Algorithms for Radio Networks

Handoff Algorithms

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Handover (Handoff)

- **Inter-Cell**
  - Participant switches to neighbor cell
  - Inter-BSC (Base Station Controller)
  - Inter-MSC (Mobile Switching Center)
  - Inter-PLMN (Public Land Mobile Network)
  - Inter-System (GSM/UMTS)
- **Intra-Cell**
  - Change of frequency of the time slot within a cell

Handoff-Control

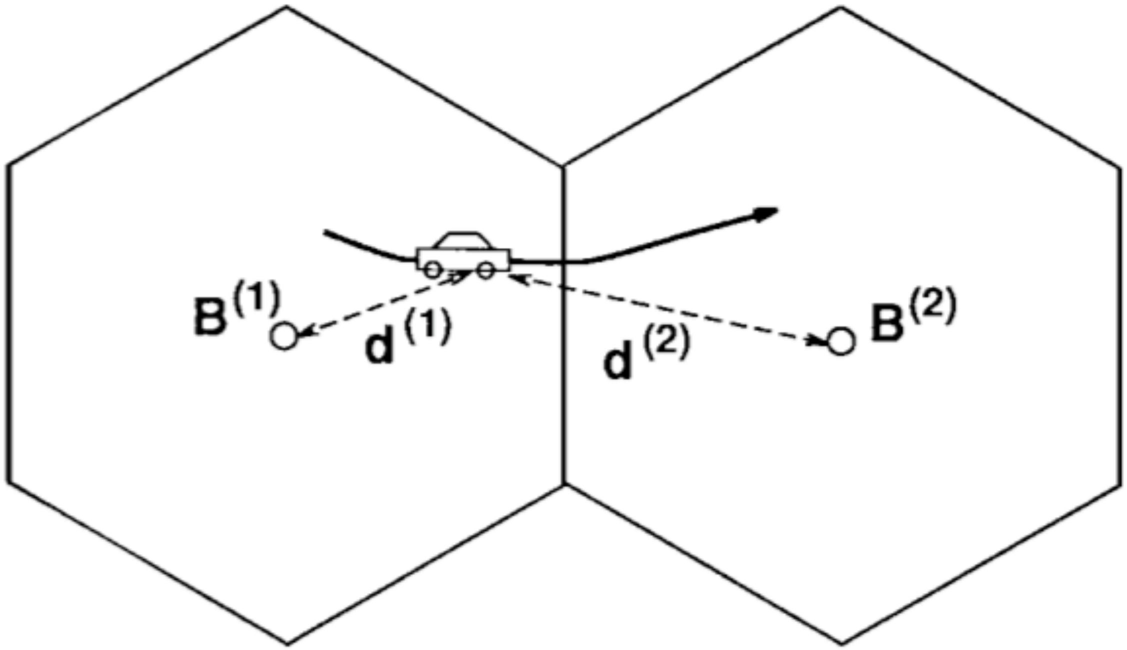
- **Network Controlled**
  - channel measurement from the network (base station)
  - networks makes decision when the handoff takes place
- **Mobile Assisted**
  - channel measurement from both sides
  - decision from the network (provider)
- **Mobile Controlled**
  - mobile device measures and decides

Hard and Soft Handoff

- **Hard Handoff**
  - First: disconnect
  - Then: create new connection
  - Necessary for frequency change
    - e.g. GSM
- **Soft Handoff**
  - First: create new connection
  - Then: delete old connection
  - Possible on same frequencys and CDMA/TDMA
    - e.g. UMTS

Handoff

- **Decision basis for handoff**
  - signal strength of current and potential cell
- **Signal strength decreases with the distance of the base station**



Problem of Handoff

- **Rajat Prakash and Venugopal V. Veeravalli**
  - Accurate Performance Analysis of Hard Handoff Algorithms, Proceedings of PIMRC'98

