# Modern Telecommunication Systems
# Lecture 10

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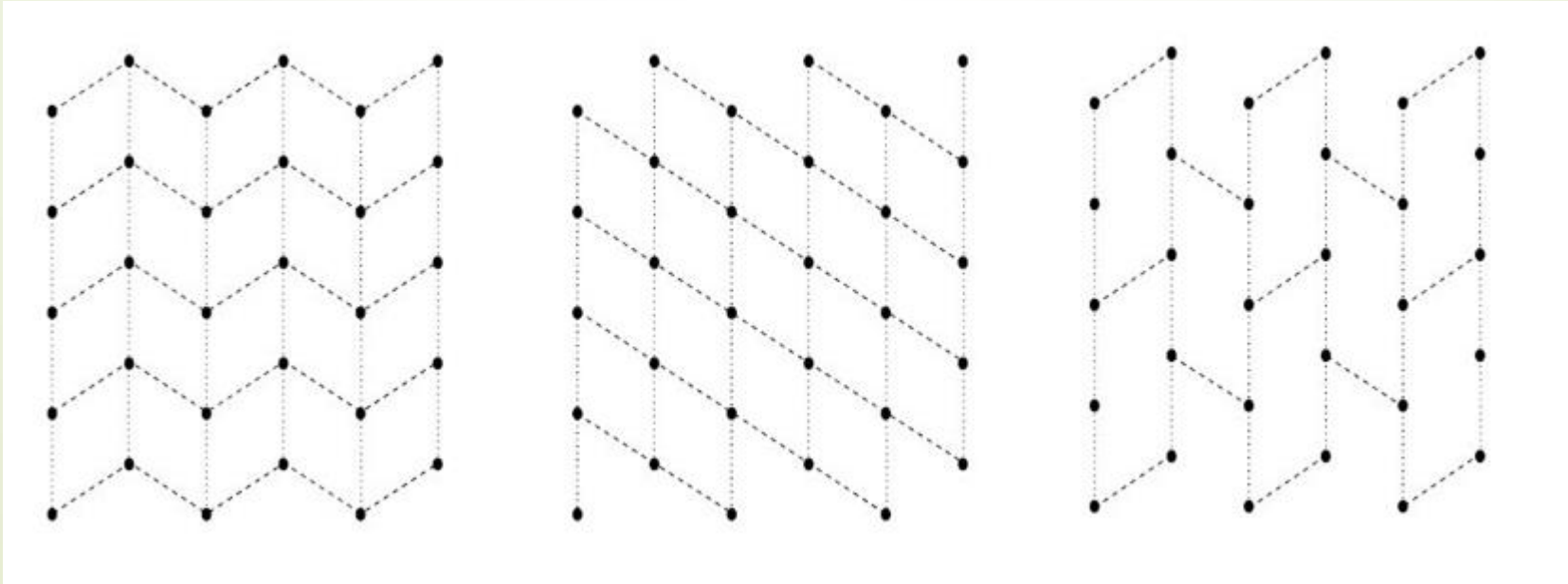
# Inter Satellite Links (ISL)

- Inter satellite communications is used primarily for "networking" a constellation of satellites at data rates up to many Gbps Or
- For data relay purposes from tens of Mbps up to Gbps.

# Inter Satellite Links (ISL)

- There are two types of Inter Satellite Links:
  - Intra-orbital links: Connect consecutive satellites on the same orbits
  - Inter-orbital links: Connect two satellites on different orbits.



# Routing

- If satellites offer ISL's
  - Traffic can be routed between satellites
  - Only one uplink and one downlink per direction needed for the connection of two mobile phones.
  - Ability of routing within the satellite n/w reduces the number of gateways needed on earth.
- Else if, satellites do not offer ISL's
  - Solution requires two uplinks and two downlinks.

