Dimensioning of WCDMA radio network subsystem for determining optimal configurations

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Agenda

- Background
- Research problem
- Definitions
- Review of prior research
- Simulations
- Conclusions

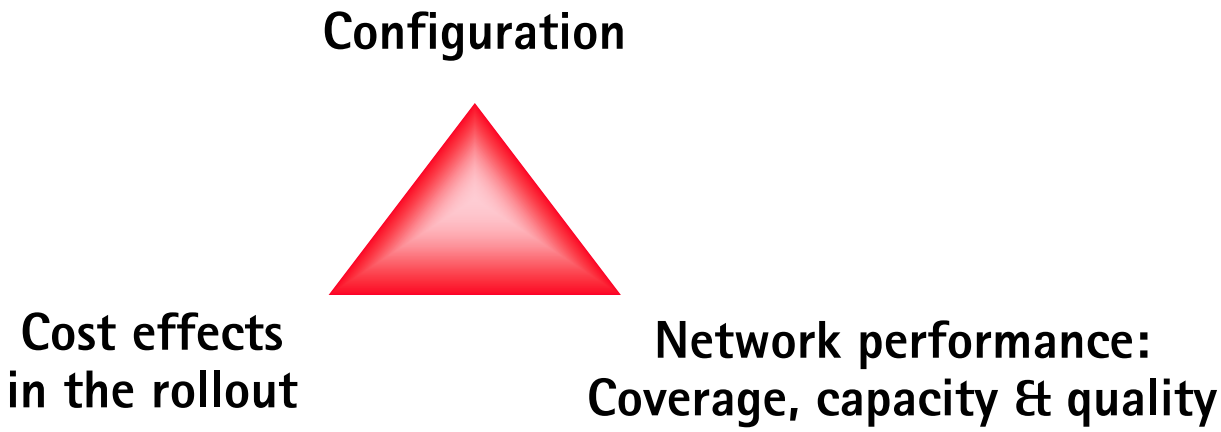
Background

- Strategic intent to rationalise and limit the number of configurations to the optimum
- Gained benefits
  - in supply logistics
  - shorter lead times in delivery
  - reduced inventories and obsolescence risk
  - reduced costs during the network life cycle in O&M, spares, etc.

  $\Rightarrow$ higher margin for the supplier, lower OPEX for the operator
- However, by limiting the variety of HW elements of different properties, the risk of impoverishing the offerings portfolio increases and the cost-performance ratio of the overall network is compromised resulting in less competitive solutions

Research problem

- Triangular framework where the configurations are interconnected with the achievable network performance and resulting cost
- The challenge is to find limited number of cost efficient configurations that meet the defined performance requirements



Definitions

- The scope of research includes base station configurations and access network transmission
  - The number and configuration of base stations drive both the performance and cost of the overall network
- Configuration refers to an assembly of base station structural elements, antenna system, and transmission equipment
- Costs are considered as configurations' characteristic impact on the required CAPEX in the rollout

Review of prior research (1/2)

- BTS site sectorisation increases offered capacity and coverage probability, also lower transmit powers are possible. However, for a cluster of cells increasing other to own cell interference *i* and SHO overhead limit the optimal sectorisation

⇒ Best performing site types in macro cellular environment*:
  - 3-sector 65° 3dB antenna beam width
  - 6-sector 33° 3dB antenna beam width

- In addition comparisons include
  - 2-sector site (in particular for highway coverage)
  - 4-sector site
- Impact of site solutions SRC** and MHA***, and also ROCs are examined
- Generally single layer macro cellular network the most cost efficient for rollout

* Source: Wacker et al.: *The Impact of Base Station Sectorisation on WCDMA Radio Network Performance*, IEEE VTC 1999
** Source: Holma, Tölli: *Simulated and Measured Performance of 4-branch Uplink Reception in WCDMA*, Paper for IEEE VTC 2001
*** Source: Cooreman: *Masthead Amplifier (MHA) Benefit*, Network Planning Belgium, February 2001, Nokia Networks

Review of prior research (2/2)

- Currently two-thirds of access network transmission implemented with microwave radio*
  - Fast and cost-efficient rollout
- Depending on link length and how competitive prices are locally, also copper/leased lines may be the underlying media
- Fibre practically only in core, although the share of fibre expected to grow along with data traffic increase and all-IP
- Tree and chain topologies most common in GSM, loops for high capacity and important links**
- GSM CT TDM-based, whereas ATM specified as WCDMA transport technology
  - Operator decision between IMA/fractional E1 and ATM network

* Source: Whitepaper: *Microwave Radio Network Planning in 3G*, 2001, Nokia Networks
** Source: Törmä: *Cellular Access Network*, Planning Aspects of 3G Networks, Merito Forum Seminar, April 2001

