



# Magister Solutions Ltd

“On the Edge of Mobile Evolution”

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# Executive Summary

- Strong background in wireless network research
  - Highly educated personnel
  - Over 100 academic publications and several patents
- Research and Development Partner
  - Standardization and implementation R&D
  - Radio network planning and optimization
  - Technology road mapping
  - Technology training
- References
  - Since founding (2005) R&D co-operation with largest network vendors and manufactures
  - Leadership and membership in partners' project teams

# Contents

- Introduction to Magister Solutions
- What is Happening on the Edge of Mobile Evolution
- Magister's Services
- Conclusion
- Questions



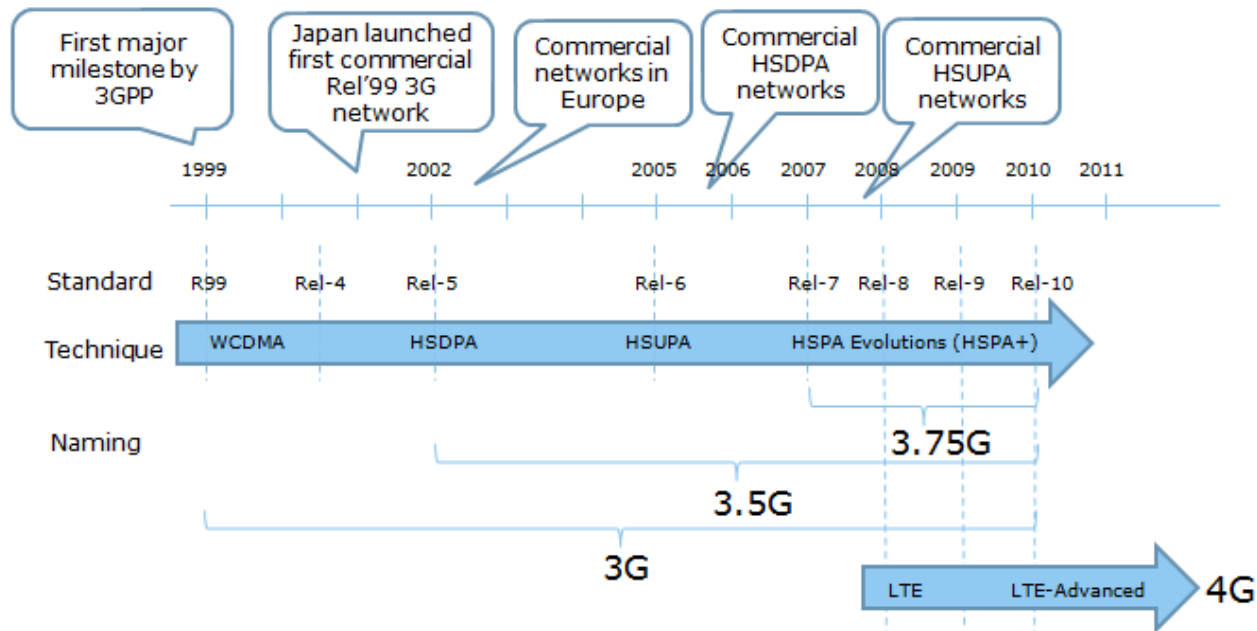
# Introduction to Magister Solutions

# Magister Solutions

- Quickly growing research and development partner offering our customers R&D which aims for true applications in mobile products, procedures and services
  - Founded 2005 and currently holds 27 employees + co-founders
  - Main office in Jyväskylä, Finland
  - Branch offices in Tampere and Helsinki, Finland
- World class expertise
  - 2 professors, 9 doctors, 10 Ph.D. students and the rest M.Sc. or equivalent
  - Over 100 international publications
  - Several patents

# Magister Solutions

- Technology competence on cutting edge technologies
  - WCDMA for UMTS (3G)
  - HSPA and HSPA+ (3.5/3.75G)
  - LTE, LTE-A and WiMAX (3.9G/4G)



# Magister Solutions

- Special areas of interest and support for 3GPP standardization activities, for instance, on
  - Voice over IP
  - Energy efficiency
  - Mobility management
  - Radio resource management development
  - System level performance analysis

# Magister Solutions – Case Tokyo (1/3)

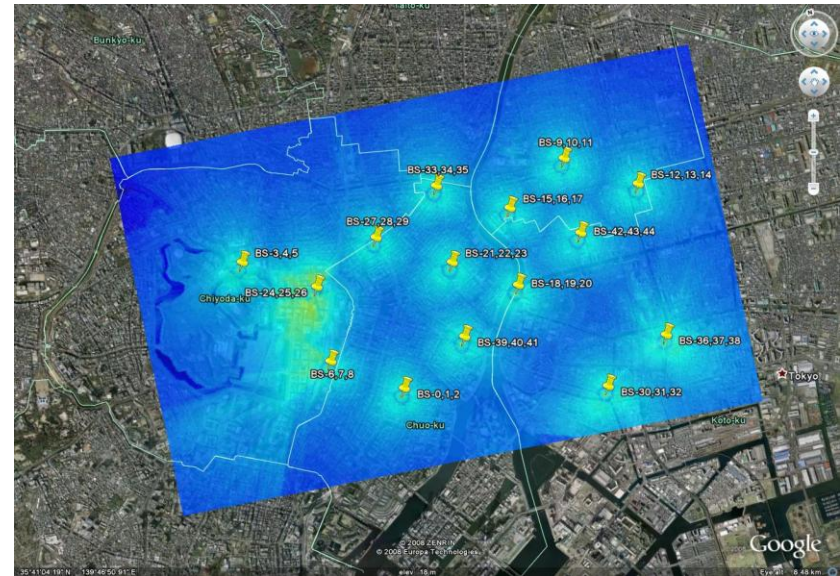
- Goal:
  - Performance benchmarking between 3G HSDPA and next generation LTE system
- Challenges:
  - It is hard to collect needed statistics from commercial networks
  - It is not affordable to build large enough test networks
  - In relation to LTE, there are only limited commercial products available