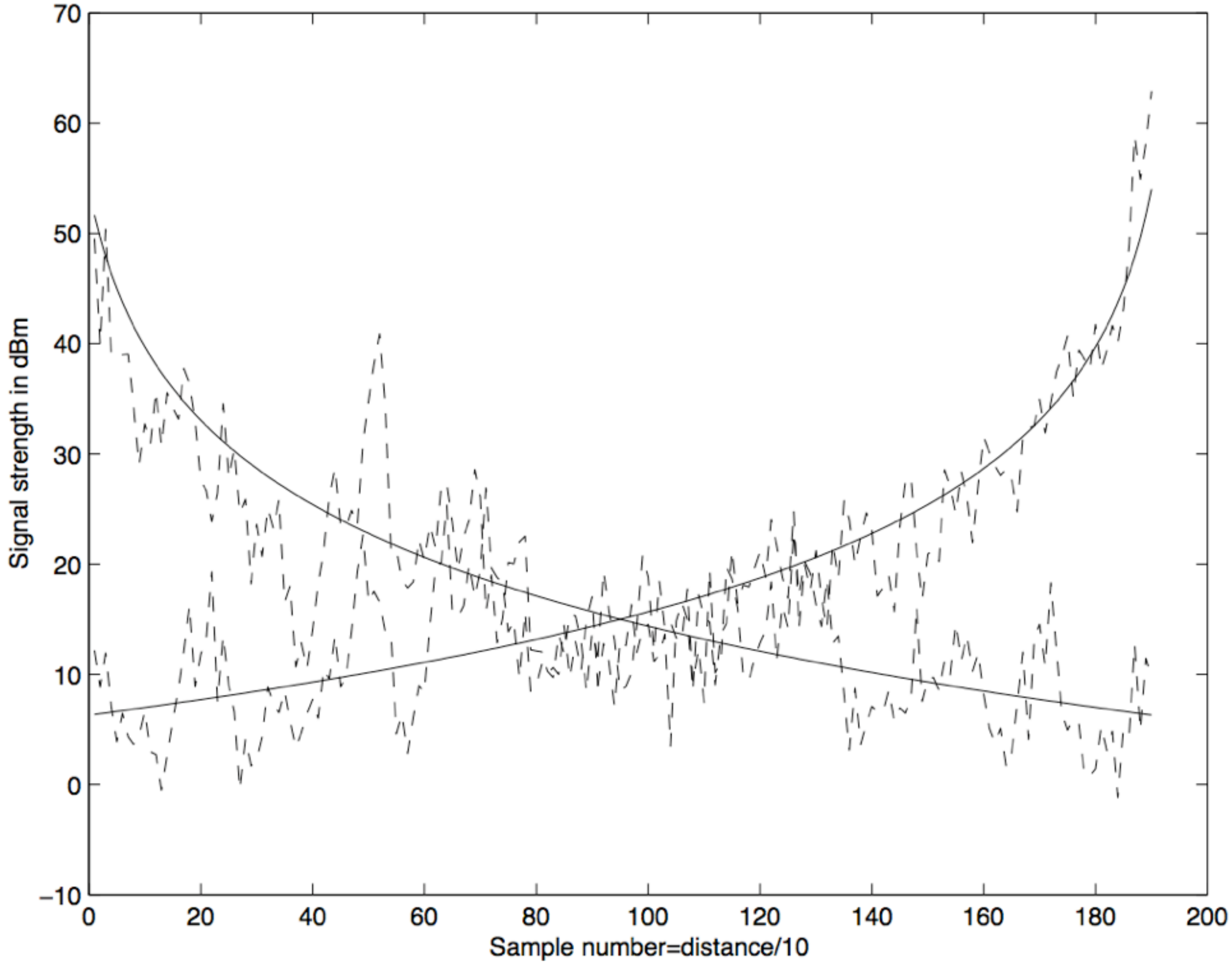


Figure 1: **The median and sample paths for a mobile moving from one base station to the other along a straight line.** The dotted lines represent one sample path of fading and the solid line is the median power. The fade margin is 15dB at the cell boundary