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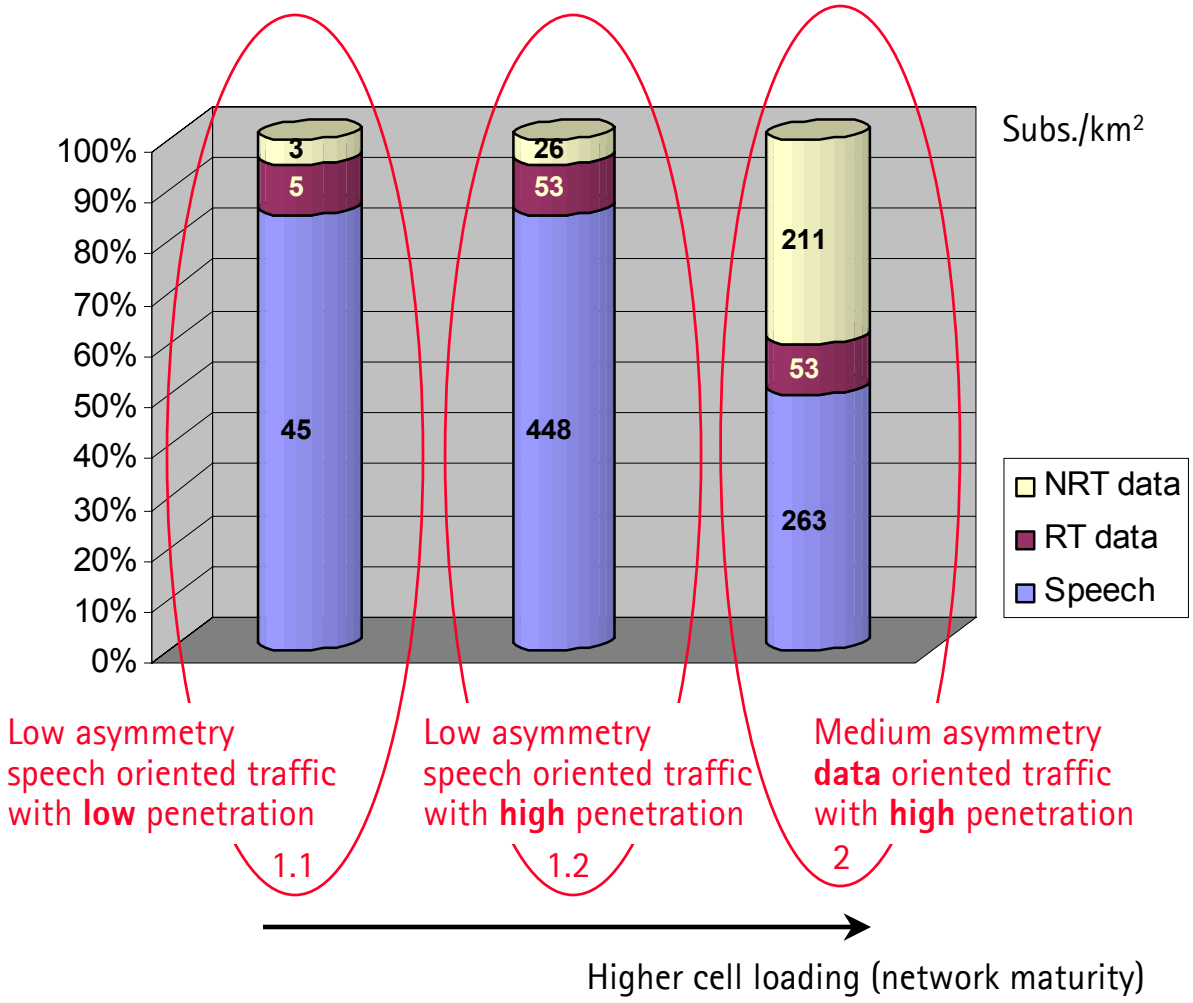
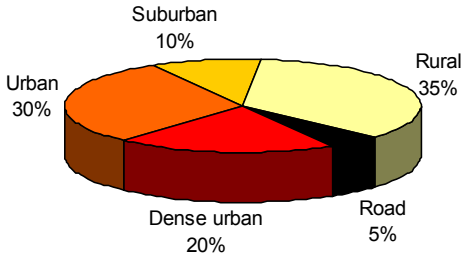
Simulations

Formulation of simulation cases

- The performance of each configuration measured by the required number of sites in the three network scenarios
- Reference for morphology classes and demographics is Helsinki/Espoo



300km² service area:



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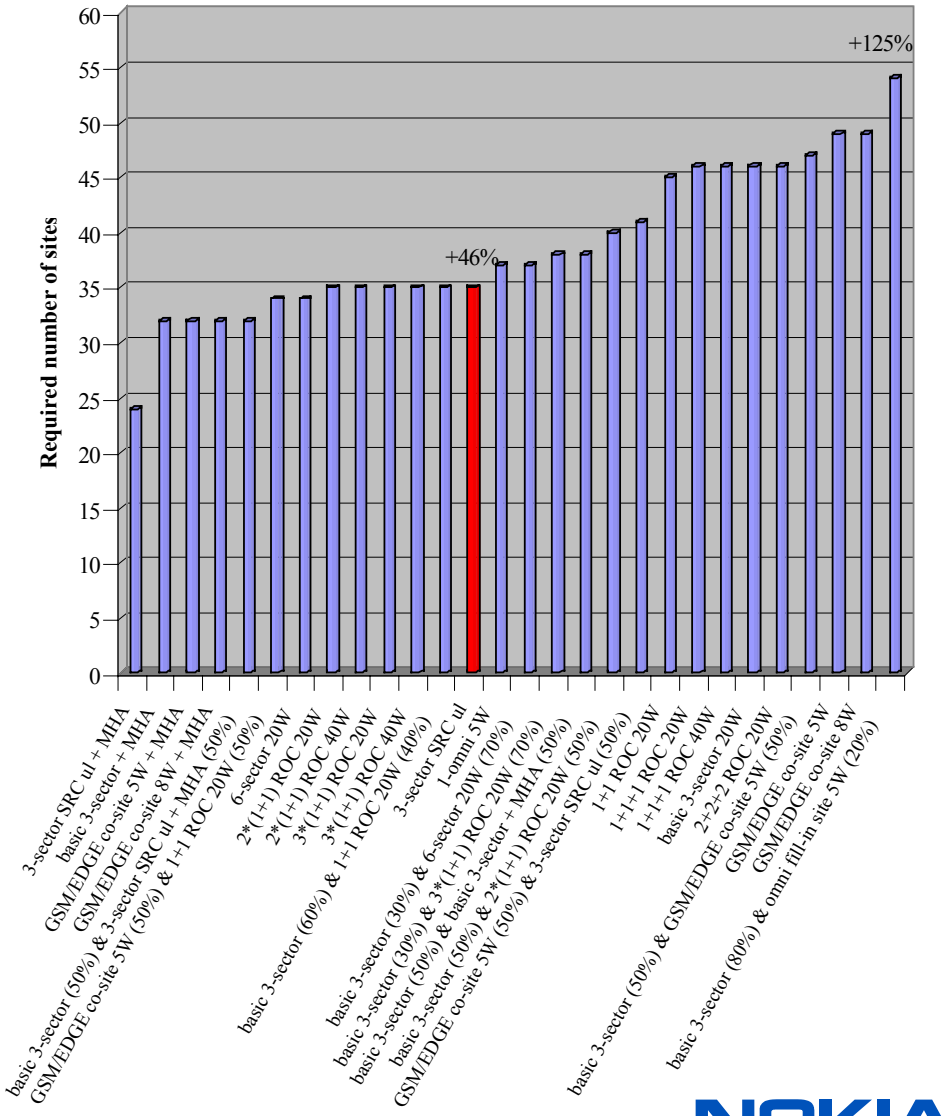
Traffic scenario 1.1

Low asymmetry speech oriented traffic with low penetration

- MHA has great importance against thermal noise in AWGN channel
- SRC & MHA together ensure high performance for 3-sector site
- Triple-mode GSM/EDGE/WCDMA cost efficient config
- 6-sector not recommended in low loading scenario (uplink load less than 10%)
- Configs UL load limited, thus low TX powers



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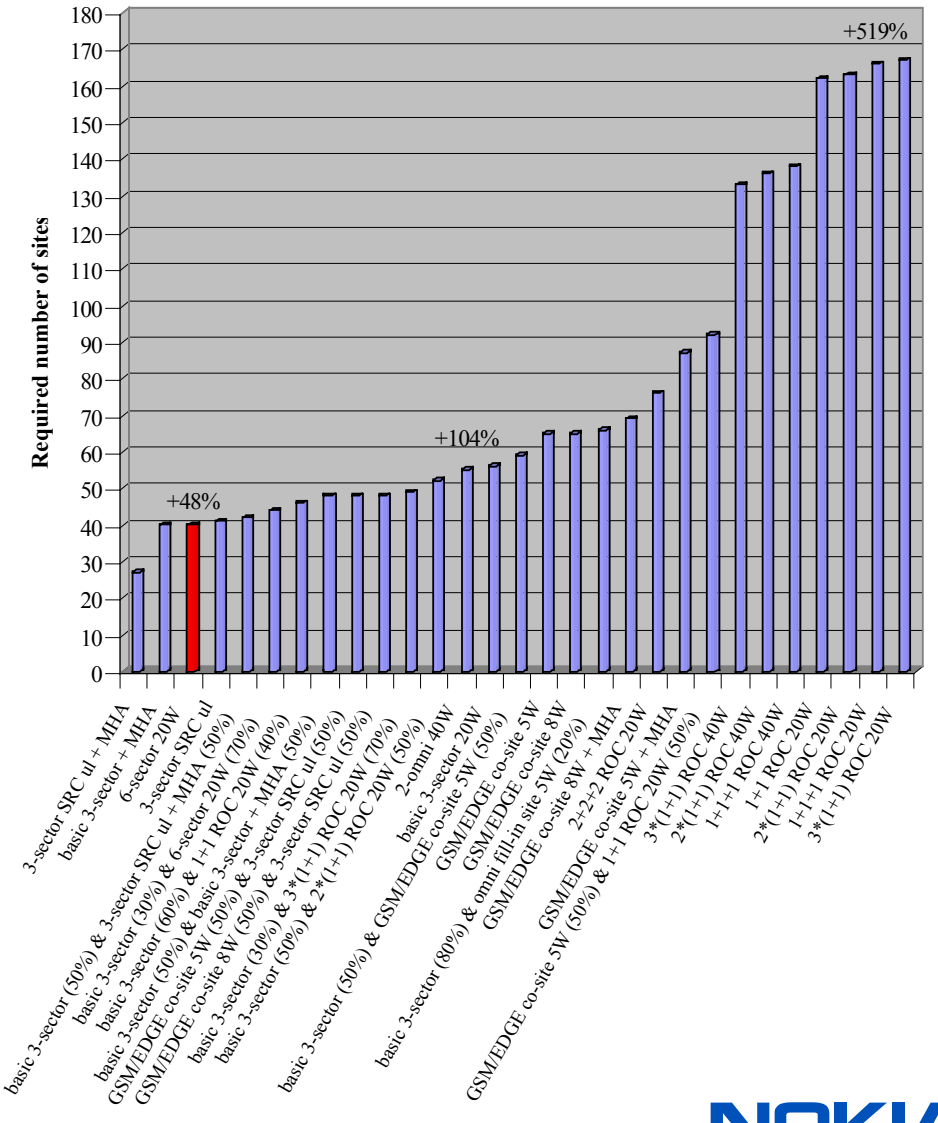
Traffic scenario 1.2

