Spread Spectrum

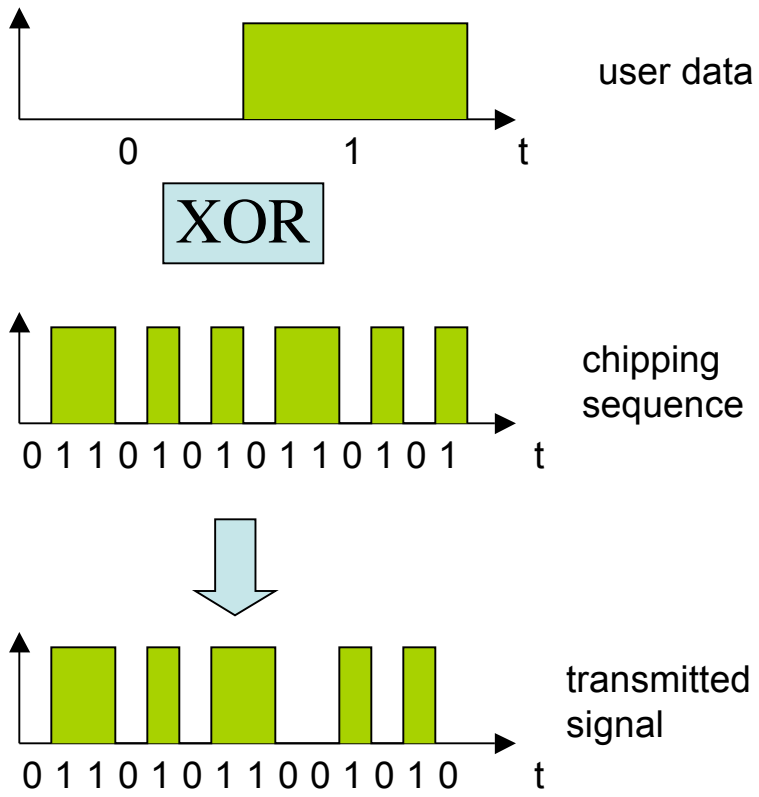
Spread Spectrum

- Basic idea: modulate baseband signal to increase bandwidth usage of the signal transmitted
  - "Spread" the signal in the frequency spectrum
- Advantages
  - Immunity to noise and multipath propagation (ISI)
    - Increased redundancy in the system
    - Early uses by military to avoid jamming
  - Can be used for hiding and encoding signals
    - Only receivers that know the spreading code can recover the data
  - Independent use of the spectrum by different users with little interference
    - Used in mobile cellular networks to implement CDM
  - Soft capacity limit, easy frequency planning

