Global ergodic capacity Closed-Form Expression of Coexisting DVB-LTE-Like Systems

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- Introduction

- Convergence between DVB & LTE

- System and signal model

- Global ergodic capacity

- Simulations

- Performance results & discussion

- Conclusions & Future works

- Major issue: spectrum congestion.

- Possibility to use the separated band or reuse the same band.

- Requisition of multimedia services: Internet, data sharing, TV, etc.

- Future broadcasting networks (DVB-NGH,…): necessary component of the future usage.

- Adaptive resource management : secondary and primary networks.

- Context of coexistence DVB(Digital Video Broadcasting) - LTE(Long Term Evolution).
    - adjacent frequency bands with same given territory.
    - same frequency bands with neighboring regions.
    - Monte Carlo simulation,...
    - Interested parameter: Protection distance.

- No recent works: ergodic capacity of full cross interfering links.

- Problem: LTE small cells into a DVB large cell.

- DVB and LTE interfere on each other.

- Useful for operators.

- Goal: Derive global ergodic capacity

  - Rayleigh fading links

  - evaluation of the global data rate of the DVB and LTE.

  - evaluation of the influence of system parameters (power, distance) on data rates.

System and signal model

Symbols	Notations
BCT	Broadcast transmitter
BCR	Broadcast receiver
BS	Base station
MS	Mobile Station
g	Channel coefficient between BCT-BCR (Rayleigh)
h_k	Channel coefficient between BS-MS_k (Rayleigh)
q_{bk}	Channel coefficient between BCT-MS_k (Rayleigh)
u_k	Channel coefficient between BS-BCR (Rayleigh)

$$y_k = \sqrt{P_k l_k} h_k x_k + \sum_{b=1}^{N_b} \sqrt{P_b l_1} q_{bk} x_b + n_k$$

