

HY-330

fall semester 2021

Introduction to telecommunication systems theory

University of Crete
Computer Science Department

Stefanos Papadakis

Spread Spectrum Systems

- ✦ FHSS:
 - ✦ Frequency-Hopping Spread Spectrum
- ✦ DSSS:
 - ✦ Direct-Sequence Spread Spectrum

FHSS/DSSS usage

- ✦ IEEE 802.11b
- ✦ IEEE 802.15.4
- ✦ Bluetooth
- ✦ CDMA
- ✦ 3G
- ✦ GPS/Galileo/GLONASS

FHSS

- Hedy Lamarr (Hedwig Eva Maria Kiesler)



- Patent: 1941

UNITED STATES PATENT OFFICE

2,292,387

SECRET COMMUNICATION SYSTEM

Hedy Kiesler Markey, Los Angeles, and George
Antheil, Manhattan Beach, Calif.

Application June 10, 1941, Serial No. 397,412

6 Claims. (Cl. 250—2)

This invention relates broadly to secret communication systems involving the use of carrier waves of different frequencies, and is especially useful in the remote control of dirigible craft, such as torpedoes.

An object of the invention is to provide a method of secret communication which is relatively simple and reliable in operation, but at the same time is difficult to discover or decipher.

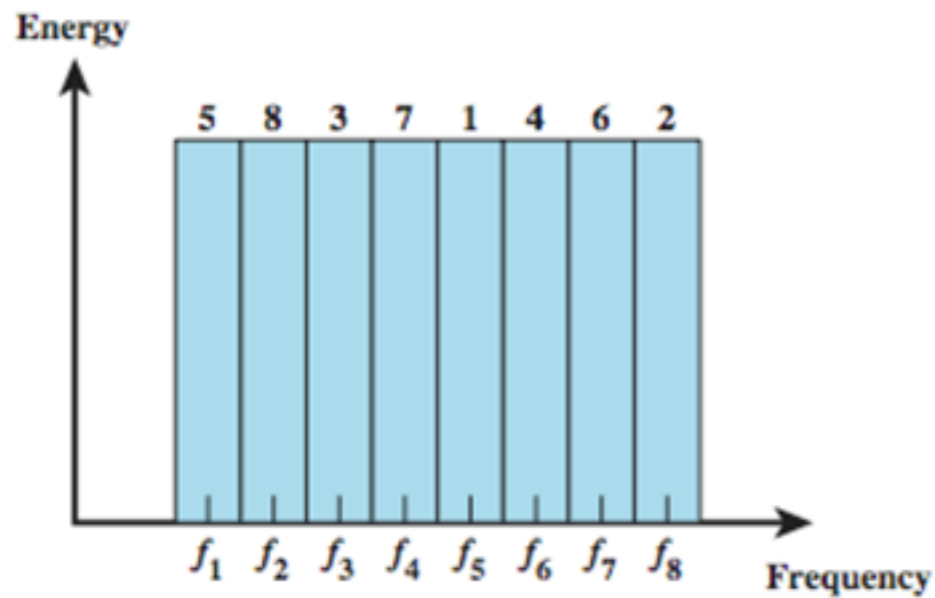
Fig. 2 is a schematic diagram of the apparatus at a receiving station;

Fig. 3 is a schematic diagram illustrating a starting circuit for starting the motors at the transmitting and receiving stations simultaneously;

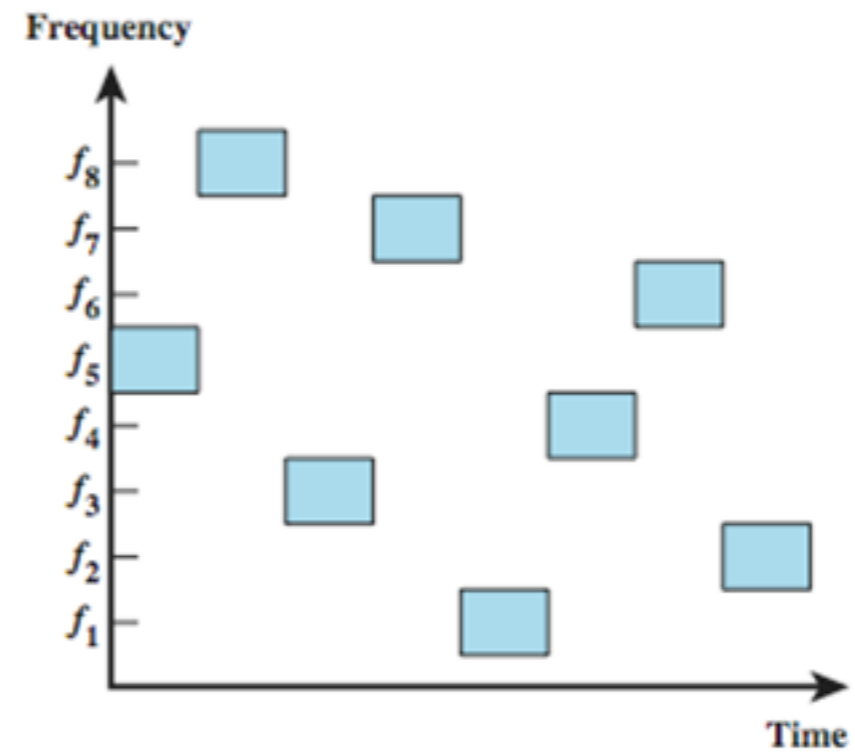
Fig. 4 is a plan view of a section of a record strip that may be employed;