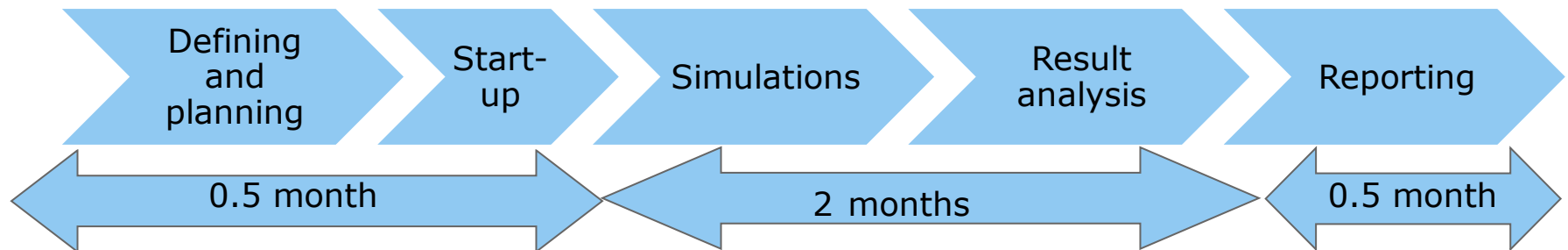
# Magister Solutions – Case Tokyo (2/3)

- Simulation based approach was selected
  - Like many vendors, operators as well as the scientific communities do for studying the wireless cellular network performance
- Digital network planning data over Tokyo map was used in the simulator
  - Realistic conditions through non-regular network layout and propagation



# Magister Solutions – Case Tokyo (3/3)

- Achievements
  - Extensive report of the bechmarking study in realistic network
  - Customer knowledge improvement to better support standardization work, network planning and optimization
  - International publications

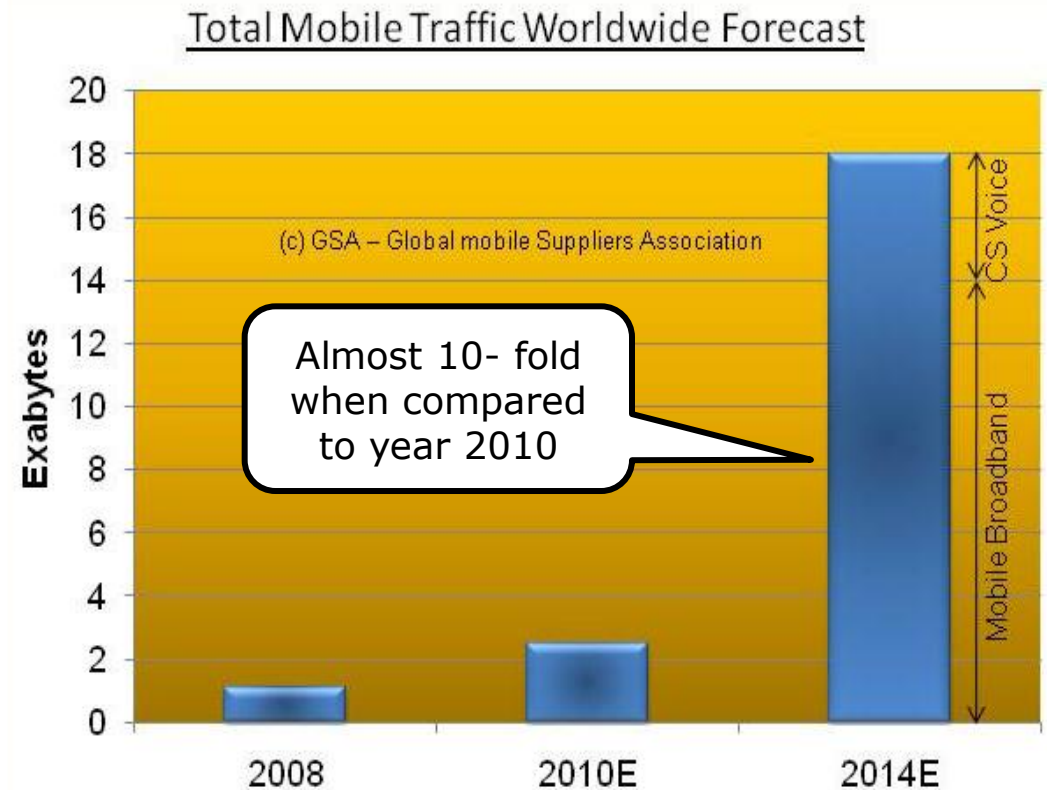




# What is Happening on the Edge of Mobile Evolution

# Market and performance situation (1/4)

Unit	Magnitude
Exabyte	1,000,000,000,000,000,000
Petabyte	1,000,000,000,000,000
Terabyte	1,000,000,000,000
Gigabyte	1,000,000,000
Megabyte	1,000,000
Kilobyte	1,000



