Mobile Computing

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Agenda

- Cellular network
- Cell structure
- Frequency reuse
- Radio propagation effect
- Mobile wireless arrangement
- Principal components
- Functionality

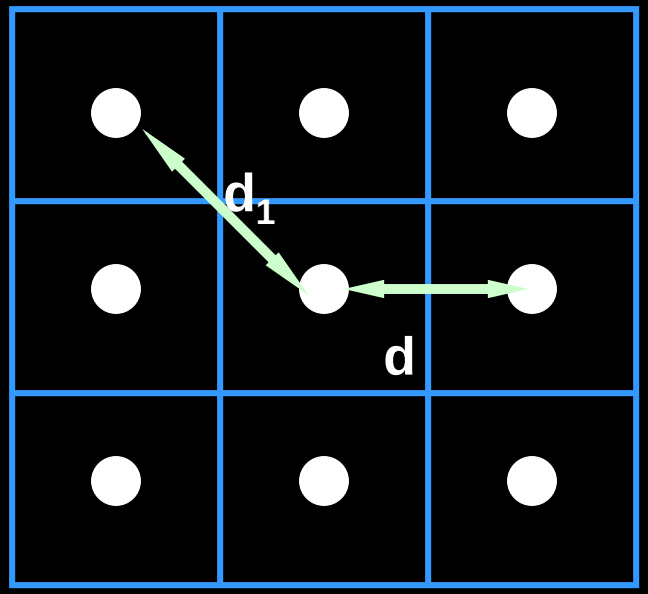
Communication modes

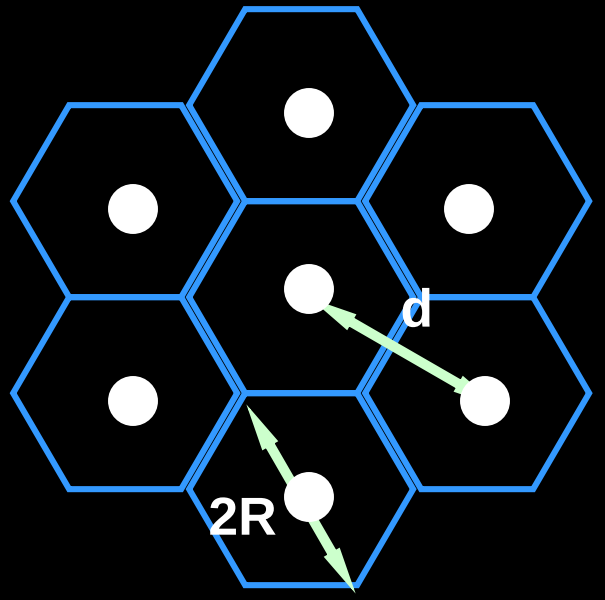
- Simplex mode
  - radio network transmits in one direction only
- Half duplex mode
  - it is capable of two way, or bi-directional, communications
- Full duplex
  - simultaneous bi-directional communications

Cellular network design

- Cellular network
  - To achieve more users
  - To have smaller transivers
- Network organization
  - Multiple low-power transmitter
  - Area divided into small structure→ cell
  - Each cell is served by its own antenna

