uses frequency hopping spread-spectrum (FHSS) technology.
- The modulation rate of Bluetooth is 1 Mbps.

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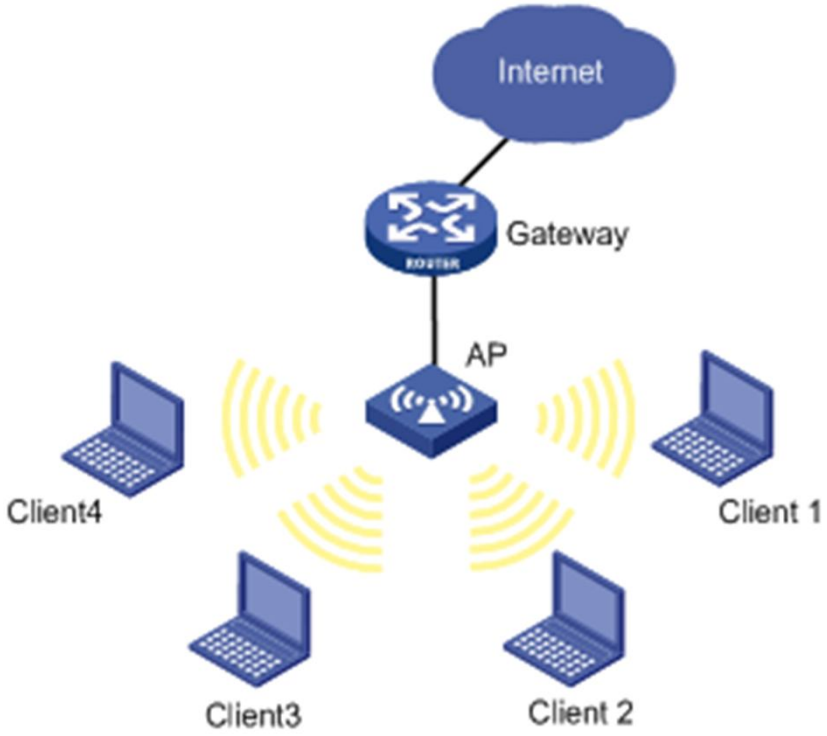
WLAN

(Wireless Local Area Network)

- WLAN berasal dari jaringan komputer berbasis IP (*internet protocol*).
- Standar WLAN adlh keluarga standar IEEE 802.11, yaitu: IEEE 802.11a, IEEE 802.11b, IEEE 802.11g, IEEE 802.11n, dll.
- Pita frekuensi yg digunakan adlh *unlicense frequency band* 2.4 GHz dan 5 GHz.
- Disebut jg dgn WiFi (Wireless Fidelity).

WLAN (lanjutan)



Spesifikasi Wi-Fi

Spesifikasi	Kecepatan	Frekuensi Band	Cocok dengan
802.11b	11 Mb/s	~2.4 GHz	b
802.11a	54 Mb/s	~5 GHz	a
802.11g	54 Mb/s	~2.4 GHz	b, g
802.11n	100 Mb/s	~2.4 GHz	b, g, n

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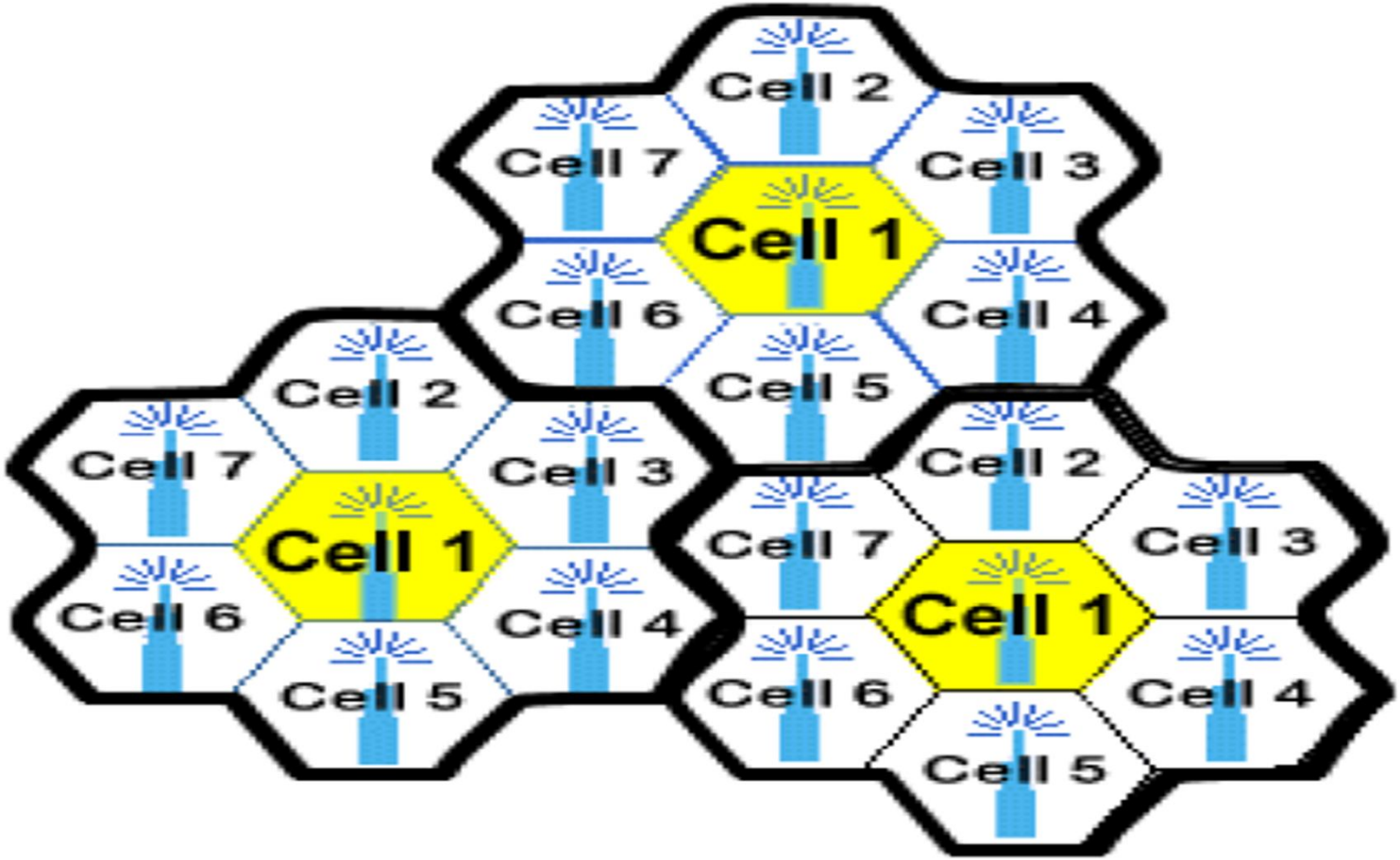
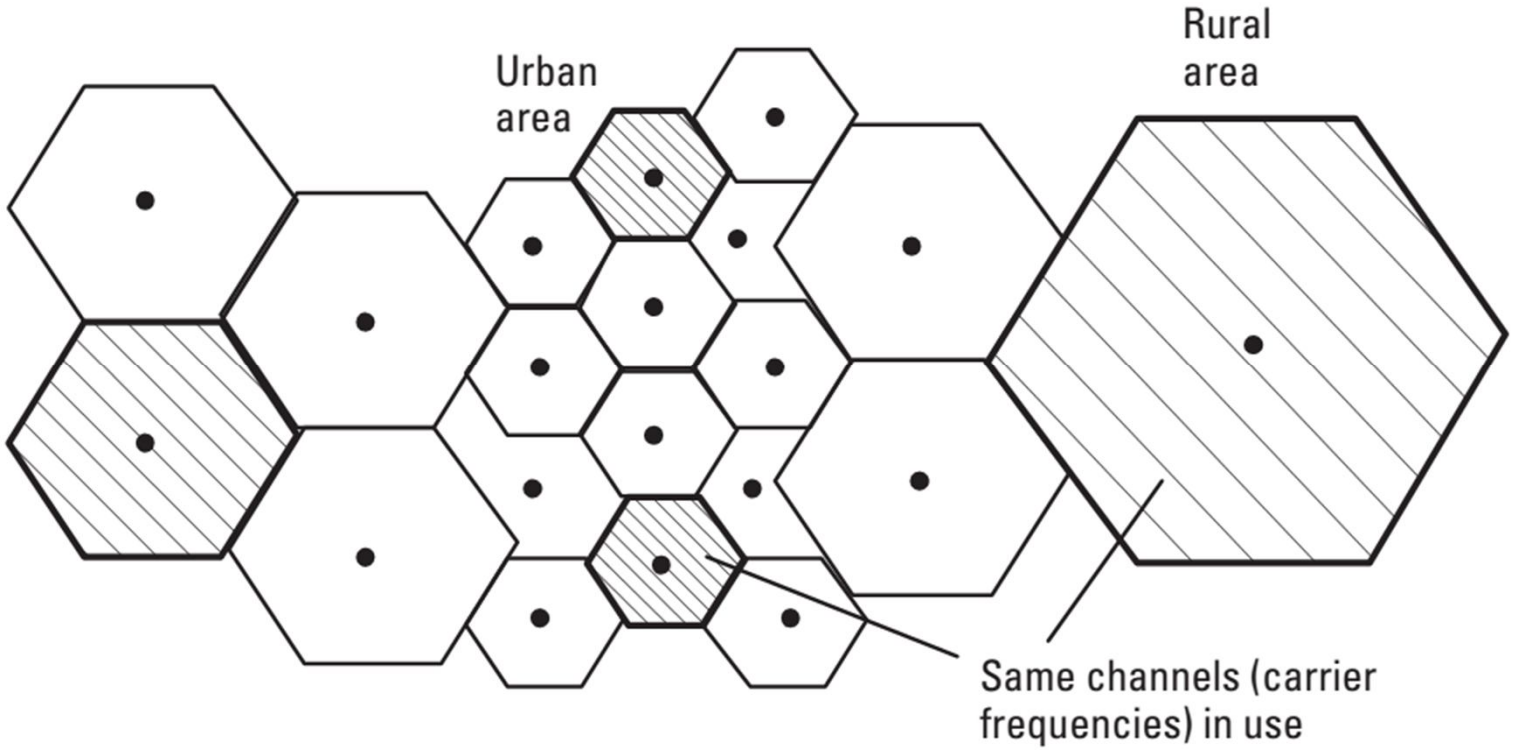
Sistem Komunikasi Seluler

- **Masalah utama** pd jaringan komunikasi bergerak tradisional adlh **rendah kapasitas** akibat **terbatasnya pita frekuensi**.
- **Jaringan selular** menyediakan solusi dgn adanya **penggunaan frekuensi yg sama** pd beberapa area dlm jaringan (dikenal dgn ***frequency reuse***).
- Mekanisme kunci lainnya adlh **handoff** atau **handover** yg memungkinkan komunikasi tdk terputus saat pengguna bergerak menuju sel (area) lain dlm jaringan.

