

CELLULAR AND MOBILE COMMUNICATIONS

SOURCE:

MOBILE CELLULAR TELECOMMUNICATIONS
BY WILLIAM C.Y. LEE

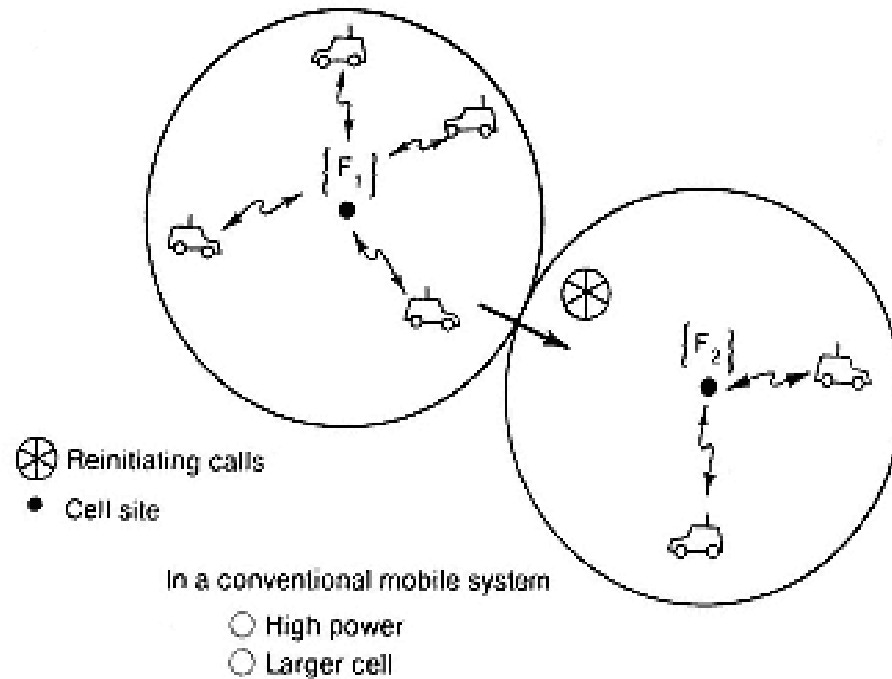
Introduction to Cellular Mobile Systems

- Why Cellular Mobile Telephone Systems?

Limitations of Conventional Mobile Telephone Systems

- operational limitations
- limited service capability
- poor service performance
- inefficient frequency spectrum utilization.

Limited Service Capability



Poor Service Performance

- In the past, a total of 33 channels were allocated to three mobile telephone systems:
- Mobile Telephone Service (MTS),
- Improved Mobile Telephone Service (IMTS) MJ systems, and
- Improved Mobile Telephone Service (IMTS) MK systems.
- The large number of subscribers created a **high blocking probability** during busy hours.
- A high-capacity system for mobile telephones was needed.

Inefficient Frequency Spectrum Utilization

the conventional system does not utilize the spectrum efficiently since each channel can only serve one customer at a time in a whole area.