Fig. 5 is a detail cross section through a rec-

FHSS

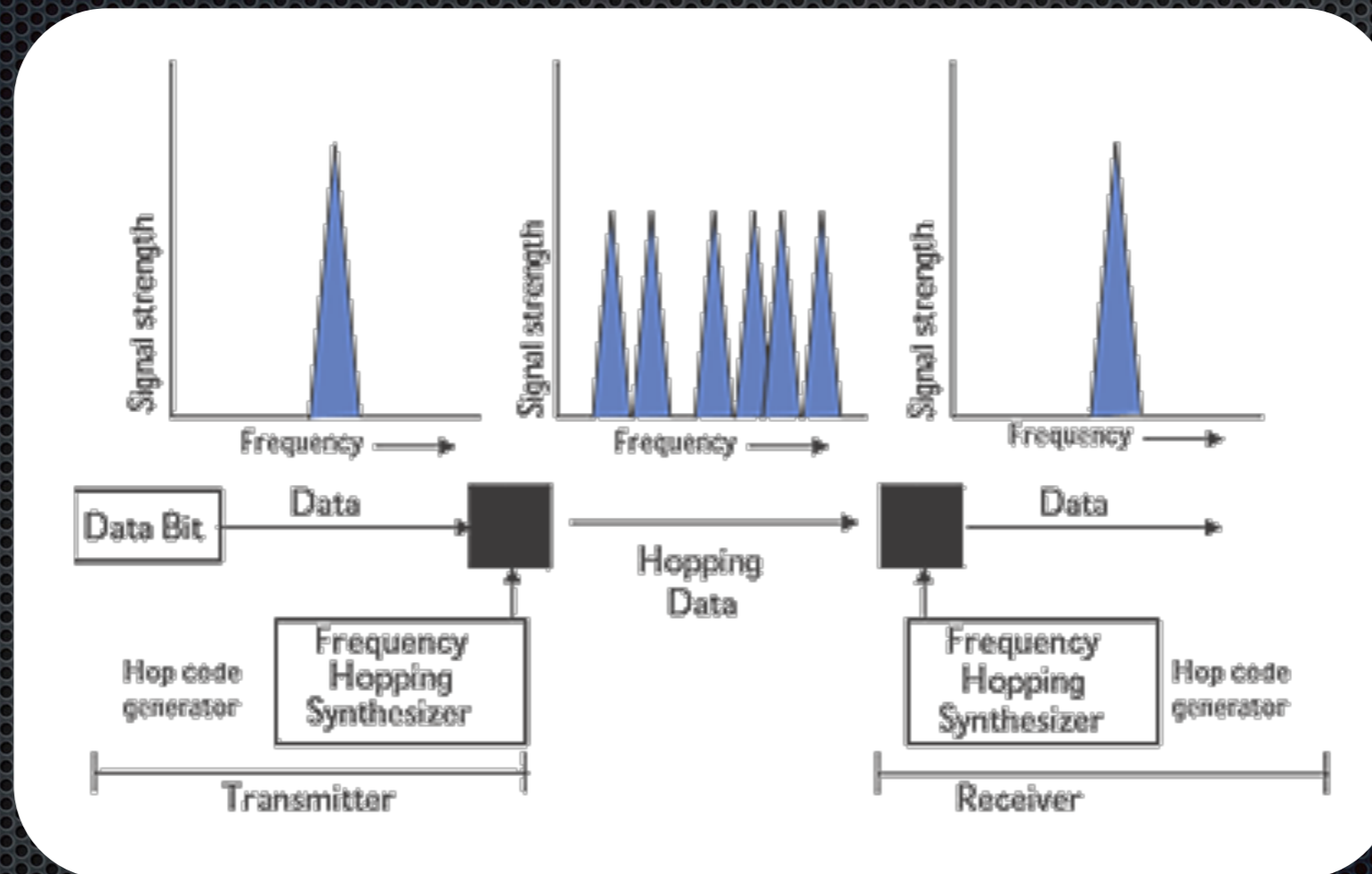