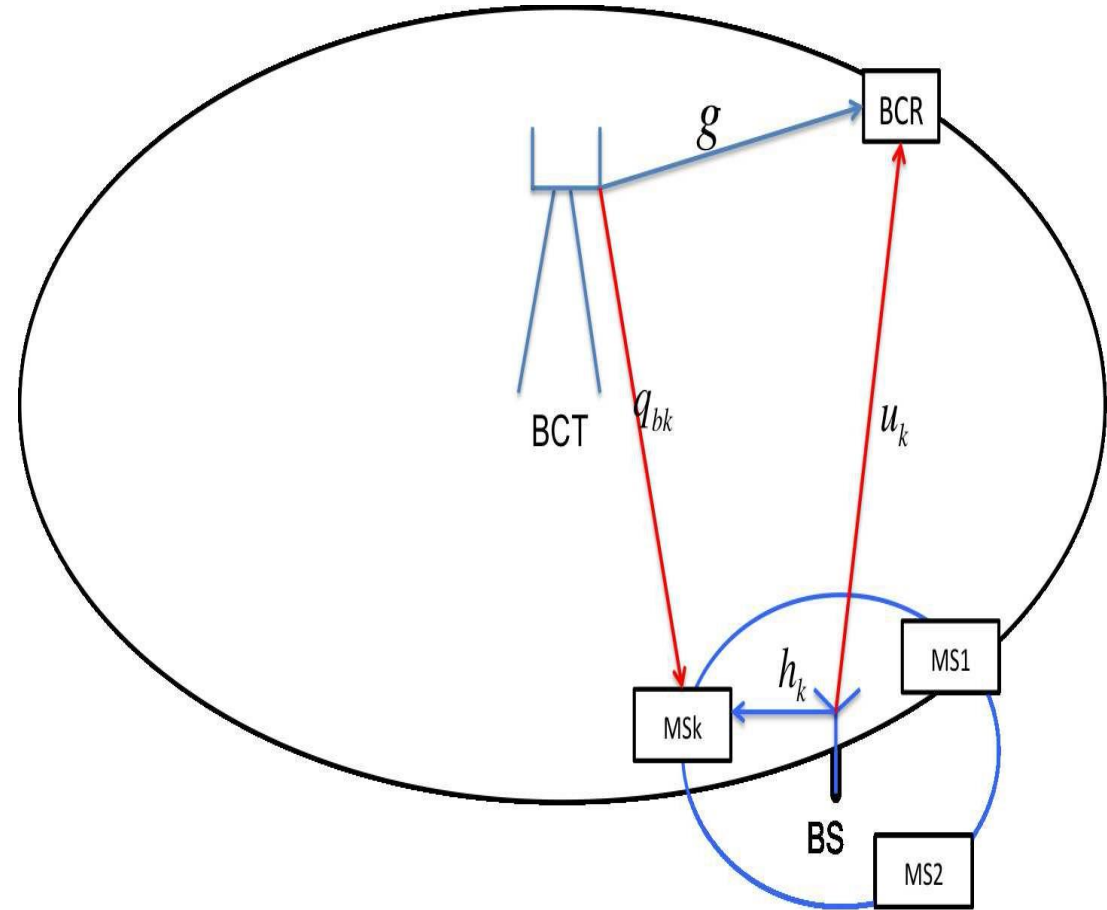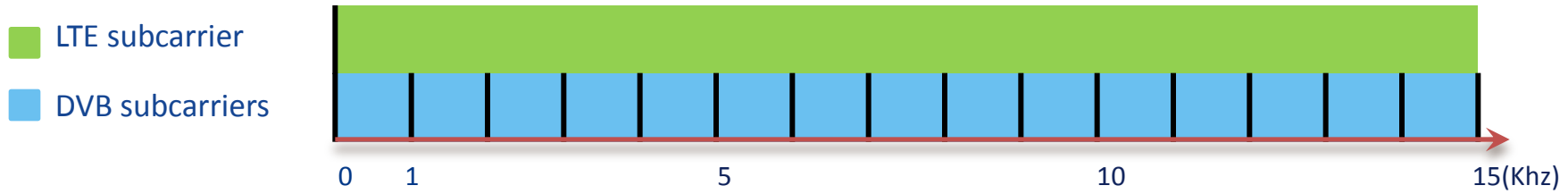$$y_b = \sqrt{P_b l_b} g x_b + \alpha \sqrt{P_k l_2} u_k x_k + n_b$$

Fig.1: System model

- LTE subcarrier is more larger than DVB subcarrier.
- Subcarrier of LTE signal = $N *$ subcarrier of DVB signal
- $N > 1$
- Subcarrier DVB signal $= \alpha *$ Subcarrier of LTE signal
- $\propto= 1/N$

In our study:
N=15
$\propto= 1/15$

LTE subcarrier

DVB subcarriers

0   1   5   10   15(Khz)

Global ergodic capacity

- Two steps:
  - SIR distribution
  - Global capacity expression
    - Derive ergodic capacity received at BCR & MS-k.
    - Sum of two capacities.
    - Bandwidth: broadcast network bandwidth

