Energy and Cost Efficiency for Wireless Access (ECEWA)

China-Finland Strategic ICT Alliance Workshop

Shanghai

3 - 4 November 2011

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ECEWA: Focus and partners

- ECEWA is a strategic Sino-Finnish collaboration project that develops *cost and energy efficient solutions to future radio access networks*.
  - Duration: 9/2010 - 8/2012
- Project partners in Finland are Ericsson, Efore, European Communications Engineering, Aalto University and Tampere University of Technology.
  - The Aalto and TUT contribution in ECEWA is 147,5 person months
- Parallel partner project in China is the *R&D of Future Wireless Networking and Core Network*

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ECEWA: Main topics

- Project breakdown to Work Packages:
  - WP 1: Architecture of future mobile networks
  - WP 2: Interference management for future wireless networks
  - WP 3: Future green wireless communication and networks
  - WP 4: Key technologies for Future IPv6-based core network
  - WP 5: Testing and Evaluation for Future Wireless Networks
- Common research plan on both finnish and chinese sides
- Many research items under these work packages are also investigated in other activities but *in ECEWA the cost and energy efficiency is the leading theme*.

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China-Finland Collaboration

Some recent joint publications between finnish and chinese researchers

- M. Zhou, Q. Cui, and R. Jäntti, "High Energy Efficiency Schemes in Multiple Relays Cooperative Network with Analgo Network Coding," In Proc. IEEE IC-BNMT2010, Bejing, China, 2010.
- J. Xu, S. Zhu, Z. Gao, and M. Valkama, "Distributed cyclic delay diversity with decision-feedback differential detection," in Proc. IEEE Int. Conf. Broadband Network and Multimedia Technology (IC-BNMT' 10), Beijing, China, Oct. 2010.
- X. Sun, S. Zhu, Z. Feng, and M. Valkama" "Cooperative amplify-and-forward scheme based on multi-access channel," in Proc. IEEE Int. Conf. Broadband Network and Multimedia Technology (IC-BNMT' 10), Beijing, China, Oct. 2010.
- M. Zhou, Q. Cui, H. Wang, X. Tao, H. Tian, and M. Valkama, "Link-oriented power allocation in multicast systems with physical layer network coding," in Proc. IEEE Wireless Communications Networking Conf. (WCNC' 11), Cancun, Mexico, March 2011.
- Q. Cui, X. Huang, M. Valkama, "Power Allocation of CA-MIMO System with Per-Carrier and Per-Antenna Power Constraints," IEEE ICC-2012.
- M. Zhou, Q. Cui, M. Valkama, H. Wang, X. Tao, and H. Tian, "Optimal energy-efficient scheme for two-way relay channel using physical layer network coding," EURASIP Journal of Wireless Communications and Networking (accepted for publication), 2012.

China-Finland Collaboration

Example research visits and researcher exchange

- Bing Luo (BUPT) in Aalto Sept 2011 – Nov 2011
- Xueging Huang (BUPT) will visit Aalto during 6.11- 4.12.2011
- Dr. Jarno Niemelä (TUT) visiting BUPT (Prof. Qimei Cui) in April-June 2012
- MSc. Yanzhao Hou (BUPT) visiting TUT for Jan-March, 2012.
- MSc. Min Zhou and Prof. Qimei Cui (BUPT) visiting TUT in spring 2012 for 2-3 months

Joint workshops

- Future Wireless Networking and Core Network Workshop, 25-26.10.2010
- China-Finland Strategic ICT Alliance Workshop in Oulu, Finland 28.4.2011
- China-Finland Strategic ICT Alliance Workshop in Shanghai, China 3-4.11.2011

