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Is RSCP/ISCP needed for HO and cell selection purposes?

TSG RAN WG4#7 7th -10th of September 1999, Makuhari, Japan

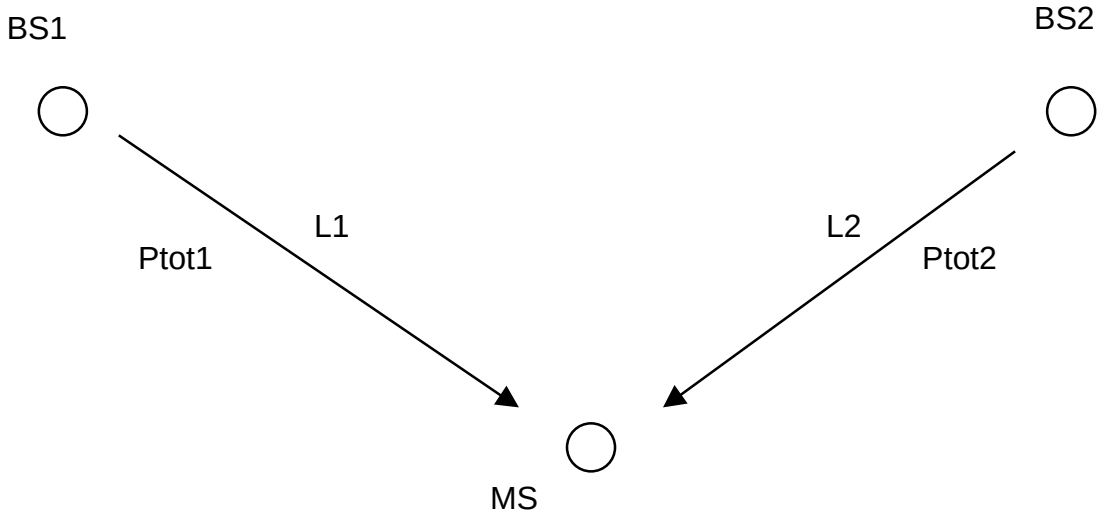
NOKIA

Introduction

- It has been proposed in 3GPP that the UE should be able to measure and report to network at least
  - RSCP - Received Signal Code Power, the received power on one code after de-spreading measured on the pilot bits. The reference point for the RSCP is the antenna connector at the UE.
  - SIR - Signal to Interference Ratio, defined as the RSCP divided by ISCP. The reference point for the SIR is the antenna connector of the UE. ISCP is the Interference Signal Code Power, the interference on the received signal after de-spreading. Only the non-orthogonal part of the interference is included in the measurement.
  - Ec/No - The recieved energy per chip divided by the power density in the band.
- These are required not only for the active set but for the neighbour measurements as well, i.e. for the handover monitoring set and cell selection/re-selection
- The benefits of having SIR measurements in addition to Ec/No in cell selection and HO has been questioned

…introduction

- The benefits of having CPICH SIR measurements in addition to CPICH Ec/No in cell selection and HO has been questioned
- SIR paradox:
  - If the pathloss L to two BS is the same and perfect orthogonality is assumed then cell with higher loading (Ptot1>Ptot2) is chosen, i.e.:



$$L_1 = L_2, \quad P_{tot1} \geq P_{tot2} \quad \Rightarrow \quad \frac{p_{tx} / L_1}{P_{tot2} / L_2 + N} \geq \frac{p_{tx} / L_2}{P_{tot1} / L_1 + N}$$

…introduction

- At first sight the SIR criteria sounds crazy - the higher loaded cells should be loaded even more
- Ideally SIR criteria minimizes locally the required DL transmission power for the individual radio link if secondary effects are not taken into account, thus theoretically SIR criteria could minimize the total DL intereference in the network and thus maximize DL capacity
- CPICH Ec/No criteria is equivalent to pathloss criteria if equal CPICH powers are assumed, i.e.

$$L_1 \leq L_2 \quad \Rightarrow \quad \frac{p_{tx} / L_1}{P_{tot1} / L_1 + P_{tot2} / L_2 + N} \geq \frac{p_{tx} / L_2}{P_{tot1} / L_1 + P_{tot2} / L_2 + N}$$

- Ec/No criteria keeps the geographical cell borders stable
- Some simulation results are shown next to investigate the differencies between SIR and Ec/No criteria in handover and cell selection

Simulation model

- The simulation model is a simple two BS, one dimensional model

- MS:s were generated one by one uniformly, randomly on the line between the two BS:s. The proportions of MS:s on the left and right half of the line could be adjusted.
- After insertion of every new MS the cell selection and power control for the new MS and the previous MS:s was simulated until convergence. The total transmission power at both BS was calculated in each step. The same MS sequence was repeated by using both handover criteria. Since there is no mobility in the model the tests were done 100 times.
- Macro and micro cell scenarios with high data rate DL connections were tested
- Uplink was not included in the simulation
- There was no soft handover but optimal selection of the better cell according both criteria. All UE measurements were ideal
- Power control was ideal, delay free DPCCH SIR based (for both HO criteria) where SIR was defined with and an orthogonality factor α as (if BS1 is the serving cell):

$$SIR = \frac{p_{tx} / L_1}{(1-\alpha)P_{tot1} / L_1 + P_{tot2} / L_2 + N}$$

Note: The same formula was used for SIR based cell selection

Simulation case 1

- Macro cell scenario
- Path loss: Okumura-Hata with BS antenna heigth=35m, L=max(70,136.866+34.786*log10(r/1000)), r in meters
- distance between BS:s: d=2000
- antenna gain 15dB
- constant power at both BS (common channels) 1W
- user bit rate 128kbit/s
- chip rate 3.84MHz
- number of MS:s: 1,…,20
- Eb/No target 4.5 dB
- system noise -97dBm
- orthogonality: α=0.5 (50% orthogonal from home cell)