(a) Channel assignment

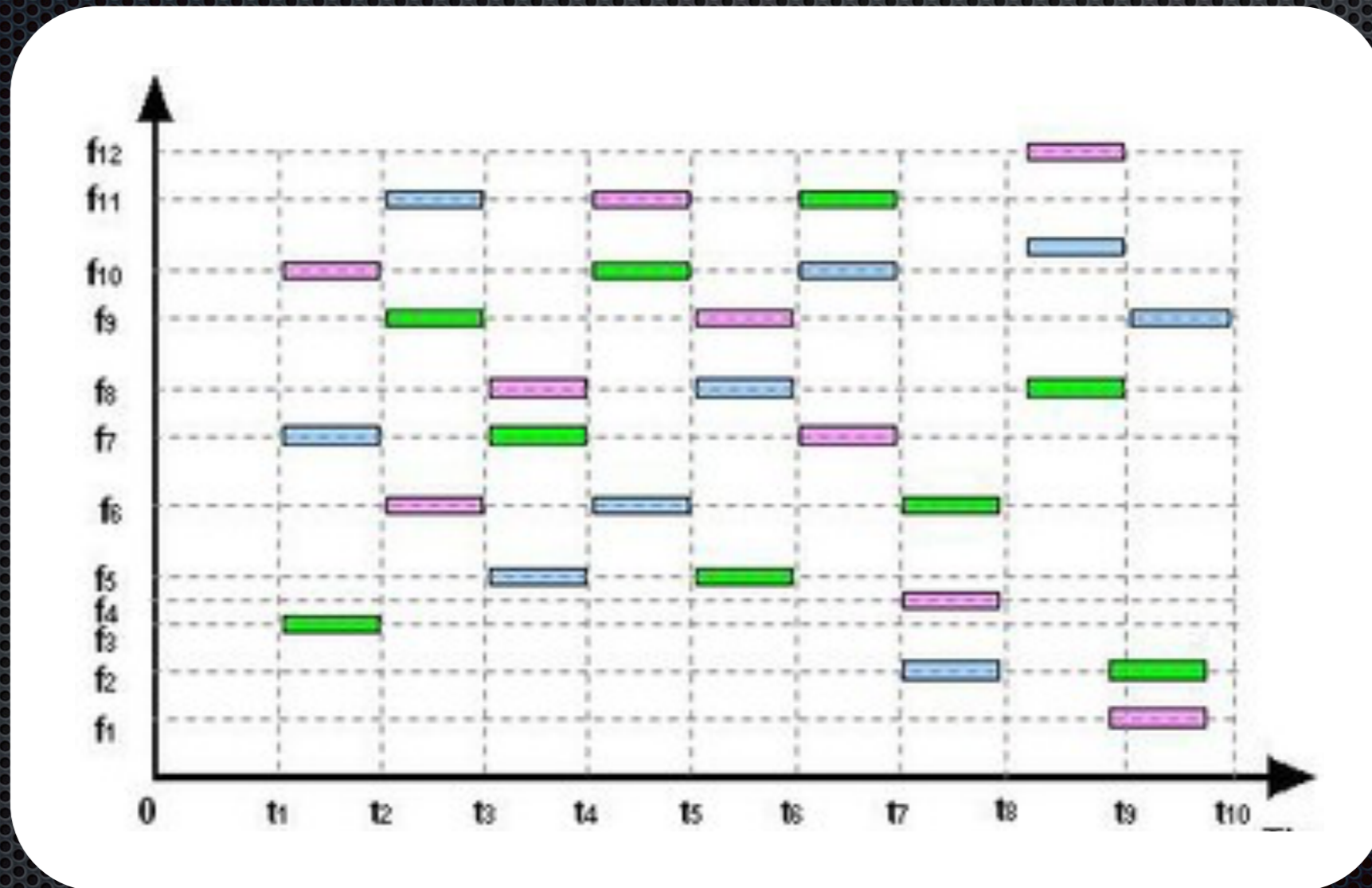


(b) Channel use

