1. **Advantages of Ad-hoc Networking:**
1. Flexibility and Mobility: Ad-hoc networks can be quickly created in situations where infrastructure is either nonexistent or impractical due to their extreme mobility.

Devices can wander freely on ad-hoc networks, which meets the needs of scenarios in which mobility is crucial.

2. Economical: Ad-hoc networks are less expensive to set up initially because they don't need an established infrastructure.

Ad-hoc networks can occasionally be implemented at a lower cost than traditional infrastructure-based networks.

3. Fast Deployment: Ad-hoc networks can be swiftly deployed, especially in situations where it might be difficult or time-consuming to build a traditional infrastructure, such as emergency situations or temporary situations.

4. Decentralization: Ad-hoc networks operate in a decentralized manner and do not have a single point of control. Resistance to isolated failure locations is strengthened by this attribute.

Challenges of Ad-hoc Networking:
1. Dynamic Topology: Ad-hoc networks' topologies frequently change as a result of device mobility, which makes it challenging to maintain dependable connections and efficient routing.

2. Scalability: Ad hoc networks may have scalability issues as the number of devices increases, which could impact the efficiency of routing algorithms.

3. Limited Resources: Ad hoc network devices sometimes have limitations in terms of memory, computation, and power. Optimizing resource usage is crucial to achieving optimal network performance.

4. Security Issues: A few of the security threats that ad hoc networks are vulnerable to are eavesdropping, impersonation, and denial-of-service assaults. Ensuring communication security in these dynamic times is a challenging undertaking.

Traditional Routing vs. Routing in Ad-hoc Networks:

Traditional Routing (Infrastructure-Based Networks):
1. Centralized Control: Routing in conventional networks is managed centrally by switches or routers. Routing algorithms are used by these devices to find each data packet's best path.

2. Fixed Infrastructure: To maintain a constant and predictable topology, conventional networks rely on a fixed infrastructure made up of switches and routers.

3. Predictable Paths: Due to their fixed infrastructure and routing techniques, older networks usually provide predictable paths.

Routing in Ad-hoc Networks:

1. Decentralized Routing: Ad hoc networks employ decentralized routing protocols to allow nodes to automatically find and maintain routes to other nodes within the network.

2. Dynamic Topology: Due to node mobility, routing in ad hoc networks must adjust to sudden changes in topology. Ad-hoc On-Demand Distance Vector (AODV) and Dynamic Source Routing (DSR) are two frequently utilized protocols.

3. On-Demand Routing: This technique, which builds routes only when needed, is typically used by ad hoc networks. This method saves resources and adjusts to shifting network circumstances.

4. Multi-Hop Communication: Ad-hoc networks usually rely on multi-hop communication, in which data packets are sent among intermediary nodes in order to reach their destination, because they lack a dependable infrastructure.

2. Vehicular Ad Hoc Networks (VANETs):

Vehicular ad hoc networks (VANETs) are a specific type of mobile ad hoc network designed for communication between vehicles and roadside infrastructure. Through the use of vehicle connectivity, VANETs enable a variety of applications for drivers and traffic management systems, increasing road safety and traffic efficiency.

Key Characteristics of VANETs:

Extremely Dynamic Topology: VANETs must function in a dynamic environment where vehicles move at varying speeds and location fast.

Obstacles, vehicle mobility, and fluctuating network conditions can cause intermittent connectivity in vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communications.

Real-Time Communication: VANET applications often require real-time communication to support safety-critical activities such as traffic management and collision avoidance.

Wireless Communication: VANETs use wireless communication technologies such as Dedicated Short-Range Communication (DSRC) and Cellular-V2X (C-V2X) to facilitate communication between cars and infrastructure.

Applications of VANETs:

Applications for Safety: Collision Warning Systems: By warning drivers of approaching collisions, these systems reduce the likelihood of accidents.

The Intersection Collision Warning system alerts drivers to potential collisions at crossings.

Applications of Traffic Efficiency: Traffic signal optimization adjusts traffic signals according to the traffic conditions at the moment in order to enhance traffic flow.