# Routing Algorithms

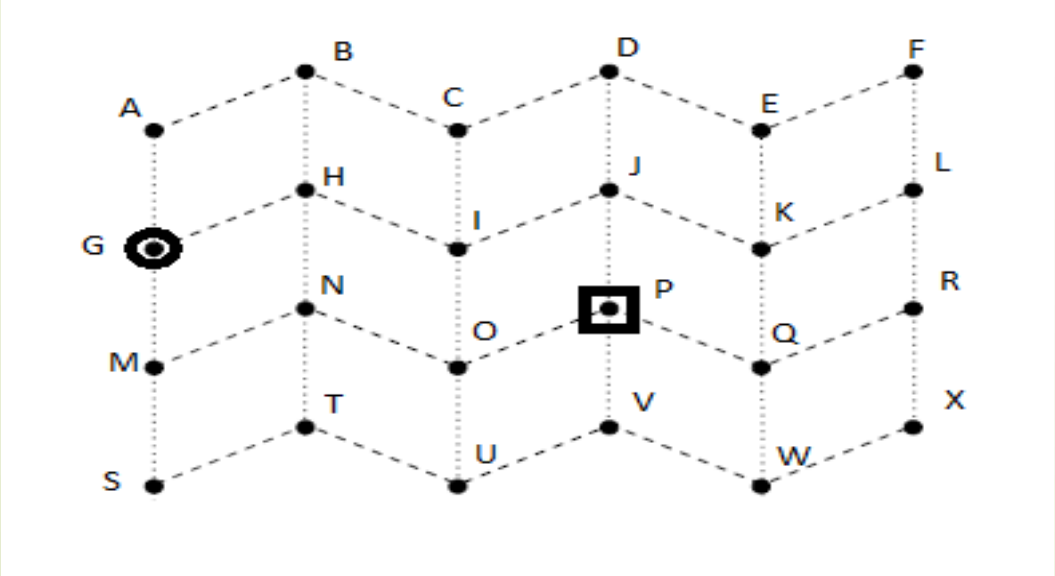
- The principle of designing a routing algorithm is to satisfy two goals:
- Reduce the new call blocking probability, thus increase the system throughput and to achieve this:
  - a route should be as short as possible in order to minimize the resource usage
  - a route should avoid going through any congested ISL
- Reduce the forced termination probability, thus increase the reliability of a connection and to achieve this.
  - the routing algorithm should provide a larger set of candidate paths such that there is a higher chance of choosing a path for connection.

# Routing Algorithms

- Minimum Hop Algorithm (MHA)
- Minimum Cost Algorithm (MCA)
- Mesh Algorithm (MA)
- Revised Mesh Algorithm (RMA)

# Minimum Hops Algorithm (MHA)

- Given a pair of source and destination satellites, the MHA finds a path with minimum number of hops
- The MHA can be implemented by the Dijkstra's shortest algorithm with cost of each edge set to 1.

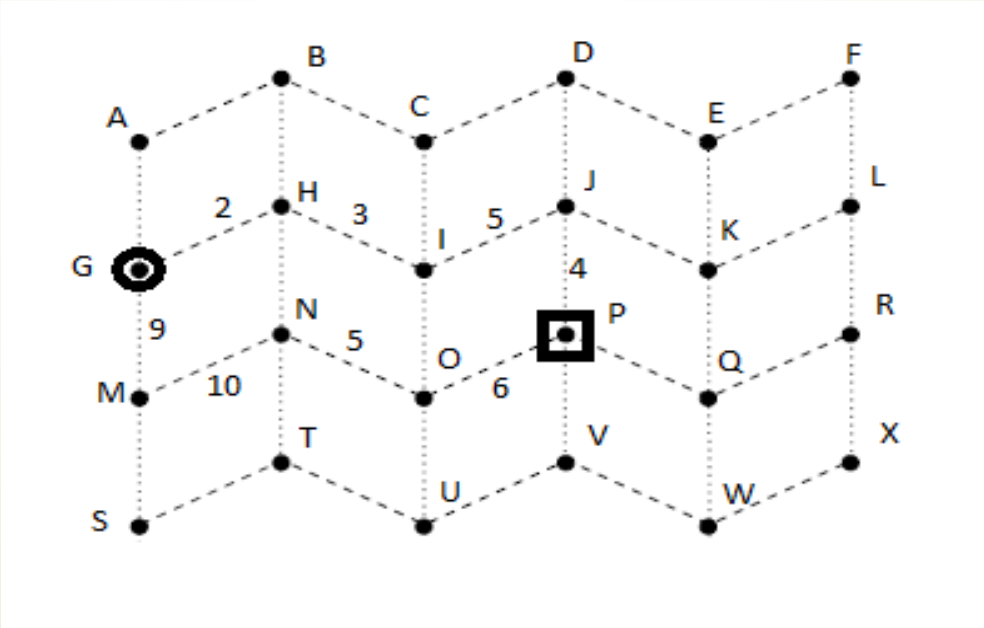



Min-hop: 4

G-H-I-J-P, G-M-N-O-P,…

# Minimum Cost Algorithm (MCA)

- The cost of link is 1/*vacancy*, where *vacancy* is # of free channels in the link. The chosen path minimizes the sum of the cost of the ISL's.
- G-M-N-O-P
- (1/9)+(1/10)+(1/5)+(1/6)=0.57



# Handover in Satellite Systems

- Hand over is very complex, due to motion of satellites.
- Intra satellite handover:
  - Handover from one spot beam to another
  - Mobile station still in the footprint of the satellite, but in another cell.
- Inter satellite handover:
  - Handover from one satellite to another satellite
  - Mobile station leaves the footprint of one satellite.