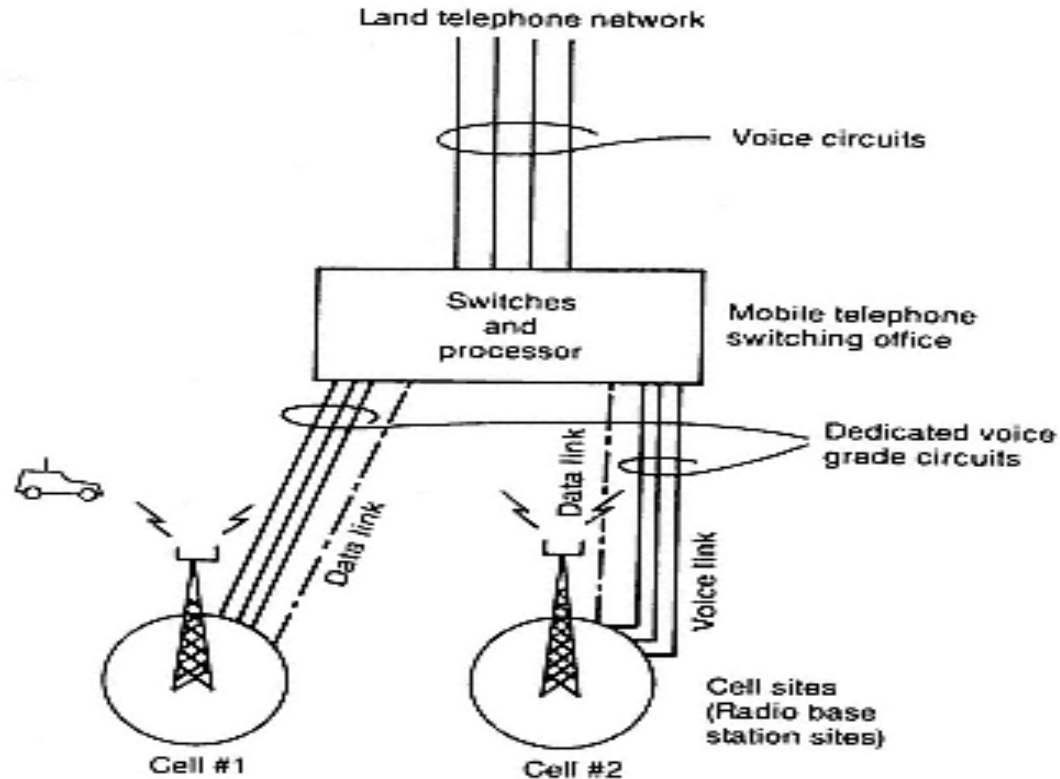
Spectrum Efficiency Considerations

- limitation - available radio frequency spectrum
- minimal bandwidth but provide high usage and consumer satisfaction.

Three major approaches to achieve the ideal are

- 1. Single-sideband (SSB), which divides the allocated frequency band into maximum numbers of channels
- 2. Cellular, which reuses the allocated frequency band in different geographic locations
- 3. Spread spectrum or frequency-hopped, which generates many codes over a wide frequency band

A Basic Cellular System



a mobile unit,
a cell site, and
a mobile telephone switching office (MTSO)

- 1. *Mobile units*. A mobile telephone unit contains a control unit, a transceiver, and an antenna system.
- 2. *Cell site*. The cell site provides interface between the MTSO and the mobile units. It has a control unit, radio cabinets, antennas, a power plant, and data terminals.
- 3. *MTSO*. The switching office, the central coordinating element for all cell sites, contains the cellular processor and cellular switch. It interfaces with telephone company zone offices, controls call processing, and handles billing activities.
- 4. *Connections*. The radio and high-speed data links connect the three subsystems. Each mobile unit can only use one channel at a time for its communication link.
- **The MTSO is the heart of the cellular mobile system. Its processor provides central coordination and cellular administration.**

Operation of Cellular Systems

- *Mobile unit initialization.*- self-location procedure
- *Mobile originated call.*- A request for service is sent on a selected set-up channel obtained from a self-location scheme
- *Network originated call.*- A land-line party dials a mobile unit number.
- *Call termination.*
- *Handoff procedure.*

Performance Criteria

- *Voice Quality*
- a set value x at which y percent of customers rate the system voice quality (from transmitter to receiver) as good or excellent, the top two circuit merits (CM) of the five listed below.

Performance Criteria

CM	Score	Quality scale
CM5	5	Excellent (speech perfectly understandable)
CM4	4	Good (speech easily understandable, some noise)
CM3	3	Fair (speech understandable with a slight effort, occasional repetitions needed)
CM2	2	Poor (speech understandable only with considerable effort, frequent repetitions needed)
CM1	1	Unsatisfactory (speech not understandable)

Performance Criteria

- *Service Quality*
 - 1. *Coverage.*
 - 2. *Required grade of service.*
 - 3. *Number of dropped calls.*

Service Quality

- The system should serve an area as large as possible.
- The transmitted power would have to be very high to illuminate weak spots with sufficient reception, a significant added cost factor.
- The higher the transmitted power, the harder it becomes to control interference.

