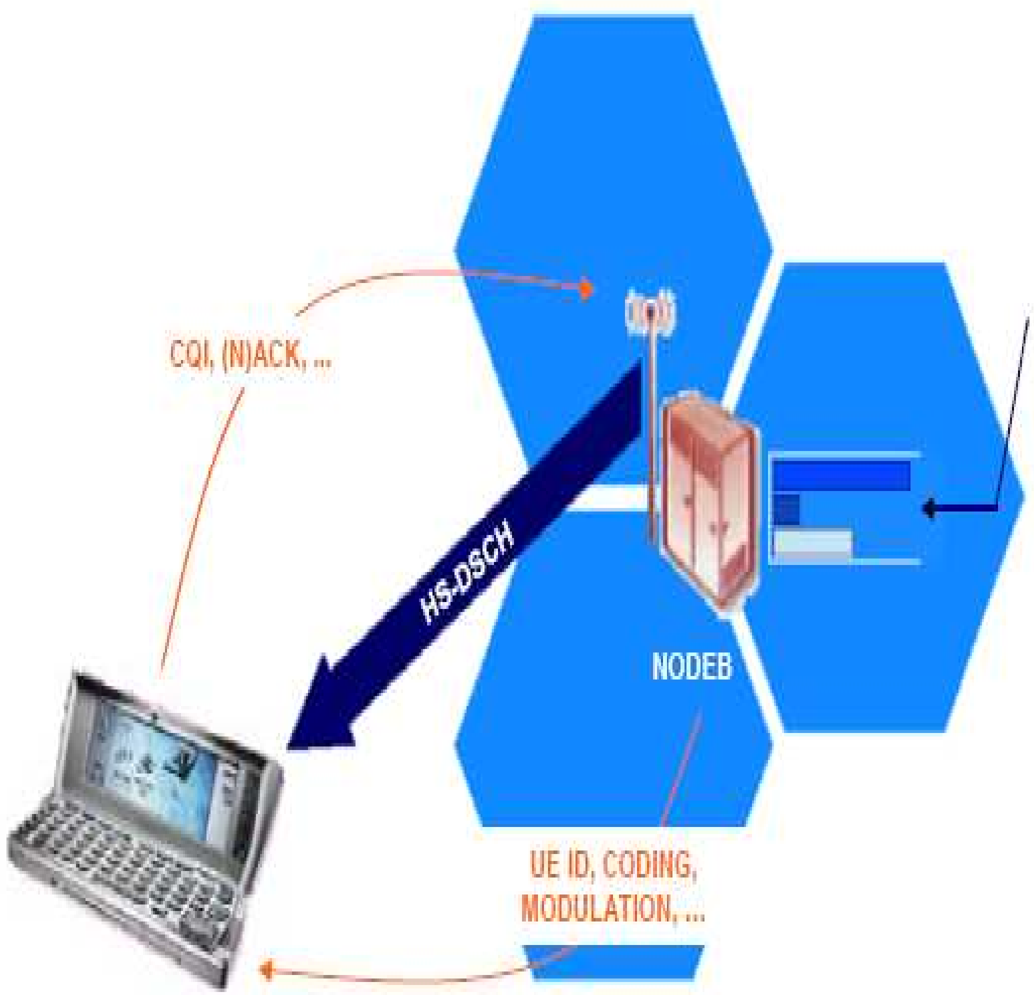
HSDPA radio network planning

S-72.4210 PG Course in Radio Communications

Tommi Heikkilä (45444T)

Outline

- Introduction
- HSDPA Deployment
- HSDPA Cell Planning
- Summary
- References
- Homework

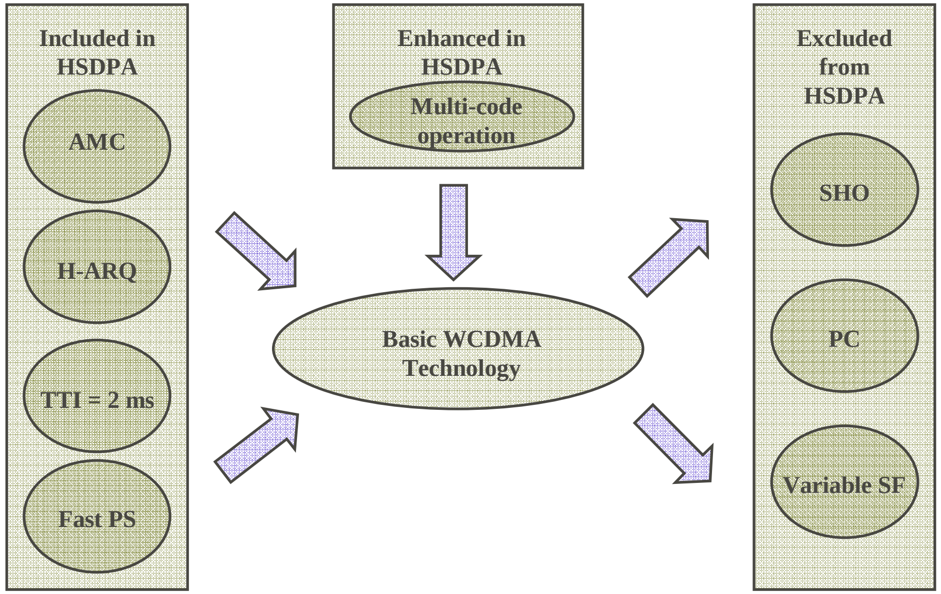


Introduction
HSDPA (High Speed Downlink Packet Access)

- Described in 3GPP Release 5 specifications
  - Enhances peak download data rate from current 384 kbps up to a theoretical maximum downloading peak rate of 14.4 Mbps (10,7 Mbps with ¾ coding rate)
  - Aimed for interactive and background services but streaming is also considered
- HSDPA brings benefits for both operators and end-users
  - Higher data rates for end-users
  - Larger and cost efficient capacity in the radio network
  - Opportunity to deliver services - existing ones and new ones - at a lower cost of bit
- Requires investments to R99/R4 UMTS (WCDMA) network
  - Affects radio network HW and SW, core network SW, and transmission network HW
  - Can be deployed using small upgrades, not required for all BSs, RNCs
  - Does not require a completely new network structure
  - Protecting the current investments made to the network

