MULTIPLE ACCESS

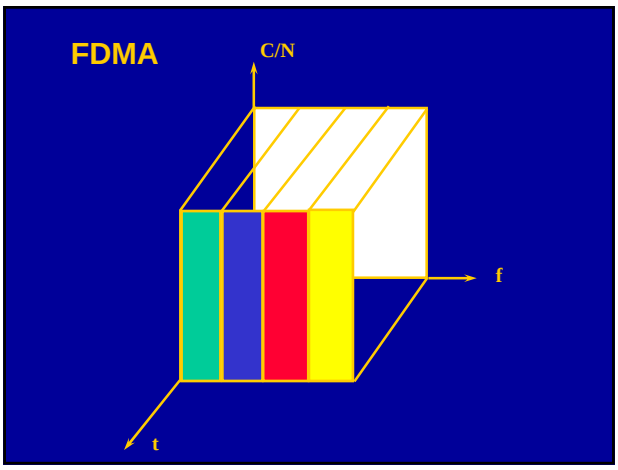
SHARING CAPACITY

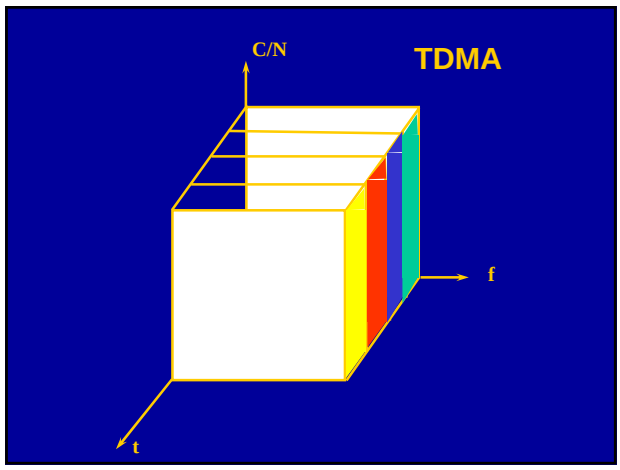
- in frequency: FDMA
  - frequency division multiple access
- in time: TDMA
  - time division multiple access
- in C/N ratio
  - code division multiple access
- in space: SDMA
  - space division multiple access

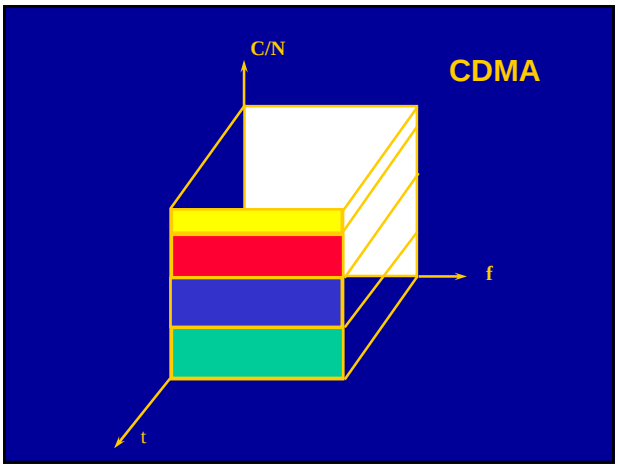
COMBINATIONS

- e.g. FDMA - TDMA:
  - multi-frequency TDMA
- TDMA-SDMA
  - satellite-switched TDMA (SS-TDMA)

SHANNON CUBE



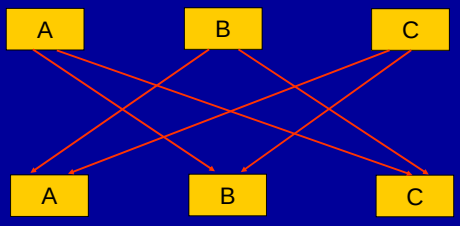




TECHNIQUES

- one carrier per station-to-station link
- one carrier per transmitting station

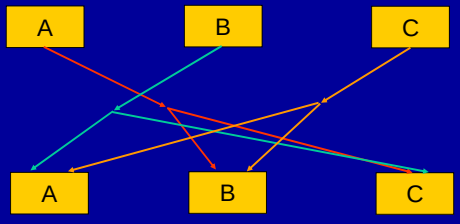
ONE CARRIER PER STATION-TO-STATION LINK



ONE CARRIER PER STATION-TO-STATION LINK

- N(N-1) carriers needed

ONE CARRIER PER TRANSMITTING STATION



ONE CARRIER PER TRANSMITTING STATION

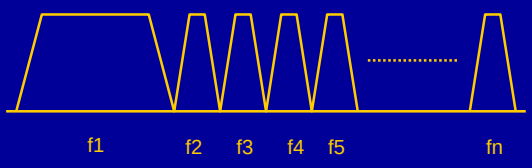
- Makes use of broadcast capability of satellite
- Number of channels = number of stations

FDMA

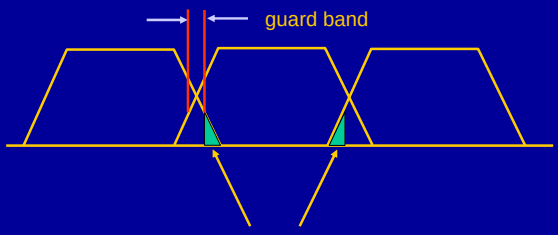
FDMA

- bandwidth divided in sub-bands on transponder
- each station can transmit simultaneously
- channels placed adjacent to each other
- guard bands between channels
- minimize adjacent channel interference

CHANNELS



ADJACENT CHANNEL INTERFERENCE (ACI)