Partners and example research highlights

Aalto, TUT, Ericsson, ECE, Efore

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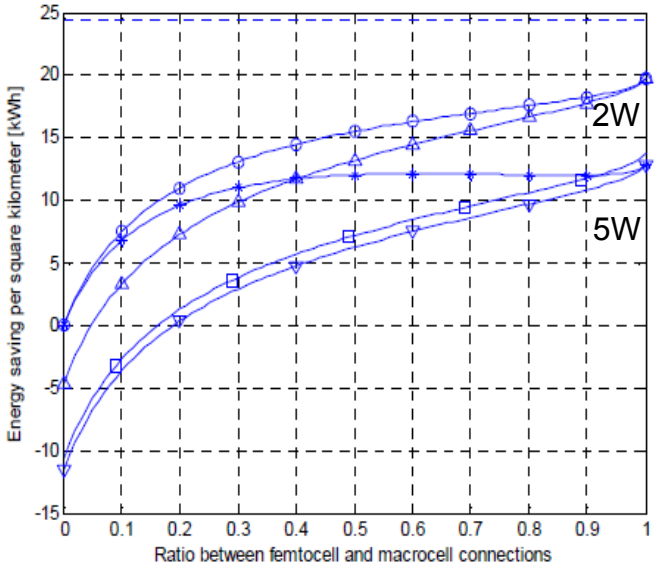
Impact of traffic variations on the energy consumption of heterogeneous networks

- Femto-cells can be used to provide improved throughputs on edges of macro-cells.
- If femto-cells are spread over the service area the decreased load on the macro-cells will increase the macro-cell radius due to cell breathing in e.g. HSPA, thus reducing the network energy consumption.

➢ *We have studied the impact of daily traffic variations to the energy consumption of the network assuming different femtocell deployment scenarios.*

- Assuming HSPA on 2.1GHz carrier frequency we found in preliminary studies that at high network load the energy saving at the macro-cell network varies between 27% and 54% when 10% to 70% of the users are connected to femto-cells. Yet, results depend on the network traffic characteristics.

➢ ***Researcher: MSc Maliha Jada, Prof. Jyri Hämäläinen***



Optimal BS energy reduction by femtocell off-loading with and without femto cell power save featuee

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To utilize fully the potential of femto-cells and other network extensions (like relays) an energy aware network planning needs to be developed for future radio systems!!

Impact of traffic variations on the energy consumption of heterogeneous networks

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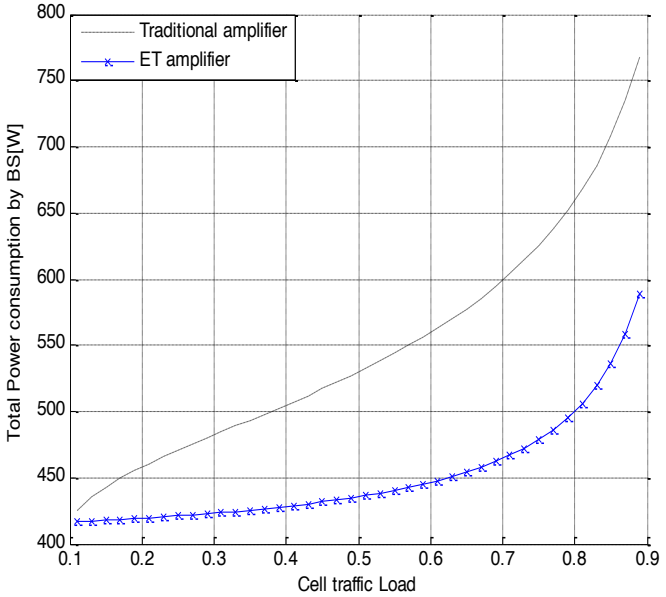
➢ *We have studied the impact of daily traffic variations to the energy consumption of the network assuming different femtocell deployment scenarios.*

➢ Our result suggest that it is possible to reduce 7%-15% of daily energy consumption by replacing the traditional power amplifiers by the Envelope Tracking amplifers.

➢ ***Researcher: MSc Aftab Hossain, Prof. Riku Jäntti***



	R= 0.7 km		R= 0.5 km	
	TA	ET	TA	ET
$(E/A)_M$ [kWh/km^2] Residential area	11.4	9.7 (-15%)	20.1	18.1 (-10%)
$(E/A)_M$ [kWh/km^2] Business area	10.8	9.5 (-12%)	19.5	18.0 (-7%)

