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Highlighting the Specific Design and Measurement Challenges Faced when Developing WCDMA Indoor Networks

Ralf Schuh
TeliaSonera Sweden
Isbergs gata 2, 20521 Malmö
Email: ralf.schuh@teliasonera.com

Outline

- Identifying and overcoming the particular design challenges of indoor WCDMA networks considering the service requirements of subscribers in offices and public buildings
- Simulating WCDMA in-building applications / solutions
- Optimising onsite measurements

In-building coverage solutions with emphasis on speech

- In offices and public building dedicated indoor systems are normally mainly for increasing the capacity
  - However, in general 9 out of 10 calls are still over fixed lines
- For speech capacity design we know:
  - # of users with mobiles in the buil
  - 50 to 100 mErlang
  - Bloc
- as "normally" we are
  - lation we know: 60 to 120 Erlang per WCDMA carrier per sector, depending on the interference. E.g. 60 Erlang/100 mErlang/user = 600 speech users (see previous IIR talks).
  - Consider also if GSM indoor system exists less speech capacity is needed for the indoor WCMDA system

Future considerations:

- **Migrating the fixed users to mobile users**
- **Fixed-mobile convergence (VoIP e.g. over WLAN)**

How “much” should we plan for data?

Locations	Main choice for data/internet connection
Offices (corporate customers)	1) LAN 2) WLAN (IEEE 802.11) 3) Cellular indoor (GPRS/EDGE/WCDM[illegible]
Larger public buildings (airport, train station, super market)	1) WLAN 2) Cellular in[illegible]
Public transp[illegible] (t[illegible]	[illegible]
S[illegible]	[illegible]A)
Pri[illegible]	[illegible]alogue modem, ADSL, FTTH, ISDN) [illegible]LAN (IEEE 802.11) 3) Cellular outdoor (GPRS/EDGE/WCDMA)
Smal[illegible] buildings (Hote[illegible]s, coffee shops, petrol stations)	1) WLAN (IEEE 802.11) 2) Cellular outdoor (GPRS/EDGE/WCDMA)

Open questions:

- **How large is the data piece for indoor cellular systems in the future?**
- **Is there a “special” indoor cellular/WCDMA data service which the LAN or WLAN can not offer?**

Speaking about time scales and interworking

- Macro/micro/pico GSM/GPRS/EDGE/WCDMA BSs
  - Passive/active distributed antenna system for larger buildings mainly designed to increase capacity (for speech service).
  - Current WCDMA radio network based on 3GPP R99. We have data rates of 384/64 kbps, mobiles with uplink data rates of 128 kbps are available e.g. the Nokia 6630.
  - 3GPP Rel-5 includes HSDPA. IPv6 is a mandatory protocol in Rel-5 which will simplify roaming between 2G/3G and WLAN. Rel-5 content functionally was frozen mid 2002 and vendors availability will be early 2006.
  - 3GPP Rel-6 includes UMA (Unlicensed Mobile Access) technical specification which supports tight interworking and HSUPA. Rel-6 content functionally was frozen Dec 2004.

- WLAN/Bluetooth access points for data and VoIP
  - Bluetooth in nearly every mobile but short range (~10 meter Class 3)
  - Private WLAN access points in many homes.
  - Only a few WLAN enabled mobiles (GSM & WLAN) on the market so far. However, promising forecasts about GSM/WCDMA/WLAN enabled mobiles.

Speaking about time scales and interworking

- Tight and loose interworking for speech and data service between cellular and WLAN networks
  - Loose interworking (IP interworking): Standardisation at 3GPP, IEEE802.11u/ IEEE802.21.
    - Works today with RADIUS roaming, mainly about authentication and billing.
    - Mobility are not solved in standard, no handover.
    - Telia HomeRun WLAN service offers “Connect Pro” which allows automatic in-logging to the “best” available connection GPRS/WCDMA, WLAN or LAN, VPN tunnel to the companies intranet and allowing seamless data sessions for the user, see www.homerun.telia.com.
  - Tight interworking (WLAN integrated in UTRAN): Standardisation at 3GPP (see Rel-6, UMA). Indoor mobile calls are routed over the fixed network using e.g. WLAN/Bluetooth.
    - Works today with proprietary solutions (for speech),
    - For UMA it needs IPsec in the mobile and in the network we need a Generic Access Network Controller (GANC) for the WLAN.
    - UMA speech over GSM/WLAN/Bluetooth trials:
      - TeliaSonera Denmark trial in Denmark
      - BTs Bluephone project in England.