With dynamic route planning, drivers can plan their routes more efficiently by having access to real-time traffic data.

Information and Entertainment: Infotainment Services: Offers information, entertainment, and other services to travelers.

Emergency Services: Vehicles are warned of approaching emergency braking situations by electronic emergency brake lights.

Alerts other drivers to the impending arrival of an emergency vehicle.

Vehicle-to-Vehicle (V2V) vs. Vehicle-to-Infrastructure (V2I) Communication:
1. Vehicle-to-Vehicle (V2V) Communication:
VANET-based inter-vehicle communication.

Key Features: Enables direct contact between neighboring cars.

Allows apps that provide collision alerts and cooperative safety features.

Transmits and receives relevant data via a wireless link, including position and speed.

Scenario example: In order to give other vehicles in the vicinity time to brake, a car warns them of an approaching collision or abrupt lane change.

2. Vehicle to Infrastructure (V2I) Communication:

Definition: Information sharing between vehicles and the roadside infrastructure.

Key Elements: involves communicating with fixed infrastructure, such as traffic signals, road signs, and sensors.

Provides traffic control applications and services.

Provides information about traffic conditions, signal timings, and road dangers.

Scenario example: One case is when traffic signals interact with approaching vehicles to modify the signal.

Examples of Circumstances

V2V Communication Scenario: A car suddenly applies the brakes due to an impediment on the road.

Use of V2V: When a car brakes, it warns other vehicles to the situation, setting off alerts and allowing other vehicles to adjust their speed appropriately.

The V2I communication scenario is set in the context of traffic congestion at a junction.

V2I Use: Traffic lights communicate with oncoming cars to enhance signal timings, smoother traffic flow, and reduced wait times at the intersection.

3. Proactive (Table-Driven) Routing Protocols:
Operation:
Constant Updates: Preventive protocols keep an up-to-date routing table with data about the whole network.

Periodic Updates: Even in the event that the network topology remains unchanged, nodes exchange routing information on a regular basis.

Benefits:

Reduced Latency for Known Routes: After the routing tables are constructed, routing choices may be determined rapidly, which reduces latency for known routes.

Stability: Because proactive protocols have the most recent network information, they are usually more stable.

Drawbacks:

Overhead: Higher control overhead results from frequent exchanges and constant updates, which use more bandwidth.

Resource Consumption: Proactive protocols are less appropriate for devices with limited resources since maintaining updated routing tables demands more computing power and energy.

Reactive (On-Demand) Routing Protocols:
Operation:
Route Discovery: When a genuine data transfer to a destination is necessary, reactive protocols do not initiate the route discovery procedure.

Absence of Periodic Updates: Unlike proactive protocols, reactive protocols do not exchange periodic updates when there are no data flows.

Advantages:

Decreased Overhead: Reactive protocols have less control overhead since they do not exchange route information continuously.

Sufficient for Adaptable Networks: perfect for networks that experience frequent topological changes and high levels of dynamic activity.

Cons:

Increased Latency for Route Establishment: The first route setup has a higher latency due to the route discovery process.

Potential for Stale Routes: Reactive protocols may contain stale route data if there are network topology changes between route discovery.

Comparison:
Overhead:
Proactive: Greater control overhead as a result of ongoing updates.

Reactive: Less control overhead because updates are made as needed.

Latency:

Proactive: Reduce latency for well-established routes.

Reactive: May have a reduced latency for routes that are already well-established, but a higher latency for new routes.

Dynamic Environments:
Proactive: Because to frequent changes, less appropriate for really dynamic environments.

Reactive: Adapts to changes as they happen, making it a good fit for dynamic networks.

Resource Consumption:
Proactive: As a result of ongoing updates, it uses more energy and processing power.

Reactive: Uses less resources in general because updates are only initiated when necessary.

Scalability:
Proactive: As the network grows in size, scalability problems could arise.

Reactive: Because resources are used as needed, it is frequently more scalable, particularly in big networks.