Computation of Signal Strength

- **Signal strength (in dB) can be computed as**

$$X(d) = \mu - \eta \log d + Z(d) \quad \mathrm{dB}$$

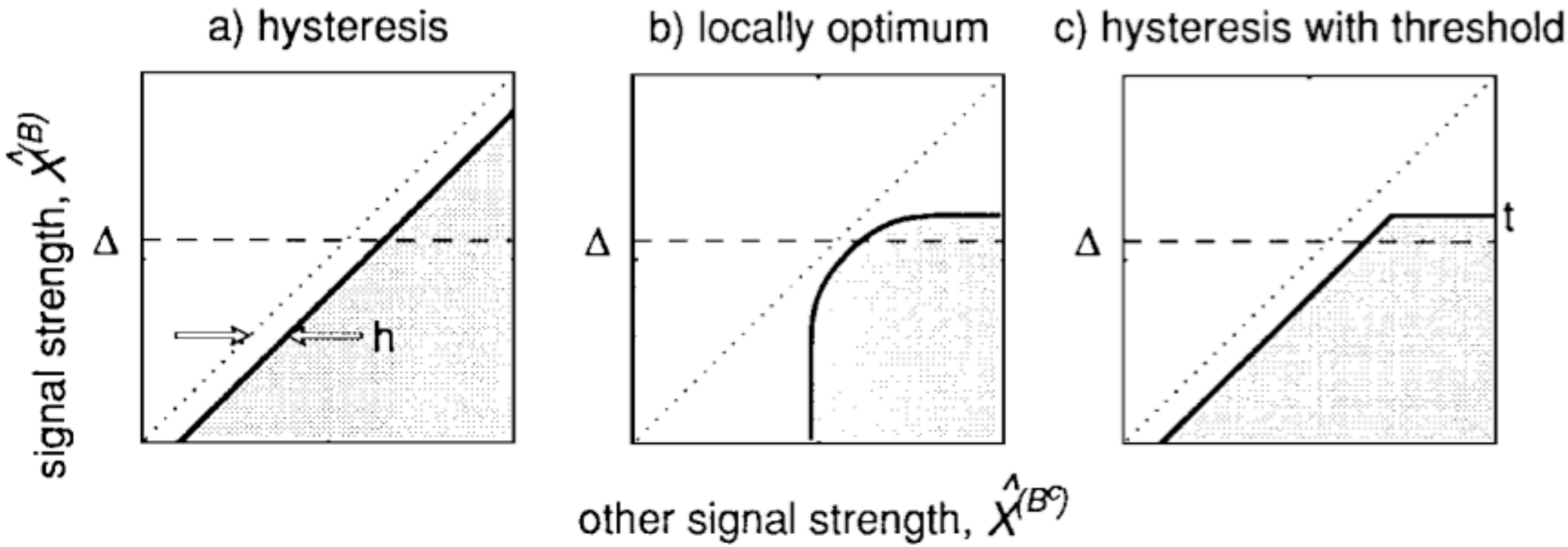
  - where d is the distance to the base station
  - μ is a constant
  - η is path loss exponent
  - Z(d) is *Shadow-Fading*-component
    - normal distributed random distribution
    - location-dependent

Decision Process

- **Regularly the base station is chosen**
- **This produces the following costs:**
  - N_{SF}: Number of time intervals with no connection (service failure)
    - arises if $X(d) < \Delta$
  - N_H: number of handovers
- **Both can not be optimized simultaneously**
- **Two possible problem definition to the optimal trade-off:**
  - Variation formulation
    - Minimize the handover, so that $E[N_{SF}] \leq \alpha$
  - Bayes formulation:
    - Minimize $c\, E[N_H] + E[N_{SF}]$

Possible Strategies for Handoff

- **Venugopal V. Veeravalli and Owen E. Kelly**
  - A Locally Optimal Handoff Algorithm for Cellular Communications, IEEE Trans. Veh. Technol, 1997 (46), 603-609



Algorithms Compared

- **Venugopal V. Veeravalli and Owen E. Kelly**
  - A Locally Optimal Handoff Algorithm for Cellular Communications, IEEE Trans. Veh. Technol, 1997 (46), 603-609