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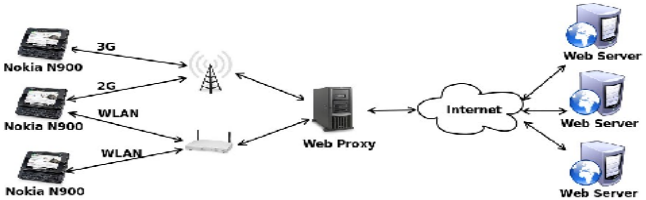
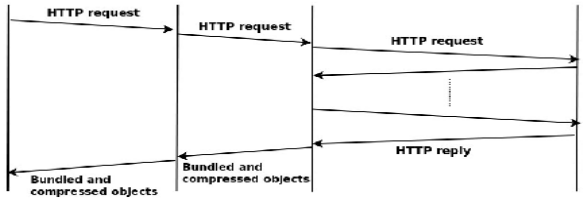
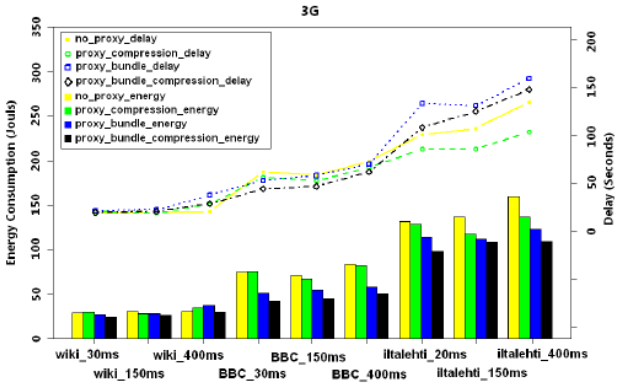
ET amplifiers could be utilized to decrease the energy consumption during medium loads. At peak loads and very low loads ET does not provide much gain.

Proxies for Energy-Efficient Web Access

- The main factor dominating the energy consumption of web access in the mobile devices is the transmission energy that is proportional to the length of a transmission and the transmit power level.
- In the case of web access, energy efficiency is intensively affected by TCP throughput, through the RTT.
- Based on our measurement, energy consumption per bit significantly increases from 0.536 uJ/bit to 2.103 uJ/bit when RTT rises from 60ms to 1060ms.
- Proxy assisted power saving technique can buffer content or even schedule the content data either to shorten total transmission time or compact data for bursty transmission giving network interfaces more time in low power mode instead of being always on.
- Our proposed proxy based architecture associated with bundling and compression yields significant energy saving. The evaluation shows that this approach can achieve up to 40% energy saving and up to 37% delay reduction.
- ***Researcher: MSc* Le Wang, Prof. Jukka Manner**







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Proxies can be utilized to significantly improve the energy efficiency of the web content in the radio access networks.

TUT Research Team and High-Lights under ECEWA Sino-Finland project

Prof. Mikko Valkama, Prof. Jukka Lempiäinen, Prof. Markku Renfors, Dr. Jarno Niemelä, MSc Tero Isotalo, et al.

Energy and Cost Efficiency in Radio Network Planning

Targeting to find optimal radio network configurations for different capacity demands using macro, micro and indoor layers

Optimal configuration: Simultaneous maximization of system capacity, network coverage, and quality with minimum radio network deployment costs and maximal energy efficiency

How?

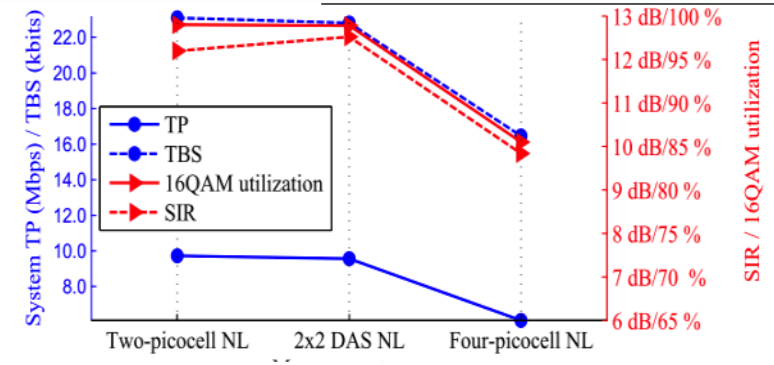
- *Coverage and capacity studies through accurate propagation modeling*
- *Analytical link budget analyses*
- *Evaluation of different network configurations that maximize cell capacities*
- *Comparison of cost and energy-efficiencies for different radio network configurations*