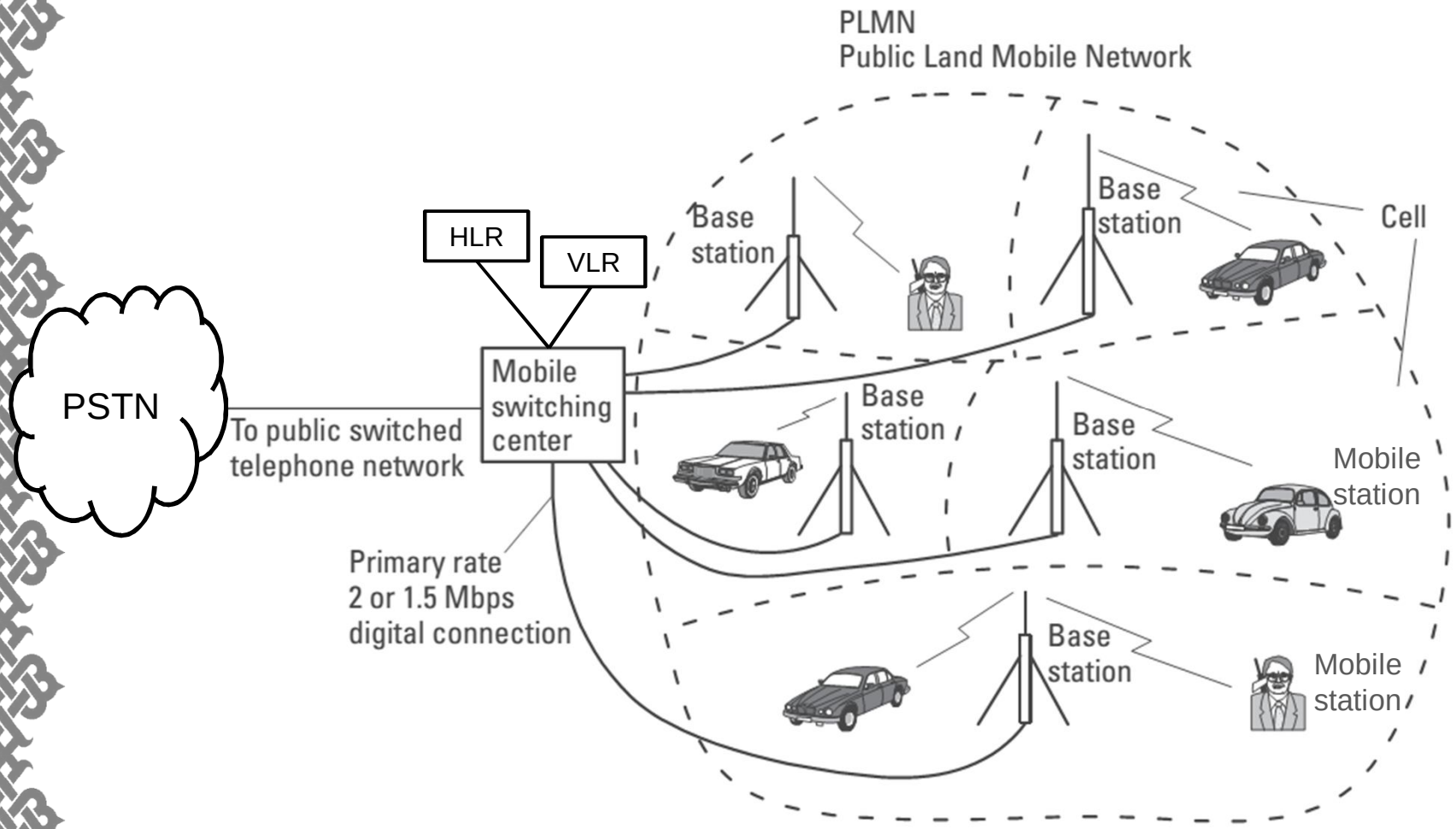
Struktrur Sel dan *Frequency Reuse*



Struktrur Sel dan *Frequency Reuse* (2)



Struktur Dasar Sistem Komunikasi Seluler



Elemen-elemen dasar pd jaringan seluler

- **Base tranceiver station (BTS)** atau terkadang disebut **base station (BS)** saja. → transceiver = transmitter/receiver.
- **Mobile station (MS)**, misalnya pesawat telepon bergerak.
- **Mobile switching center (MSC)**, yang bertindak seperti sentral lokal pd jaringan tetap (PSTN).
- Jaringan seluler dirancang utk jaringan akses, karena itu tdk memiliki hirarki swicthing dan untuk sambungan jarak jauh dan internasional menggunakan jaringan tetap *(fixed network)* sbg penghubung.

Karakteristik penting dari sistem seluler

- **Frequency reuse** provides a much larger number of communication channels than the number of channels allocated to the system.
- Automatic intercellular transfer, or a **handover** (or **handoff**), ensures continuity of communication when there is a need to change BSs.
- **Continuous monitoring** of communication between the mobile and BS verifies the quality and detects the need for a cell transfer.
- **Automatic location** of mobile stations within the network ensures that calls can be routed to mobiles.
- Mobile stations **continuously listen** to a common channel of the network in order to receive a call.

Karakteristik penting dari sistem seluler (2)

- Area pd jaringan seluler dibagi menjadi beberapa **sel**.
- **Daya** BS dan MS secara otomatis berkurang dgn berkurangnya ukuran sel.
- **Daya transmisi** BS dan MS dikontrol agar sekecil mungkin, utk mencegah interferensi pd sel lain yg menggunakan frekuensi yg sama ***(reuse of frequency)***.
- Dgn adanya *frequency reuse,* operator dpt menambah **kapasitas jaringan** dgn memperkecil ukuran sel.
- ***Low transmission power*** menjadikan masa operasi baterai lbh lama dan pelanggan lbh aman.
- Database: ***home location register*** **(HLR)** dan ***visitor location register*** **(VLR)**.

HLR dan VLR

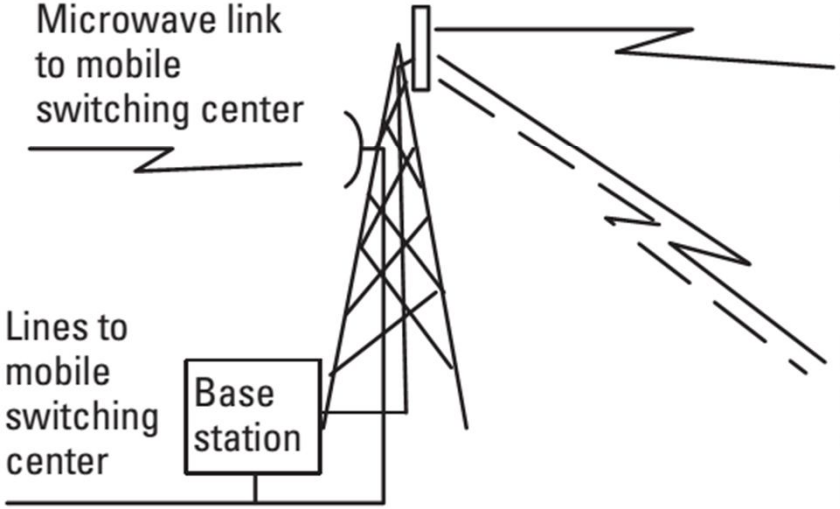
- Setiap pelanggan didaftarkan pd suatu HLR oleh operator-nya.
- **HLR** menyimpan informasi ttg seluruh pelanggan yg terdaftar pd-nya, misalnya: dimana lokasinya saat ini, layanan apa digunakan, ke nomor nama panggilan harus ditransfer.
- **VLR** menyimpan informasi ttg seluruh pelanggan yg berada dlm area-nya.
- VLR biasanya terpadu dlm MSC, tp HLR biasanya terpisah secara fisik.

Kanal radio pd jaringan seluler

- **Duplexing:**
  - **Downlink** atau **forward link** adlh kanal transmisi dari jaringan (BTS) ke MS.
  - **Uplink** atau **reverse link** adlh kanal transmisi dari MS ke BTS.
  - Pilihan duplexing: FDD dan TDD
- **Kanal kendali dan kanal trafik:**
  - Kanal kontrol ***(control channel)*** utk signalling dan kebutuhan kontrol lainnya.
  - Kanal trafik ***(traffic channel*** atau ***dedicated channel)*** utk mengalirkan trafik (suara, data, dll.)

Jenis-jenis kanal radio pd sistem komunikasi seluler

HLR, home location register, stores subscriber information and updated location information (VLR address). Each subscriber is registered in one fixed HLR.
VLR, visitors location register, stores subscriber information of each MS located in its area.



