Computer Networks

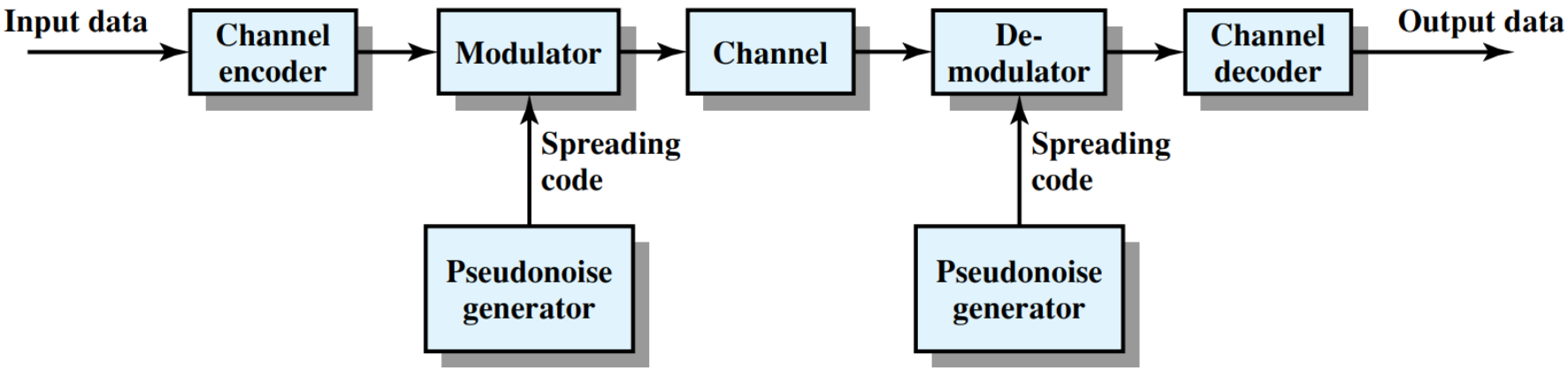
Spread Spectrum

Amitangshu Pal
Computer Science and Engineering
IIT Kanpur

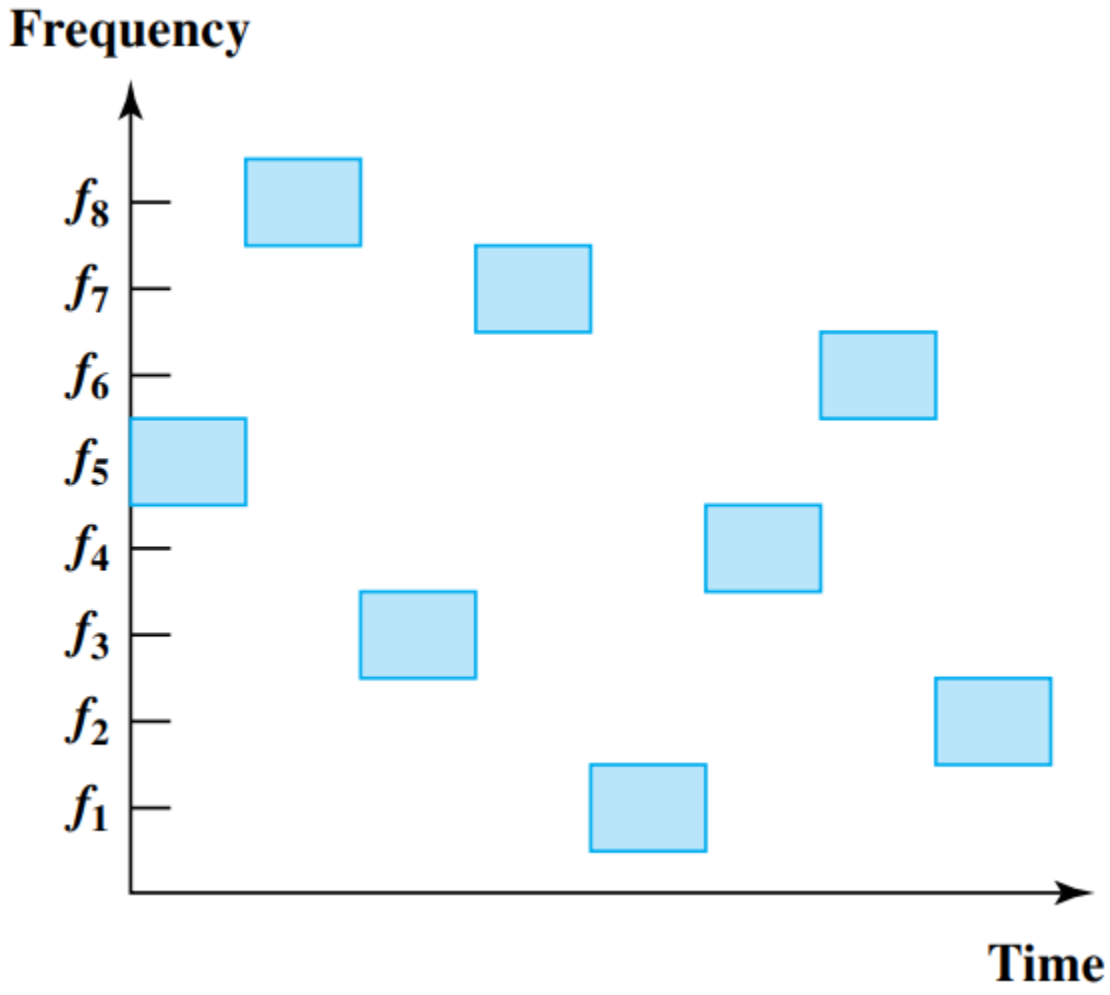
Spread Spectrum

- **Developed initially for military and intelligence requirements**
  - **Spread the information over a wider bandwidth**