Source of data: Informa Telecoms and Media – March 2010

# Market and performance situation (2/4)

- In Finland alone there are over 8 million GSM and WCDMA-HSPA mobile subscriptions
  - World wide over 4.7 billion subscriptions
- 3G (incl. HSPA)
  - Over 650 million 3G subscriptions
  - Commercially launched by 383 operators in 156 countries
  - Network peak data rates
    - 247 commercial HSPA networks, i.e 65%, support 7.2 Mbps (peak DL) or higher
    - 58 HSUPA networks support up to 5.8 Mbps peak UL and another 5 networks support 11.5 Mbps peak

# Market and performance situation (3/4)

- Device peak data rates (excl. notebooks, e-book readers)
  - 2,221 (out of 2922) devices support 3.6 Mbps peak or higher
  - 1,435 devices support 7.2 Mbps peak or higher
- Operating band
  - 27 commercial UMTS900 operators launched in 20 countries (i.e. HSPA launched in the 900 MHz band; some have launched HSPA+)
  - 2,183 HSPA devices (90%) operate in 2100 MHz band
  - 817 tri-band HSPA devices 850/1900/2100 MHz
- Source: Global mobile Suppliers Association (GSA) surveys

# Market and performance situation (4/4)

- Long Term Evolution (LTE)
  - "TeliaSonera launches 4G services commercially to customers in Stockholm, Sweden and Oslo, Norway"<http://www.teliasonera.com/News-and-Archive/Press-releases/2009/TeliaSonera-first-in-the-world-with-4G-services/>
  - "Elisa's 4G network enables mobile connections of up to 100 Mbps in Finland"<http://www.elisa.com/on-elisa/140/130.00/16349/>
  - "Nokia Siemens Networks and Nokia conduct first LTE call at 800 MHz"<http://www.nokiasiemensnetworks.com/news-events/press-room/press-releases/nsn-and-nokia-conduct-first-lte-call-at-800-mhz>
  - "Verizon Launches 4G LTE In 38 Major Metropolitan Areas By The End Of The Year"<http://news.vzw.com/news/2010/10/pr2010-10-01c.html>
  - "Moving from the lab to production: Nokia trials first LTE modem"<http://research.nokia.com/news/5461>
  - "ST-Ericsson and Ericsson first to achieve LTE and HSPA mobility with a multimode device"[http://www.stericsson.com/press\\_releases/LTE\\_HSPA.jsp](http://www.stericsson.com/press_releases/LTE_HSPA.jsp)
  - "Nokia Will Release Phones with 4G Support in 2010"<http://www.nokiaphones.net/nokia-will-release-phones-with-4g-support-in-2010/>

# Topics in 3GPP standardization (1/3)

- Magister Solutions is taking actively part into 3GPP standardization work through it's partners
  - In the following most recent and active trends in terms of 3GPP are discussed
- HSPA+
  - Machine Type Communications (MTC)
    - Architectural enhancements to support a large number of Machine-Type Communication (MTC) devices in the network;
    - Architectural enhancements to fulfil MTC service requirements;
    - Support combinations of architectural enhancements for MTC, though not all combinations may be possible.



# Topics in 3GPP standardization (2/3)

- HSDPA
  - Coordinated multipoint transmissions (CoMP)
  - 8-carrier HSDPA
  - CELL\_FACH enhancements
- HSUPA
  - Open loop transmit diversity (OLTD)
    - Switched Antenna Transmit Diversity
    - Beamforming
  - Closed loop transmit diversity (CL Tx div.)
    - Beamforming
  - Multiple input multiple output (MIMO)

# Topics in 3GPP standardization (3/3)

- LTE and LTE-Advanced
  - Minimization of drive tests (MDT)
  - Relays
  - Heterogeneous networks (HetNet)
    - Closed subscriber group (CSG)
    - Mobility improvements
  - Enhanced uplink transmissions
  - Energy efficiency and savings
  - MBMS enhancements
  - Enhanced Interference Coordination and Cancellation
  - Carrier aggregation
    - Discontinuous reception (DRX)


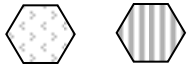
# Simulator types (1/2)

