

Rural Telecommunications

(5) Radio Frequency Spectrum and Access Technology I – Cellular Systems

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Wireless Channel

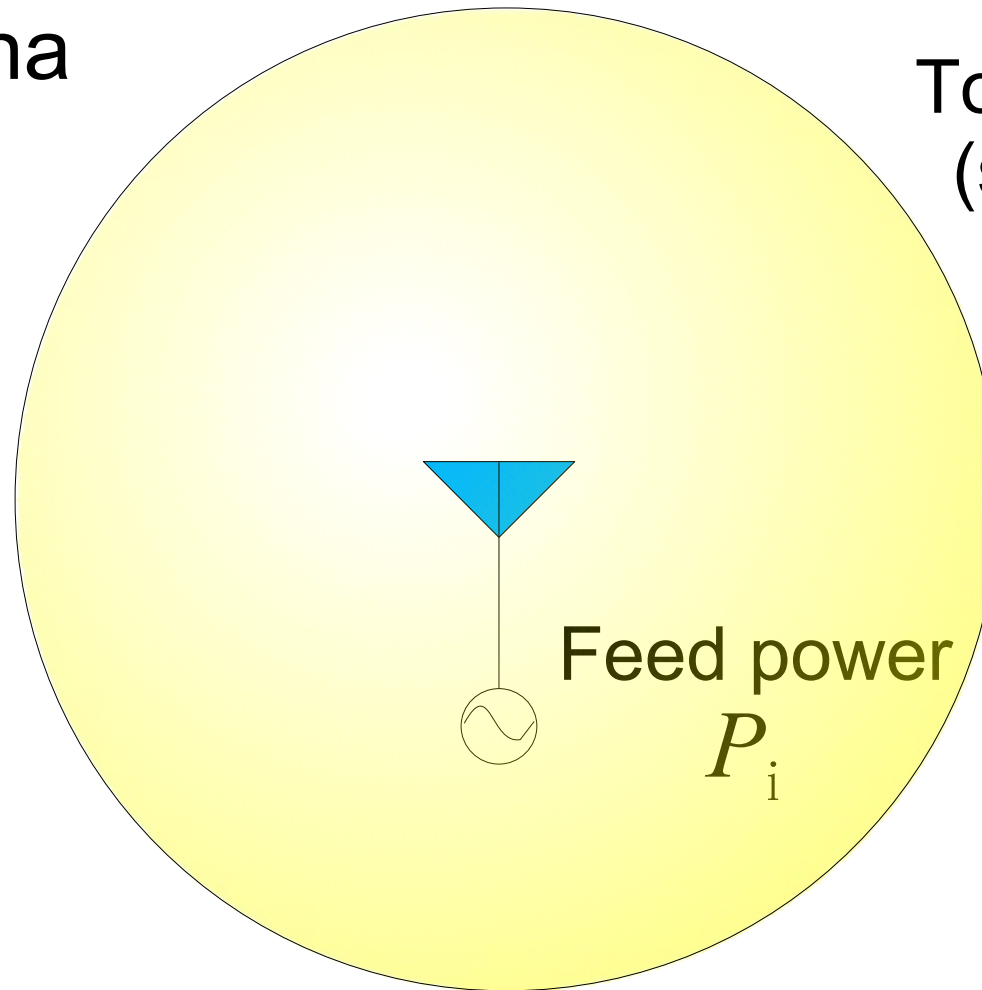
- Radiowave propagation
 - Natural phenomenon: impossible to control
- Antennas
 - Parts of radio system: possible to design

Antenna Efficiency

Tx antenna

Total radiated power
(sum over sphere)