  - **Make jamming and interception more difficult**

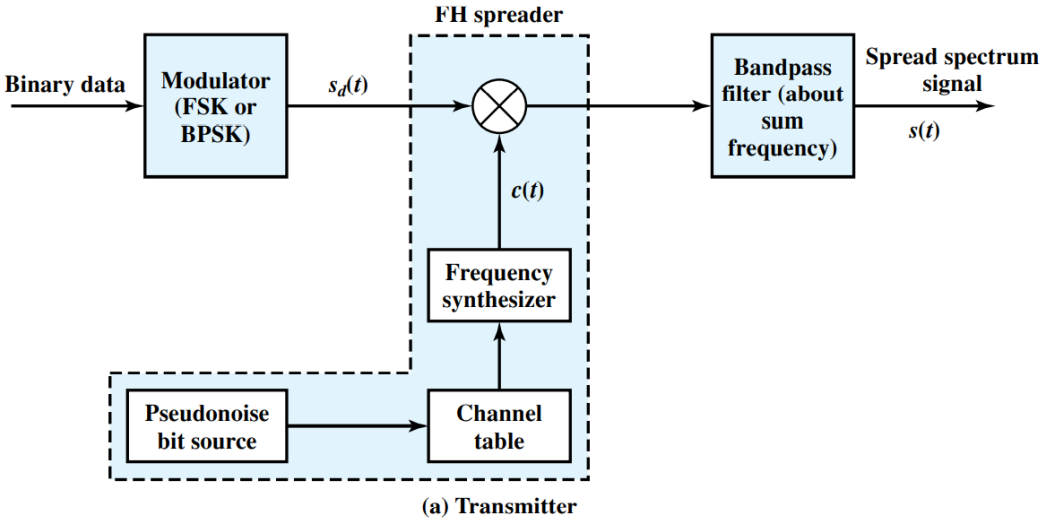
- **We will learn three types of spread spectrum**
  - **Frequency Hopping Spread Spectrum**
  - **Direct Sequence Spread Spectrum**
  - **Code Division Multiple Access**