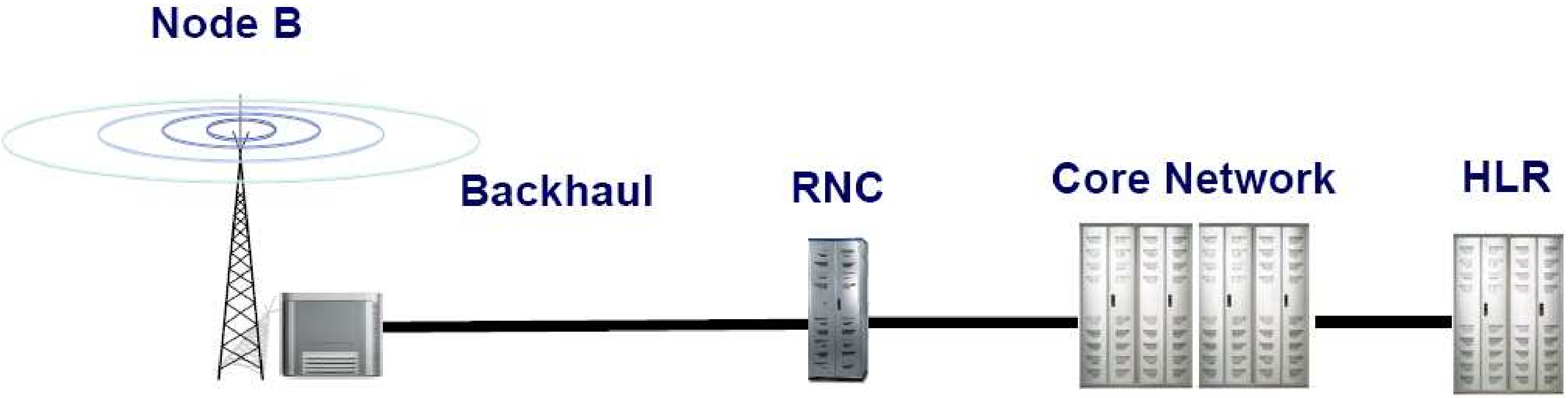
Introduction
HSDPA Basics

- In order to reduce Round Trip Time (RTT) new features have been implemented in BS, closer to the air interface
- **Adaptive Modulation and Coding (AMC)**
  - Depending on UE channel conditions (CQI)
  - QPSK, 16QAM
  - Coding rate (1/4 – 3/4)
  - Data rate adapted on 2 ms time basis
- **Fast Retransmission**
  - Hybrid Automatic Repeat reQuest (HARQ)
  - UE soft-combines data
  - Reduced RTT
- **Fast Packet Scheduling (PS)**
  - Scheduling of users on 2 ms time basis
- New radio channels included for HSDPA
  - DL: HS-(P)DSCH, HS-SCCH
  - UL: HS-DPCCH



- It is important to note that downlink HSDPA is a shared data channel
  - End user throughput depends on the number of the other users on the same HSDPA cell
  - Capacity planning and dimensioning of HSDPA is different to non-real time (NRT) DCH bearer

Introduction
Key Network Impacts and Investments of HSDPA



Node B

- Increased processing power (H/W)
- RF power allocation to HSDPA
- Management of new device categories & signalling ch.
- Software upgrade

Backhaul

- Additional backhaul bandwidth to support higher data rates

RNC

- Additional capacity
- Software upgrade

Core Network

- Additional capacity

HLR

- Extended QoS field for HSDPA devices (for data rates >8 Mbps)

Reference [4]

HSDPA Deployment Process

Assessment of existing R99 network

- Hardware configuration audit used to verify suitability for HSDPA

Analysis of existing R99 network performance

- Field measurement surveys to evaluate HSDPA performance
- Monitor and analyse network performance and used resources
  - Average used BS power for existing traffic
  - Mixed or separate carrier for HSDPA?
  - BS processing card, RNC, and Iub usage
  - Need for new elements?
  - SHO areas and overhead analysis provide information for planning HSDPA mobility and performance

HSDPA performance target definition and selection of deployment strategy

- Several design and upgrade options for coverage and capacity
- Depends on strategy and traffic load in existing R99 network
- When, how and where HSDPA is deployed into the network

Configuration and capacity planning

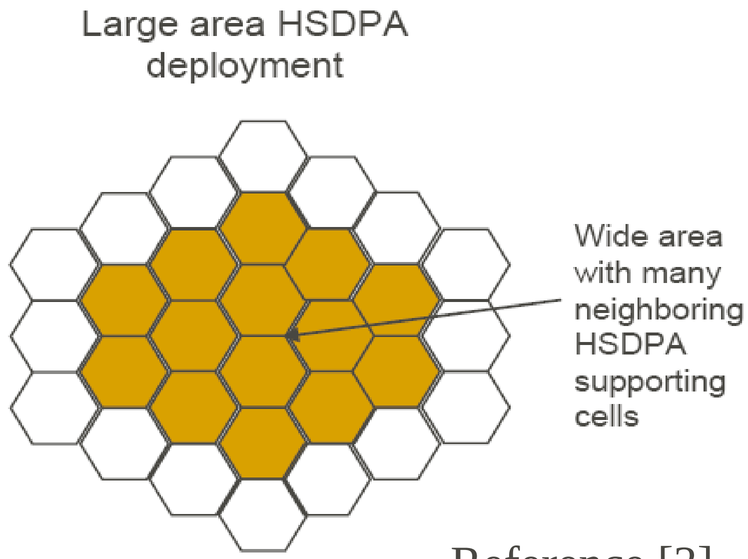
- Iub interface and Base Station configurations based on
  - Selected HSDPA deployment strategy
  - Cell average throughput requirements
- For each Base Station
  - Carrier configuration (single or multi?)
  - HSDPA capable HW for traffic processing
  - Iub capacity and ATM or IP configurations
- RNC
  - Feature activation and management on cell basis
  - HW processing capacity, interface capacity