Direct Sequence Spread Spectrum

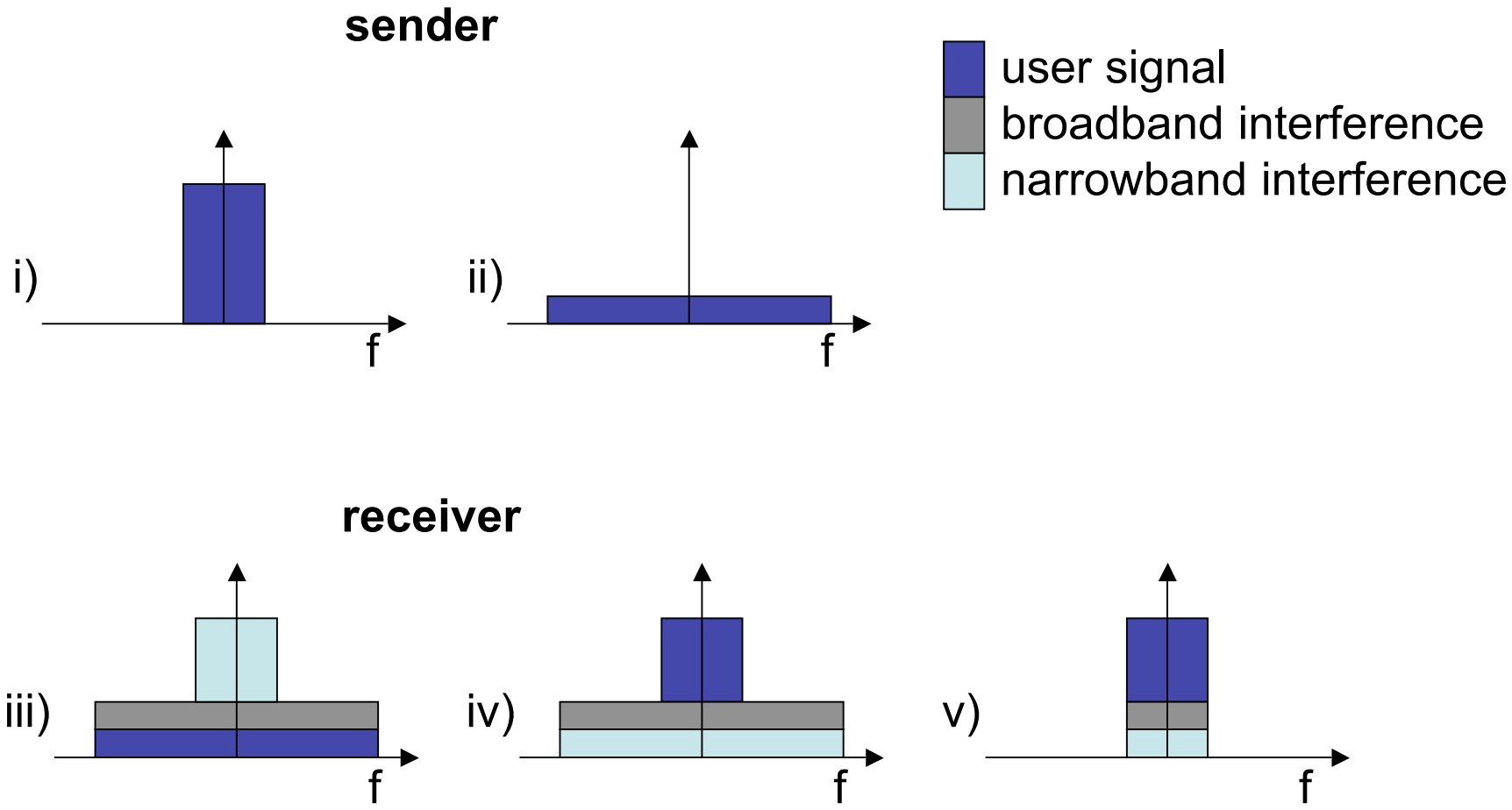
- Each bit in original signal represented by multiple bits in transmitted signal
- Spreading done by XOR of user data with a "chipping sequence"

- Spread signal bandwidth proportional to length of chipping sequence
- Typically uses (B)PSK