Adaptability:
Proactive: More appropriate in situations when network topology changes seldom.
Reactive: More adaptable to frequent changes in the network.

4. Dynamic Source Routing (DSR) is a reactive (on-demand) routing technique for wireless ad hoc networks. DSR allows nodes to dynamically find and maintain routes to destinations based on current demand. It is well known for being user-friendly and effective at handling dynamic, ever-changing network topologies.

Route Discovery in DSR:
Route Request (RREQ): When a source node wants to send data to a destination for which it does not yet have a route, it sends a Route Request (RREQ) packet.

->The RREQ packet contains a unique identity, the address of the originating node, the address of the destination node, and a list of all the nodes the request passed through.

RREQ broadcasting: Every neighbor that is close to the source node receives an RREQ packet from it.

->An intermediate node rebroadcasts the RREQ packet to its neighbors upon receiving it if it hasn't processed a comparable RREQ before or if it has a path to the destination.

Route Reply (RREP): When an RREQ packet arrives at its destination or at an intermediary node that has a route to the destination.
-> The RREP packet contains the route from the source to the destination.

Unicast RREP: The RREP returns to the source node via the reverse path that was indicated in the RREQ packet in a unicast fashion.

Each intermediate node updates its route cache using information from the RREP.

Routine route maintenance is the process by which nodes update their route caches and remove old routes.

-> If a route is broken (due to node migration or link failure, for example), the source node initiates a fresh route discovery procedure.

Key Features of DSR:

1. Source Routing: DSR uses source routing, where the entire path is contained in the packet header. Every node on the path sends the packet based on the pre-established list of nodes in the header.

2. Loop Avoidance: Intermediary nodes maintain a cache of their routes in order to detect and avoid loops. A node won't rebroadcast an RREQ packet if it has previously processed a request of the same kind or if it has a cached route to the destination.

3. Route Caching: Nodes cache routes they detect to avoid repeatedly discovering the same path. Caching reduces control overhead and improves the efficiency of route discovery.

4. Multiple Routes: DSR allows the source node to maintain multiple routes that lead to the destination. The source's flexibility allows it to choose another path in the case that the primary one is blocked or unavailable.

5. Promiscuous Mode: Nodes must operate in promiscuous mode in order for DSR to work, allowing them to accept packets that are not meant for them. For nodes to process and overhear routing packets like RREP and RREQ, they require this mode.

6. Adaptability to Network Changes: Due to its ability to adapt well to changes in network topology, DSR is a good fit for dynamic and mobile ad hoc networks. Because to the reactive architecture of the protocol, routes are only discovered when required.

5. The many generations of cellular networks are arranged according to the advancement of technology and standards. Mobile communication skills have advanced significantly with each generation. An outline of the major cellular network generations and the significant advancements brought about by each is shown below:

1. First Generation (1G): Included people born in late 1970s and early 1990s.

Technology: Analog voice transmission.

Key features: The initial mobile networks provided basic voice calling functionalities. limited capacity for data transmission. Disparity between different networks.

2. Second Generation (2G): The period frame covered was the early 1990s to mid-2000s.

Technology: Digital voice transmission is exemplified by GSM and CDMA.

Important Features: Digital technology introduced for improved voice quality and encryption. Support for text messaging (SMS) and basic data services (up to 64 kbps). the introduction of standardization resulting from the extensive use of the GSM (Global System for Mobile Communications).

3. 2.5 Generation (2.5G): During the latter part of the 1990s and the early 2000s.

Technology: Enhanced 2G technologies, including GPRS and EDGE.

Principal attributes: Enhanced data rates relative to 2G. The introduction of General Packet Radio Service (GPRS) made packet-switched data transport possible. Enhanced Data Rates for GSM Evolution (EDGE) allowed for faster data speeds.

4. Third Generation (3G): From the early 2000s until the middle of the 2010s.

Technology: CDMA2000, Wideband CDMA (WCDMA).

Important Features: Supports higher-speed internet access (up to several Mbps) with a notable improvement in data throughput. introduction of mobile broadband, video calling, and multimedia services. Both voice quality and network bandwidth were increased.