$$P_r$$

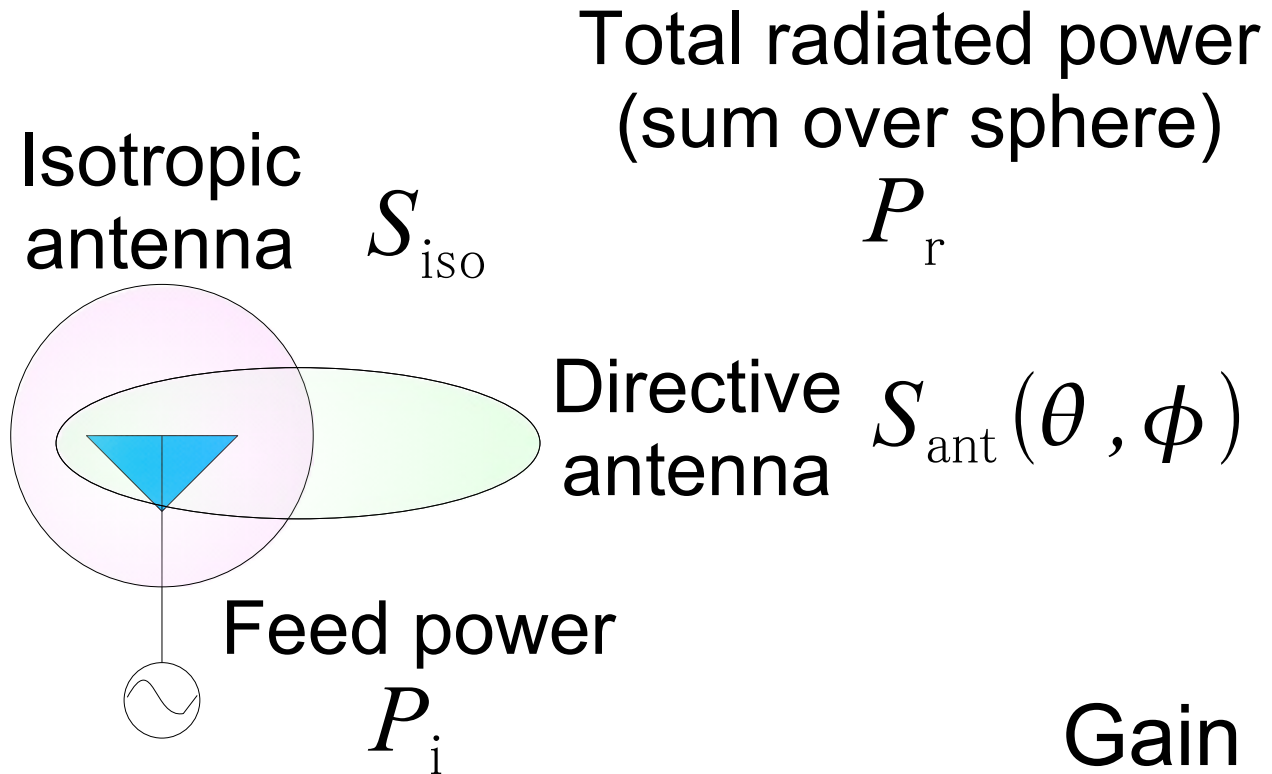


Feed power
 P_i

Efficiency $\eta = \frac{P_r}{P_i}$

Antenna Directivity and Gain

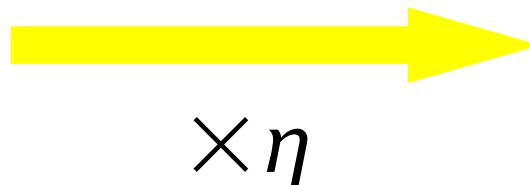
Directivity
angular power
intensity distribution



Directivity

$$D = \frac{S_{\text{ant}}(\theta, \phi)}{S_{\text{iso}}}$$

for common P_r



Gain

$$G = \frac{S_{\text{ant}}(\theta, \phi)}{S_{\text{iso}}}$$

for common P_i

Reciprocity

When the antenna is used for transmission and reception, the following properties are the common.

- Antenna efficiency
 - Transmission: radiated power / feed input power
 - Reception: feed output power / incident power
- Antenna gain and directivity
 - Transmission: strength
 - Reception: sensitivity

Why spectrum is important?

- Frequency is a tool to easily separate the signals.
- Finite resource to share
- To avoid interference
- Frequency is reused only if two stations are far apart.
- Different frequencies have different characteristics.

Principal Uses and Characteristics of Radio Wave

30kHz/10km	LF
300kHz/1km	MF
3MHz/100m	HF
30MHz/10m	

LF

- Radiobeacons for vessels and aircrafts
- Standard frequency and time signal
- Radio broadcasting (Only in North Asia and Europe)
- Remote controller (keyless entry)
- Stable propagation in long distance

Principal Uses and Characteristics of Radio Wave

30kHz/10km	LF
300kHz/1km	MF
3MHz/100m	HF
30MHz/10m	

MF

- Maritime communications
- Radio broadcasting (AM)
- Propagation in tens of km
- Simple receiver (AM)

Principal Uses and Characteristics of Radio Wave

HF

30kHz/10km	LF
300kHz/1km	MF
3MHz/100m	HF
30MHz/10m	

- Maritime and aeronautical communications
- International communications
- International radio broadcasting
- Amateur radio
- Historically used for international links

