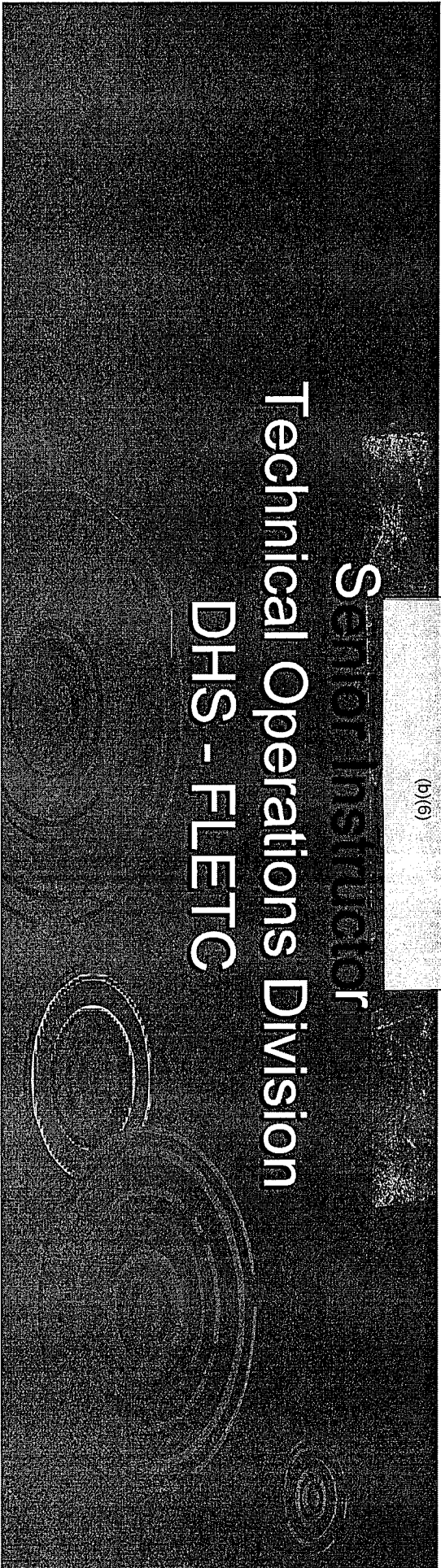


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Mobile Device Investigations Program

(b)(6)

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Technical Operations Division
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Frequency Reuse and Planning

Cellular Technology enables mobile communication because they use of a complex two-way radio system between the mobile unit and the wireless network.

It uses radio frequencies (radio channels) over and over again throughout a market with minimal interference, to serve a large number of simultaneous conversations.

This concept is the central tenet to cellular design and is called frequency reuse.

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Frequency Reuse and Planning

Repeatedly reusing radio frequencies over a geographical area.

Most frequency reuse plans are produced in groups of seven cells.

A decorative graphic consisting of several sets of concentric circles in a lighter blue shade, arranged in a pattern that suggests a cellular or network structure, located in the bottom right area of the slide.