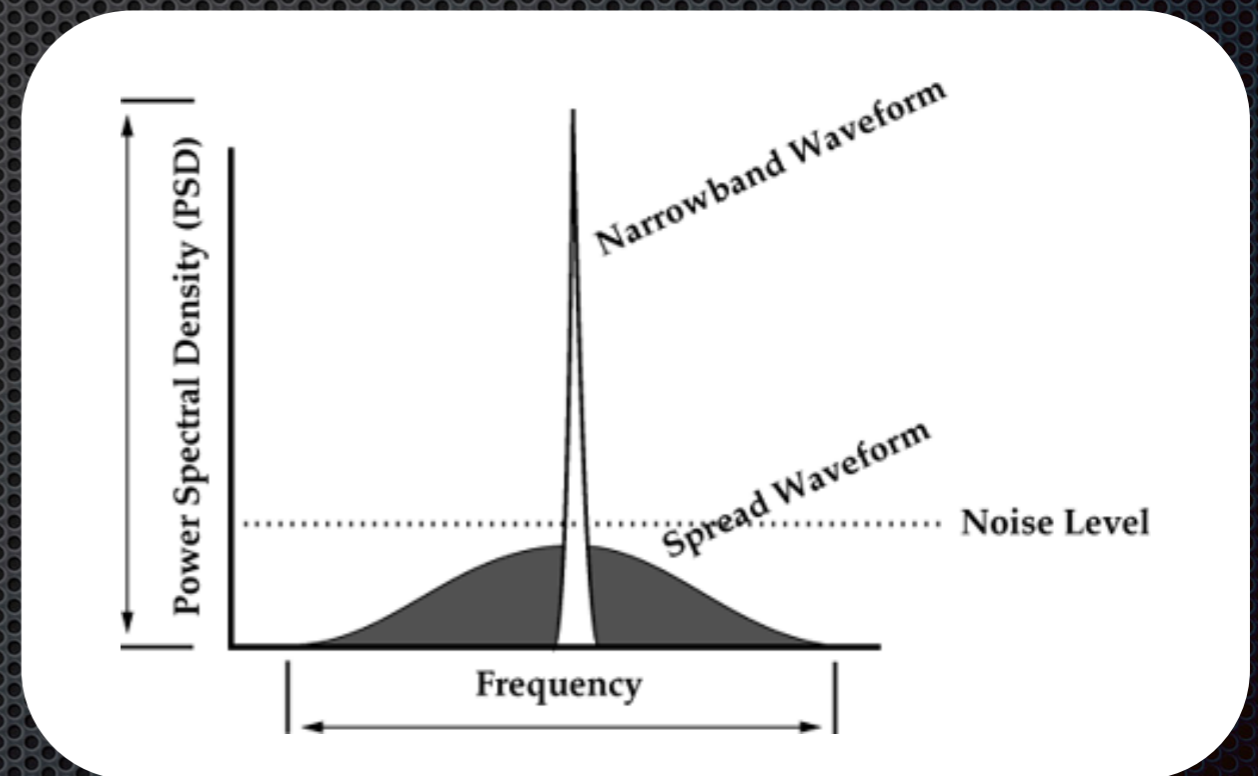
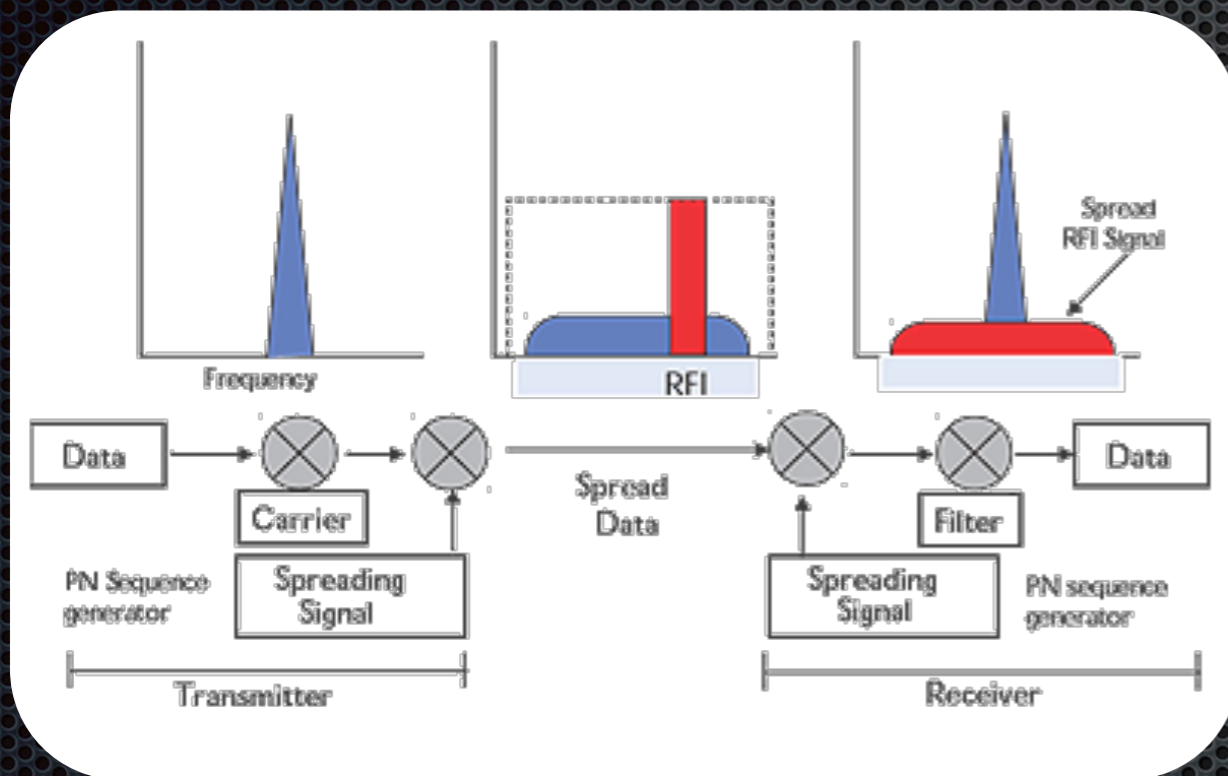
FHSS