Low asymmetry speech oriented traffic with high penetration

- 3-sector site with SRC & MHA clearly the best alternative
- Top four configs utilise two or three carriers per sector
  → impact of available bandwidth on the operator's business case
- ROCs run out of capability to meet rising loads, uplink load at around 30-40%



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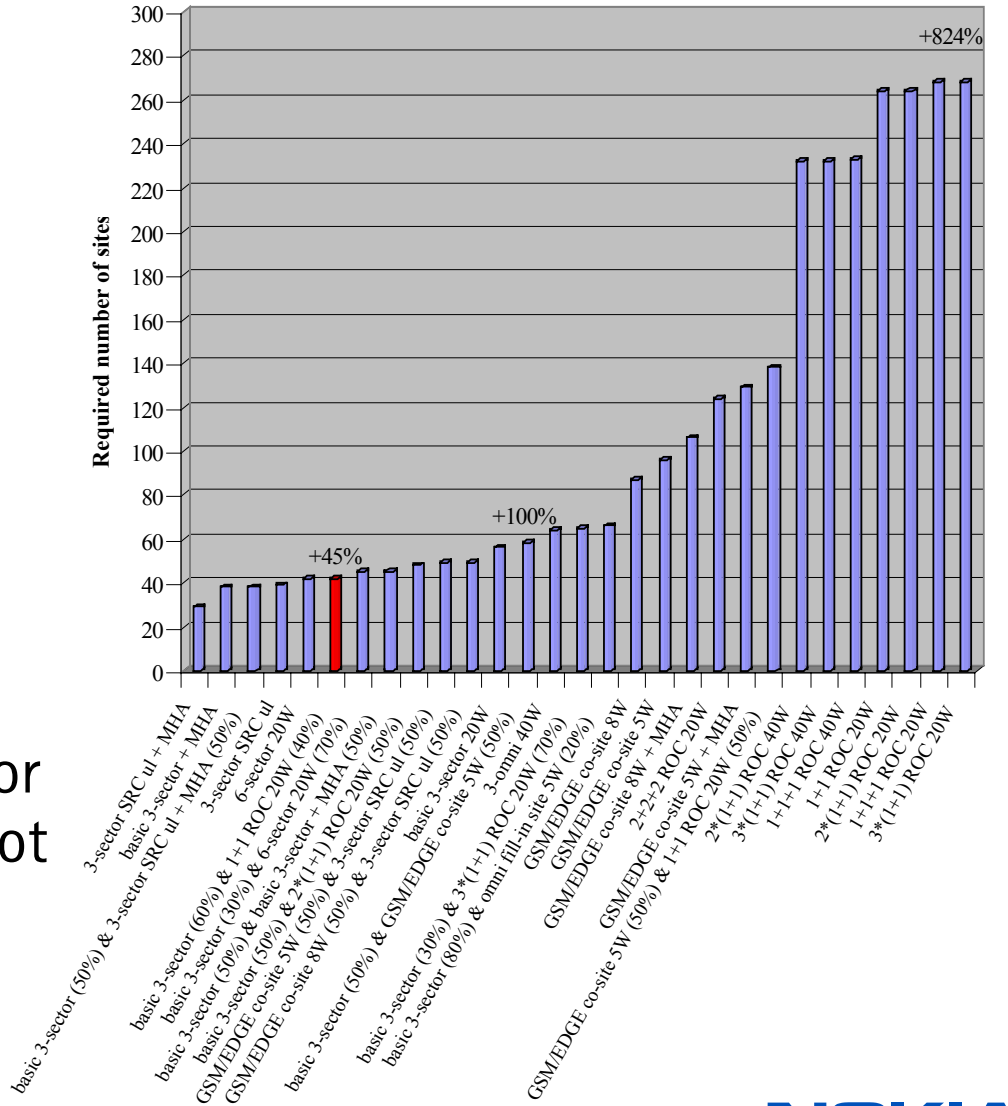
Traffic scenario 2

Medium asymmetry data oriented traffic with high penetration

- Configs TX power limited
- Transmit diversity, i.e. SRC dl, would drive the site count even lower
- 6-sector config's capacity assets fully used and therefore it is a valid alternative
  - in targeted urban and suburban areas,
  - where traffic is expected to concentrate and grow rapidly, or
  - as a mirco cellular layer for hot spots



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Cost-performance analysis

- Site count × cost per site

Traffic scenario 1.1

Configuration	Number of sites	Overall RAN cost impact
1. 3-sector triple-mode 5W + MHA	32	0.0%
2. 3-sector SRC ul + MHA	24	+10.9%
3. 3-sector 1+1+1 ROC	46	+22.9%
4. Basic 3-sector + MHA	33	+29.3%
5. 3-sector SRC ul	35	+32.4%
6. 3-sector triple-mode 5W	49	+32.6%
7. Basic 3-sector	46	+61.0%
8. 6-sector	34	+140.0%