# Handover in Satellite Systems

- Gateway handover:
  - Handover from one gateway to another
  - Mobile station still in the footprint of a satellite, but satellite moves away from the current gateway
- Inter system handover:
  - Handover from the satellite network to a terrestrial cellular network
  - Mobile station can use a terrestrial network again which might be cheaper, have a lower latency.

# Global Positioning System

- The Global Positioning System (GPS), also known as Navstar, is a satellite-based navigation system that can be used by anyone with an appropriate receiver to pinpoint his or her location on earth.
- GPS was developed by the US Air Force for the Department of Defense as a continuous global radio navigation system.
- The GPS system consists of three major segments: the space segment, the control segment, and the user segment.

# Global Positioning System

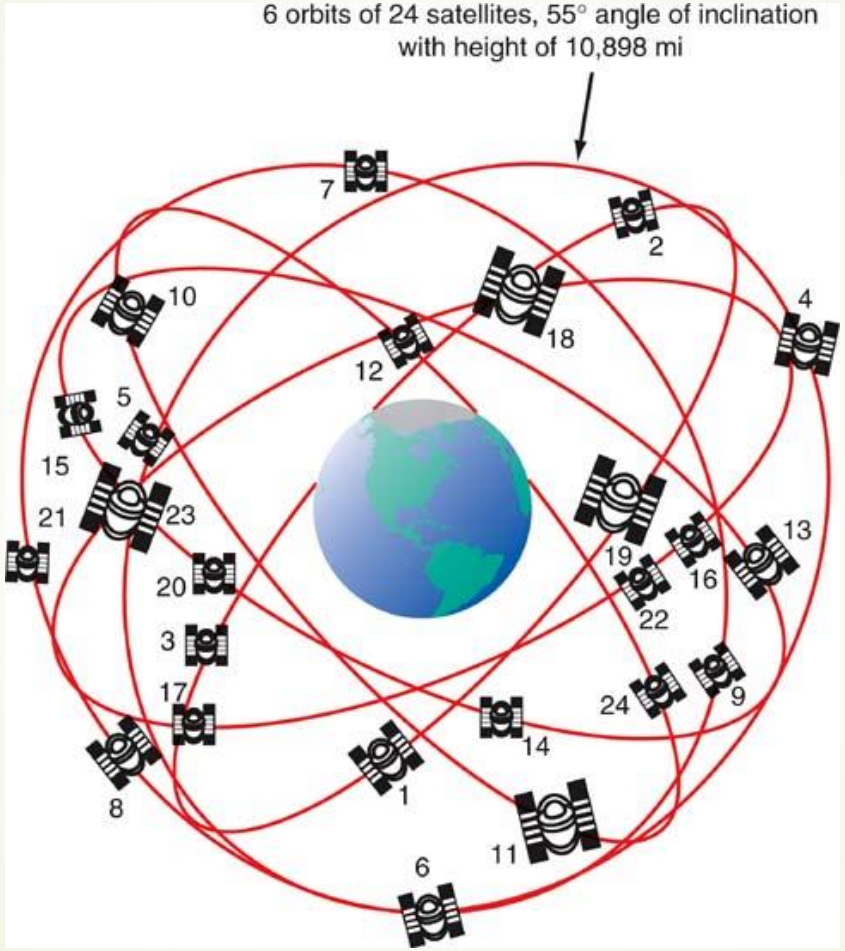
- Space Segment:
  - The space segment is the constellation of satellites orbiting above the earth that contain transmitters which send highly accurate timing information to GPS receivers on earth.
  - The GPS consists of 24 main operational satellites and 3 active spare satellites arranged in six orbits of 3 or 4 satellites each.

# Global Positioning System

Space Segment:

- Each of the satellites contains four highly accurate atomic clocks.
- These clocks are used to generate a unique pseudorandom code identifying the specific satellite that is transmitted to earth.
- The satellite also transmits a set of digitally coded **ephemeris data** that completely defines its precise orbit.

# Global Positioning System




The GPS space segment

# Global Positioning System

Control Segment:

- The control segment of the GPS system refers to the various ground stations that monitor the satellites and provide control and update information.
  - The master control station is operated by the U.S. Air Force in Colorado Springs.
  - Four additional monitoring and control stations constantly monitor the satellites and collect range information from each.

