Space Technology

Satellite Communications:
propagation, measurements, the radio channel
2.

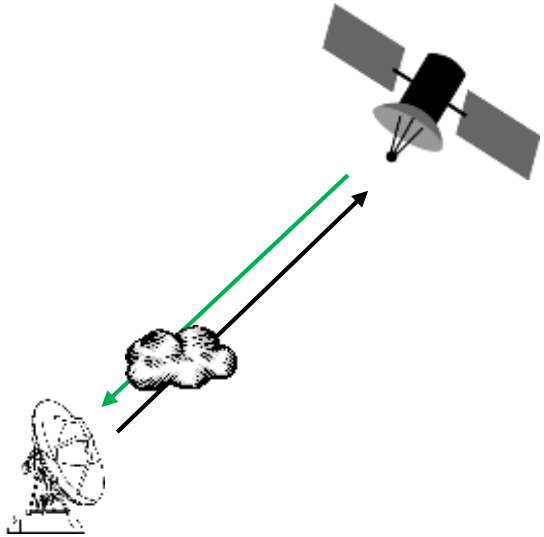
László Csurgai-Horváth

Department of Broadband Infocommunications
and Electromagnetic Theory

Budapest University of Technology and Economics

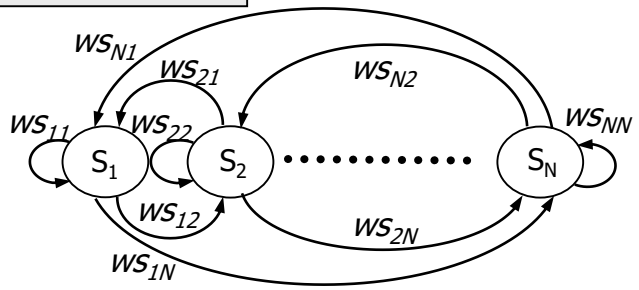
Fade mitigation techniques

- Increase the fade margin
- Adaptive transmit power control
- Adaptive modulation
- Source and channel coding
- Spread spectrum
  - Frequency hopping (FH)
  - Direct sequence (DS)
- Channel equalization (frequency selective fading)
- Diversity
- Cognitive radio