Traffic scenario 1.2

Configuration	Number of sites	Overall RAN cost impact
1. 3-sector SRC ul	40	0.0%
2. 3-sector triple-mode 5W	65	+1.4%
3. Basic 3-sector + MHA	40	+2.7%
4. Basic 3-sector	56	+13.0%
5. 3-sector SRC ul + MHA	27	+15.9%
6. 6-sector	40	+62.9%
7. 3-sector 1+1+1 ROC	166	+155.9%

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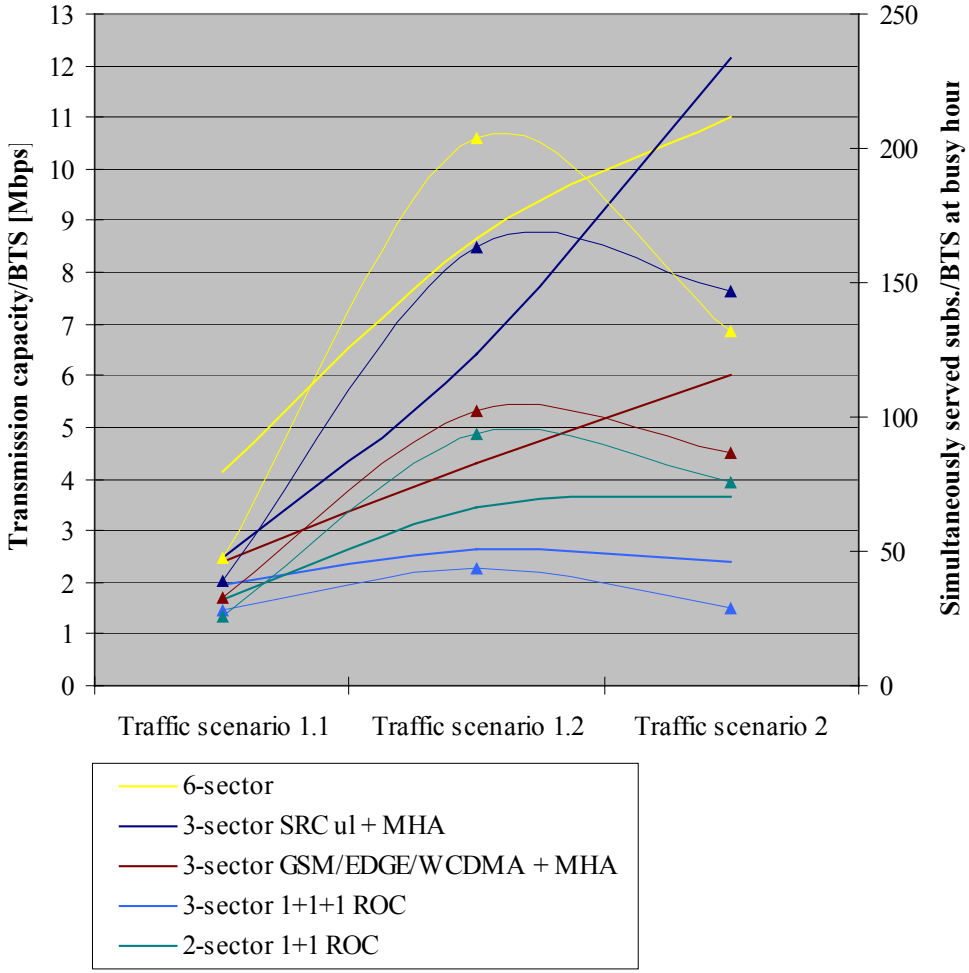
Transmission capacity development

- In the likely rollout scenario 1.1 relatively low capacities per BTS
  - Co-siting possible upon an existing topology and TDM-based CT network
  - 2×2M medium adequate
- Scenario 2 represents transmission capacity peak
- Based on the analysis 58GHz short haul MWR not in demand



Conclusions

NetDim results, general

- Selection of service mix has paramount effect on the required number of sites for given capacity, coverage, and QoS targets
- The site count can be minimised with diversity techniques, by adding carriers, and increasing transmit power
- In conservative loading scenario cost for capacity is high in WCDMA compared to GSM→GPRS→EDGE evolution path, because technological discontinuity to 3G demands higher investments regardless of the projected subscribers
- Optimal sectorisation for macro cellular environment is 3-sector site both from performance point of view and in terms of co-siting

NetAct results, general

- With low additional investment into transmission capacity the capability to serve simultaneous subscribers increases considerably
- As data traffic share breaks to 40%, transmission capacities per base station as high as 12Mbps at busy hour
- Despite of reuse of legacy equipment and existing media, dedicated WCDMA transmission is needed from the beginning
  - Higher capacities compared to max. of 1-2Mbps per GSM site
  - Higher site density
  - ATM transport