Cellular Geometries





$d_1 = 1.414\ d$

$d = \sqrt{3}\ R$

Frequency reuse

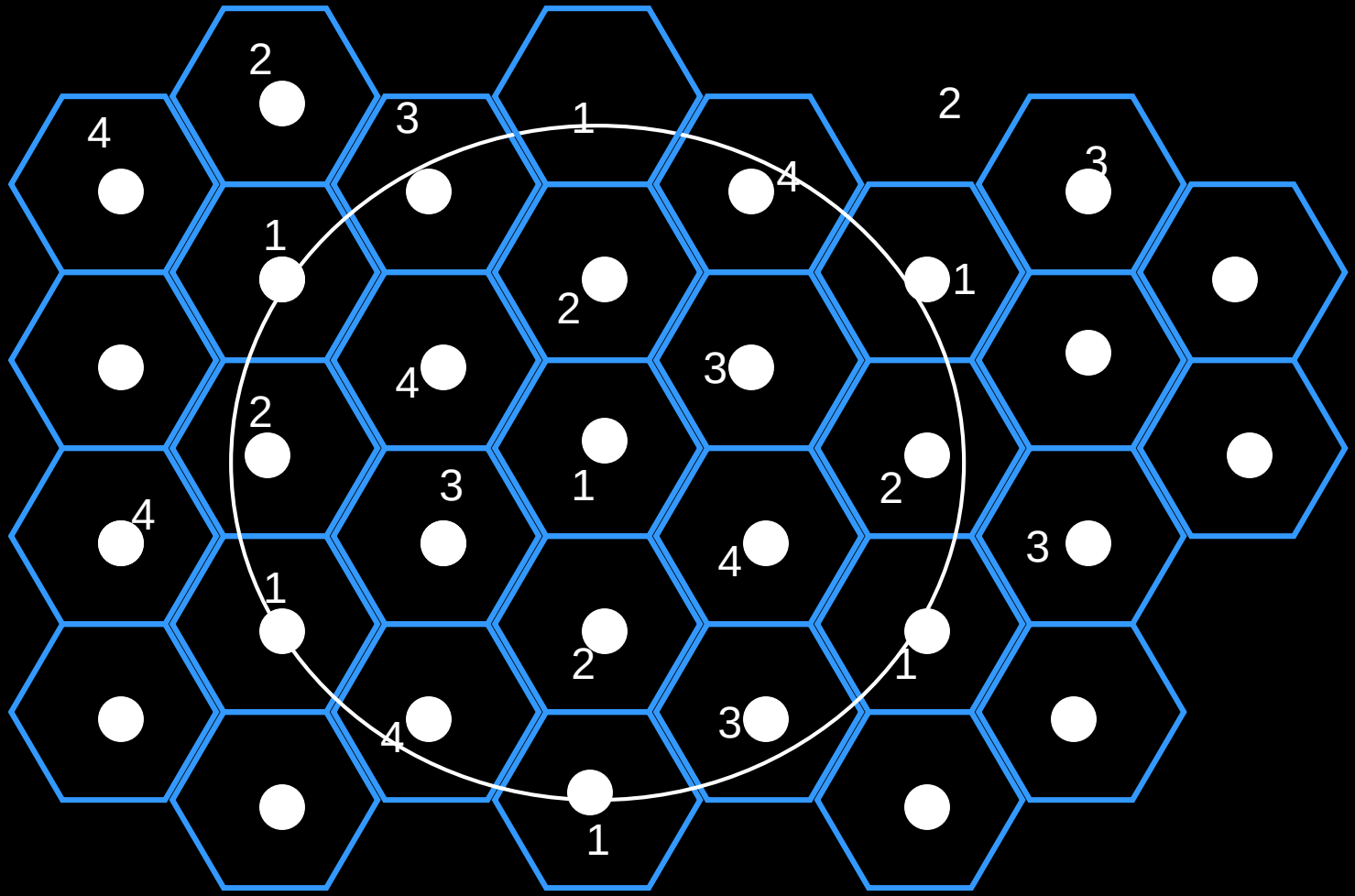
- Each cell has a base transceiver
- Same frequency used in nearby cells
- Generally 10 to 50 frequencies are assigned to each cell
- Essential issue is to determine intervening cells between two cells using the same frequency so that the two cells do not interfere with each other
- In a hexagonal cell pattern,