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7

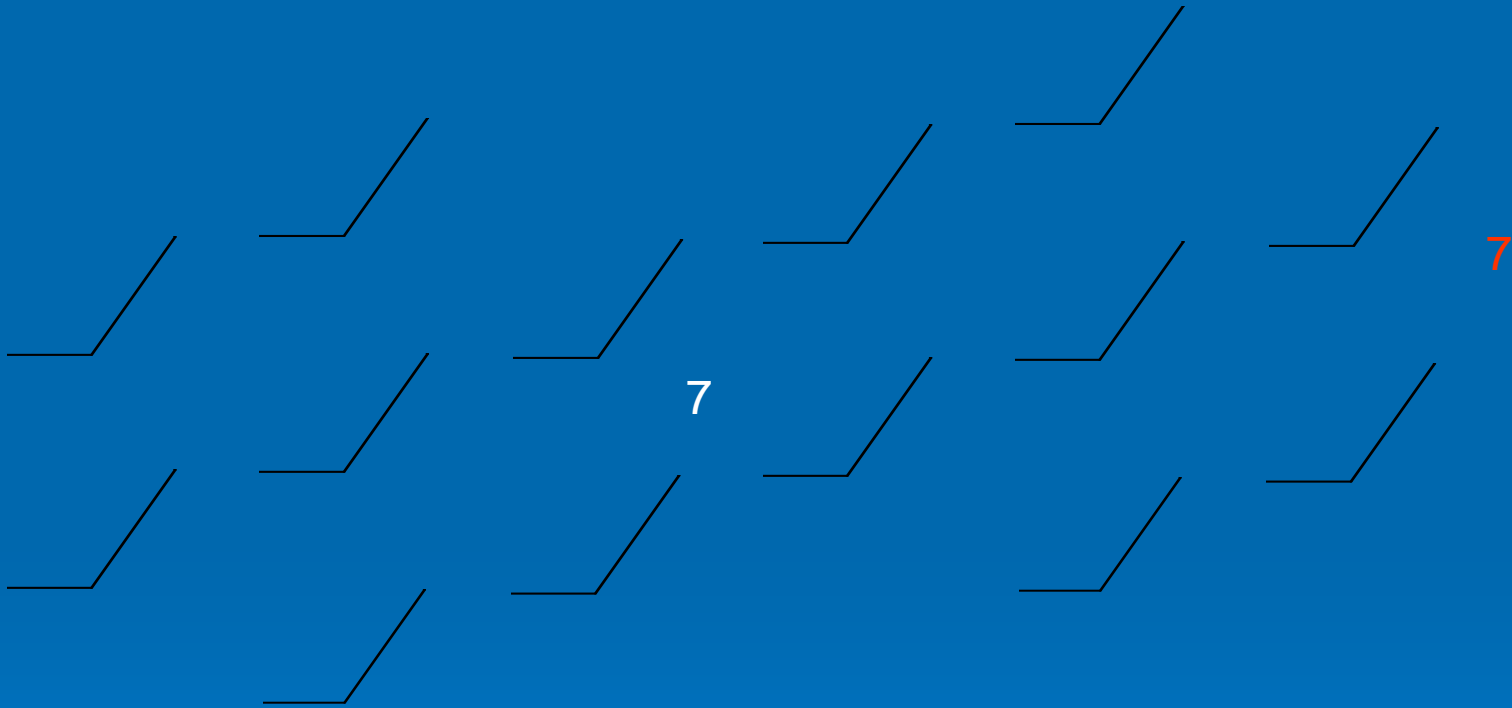
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Frequency Reuse and Planning


There are numerous seven cell frequency reuse groups in each cellular carriers Metropolitan Statistical Area (MSA) or Rural Service Areas (RSA).

Higher traffic cells will receive more radio channels according to customer usage or subscriber density.

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Frequency Reuse and Planning

A frequency reuse plan is defined as how radio frequency (RF) engineers subdivide and assign the FCC allocated radio spectrum throughout the carriers market.

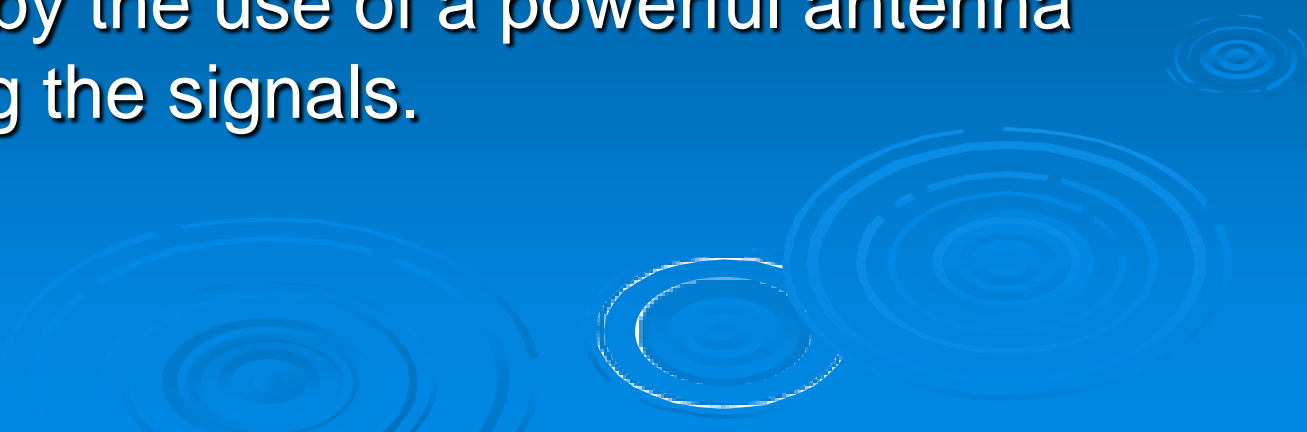
A decorative graphic consisting of several sets of concentric circles in a lighter blue shade, resembling ripples in water, located in the bottom right corner of the slide.