5. Fourth Generation (4G): From the late 2000s until the present.

Technology: WiMAX and LTE (Long-Term Evolution).

Important features include enhanced spectral efficiency and a sharp rise in data rates—up to several tens of megabits per second. low latency connections and smooth handovers. the advent of all-IP (Internet Protocol) networks, which allow for improved internet integration.

Improved support for streaming high-definition videos, internet gaming, and multimedia apps.

6. Fifth Generation (5G): Duration: started to be used in the late 2010s and is still developing.

Technology: mmWave, NR (New Radio).

Important characteristics: Enormous growth in data speeds (up to several Gbps) and communication with minimal latency. increased effectiveness and capacity of the network, enabling a vast number of linked devices (IoT). integration of cutting-edge technology such as beamforming and massive MIMO (multiple input multiple output). enhanced network management and energy efficiency.

Future Generations (Beyond 5G): In order to improve latency, data throughput, and network capabilities, ongoing research and development is being done to build networks that will beyond 5G (6G). Research on cutting-edge technologies such as holographic communications, terahertz communication, and improved AI integration. Generations of cellular networks emerge, expanding upon the work of the generation that came before them with new technology advancements that improve user experience, unlock new services, and cater to the shifting needs of the mobile communication industry.

6.

1. Cell Splitting: Cell splitting entails the process of dividing a sizable cell into smaller units, consequently augmenting the quantity of cells within a specified geographic region.

Key Contributions to Capacity Increase:

1. Frequency Reuse: Cell splitting enables the repeated utilization of the same frequency spectrum in non-adjacent cells. Through the reduction of cell size, frequency channels can be more regularly reused throughout the network, resulting in heightened capacity.

2. Spatial Reuse:

Diminished cell sizes promote a more effective utilization of available frequencies across diverse areas. The increased spatial separation between cells elevates overall spatial reuse and enhances network capacity.

3. Mitigated Interference:

The smaller cell sizes lead to minimized interference between adjacent cells. This translates to improved signal quality, fewer call drops, and an overall enhancement in communication reliability for users.

2. Cell Sectoring:

Cell sectoring encompasses the partitioning of a cell into directional sectors or pie-shaped segments through the use of directional antennas.
Key Contributions to Capacity Increase:

1. Focused Coverage: Cell sectoring enables the concentration of radio frequency energy in specific directions. This focused coverage allows for better utilization of available resources and improved signal strength within designated sectors.

2. Enhanced Frequency Reuse:

Similar to cell splitting, cell sectoring supports the reuse of the same frequencies in non-overlapping sectors. This improves spectral efficiency and enables a higher number of simultaneous connections.

3. Increased System Capacity:

By directing signals toward specific sectors, cell sectoring enhances the capacity of the network. This is particularly useful in high-traffic areas or along specific routes where concentrated coverage is needed.

Cell splitting and cell sectoring are essential strategies for enhancing the capacity of cellular networks. Cell splitting achieves this objective by breaking down large cells into smaller units, while cell sectoring optimizes both coverage and capacity by dividing cells into directional sectors. These techniques are vital to address the increasing demand for mobile services, enhance overall network efficiency, and deliver an improved user experience.

7. Frequency Reuse in Cellular Networks:
Frequency reuse stands as a foundational principle in cellular networks, entailing the strategic allocation and repetition of identical radio frequencies across diverse cells within a network. The objective is to optimize the utilization of the available frequency spectrum, facilitating multiple cells to harmoniously share a common set of frequencies without inducing substantial interference. This methodology plays a pivotal role in maximizing network capacity, catering to a substantial user base, and enhancing the overall efficiency of spectral resources.