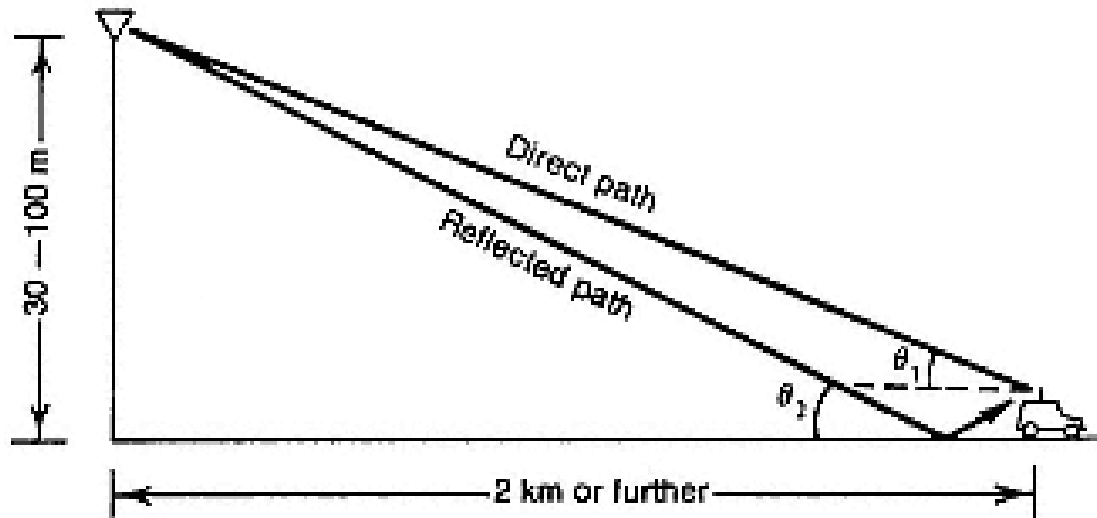
Number of dropped calls.

- A high drop rate could be caused by either
- coverage problems or
- handoff problems related to inadequate channel availability.

Performance Criteria

- *Special Features*
 - call forwarding,
 - call waiting,
 - voice stored (VSR) box,
 - automatic roaming, or navigation services
- NO EXTRA COST

Uniqueness of Mobile Radio Environment



Mobile radio transmission model.

The Propagation Attenuation

- the propagation path loss increases not only with frequency but also with distance
- The propagation path loss would be 40 dB/dec
- This means that a 40-dB loss at a signal receiver will be observed by the mobile unit as it moves from 1 to 10 km.

$$C \propto R^{-4} = \alpha R^{-4} \quad (16-1)$$

- where C = received carrier power
- R = distance measured from the transmitter to the receiver

- The difference in power reception at two different distances R_1 and R_2 will result in