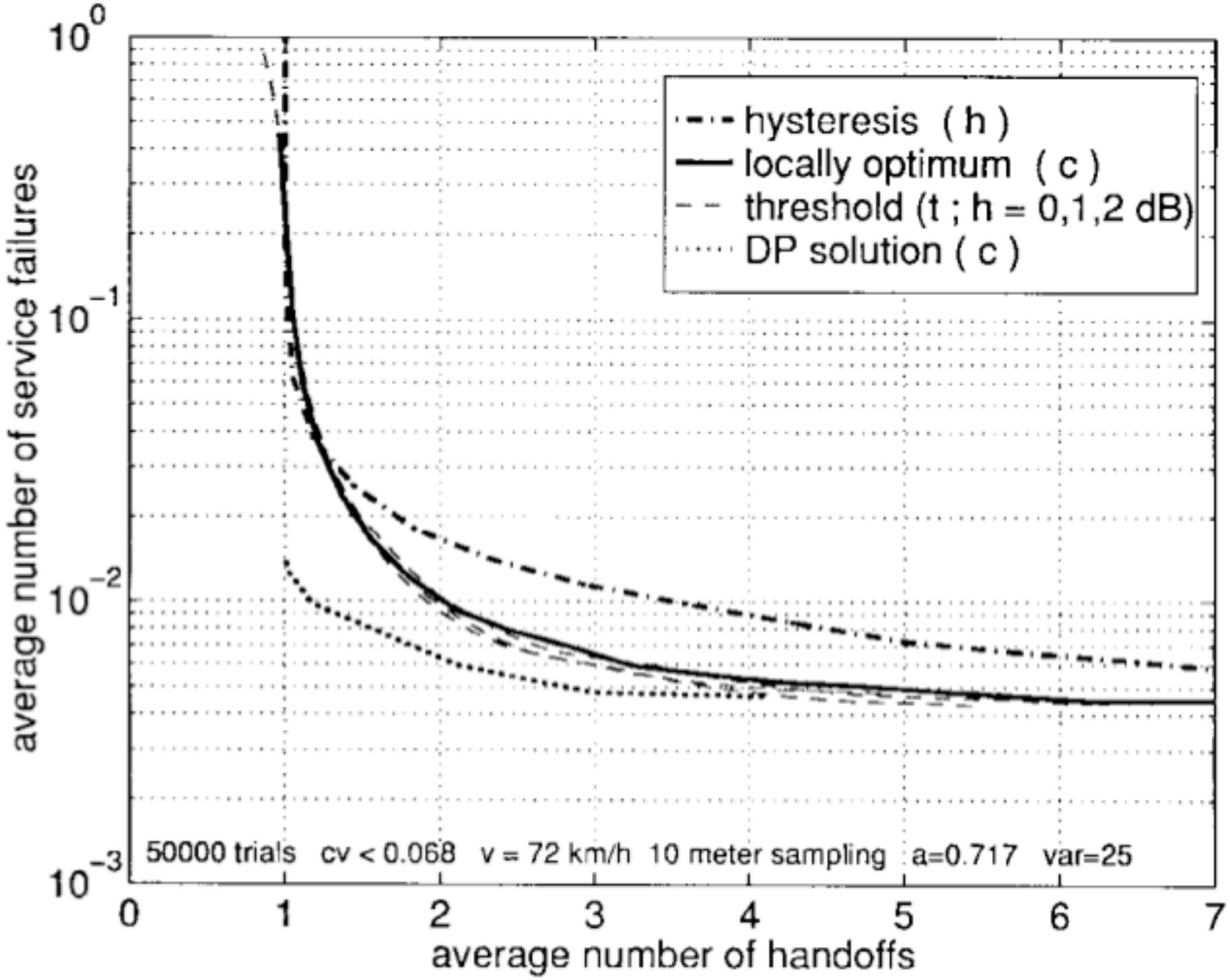


Fig. 3. Performance comparison. We compare the tradeoff between handoffs and service failures for three strategies to each other and to the best achievable (dynamic programming solution). Each curve is parameterized by the variable in parenthesis. With a single parameter, the locally optimum test follows the best performance that is achievable using two parameter hysteresis-threshold tests.