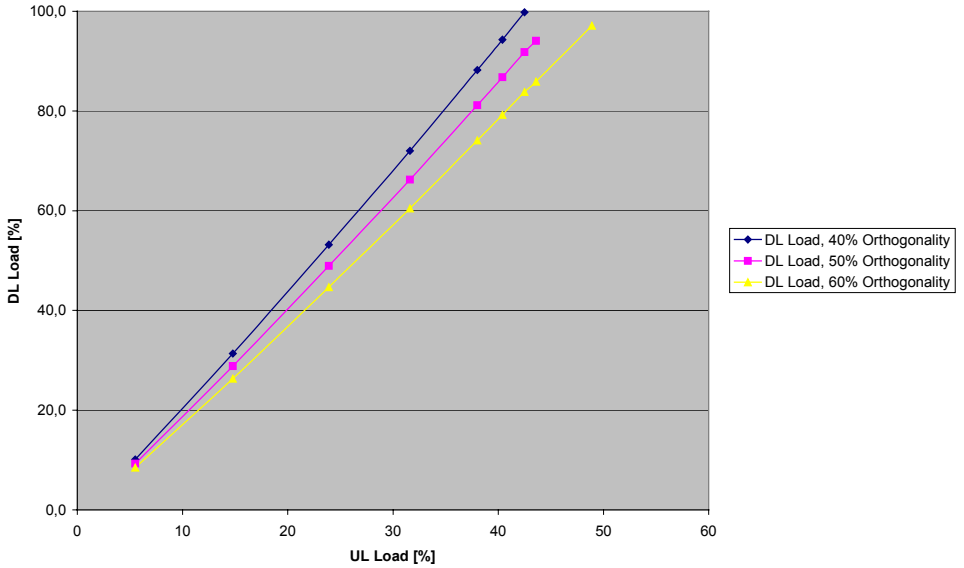
Optimal configurations

	Low asymmetry speech oriented traffic with low penetration	Low asymmetry speech oriented traffic with high penetration	Medium asymmetry data oriented traffic with high penetration
6-sector @ 20W per carrier, Antenna system: 33°/18dBi TRS media: SDH radio, leased lines, fibre			Config: 1+1+1+1+1+1 TRS capacity: 7×2M
3-sector ROC @ 20W per carrier, Antenna system: 65°/18dBi TRS media: PDH radio, leased lines	Config: 1+1+1 TRS capacity: 2×2M		
3-sector triple-mode GSM/EDGE/WCDMA @ 5W per carrier, Antenna system: 65°/18dBi, MHA TRS media: PDH radio, leased lines	Config: 1+1+1 TRS capacity: 2×2M		
2-sector ROC @ 20W per carrier, Antenna system: 120°/18dBi TRS media: PDH radio	Config: 1+1 TRS capacity: 2×2M	Config: 1+1 TRS capacity: 3×2M	Config: 1+1 TRS capacity: 3×2M
3-sector @ 20W per carrier, Antenna system: 65°/18dBi, SRC ul and MHA TRS media: PDH (SDH) radio, leased lines, fibre	Config: 1+1+1 TRS capacity: 2×2M	Config: 2+2+2 TRS capacity: 5×2M	Config: 3+3+3 TRS capacity: 7×2M

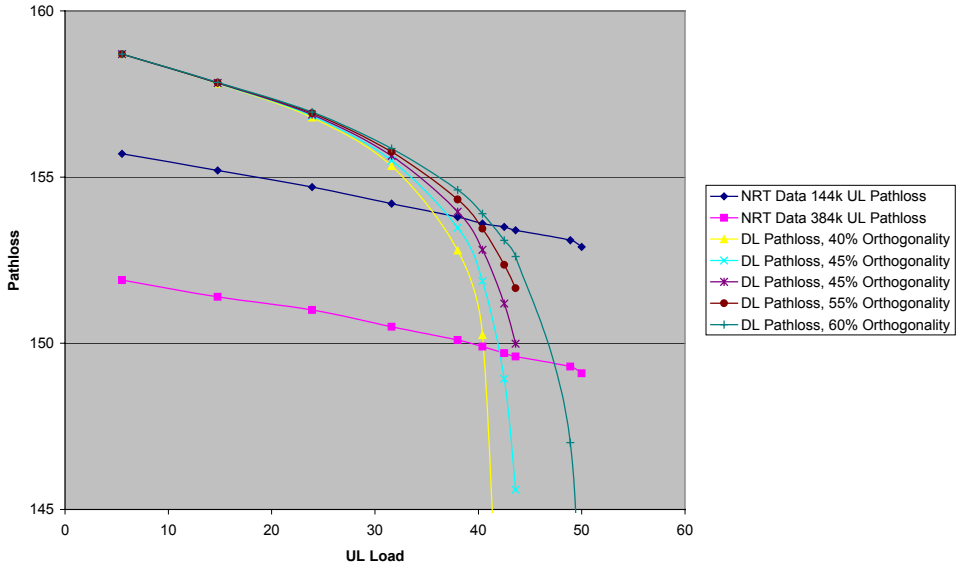
Support slides

Impact of DL code orthogonality

For a given maximum UL load, the greater orthogonality allows for higher DL load, i.e. more *capacity*



For a given maximum UL load, the greater orthogonality allows for higher tolerable path loss, meaning more *coverage*