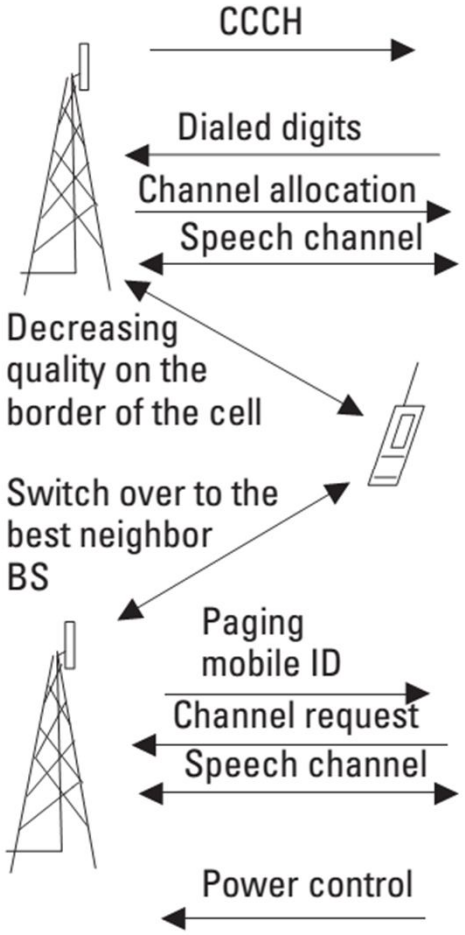
Common control channel that all mobiles listen to when they are in idle mode. Call request messages are sent on this channel in the case of an outgoing call and paging messages are sent in the case of an incoming call.

Dedicated channels that are used for calls (speech or traffic channels) when a mobile is in dedicated mode. Each dedicated channel has its own control channel for performance monitoring and control.

Prinsip kerja (operasi dasar) jaringan seluler

- Setiap MS mendapat identifikasi (identitas), berupa nomor telepon atau kode lain.
- Beberapa modus operasi:
  - MS in idle mode
  - Outgoing call
  - Incoming call
  - Handover (handoff)
  - MS transmitting power

Operasi dasar pd jaringan seluler



In idle mode the mobile station listens to the common control channel, CCCH.

Outgoing call: The dialed digits are sent to the network and a voice channel is allocated.

Handover: When the MS moves towards the edge of the base station area, communication quality is decreased. A new cell is selected with the help of measuring results of the neighbor cells. A new channel is then allocated and BS and MS switch to it at the same time.

Incoming call: Paging message is sent over the common control channel. When MS receives its own identification, it requests a traffic or voice channel, which is then allocated.

Transmission power is controlled to be as low as possible to minimize interference with other cells.

Generasi Jaringan Seluler

Generation	Name	Features
1 (1980)	NMT (*Nordic Mobile Telephone*), …	Analog Voice
2 (1992)	GSM (*Global System for Mobile communications*) - GSM 900, GSM 1800 IS95 (*Interim Standard*) based on CDMA - IS95a,b …cdmaOne	Digital Voice + data
2,5 (1999)	GPRS (*General Packet Radio Service*) EGPRS/EDGE (*Enhanced GPRS/Enhanced Data rates for Global Evolution*)	
3 (2001)	WCDMA/UMTS (*Universal Mobile Telecommunication System*) cdma2000 (*code division multiple access*)	Multimedia
4 (2011)	LTE/LTE-A (*Long Term Evolution – Advanced*), WiMAX IEEE802.16	OFDMA, high speed data, full mobility, and convergence
5 (2020)..?	…… ?	

1G

Year	Events
1970s	Developments of radio and computer technologies for 800/900 MHz mobile communication
1976	WARC (world administrative radio conference) allocates spectrum for cellular radio
1979	NTT (Nippon Telephone & Telegraph) introduces the first cellular system in Japan
1981	NMT (Nordic Mobile Telephone) 900 system introduced by Ericsson Radio System AB and deployed in Scandinavia
1984	AMPS (advanced mobile phone service) introduced by AT&T in North America

1G (lanjutan)

Table 4.5 First Generation Cellular Standards

Parameter	*AMPS*	*TACS*	*NMT900*	*NTT*
Frequency (MHz)				
Reverse	824–849	890–905	890–905	860–885 843–846
Forward	869–894	935–960	935–960	915–940 898–901
Duplex separation (MHz)	45	45	45	55
Channel spacing (kHz)	30	25	25/12.5	25/12.5/6.25
Number of full-duplex channels	832	600	1,999	600–2,400
Voice transmission	FM with ±8-kHz deviation	FM with ±9.5-kHz deviation	PM with ±5-kHz deviation	FM with ±5-kHz deviation
Data transmission	FSK with ±8-kHz deviation, 10 kbit/s	FSK with ±6.4-kHz deviation, 8 kbit/s	FFSK with ±3.5-kHz deviation, 1.2 kbit/s	FFSK with ±4.5-kHz deviation, 0.3 kbit/s
Mobile Tx. power (W)	3	7	6	5
Base station ERP (W/channel) max	100	100	100	100

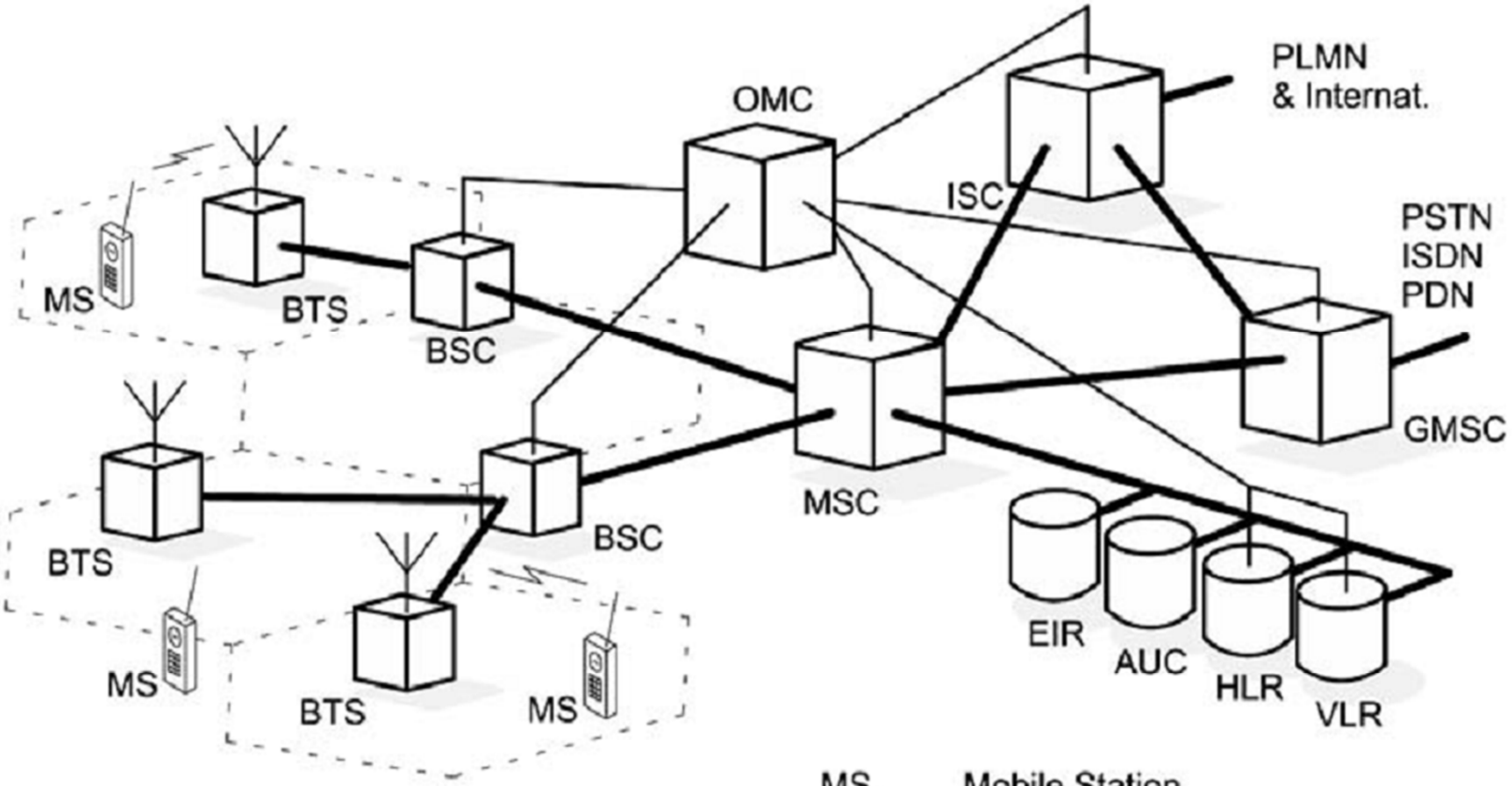
2G

Year	Events
1982	CEPT (Conference European des Post of Telecommunications) establishes GSM (global special mobile) to define future Pan-European cellular radio standards
1990	Interim Standard IS-54 (USDC: United States digital cellular) adopted by TIA (Telecommunications Industry Association)
1990	Interim Standard IS-19B (NAMPS: narrowband AMPS) adopted by TIA
1991	Japanese PDC system standardized by the MPT (Ministry of Posts and Telecommunications)
1992	Phase I GSM system is operational
1993	Interim Standard IS-95 (CDMA) adopted by TIA
1994	Interim Standard IS-136 adopted by TIA
1995	PCS Licenses issued in North America
1996	Phase II GSM is operational
1997	North American PCS deploys GSM, IS-54, IS-95
1999	IS-54: used in North America; IS-95: used in North America, Hong Kong, Israel, Japan, South Korea, and China; GSM: used in 110 countries

Standar-standar pokok 2G

- GSM (TDMA) Eropa & Dunia
- PDC (TDMA) Jepang
- IS-54/IS-136 (TDMA) Amerika Utara
- IS-95 (CDMA) Amerika Utara