Contributions to Optimal Spectrum Utilization:

1. **Increased Capacity:** Through the strategic reuse of frequencies in non-adjacent cells, the network gains the ability to utilize the same frequency channels extensively. This leads to an augmented capacity for accommodating simultaneous connections, allowing for the support of a larger user base within the designated frequency range.
2. **Reduced Interference:** Meticulously designed frequency reuse patterns work to minimize interference between neighboring cells. This reduction in interference has a positive impact on signal quality, resulting in fewer dropped calls and an overall enhancement in the reliability of communication.
3. **Enhanced Spectral Efficiency:** Spectral efficiency measures the amount of data transmitted over a specified bandwidth. Frequency reuse plays a pivotal role in enhancing spectral efficiency by permitting the same frequencies to serve multiple cells. This maximizes the utilization of available spectrum resources, contributing to an overall improvement in efficiency.

Factors Influencing Frequency Reuse Patterns:

Cell Size:

The dimensions of cells play a pivotal role in shaping the frequency reuse pattern. Smaller cells facilitate more frequent reuse, contributing to increased capacity and heightened spectral efficiency.

Propagation Characteristics:

The unique propagation characteristics of radio waves within a specific environment guide the formulation of the frequency reuse pattern. Elements such as path loss, shadowing, and interference influence decisions related to optimal cell placement and frequency assignment.

Interference Management:

Effective interference management is paramount. Minimizing interference between neighboring cells is a critical consideration in frequency reuse planning. Strategic frequency planning and management tactics are employed to ensure that co-channel interference is maintained at acceptable levels, thereby preserving the integrity of the communication network.

Frequency Bandwidth: The extent of available frequency bandwidth directly governs the number of frequency channels viable for reuse across the network. An efficient frequency reuse strategy comprehensively assesses the total available spectrum, striving to optimize its utilization.

Cell Density: The concentration of cells within a specific area significantly influences the frequency reuse pattern. In densely populated urban areas, where cell density is high, there may be a need for a reduced frequency reuse distance to effectively cater to the elevated demand for network resources.

8. Paging serves as a fundamental process in mobile cellular networks, playing a pivotal role in connecting two mobile phones. Its primary function is to locate and notify a specific mobile device during an incoming call or when the network intends to deliver a message. Here's how paging contributes to connection establishment:

1. **Incoming Call Notification:**
    - When a call is initiated, the network employs the paging process to locate the recipient's mobile device within the appropriate cell, facilitating call establishment.
2. **Idle Mode:**
    - Mobile phones often operate in an idle mode, conserving power when not actively engaged in calls or data sessions.
3. **Paging Channel:**
    - A dedicated paging channel is utilized by the network to broadcast paging messages within a specific cell, serving as a control channel for message delivery.
4. **Cell Identity:**
    - Each cell in the cellular network possesses a unique identity, allowing the network to address paging messages to devices within a specific cell.
5. **Location Update:**
    - Periodic location updates from mobile devices inform the network about their current cell, essential for directing paging messages to the correct location.
6. **Selective Paging:**
    - To minimize resource usage, selective paging targets the device believed to be most likely in the cell based on the last known location, reducing the number of devices paged.
7. **Paging Response:**
    - Upon receiving a paging message, the mobile device responds, signaling its availability to accept the incoming call or message.
8. **Connection Establishment:**
    - A positive response triggers the network to establish the connection, involving the setup of signaling and traffic channels for voice or data communication.
9. **Handover Considerations:**
    - In scenarios where the mobile device is in motion, handover procedures ensure a seamless transition if the device moves between cells during the call setup, maintaining connection continuity.

9. The handoff process, also known as handover, is instrumental in upholding a call between two mobile phones as users traverse the coverage area of a cellular network. Its primary objective is to ensure a seamless and uninterrupted communication experience as a mobile device transition from one cell to another. Here's a step-by-step elucidation of the role of handoff in call maintenance:

1. **Initial Call Setup:**
   - The network initiates a call by allocating requisite resources, such as voice and signaling channels, to support the communication session.
2. **User Mobility:**
   - As users move, especially in scenarios involving vehicles or pedestrians, transitioning from one cell's coverage area to another prompts the necessity for a handoff to maintain call continuity.
3. **Signal Strength Monitoring:**
   - Continuous monitoring of signal strength and quality occurs between the mobile device and the serving cell. If the signal falls below a certain threshold or deteriorates in quality, the network contemplates initiating a handoff.
4. **Neighbor Cell Selection:**
   - Based on monitored signal strength and quality, the network identifies neighboring cells—referred to as candidate or neighbor cells—that can potentially offer superior coverage for the moving mobile device.
5. **Handoff Decision:**
   - A handoff decision is made when the network determines that the signal quality in the current cell is degrading, and transitioning to a neighbor cell would likely enhance call quality.
6. **Handoff Execution:**
   - Upon making the handoff decision, the network instructs the involved mobile devices to switch to allocated resources in the target cell. This seamless transfer involves moving the ongoing call from the current channel to a new channel in the target cell.
7. **Connection Continuity:**
   - The handoff process is designed to be transparent to users, ensuring a smooth transition. As the call transfers to the new cell, users should experience no noticeable disruptions, allowing the conversation to continue without drops or interruptions.
8. **Verification and Optimization:**
   - Following handoff execution, the network verifies connection stability and quality in the new cell, optimizing parameters if necessary to ensure call stability as the mobile device continues to move.

9. **Repeat as Needed:**
    - If the mobile device persists in movement and nears the edge of the current cell's coverage area, the handoff process may be repeated as required. The network consistently evaluates signal conditions, executing handoffs to uphold call quality.

10. Challenges in Deploying and Operating 5G Networks:

1. **Infrastructure Deployment:**
    - *Challenge:* Establishing an extensive 5G infrastructure demands significant investments in new equipment, such as small cells, antennas, and backhaul solutions. This process is time-consuming and may encounter regulatory obstacles.
2. **High-Frequency Spectrum Utilization:**
    - *Challenge:* 5G networks leverage higher frequency bands, including millimeter waves, with shorter range and increased susceptibility to signal attenuation. This necessitates a denser network infrastructure and presents challenges in ensuring consistent coverage, particularly in rural or less populated areas.
3. **Backhaul and Fronthaul Connectivity:**
    - *Challenge:* The heightened data rates and capacity of 5G networks require robust backhaul and fronthaul connections for data transport between base stations and the core network. Achieving high-capacity, low-latency connectivity poses a significant challenge.
4. **Interference and Signal Penetration:**
    - *Challenge:* Millimeter-wave frequencies in certain 5G deployments are sensitive to obstacles and atmospheric conditions, leading to difficulties in signal penetration and potential interference.
5. **Energy Consumption:**
    - *Challenge:* The deployment of numerous small cells and increased network density in 5G may result in higher energy consumption. Optimizing energy efficiency is crucial for sustainable operation.
6. **Device Compatibility:**
    - *Challenge:* Older devices may lack compatibility with 5G networks, requiring users to upgrade for access to the new technology. Managing this transition period poses challenges in terms of user adoption and device compatibility.
7. **Security Concerns:**
    - *Challenge:* The heightened reliance on software-defined networking and virtualization in 5G introduces new attack surfaces and security concerns. Ensuring the security of critical infrastructure and data becomes more intricate.

8. **Regulatory and Spectrum Allocation:**
    - *Challenge:* Regulatory processes and spectrum allocation can impact deployment timelines and costs. Achieving global harmony in regulations and efficiently allocating spectrum remain ongoing challenges.

How 5G Mitigates These Challenges:

Densification and Small Cells:

Solution: 5G networks employ small cells to enhance network density, thereby improving coverage and capacity. This approach effectively addresses challenges associated with infrastructure deployment, ensuring more consistent connectivity.

Dynamic Spectrum Sharing:

Solution: 5G incorporates technologies like dynamic spectrum sharing, optimizing the use of available spectrum. This solution effectively addresses challenges related to spectrum utilization and facilitates a smoother transition from 4G to 5G.

Massive MIMO and Beamforming:

Solution: 5G utilizes Massive Multiple Input Multiple Output (MIMO) and beamforming technologies to elevate signal quality, extend coverage, and tackle challenges linked to signal penetration and interference.