Principal Uses and Characteristics of Radio Wave

30MHz/10m	VHF
300MHz/1m	UHF
3GHz/10cm	SHF (Microwave)
30GHz/1cm	

VHF

- FM broadcasting
(incl. community radio)
- TV broadcasting
- Utility radio
disaster prevention,
administrative, fire
protection, railway
- Air traffic control
- Paging
- Amateur radio
- Cordless phone

Principal Uses and Characteristics of Radio Wave

30MHz/10m	VHF
300MHz/1m	UHF
3GHz/10cm	SHF (Microwave)
30GHz/1cm	

Most important band nowadays.

- Cellular phone
- Trunked radio
- Utility radio
 - taxi, disaster prevention, administrative, railway
- TV broadcasting
- Mobile satellite communications
- Radar
- Amateur radio
- Wireless LAN
- Cordless phone
- ISM (industry, science, and medical) equipments

Principal Uses and Characteristics of Radio Wave

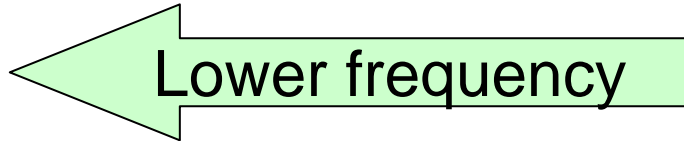
30MHz/10m	VHF
300MHz/1m	UHF
3GHz/10cm	SHF (Microwave)
30GHz/1cm	

**Most important band
in near future.**

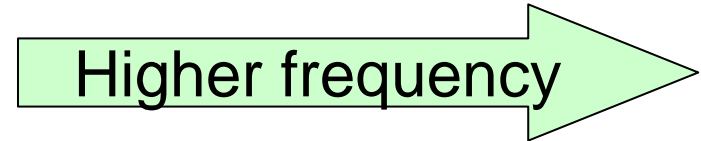
SHF (microwave)

- Wireless LAN
- Fixed microwave link
- Fixed wireless access
- Dedicated short range communications
- Broadcasting relay
- Satellite communications
- Satellite broadcasting
- Radar
- Radio astronomy

Characteristics of Radio Wave



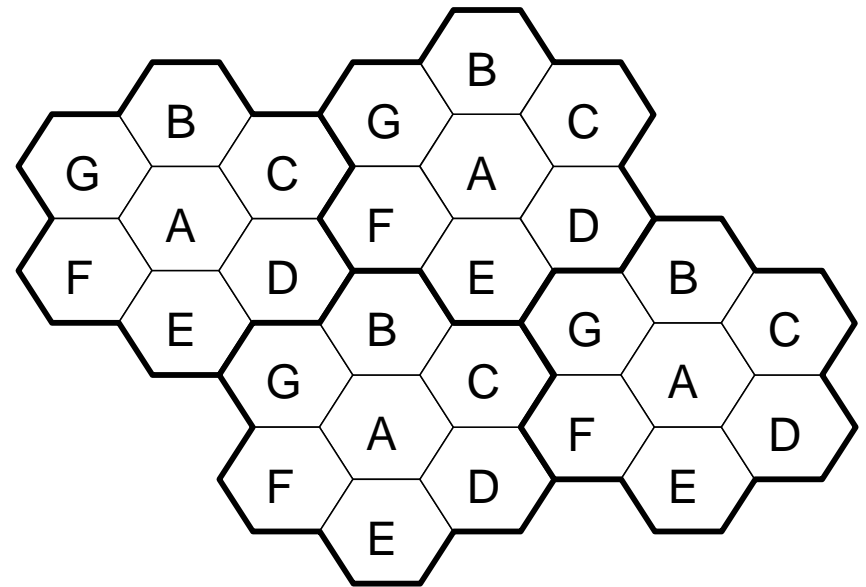
- Diffraction dominant propagation
 - Long distance
- Narrower bandwidth
 - Low data rate
- Cheaper equipments
- Bigger and less directive antennas



- Line-of-sight dominant propagation
 - Short distance
- Wider bandwidth
 - High data rate
- More expensive equipments
- Smaller and more directive antennas