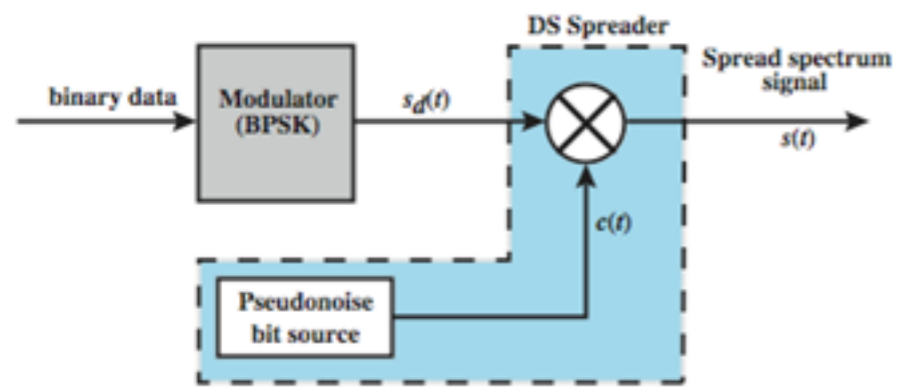
FHSS Multiple Access



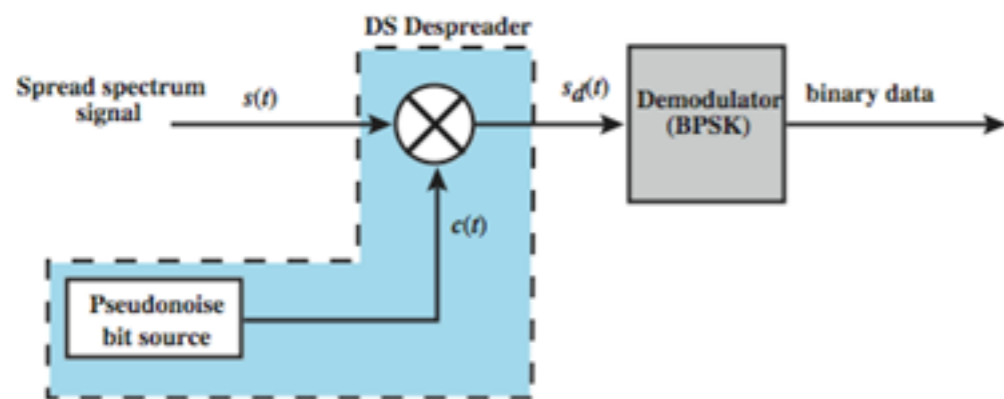
DSSS



DSSS



(a) Transmitter



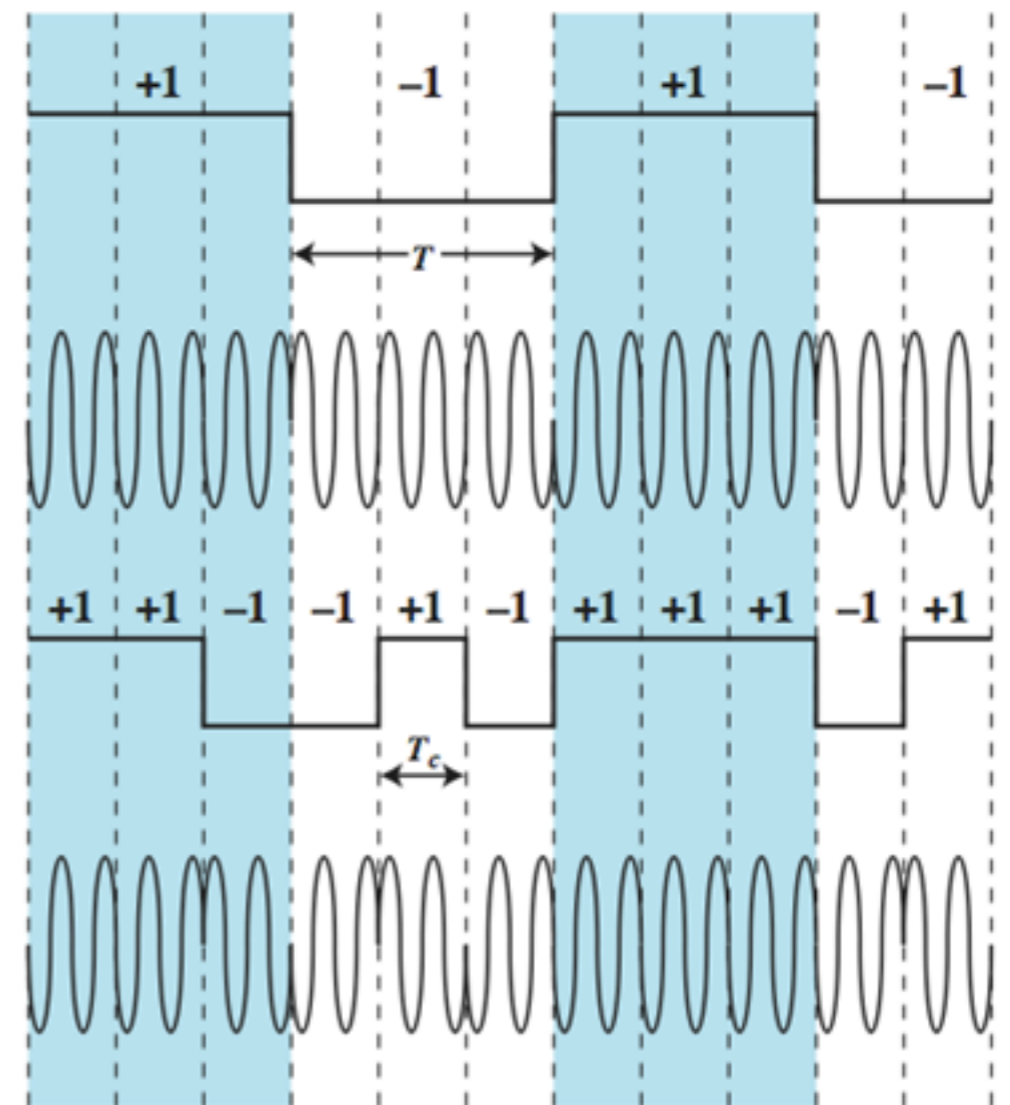