Definition of parameter sets for HSDPA capable cells

- Parameter values should be chosen according to the dimensioning calculations and the approach chosen for HSDPA service quality
- Different for different site types
- Values should be updated as the traffic load evolves

HSDPA Deployment
Coverage Options – Full Coverage

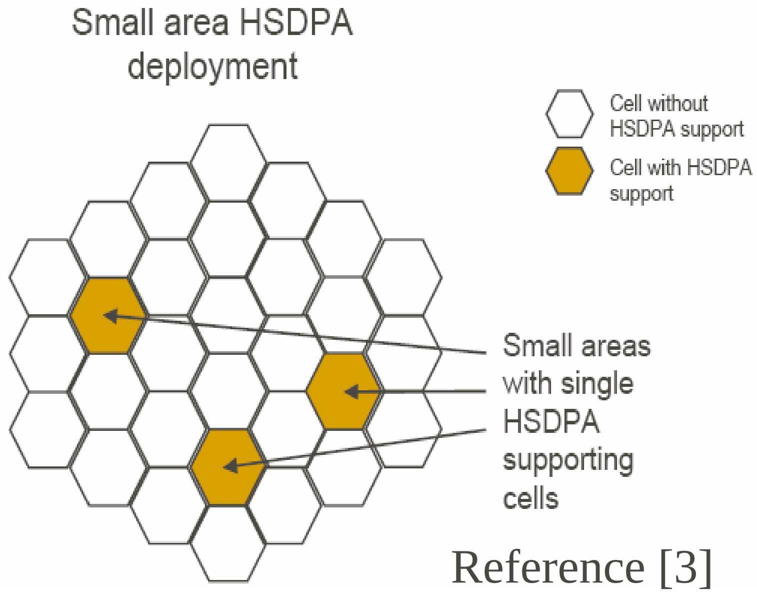
- Reduced UL coverage may arise due to interference
  - Interference issues need a lot of attention
- Mobility has to work well
  - Optional features may be required from vendors
- Inefficient radio and transmission capacity allocation
- Expensive to allocate HSDPA in all cells
  - Not suitable for cost efficient operation in the initial roll-out of HSDPA



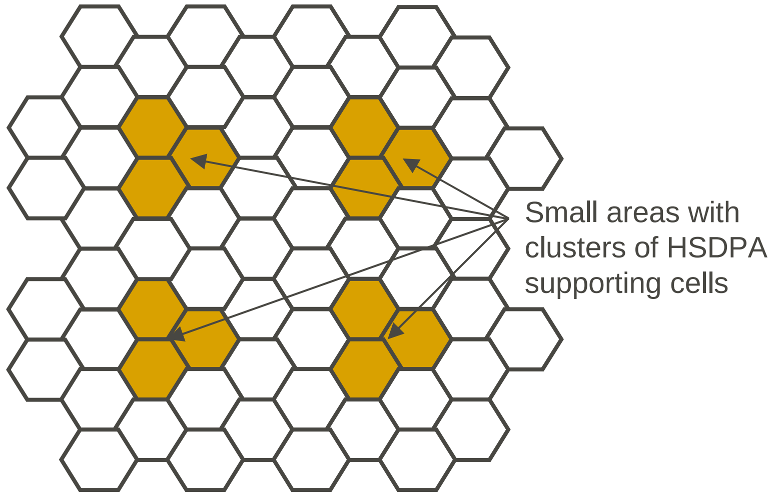
Reference [3]

HSDPA Deployment
Coverage Options – Hotspot and Cluster Coverage

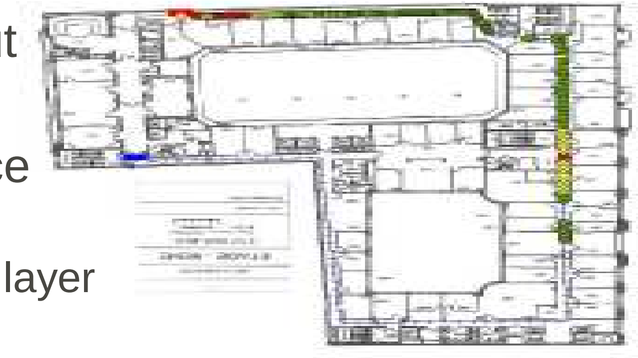
- HSDPA allocated for already high R99 NRT DCH usage areas
  - Based on UMTS and GSM network traffic measurements
- Some mobility features needed but not necessarily for the basic operation
  - HSDPA <-> DCH transitions need support from vendors
  - Cluster coverage may need some mobility support
- Cost efficient for HSDPA roll-out as the capacity is added to those cell having highest possibility for HSDPA traffic



Reference [3]



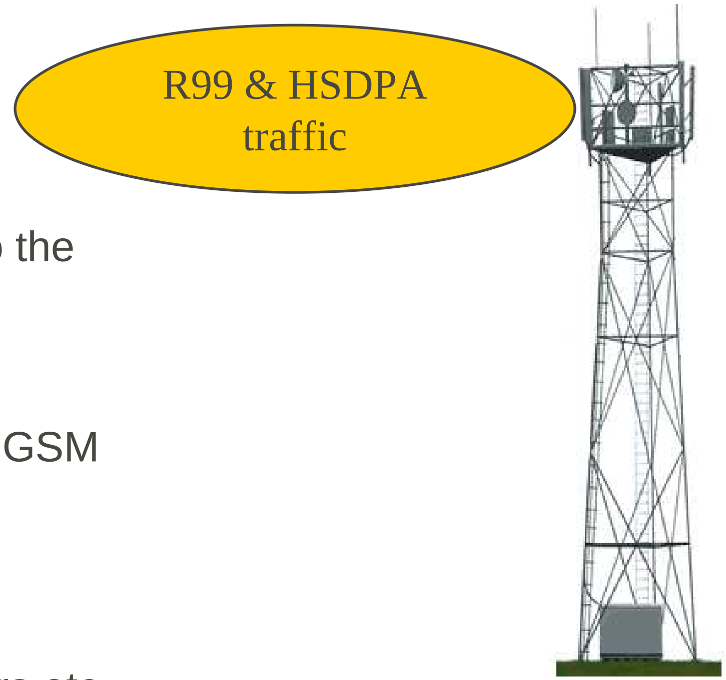
HSDPA Deployment
Coverage Options – Indoor Coverage



