Lecture 13

PRINCIPLES OF SATELLITE COMMUNICATION

Time Division Multiple Access and ALOHA

- TDMA is a good fit for all forms of digital communications and should be considered as one option during the design of a satellite application.
- The complexity of maintaining synchronization and control has been overcome through miniaturization of the electronics and by way of improvements in network management systems.
- With the rapid introduction of TDMA in terrestrial radio networks like the GSM standard, we will see greater economies of scale and corresponding price reductions in satellite TDMA equipment.

Code Division Multiple Access

- CDMA, also called spread spectrum communication, differs from FDMA and TDMA because it allows users to literally transmit on top of each other.
- This feature has allowed CDMA to gain attention in commercial satellite communication.
- It was originally developed for use in military satellite communication where its inherent anti-jam and security features are highly desirable.
- CDMA was adopted in cellular mobile telephone as an interference-tolerant communication technology that increases capacity above analog systems.

Code Division Multiple Access

- It has not been proven that CDMA is universally superior as this depends on the specific requirements.
- For example, an effective CDMA system requires contiguous bandwidth equal to at least the spread bandwidth.
- Two forms of CDMA are applied in practice:

  (1) direct sequence spread spectrum (DSSS) and

  (2) frequency hopping spread spectrum (FHSS).
- FHSS has been used by the OmniTracs and Eutel-Tracs mobile messaging systems for more than 10 years now, and only recently has it been applied in the consumer's commercial world in the form of the Bluetooth wireless LAN standard. However, most CDMA applications over commercial satellites employ DSSS (as do the cellular networks developed by Qualcomm).

Code Division Multiple Access

- Consider the following summary of the features of spread spectrum technology (whether DSSS or FHSS):
  - Simplified multiple access: no requirement for coordination among users;
  - Selective addressing capability if each station has a unique chip code sequence—provides authentication: alternatively, a common code may still perform the CDMA function adequately since the probability of stations happening to be in synch is approximately $1/n$;
  - Relative security from eavesdroppers: the low spread power and relatively fast direct sequence modulation by the pseudorandom code make detection difficult;
  - Interference rejection: the spread-spectrum receiver treats the other DSSS signals as thermal noise and suppresses narrowband interference.

Code Division Multiple Access

- A typical CDMA receiver must carry out the following functions in order to acquire the signal, maintain synchronization, and reliably recover the data:
  - Synchronization with the incoming code through the technique of correlation detection;
  - De-spreading of the carrier;
  - Tracking the spreading signal to maintain synchronization;
  - Demodulation of the basic data stream;
  - Timing and bit detection;
  - Forward error correction to reduce the effective error rate;

Code Division Multiple Access

- The first three functions are needed to extract the signal from the clutter of noise and other signals.
- The processes of demodulation, bit timing and detection, and FEC are standard for a digital receiver, regardless of the multiple access method.

Multiple Access Summary

- The bottom line in multiple access is that there is no single system that provides a universal answer.
- FDMA, TDMA, and CDMA will each continue to have a place in building the applications of the future.
- They can all be applied to digital communications and satellite links.
- When a specific application is considered, it is recommended to perform the comparison to make the most intelligent selection.

Frequency Band Trade-Offs

- Satellite communication is a form of radio or wireless communication and therefore must compete with other existing and potential uses of the radio spectrum.
- During the initial 10 years of development of these applications, there appeared to be more or less ample bandwidth, limited only by what was physically or economically justified by the rather small and low powered satellites of the time.
- In later years, as satellites grew in capability, the allocation of spectrum has become a domestic and international battlefield as service providers fight among themselves, joined by their respective governments when the battle extends across borders.
- So, we must consider all of the factors when selecting a band for a particular application.

Frequency Band Trade-Offs

- The most attractive portion of the radio spectrum for satellite communication lies between 1 and 30 GHz.
- The relationship of frequency, bandwidth, and application are shown in Figure 2.9.
- The scale along the *x*-axis is logarithmic in order to show all of the satellite bands; however, observe that the bandwidth available for applications increases in real terms as one moves toward the right (i.e., frequencies above 3 GHz).
- Also, the precise amount of spectrum that is available for services in a given region or country is usually less than Figure 2.9 indicates.

Frequency Band Trade-Offs

- Letter band designations, frequency in Gigahertz:
  - L: 1.0–2.0;
  - S: 2.0–4.0;
  - C: 4.0–8.0;
  - X: 8–12;
  - Ku: 12–18;
  - Ka: 18–40;
  - Q: 40–60;
  - V: 60–75;
  - W: 75–110.