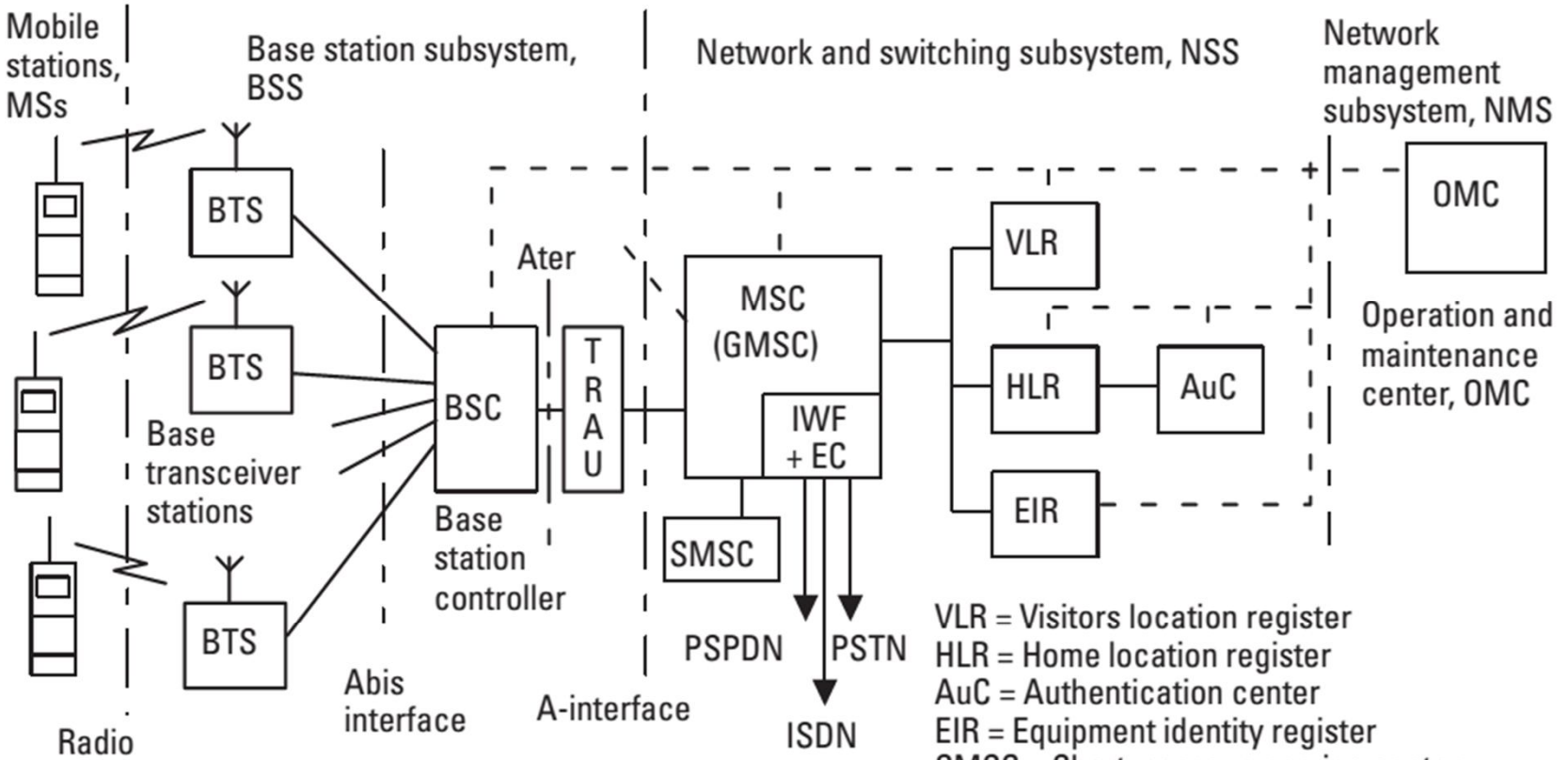
Arsitektur GSM



BTS	Base Transceiver Station
BSC	Base Station Controller
MSC	Mobile Switching Center
GMSC	Gateway MSC
ISC	International Switching Center

MS	Mobile Station
HLR	Home Location Register
VLR	Visited Location Register
EIR	Equipment Identity Register
AUC	Authentication Center
OMC	Operation and Maintenance Center

Arsitektur GSM (lengkap)



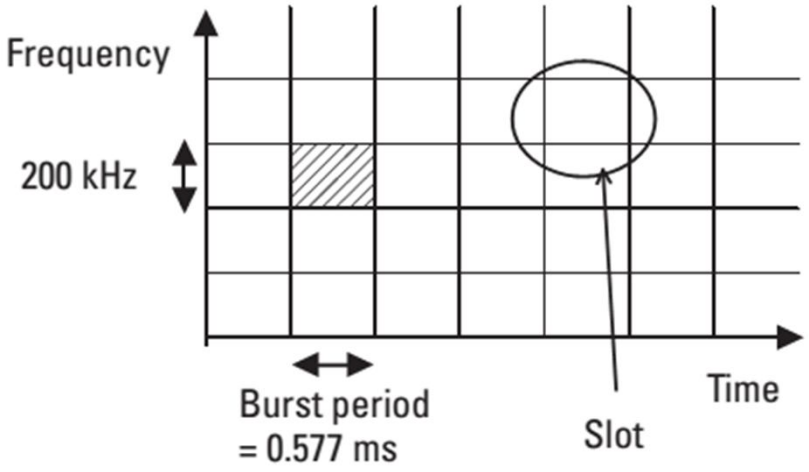
Characteristics of TDMA-Based Digital Cellular Systems

Table 4.6 Characteristics of TDMA-Based Digital Cellular Systems

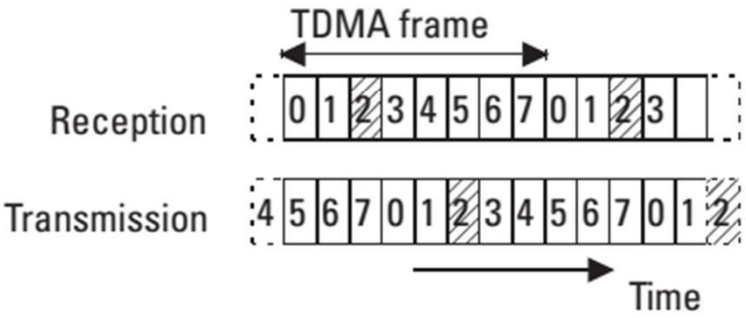
Standard	*Mobile Tx/Base Tx (MHz)*	*Access Method*	*Carrier Spacing (kHz)*	*Modulation*	*Channel Bit Rate kbit/s*	*Full-Rate Speech Coding kbit/s*	*Channels per Carrier (fr/hr)*
IS-54 (D-AMPS)	824–849/ 869–894	FDMA/TDMA/ FDD	30	$\pi/4$- differential quadrature phase shift keying (DQPSK)	48.6	7.95 (13 w/FEC)	3 /6
PDC	810–915/ 940–960	FDMA/TDMA/ FDD	25	$\pi/4$-DQPSK	42.0	6.7 (11.2 w/FEC)	3/6
GSM	890–915/ 935–960	FDMA/TDMA/ FDD	200	GMSK	270.8	13 (22.8 w/FEC)	8/16

Multiple-Access pada GSM: TDMA-FDMA

A transmission burst occupies a window in time and frequency called a slot.
There are eight time slots on each carrier frequency.
Eight simultaneous calls may use the same frequency.



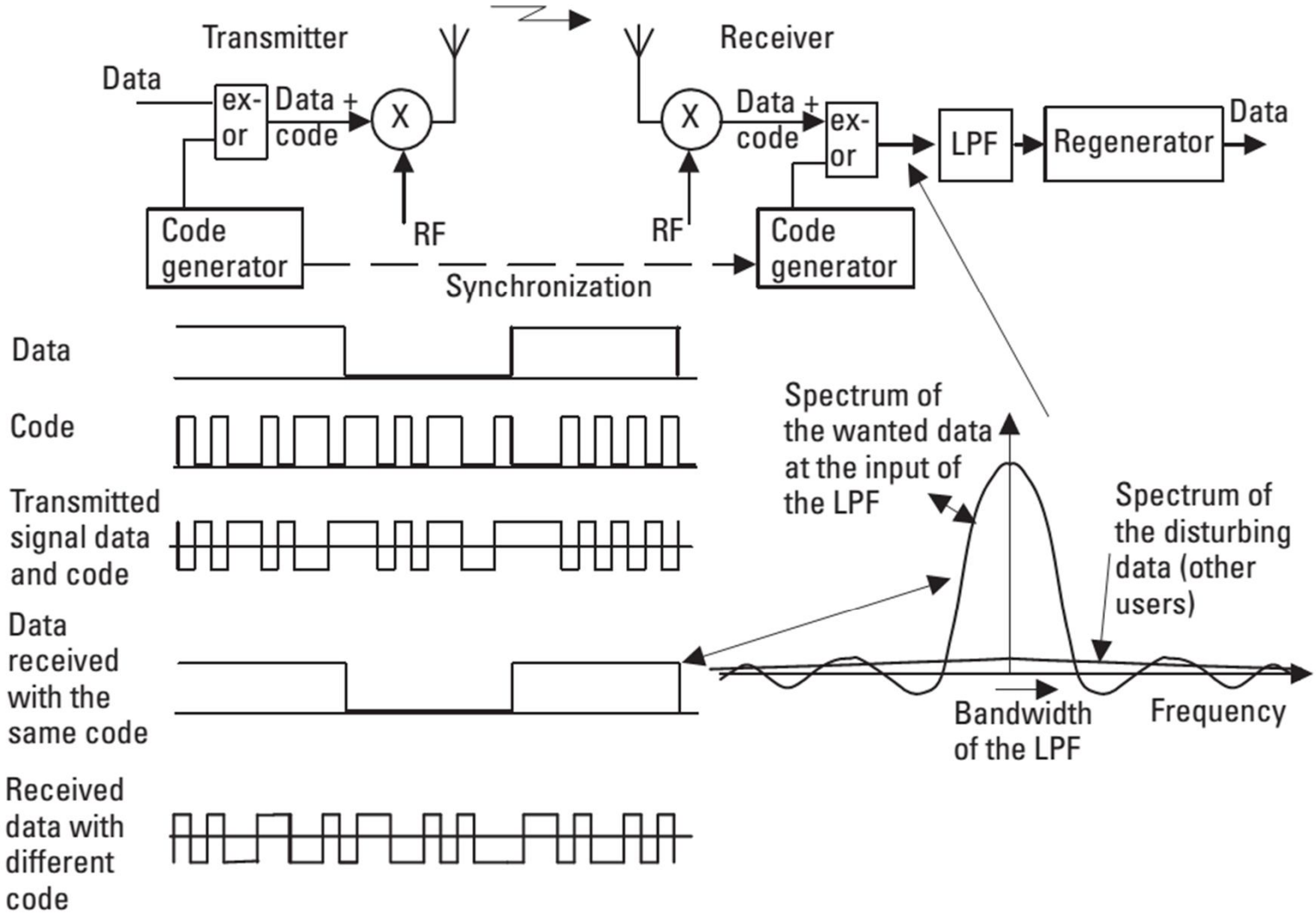
Emission of a mobile station takes place 3 burst periods later than reception.