…simulation case 1

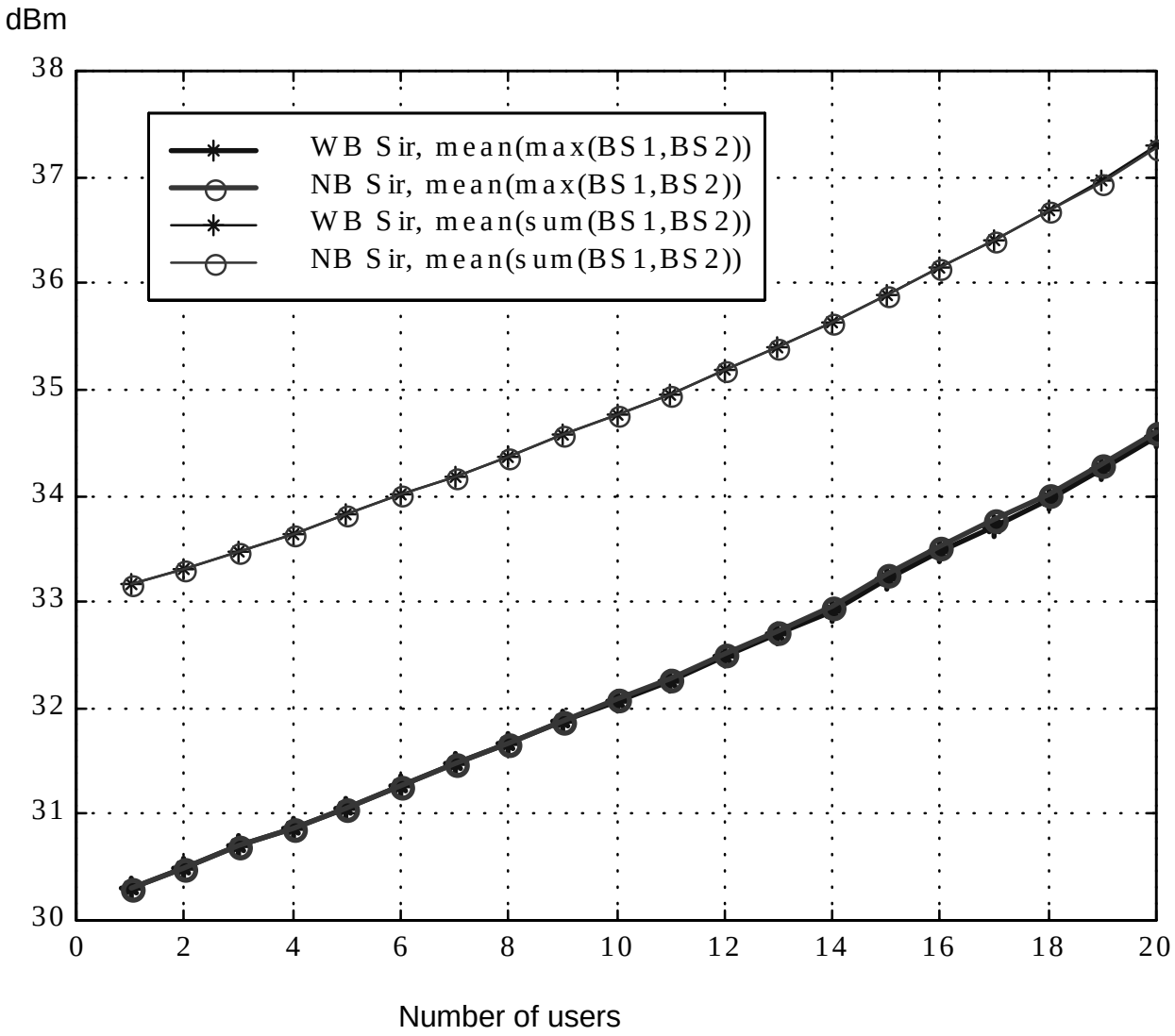


Figure 1.1 Case 1, averages over the 100 snapshots

- WB means Ec/No criterion, NB means SIR criterion
- lower lines: in each simulation the **maximum** of the total BS power at BS1 and total BS power at BS2 has been calculated (linear) averaged over the 100 snapshots
- upper lines: in each simulation the **sum** of the total BS power at BS1 and BS2 has been calculated and averaged over the 100 snapshots