$$\frac{C_2}{C_1} = \left(\frac{R_2}{R_1} \right)^{-4} \quad (1.6-2a)$$

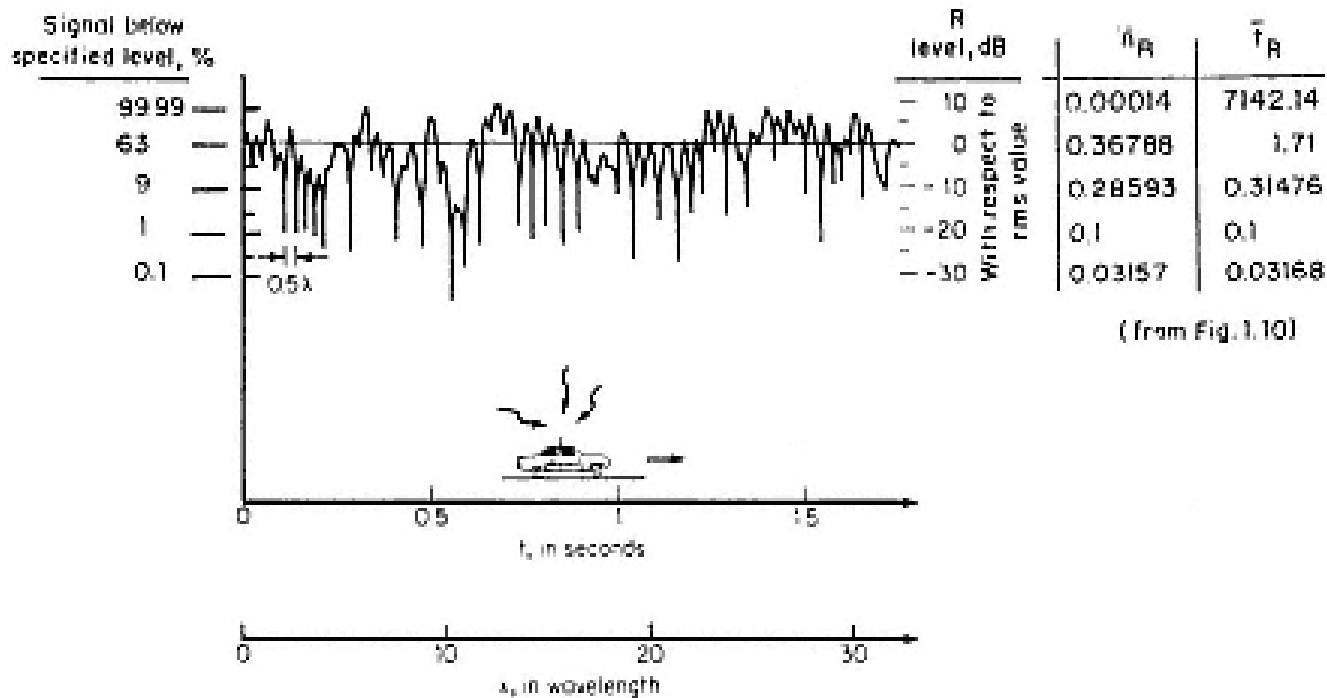
- and the decibel expression is

$$\Delta C \text{ (in dB)} = C_2 - C_1 \text{ (in dB)}$$

$$= 10 \log \frac{C_2}{C_1} = 40 \log \frac{R_1}{R_2} \quad (1.6-2b)$$

- When $R_2 = 2R_1$, $DC = 12 \text{ dB}$; when $R_2 = 10R_1$, $DC = 40 \text{ dB}$.

A typical fading signal received while the mobile unit is moving (**Severe Fading**)

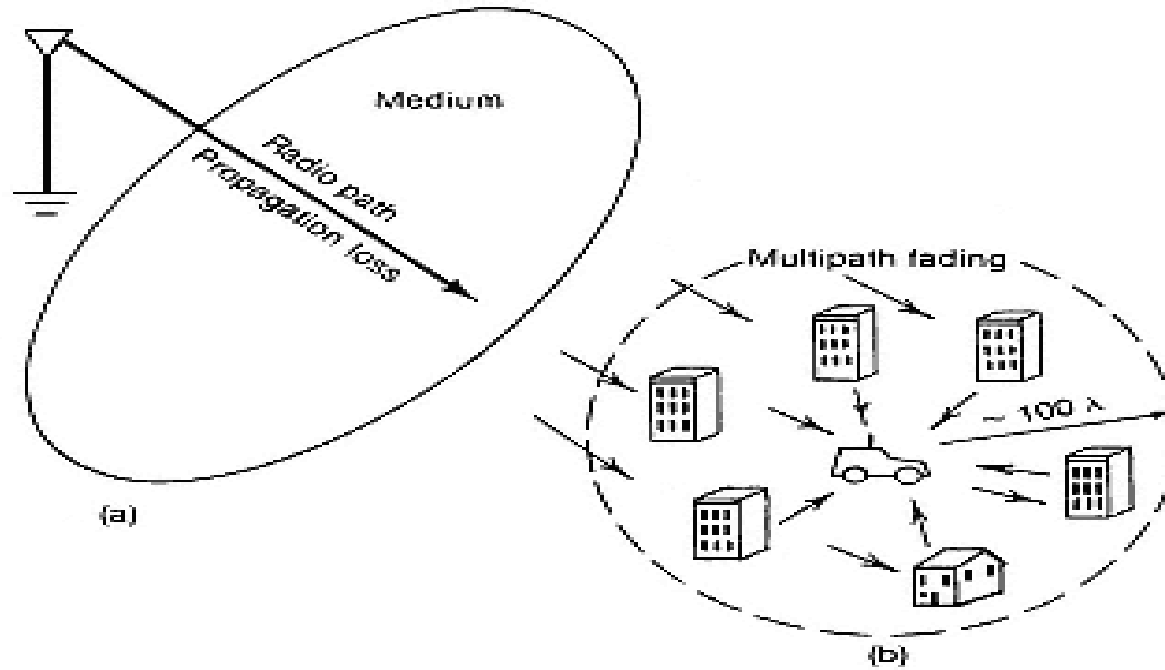


$$p(R) = R_B^{-R^2} \quad \text{cumulative probability distribution}$$

$$\bar{n}(R) = \frac{QV}{\sqrt{2\pi}} \times n_R \quad \text{level crossing rate}$$

$$\bar{t}(R) = \frac{\sqrt{2\pi}}{QV} \times \bar{t}_R \quad \text{average duration of fades}$$