- Can potentially offer high average HSDPA throughput
  - Dedicated carrier frequency is useful
- Performance depends on SINR (Signal to Interference and Noise Ratio) conditions as in macro cells
  - Good isolation (=Geometry factor) from the macro cell layer
- Implementation options: Active or passive DAS, Repeaters, Indoor pico cells
- High number of antennas connected to the DAS (Distributed Antenna System) leading to cable losses
  - High power need to be assigned to HSDPA
- HSDPA indoor link budget should take into account the following
  - Low downlink transmit power radiated by the DAS
  - High orthogonality reducing the level of the cell's interference
  - Lack of soft handover gain
  - No fast fading margin due to no power control
  - Reduced slow fading margin
  - Potentially high level of inter-cell interference from the macro cell layer

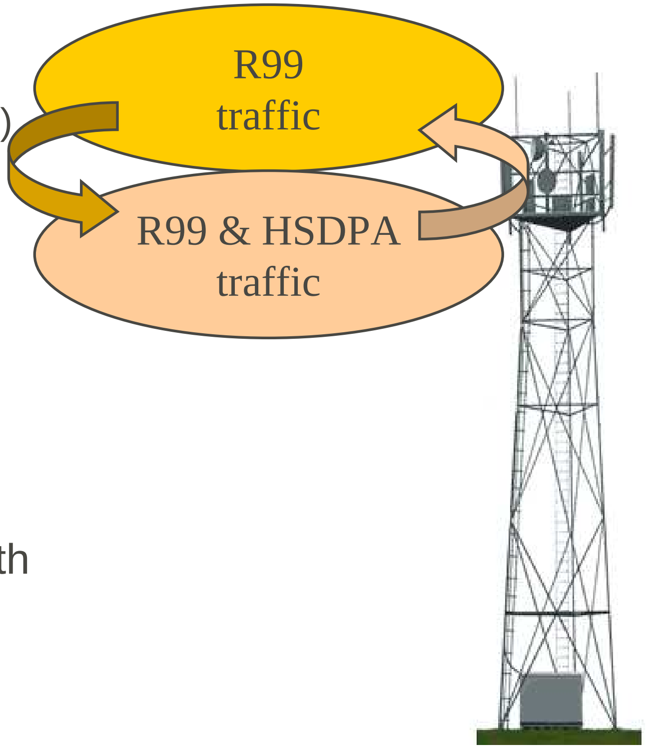
HSDPA Deployment
Layering Options – Single Layer (1 Carrier)

- Shared UMTS carrier for HSDPA and R99 DCH traffic
  - BS power shared for CCH, R99 DCH, and HSDPA traffic
- Effect on R99 DCH users must be considered
  - Suitable for cells with low to medium R99 traffic
  - Traffic measurement data required for decisions
  - R99 DCH traffic QoS should not decreased due to the introduction of HSDPA into the network -> some prioritisation rules needed
  - CPICH Ec/No degradation -> UEs might camp on GSM
- Cost efficient solutions
  - Initial network set-up for most operators
  - No extra costs such as amplifiers, filters, combiners etc… needed for implementing additional carriers to BTSs



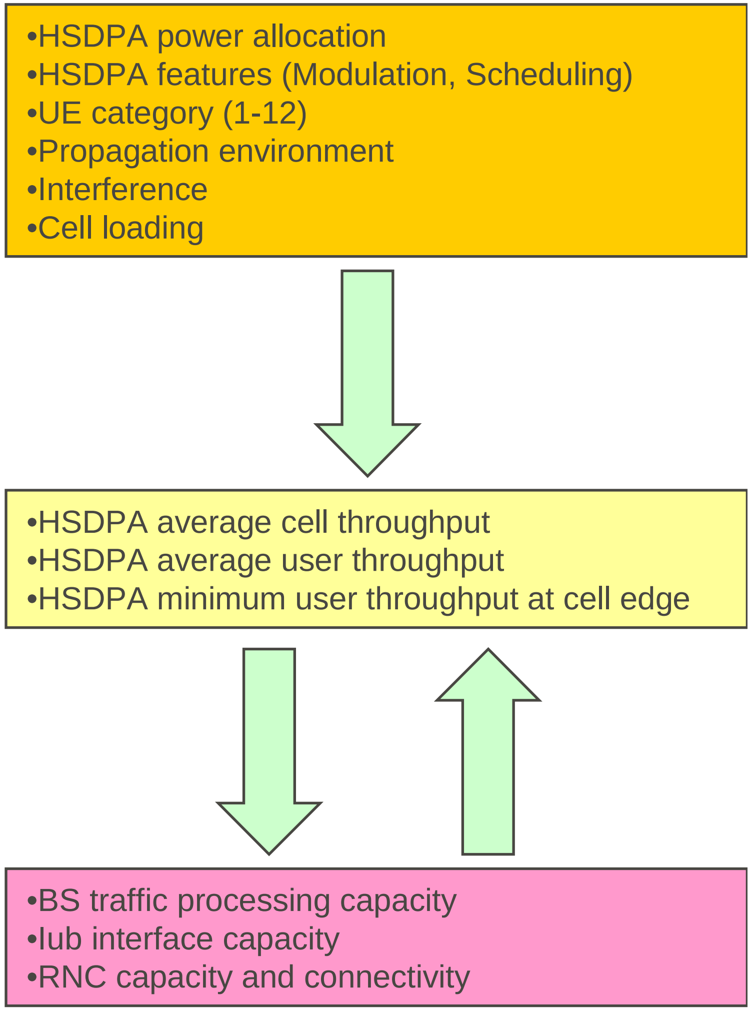
HSDPA Deployment
Layering Options –Multiple Layers (2-3 Carriers)