Example: Dense indoor network deployments

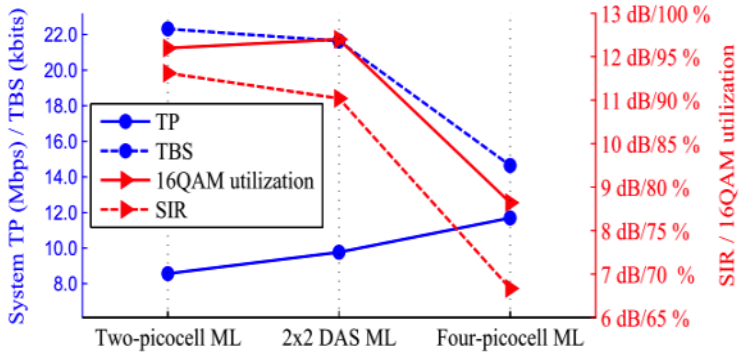
Tero Isotalo, Jarno Niemelä, et al.

- Study the impact of heavy intercell interference on HSPA indoor networks
- Measurement based study, commercial Rel'7 UMTS devices
- Two different room scenarios (small and large)
- Comparing e.g. two-picocell, 2x2 DAS and four-picocell layouts
- Outcomes: two-pico and 2x2 DAS similar performance, four-pico lowest SIR but highest system througput at max load

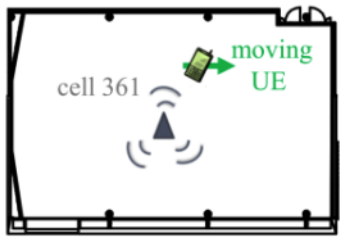
HSPA/HSPA+ *Idle and data mode transfer*		
Modes	Case	P-CCPCH power level (neigh. cell load)
Single-cell		--
Multi-cell	NL	-6 dB
	1L	0 dB
	2L	6 dB
	3L	9 dB
	ML	12 dB



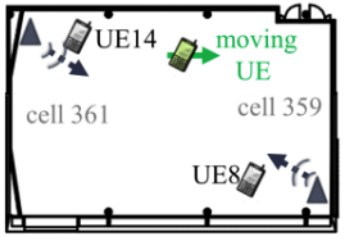
(a) NL case.



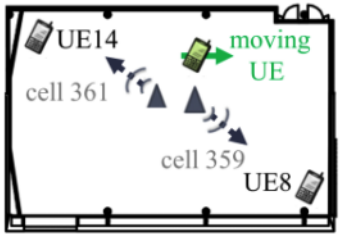
(b) ML case.



(a) One-cell.



(b) Multicell #1.



(c) Multicell #2.

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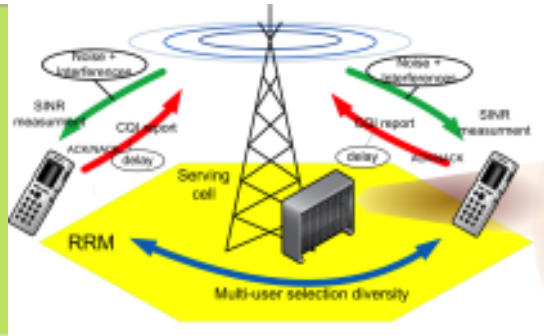
TUT Research Team and High-Lights under ECEWA Sino-Finland project



Prof. Mikko Valkama, Prof. Jukka Lempiäinen, Prof. Markku Renfors, Dr. Jarno Niemelä, MSc Tero Isotalo, et al.

Energy and Cost Efficiency in Radio Resource Management

- *Practical channel-aware yet energy-efficient data schedulers with fairness-constraints e.g. for best-effort and guaranteed bit rate (e.g. video streaming) data traffic types in packet radio systems*

  How to control the tradeoffs between energy usage, user fairness, throughput distribution and QoS parameters with proper scheduling metric design under limited channel feedback

- *Energy- and cost-efficient VoIP schedulers for LTE type packet radio systems; dynamic vs. semi-persistent scheduling and related control channel resource allocation*

  How to handle retransmissions, how to control the scheduling delay and other VoIP QoS requirements, packet bundling possibilities; related control channel designs and resource allocation algorithms for VoIP

  In general, targeting to support more VoIP users / MHz with given overall transmit energy