Bidirectional radio transmission has fixed duplex distance:
45 MHz (900 MHz band) and
95 MHz (1,800 MHz band).

A mobile station receives, shifts the frequency by 45 or 95 MHz, and emits a moment later.

Multiple-Access pada IS-95: CDMA

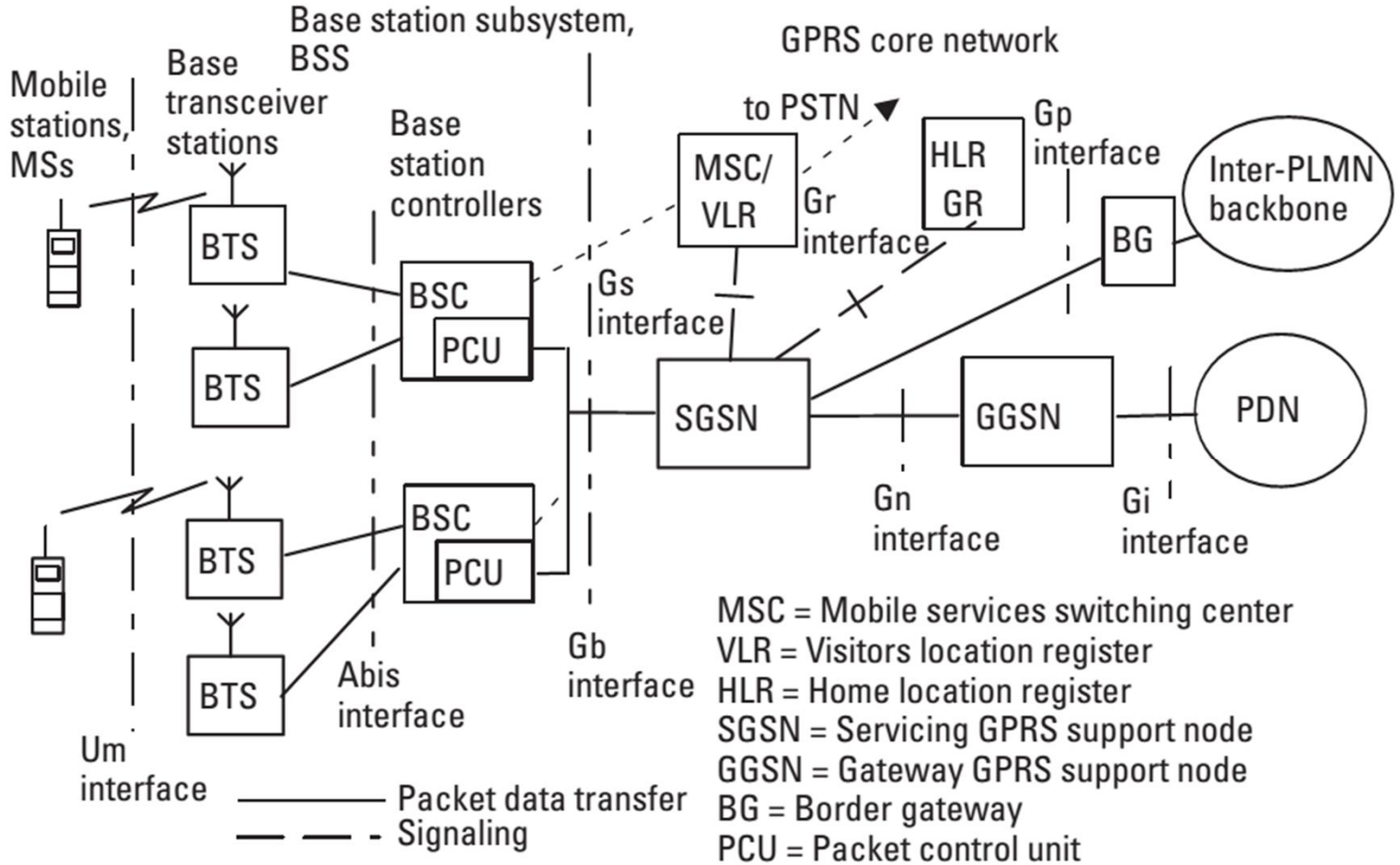


Pita Frekuensi yg Digunakan pd (beberapa) 1G dan 2G

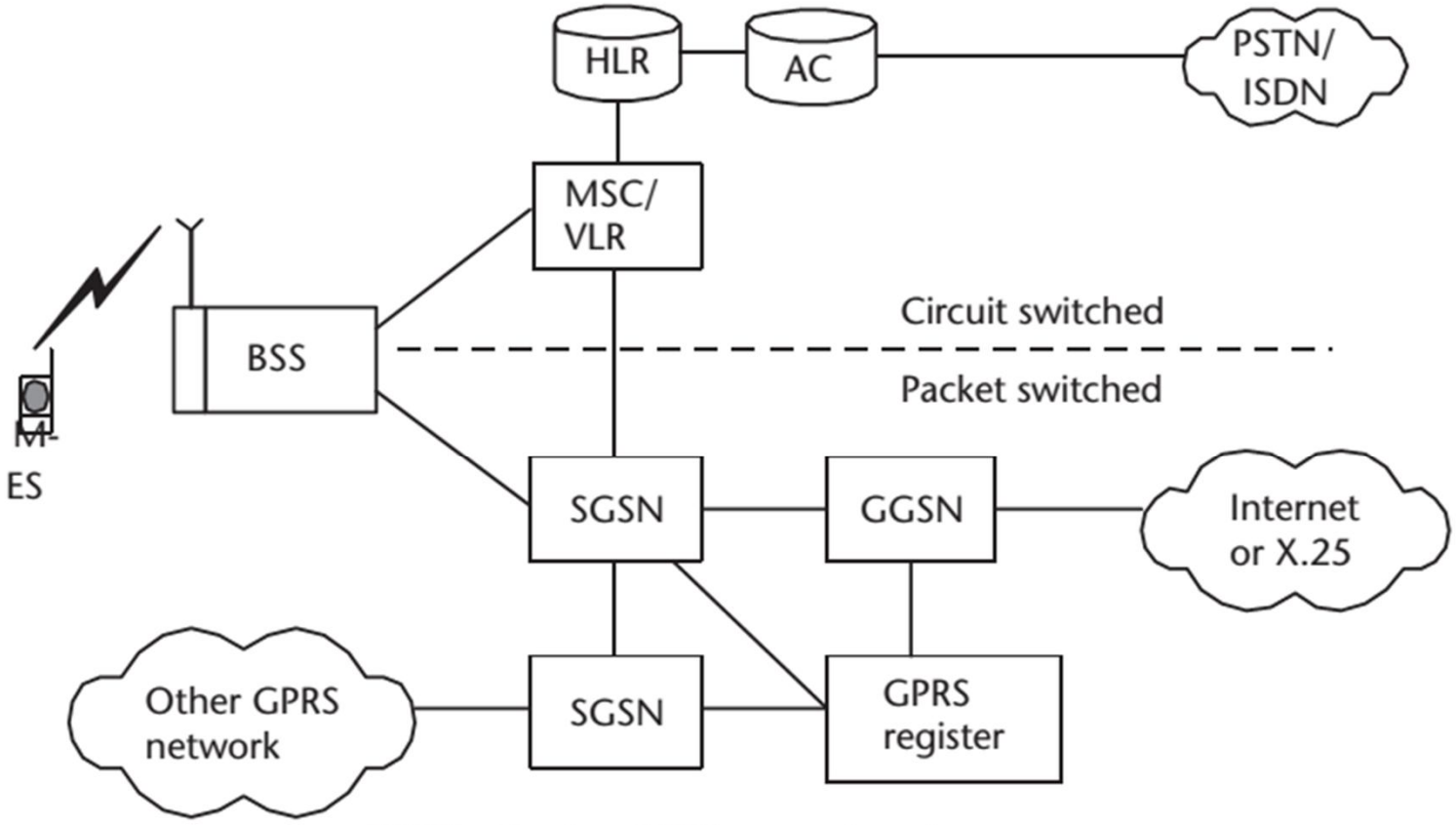
Table 1.10: ▶
Frequency Range Used in Different Systems (an Example)

Systems	BS Transmitting Range/MS Receiving Range	BS Receiving Range/MS Transmitting Range	RF Channel
FDMA (AMPS)	870–890 MHz	825–845 MHz	0.03 MHz
TDMA (GSM 900)	935–960 MHz	890–915 MHz	0.20 MHz
TDMA (GSM 1800)	1805–1880 MHz	1710–1785 MHz	0.20 MHz
CDMA (IS-95)	869–894 MHz	824–849 MHz	1.25 MHz