$$N = I^2 + J^2 + (I \times J)$$

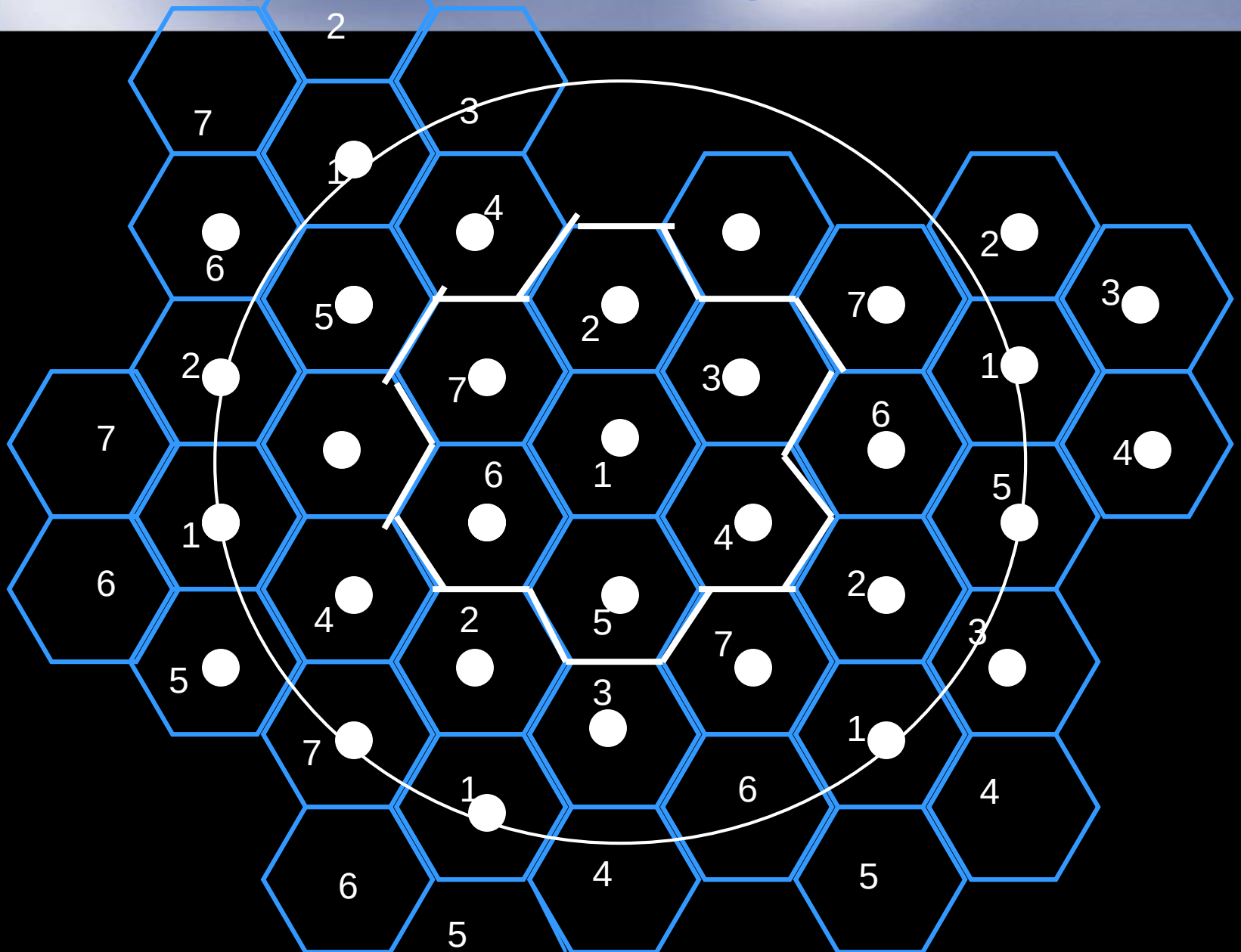
I, J = 0, 1, 2, 3 …

  - D = minimum distance between centers of cells that use the same band of frequencies (called cochannels)
  - R = radius of a cell
  - d = distance between centers of adjacent cells
  - N = number of cells in a repetitious pattern called *reuse factor*
- Possible values of N are 1, 3, 4, 7, 9, etc and *D/R = √(3N)*