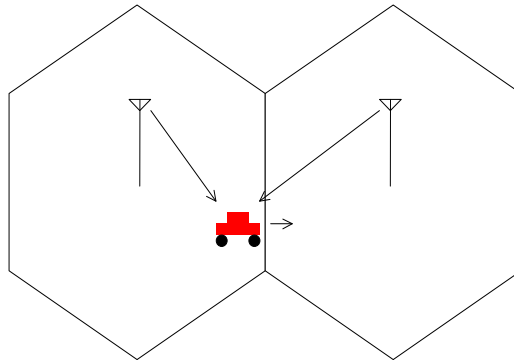
Cellular Concept

- Each base station (BS) covers a cell
- Spatial frequency reuse technique (in FDMA/TDMA)
- Reuse factor limited by co-channel interference (in FDMA/TDMA)



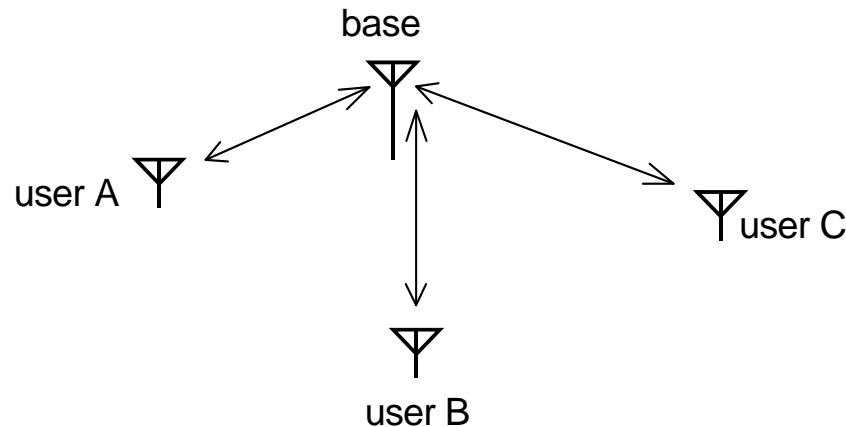
Handoff

- Smooth transition of wireless link between adjacent cells



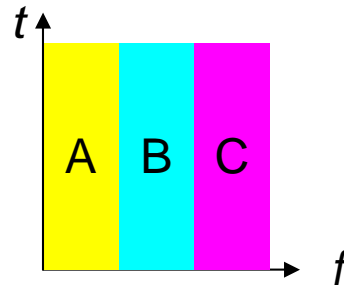
Multiple Access (1)

- Multiple users share the same transmission channel



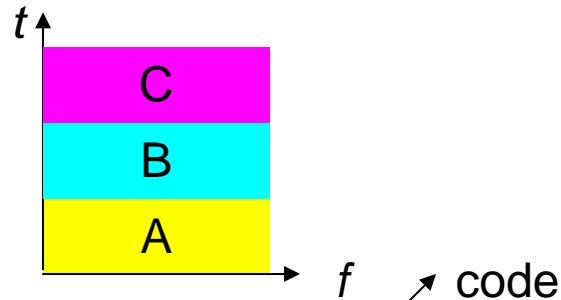
Multiple Access (2)

Frequency division
(FDMA)



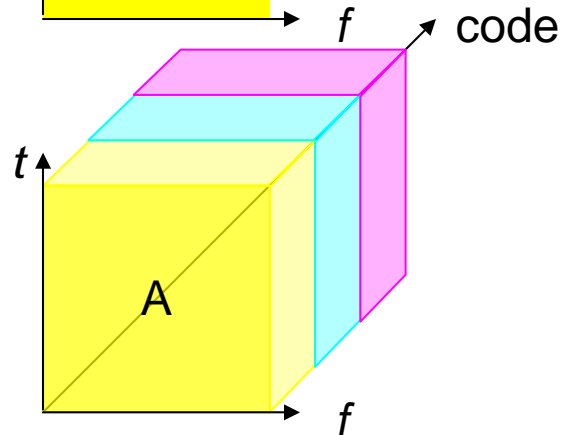
Duplex (TDD/FDD)
CSMA

Time division
(TDMA)



Filter and duplex
issue

Code division
(CDMA)



Evolution of Cellular Systems

3.9G

	1G (analog) 1979	2G (digital) 1993	2.5G (packet) 1997	3G (multimedia) 2001	3.5G (HS DL) 2006	4G (broadband) 2011?
Europe and rest	Local analog systems	GSM	GPRS	UMTS/ WCDMA	HSDPA => LTE	IMT- Advanced
Japan	Local system	PDC	PDC packet			
USA	AMPS TACS	IS-136 (TDMA)	IS-95 (cdmaOne)		EV-DO	

WiMAX

IMT-2000