

## FADE MITIGATION

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## METHODS

- Uplink power control
- Site diversity
- Frequency diversity
- Variable transmission techniques

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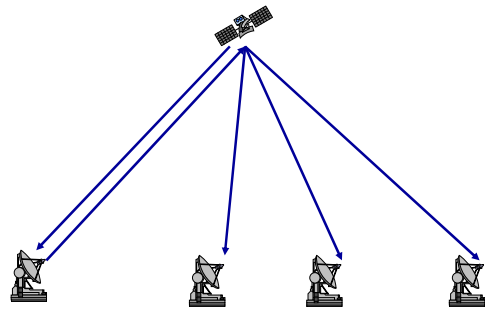
## UPLINK POWER CONTROL

- Compensation of fade by increasing the uplink power
- Sufficient power margin required
- Cases:
  - uplink fade
  - downlink fade
  - up - and downlink fade

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## BROADCAST SCENARIO

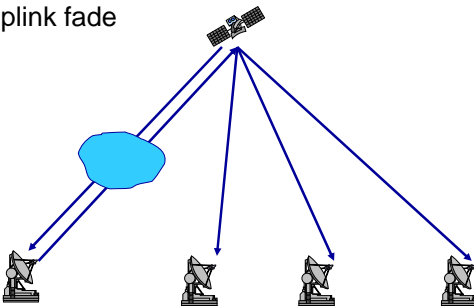


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## BROADCAST SCENARIO

- Uplink fade



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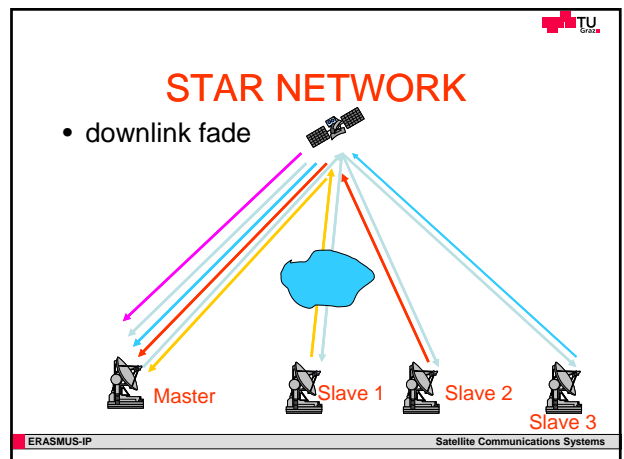