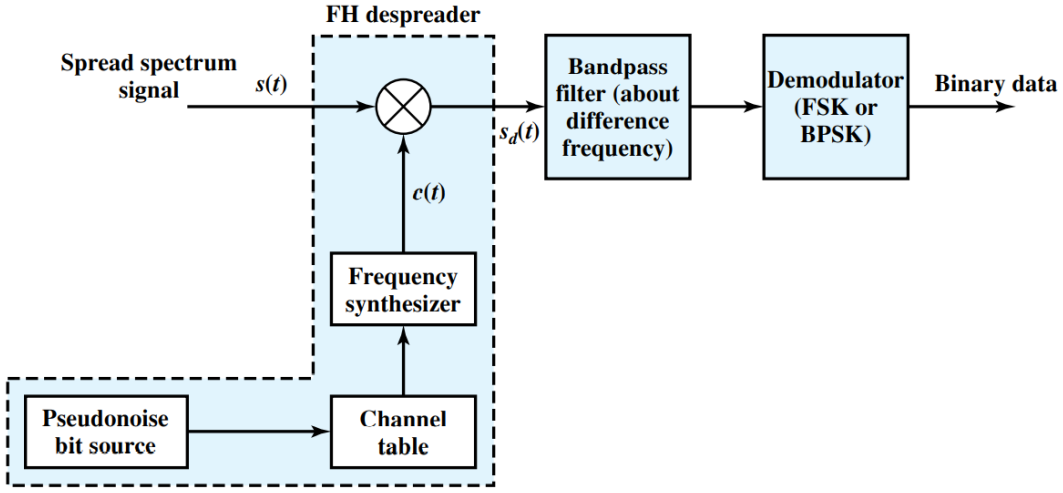
Frequency Hopping Spread Spectrum



FHSS

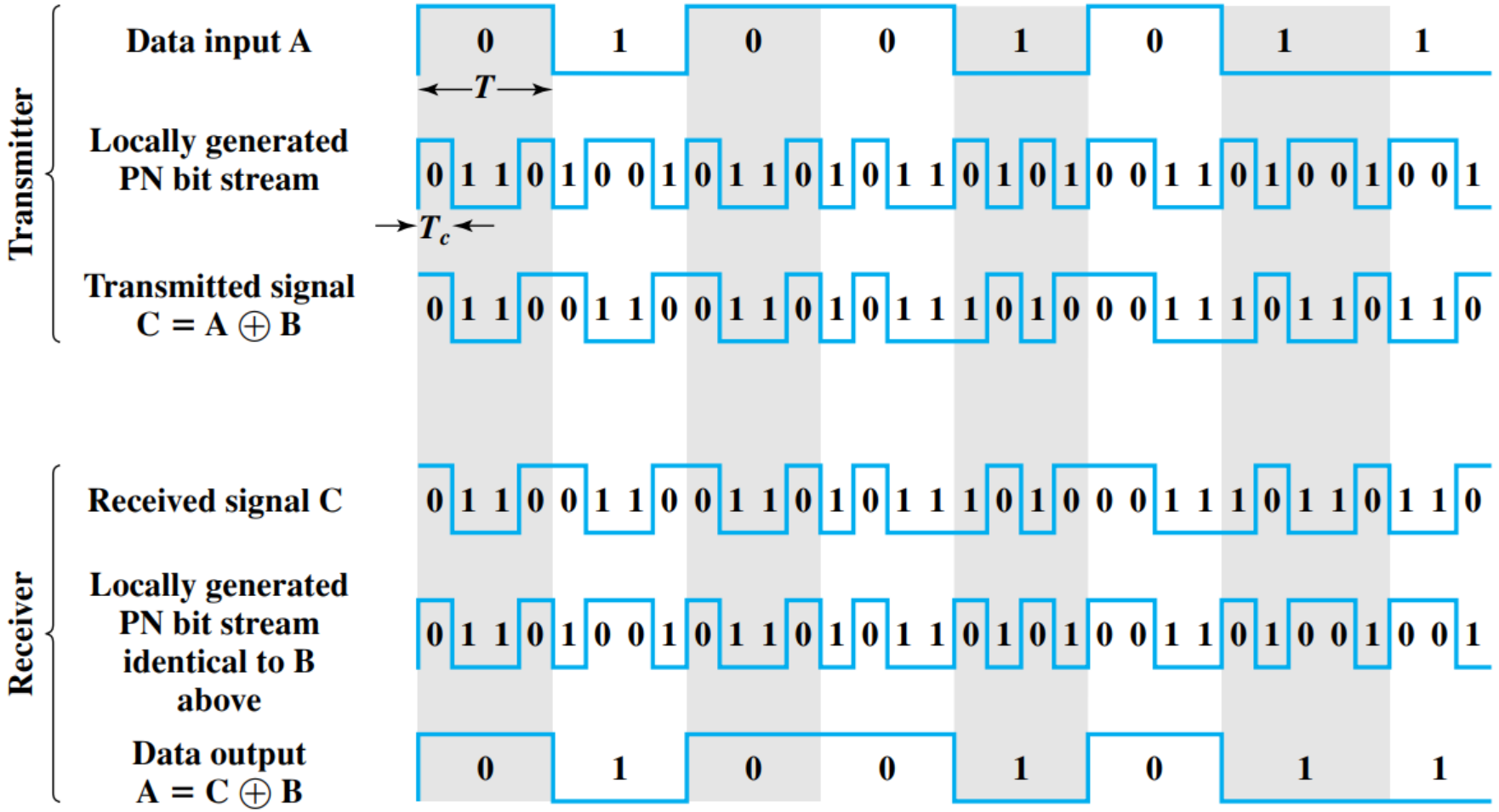


(a) Transmitter

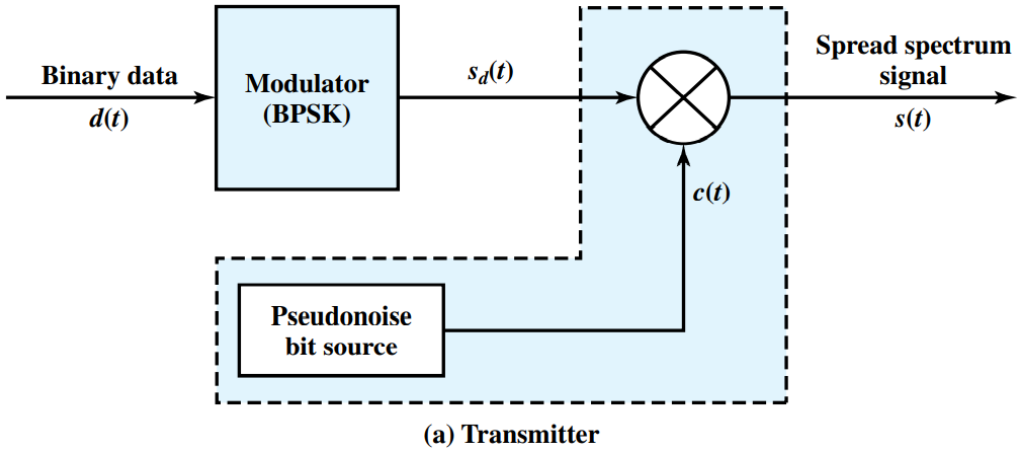


(b) Receiver

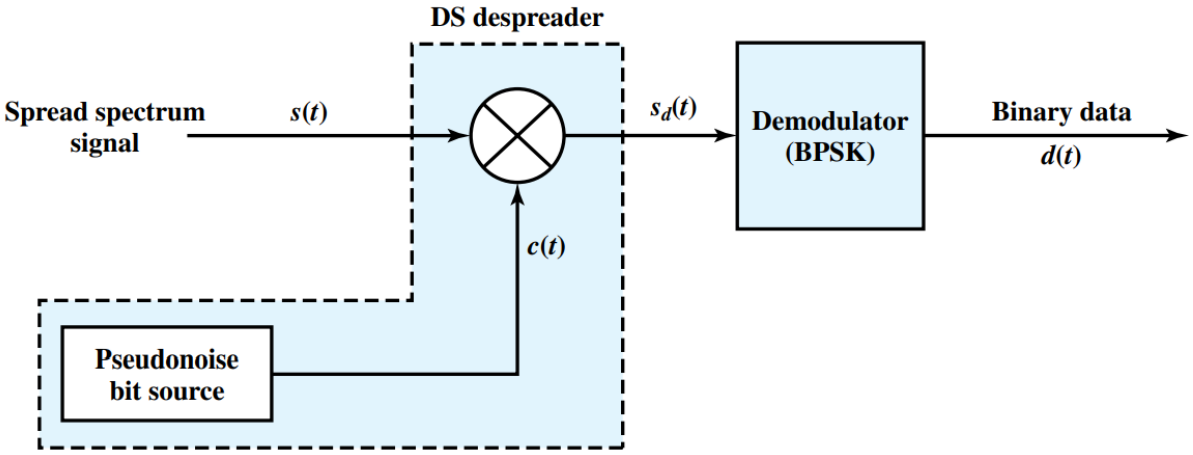
Direct Sequence Spread Spectrum



DSSS

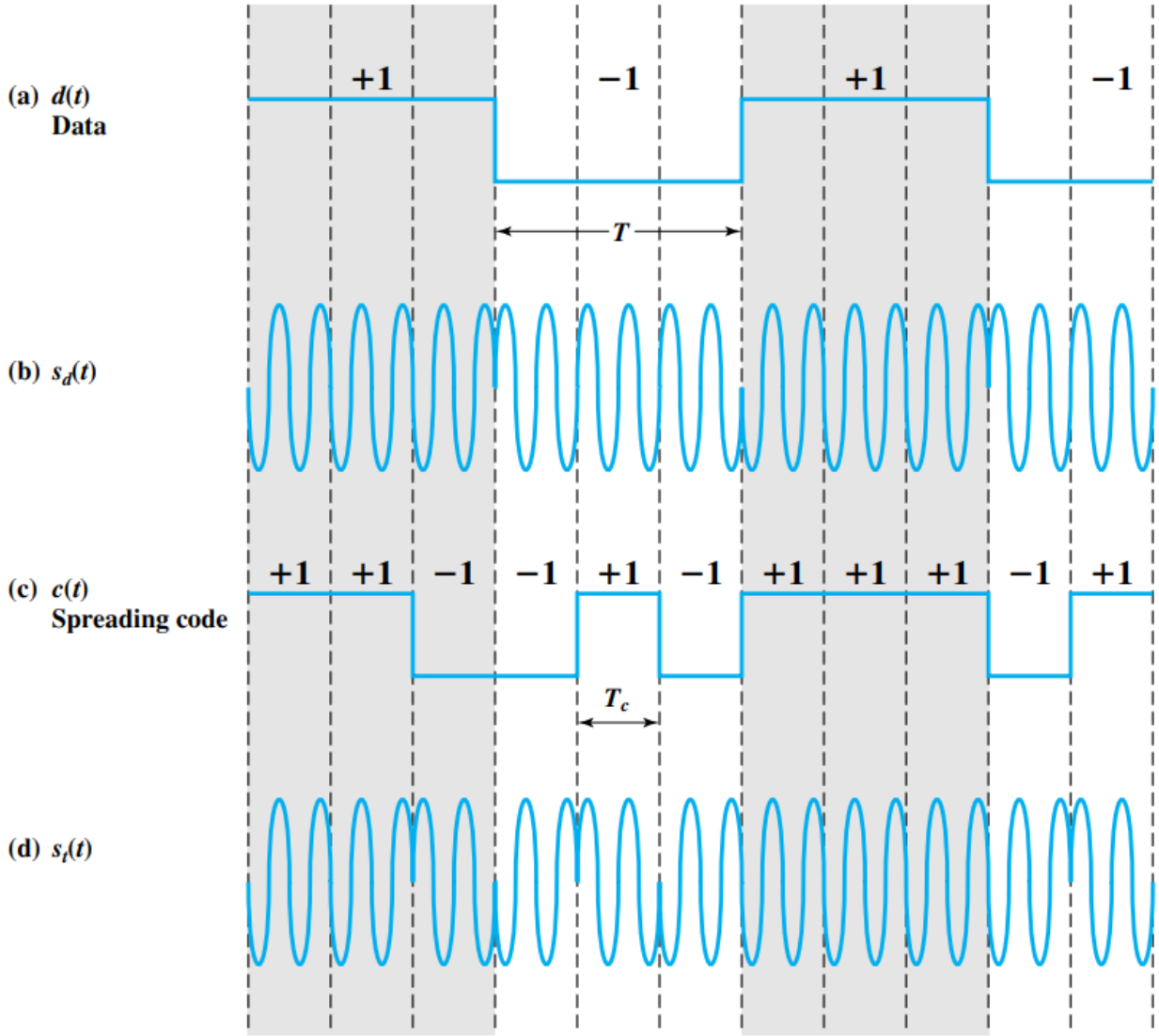


(a) Transmitter



(b) Receiver

DSSS



CDMA

$$A = (-1\ -1\ -1\ +1\ +1\ -1\ +1\ +1)$$