MS-k SINR

$$\gamma_k = \frac{P_m l_m |h_k|^2}{\sigma_m^2 + N_b P_b l_1 |q_{bk}|^2}$$

BCR SINR

$$\gamma_b = \frac{P_b l_b |g|^2}{\sigma_b^2 + \alpha^2 P_m l_2 |u_k|^2}$$

Noise neglection
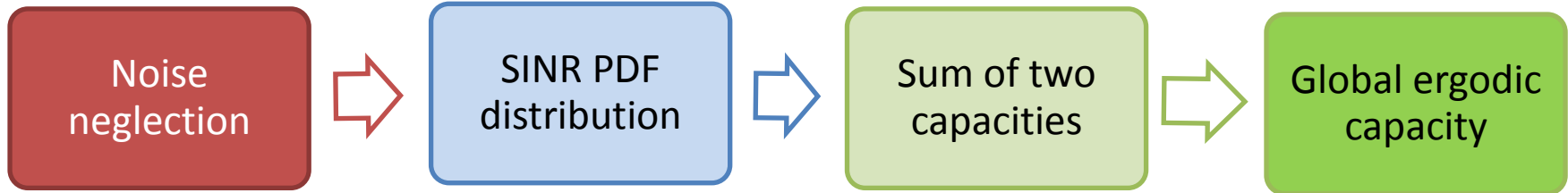
Joint PDF expression

$$p_{\tilde{\gamma}_k}(s) = \int_0^\infty p_{\tilde{\gamma}_k, T}(s, t) dt$$

PDF of MS-k SIR

$$p_{\tilde{\gamma}_k}(s) = \frac{P_m P_b l_m l_1 N_b}{(P_b l_1 N_b s + P_m l_m)^2}$$

PDF of BCR SIR

$$p_{\tilde{\gamma}_b}(s) = \frac{P_m P_b l_m l_2 \alpha^2}{(\alpha^2 P_m l_2 s + P_b l_b)^2}$$

Global capacity expression

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[ Noise neglection ]  ⟹  [ SINR PDF distribution ]  ⟹  [ Sum of two capacities ]  ⟹  [ Global ergodic capacity ]
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$$C_{\text{global}} = \mathbb{E}_{h_k, q_{bk}} \log_2 \left(1 + \gamma_k\right) + \mathbb{E}_{g, u_k} \log_2 \left(1 + \gamma_b\right)$$

$$C_{\text{global}} = \mathbb{E}_{\tilde{\gamma}_k} \log_2 \left(1 + \tilde{\gamma}_k\right) + \mathbb{E}_{\tilde{\gamma}_b} \log_2 \left(1 + \tilde{\gamma}_b\right)$$

Global ergodic capacity derived

$$C_{\text{global}}(bits/s) = W_b \left(\frac{P_m l_m}{N_b P_b l_1 - P_m l_m} \log_2 \frac{N_b P_b l_1}{P_m l_m} + \frac{P_b l_b}{\alpha^2 P_m l_2 - P_b l_b} \log_2 \frac{\alpha^2 P_m l_2}{P_b l_b} \right)$$