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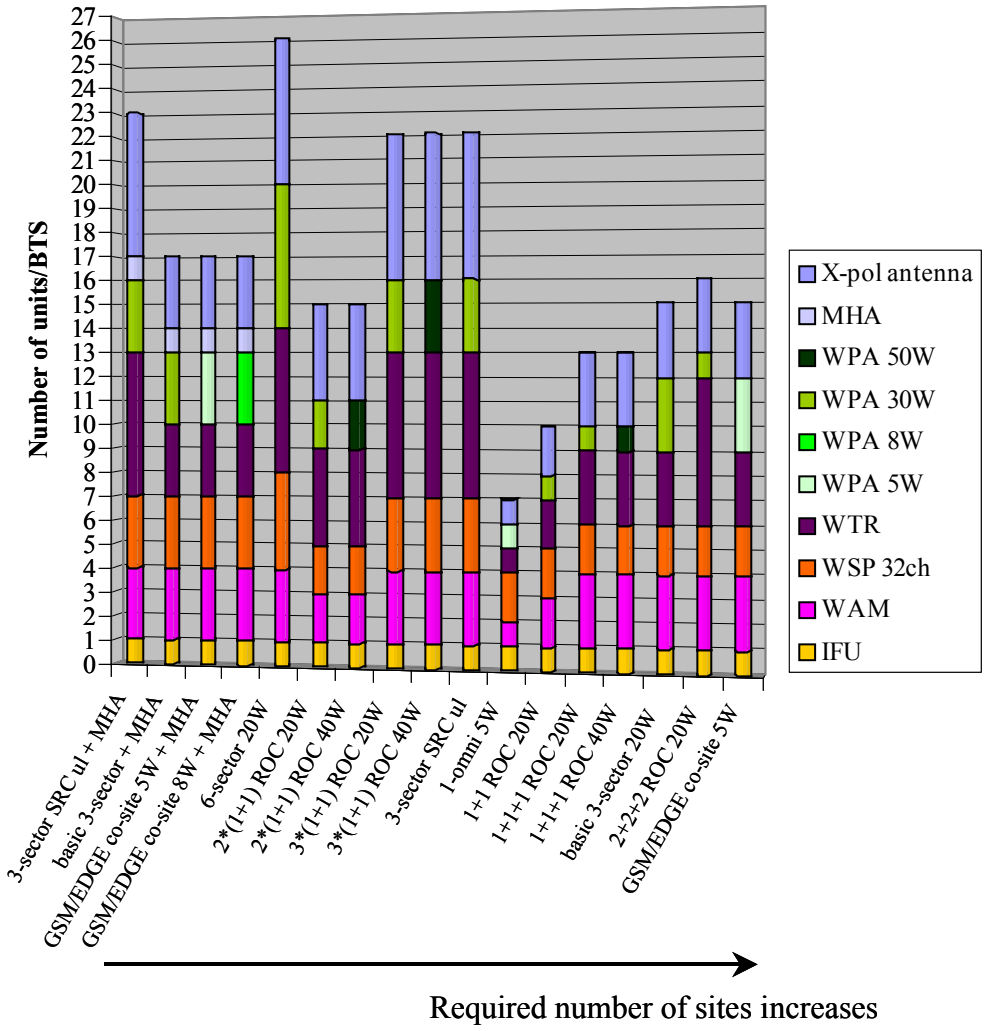
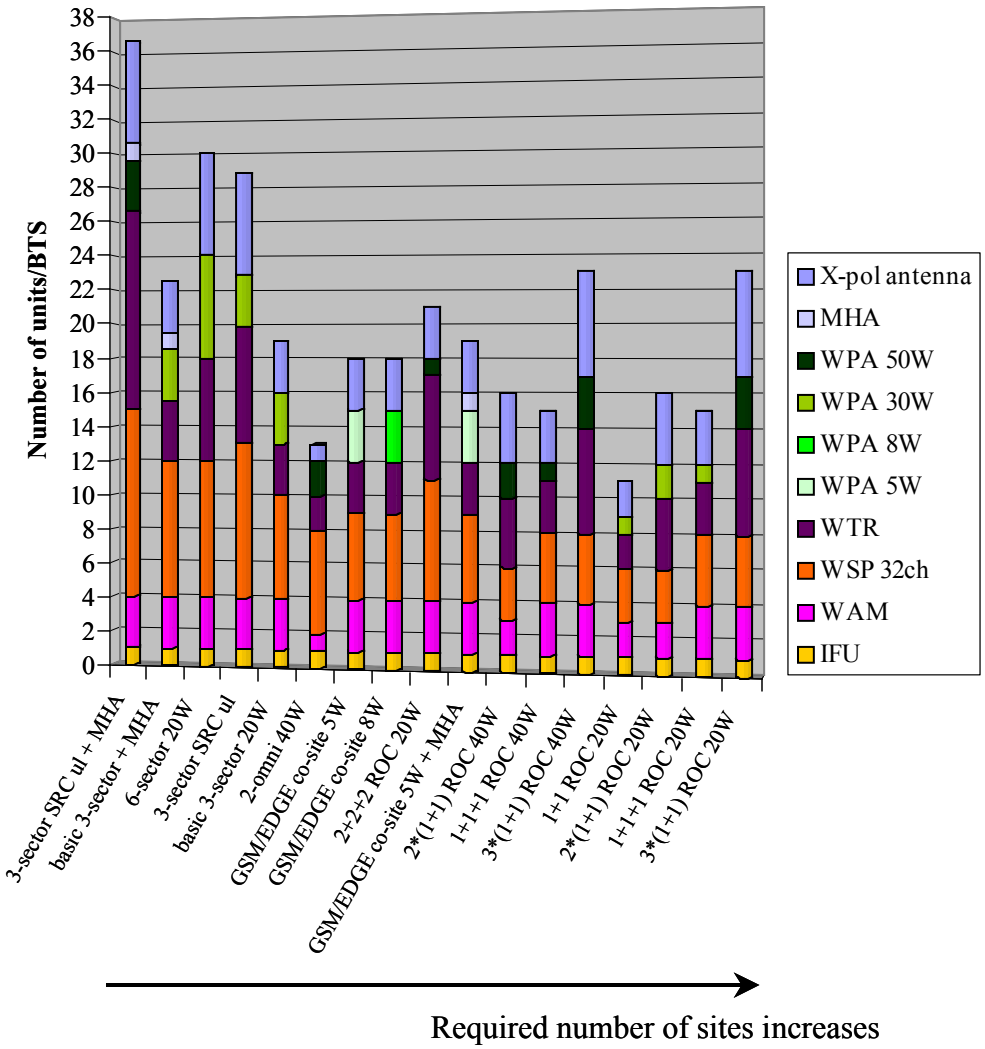
Hardware assembly in 1.1