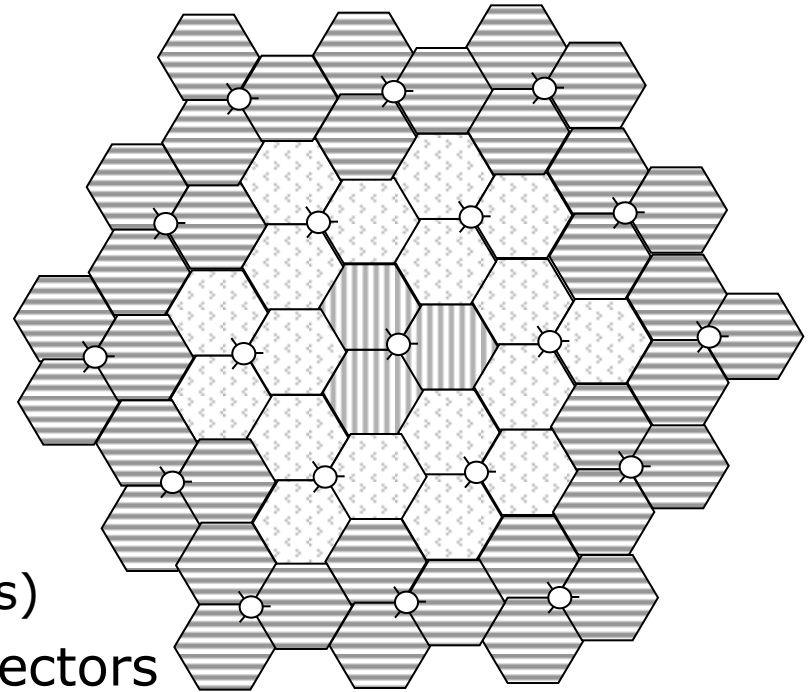
- Mobile network simulators can be roughly categorized in *link level* and *system level* simulators
  - Link level simulators model in high detail the radio interface between a UE (*user equipment or mobile station*) and Node B (base station). Link level simulators operate on chip or symbol level (3.84 Mcps (Mega chips per second) for WCDMA)
  - System level simulators model a full network usually including multiple Node Bs and number of mobile stations. Slot-level modeling is sufficient for system simulation (1 slot = 2560 chips = 0.66667 ms)

# Simulator types (2/2)

System simulators			
	Static simulations "Snapshot"	Quasi-Static Simulations	Dynamic simulations
Algorithms	Simplified and limited algorithms, e.g no outer power control	Extensively modelled RRM	Fully modelled RRM
Path Loss	Fixed	Fixed	Varied every timeslot (slot, TTI, etc.)
Time Domain	No	Yes	Yes
Mobility	Static	Static	Moving randomly
Computational Complexity	Fast	Middle	Slow
USE Cases	Interference study between systems, etc.	RRM study excluding mobility, etc.	Mobility Study, RRM Study, etc.

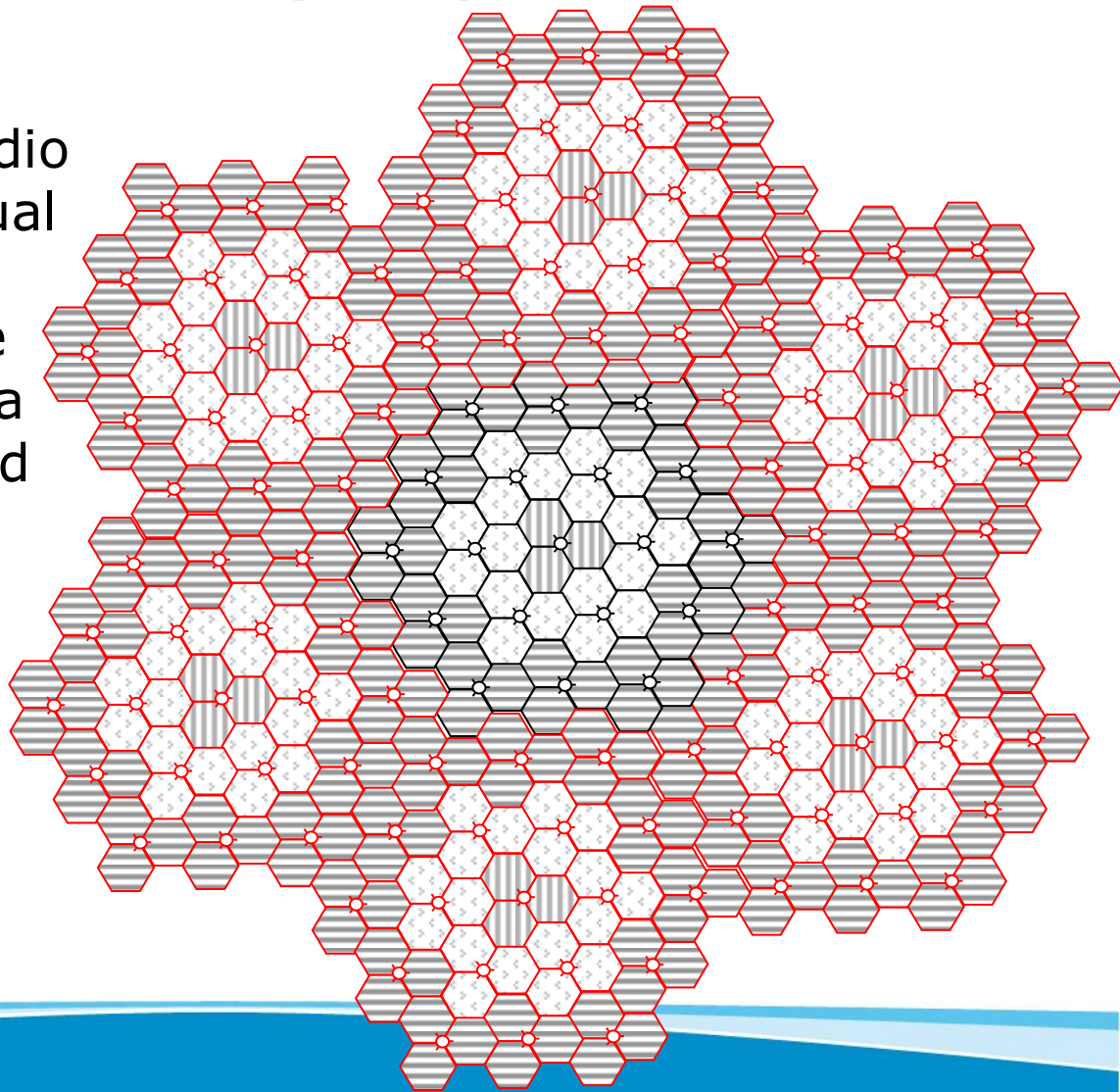
# Simulation scenarios (1/2)