- Apply realistic values of DVB & LTE network parameters:
  - Path loss attenuation factor: 2.5 in DVB, 3 in LTE
  - DVB bandwidth : *Wb*=6.8 MHz
  - Maximum total broadcast power=10 KW: *Pbmax*=1,47W
  - Maximum total BS power=50 W: *Pmmax*=0,09W
- DVB cell radius =100Km
- LTE cell radius=1Km
- Distance BCT-MS=100Km
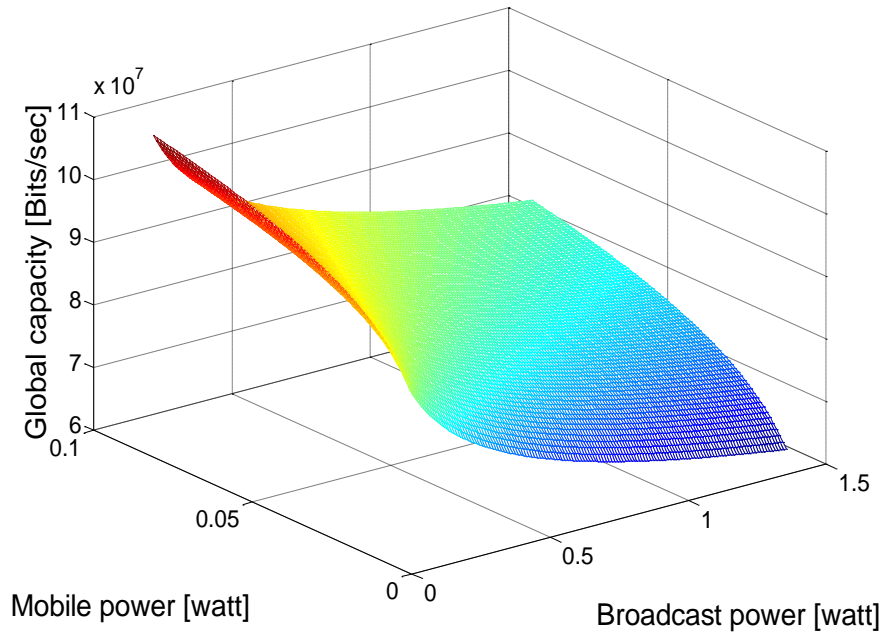- Distance BS-BCR: *d*
  - Interested parameter to study
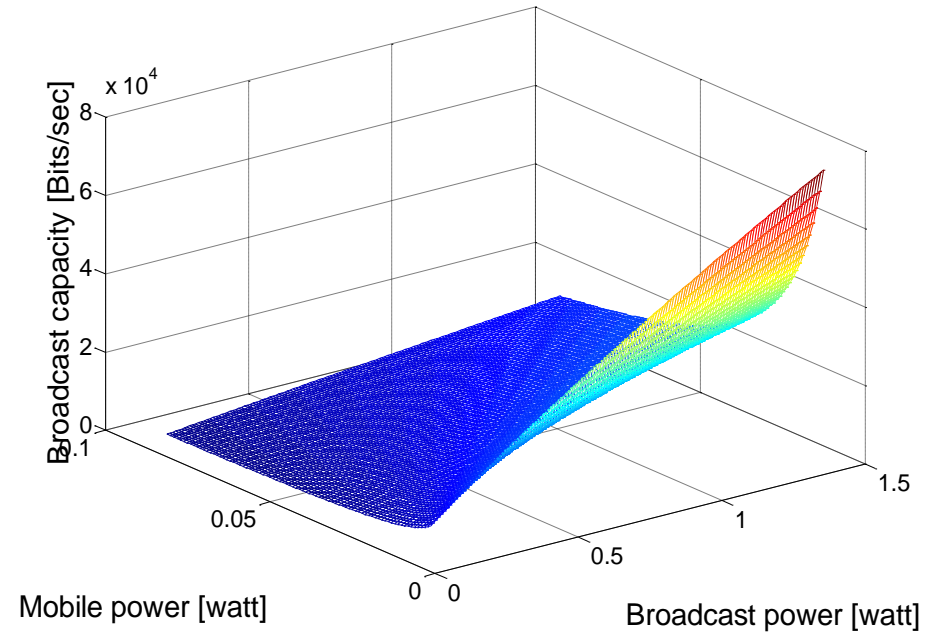
Fig.2: Global capacity in function of P_m and P_b

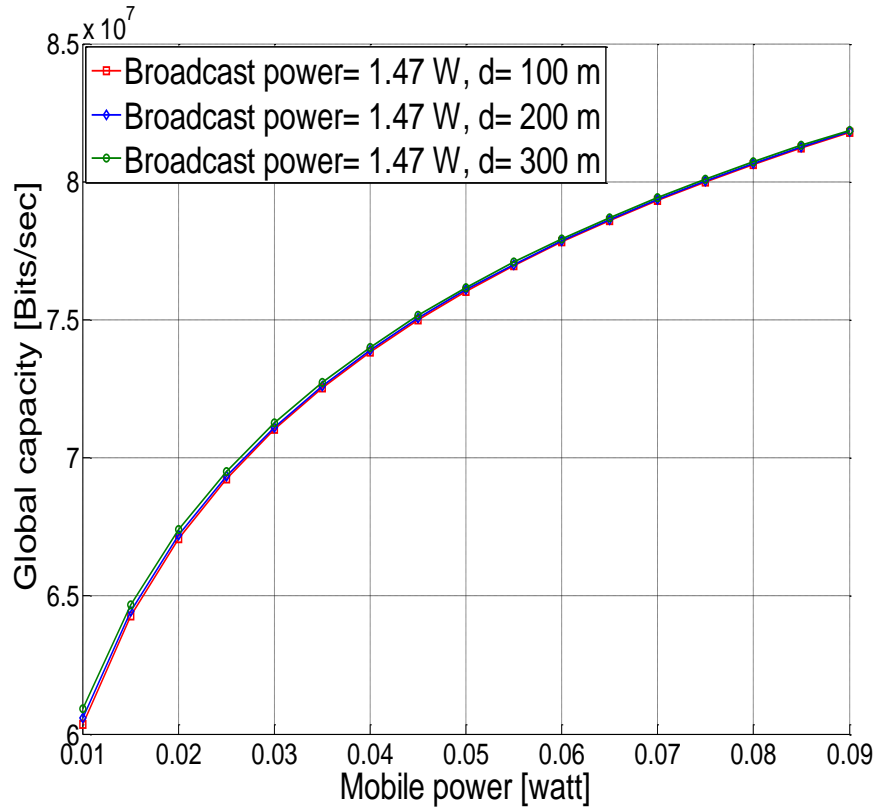Fig.3: Broadcast capacity in function of P_m and P_b