…simulation case 1

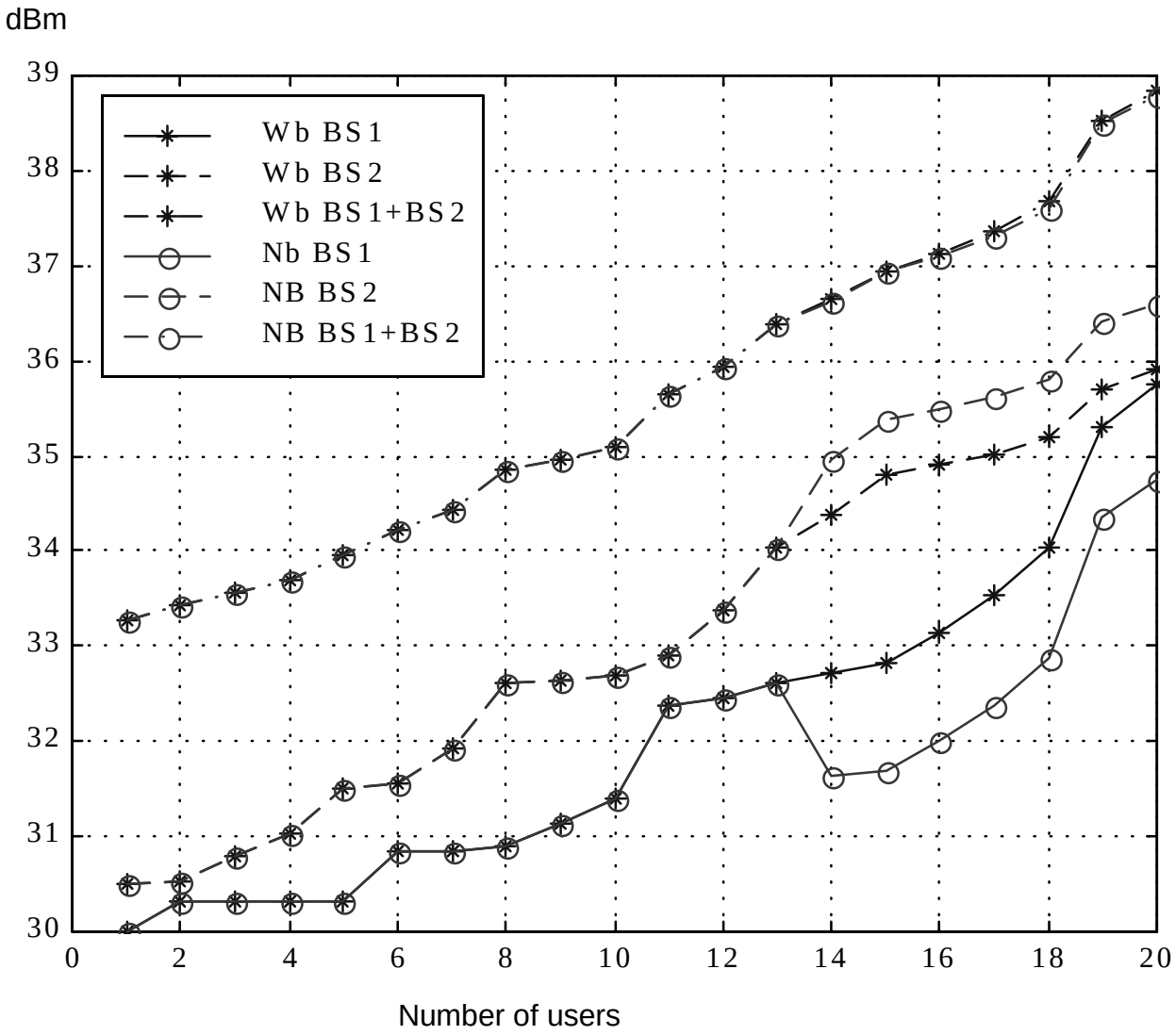


Figure 1.2 Case 1, a snapshot when there was a difference

- WB means Ec/No criterion, NB means SIR criterion

Observations:

- for SIR the total transmission power BS1+BS2 is sligthly lower
- for Ec/No the peak power is sligthly lower
- Ec/No tends to balance the powers

Simulation case 2

- Just like case 1 but unequal loading: 70 % of MS:s on the left half of the line (BS1), 30% of MS:s on the right half of the line (BS2)
  - Macro cell scenario
  - Path loss: Okumura-Hata with BS antenna heigth=35m, L=max(70,136.866+34.786*log10(r/1000)), r in meters
  - distance between BS:s: d=2000
  - antenna gain 15dB
  - constant power at both BS (common channels) 1W
  - user bit rate 128kbit/s
  - chip rate 3.84MHz
  - number of MS:s: 1,…,20
  - Eb/No target 4.5 dB
  - system noise -97dBm
  - orthogonality: α=0.5 (50% orthogonal from home cell)