$$B = (-1\ -1\ +1\ -1\ +1\ +1\ +1\ -1)$$
$$C = (-1\ +1\ -1\ +1\ +1\ +1\ -1\ -1)$$
$$D = (-1\ +1\ -1\ -1\ -1\ -1\ +1\ -1)$$

- **All chip sequences are orthogonal**

$$S \blacksquare T = \frac{1}{m}\sum_{i=1}^{m} S_i T_i = 0$$

$$S \blacksquare S = \frac{1}{m}\sum_{i=1}^{m} S_i S_i = \frac{1}{m}\sum_{i=1}^{m} S_i^2 = \frac{1}{m}\sum_{i=1}^{m} (\pm 1)^2 = 1$$

CDMA

$$A = (-1\ -1\ -1\ +1\ +1\ -1\ +1\ +1)$$
$$B = (-1\ -1\ +1\ -1\ +1\ +1\ +1\ -1)$$
$$C = (-1\ +1\ -1\ +1\ +1\ +1\ -1\ -1)$$
$$D = (-1\ +1\ -1\ -1\ -1\ -1\ +1\ -1)$$

$S_1 = C = (-1\ +1\ -1\ +1\ +1\ +1\ -1\ -1)$

$S_2 = B+C = (-2\ 0\ 0\ 0\ +2\ +2\ 0\ -2)$

$S_3 = A+\overline{B} = (-1\ +1\ -1\ +1\ +1\ +1\ -1\ -1)$

$S_4 = A+\overline{B}+C = (-1\ +1\ -3\ +3\ +1\ -1\ -1\ +1)$

$S_5 = A+B+C+D = (-4\ \ 0\ -2\ 0\ +2\ 0\ +2\ -2)$

$S_6 = A+B+\overline{C}+D = (-2\ \ -2\ 0\ -2\ 0\ -2\ +4\ 0)$

CDMA

- Proof:
  - Let's consider the case of $S = (A + \bar{B} + C)$

$$S \blacksquare C = (A + \bar{B} + C) \blacksquare C = A \blacksquare C + \bar{B} \blacksquare C + C \blacksquare C$$
$$= 0 + 0 + 1 = 1$$

- One significant assumption is that, the chips are synchronized in time at the receiver
  - Asynchronous CDMA
- Used in cellular networks, satellites and cable networks

THANK YOU

QUESTIONS???