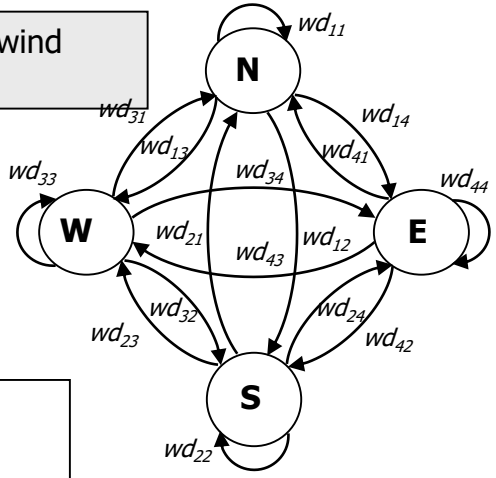


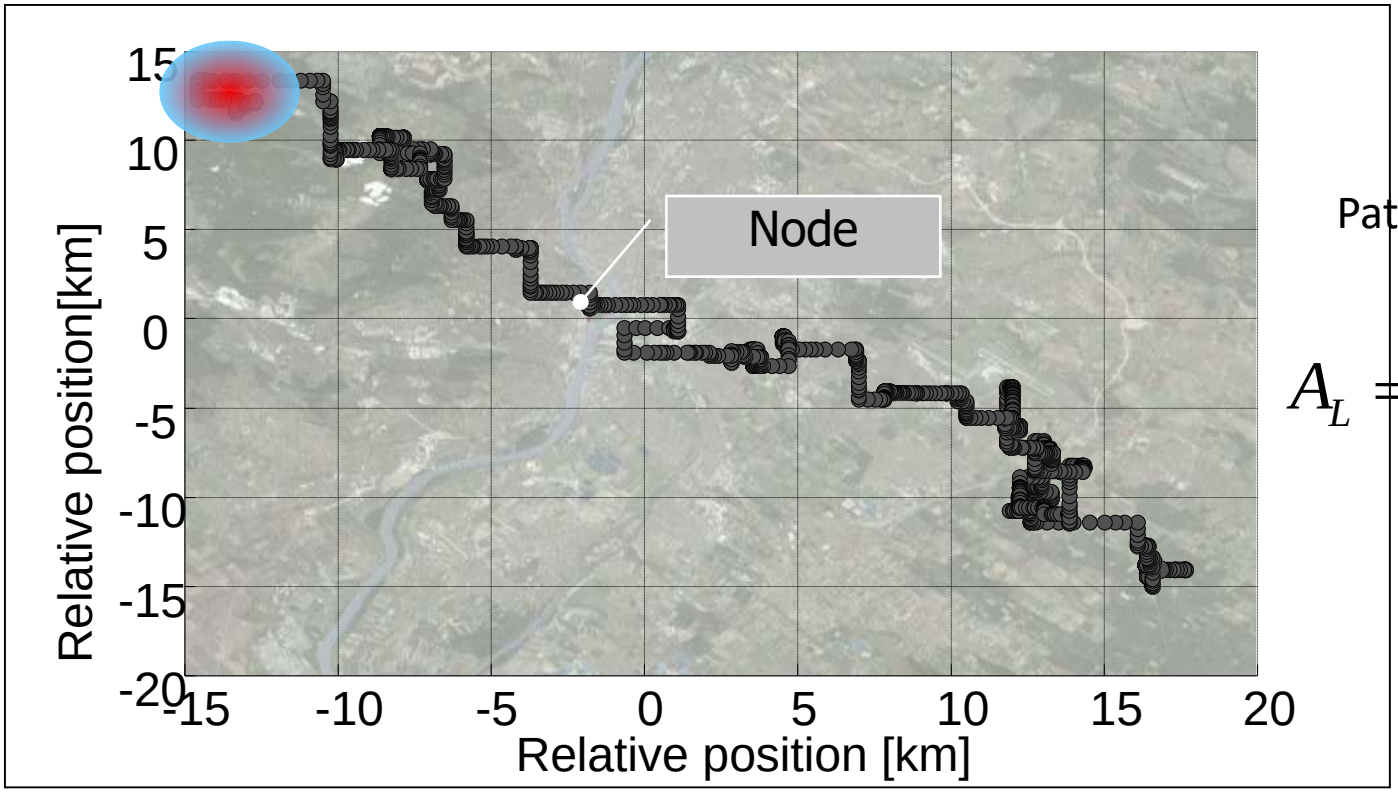
Time series generation

Markov model of wind speed:



Markov model of wind direction:





Path attenuation:

$$A_L = \int_0^L kR_n^{\alpha}(x_n, y_n)dl$$

Modulation

Analog modulations (e.g. FM/PM):

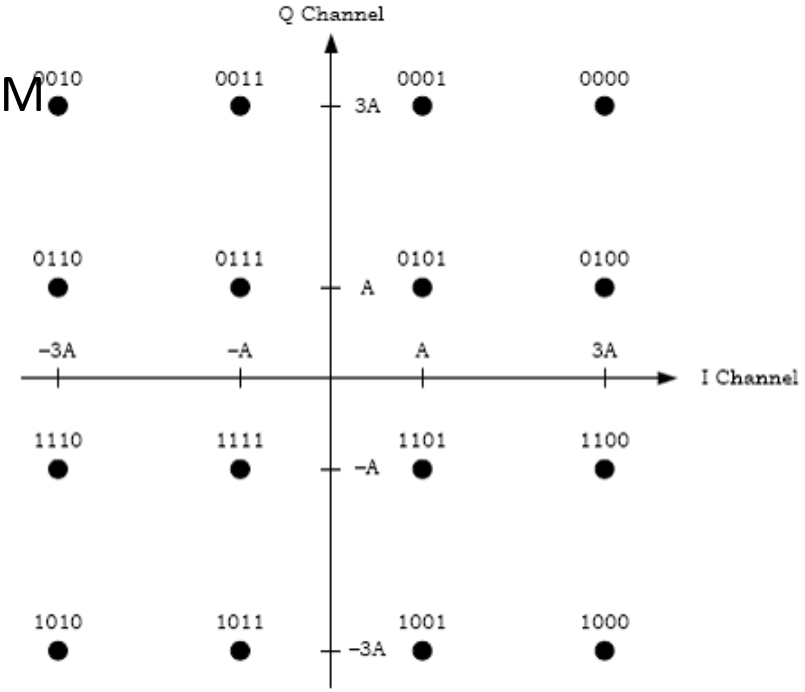
- For real-time analog measurement data transmisson (video, sounding rockets, etc.)