…simulation case 2

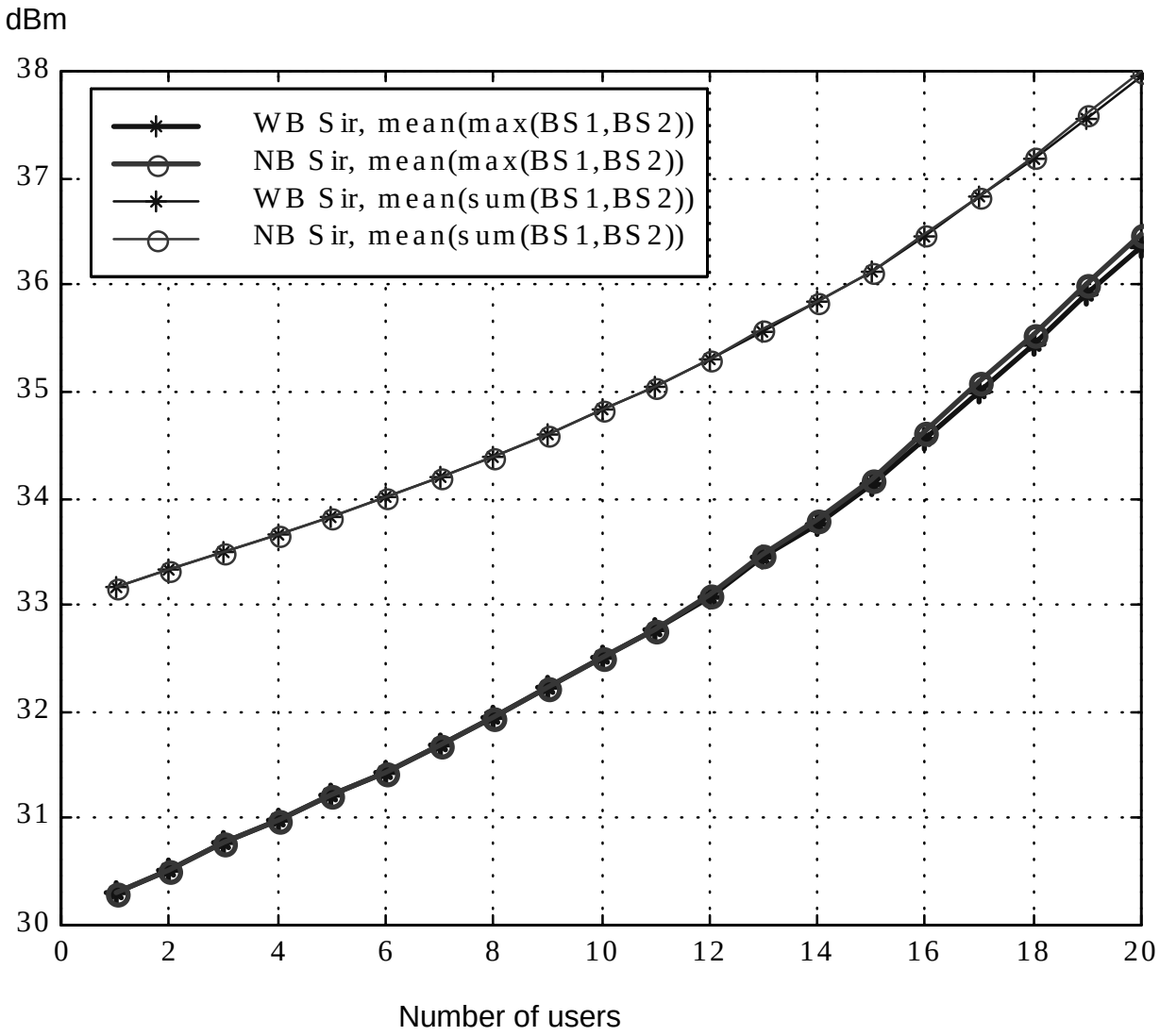


Figure 2.1, averages over the 100 snapshots

- WB means Ec/No criterion, NB means SIR criterion
- lower lines: in each simulation the **maximum** of the total BS power at BS1 and total BS power at BS2 has been calculated (linear) averaged over the 100 snapshots
- upper lines: in each simulation the **sum** of the total BS power at BS1 and BS2 has been calculated and averaged over the 100 snapshots

…simulation case 2

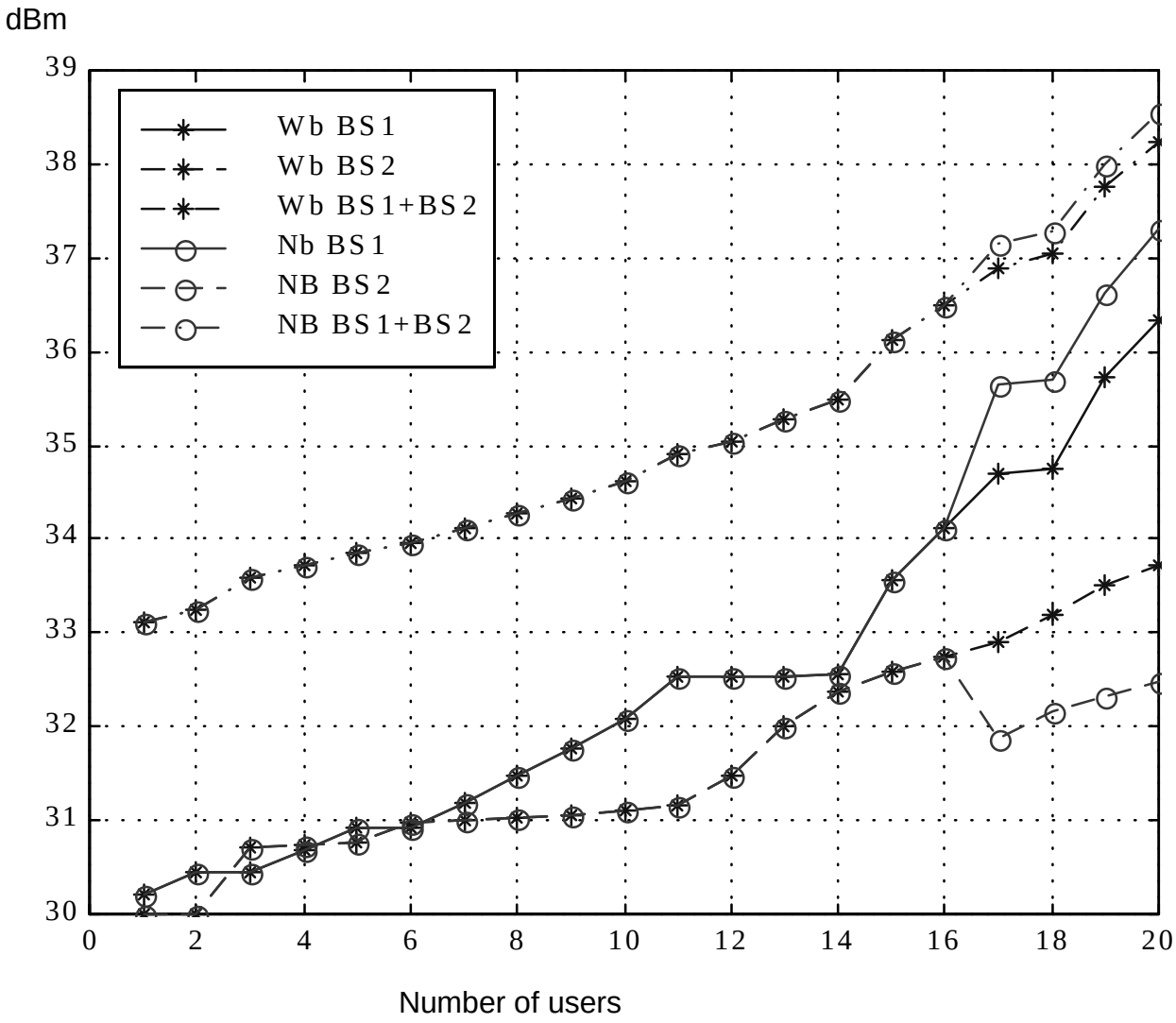


Figure 2.2, a snapshot when there was a difference

- WB means Ec/No criterion, NB means SIR criterion

Observations:

- for Ec/No the total transmission power BS1+BS2 is sligthly lower
- for Ec/No the peak power is sligthly lower
- Ec/No tends to balance the powers