Frequency reuse pattern for N = 4



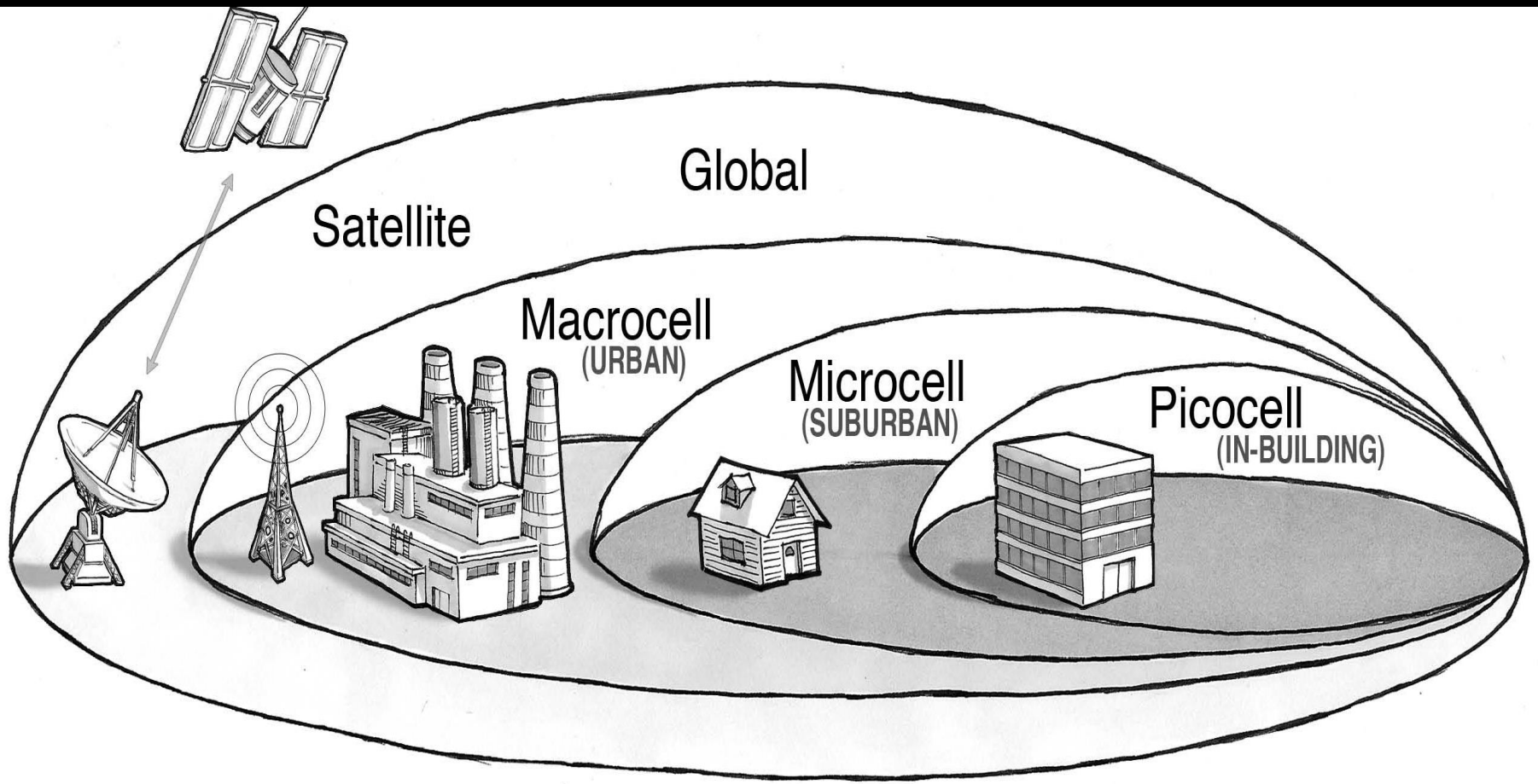
Frequency reuse pattern for N = 7



Increasing Capacity

- Add new channel
- Cell splitting
  - Original cell size 6.5 km to 13 km.
  - Smaller cells (1.5 km); less power level, more frequent handoff
- Cell sectoring
  - 3 to 6 sectors per cell
  - Each sector is assigned separate subset of the cell's channel
  - Directional antennas are used at the base station
- Microcell

An early International Mobile Telecommunication (IMT-2000) concept diagram from the ITU



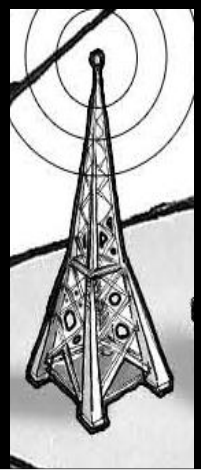
Typical parameters for Macrocell and Microcell