- Two wrap-around scenarios
  - Three Tiers 
    - Hexagonal network of 19 Sites
    - 3 sectors per site
  - Two Tiers 
    - Hexagonal network of 7 sites
    - 3 sectors per site
- Non-wraparound scenarios
  - 1 site with 1-3 sectors  
(used mainly for testing purposes)
- Statistics are gathered from all sectors



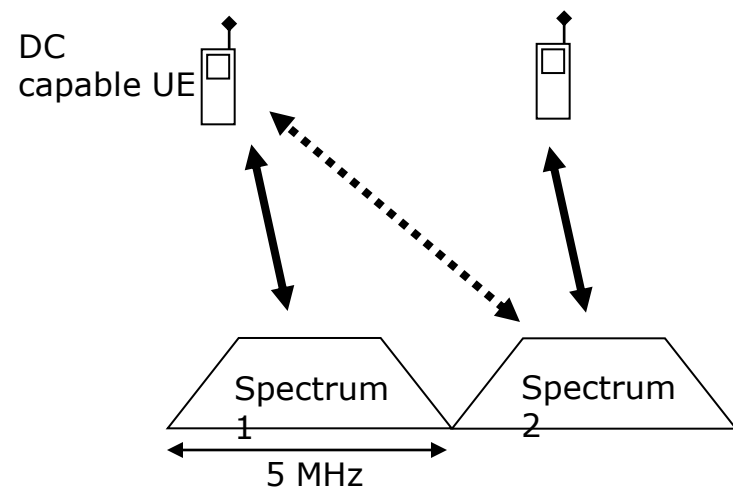
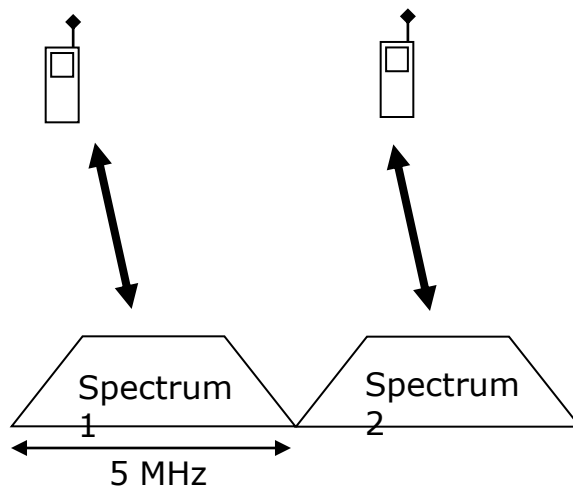
# Simulation scenarios (1/2)

- With wrap-around radio conditions of the actual simulation area are replicated around the actual simulation area where UEs are located



