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SIX DAYS • THREE CONFERENCES • ONE EXHIBITION
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Exhibition Opening Hours:
• Tuesday 8th September: 9.30 – 18.00
• Wednesday 9th September: 9:30 – 17.30
• Thursday 10th September: 9:30 – 16.30

Consumption, capacity and cost global optimization

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Special session System modeling and optimization

Outlook of presentation

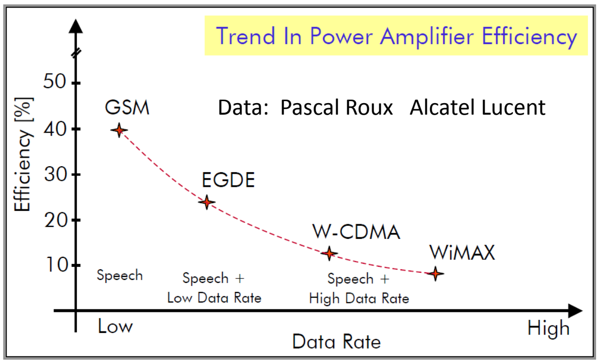
- Introduction
- C/(N+I) optimization
- Spectrum efficiency and capacity
- Cost versus power curves
- Global optimization
- Interference effect and mitigation
- Conclusion and further work

Introduction

- Since the 1970s satellite communication have been optimized principally for RF power or consumed power versus capacity
- On the other hand, ground communication have been optimized generally for cost versus capacity
- Both these approaches must be combined now in a global optimization

Efficiency of base stations

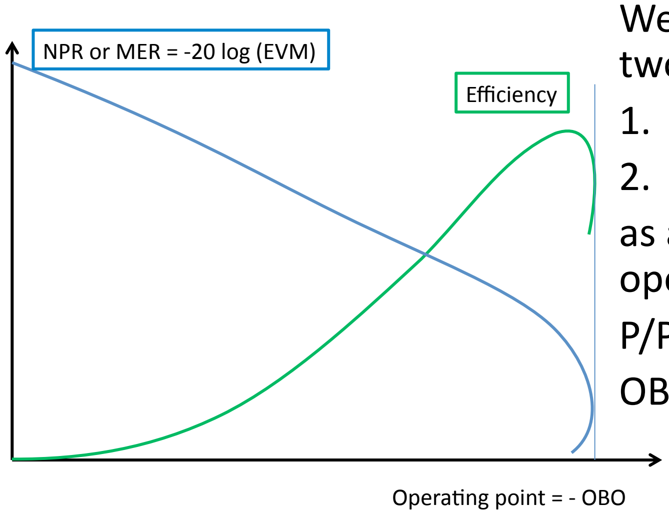
- Efficiency of telephony base stations is now a big problem



C/(N+I) optimization

- C/(N+I) optimization allows us to define the operating point and the lowest saturation RF output power necessary for a non-linear amplifier in a noisy communication channel
- It is most useful when the main limit is the maximum RF power permitted by a given technology (such as travelling wave tubes or solid state amplifiers)

Amplifier curves for optimization



We start from two curves:

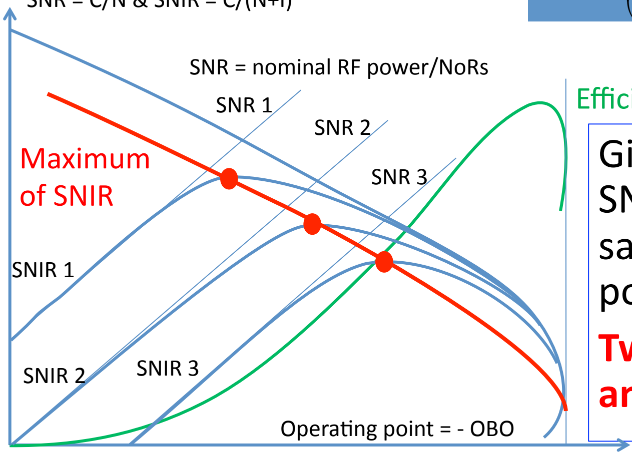
1. Efficiency
2. Linearity

as a function of operating point P/Psat or OBO = Psat/P

Adding channel noise

NPR or MER = -20 log EVM
SNR = C/N & SNIR = C/(N+I)

$$SNIR^{-1} = \left(\frac{C}{N+I}\right)^{-1} = \left(\frac{C}{N}\right)^{-1} + \left(\frac{C}{I}\right)^{-1}$$