Simulation case 3

- Just like case 1 but unequal loading: Common channel power of BS1 = 3 Watts, common channel power of BS2 = 0.5 Watts
  - Macro cell scenario
  - Path loss: Okumura-Hata with BS antenna heigth=35m, L=max(70,136.866+34.786*log10(r/1000)), r in meters
  - distance between BS:s: d=2000
  - antenna gain 15dB
  - constant power at both BS (common channels) 1W
  - user bit rate 128kbit/s
  - chip rate 3.84MHz
  - number of MS:s: 1,…,20
  - Eb/No target 4.5 dB
  - system noise -97dBm
  - orthogonality: α=0.5 (50% orthogonal from home cell)

…simulation case 3

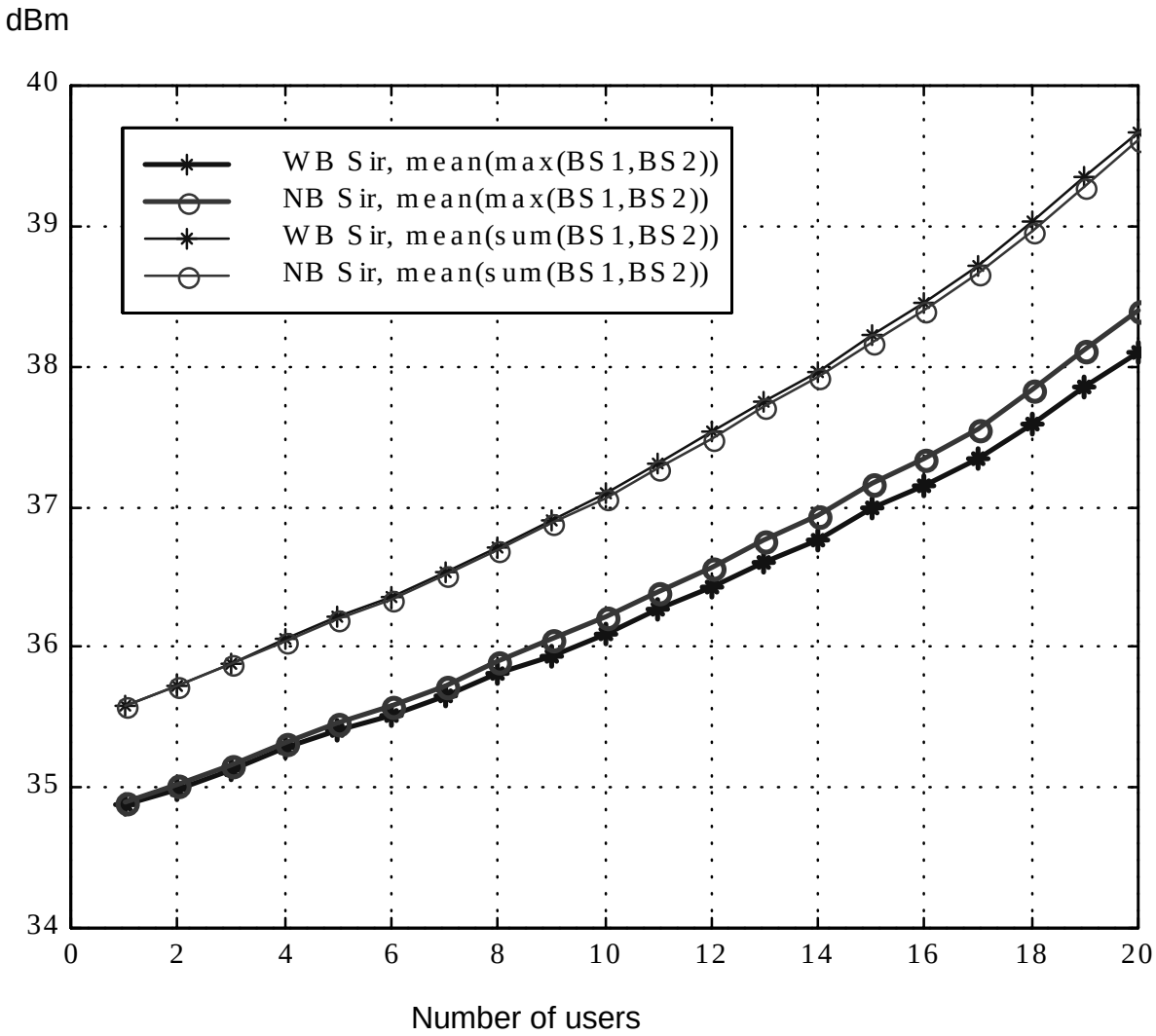


Figure 3.1, averages over the 100 snapshots

- WB means Ec/No criterion, NB means SIR criterion
- lower lines: in each simulation the **maximum** of the total BS power at BS1 and total BS power at BS2 has been calculated (linear) averaged over the 100 snapshots
- upper lines: in each simulation the **sum** of the total BS power at BS1 and BS2 has been calculated and averaged over the 100 snapshots