# Global Positioning System

Control Segment

- The information is sent back to the master control station in Colorado, where all the information is collected and position data on each satellite calculated.
- The master control station then transmits new ephemeris and clock data to each satellite on the S-band uplink once per day.

# Global Positioning System

GPS Receivers:

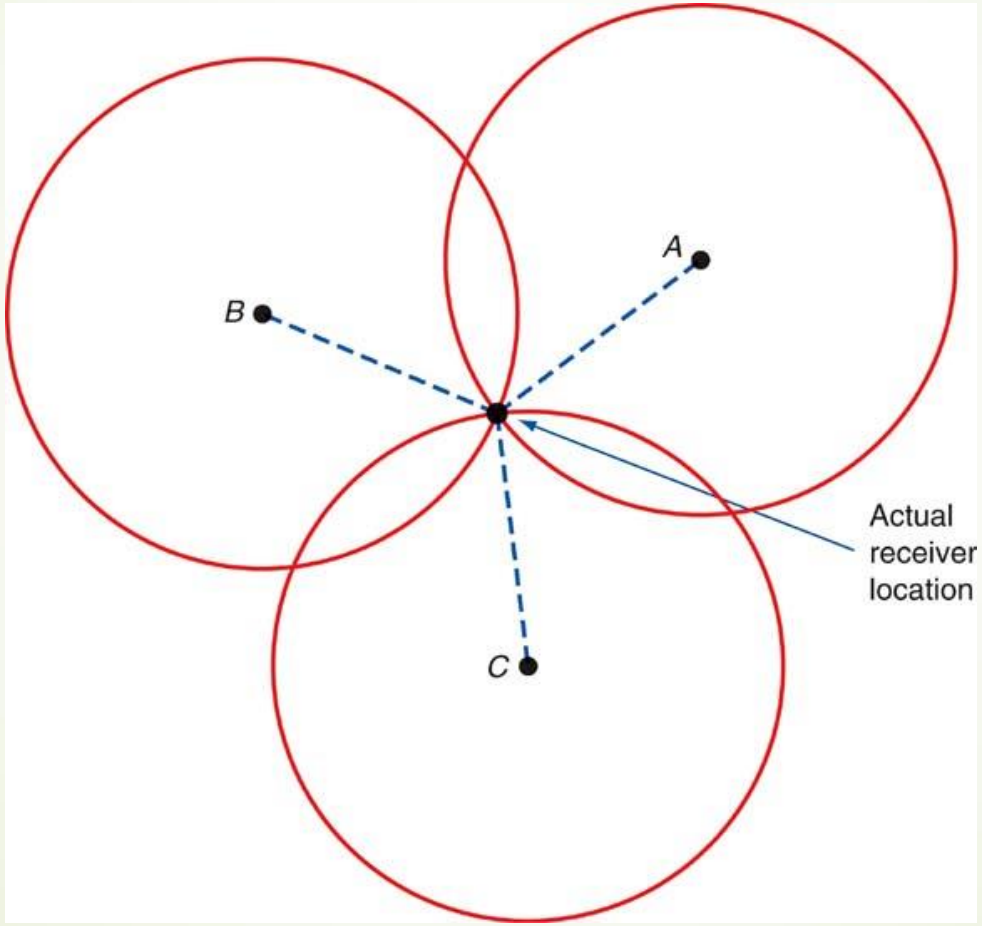
- A GPS receiver is a complex super heterodyne microwave receiver designed to pick up the GPS signals, decode them, and then compute the location of the receiver.
- The output is usually an LCD display giving latitude, longitude, and altitude information and/or a map of the area.
- The most widely used GPS receiver is the popular handheld portable type, not much larger than an oversized handheld calculator.

# Global Positioning System

GPS Receivers

- The receiver performs a time multiplexing operation on the four satellites within view of the receiver.
- The data is extracted from each of the four satellites and stored in the receiver’s memory.
- Data from three satellites is needed to fix the receiver’s position.
- If data from a fourth satellite is available, altitude can be calculated.

# Global Positioning System




How triangulation works to locate a GPS receiver

# Global Positioning System

GPS Applications

- The primary application of the GPS is military and related navigation.
- GPS is used by all services for ships, aircraft, and ground troops.
- Most civilian applications also involve navigation, which is usually marine or aviation-related.

# Global Positioning System

GPS Applications

- Commercial applications include surveying, mapmaking, and construction.
- Vehicle location is a growing application for trucking and delivery companies, taxi, bus, and train transportation.
- Police, fire, ambulance, and forest services also use GPS.

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