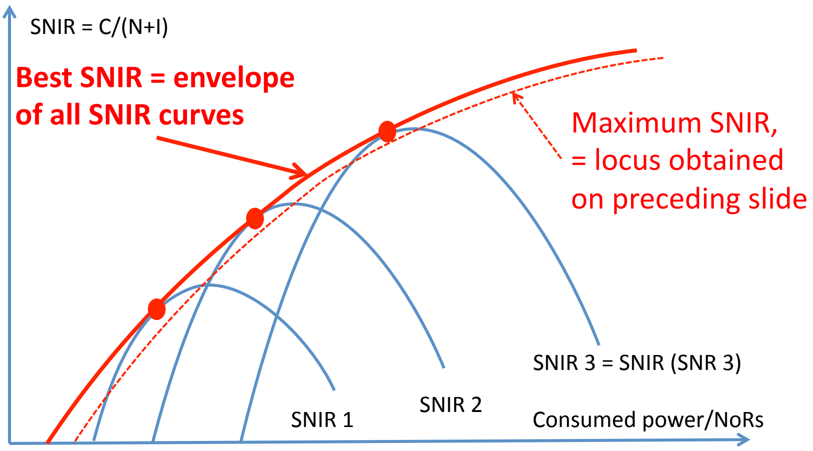


Gives the best SNIR for a given saturated RF power amplifier

Two curves per amplifier

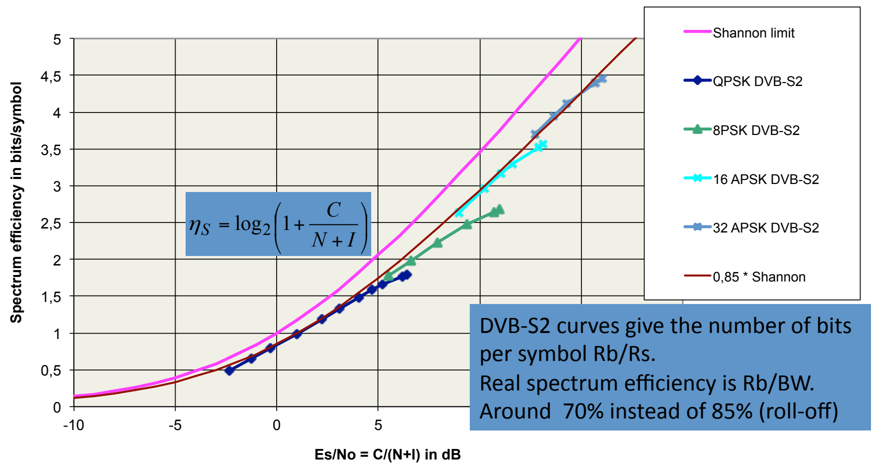
Combination of both curves

Using SNIR and efficiency curves, we draw SNIR versus consumed power curves (or SNIR versus dissipated power curves) .
Their envelope gives the optimum operating point, SNIR and power