In “large” offices and public buildings we have existing DASs for GSM and WCDMA and it is difficult to foresee a large penetration of WLAN enabled mobile terminals in the next two years.

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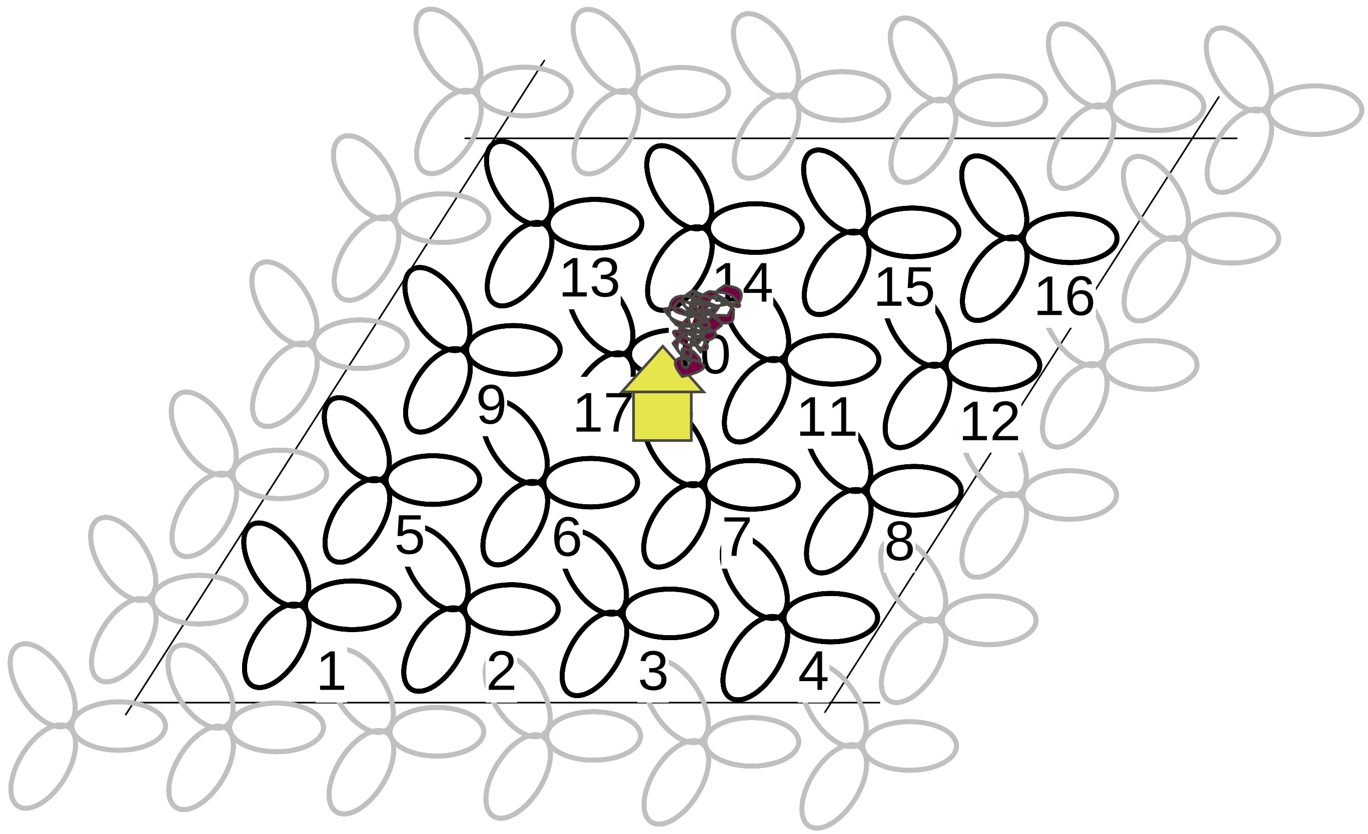
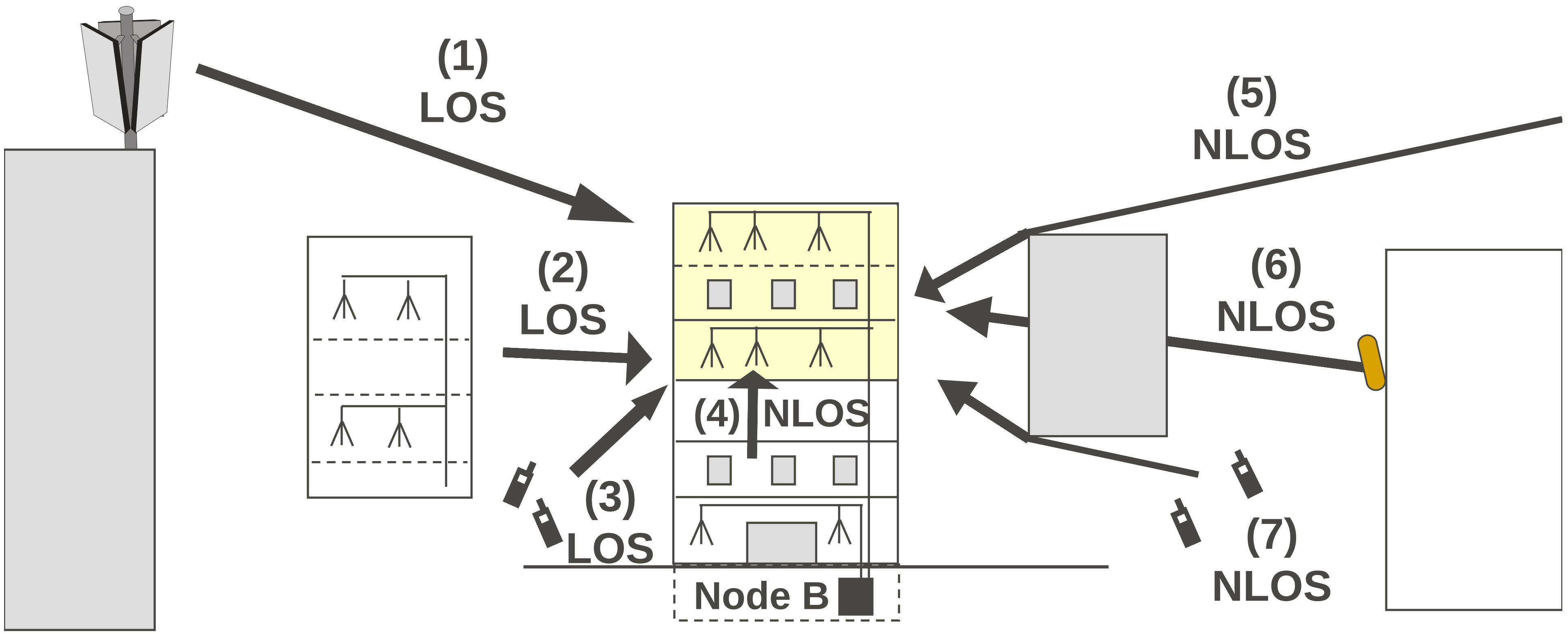
Simulation: Outdoor-to-indoor and dedicated indoor coverage



Interference sources



LOS/NLOS probability

We studied the LOS probability from outdoor antennas above the rooftop to buildings within a radius of 300 meter (from the digital maps of 3 European cities):

- 50 to 90% to the rooftop of these buildings (high interference)
- 8 to 31% to the middle of the buildings
- 5 to 31% to 2 meter above the ground

