strato 2
Data link

- FEC
- ARQ
- Accesso multiplo ⇐

METODI DI ACCESSO MULTIPLO

Tecniche per condividere nel modo più efficiente possibile una risorsa comune

↑ canale di trasmissione

Accesso:

- deterministico: utilizzo risorsa determinato a priori
- controllato: l'utente chiede il turno e poi usa la risorsa in modo esclusivo finché ha il turno
- casuale: accesso indipendente da quello degli altri.

Parametri caratteristici

- Throughput S: in una sezione della rete S è il rapporto fra $\frac{\text{bit corretti}}{\text{sec.}}$ e $\frac{\text{bit}}{\text{sec.}}$

↑ vel. trasm. riferita ai soli bit corretti

↑ vel. trasm.

Nei casi da noi considerati $S = \rho$

- Traffico offerto G : in una sezione della rete è il rapporto numero medio bit/s che un terminale prova a trasmetter e la la velocità di trasmissione

- Tempo di accesso t_{ACC} : tempo medio fra l'arrivo di un pkt ad una stazione e la corretta ricezione al destinatario.

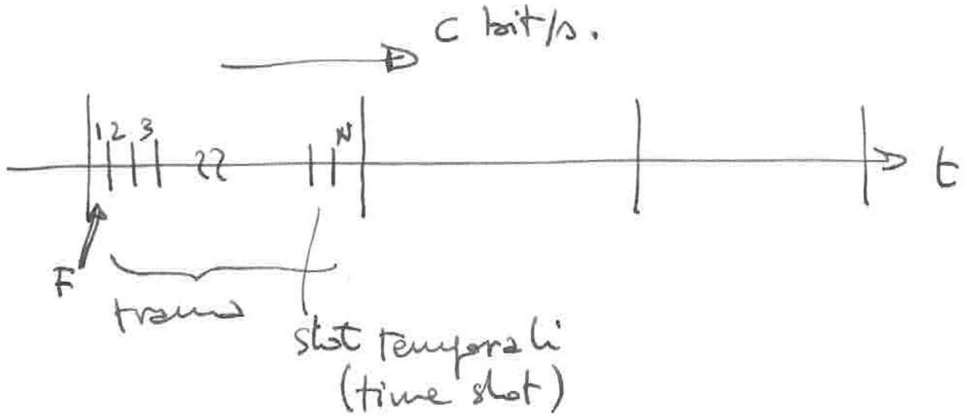
Assunzioni

- canale con prob. di errore trascurabile
- N staz. che vogliono accedere alla risorsa condivisa
- C bit/s. velocità di trasm. (incluse eventuali ritrasm.)
- distrib. tempi interarrivo pkt poissoniana, arrival rate λ pkt/s. su singola stazione
- lungh. pkt F (anche aleatoria)

ACCESSO DETERMINISTICO

canali ortogonali

Time division multiple access (TDMA)



$\frac{C}{N}$ bit/s. per stazione

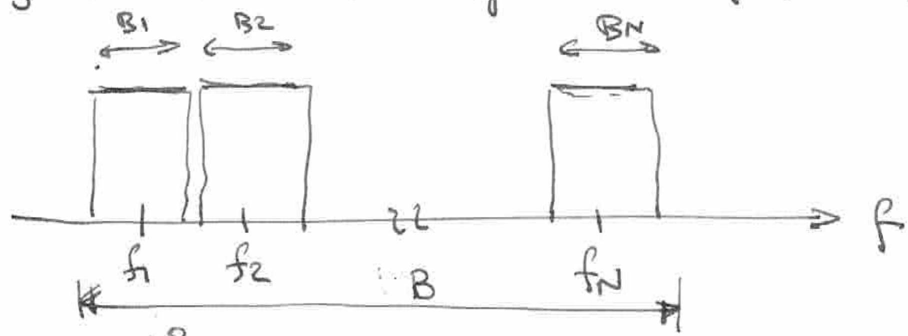
F bit/pkt

$$\mu = \frac{C}{N F} \quad \left[\frac{pkt}{s.}\right]$$

tasso di servizio

servizio ⟷ trasmissione

Frequency division multiple access (FDMA)



$B_i = \frac{B}{N}$

$C \propto B$

vel. per ogni staz. $\propto \frac{C}{N}$ $\frac{bit}{s.}$ per staz.

$$\mu = \frac{C}{N F} \quad \left[\frac{pkt}{s.}\right]$$

parametri caratt. $S = f$, t_{acc}

Esistono tecniche ibride a divisione di tempo e frequenza.