Digital modulations:

- Commonly used (e.g. PSK, FSK, QPSK, QAM)
- Various bit error probability

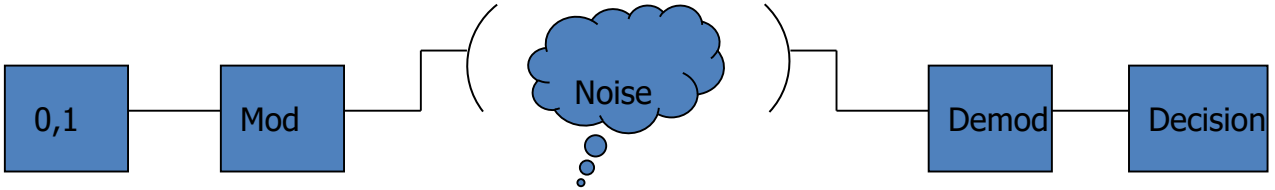
Digital representation of an analog signal: e.g. PCM

- Analog value -> quantization (sampling theorem)



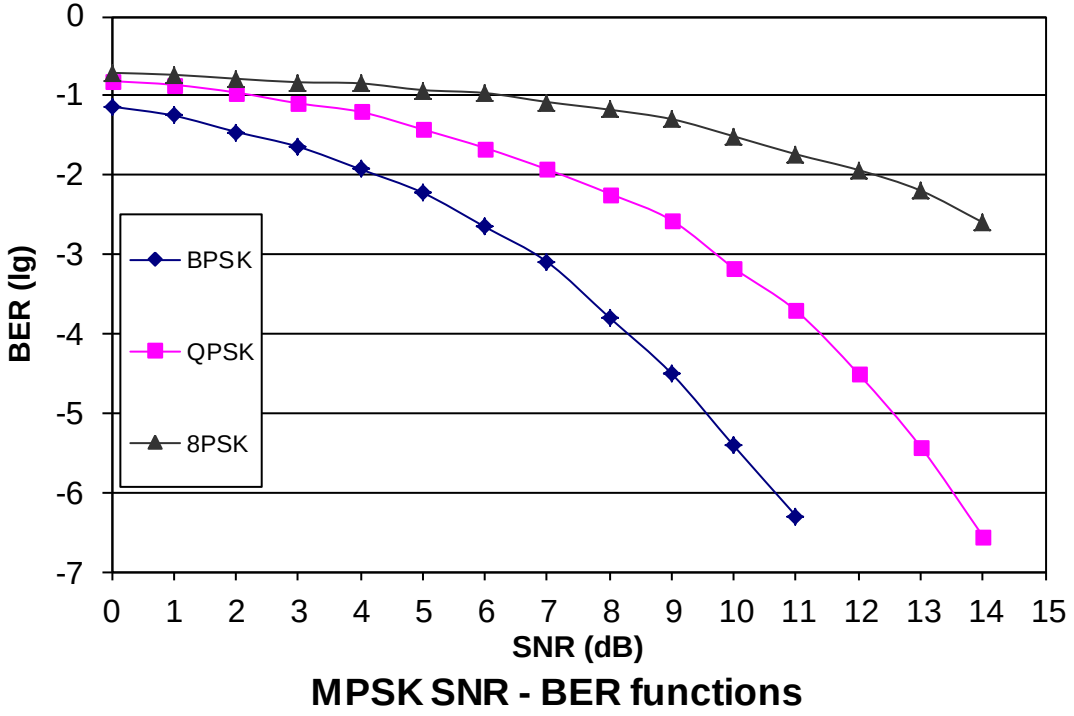
16QAM signal constellation

Effects of noise



Noise sources:

- Thermal
- Human generated
- Receiver noise



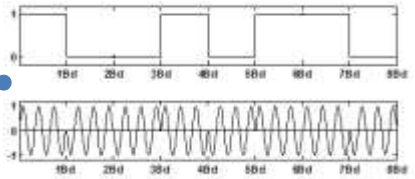
MPSK SNR - BER functions

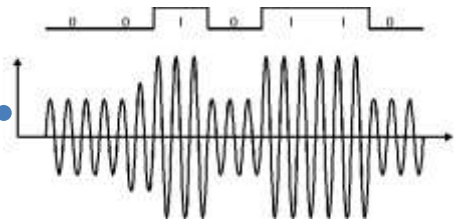
Shannon-Hartley equation(1948):
(AWGN)

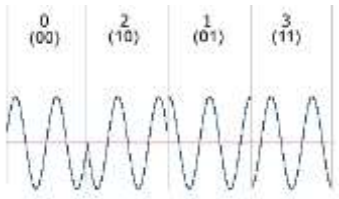
$$C_{[bit/s]} = B_{[Hz]} \log_2 \left(1 + \frac{S_{[W]}}{N_{[W]}} \right)$$

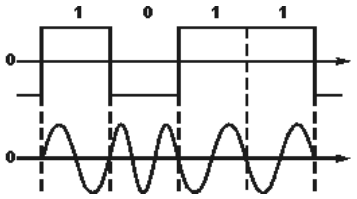
Digital modulations and spectral efficiency

Modulation	Spectral efficiency (bit/sec/Hz)
BPSK	0.59
BAM	1.02
QPSK	1.18
MSK	1.29
GMSK	1.45
QAM	2.04









Requirements and possibilities

Satellite radio communication:

the actual task

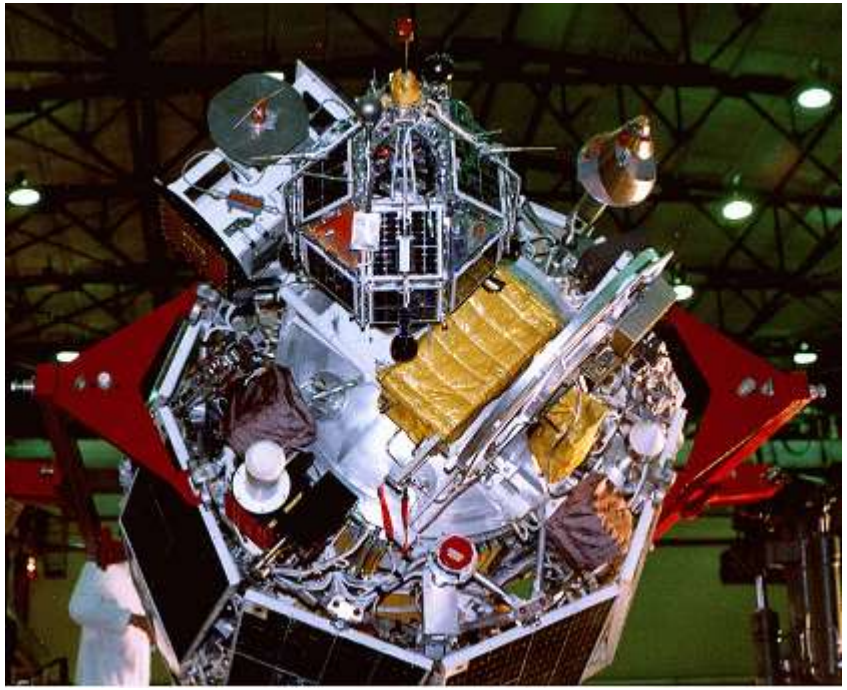
- boundary conditions
- technical possibilities