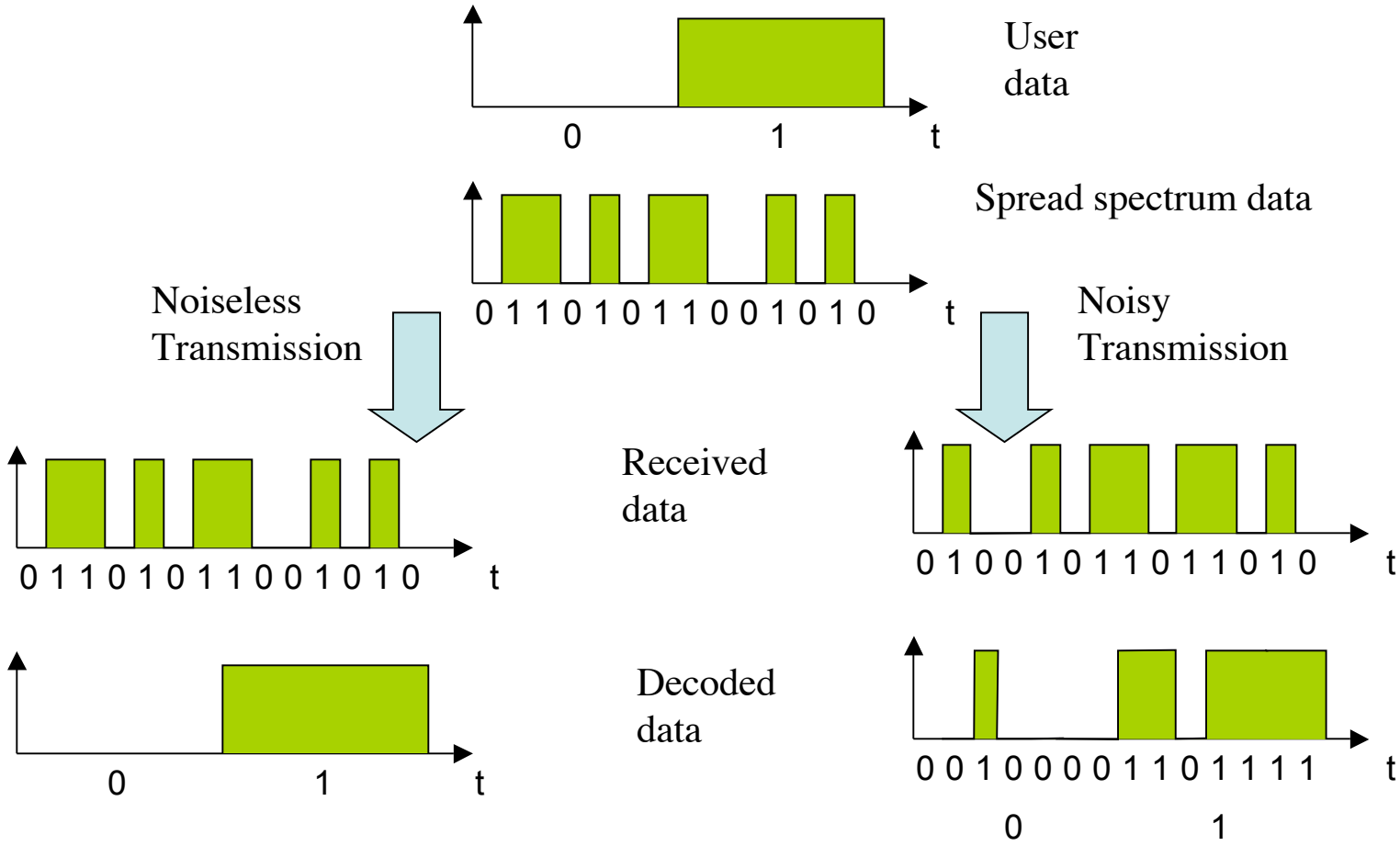
Direct Sequence Spread Spectrum II

Effects of spreading and interference



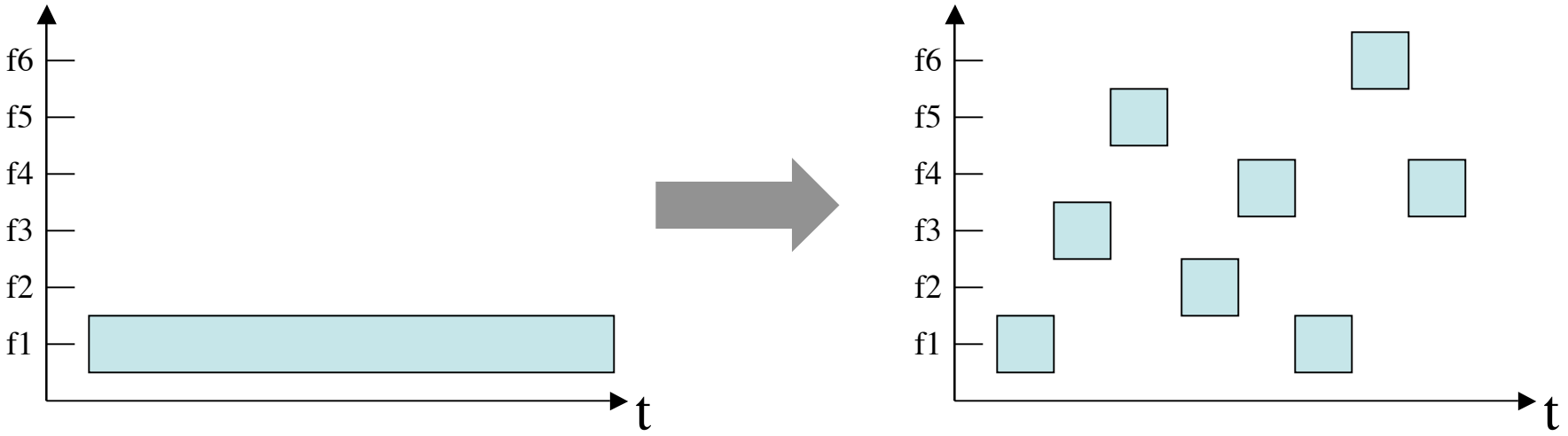
Direct Sequence Spread Spectrum III

Noisy signal reception



Frequency Hopping Spread Spectrum

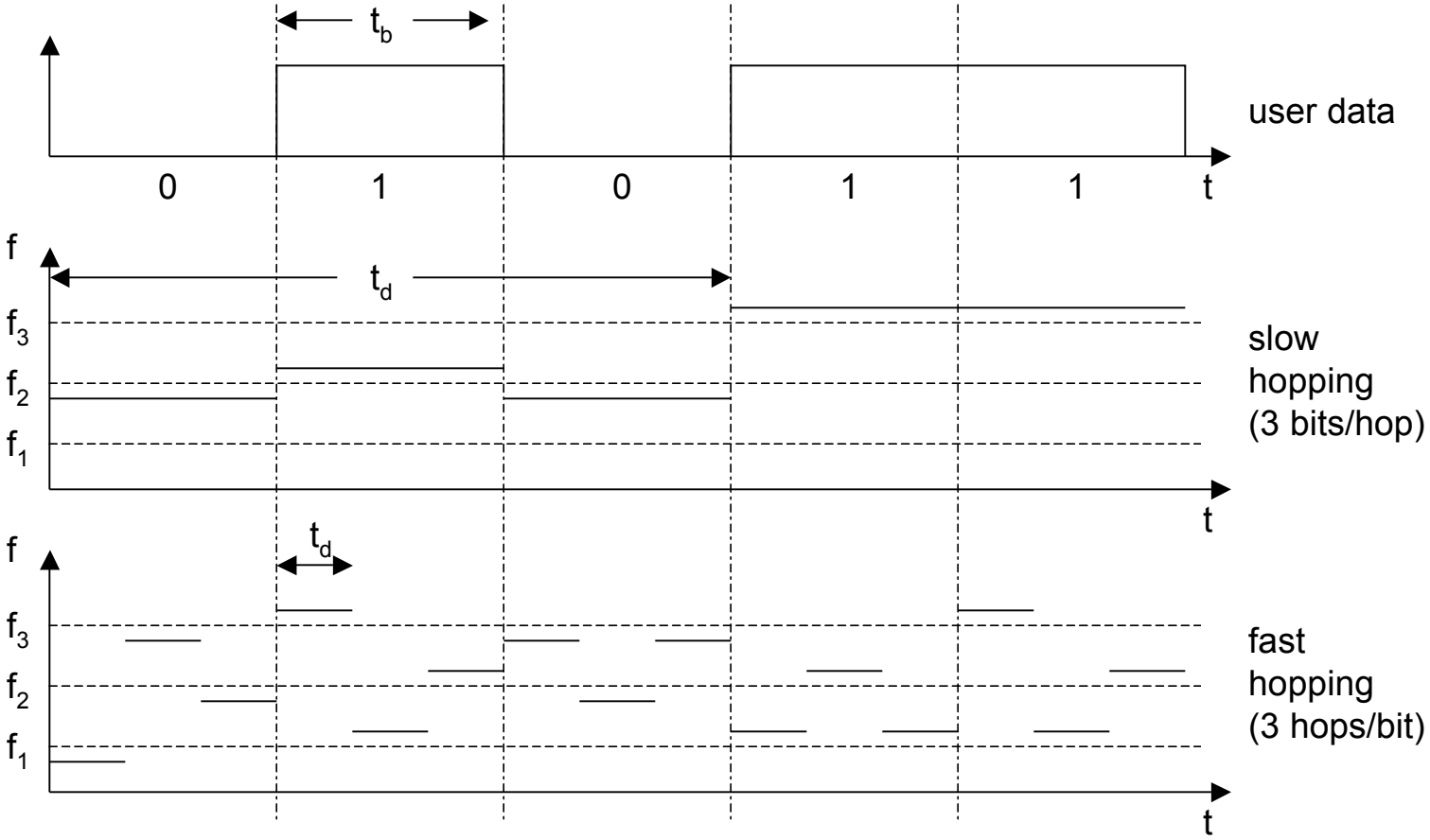
- Signal transmitted over randomised series of frequencies, hopping between frequencies at fixed intervals
- Receiver hops between listening frequencies in sync with the sender
- Uses FSK



Frequency Hopping Spread Spectrum II

- Advantages
  - Frequency selective fading and interference limited to short periods
  - Simple Implementation
  - Uses only small portion of spectrum at any time
  - Tap-resistant
- Disadvantages
  - Not as robust as DSSS
  - Simpler to detect than DSSS
- Two versions
  - Slow Hopping: several bits per frequency
  - Fast Hopping: several frequencies per bit
    - More resistant to noise or jamming, more complex

Frequency Hopping Spread Spectrum III



t_b: bit period t_d: dwell time

FHSS and DSSS comparison

	FHSS	DSSS
Bandwidth	Depends on tuning range	Relative to the chip rate
Synchronisation / timing	Not critical, slow hop rates	Crucial with small chip duration
Spectrum	Narrow, changed frequently	Very wide all the time
Multipath diversity	Freq. diversity in fast hopping	Short chips result in time diversity

Generation of spreading sequence

- The spreading sequence or code is chosen so that the final signal is noiselike
- Ideal spreading sequence is a random sequence, impractical due to lack of shared info
- Two categories of spreading sequences
  - Pseudo-noise (PN) sequences
    - Periodic binary sequence that appears random
    - Not statistically random, but very difficult to predict
    - Used for FHSS and DSSS without CDMA
  - Orthogonal codes
    - Zero cross-correlation, but requires synchronisation
    - Useful for CDMA
- Multiple spreading: use orthogonal codes to separate users on same cell, PN to lower correlation between cells