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How Frequency Reuse systems work

In concept frequency reuse maximizes coverage area and simultaneous conversation handling

Consider the fact that cellular communication is made possible by the transmission of RF. This is achieved by the use of a powerful antenna broadcasting the signals.



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How Frequency Reuse Systems Work

If you have one powerful antenna you would be able to handling conversations based on the number of channels you have available.

The first step for frequency reuse is the cell system of the network.

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How Frequency Reuse systems work

Each antenna in the various cells operate on the same RF that are assigned.

If your original antenna could handle 7 calls and you increased the number of antennas by 10
- 70 simultaneous calls.

The concept goes beyond the number of antennas and deals with how the radio frequency itself is used and reused.

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How Frequency Reuse systems work

Each cell has its own antenna and low power Base Station to handle the traffic within it's area.

Each Base Station is assigned frequencies with neighboring base Stations being assigned different frequencies.

Carriers are then able to reassign these frequencies to other areas that are not to geographically close to the other Base Stations and cells.

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How does Frequency Reuse systems work?

Consider your local radio station broadcast. As you travel farther away from the radio base it weakens until you lose the signal.

Now consider all the cars driving around you are listening are to different stations.

The radio station would be the Base Station and the vehicles would be the cells.

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Geographical Limits

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Distance to Reuse Ratio

The Distance to Reuse ratio defines how much geographical distance is required between cells in a cell system to avoid and limit interference.

The overall geographic size of cell base stations along with the power of the antenna determine the distance to reuse ratio

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Distance to Reuse Ratio

What happens when I move about a cell coverage area or move into another cell area?

Another requirement of the wireless system is frequency agility.

This is the ability of the mobile unit to operate on any given frequency within their assigned spectrum.

This allows the mobile unit to switch from one channel to the another seamlessly and allows for another a important component of cellular technology – Call Hand Off

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Call Handoff

Call handoff can best be described as the process of passing from one Base Transceiver Station (BTS) to another maintaining connection to your network.

When you leave your particular network and are passed to another network - the roaming process.

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Define Call Handoff

Without Call Handoff, Frequency Reuse would not be possible and vice versa.

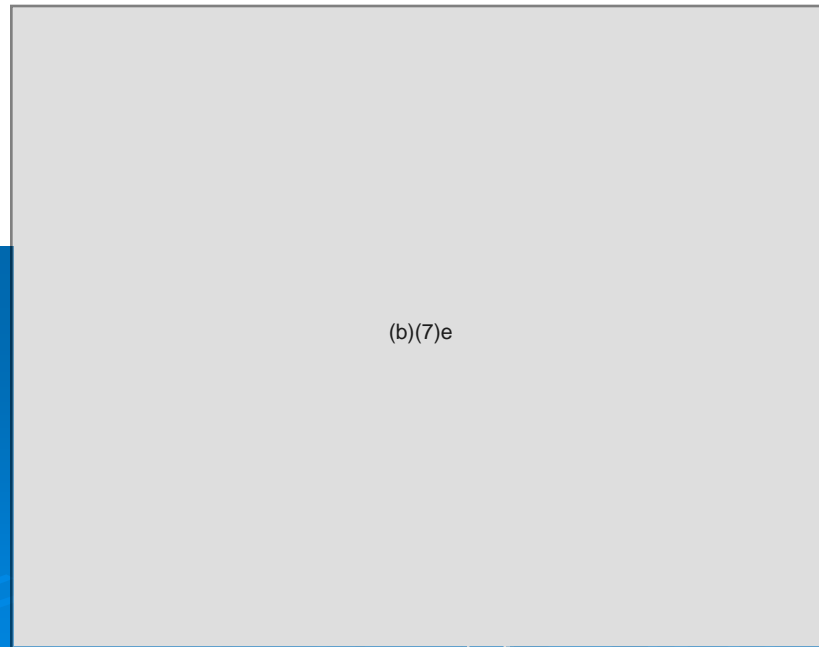
The MSC monitors the power levels of the mobile units.