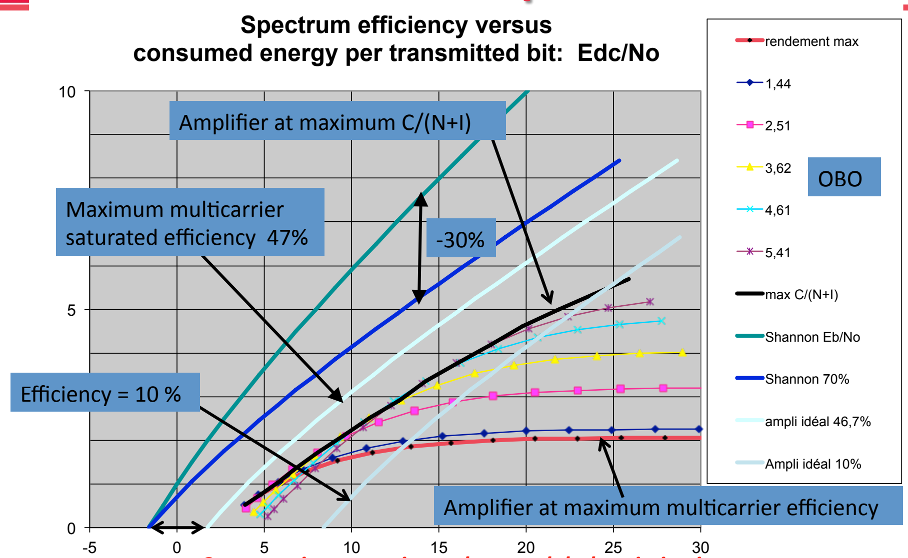


Spectrum efficiency

Shannon curve and DVB/S2 demodulator performance



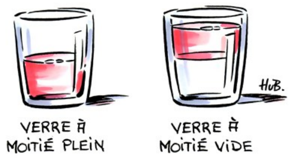
Combination of amplifier and demodulator performances



First synthesis on this merit curve

1. We are far (> 15 dB) from Shannon curve

2. There is a large margin for improvement



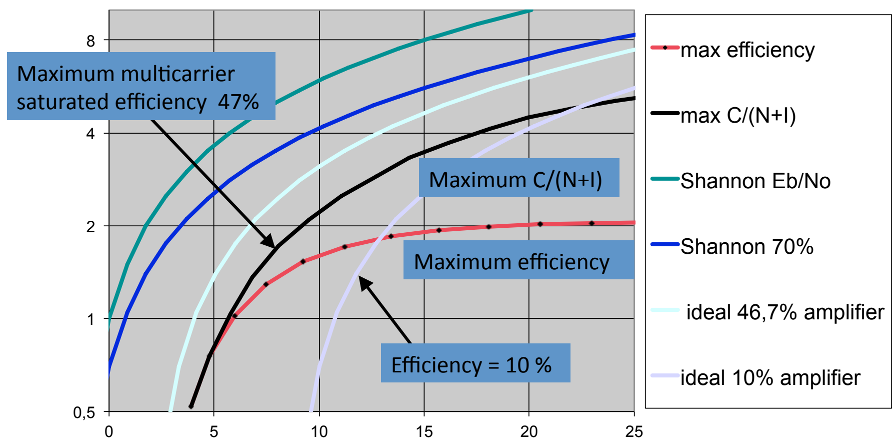
No significant improvement will be obtained by improving:

- Amplifiers technology only
- Linearizers technology only
- Signals, demodulators and error correction design only
- Equalizers technology only

- We must improve all the non linear chain (from transmission to reception) and the signals, modulation and demodulation

Same curves with log scale

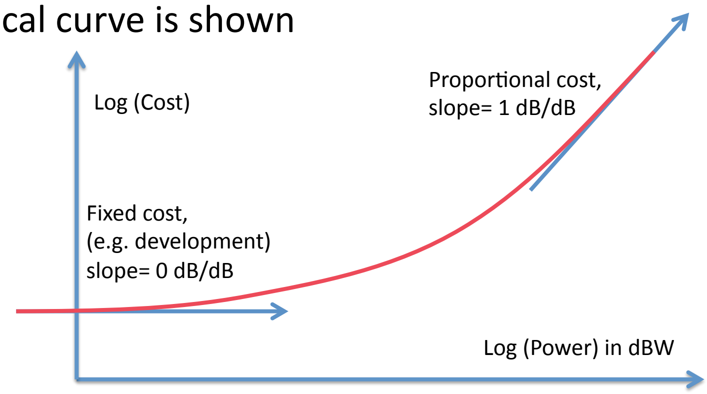
Spectrum efficiency (log scale) versus Edc/No