# HSUPA Dual Carrier capability\*

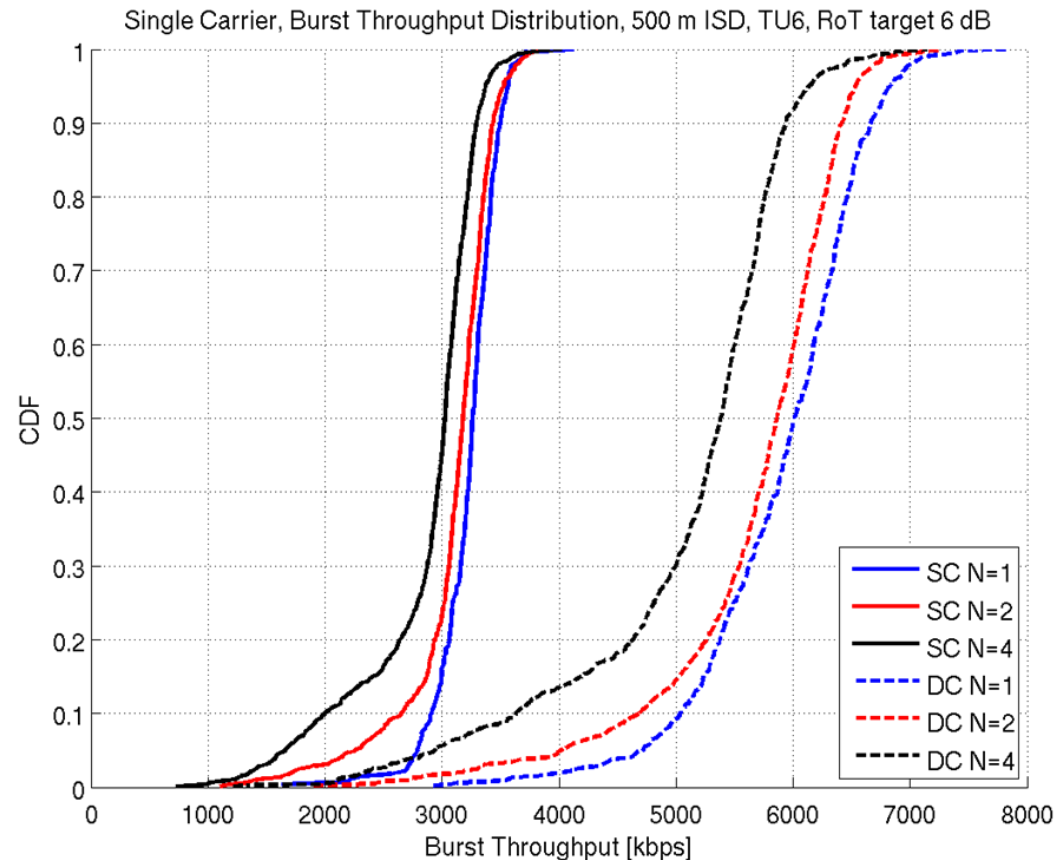
- Currently HSUPA uses 5 MHz bandwidth
- As operators may already have multiple 5MHz spectrums, *Dual Carrier (DC)* would enable e.g.
  - load balancing between carriers (without radio bearer reconfiguration)
  - maximizing the use of resources
  - users with adequate power resources can in theory to double their peak data rate



\*Results by Ilmary Riepo, IEEE SWPC, 2010.

# DC-HSUPA simulations (500m cell)

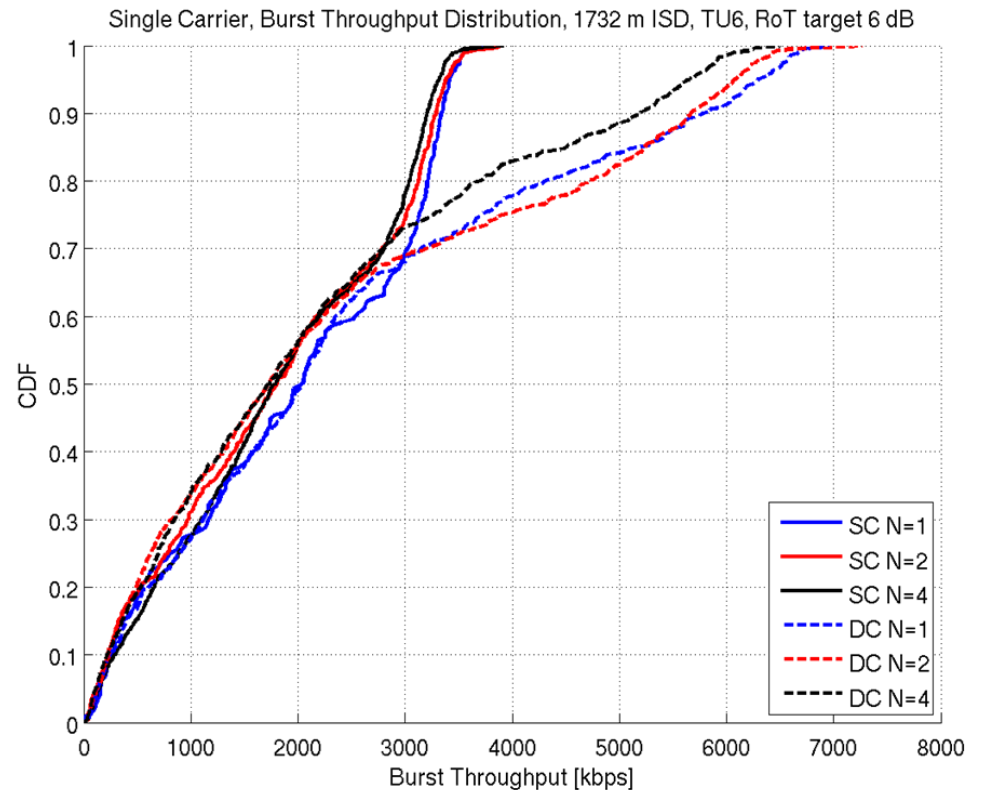
- Solid lines = Single Carrier
- Dashed lines = Dual Carrier
- The figure shows that in 500m cell using Dual Carrier HSUPA can double the throughput of users when the cell is not highly loaded
- Especially when  $N=4$ , meaning that there are 4 UEs per 5 MHz bandwidth, Dual Carrier is not able to meet two times single carrier capacity (DPCCH overhead)