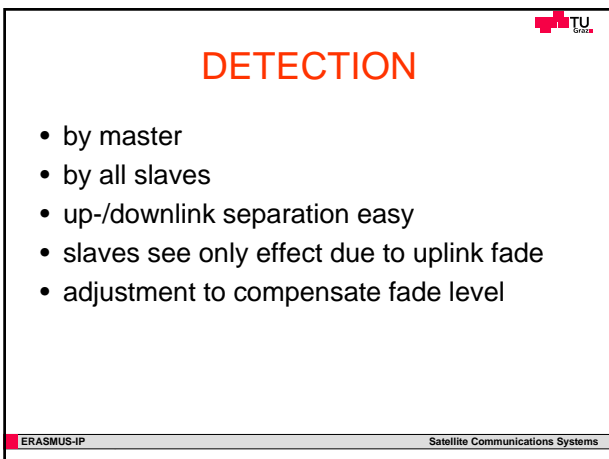
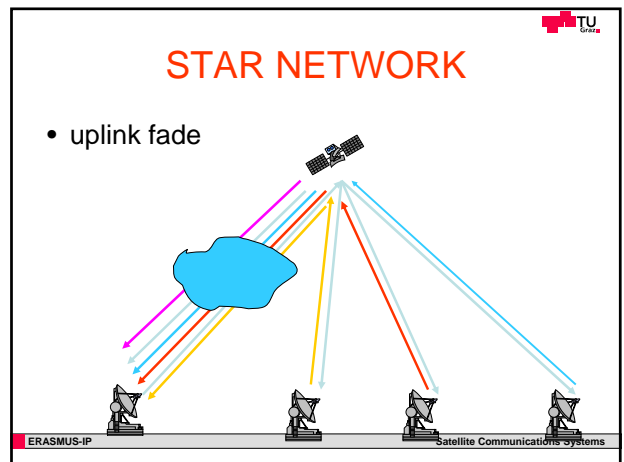
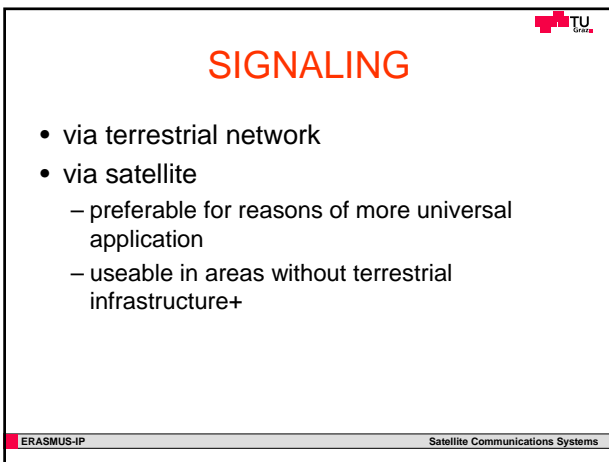
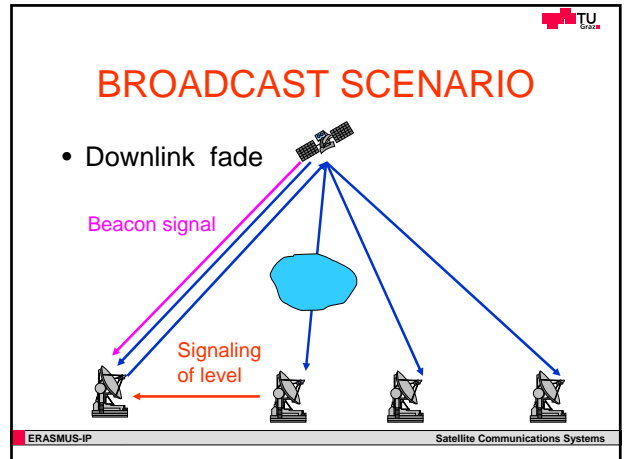
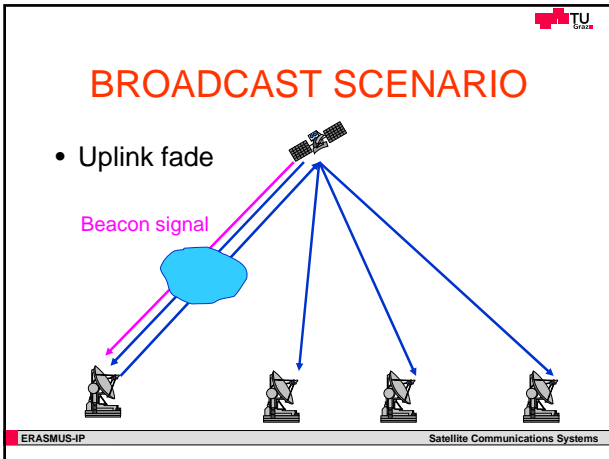
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## MASTER STATION

- Detects that own signal is weaker
- Separation of uplink and downlink contribution
  - by calculation
  - using additional beacon signal

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## ACTION

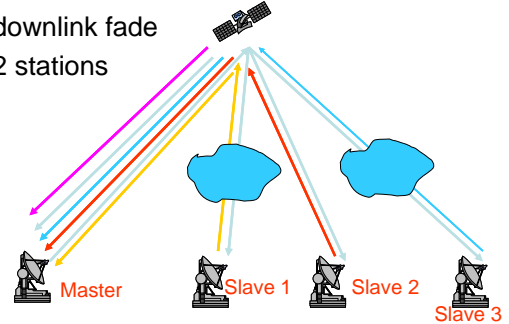
- slave 1 signals request for increase of power
- master adjusts power level accordingly
- master will notice lower level by Slave 1
- master requests increase of uplink power for Slave 1 to compensate local uplink fade