Simulation results

- Input parameters outdoor/indoor:
  - Cell radius 300/25 metre
  - Feeder loss 3/35 dB
  - Path loss model Walfish-Ikegami/COST 231 multiple wall model
  - Orthogonality factor 0.5/0.2

Indoor	LOS	NLOS
i-factor	0.5 to 0.8	0.1 to 0.2
SHO area (indoor-to-outdoor)	20 to 23%	2 to 4%
Indoor-to-outdoor connections	33 to 36%	1 to 4%
Capacity speech Erlang with activity factor 0.5 per carrier per sector	60	120

Limiting interference

- **Metalised windows** give some extra attenuation. Essential for modern buildings with large window areas.
- **Tune the outdoor network** to avoid strong radiation to the building with dedicated indoor system. Micro cells with antennas below roof top.
- **Use separate indoor carriers and hierarchical cell architecture**. The problem is that many operators have only 2 to 3 WCDMA carriers. However:
  - In some countries like Sweden and Germany UMTS frequency spectrum in the core band at around 2 GHz was returned and could be used.
  - Future UMTS extension band (2.5 GHz) should be around 2008 available
- Keep the **indoor feeder loss low** (20 to 30 dB), but consider also the cost factor.
- Don’t increase the pilot power in order to “force” the indoor users to the indoor system as this would pollute also the outdoor network.

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Dedicated indoor GSM/WCDMA solution at the Ericsson building in Lindholmspiren, Gothenburg

- Office building complex with
  1600 employees, 52 400 m^2
  10 floors (8 above ground)
- GSM 1800 (1 x RBS 2206 plus 3 x RBS 2202),
  two GSM operators
- WCDMA (1 x RBS 3202
  with 3 TRXs)
- 3 cells (3 x Combining Boxes)
- 124 antennas
- 400 of the employees have a 3G phone as the only phone (SonyEricsson Z1010) while the rest have GSM phones

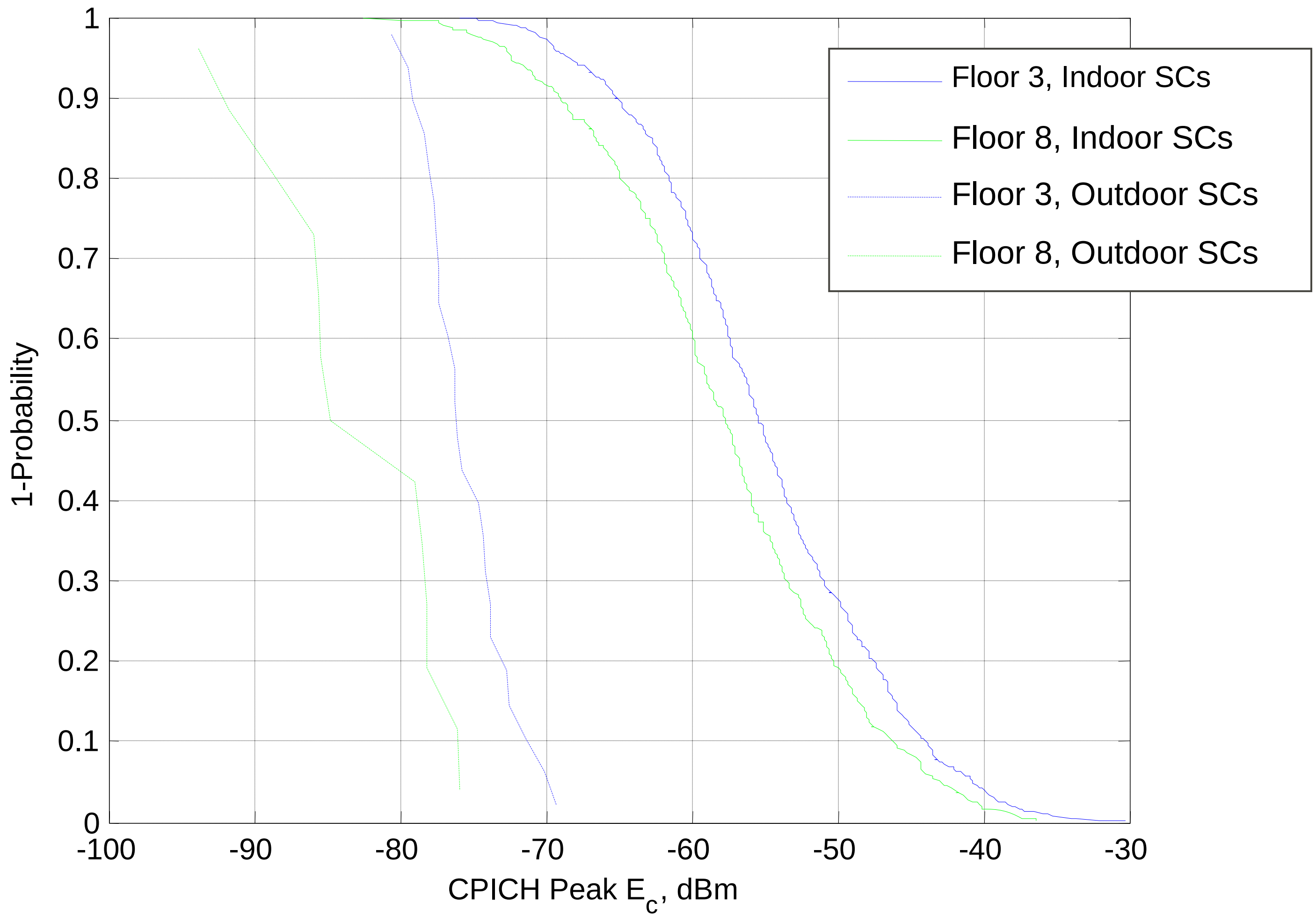
Dedicated indoor GSM/WCDMA solution at the Ericsson building in Lindholmspiren, Gothenburg