Throughput $\boxed{S = \rho = \frac{\lambda}{\mu} = \lambda \frac{NF}{C}}$ per TDMA e FDMA

$$t_{ACC}^{(TDMA)} = W_q + W_{SLOT} + t_x|_c + \tau_p$$

tempo di acc. medio; attesa in coda; attesa slot; servizio condiz. alla piena disp. del canale; ritardo propagazione

$$t_x|_c = \frac{F}{C}$$

M/D/1 (sottocaso M/G/1)

$$W_q = E\{t_q\} = \frac{\lambda E\{t_x^2\}}{2(1-\rho)} = \frac{\lambda N^2 F^2}{2C^2(1-\rho)} = \frac{S}{1-S}\frac{NF}{2C}$$

$t_x = \frac{NF}{C}$ $\qquad$ $S = \rho = \frac{\lambda NF}{C}$

$$W_{SLOT} = \frac{NF}{2C}$$

$$t_{ACC}^{(TDMA)} = \frac{S}{1-S}\frac{NF}{2C} + \frac{NF}{2C} + \frac{F}{C} + \tau_p$$

$\frac{\tau_p}{t_F} = \alpha$

$t_F = \frac{F}{C}$

$$\boxed{t_{ACC}^{(TDMA)} = \frac{F}{C}\left[\frac{S}{1-S}\frac{N}{2} + \frac{N}{2} + 1 + \alpha\right]}$$

lungh. pkt; vel. trasm; throughput; staz.; ritardo di propag.

FDMA

tempo servizio sempre $t_x = \frac{NF}{C}$

non ho slot

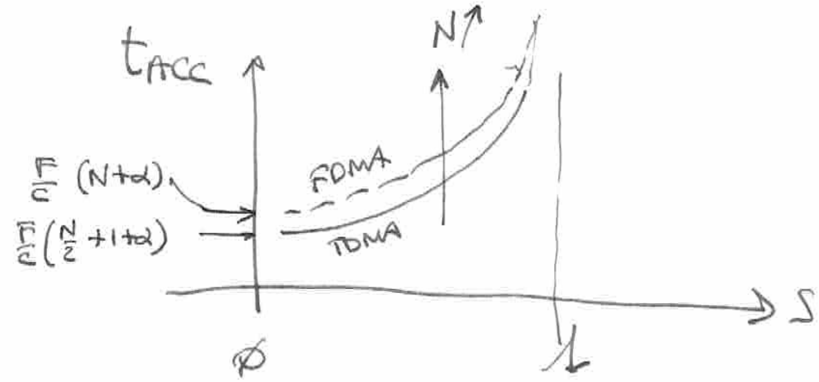
$$t_{ACC}^{(FDMA)} = W_q + t_x + \tau_p$$

$$= \frac{S}{1-S}\frac{NF}{2C} + \frac{NF}{C} + \tau_p$$

$$\Downarrow$$

$$t_{ACC}^{(FDMA)} = \frac{F}{C}\left[\frac{S}{1-S}\frac{N}{2} + N + \alpha\right]$$

$$t_{ACC}^{(TDMA)} = \frac{F}{C}\left[\frac{S}{1-S}\frac{N}{2} + \frac{N}{2} + 1 + \alpha\right]$$



- sia per TDMA che per FDMA $t_{ACC} \propto N$
- TDMA prestaz. migliori del FDMA ma, attenzione, nelle ipotesi fatte (traffico markoviano)