(b) Receiver

(a) $d(t)$ data

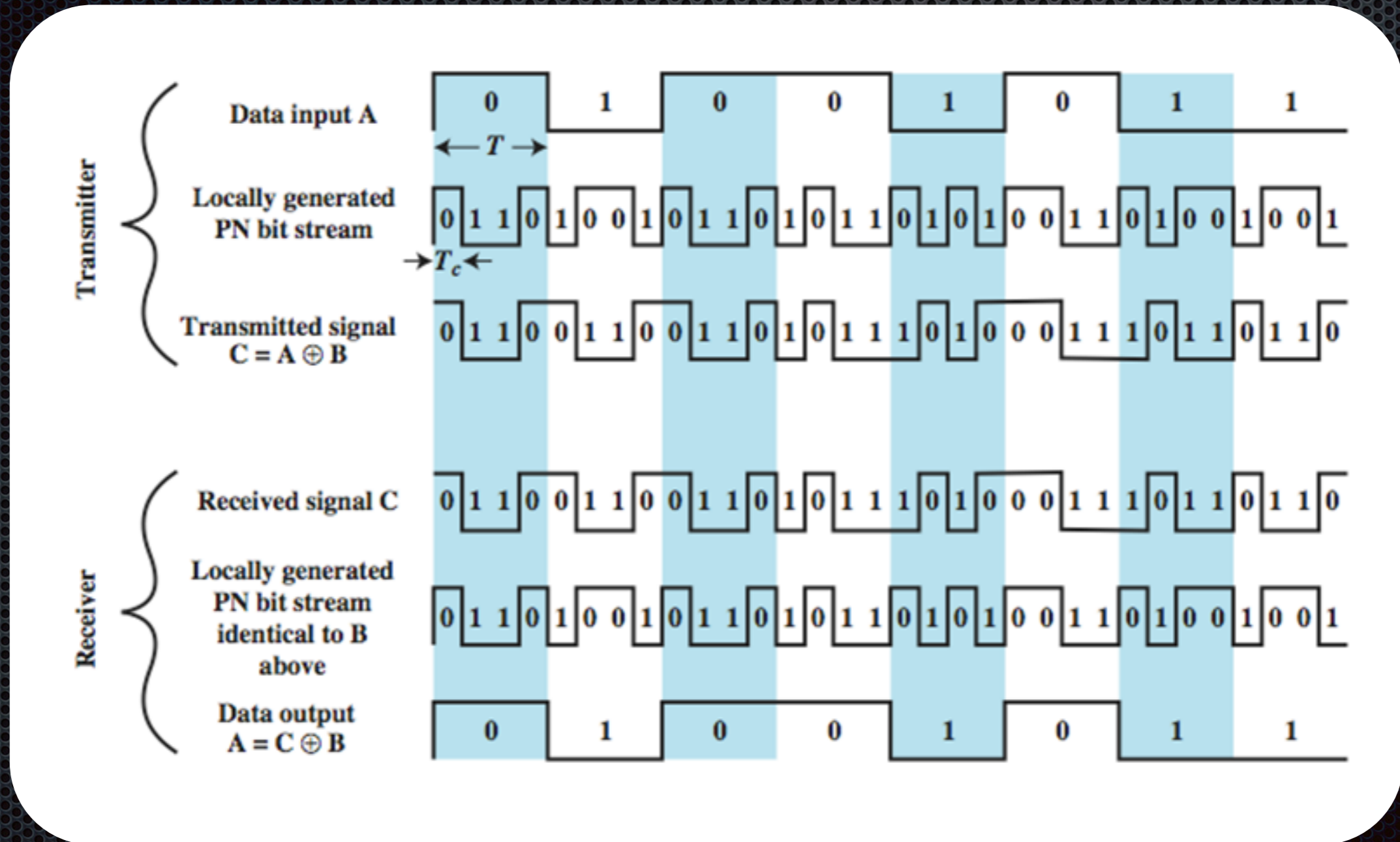
(b) $s_d(t)$

(c) $c(t)$ spreading code

(d) $s_f(t)$



DSSS



DSSS