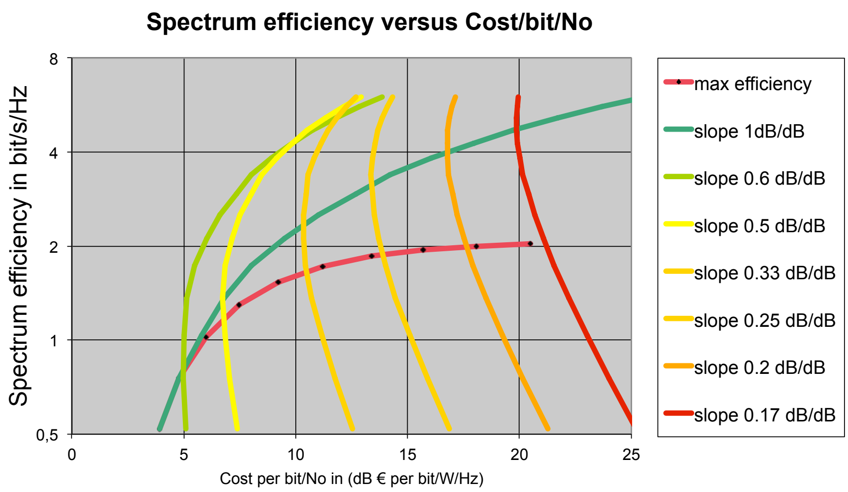
Cost versus power curves

We use only the log derivative of cost versus power (Rf or consumed) curves: slopes 0 to 1 dB/dB

A typical curve is shown



Global optimization



Multibeam and constellations

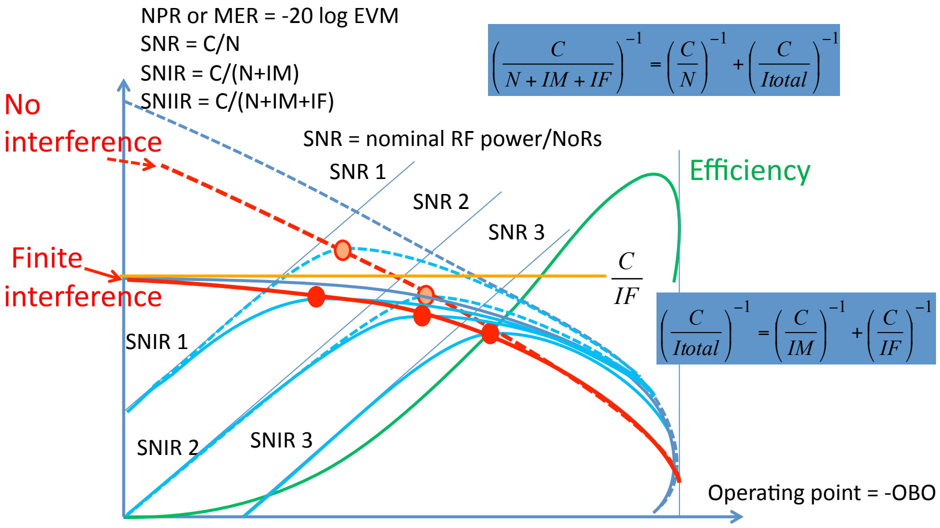
- How to increase system capacity when limited by transmitted bit cost increase ?

=> Duplicate the transmission:
  - Capacity doubles
  - Cost per transmitted bit stay the same
- Increase frequency bandwidth (if possible)
- Multibeam satellites
- Constellations of satellites
- Smaller cells: Microcells, nanocells, picocells

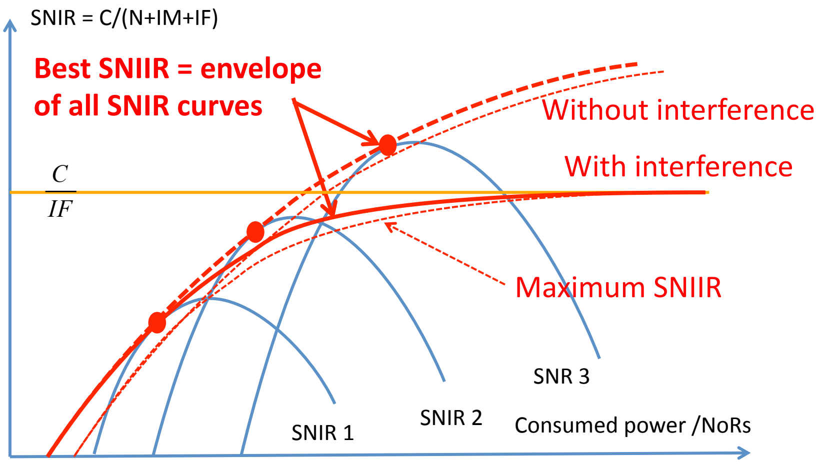
Interference effect

- The frequency spectrum is limited so all these duplicated transmission systems will use the same spectrum
- Interference will reduce the capacity of each transmission channel
- Interference can be taken into account in the C/(N+IM+IN) or SNIIR ratio
- Optimization with interference reduces again the spectral efficiency that can be achieved