Mobile Fading Characteristics



Delay Spread

- the signal transmitted from a cell site and arriving at a mobile unit will be from different paths
- each path has a different path length
- the time of arrival for each path is different.
- For an impulse transmitted at the cell site, by the time this impulse is received at the mobile unit it is no longer an impulse but rather a pulse with a spread width that we call the *delay spread*.

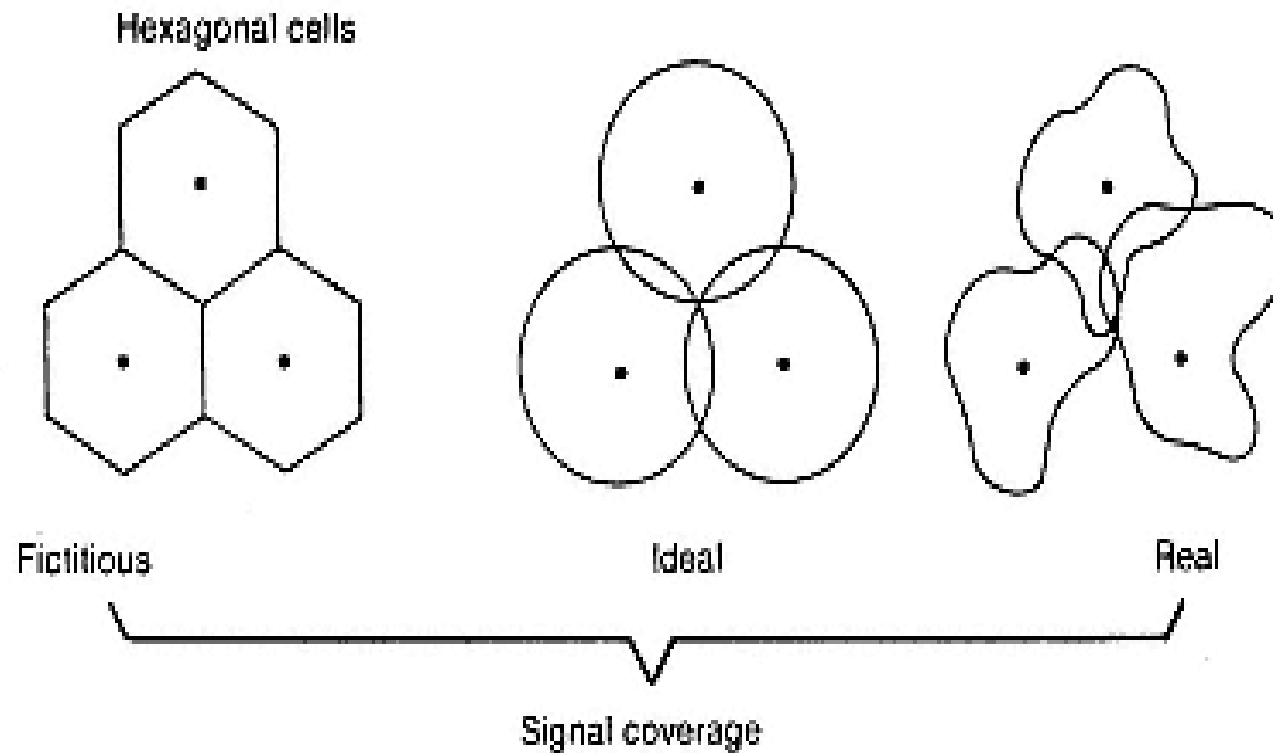
Coherence Bandwidth

- bandwidth in which either the amplitudes or the phases of two received signals have a high degree of similarity

Noise Level in Cellular Frequency Band

- The Ignition Noise- the vehicle ignition noise
- 800 MHz Emission Noise-
- *Amplifier Noise*

Marketing Image of Hexagonal-shaped Cells



- Analog Cellular Systems
- Digital Cellular Systems