When the MSC detects the mobile unit power levels degrading it seeks out other BTSs.

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➤ Define Call Handoff

Base station coverage overlap with other cells in the area and it is this overlapping that allows call handoff to occur.



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Define Call Handoff

Base station coverage overlap with other cells in the area and it is this overlapping that allows call handoff to occur.

This action is handled by a microprocessor at the MSC and is seamless to the user.

This is a complex act that uses frequency synthesizers, the controller, and memory functions within the wireless handset.

This is why cellular phones must have frequency agility or the ability to change from one channel to another.

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Wireless Network Design Maps

The FCC requires the use of United States Geographical Survey maps in the planning and development of the wireless network.

As it relates to planning it is important that all carriers use the same maps to lend conformity to the planning process.

Since the BTS operates at specific power levels it is very important to know where other towers are to avoid and/or minimize interference.

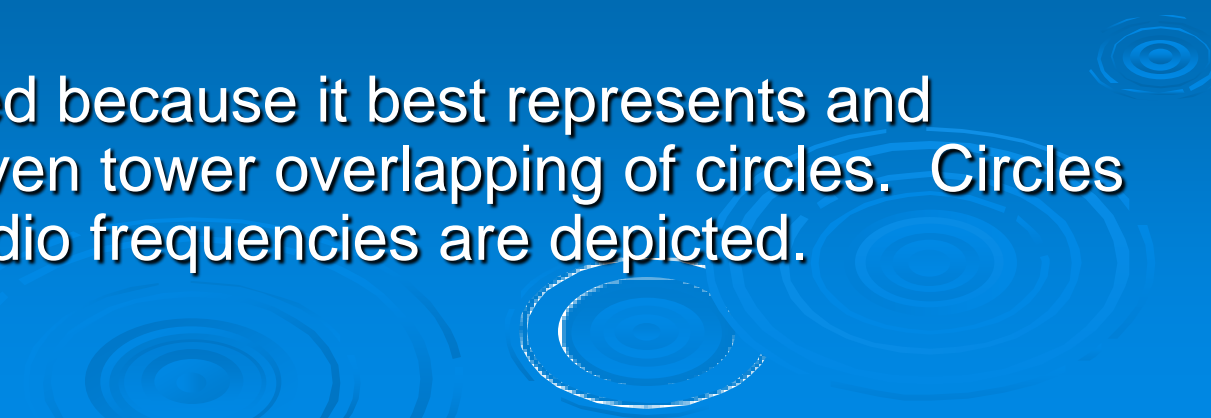
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Hexagon Grid

The hexagon grid design is the predominant engineering design tool in the wireless industry.

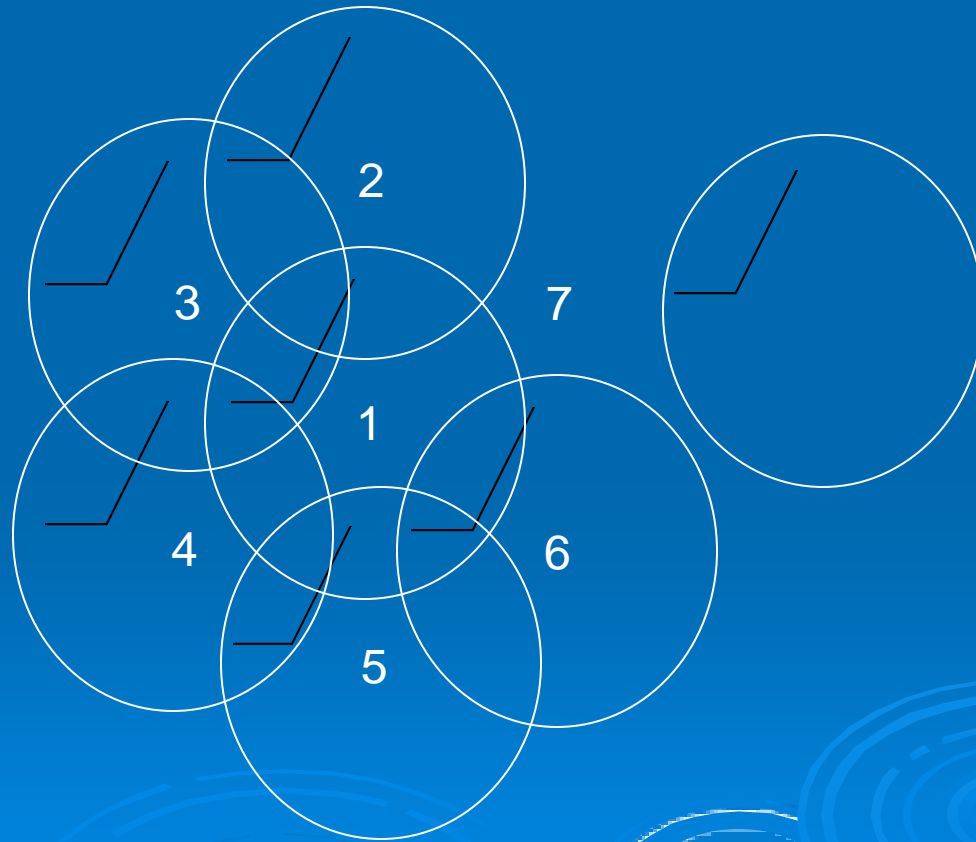
There are other design models configured in squares, circles, octagons, etc. depending on the number of cell towers in the design.