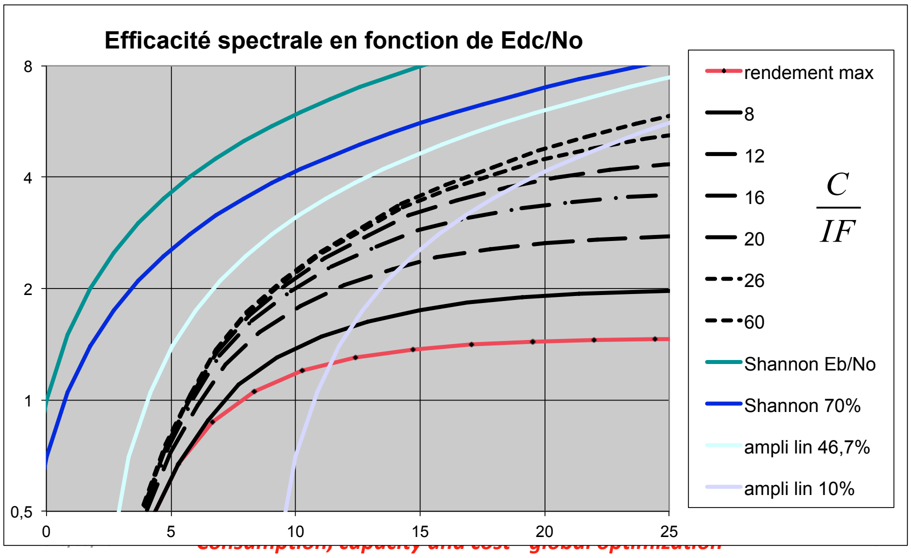
Minimization of RF power with interference



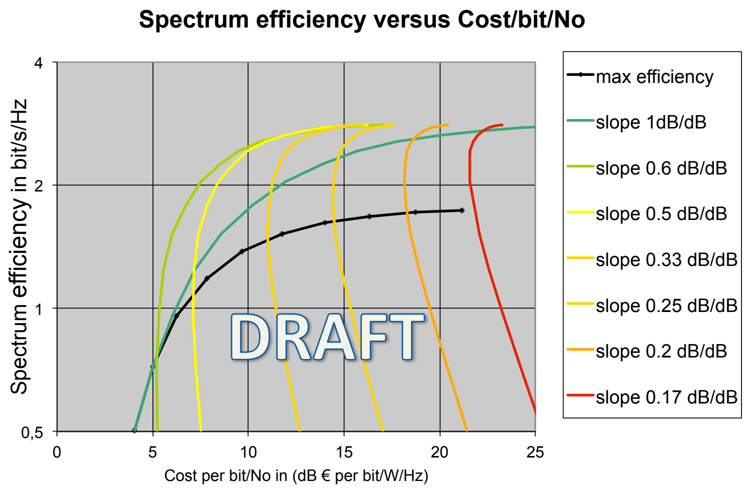
Minimization of consumed power with interference



Degradation of spectrum efficiency with interference level



Global optimization for 12 dB C/IF



Interference mitigation

- MIMO on return link and pre-coding on forward link are possible means to reduce the effect of interference
  - Complex data processing of all interfering transmission channels in a single base station or satellite gateway
- Cognitive radio
- Increase bandwidth at same frequency
- Use higher frequencies and wider bandwidth
- Do all of the above

or

- Increase the number of channels and use robust transmission signals with low spectrum efficiency

Conclusion

- Optimization of RF or consumed power for given capacity goes in the good direction
- The non linear signal transmission chain must be optimized globally
- There is an economic limit to the efficiency that can be used in a given channel
- To increase capacity, more transmission channels must be used in parallel
- Interference must be mitigated
- Data processing complexity and cost may limit the system capacity

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