- 1st carrier can be dedicated for R99 DCH traffic
- 2nd carrier can be fully or partly allocated for HSDPA enhanced capacity and performance
  - More carriers are added to high traffic areas (Hotspots/Cluster)
  - Based on traffic predictions and measurements
  - Dedicated carrier if there is high R99 traffic in the area
- BS power resources for R99 DCHs better guaranteed
- HSDPA users directed or handed over to a second carrier
- Additional BS equipment needed for 2nd carrier -> costs
- Fully dedicated HSDPA carrier is not a practical solution with the current handover and load control features vendors are offering
- Multiple mixed carriers with R99 & HSDPA traffic would be cost efficient solutions for the operator but vendors do not have adequate service and load sharing features



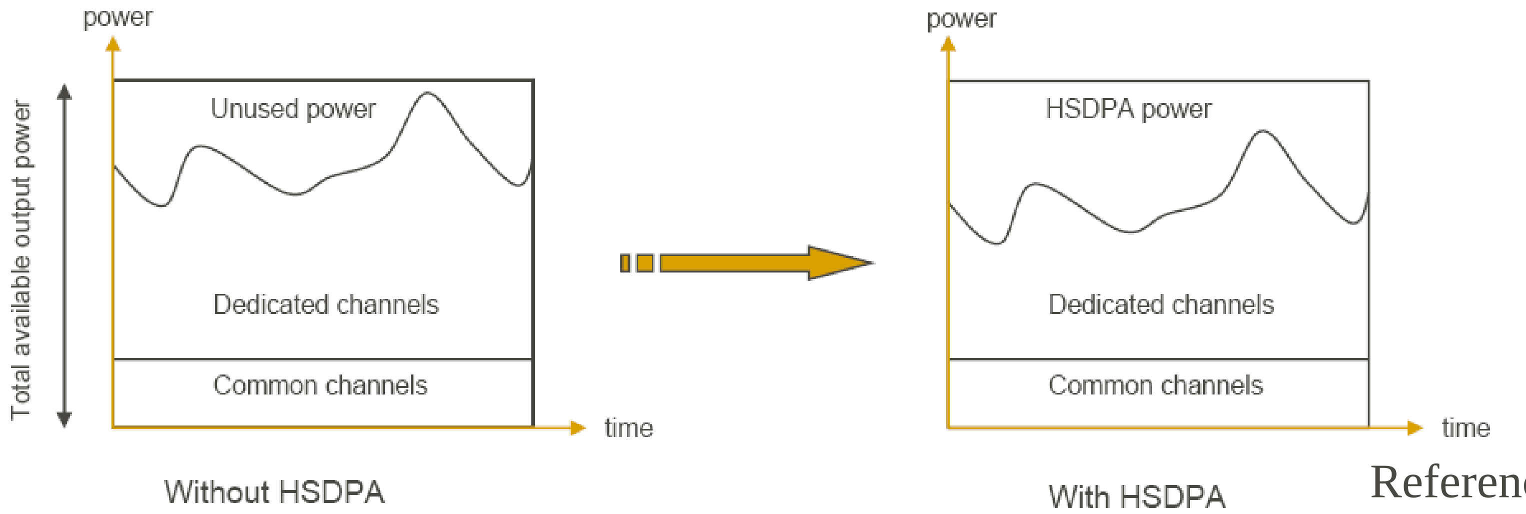
HSDPA Cell Planning
General

- Aims to the best HSDPA coverage, capacity and performance
  - Depends on radio propagation and SINR conditions
  - Clear dominance areas and good cell isolation
  - Not too large SHO areas (HSDPA does not work in SHO)
- Geometry factor is one of the most important parameters affecting the HSDPA throughput $G = \frac{I_{or}}{I_{oc}}$
  - Own cell total wideband received power, Ior
  - Other cell total received power plus noise power, Ioc
- R99 network should be planned well for high HSDPA performance
  - Interference from neighboring sites should be limited
  - Not too excessive soft or softer handover (SHO) areas
  - SHO overhead more crucial for HSDPA than for R99 traffic
- High-rise overlay sites on the same carrier should also be avoided
- The best HSDPA performance is achieved in line of sight scenario



HSDPA Cell Planning
BS Power Usage

- HSDPA can use the remaining output power not used by R99 DCHs
- Implies possibilities for a more efficient usage of the available BS output power



Reference [3]

- To achieve good performance in a WCDMA network all parameters determining interference levels need to be well tuned
- Increased average BS output power can increase the inter cell interference in WCDMA, and can then impact the overall system capacity

HSDPA Cell Planning
Air Interface Dimensioning

- The most important dimensioning target for HSDPA is the average throughput
  - Depends on the amount of power allocated for HSDPA
- How much power should be allocated for HSDPA?
  - Enough to achieve the HSDPA throughput targets
  - Some power should be reserved for R99 DCH traffic
- HSDPA downlink data is carried on a shared channel
  - Different variables have to be considered in HSDPA dimensioning as in NRT DCH data bearer dimensioning

HSDPA Cell Planning
Air Interface Dimensioning - Coverage and Throughput

- HSDPA can enable a wider coverage than R99 due to the adaptive modulation, coding and the fast scheduler in the BS
  - Works at the cell border of a R99 DCH, but the user throughput can vary significantly
- Throughput is not a single concept in HSDPA
  - Average HSDPA cell throughput for single users
  - Minimum throughput at the cell edge for a single user
  - Average HSDPA users throughput
- HSDPA coverage can be understood as a combination of these and all of them can have different dimensioning targets
- The average HSDPA cell throughput and the minimum throughput at the cell edge for a single user are not dependent on the number of simultaneous HSDPA users in the cell
  - Commonly used to set the dimensioning target for HSDPA coverage
- HSDPA throughput depends directly on the radio channel conditions
  - Changing rapidly all the time due to the fast fading of the radio channel (BS uses link adaptation)
  - The achieved throughput is different in every TTI (2 ms)
- Average throughput in a certain location can be estimated if the average SINR is known