…simulation case 3

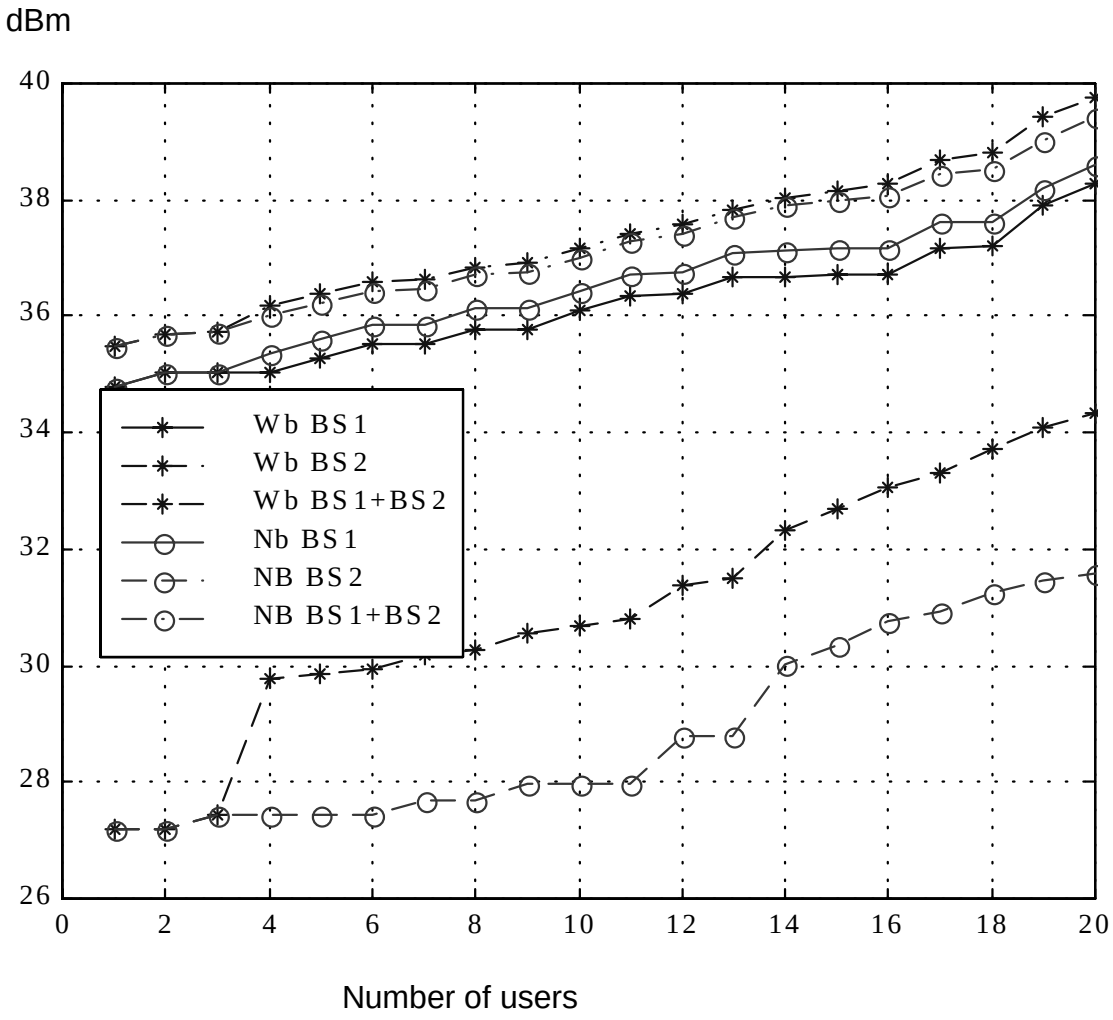


Figure 3.2, a snapshot when there was a difference

- WB means Ec/No criterion, NB means SIR criterion

Observations:

- for SIR the total transmission power BS1+BS2 is sligthly lower
- for Ec/No the peak power is sligthly lower
- Ec/No tends to balance the powers

Simulation case 4

- Micro cell scenario
  - Path loss: Dual slope:

    L=max(53,K), where

    K= 38+20*log10(r) if r < 300m (free space loss)

    38+20*log10(300)+40*log10(r/300) if r >300m
  - distance between BS:s: d=1000
  - antenna gain 3dB
  - constant power at both BS (common channels) 0.1W
  - **user bit rate 512kbit/s**
  - chip rate 3.84MHz
  - number of MS:s: 1,…,16
  - Eb/No target 4.5 dB
  - system noise -97dBm
  - **orthogonality: α=1** (perfectly orthogonal from home cell)