- Indoor Macro Node B: Pmax = 43 dBm, CPICH = 32 dBm
- Passive DAS losses range from 23 to 33 dB at UMTS frequencies
- CPICH EIRP ranges from 1 dBm to 11 dBm (mainly omni-antennas)
- Cell radius per antenna ~14 to 18 meter
- Optimized RANOS settings for the indoor
- Three E1 lines
- Distance to closest outdoor Node Bs are about 500 to 800 meter

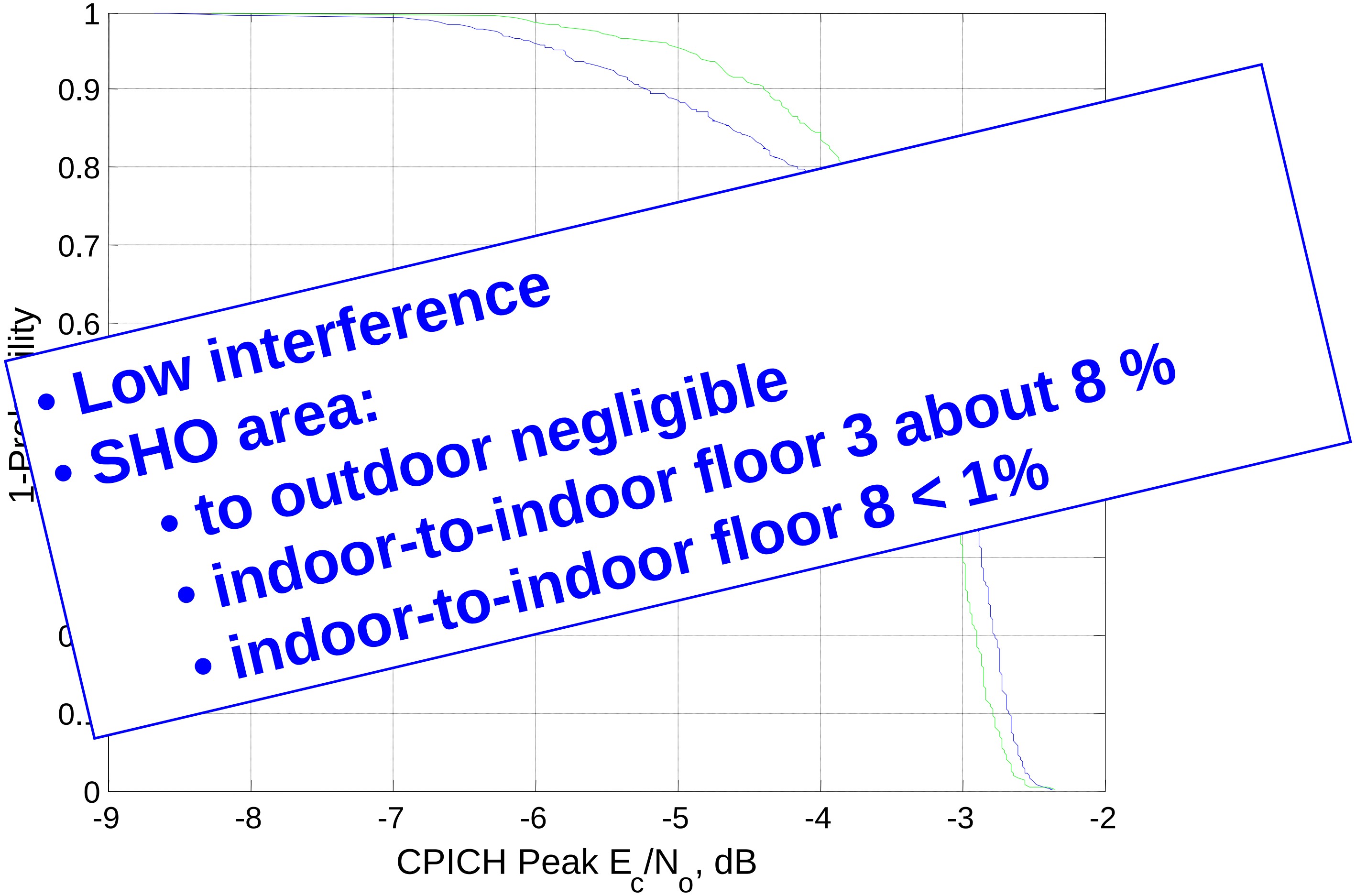
Test and measurement tools

- Software: TEMS and Agilent Nitro Chariot from NetIQ
- Mobiles: Qualcomm TM6200, SonyEricsson Z1010, Motorola A835, Nokia 6650
- Agilent scanner
- Various laptops
- Tektronix YBT250 BTS Transmitter and Interference Analyzer

Coverage measurement



Coverage measurement



- Low interference
- SHO area:
  - to outdoor negligible
  - indoor-to-indoor floor 3 about 8 %
  - indoor-to-indoor floor 8 < 1%

Load test

- With up to 11 mobiles located in different meeting rooms.
- We used FTP download
- **Room A:** Signal only from one sector (low interference from the other cells), ~15 metre from the antenna.
  - **We achieved average user throughput of ~2400 kbps.** This meant six 384 kbps connections, two 128 kbps packet switched connection and two video calls (New record!).
  - The Node B transmit power per data channel was ~ 28 dBm. We were code limited
- **Room B:** Strong SHO to the various indoor cells
  - We achieved average user throughput of ~1900 kbps. This meant five 384 kbps connections and two 128 kbps packet switched connection.
  - We were interference limited

Summary

- Current indoor GSM and WCDMA systems are mainly designed and used for speech service.
- Indoor simulation and measurement results showed: (*i*) very good code orthogonality, (*ii*) small soft-handover area and (*iii*) low interference from the outdoor cells
- Load test with record downlink total average user throughputs of up to ~2400 kbps within one sector using one WCDMA carrier are achieved in TeliaSonera’s live 3G network in Göteborg, Sweden, in the Ericsson building at Lindholmspiren
- Minimize interference from the outdoor network. In the future for some building separate indoor carrier using hierarchical cell architecture may be necessary in order to limit the number of SHOs.

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