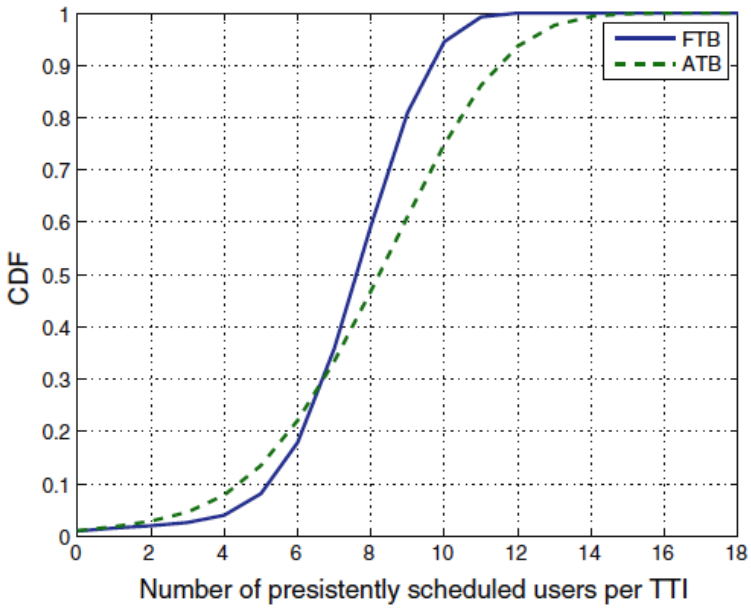
- *Related channel quality (CQI) reporting schemes*

Example: Energy and cost-efficient VoIP support in OFDMA based packet radio networks

Yong Fan, Mikko Valkama, et al.

Key components

- Talk-spurt based persistent resource allocation with adaptive transmission bandwidth for first transmissions
- VoIP optimized dynamic scheduling for re-transmissions
- Frequency diversity through scattered PRB allocations in localized and distributed transmission modes
- Realistic system-level performance analysis
- Realistic VoIP QoS and capacity criteria



Performance results, ATB vs. FTB

Deployment scenario	Approach	VoIP capacity	Capacity gain over FTB (%)	Average power consum. per UE
3GPP Macro Case1	FTB	320	0	125 mW
	ATB	355	11	113 mW
3GPP Macro Case 3	FTB	290	0	138 mW
	ATB	313	8	128 mW

Ericsson ECEWA highlights

- Research has been focused on heterogeneous network deployments as a tool to provide cost and energy efficient mobile broadband
- The performance of network densification options such as Macro only, Macro+Pico, Macro+Femto has been analyzed through system simulations
- Energy efficiency of different deployment options analyzed through energy efficiency models developed by EU project EARTH
- Performance aspects of LTE relays have also been analyzed, with focus on link layer protocol impact on performance and cell selection issues
- The results have been published in a series of conference papers and a doctoral thesis is being written

Contents

- ECE research activities are based on work divided in packages WP1 and WP2.
- The following items have been delivered during the period of 01.01 – 31.08.2011:

WP1 - Architecture of future mobile networks

- Methods and scenario studies of multi-antenna/multi-beams configurations as integral part of future networks
  - Research works on Capacity Impact of multi-antennas/multi beams in existing macro cell network structures
    - **Utilisations of cloud computing based planning and optimization platform eepos for Multi-antenna/multi beams program / Initial capacity simulations studies**
    - **Journal Paper – "Macro Cell Capacity in Mobile Networks"**

WP2 - Interference management for future wireless networks

- Methods and scenario studies of multi-antenna/multi-beam configurations as integral part of future networks
  - Specification - Multi antenna/multi beam configurations representations in cloud computing based planning and optimization solution eepos
  - First implementation representation - Multi antenna/multi beam configurations representations in cloud computing based planning and optimization solution platform eepos

Briefly about Efore - Mozilla Firefox

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Briefly about Efore

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- Efore world-wide
- Mission, Vision and Operating Principles
- Values
- Quality
- Environment
- Certificates
- Executive Management Team

Briefly about Efore

Efore Group is an international company which develops and produces demanding power products. The company has been established in 1975. Efore's head office is based in Finland and its production units are located in China and in Estonia. Efore is present also in Sweden.

The Efore Group employs globally approximately 821 people and in the fiscal year ending in October 2010, Efore's consolidated net sales amounted to EUR 69,7 million. The company's share is quoted on the Nasdaq OMX Helsinki Ltd.

Read more about Efore's development phases here

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