HSDPA Cell Planning
Air Interface Dimensioning – UL Link Budget

- Normal WCDMA UL link budget calculation
  - Coverage is uplink limited
- The UL data of the HSDPA connection is carried on an associated DPCH, which is a normal NRT data bearer
  - 64, 128 and 384 kbps usually supported by the vendors in UL
- Additional margin is required in the UL link budget to take into account the power requirements of HS-DPCCH
  - Depends on the UL bearer data rate

Reference [3]

HSDPA Cell Planning
Air Interface Dimensioning – DL Link Budget

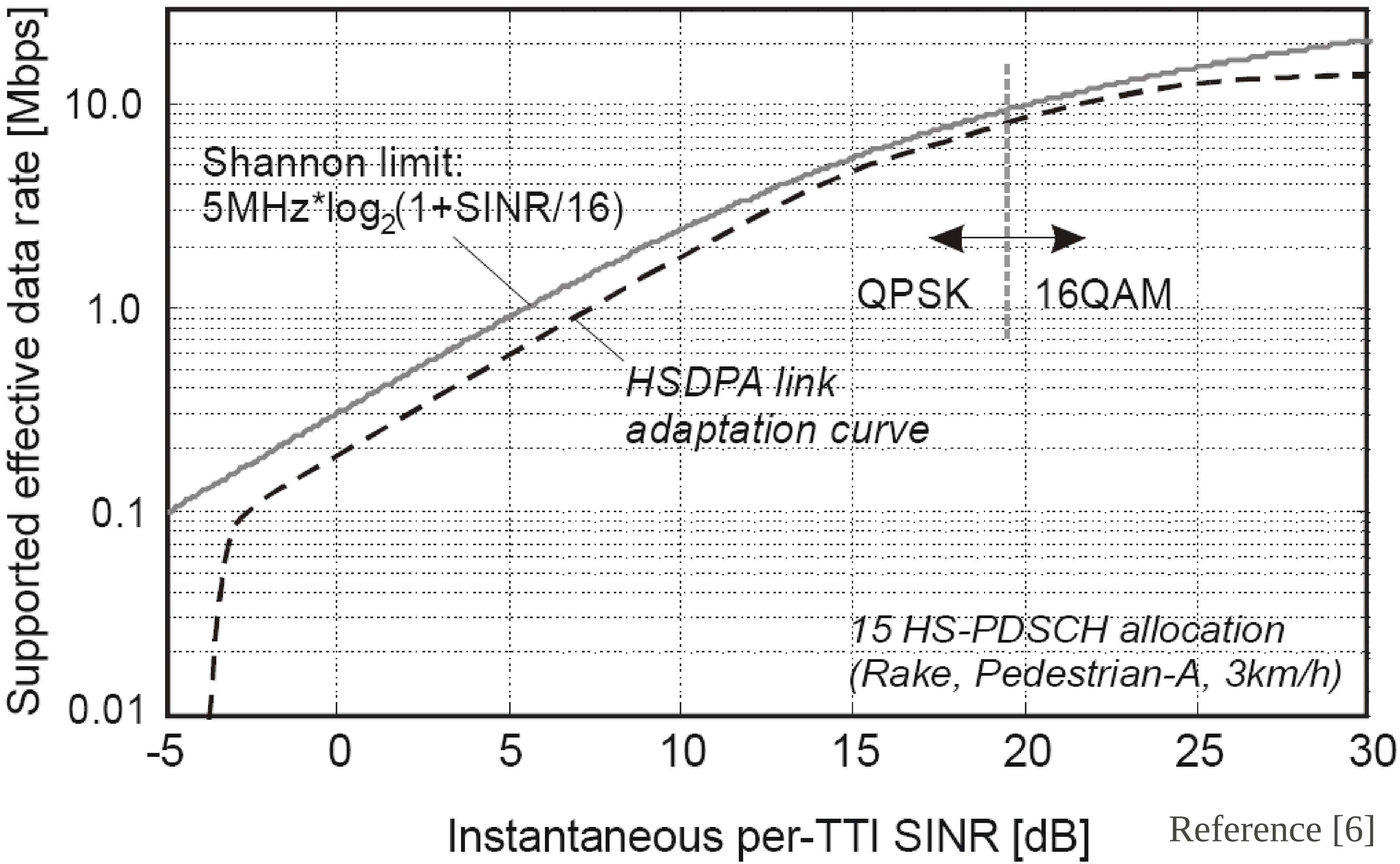
- Using Eb/No or Es/No in the link budget would require that the bitrate or the number of codes is known
  - Bitrate and number of codes can change in every TTI (2 ms)
- Average SINR allows to create DL link budget for HSDPA
  - Does not depend on bitrate or number codes for HSDPA
  - Can be calculated when HSDPA power, BS total TX power, orthogonality and G-factor are known

$$SINR = SF_{HSDPA} \times \frac{P_{HSDPA}}{P_{TOT\_TX}\left[1-\alpha+\frac{1}{G}\right]}$$

  - SF_{HSDPA} is the Spreading Factor (16)
  - P_{HSDPA} is the allocated transmission power of HS-PDSCH
  - P_{TOT_TX} is BS total power, including HS-PDSCH and HS-SCCH powers
  - α is the DL orthogonality in certain location in the cell
  - G is geometry factor

Base Station		
Max Tx Power (HSDPA)	6.5	W
Max Tx Power (HSDPA)	38.1	dBm
Tx Antenna Gain	18	dBi
Cable Loss	4	dB
EIRP	52.1	dBm
Receiver - Handset		
Handset Noise Figure	8	dB
Thermal Noise	-108	dBm
Background RSSI	-100	dBm
Planned DL load	87	%
Interference Margin	8.9	dB
Interference Floor	-91.1	dBm
SINR	2.1	dB
Service processing gain	12.0	dB
Rx Antenna Gain	0	dBi
Body Loss	0	dB
Receiver Sensitivity	-101.1	dB
DL Fast Fade Margin	0	dB
DL Soft Handover Gain	0	dB
Max. Path Loss	**153.2**	dB