- GSM/EDGE/WCDMA 5W and 1+1+1 ROC 20W are light configs in terms of WPAs, also small power consumption
- The general rules
  1 WAM per 1 WTR
  1 WAM per 3 WSPs
  are not necessarily true with low loading, so even fewer WAMs may be adequate



Hardware assembly in 1.2

- Growing demand for capacity shows as increase in the number of WTRs, and thus also in CEs



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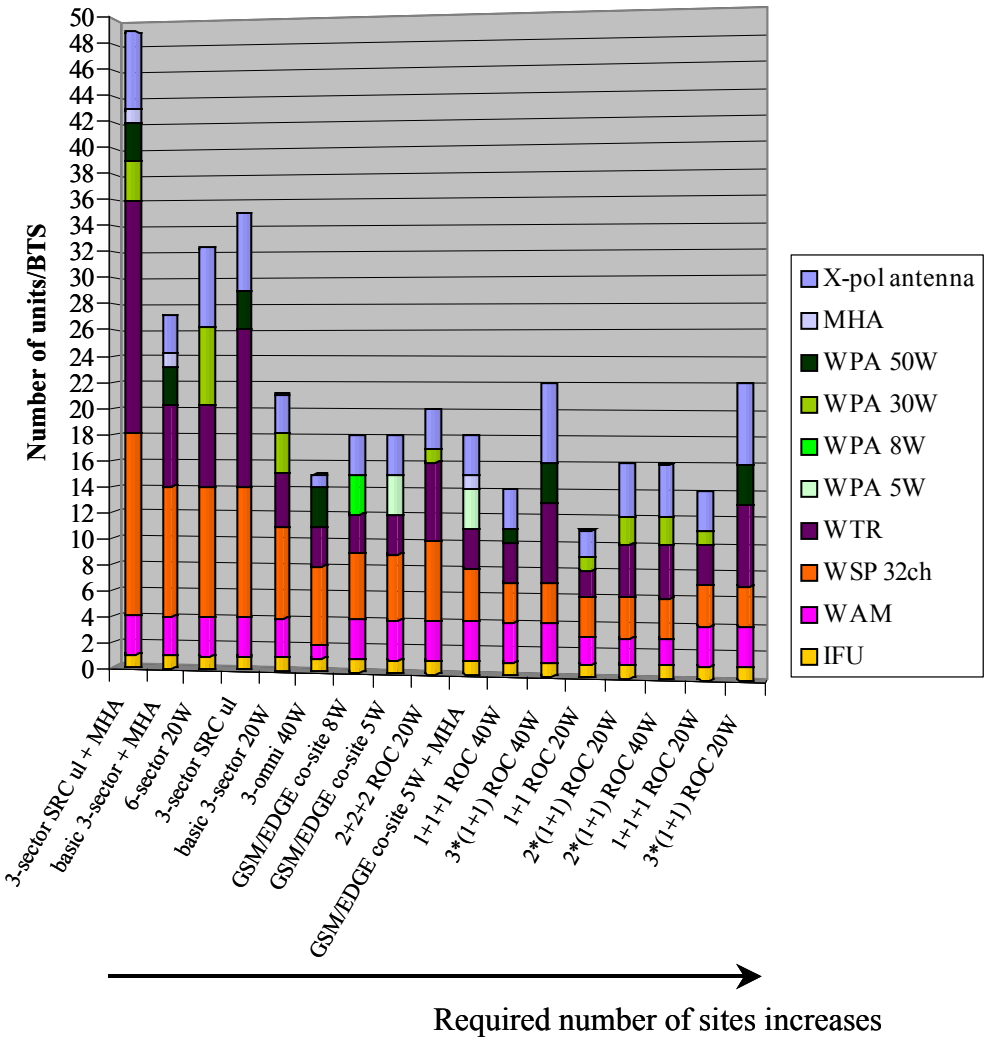
Hardware assembly in 2

- Although the difference in HW setup per BTS is in favour of e.g. ROCs, the difference in required number of sites is equally remarkable
- Figure shows the required changes in site configurations once asymmetric data oriented traffic with high penetration becomes reality



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