

7.18 Low Earth Orbit (LEO) Satellites And Clusters

For communication, the primary alternative to GEO is known as *Low Earth Orbit (LEO)*, which is defined as altitudes up to 2000 Kilometers. As a practical matter, a satellite must be placed above the fringe of the atmosphere to avoid the drag produced by encountering gases. Thus, LEO satellites are typically placed at altitudes of 500 Kilometers or higher. LEO offers the advantage of short delays (typically 1 to 4 milliseconds), but the disadvantage that the orbit of a satellite does not match the rotation of the earth. Thus, from an observer's point of view on the earth, an LEO satellite appears to move across the sky, which means a ground station must have an antenna that can rotate to track the satellite. Tracking is difficult because satellites move rapidly. The lowest altitude LEO satellites orbit the earth in approximately 90 minutes; higher LEO satellites require several hours.

The general technique used with LEO satellites is known as *clustering* or *array deployment*. A large group of LEO satellites are designed to work together. In addition to communicating with ground stations, a satellite in the group can also communicate with other satellites in the group. Members of the group stay in communication, and agree to forward messages, as needed. For example, consider what happens when a user in Europe sends a message to a user in North America. A ground station in Europe transmits the message to the satellite currently overhead. The satellites in the cluster communicate to forward the message to the satellite in the cluster that is currently over a ground station in North America. Finally, the satellite currently over North America transmits the message to a ground station. To summarize:

A cluster of LEO satellites work together to forward messages. Members of the cluster must know which satellite is currently over a given area of the earth, and forward messages to the appropriate member for transmission to a ground station.

7.19 Tradeoffs Among Media Types

The choice of medium is complex, and involves the evaluation of multiple factors. Items that must be considered include:

- **Cost:** materials, installation, operation, and maintenance
- **Data rate:** number of bits per second that can be sent
- **Delay:** time required for signal propagation or processing
- **Affect on signal:** attenuation and distortion
- **Environment:** susceptibility to interference and electrical noise
- **Security:** susceptibility to eavesdropping