HSDPA Cell Planning
Air Interface Dimensioning - Coverage and Throughput



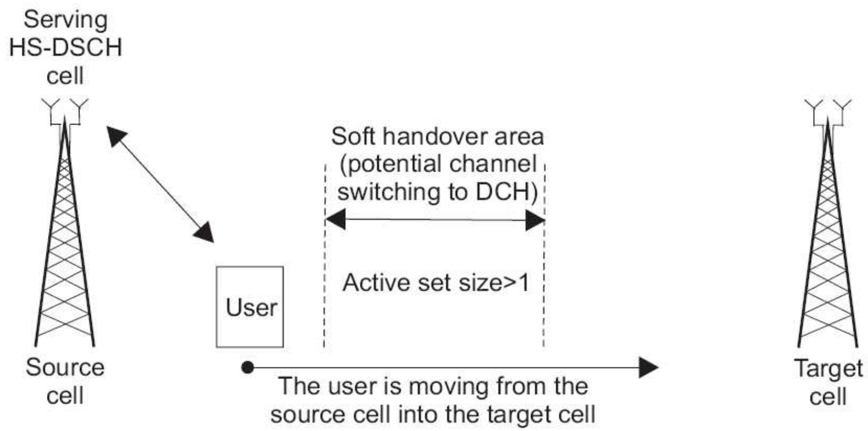
Reference [6]

HSDPA Cell Planning
Key Parameters for HSDPA

- HSDPA transmission power depends on the implementation strategy, HSDPA throughput targets and DCH traffic load
- For a mixed R99 and HSDPA traffic power is around 4 to 7 W
- For a dedicated HSDPA carrier power is around 10 to 12 W
  - Assumed that maximum transmission power of the BS is 20 W
- Power must be high enough to handle traffic and signaling channels
- Radio channel affects to the amount of power needed
- No power control for HSDPA power
- Too low power leads to no or low throughput
- Low cell power can be handled via more codes and lower code rate
- Too high power leads to possible overload situation and interference

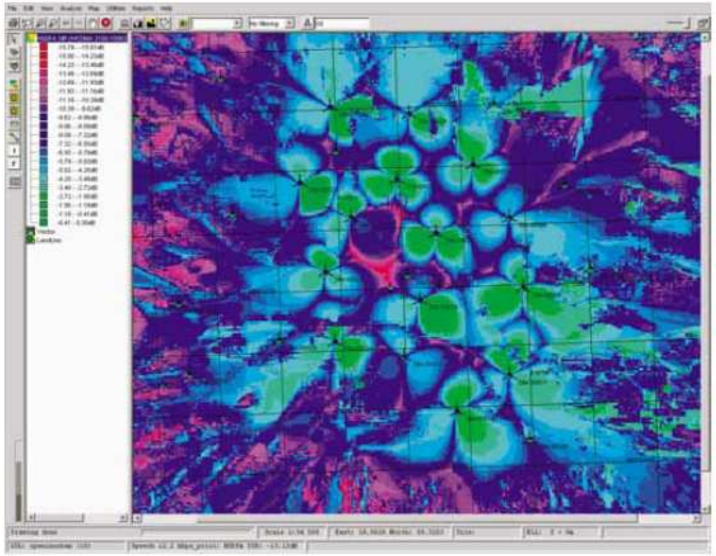
HSDPA Cell Planning
Key Parameters for HSDPA

- Admission thresholds for DCH and HSDPA users
- Priority parameters between for DCH and HSDPA users
- Mobility parameters
  - Soft handover (SHO) is not applicable to HSDPA
  - Possible interruptions in the data transmission
  - Option 1, Channel switching between HS-DSCH and DCH (R99/R4)
  - Option 2, Change of serving HS-DSCH cell
  - Separate Soft handover (SHO) parameters can be applied for HSDPA if supported by network vendor