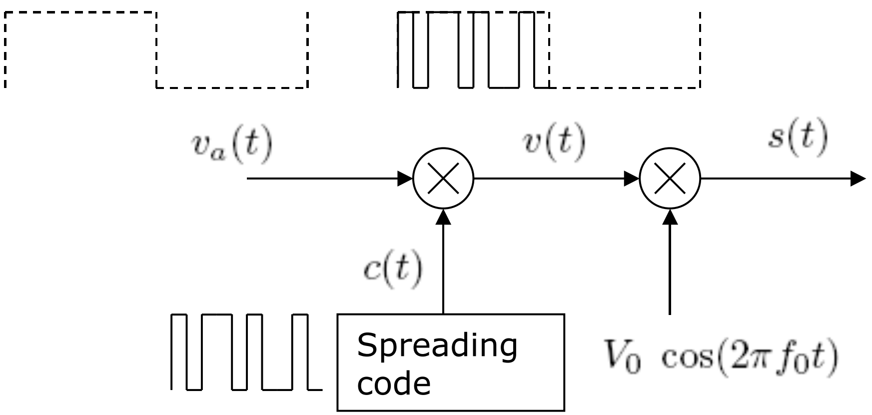
CDMA systems - 1

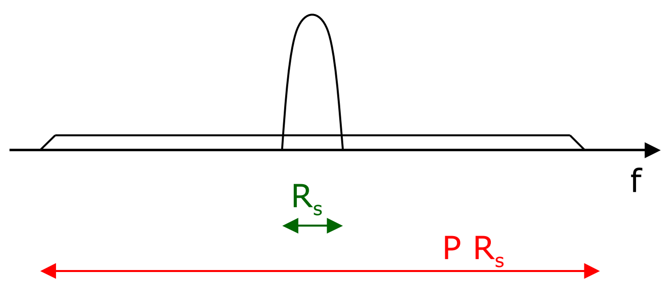
CDMA technique is used in 3G cellular systems, WLAN, GPS,…

Based on spread spectrum technique (e.g., direct sequence DS-CDMA or frequency hopping FH-CDMA)

DS-CDMA

Signal to be modulated is multiplied by a *spreading code sequence* of length P (spreading factor) composed by chip varying faster than transmitted symbols.

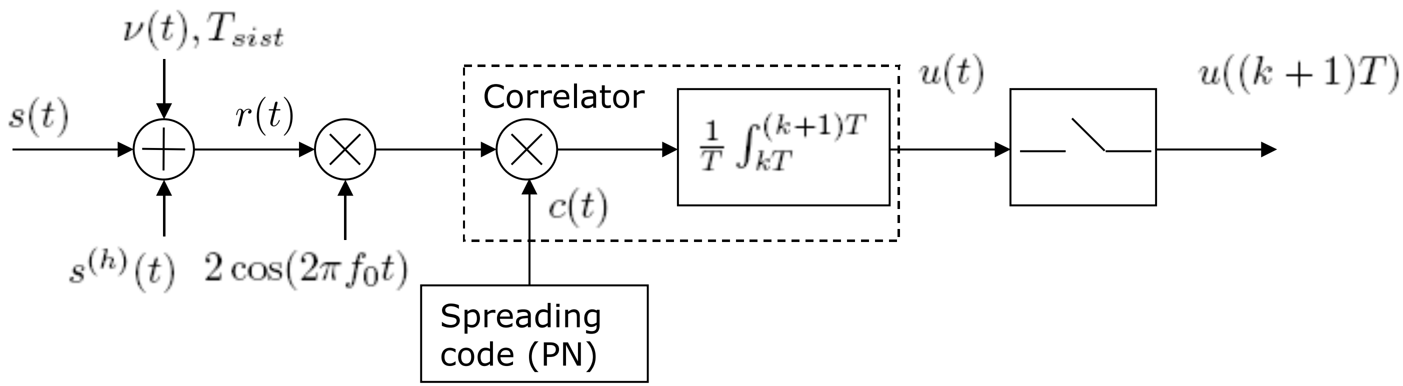




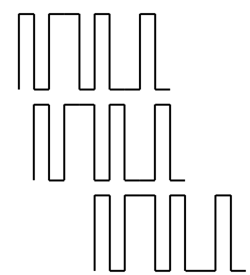
CDMA systems - 2

DS-CDMA receiver

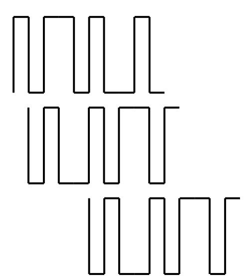
The performance depends on correlation properties of code sequences (assuming undistorted reception of transmitted signal)



Autocorrelation properties for synchronization (acquisition & tracking)