GUARD BANDS

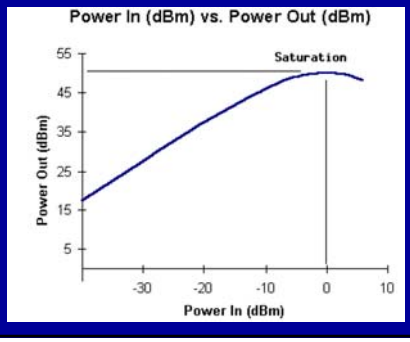
- If wide: easy filtering
- however: bandwidth-inefficient
- compromise

INTERMODULATION

- non-linear transfer characteristic of transponder
- multi-carrier transmission by earth station: HPA has non-linearities
- intermodulation products
- linear combinations of input frequencies

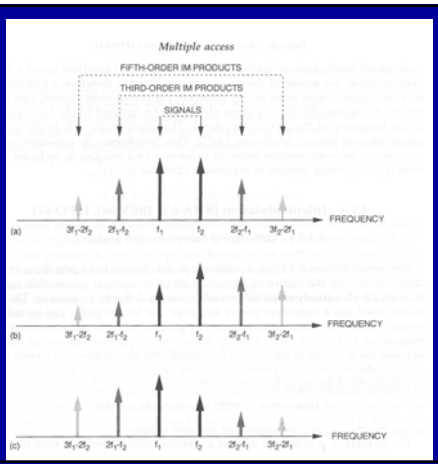
$$f_{IM} = m_1 f_1 + m_2 f_2 + m_3 f_3 + \cdots m_n f_n$$

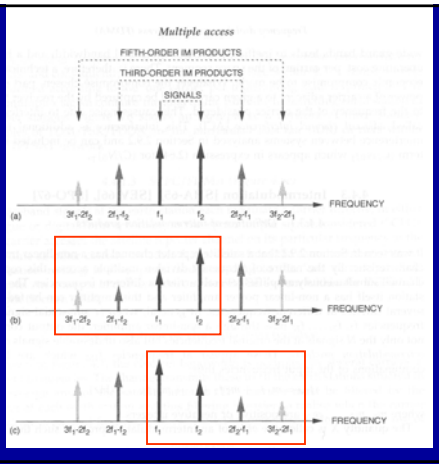
Typical Transfer Characteristic of a Transponder



INTERMODULATION

- if center frequency is large with respect to passband (transponder) only odd order products fall within passband.
- amplitude of intermod products decreases with order
- in practice: only products of order 3, lesser extent 5 are significant





CONCLUSION

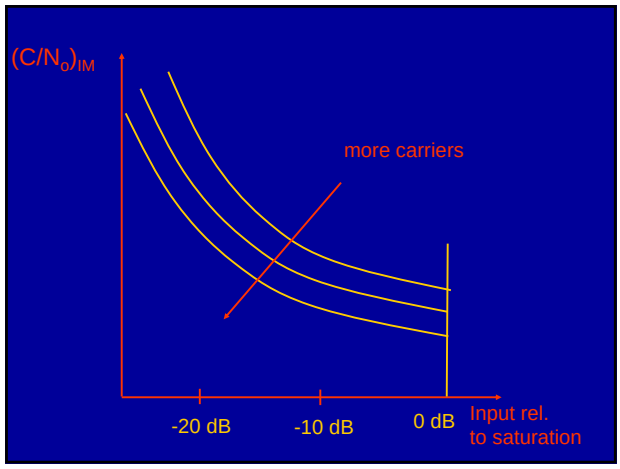
- put stronger signal at edges of usable spectrum
- stronger intermodulation products fall outside the transponder band

INTERMODULATION NOISE

- Carrier modulated: intermod. products are no longer spectral lines
- dispersed spectrum
- if larger number of carriers: superposition of intermod. products leads to constant spectral density over band -> like white noise

$(C/N_o)_{IM}$

- Depends on
  - transfer characteristics
  - number of carriers



C/N_o

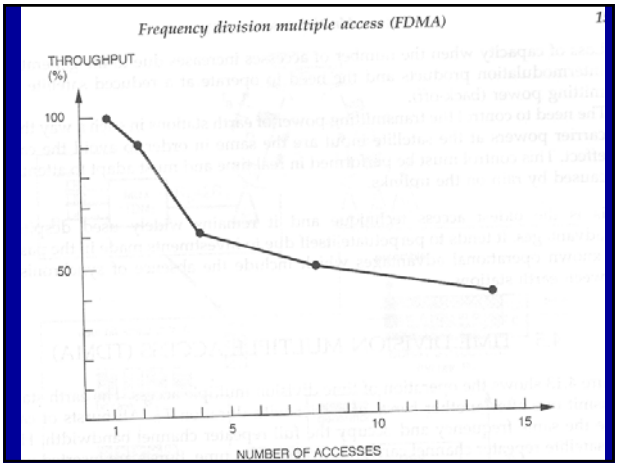
- Intermodulation noise is added:

$$(C/N_o)_{tot}^{-1} = (C/N_o)_u^{-1} + (C/N_o)_d^{-1} + (C/N_o)_I^{-1} + (C/N_o)_{IM}^{-1}$$

$$(C/N_o)_{IM}^{-1} = (C/N_o)_{IM,u}^{-1} + (C/N_o)_{IM,d}^{-1}$$

Overall Capacity

- total C/N_o always less than single-carrier operation
- C/N_o becomes less with higher number of carriers



SUMMARY FDMA (1)

- continuous access to satellite in given band
- lack of flexibility in case of reconfiguration (change of frequency plan, TX, RX frequencies, filter bandwidth)
- loss of capacity with higher number of accesses due to intermod. noise

SUMMARY FDMA (2)

- need to control TX power of each station to keep equal power at transponder (avoid capture effect)
- oldest technique, still in use
  - SCPC FDMA (single channel per carrier)
- simple