1. : Cubesat

Masat-1:

1 kg
LEO
437.345 MHz
100/400 mW
625/1250 bps
2-GFSK modulation

2. : Satellite for plasmaphysics



Intercosmos 24 (Active):

1570kg

LEO

460.4 MHz

2.5 W

10/20/40/80 kbps

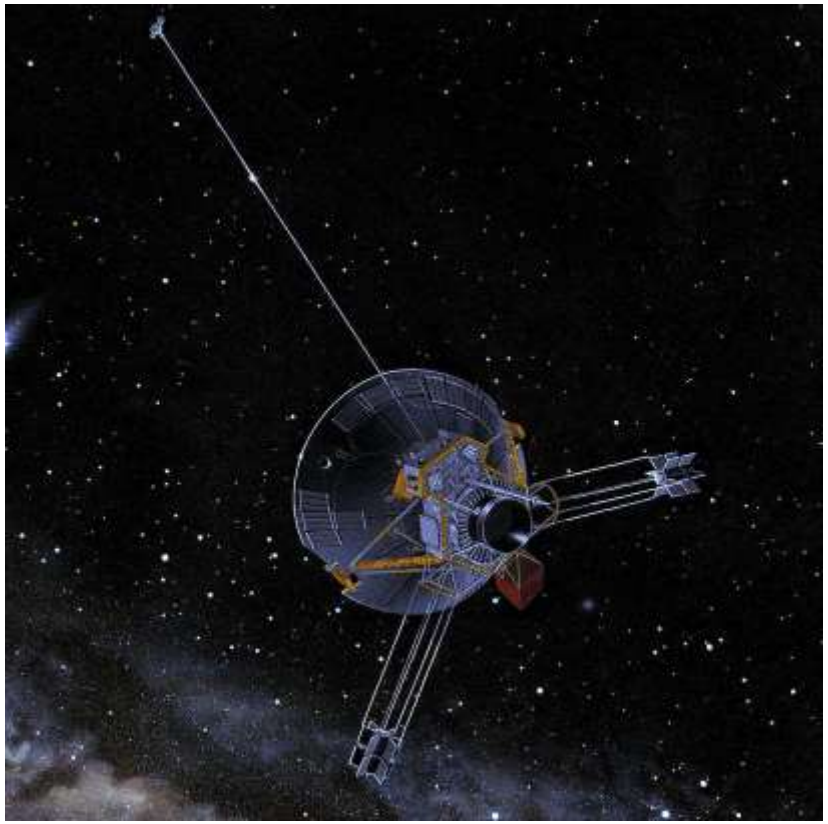
BPSK modulation

3. : Communications satellite

Astra 2F:

6000kg
geostationary
~10-13 GHz
13 KW onboard power
- digital TV channels (DVB-S)
- 20Mbps transponder (Ka band)

4. : Space sounder



Pioneer 10 (1972-2007):

258kg
interplanetary sounder
8 W
2110 MHz uplink
2292 MHz downlink
konvolution coder
256 bps initial data speed
End of life:
- distance>100.000AU
- received power<-180dBm
- SNR<0.5dB

4. : Mobile communications satellite (Alphasat)

Alphasat (2014-2029):

8100kg
BGAN (Broadband Global Area Network)
12-18 kW
Ø12m antenna
750 channel
400-500 beam
L-band(1.6 GHz)

Ka-band (ESA)

Q-band (ESA)

The future: terabit/s satellite communications

“State of the art” technology:

multiple narrow beams
frequency recycling
use of Ka band
100Gbps full capacity

How to increase capacity?

increased bandwidth
use of Q/V band
more narrow beams
optical communications

~ Year 2020

Review of Terabit/s Satellite, the Next Generation of HTS Systems (ASMS 2014)

Main topics / questions

- Methods to decrease fade effects
- Digitization, source coding, channel coding
- The role of modulation
- Noise, SNR and BER