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## STAR NETWORK

- downlink fade
- 2 stations



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## ACTION

- slave 1 and 3 signal request for increase of power
- master adjusts power level accordingly to compensate worst case
- master will notice lower level by Slave 1 and 3
- master requests increase of uplink power for Slave 1 and 3 to compensate local uplink fades

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## LIMITATION

- in an FDMA system sum of power of all carriers at transponder input **MUST NOT** exceed the linear region of the transponder
- C/I level could be used as a control criterion

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## SITE DIVERSITY

- high attenuation only in small geographical areas
- 2 locations separated by 8 - 10 km: rain events statistically independent
- route traffic to less affected ground station

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## SITE DIVERSITY

- additional earth station(s) needed
- cost factor
- reliable links and proper synchronization between stations needed to route the traffic

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## FREQUENCY DIVERSITY

- lower frequencies less affected by rain than higher frequencies
- multi-band earth station or different dedicated earth stations for different frequency bands (Ka, Ku, C)
- route traffic to station which is least affected, satisfies QoS
- high cost!

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## ADAPTIVE TRANSMISSION

- Signal/noise ratio depends on bandwidth
- In case of fade reduce bandwidth
- Throughput decreases
- Lower priority traffic is put in queue until the fade event is over.

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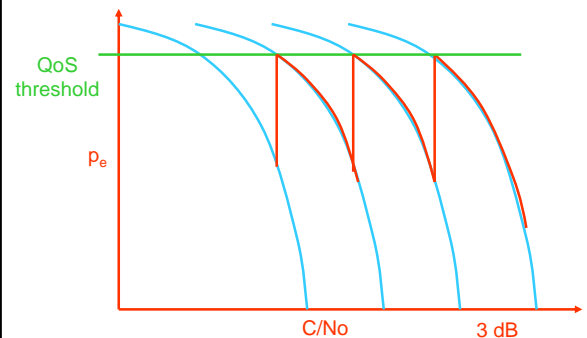
## ADAPTIVE TRANSMISSION RATE

- reducing the data rate by 1/2 improves signal/noise ratio by 3 dB
- change data rate when highest acceptable BER is reached

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## ADAPTIVE DATA RATE

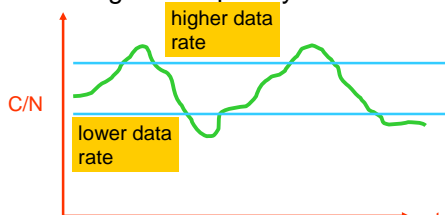


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## HYSTERESIS

- signal/noise ratio may vary quickly
- particularly at Ka-band
- avoid switching too frequently



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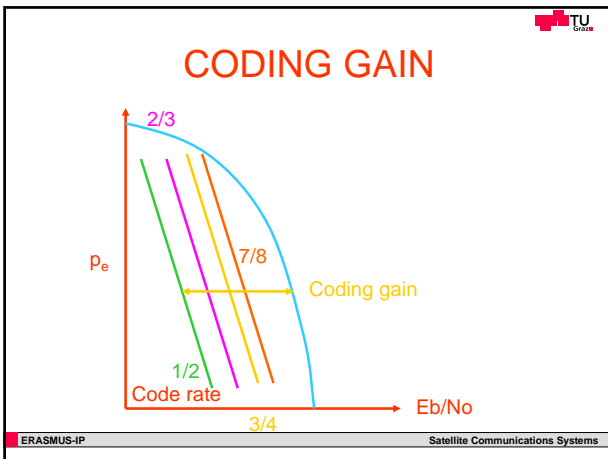
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## ADAPTIVE CODING

- Forward-error correction coding: coding gain depends on redundancy
- good channel conditions: less redundancy -> for given channel rate more throughput
- fading: more redundancy -> less throughput (or for constant throughput more bandwidth required)

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- ### COMBINATION
- adaptive data rates & adaptive coding
  - very powerful
  - not all combinations suitable
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- ### IMPLEMENTATION
- digital modems make data rate change easy
  - signal/noise ratio or BER must be known
  - some demod. algorithms allow estimation of signal quality
  - direct measurement
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- ### ADAPTIVE TRANSMISSION
- relatively cheap to implement
  - combination with uplink power control possible
  - very powerful fade mitigation system
  - important for Ka-band, where deep fade can happen
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