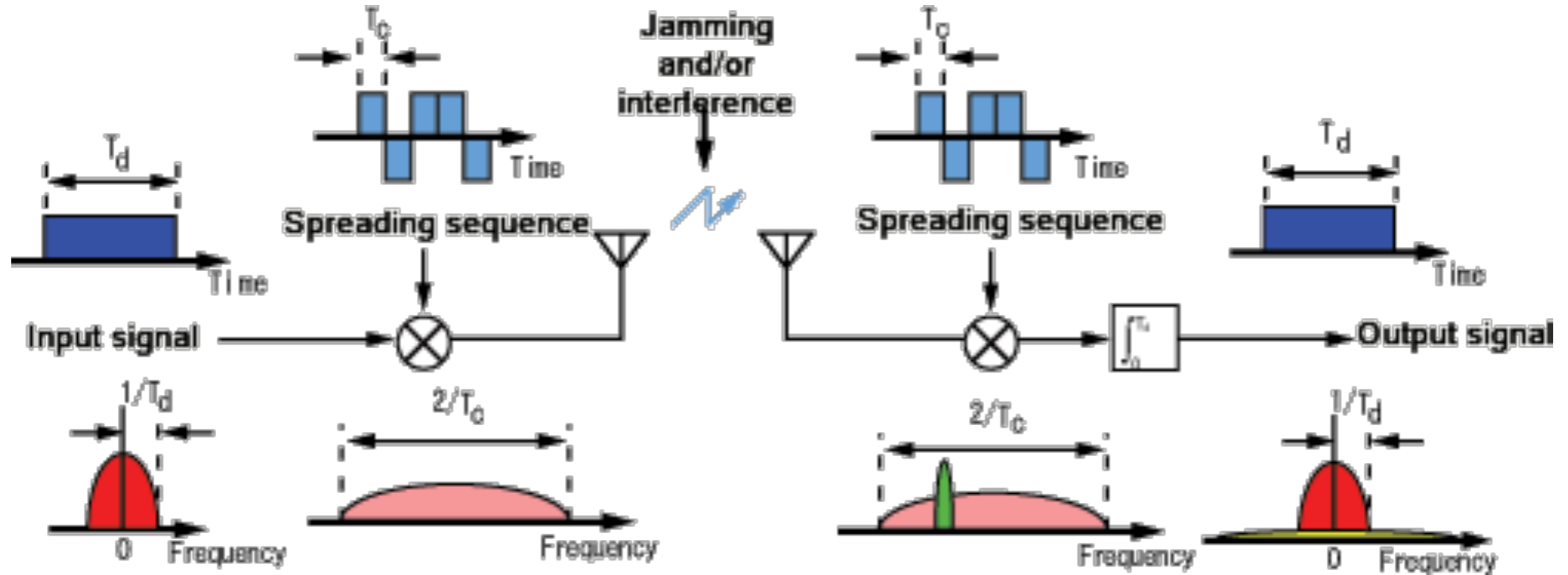
- Chip (spreading sequence):
PN code
- Chip rate \gg bit rate
- Data x Chip (spreading):
“white noise”
- Processing Gain /
Spreading Factor