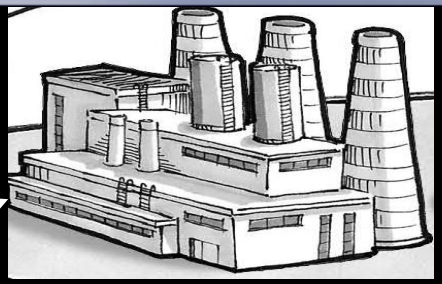
	Macrocell	**Microcell**
Cell radius	1 to 20 km	0.1 to 1 km
Transmission power	1 to 10 W	0.1 to 1 W
Average delay spread	0.1 to 10 μs	10 to 100 ns
Maximum bit rate	0.3 Mbps	1 Mbps

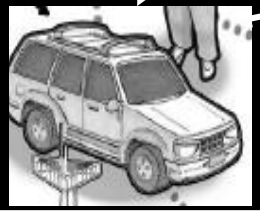
Carrier to Interference ratio

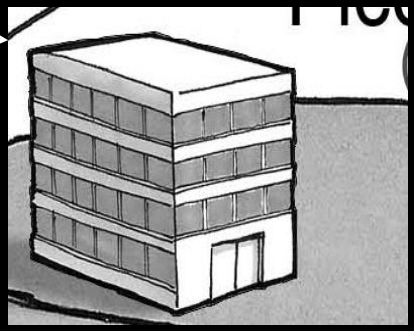
- A mobile handset which is moving in a cell will record a signal strength that varies.
- Signal strength is subject to slow fading, fast fading and interference from other signals, resulting in degradation of the carrier-to-interference (C/I) ratio.
- A high C/I ratio yields quality communication.
- A good C/I ratio is achieved in cellular systems by using optimum power levels through the power control of most links.
- When carrier power is too high, excessive interference is created, degrading the C/I ratio for other traffic and reducing the traffic capacity of the radio subsystem.
- When carrier power is too low, C/I is too low and QoS targets are not met.

Multipath Interference









Multipath Propagation

- Reflection
  - Reflection from a flat surface that is large relative to the wavelength of the signal
  - Reflected wave is 180 degree out of phase with LOS signal tending to cancel LOS signal
  - Ex: ground reflected wave
- Diffraction
  - Occurs from an edge of impenetrable body
  - Waves propagate in different direction with the edge as the source
- Scattering
  - For obstacles of the order of wavelength of the signal
  - Lamp post, traffic sign

Types of Fading

- Fast Fading:
  - Signal change occurs over one-half a wavelength
  - At a frequency of 900 MHz.(0.33m), rapid change in amplitude (as much as 20 or 30 dB).
- Slow fading
  - Over long distance slow changes in amplitude occurs as user passes through buildings, heights, vacant places etc.
- Flat fading
  - All frequency components fluctuate in same proportion