# DC-HSUPA simulations (1732m cell)

- For larger 1732m cell the benefit of two carriers is nonexistent for most UEs, as was predicted from single carrier power distribution
- Around 30% of users experience some gain over single carrier, but only a few can double their throughput

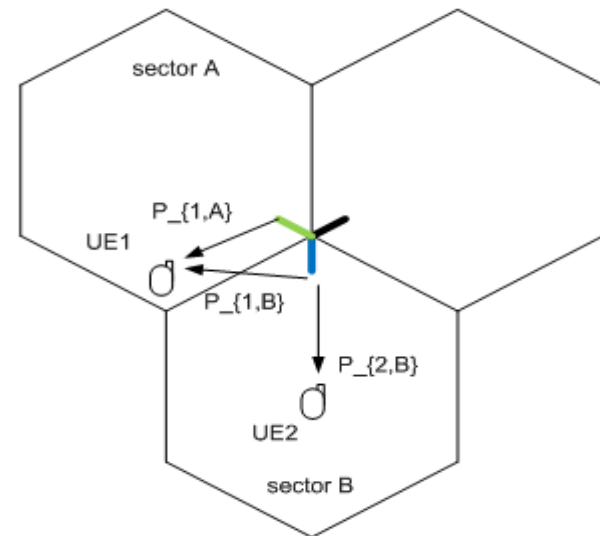
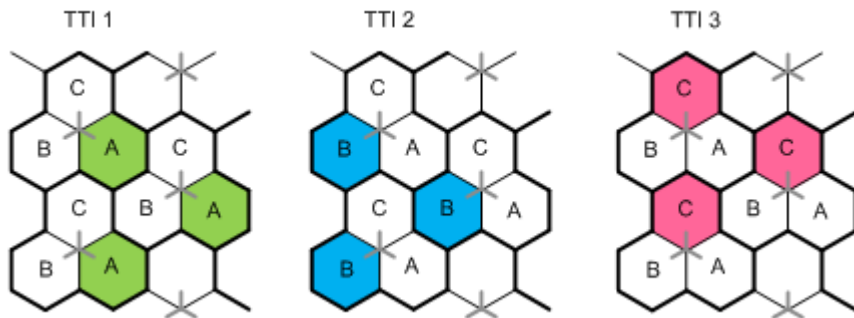


# Multipoint transmission

- Even with advanced radio transceivers in place, there is still scope for improving cell edge user experience in HSPA
- Problems in many HSPA networks are capacity saturation and inadequate cell edge performance
- Nevertheless, neither the capacity nor the quality potential of the network as a whole is fully utilized
  - Adjacent sectors and frequency carriers are often unevenly loaded; different topological layers in the network (e.g. macro, pico, femto) are sometimes unevenly loaded as well
  - Most UEs with poor serving cell data rates can often receive signals from other cells which are yet fully exploited in HSPA+
- *The next step in the evolution of HSPA must take all this into consideration*

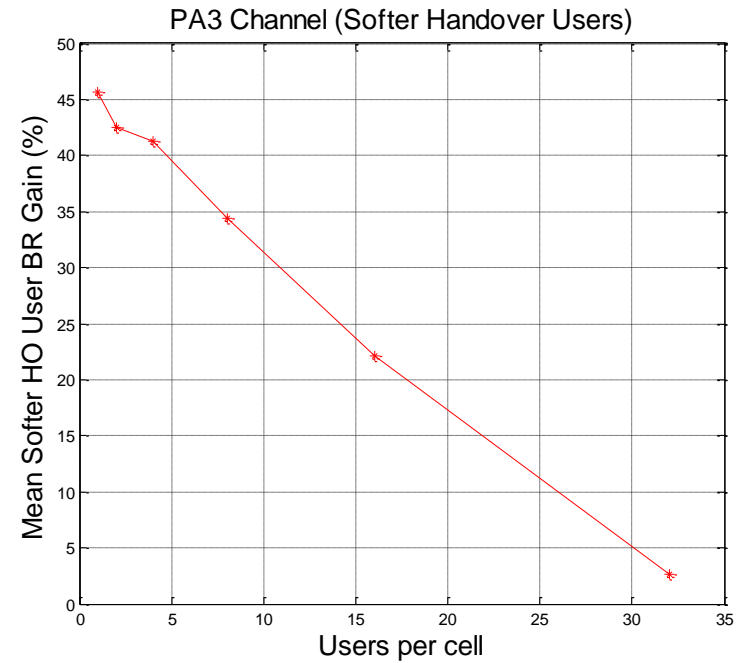
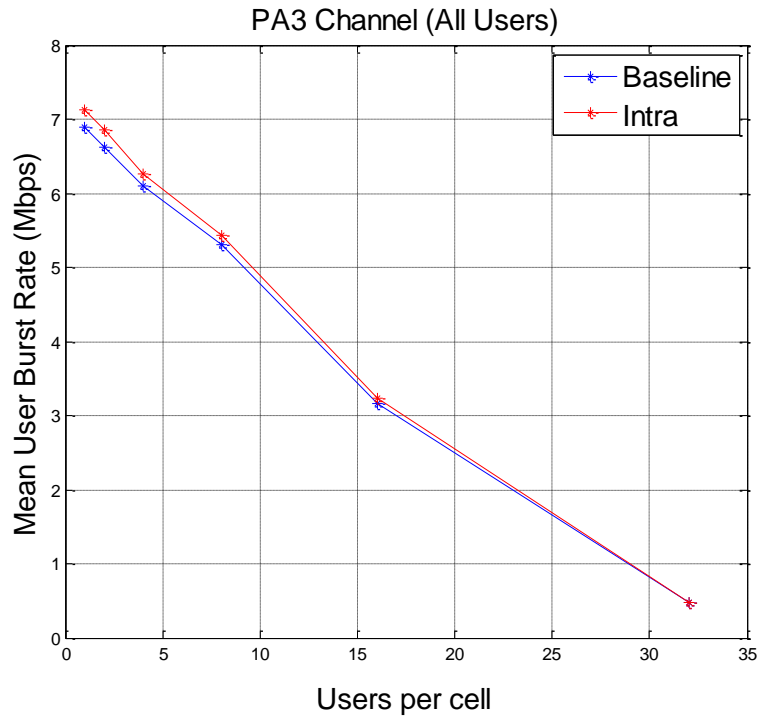
# Multipoint transmission