Handoffs during different speeds

- **Venugopal V. Veeravalli and Owen E. Kelly**
  - A Locally Optimal Handoff Algorithm for Cellular Communications, IEEE Trans. Veh. Technol, 1997 (46), 603-609

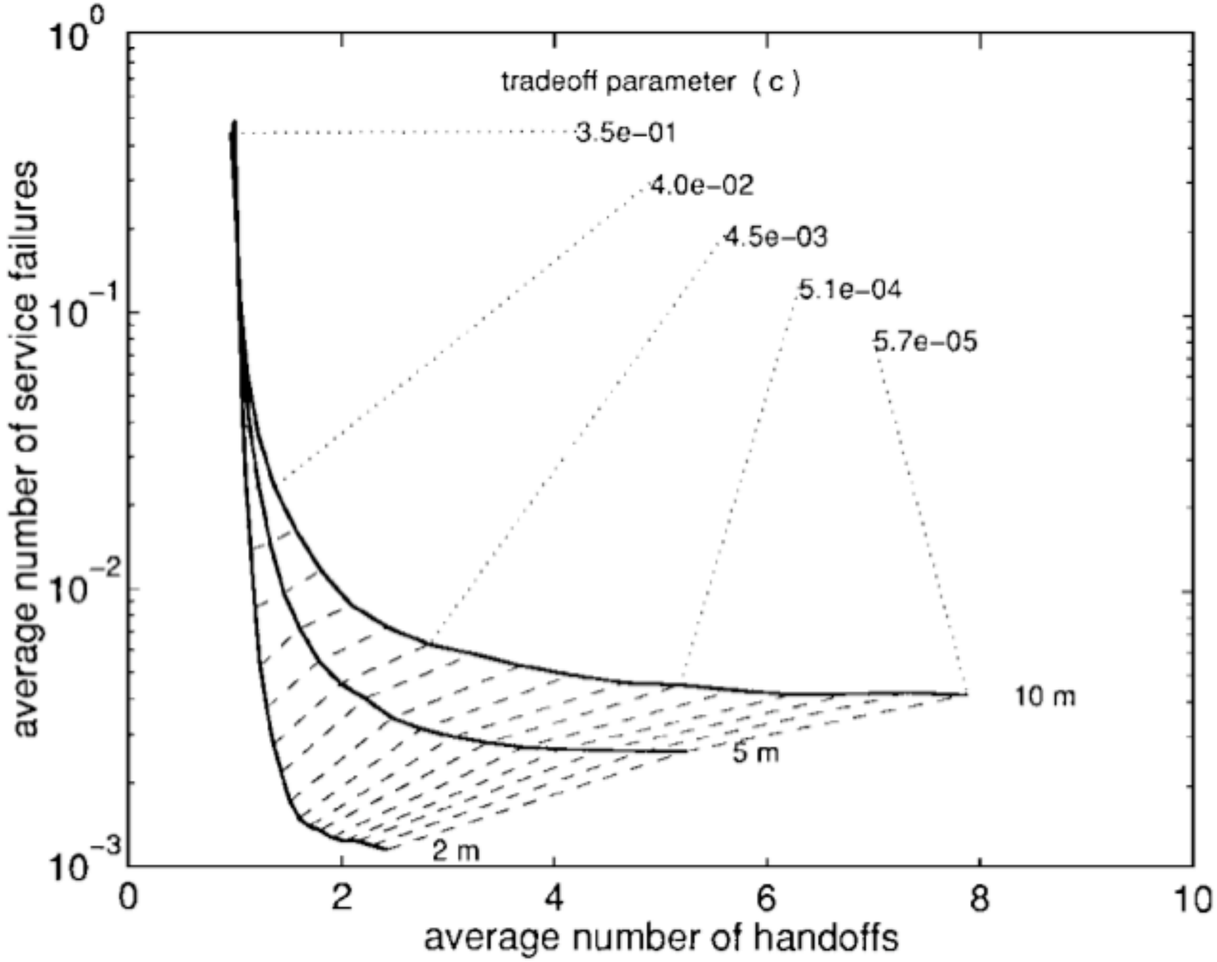


Fig. 4. Tradeoff curve parametrization. Performance of the locally optimum test is shown at sampling distances corresponding to mobile speeds 14.4, 36, and 72 km/h (assuming $t_s = 0.5$ s). Dashed lines connect points of the equal tradeoff parameter. Unlabeled tradeoff values are spaced logarithmically between indicated values.

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