"Wireless Communications and Networks", William Stallings

Types of Fading

- For urban environment, predicted path loss is,

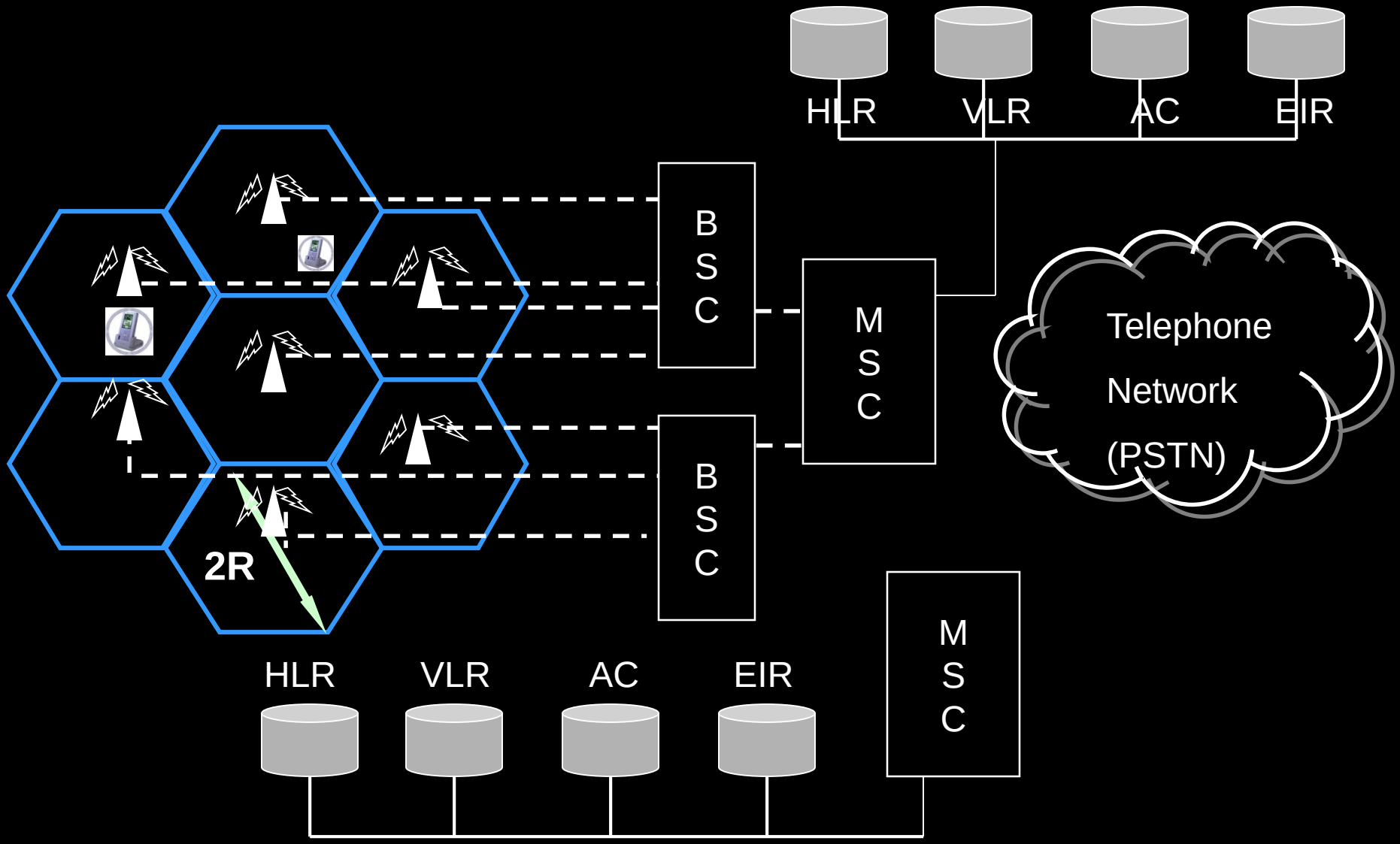
$$L_{dB} = 69.55 + 26.16 f_c - 13.82 \log h_r - A(h_r) + (44.9 - 6.55 h_t) \log d$$

- f_c → carrier frequency in MHz.
- $A(h_r)$ → correctional factor for mobile antenna height
- h_t → height of transmitter antenna
- h_r → height of receiving antenna

Fading Channels

- ***AWGN***
  - Signal degrades by thermal noise associated with the physical channel
  - Also for end users electronic equipment.
- ***Rayleigh***
  - Multiple indirect paths between transmitter and receiver
  - Suited for outdoor environment
- ***Rician***
  - A direct LOS path with number of indirect multipath between transmitter and receiver
  - Bets suited for smaller cells in more open environment

Mobile Wireless Arrangement



Principle components

- Base transceiver station (**BTS**) or Base station (**BS**)
  - Base station controller (**BSC**), a mobile unit
  - It manages air interface between MS and BS
  - Helps in power control (*radio resource management*)
- Mobile switching center (**MSC**)
  - Responsible for switching calls from cell to cell, providing backup interfacing with telephone network
  - *Call management/connection management* function *(CM)*
- **BSC**, introduced in second generation mobile systems
  - Mainly offload functions from MSCs
  - Controls BSs
  - Handover operation management
  - Frequency administration between BSs and MSs

Principle components

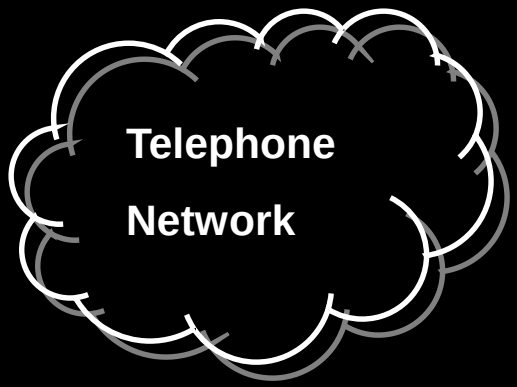
- Mobile station (**MS**):
  - A mobile unit, transceiver installed in track, car, portable telephone etc
  - Subscriber identity module (SIM)
  - Identified using International mobile equipment identity (IMEI)