Crosscorrelation properties for interference rejection



Multiple access

Radio resources are shared by different users

Depending on resources utilization, used multiple access protocols can be

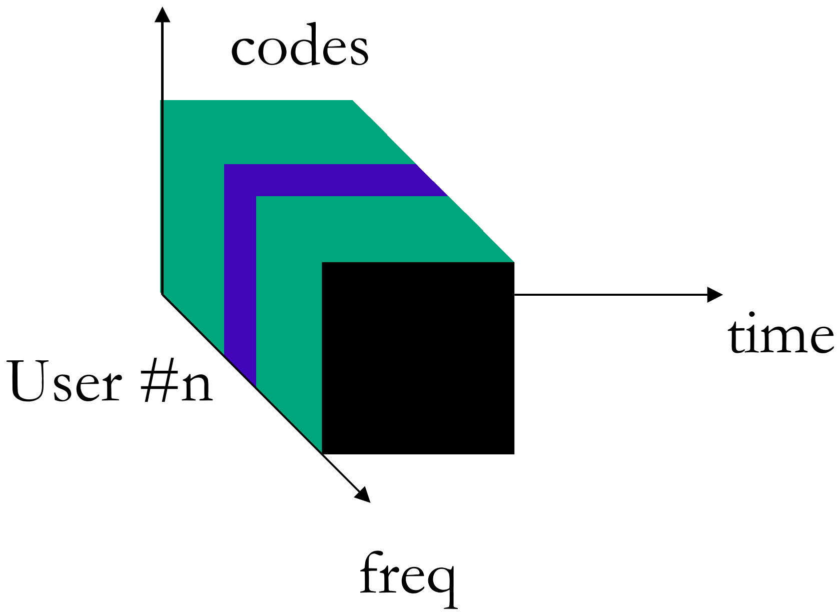
Random: wired (ethernet) and wireless (IEEE802.11) LAN (e.g., Aloha, CSMA)

Deterministic: cellular systems (e.g., FDMA, TDMA, CDMA and hybrid solutions)

The main service for cellular systems is to carry voice traffic → deterministic protocols

Frequency Division Multiple Access (FDMA)

Radio Users separated in frequency
Logical channel: carrier



Ex.: E-TACS

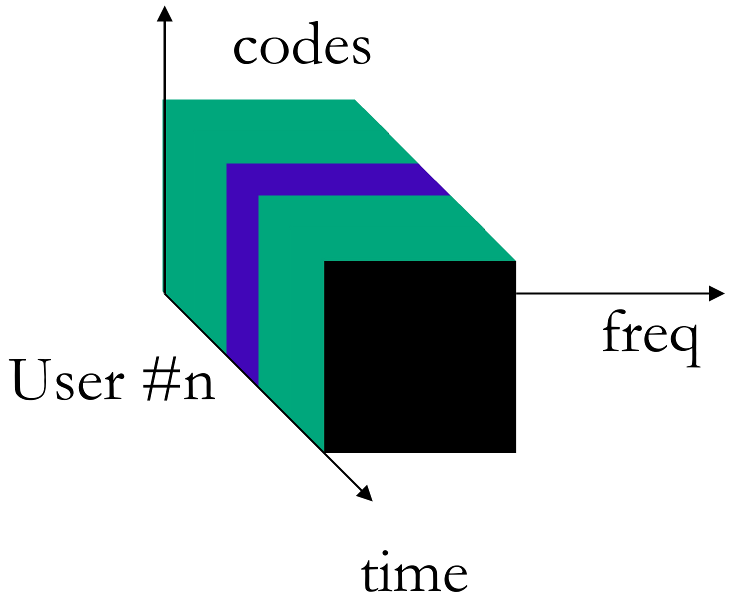
(-) Interference from adjacent channel due to the overlaying of the filters mask

(-) Different carriers tx from the BS ⇒ envelope of the total tx signal is not constant ⇒ distortion due to non-linearities (HPA)

(+) The noise equivalent bandwidth is ~ the overall bandwidth divided by the number of carriers ⇒ high SNR

Time Division Multiple Access (TDMA)