The hexagon is used because it best represents and simulates the seven tower overlapping of circles. Circles being the way radio frequencies are depicted.



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Hexagon Grid



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Hexagon Grid

In viewing our hexagon grid we can see where frequencies overlap from one cell to the other.

It is at these points, the system can determine the best place to perform call handout.

Each tower would be 60 degrees from the other, therefore depending on which tower gives the best signal you can determine a number of things about the mobile unit.

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Hexagon Grid?

You can estimate its distance from the tower based on power levels.

The direction in which the mobile unit is moving within the grid.

With the wireless systems GPS timing you determine the rate at which the handoffs are made.

By knowing the distance to reuse and the hand off rate you can determine the speed at which the mobile unit is traveling.

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Fundamental Components of a Wireless System

There are five main components to a wireless network. They are;

1. The Mobile Unit
2. The Cell Base Station
3. The Backhaul or Fixed Network
4. The Mobile Switching Center
5. The interconnection to the Public Switched Telephone Network (PSTN)

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The Mobile Unit

There are two classifications of mobiles units in use today when we speak of cellular telephones and mobile devices.

1. The Portable telephone or device – these are your small handsets, portable devices with network connection capabilities such as PDAs and GPS units.
2. The Mobile telephone or device – devices that are mounted in the locomotion device, such as installed telephones and GPS units.

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The Cell Base Station

The Cell Base Station is the physical location of some of the equipment needed to operate the wireless network, such as antennas, GPS timing systems, cell towers etc.

The size of the base station is dependent upon it's location and system needs.



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The Cell Base Station

Raw Land Sites

Rooftop Sites

Water Tank Sites

Co-located Sites

Stealth Sites



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The Cell Base Station

Microcells – an outdoors network base station usually on rooftops, water tanks and the like. The Base Station range of a Microcell is generally 100 meters to 1000 meters.

Picocells – the smallest, usually used indoors and intended to provide coverage for a small area. The Base Station range of a Picocell is generally less than 100 meters

Nanocells – mobile and easily installed. Nanocells can be mounted on walls, in vehicles or outdoor weatherproof enclosure. Coverage is dependant you configuration.

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The Cell Base Station - Macrocells



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The Cell Base Station - Microcells



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The Cell Base Station - Picocells



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The Backhaul or Fixed Network

A complex collection of systems that connect the Base Stations to the Base Station Controller, which then connects to the Mobile Switching Center.

This network connects the mobile users to others on its network and to the outside world.

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The Mobile Switching Center

Often called the brains of a wireless network, the MSC is responsible for switching data packets from one network path to another. This process is called Call Routing.

MSC provides subscriber service information such as user registration, authentication and location updating.

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Interconnection to the PSTN

In order for mobile units to connect to landline users there must be a system in place to achieve these goals.

This is completed by having a physical connection to the PSTN.

This is done by the use of a data system known as the PDSN or Public Data Switched Node. .

There are other forms of connection such as the Asynchronous Transfer Mode or ATM and TCP/IP connections..