Fiber Optic Backhaul:

Solution: To meet heightened data rates and low-latency requirements, 5G networks often rely on fiber optic backhaul solutions. This ensures high-capacity, low-latency connectivity between base stations and the core network.

Energy-Efficient Technologies:

Solution: 5G standards incorporate features to enhance energy efficiency, including the dynamic adjustment of network resources based on demand. This effectively addresses challenges associated with energy consumption.

Enhanced Security Protocols:

Solution: 5G integrates advanced security features, including end-to-end encryption and improved authentication mechanisms. These measures effectively address security concerns linked to increased virtualization and software-defined networking use.

Global Standards and Cooperation:

Solution: Collaborative efforts toward global standardization and cooperation among industry stakeholders contribute to addressing challenges related to regulatory processes and spectrum allocation. This fosters a more harmonized and interoperable 5G ecosystem.

11.

11) Signal to Interference Ratio $= \frac{S}{I} = \frac{S}{\sum_{i=1}^{i_0} I_i}$

$$\frac{S}{I} = \frac{(D/R)^n}{i_0} = \frac{(\sqrt{3N})^n}{6}$$

Given $\frac{S}{I} = 15dB = 10\log_{10}(S/I)$

$$\Rightarrow \frac{S}{I} = (10)^{15/10} \Rightarrow \frac{S}{I} = 31.63$$

$$= \frac{(\sqrt{3N})^n}{6} = 31.63$$

(a) Given $n=4$ $\Rightarrow \frac{(\sqrt{3N})^4}{6} = 31.63$

$$\Rightarrow (\sqrt{3N})^4 = 189.736$$

$$3N = 13.7745$$

$$N = 4.59$$

N=7 should be used

$$N=7 \Rightarrow \frac{S}{I} = \frac{(\sqrt{3\times7})^4}{6} = 73.5 = 18.66dB$$

(b) Given $n=3$ $\Rightarrow \frac{S}{I} = \frac{(\sqrt{3N})^3}{6} = 31.63$ [15dB]

$$= (3N)^{1.5} = 31.63\times6$$

$$N = \left(\frac{31.63\times6}{3}\right)^{2/3}$$

$N = 11.008 \Rightarrow N = 12$ should be used.

$$N = 12 \Rightarrow \frac{S}{I} = \frac{(\sqrt{3 \times 12})^3}{6}$$

$$= 36$$

$$\Rightarrow \frac{S}{I} = 10 \log_{10}(36) \Rightarrow \frac{S}{I} = 15.56 dB$$

12.

12) Total bandwidth = 33 MHz.
Channel BW = 25 kHz.
2 simplex channels = 50 kHz / duplex channel.
Total available channels = 33,000 / 50 = 660 channels

a) For N = 4, total no. of channel available per cell.
660/4 = 165 channels.

b) For N = 7, total no. of channels available per cell.
660/7 = 95 channels.

c) For N = 12, total no of channels available per cell
660/12 = 55 channels

A. 1 MHz spectrum for control channels implies that there are 1000k/50k = 20 control channels out of the 660 channels available.

To evenly distribute the control & voice channels, simply allocate the same no. of channels in each cell wherever possible. Here, the 660 channels must be evenly distributed each cell within the cluster.

In practice, only the 640 voice channels would be allocated, since the control channels are allocated separately as 1 per cell.

a) For N = 4, 4 cells (5 control channels + 160 voice channels). In practice, however, each cell only needs a single control channel (20 channel), 4 cells (160 voice channels) Total = ~~160~~ 640

b) For N = 7, 4 cells (3 control channels + 92 voice channels) + 2 cells (3 control channels + 90 voice channels) + 1 cell (2 control channels + 92 voice channels). In practice, however each cell would have one control channel, 4 cells (91 voice channels) + 3 cells (92 voice channels).
Total = 640.

c) For N = 12, 8 cells (2 control channels + 53 voice channels) + 4 cells (1 control channel + 54 voice channels). In practice, however each cell would have one control channel, 8 cells (53 voice channels) + 4 cells (54 voice channels) Total = 640.