- Multipoint techniques can be divided roughly into three categories
  - Switched transmit diversity (DTX)
  - Single frequency network transmissions (SFN)
  - Multiple flow transmission techniques (MFlow)



Source: Multi-cell transmission techniques for HSDPA, Nokia, NSN, R1-104913

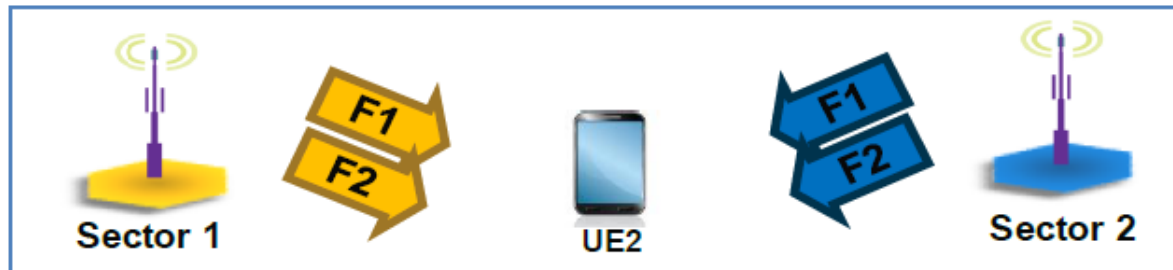
# Mflow achivable gaines



Simulation results by Qualcomm

# Dual Frequency Quad Cell HSPA (DF4C-HSPA)

- DF4C-HSPA can be seen as a natural extension of DFDC-HSPA, suitable for networks with UEs having four receiver chains
- DF4C-HSPA allows use of the four receiver chains by scheduling four independent transport blocks to the UE from two different sectors on two different frequency carriers. DF4C-HSPA is illustrated in Figure 4.



**Figure 4: DF4C-HSPA**

- Source: HSPA+ Advanced Smart Networks: Multipoint Transmission, Qualcomm 2011

# Magister references from previous studies

- Other examples of case studies
  - Case: LTE VoIP
    - "Trade-off Between Increased Talk-time and LTE Performance"
  - Case: Drive Test Minimization
    - "Coverage Optimization with Extended RLF Reporting"
  - Case: Self Optimizing Networks
    - Enhanced network and handover performance through dynamic load balancing
  - Case: Next Generation Mobile Network (operator alliance)
    - Better view of typical user data rates of LTE and HSPA systems than peak data rates lead to assume
  - Case :Carrier Extension for HSUPA
    - Standardized dual carrier (5+5 Mhz) operation for HSUPA



# Services

# Services

- Standardization Related R&D and Overviews
  - *Striving to be active in the standardization work?*
    - *Partner with our R&D*
  - *Unsure of latest technology developments in 3GPP standardization?*
    - *Order quarterly review of latest activities and decisions*
- Radio Network Planning and Optimization
  - *Interested in improving the network performance?*
    - *Let's plan together the best ways to measure the current and the targeted network performance and optimization of network parameters*



# Services

- Technology Roadmapping
  - *Are the actual benefits of a feature unclear?*
    - *Let's have a look together through practical performance analysis*
  - *Unsure in which steps to take new technology into use?*
    - *We can assist by creating a tailored plan for you*
- Technology Training
  - Need to build up your expertise or bridge a gap between academia and industry know-how?
    - Ask more about our trainings which include intensive 1 day trainings on WCDMA basics, HSPA basics, HSPA evolutions, LTE basics, enhancements on LTE and WiMAX basics



# Conclusion

# Summary

- Unique expertise and know-how on the current standardization and research activities on cutting edge wireless technologies
- Service portfolio includes
  - Standardization and implementation R&D
  - Radio network planning and optimization
  - Technology road mapping
  - Technology training
- Trusted customer relationships with largest network and device vendors – Do you want to be part of it?

Thank you for your attention!  
Any questions?

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