Lecture 16: Duplex Communication Systems

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A duplex communication system is composed of two or more connected devices that can communicate with one another in both directions. Duplex systems are employed in many communications networks, either to allow for simultaneous communication in both directions between two connected parties or to provide a reverse path for the monitoring and remote adjustment of equipment in the field. In wireless systems, we can consider two types of duplex communication systems: half-duplex and full-duplex.

I. Half Duplex

A half-duplex system provides communication in both directions, but only one direction at a time (not simultaneously). Typically, once a device begins receiving a signal, it must wait for the transmitter to stop transmitting, before replying.

An example of a half-duplex system is a two-device system such as a walkie-talkie, wherein one must use ”over” or another previously designated keyword to indicate the end of transmission, and ensure that only one party transmits at a time, because both parties transmit and receive on the same frequency.

Half-duplex systems are usually used to conserve bandwidth, since only a single communication channel is needed, which is shared alternately between the two directions. For example, a walkie-talkie requires only a single frequency for bidirectional communication, while a cell phone, which is a full-duplex device, requires two frequencies to carry the two simultaneous voice channels, one in each direction.

In half-duplex systems, if more than one device transmits at the same time, a collision occurs, resulting in lost messages.

II. Full Duplex

A full-duplex system allows communication in both directions, and, unlike half-duplex, allows this to happen simultaneously. Telephone networks are full-duplex, since they allow both callers to speak and be heard at the same time.

With the arrival of the latest generation wireless systems, we can divide the full duplex scheme into two sub schemes: typical full-duplex and real full-duplex.

A. Typical Full Duplex

The name “typical” is because this scheme has been and is currently used. An example of typical full duplex is a two-way radio, where the devices transmit on one frequency and receive on another; this is also called frequency-division duplex.

In the case of typical full-duplex, there are no collisions so time is not wasted by having to retransmit frames. Second, full transmission capacity is available in both directions because the send and receive functions are separate.

The typical full duplex schemes can be divided into Time-division duplexing (TDD) and Frequency-division duplexing (FDD).

1) Frequency Division Duplexing (FDD): Means that the transmitter and receiver operate at different carrier frequencies. That is, the transmission frequency for one device is the reception frequency for the other device and vice versa.

2) Time Division Duplexing (TDD): Means that the transmitter and receiver operate at the same carrier frequency. However, they transmit at different and receive at different time slots. However, the user does not realize that these transmissions are made at different times. Thus, it seems that communication is continuous between both devices.

B. Real Full Duplex

One of the schemes being proposed for use with 5G mobile communications systems is that of single channel full duplex or real full duplex communication.

While existing mobile cellular communications systems currently use forms of full duplex, these use different frequencies for transmit and receive, (FDD or TDD). The 5G full duplex scheme being developed allows simultaneous transmission and reception on the same channel at the same time.

This 5G full duplex offers several advantages:

- **Effectively doubles spectrum efficiency.** By employing a 5G full duplex scheme using a single channel, only one channel is needed to transmit data to and from the base station rather than two for an FDD scheme, or when using a TDD scheme the full transmission time can be utilized in both direction rather than half - the scheme effectively makes TDD schemes redundant. This effectively doubles the spectrum efficiency.
- **Fading characteristics.** As the same channel is used in both direction the fading/propagation characteristics will be the same. Difficulties can arise using an FDD scheme when one channel is affected by fading and the other less so.
- **Filtering.** FDD requires filters to be used to ensure that the transmitted signal did not enter the receiver and desensitize it. As more bands were added, more filters were required with a resulting increase in loss and drop in performance. By using single channel 5G full duplex, this issue can be overcome as techniques used have been shown to be capable of use over a wide bandwidth.
- **Enhanced interference coordination.** The simultaneous reception of feedback information while transmitting data, possible using 5G full duplex reduce the air interface delays and provide much tighter time/phase synchronisation for techniques like Coordinated Multipoint, CoMP (which is also part of the 4G LTE standard).

Many researchers have spent time investigating and developing the technology and now it seems likely that full duplex can be used as part of the 5G communications system. The main amount of reduction of the transmitted signal is provided by using RF cancellation techniques - often referred to as self-interference cancelation, SIC. Much investigation work has been ongoing to improve the performance and enable 5G full duplex in a single channel to be a realistic option.

REFERENCES

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