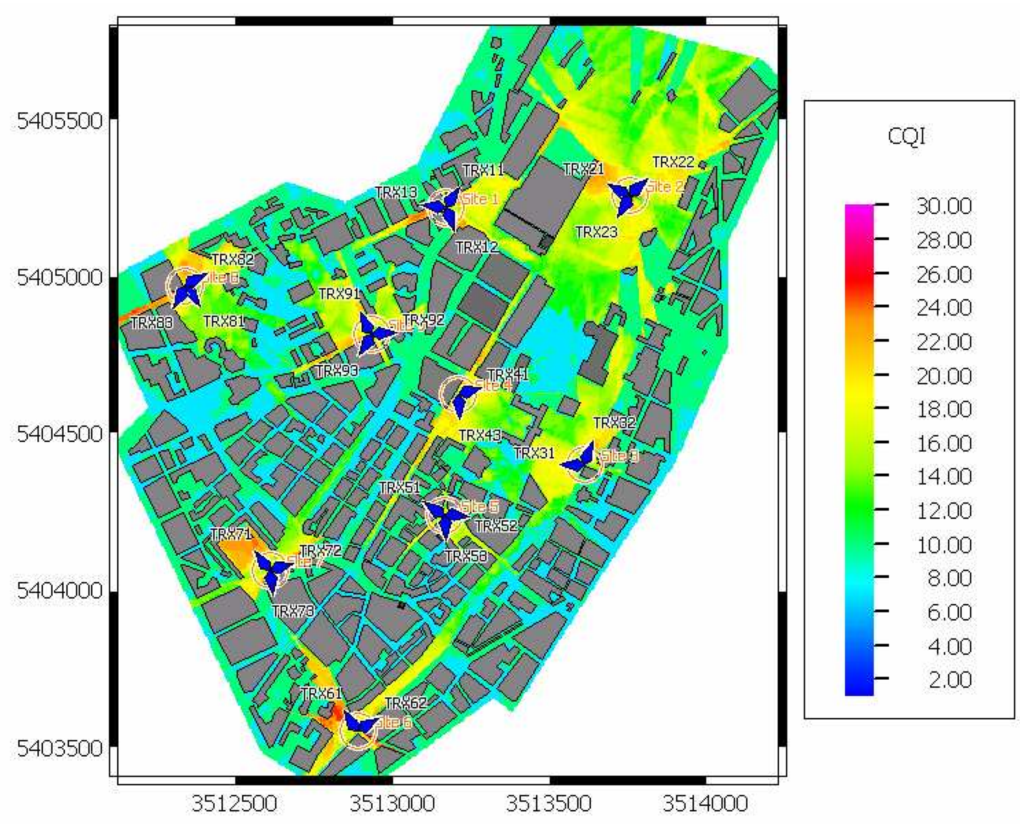
HSDPA Cell Planning
Planning Tools

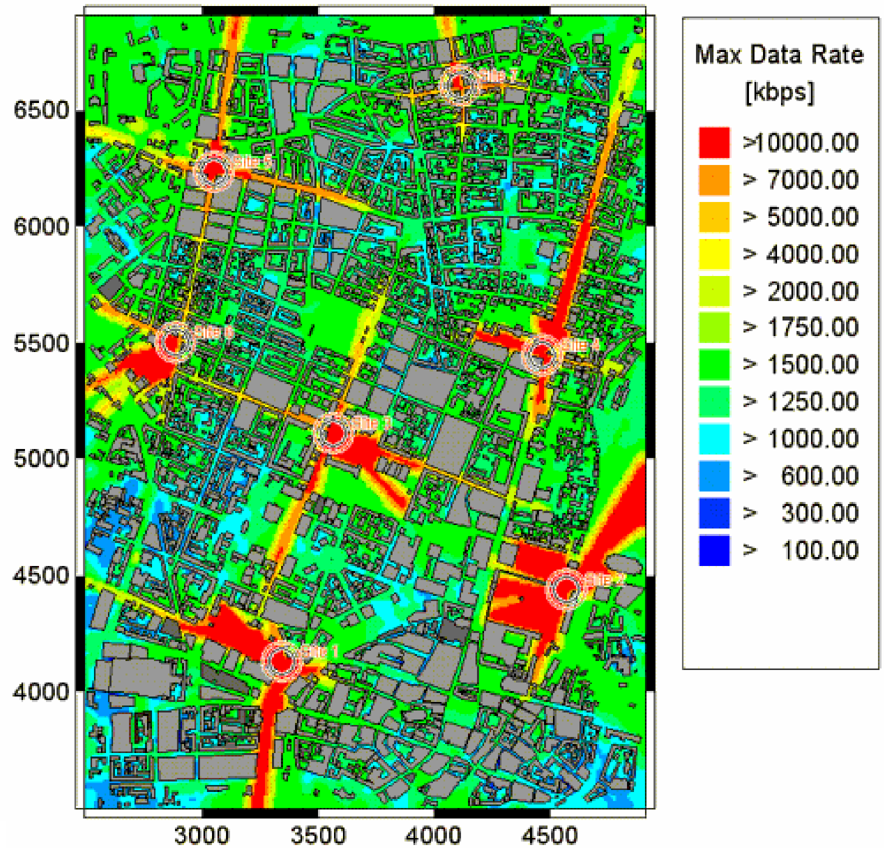
- Should provide the planner with HSDPA network coverage, quality, and capacity figures
  - HSDPA equipment modelling including modulation schemes and throughputs vs. pilot C/I
  - HSDPA activation at cell or cell group level
  - HSDPA throughput prediction plot
  - CQI prediction plot
  - Ec/No HS-PDSCH prediction plot
  - HSDPA SIR plot
- Can be based on
  - Basic DL power estimates for HSDPA or
  - Monte-Carlo Simulations
    - Accurately model HSDPA capabilities
    - Random user distribution and simulation of HSDPA-related radio channels
    - Simulation provides coverage- and capacity related plots and statistics for use in HSDPA planning
- Atoll, TEMS CellPlanner (Ericsson)



Example plot for HSDPA.

HSDPA Cell Planning
Planning Tools





Summary

- HSDPA offers high data rates for end-users and cost efficient capacity enhancement to the WCDMA radio network
- HSDPA requires investments to R99/R4 UMTS (WCDMA) network elements
- Before implementing HSDPA the R99 network needs element and performance audit to make sure HSDPA can be efficiently deployed
- HSDPA strategy and performance targets need to be defined before detailed configuration, capacity and parameter planning can be executed
- HSDPA coverage and layering options for specific areas need to be desided by the operator with the costs and vendor feature restrictions in mind
- HSDPA performance depends on radio propagation, SINR conditions, cell dominance area, cell isolation, and SHO overhead
- The most important dimensioning target for HSDPA is the average throughput
- SINR requirement is more useful in link budget than Eb/No requirement
- HSDPA TX power, admission, priority, and mobility parameters are important

References

[1] Holma, Toskala, “WCDMA for UMTS”, John Wiley & Sons, 2004.

[2] Qualcomm, “HSDPA for Improved Downlink Data Transfer”, 2004

[3] Ljung, “Identifying And Overcoming The Strategic And Technical Constraints On HSDPA Deployment”, Planning and Deploying HSDPA, IIR Conference, Amsterdam 2005

[4] Malcolm Read, “Implementing HSDPA – Costs and Opportunities, Planning and Deploying HSDPA”, IIR Conference, Amsterdam 2005

[5] Thomas Baumgartner, ”HSDPA Planning and Deployment”, IIR Conference, Amsterdam 2005

[6] Jussi Kähtävä, “WCDMA evolution with HSDPA”, CIC 2004, Korea

Homework

- What is the maximum pathloss for HSDPA service?
  - HSDPA transmission power, P_{HSDPA} = 5 W
  - Base station antenna gain = 16,5 dB
  - Base station cable loss = 3 dB
  - Mobile receiver noise figure = 7 dB
  - Planned DL load = 75 %
  - Minimum SINR requirement = 2,5 dB
  - Service processing gain = 12 dB
  - Rx antenna gain = 2 dBi
  - Body loss 1 dB
- Why soft handover gain cannot be used for HSDPA DL link budget?
- Why is SINR useful in HSDPA DL link budget?