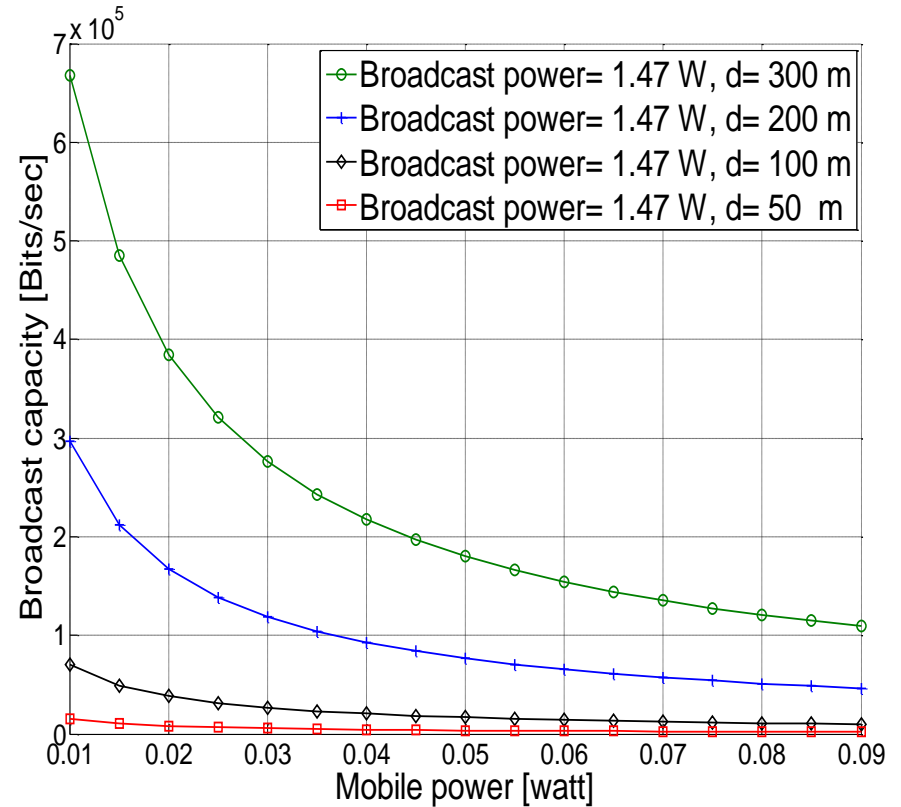Fig.4: Global capacity in function of P_m, with d=100, 200, 300m

Fig.5: Broadcast capacity in function of P_m, with d=50, 100, 200, 300m

- Conclusions :

  - Derivation of the global ergodic capacity

  - Dependence of the broadcast signal reception on d.

  - Global capacity: not a convex function of Pm and Pb.

- Future work:

  - Broadcast and mobile capacities are both opposite objectives.

  - Guarantee QOS.

  - Further work: the multi objectives maximization problem.

  - Usefulness of global ergodic capacity expression derived.

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Thank you ☺