…simulation case 4

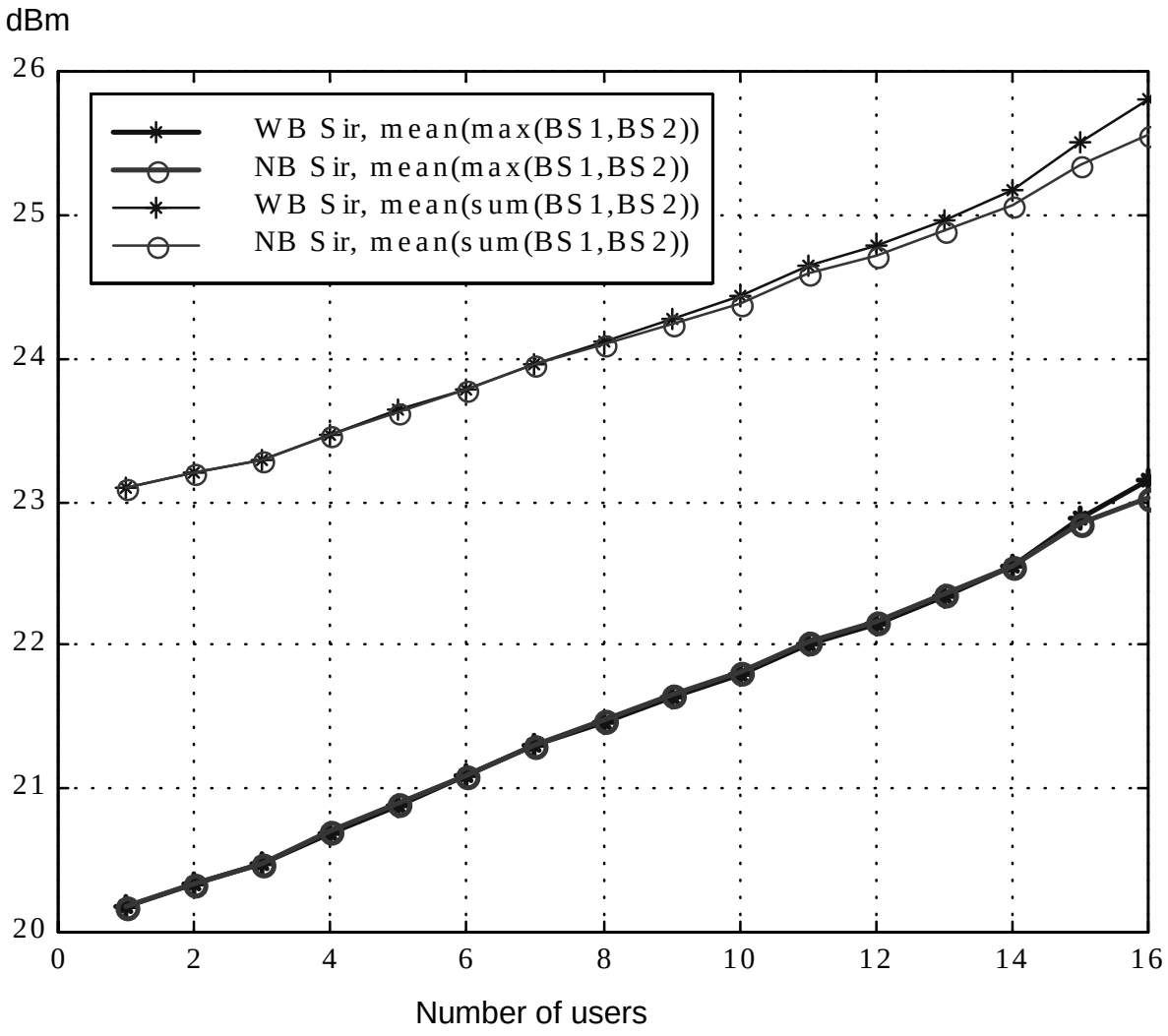


Figure 4.1, averages over the 100 snapshots

- WB means Ec/No criterion, NB means SIR criterion
- lower lines: in each simulation the **maximum** of the total BS power at BS1 and total BS power at BS2 has been calculated (linear) averaged over the 100 snapshots
- upper lines: in each simulation the **sum** of the total BS power at BS1 and BS2 has been calculated and averaged over the 100 snapshots

…simulation case 4

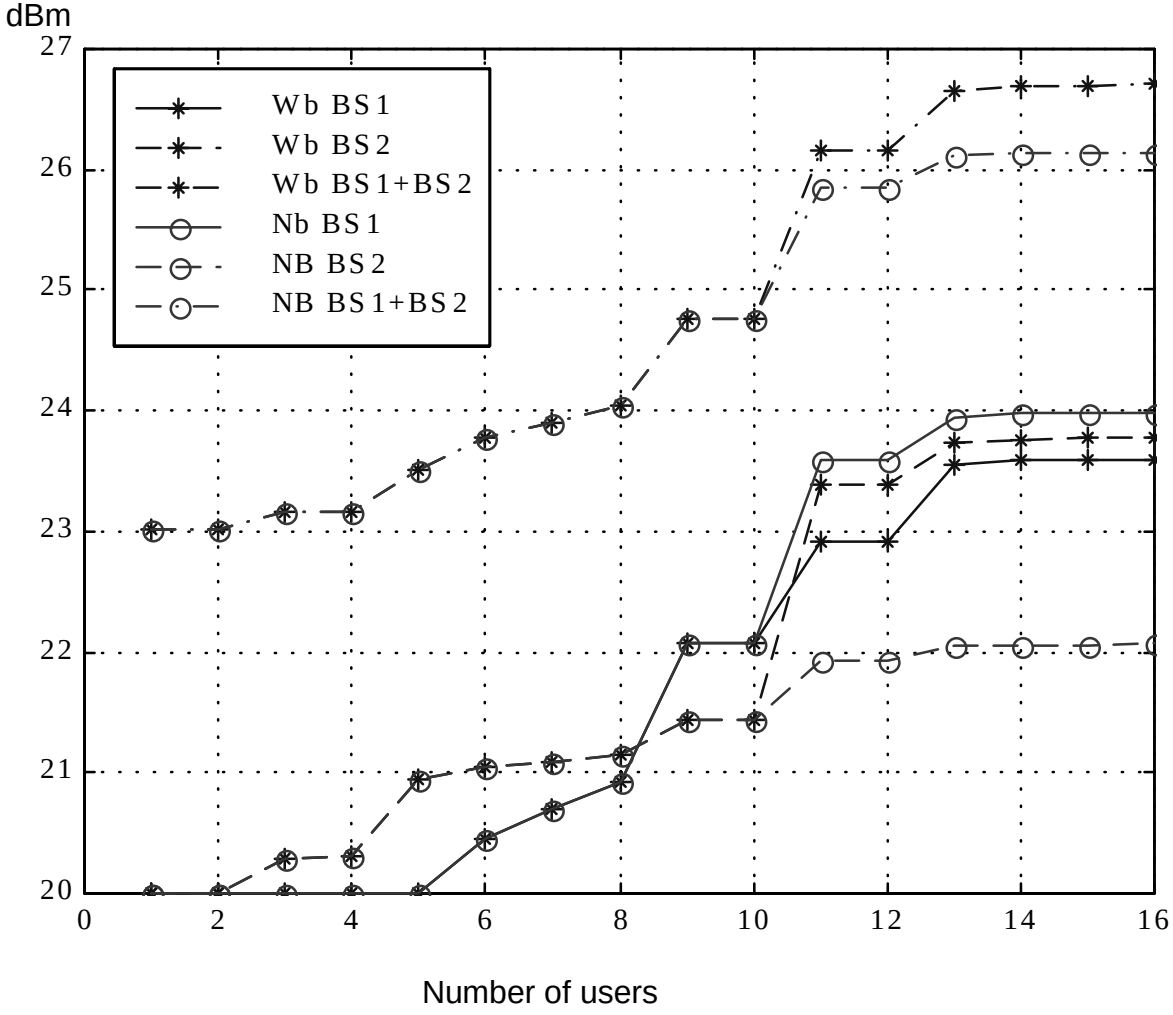


Figure 4.2, a snapshot when there was a difference

- WB means Ec/No criterion, NB means SIR criterion

Observations:

- for SIR the total transmission power BS1+BS2 is sligthly lower
- for Ec/No the peak power is sligthly lower
- Ec/No tends to balance the powers
- This behaviour doesn't explain the Figure 4.1 where the average maximum power was sligthly higher for WB than for NB

…simulation case 4

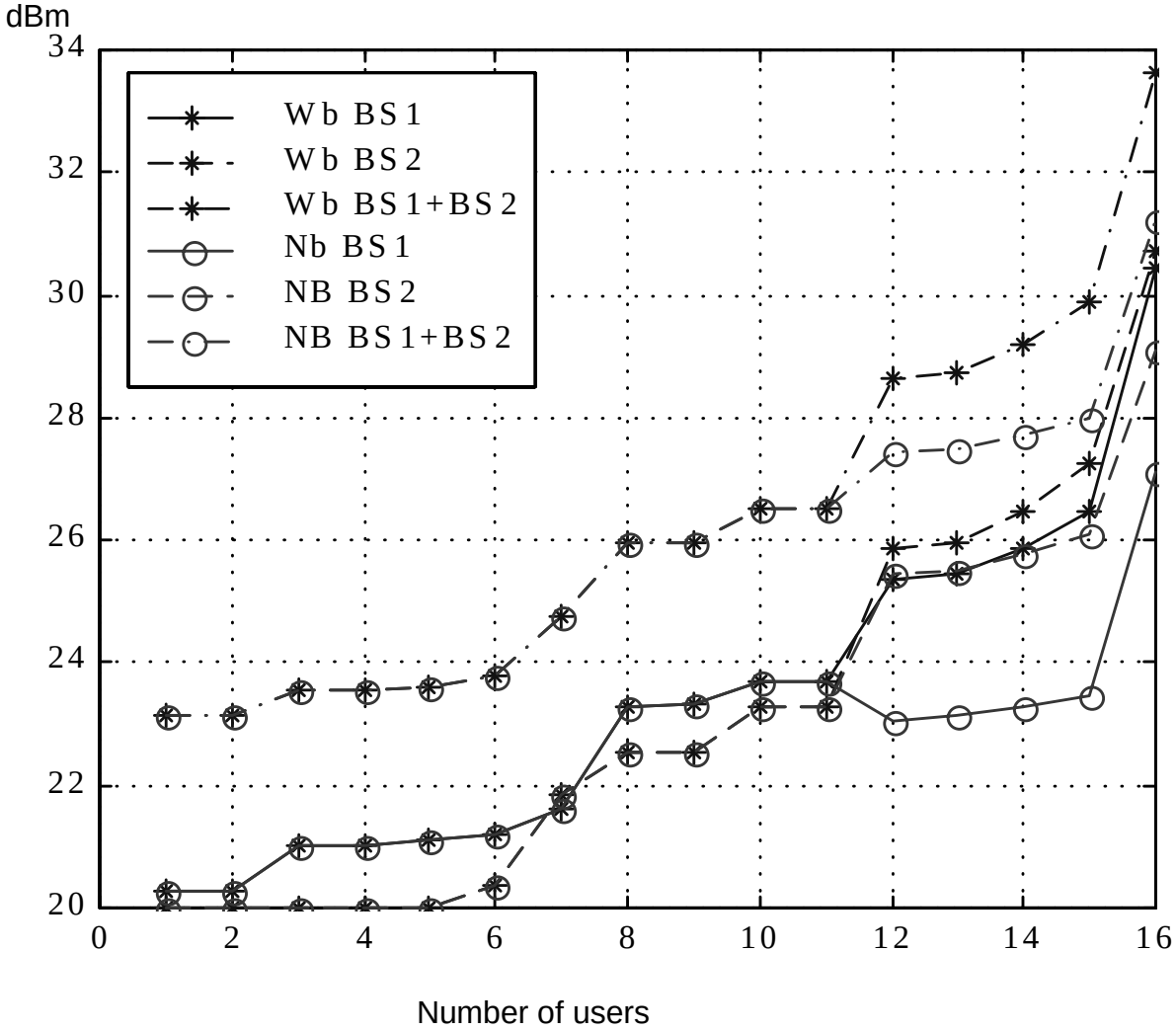


Figure 4.3, another snapshot when there was a difference in case 4

- WB means Ec/No criterion, NB means SIR criterion

Observations:

- In this snapshot the system approaches the pole capacity (because of bad intereference situation) and WB goes sligthly faster to overload.

Conclusions

- In the simulations there was not much DL performance difference between the SIR based and Ec/No based cell selection

  Limitations in the simulations:

  - SHO was not taken into account but SHO would probably make the difference smaller, in the simulations a strict border between the cells would change to a region between the cells
  - only one dimensional two BS model was used but using full model would probably make the difference smaller (?)
  - UE measurement errors were not considered
  - DL SIR has the tendency to minimize total BS power calculated over the network, DL Ec/No has the tendency to minimize the BS peak power. Also with Ec/No BS powers are more stable.
- DL SIR collects MS:s to highly loaded cells
- DL Ec/No shares the loading evenly
- With DL SIR bigger margins are needed in the number channel units

… conclusions

- DL SIR doesn't help UL, vice versa, Ec/No is a compromise between UL and DL in highly orthogonal cases.
- SIR measurement is probably more noisy or late than Ec/No since the interference measurements must be done from symbols rather than from chips (i.e. either less samples or longer filtering)
- The definition of despread SIR in DL is very difficult to make since it is in reality far away from ideal (what is the definition of ideal SIR in the case of multipath -> depends on how the multipaths are combined if wanted to reflect the SIR used for PC)
- SHO areas are easier to control with Ec/No than with SIR
- Requiring both SIR and Ec/No in UE neighbour measurements increases greatly UE's complexity
- Theoretically, with DL SIR higher DL capacity can be achieved in some scenarios, than with DL Ec/No but for example by adjusting CPICH Ec according to loading could lead to same capacity when using Ec/No