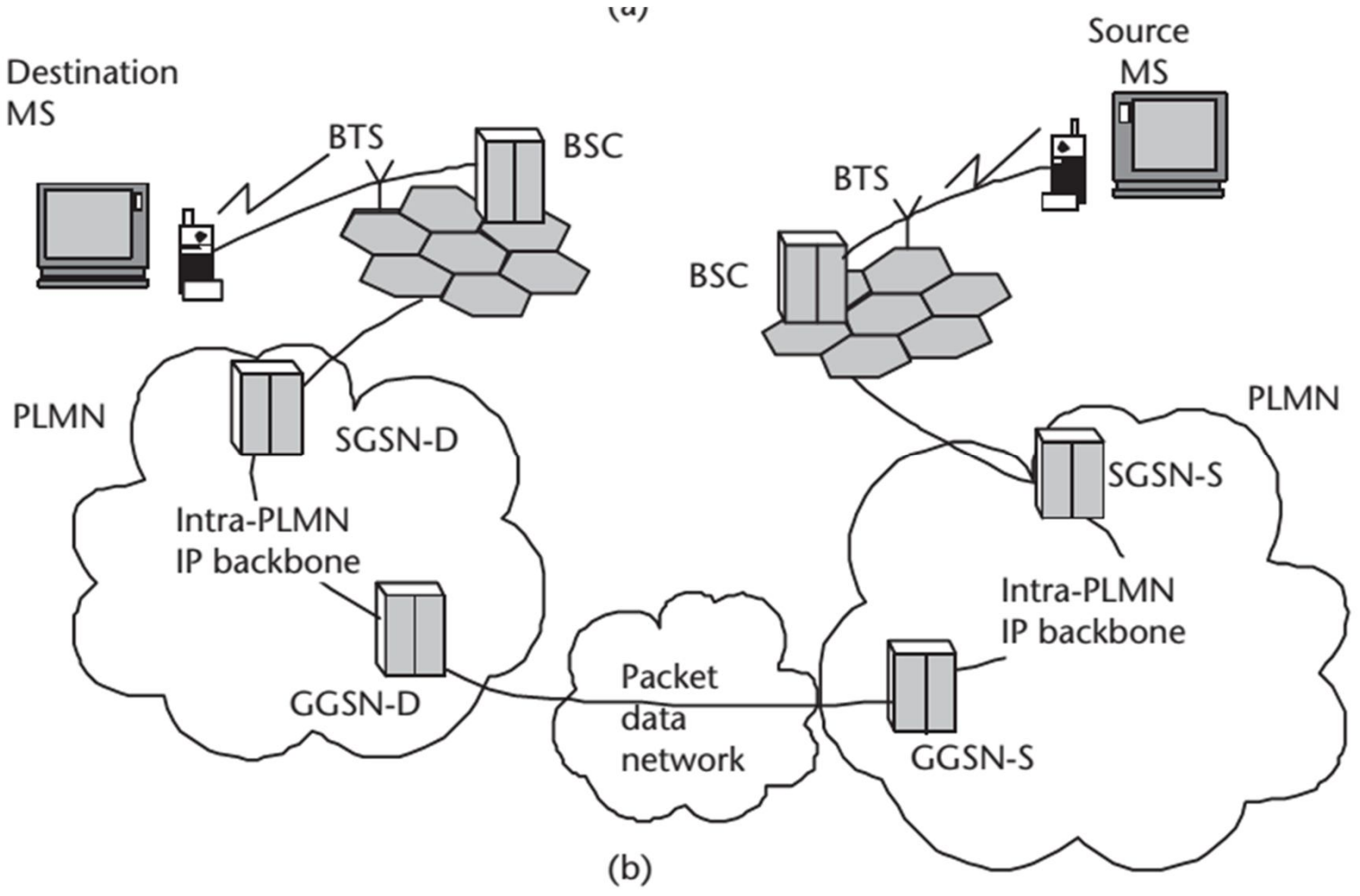
2.5G; GPRS


Base station subsystem, BSS
GPRS core network
Mobile stations, MSs
Base transceiver stations
Base station controllers
to PSTN
MSC/ VLR
Gr interface
HLR GR
Gp interface
Inter-PLMN backbone
BG
BTS
BSC
PCU
Gs interface
SGSN
GGSN
PDN
Gn interface
Gi interface
Gb interface
Abis interface
Um interface
Packet data transfer
Signaling
MSC = Mobile services switching center
VLR = Visitors location register
HLR = Home location register
SGSN = Servicing GPRS support node
GGSN = Gateway GPRS support node
BG = Border gateway
PCU = Packet control unit
PDN = Public data network

GPRS (lanjutan)



GPRS (lanjutan)



3G

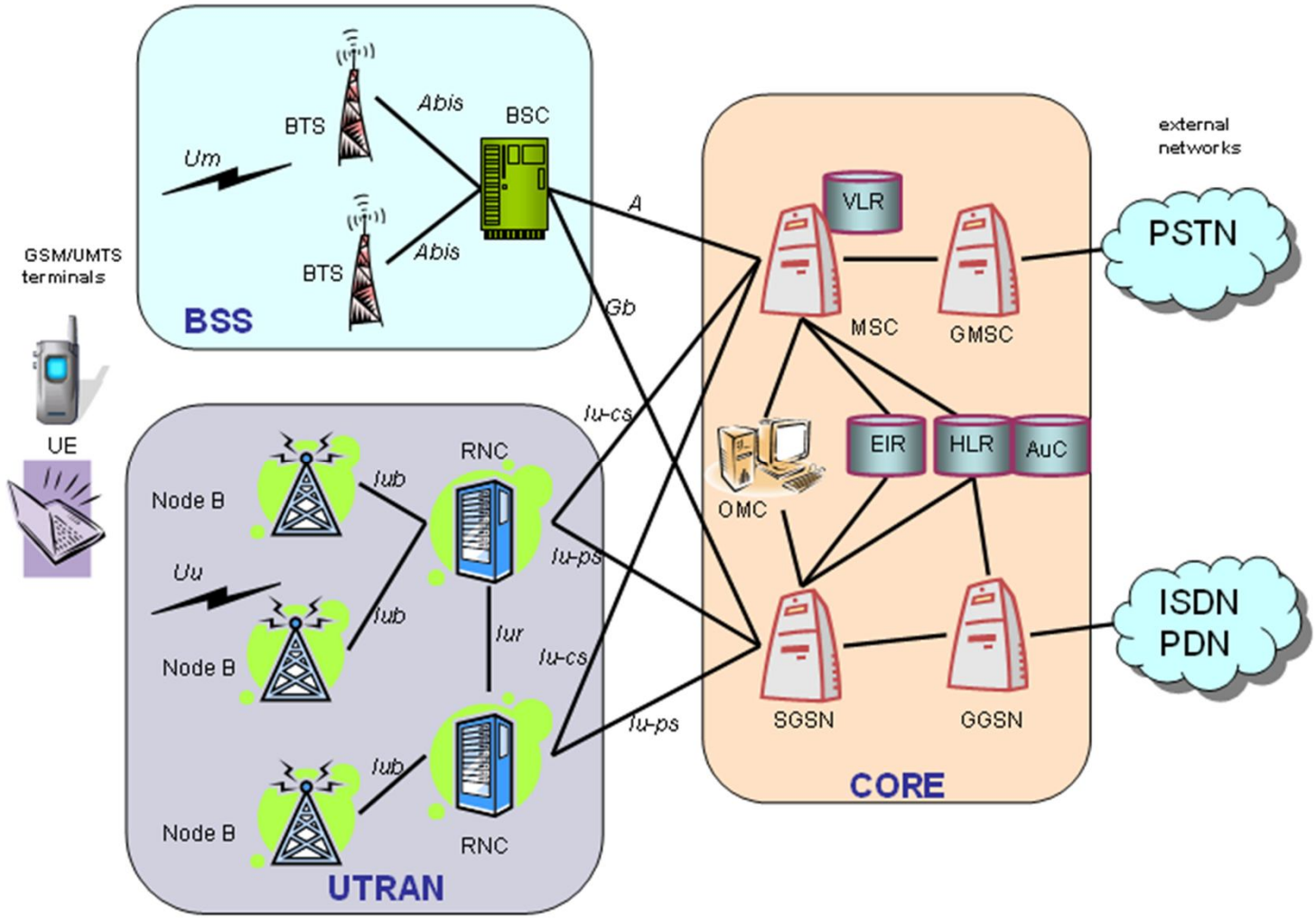
IMT-2000	**- Fulfill one's dream of anywhere, anytime communication**
Key Features	- High degree of commonality of design worldwide - Compatibility of services within IMT-2000 and with the fixed networks - High quality - Small terminal for worldwide use - Worldwide roaming capability - Capability for multimedia applications and a wide range of services and terminals
Important Component	- 2 Mbps for fixed environment - 384 kbps for indoor/outdoor and pedestrian environment - 144 kbps for vehicular environment
Standardization Work	- In progress (see Table 1.6)
Scheduled Service	- Started in October 2001 in Japan (W-CDMA) - Started in December 2001 in Europe - Started in January 2002 in South Korea - Started in October 2003 in USA

3G (lanjutan)