Users separated in time
Logical channel: time-slot
⇒ time framing



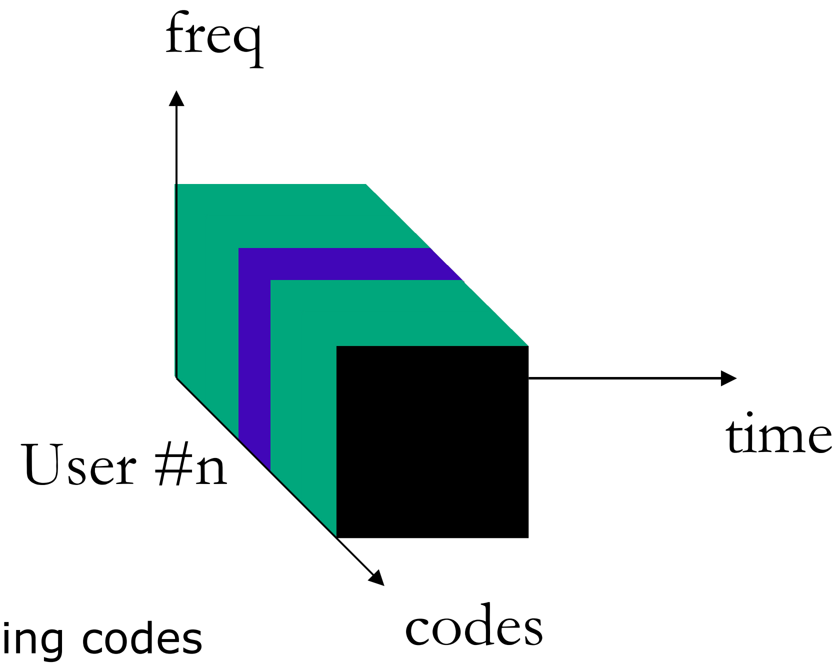
(-) synchronization

(-) each transmission require a rate N_T times the data rate necessary for each conversation, N_T being the number of time slots per frame

(+) only one modem for BTS that receive all channels and can estimate the channel for each communication

Code Division Multiple Access (CDMA)

Spread spectrum: signal is spread on a large band by using a code sequence independent on infos.



Users are separated by different spreading codes

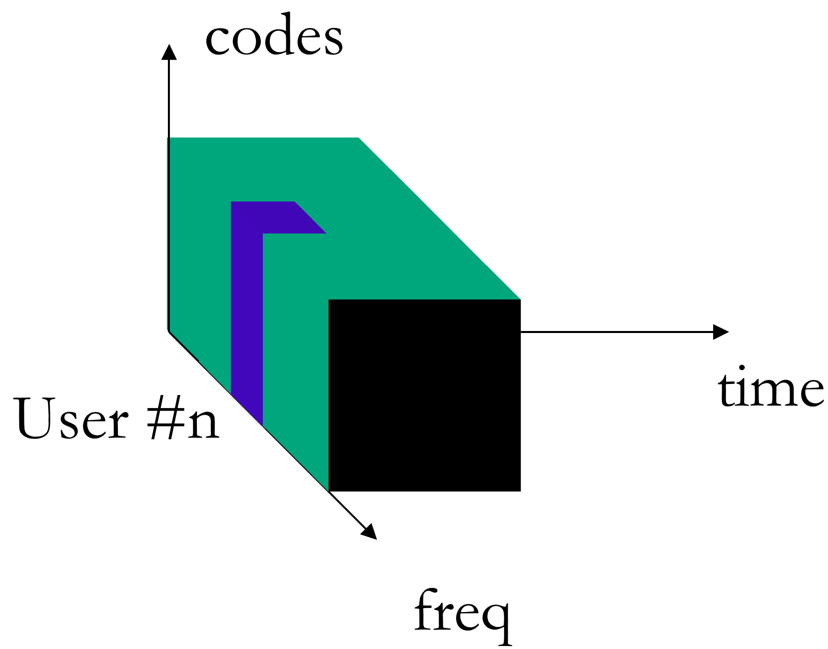
(-) near-far ⇒ accurate power control is mandatory
(+) robustness to interference and jamming
(+) more security for the conversation
(+) asynchronous access possible
(+) coexistence of different systems in the same band
(+) soft capacity

Interference rejection depends on auto and cross-correlation properties of the spreading sequences.

Hybrid: FTDMA

Logical channel:
a couple time slot - carrier frequency.

Ex.: GSM = 2,4,8,.. carriers
x 8 time slots per frame



Hybrid: TCDMA

Logical channel:
a couple time slot - spreading sequence.

Ex.: 3G WCDMA (TDD mode)