- SIM contains personal identity number (PIN), PIN unblocking number (PUK), authentication key K_i and the international mobile subscriber identity (IMSE), temporary MSE (TMSE)

Principle components

- Databases used in all mobile stations
  - Home location register (**HLR**)
    - Keeps track of a subscriber location
    - Keeps track of subscriber's accounting information
    - Subscribed service provider
  - Visitor location register (**VLR**)
    - Keeps track of a visiting subscriber location
    - Helps subscriber log on to new location
- Authentication control/access control (**AC**)
  - Contains authentication and encryption information of each subscriber
  - Interacts with HLR, VLR
- Equipment identity register (**EIR**)
  - Contains information of MS equipment

Connection Management (CM) operation



Gateway MSC

Terminating MSC

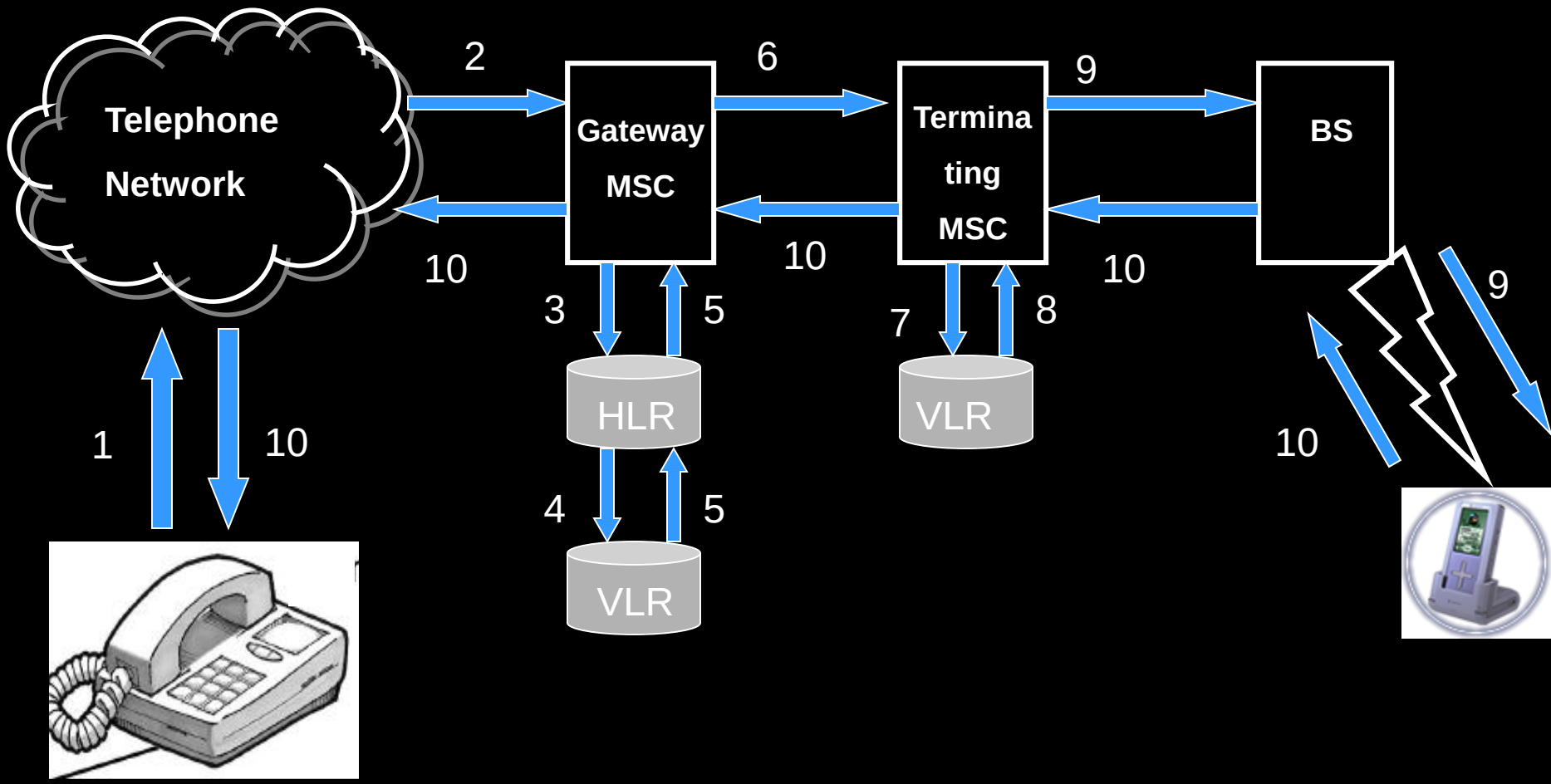
BS

HLR

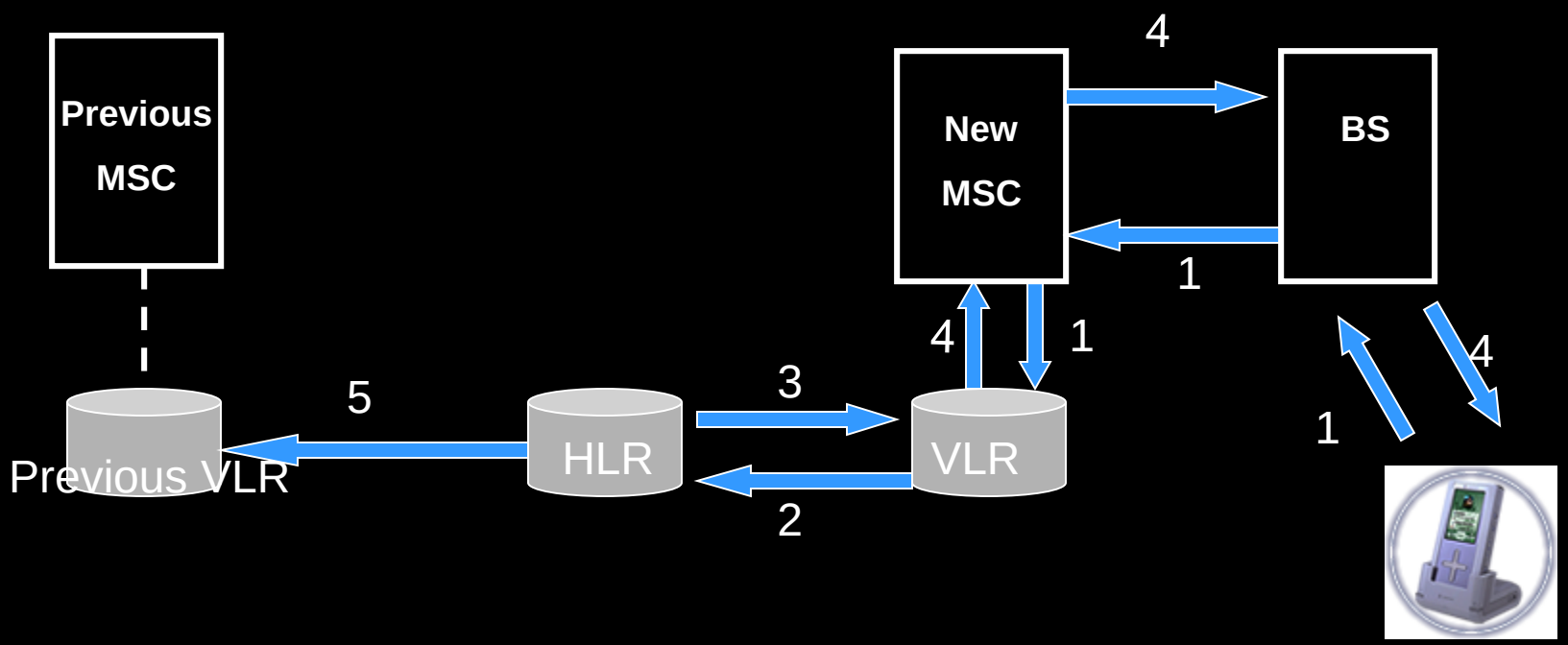
VLR

VLR

Connection Management (CM) operation



Mobility Management (MM) operation



Thank You!