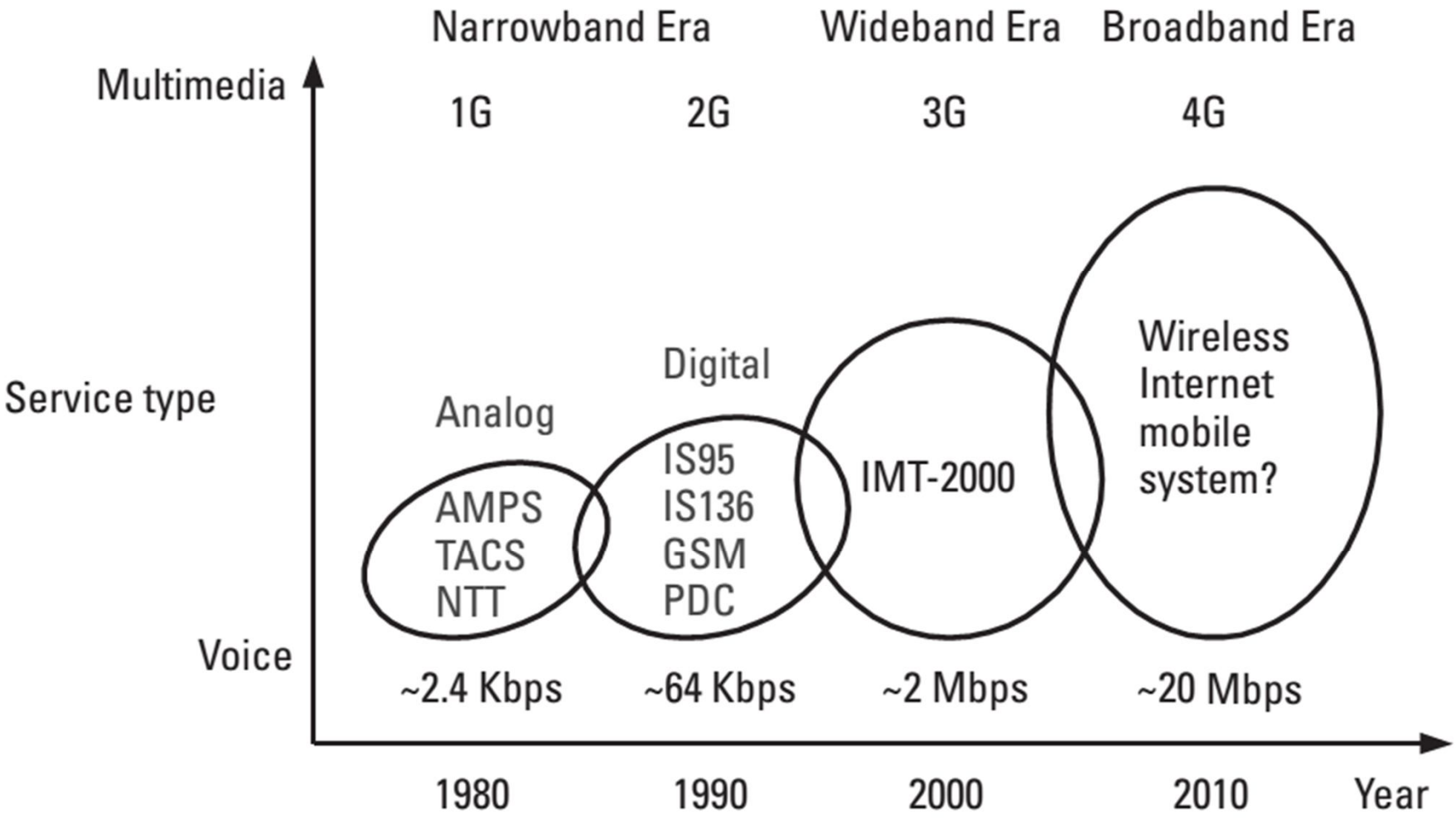
Table 4.9 Harmonized Family of Four Third Generation Standards

W-CDMA DS-CDMA	*W-CDMA Multicarrier*	*W-CDMA TDD*	*TDMA EDGE/UWC-136*
WCDMA as per 3GPP /UMTS	cdma2000 as per 3GPP2	As per 3GPP	As per ETSI/UWC
New spectrum	IS-95 spectrum overlay	Unpaired spectrum	Existing spectrum, 200-kHz TDMA
FDD	FDD	TDD	High-level modulation with link adaptation
Chip rate 3.84 Mc/s	Chip rate 3.6864 Mc/s	Chip rate 3.84 Mc/s	
Asynchronous (synchronous operation supported)	Synchronous		

Arsitektur UMTS/WCDMA



1G, 2G, 3G, 4G

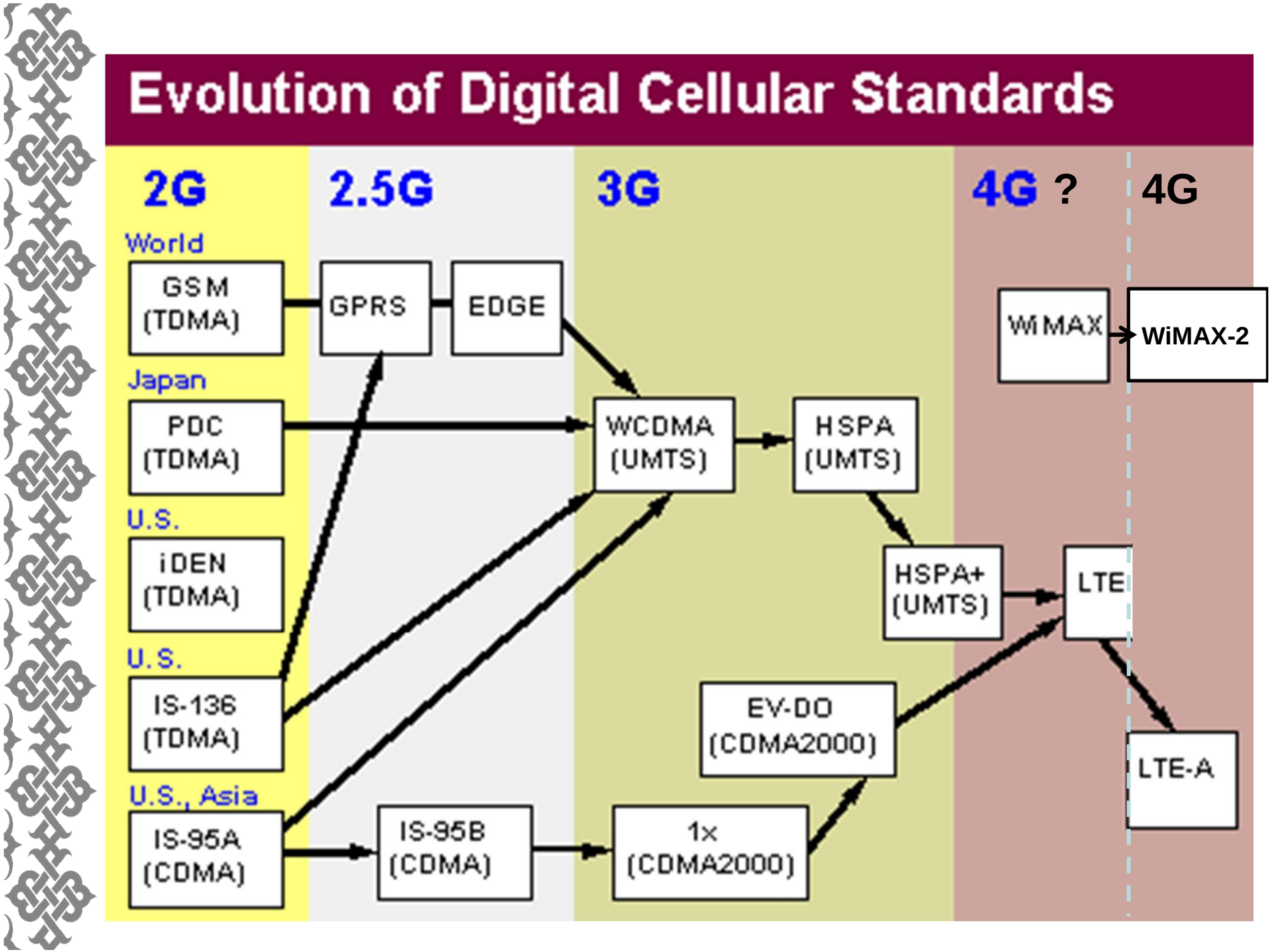

Narrowband Era
Wideband Era
Broadband Era
Multimedia
1G
2G
3G
4G
Service type
Digital
Analog
Wireless Internet mobile system?
IS95
IS136
GSM
PDC
IMT-2000
AMPS
TACS
NTT
Voice
~2.4 Kbps
~64 Kbps
~2 Mbps
~20 Mbps
1980
1990
2000
2010
Year