$$1/T_c \gg 1/T_b$$

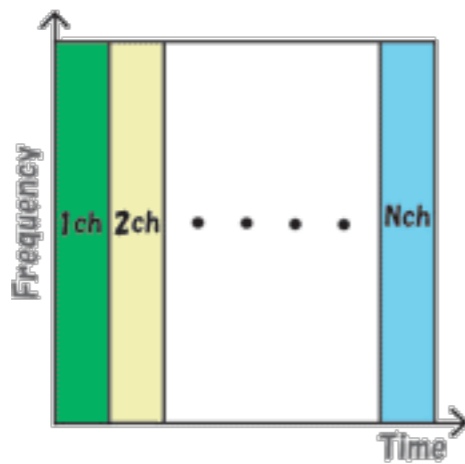
$$Tx = D \oplus C$$

$$T_b/T_c$$

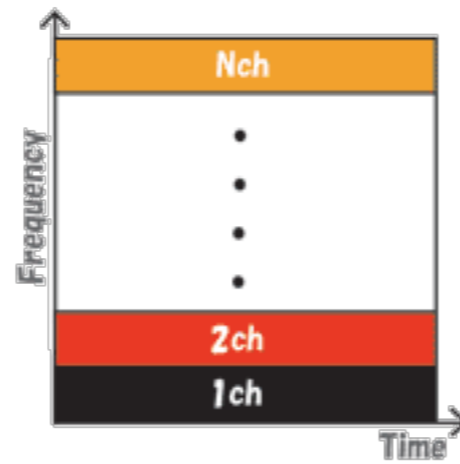
DSSS



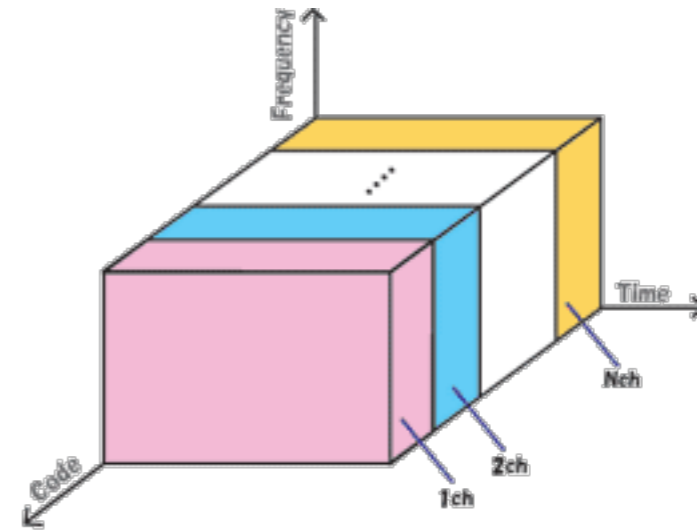
Multiple Access



(a) TDMA

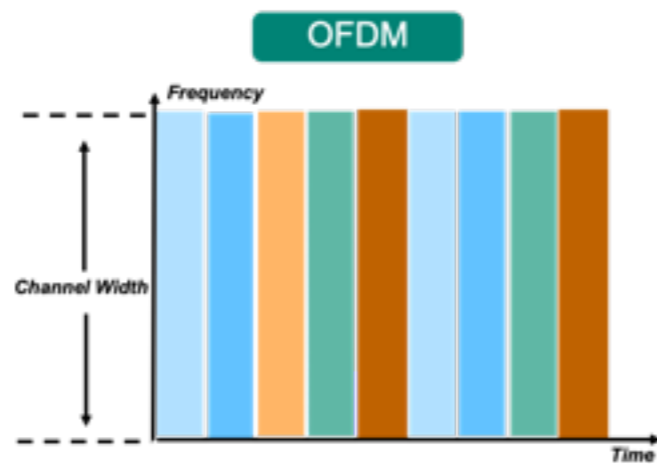


(b) FDMA

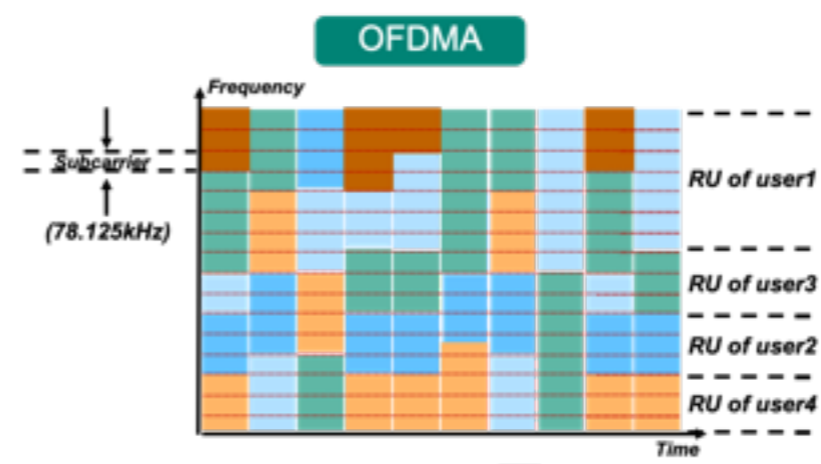


(c) CDMA

Multiple Access



TDMA



Wi-fi packets:
User1 User2 User3 User4 User5

OFDMA