1G, 2G, 3G, 4G

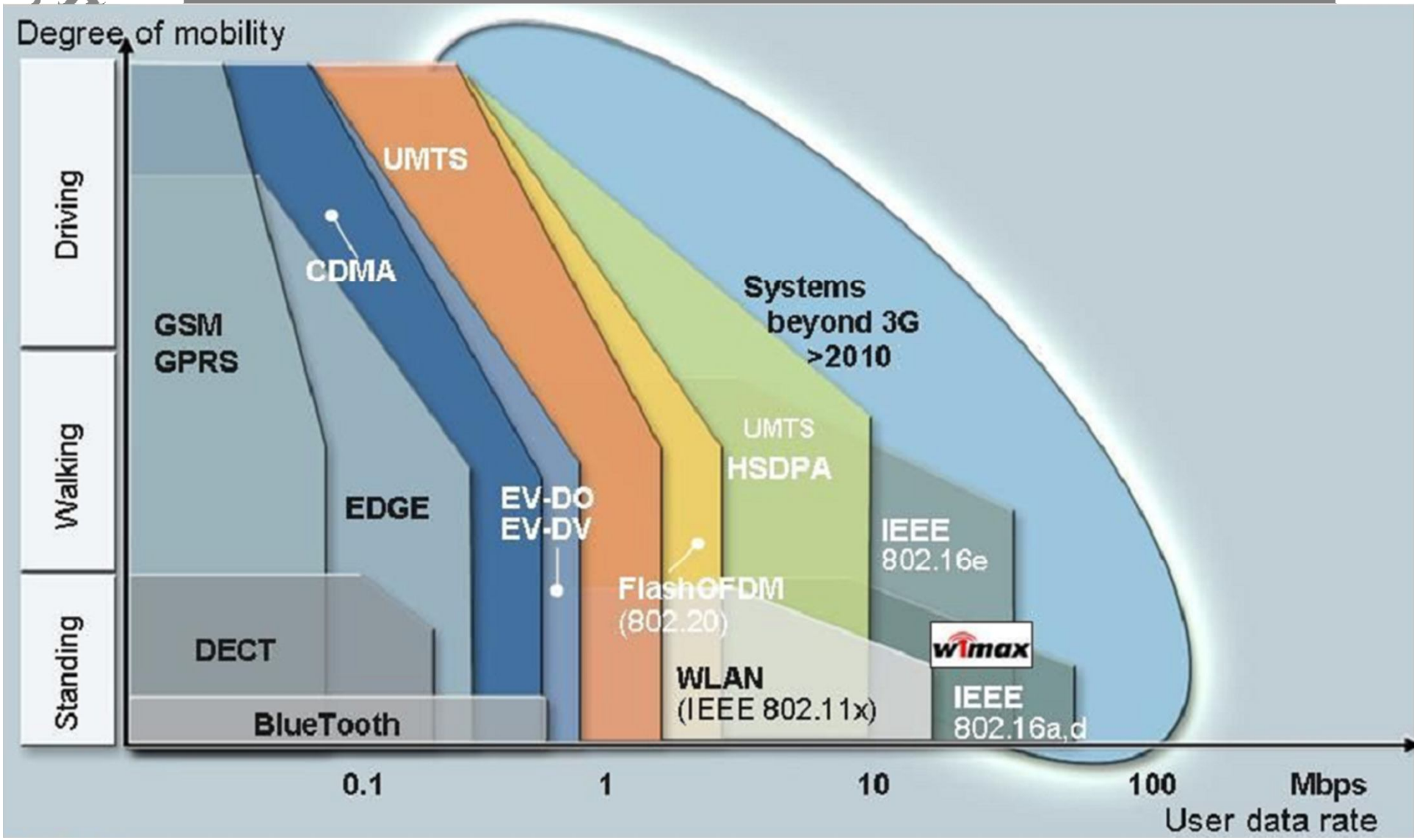

1G
• Voice Signals Only
• Analogue Cellular Phones
• NMT, AMPS, TACS
2G
• Voice & Data Signals
• Digital Fidelity Cellular Phones
• GSM, CDMA (IS-95), D-AMPS (IS-34/136), PDC
2.5G
• Enhance 2G
• Higher Data Rates
• GPRS, EDGE
3G
• Voice, Data & Video Signals
• Video Telephony / Internet Surfing
• 3G, W-CDMA/UMTS , CDMA2000, UWC-136
4G
• Enhanced 3G / Interoperability Protocol
• High Speed & IP-based
• 4G, Mobile IP : LTE-Advanced, WiMAX-2

The evolution of mobile standards

Mobile standards	3GPP		Qualcomm	China	IEEE
Carriers using:	AT&T and T-Mobile US, majority of global carriers		Sprint, Verizon Wireless	China Mobile	Sprint
2G: digital + data services	GSM: 2G		CDMAOne		
	GPRS: 2.5G				
	EDGE: 2.75G				
3G: at least 200 kbps iPhone 4 currently delivers up to 7.2Mbps down, 5.8Mbps up	Release 4	UMTS 3G	CDMA2000 EVDO rev 0	TD-SCDMA (up to 2Mbps)	
	Release 5	HSDPA 3.5G (to 21Mbps down)	CDMA2000 EVDO rev A (up to 3.1Mbps down, 1.8 up)		
	Release 6	HSUPA 3.5G (to 5.8Mbps up)	EVDO Rev C / Ultra Mobile Broadband Canceled: Sprint moving to WiMAX, Verizon moving to 3GPP LTE		Mobile WiMAX 3.9G (4 Mbps cap on EVO "4G")
	Release 7	HSPA+ 3.5G			
	Release 8/9	LTE 3.9G			
4G: at least 100 Mbps, IP-based	Release 10	LTE Advanced		TD-LTE	WiMAX 4G


Evolution of Digital Cellular Standards
2G
2.5G
3G
4G ?
4G
World
GSM (TDMA)
GPRS
EDGE
Japan
PDC (TDMA)
U.S.
iDEN (TDMA)
U.S.
IS-136 (TDMA)
U.S., Asia
IS-95A (CDMA)
IS-95B (CDMA)
WCDMA (UMTS)
HSPA (UMTS)
HSPA+ (UMTS)
1x (CDMA2000)
EV-DO (CDMA2000)
WiMAX
WiMAX-2
LTE
LTE-A

Fleksibelitas Berbagai Teknologi Nirkabel



Lampiran:

Kode ASCII

Decimal - Binary - Octal - Hex – ASCII Conversion Chart

Decimal	Binary	Octal	Hex	ASCII	Decimal	Binary	Octal	Hex	ASCII	Decimal	Binary	Octal	Hex	ASCII	Decimal	Binary	Octal	Hex	ASCII
0	00000000	000	00	NUL	32	00100000	040	20	SP	64	01000000	100	40	@	96	01100000	140	60	`
1	00000001	001	01	SOH	33	00100001	041	21	!	65	01000001	101	41	A	97	01100001	141	61	a
2	00000010	002	02	STX	34	00100010	042	22	"	66	01000010	102	42	B	98	01100010	142	62	b
3	00000011	003	03	ETX	35	00100011	043	23	#	67	01000011	103	43	C	99	01100011	143	63	c
4	00000100	004	04	EOT	36	00100100	044	24	$	68	01000100	104	44	D	100	01100100	144	64	d
5	00000101	005	05	ENQ	37	00100101	045	25	%	69	01000101	105	45	E	101	01100101	145	65	e
6	00000110	006	06	ACK	38	00100110	046	26	&	70	01000110	106	46	F	102	01100110	146	66	f
7	00000111	007	07	BEL	39	00100111	047	27	'	71	01000111	107	47	G	103	01100111	147	67	g
8	00001000	010	08	BS	40	00101000	050	28	(	72	01001000	110	48	H	104	01101000	150	68	h
9	00001001	011	09	HT	41	00101001	051	29	)	73	01001001	111	49	I	105	01101001	151	69	i
10	00001010	012	0A	LF	42	00101010	052	2A	*	74	01001010	112	4A	J	106	01101010	152	6A	j
11	00001011	013	0B	VT	43	00101011	053	2B	+	75	01001011	113	4B	K	107	01101011	153	6B	k
12	00001100	014	0C	FF	44	00101100	054	2C	,	76	01001100	114	4C	L	108	01101100	154	6C	l
13	00001101	015	0D	CR	45	00101101	055	2D	-	77	01001101	115	4D	M	109	01101101	155	6D	m
14	00001110	016	0E	SO	46	00101110	056	2E	.	78	01001110	116	4E	N	110	01101110	156	6E	n
15	00001111	017	0F	SI	47	00101111	057	2F	/	79	01001111	117	4F	O	111	01101111	157	6F	o
16	00010000	020	10	DLE	48	00110000	060	30	0	80	01010000	120	50	P	112	01110000	160	70	p
17	00010001	021	11	DC1	49	00110001	061	31	1	81	01010001	121	51	Q	113	01110001	161	71	q
18	00010010	022	12	DC2	50	00110010	062	32	2	82	01010010	122	52	R	114	01110010	162	72	r
19	00010011	023	13	DC3	51	00110011	063	33	3	83	01010011	123	53	S	115	01110011	163	73	s
20	00010100	024	14	DC4	52	00110100	064	34	4	84	01010100	124	54	T	116	01110100	164	74	t
21	00010101	025	15	NAK	53	00110101	065	35	5	85	01010101	125	55	U	117	01110101	165	75	u
22	00010110	026	16	SYN	54	00110110	066	36	6	86	01010110	126	56	V	118	01110110	166	76	v
23	00010111	027	17	ETB	55	00110111	067	37	7	87	01010111	127	57	W	119	01110111	167	77	w
24	00011000	030	18	CAN	56	00111000	070	38	8	88	01011000	130	58	X	120	01111000	170	78	x
25	00011001	031	19	EM	57	00111001	071	39	9	89	01011001	131	59	Y	121	01111001	171	79	y
26	00011010	032	1A	SUB	58	00111010	072	3A	:	90	01011010	132	5A	Z	122	01111010	172	7A	z
27	00011011	033	1B	ESC	59	00111011	073	3B	;	91	01011011	133	5B	[	123	01111011	173	7B	{
28	00011100	034	1C	FS	60	00111100	074	3C	<	92	01011100	134	5C	\	124	01111100	174	7C	|
29	00011101	035	1D	GS	61	00111101	075	3D	=	93	01011101	135	5D	]	125	01111101	175	7D	}
30	00011110	036	1E	RS	62	00111110	076	3E	>	94	01011110	136	5E	^	126	01111110	176	7E	~
31	00011111	037	1F	US	63	00111111	077	3F	?	95	01011111	137	5F	_	127	01111111	177	7F	DEL

Catatan: Bit pertama adalah bit paritas, tidak mesti 0. Ini akan bergantung pada kode paritas yg digunakan; *Even Parity Check* ataupun *Old Parity Check*.

PR-9

- Soal-soal PR-9 ada di file tersendiri.

Spirit Minggu Ini

- *“Dan orang-orang yang bersungguh-sungguh di jalan Kami niscaya Kami akan tunjukkan kepadanya jalan-jalan Kami. Sesungguhnya Allah bersama orang-orang yang berbuat baik.”*
  (Q.S. Al Ankabut [29] : 69)

Sekian, terima kasih, semoga berkah.

Ada pertanyaan?

Softcopy bahan kuliah tersedia di **http://adf.ly/1Yc3US**
dan **http://repository.unimal.ac.id**

Kuliah Pengganti

- **Kelas A4:**
  Rabu, 18 Mei 2016
  jam 14.00-16.30 WIB

- **Kelas A2:**
  Selasa, 17 Mei 2016
  jam 14.00-16.30 WIB