Open Innovation Newsletter | **Nokia** Research Center (NRC) | April 2009

NOKIA

Open Threads

Welcome to Open Threads

Welcome to Open Threads, the Nokia Research Center (NRC) newsletter that highlights our Open Innovation activities across the globe.

For more than three years NRC has actively engaged in Open Innovation through research collaborations with major universities around the world. These relationships and the success of our "open innovation" activities depend on the individuals involved – their expertise, enthusiasm, creativity and commitment. Open Threads aims at sharing the success stories and learning experiences of the people engaged in NRC's open innovation activities.

Open Threads will illustrate how open innovation, when properly done, can both accelerate innovation as well as create tremendous value for all the parties involved. Across the globe, across scientific domains, and at the convergence of several industries and businesses, the stories covered in Open Threads exemplify the formation of creative ecosystems, the acceleration of research progress, the co-creation of novel applications and the fulfillment of personal aspirations. These goals are achieved by sharing resources, leveraging ideas and tapping complementary expertise in a truly collaborative fashion. In the process, new skills are developed on all sides, in a two-way learning process.

It is important to note that the success of open innovation at NRC builds on the ideals provided by the Nokia corporate culture. The level of technical and scientific achievements made possible by engaging with external collaborators, and combining a shared passion for innovation is evident in our Nokia Technology Insights series of papers (downloadable at http://research.nokia.com/). Open Threads provides a complementary, but equally insightful view into the more human aspects of our collaborative work, as well as the variety of operational modes through which Open Innovation can be implemented. Internships, the direct funding of academic research, donations of devices and the creation of shared physical spaces are some of the approaches that enable open innovation collaborations in and around NRC.

We hope you will find the variety of the articles in Open Threads interesting and inspiring. To find out more about NRC and our collaborative research activities, we invite you to visit our website. There you will find a variety of information and opportunities, including news, updates, calls for proposal, job openings, white papers, application downloads and demos.

Best Regards,
Claudio

Dr. Claudio Marinelli
Director of Open Innovation and Academic Relations
Nokia Research Center

Dr. Claudio Marinelli – editor in chief of Open Threads - is responsible for the strategic and operational aspects of the collaborative research activities performed by the NRC laboratories across the globe.

Dr. Marinelli has a technical background in semiconductor materials, photonics and nanotechnology. His expertise includes innovation management, emerging technology entrepreneurship and investments.

For more information about Claudio go to http://research.nokia.com/people/claudio_marinelli/index.html

Dr. Henry Tirri
SVP, Head of Nokia Research Center

Building an Open Innovation Network

Nokia Research Center (NRC) is chartered with exploring new frontiers for mobility, solving scientific challenges to transform the converging Internet and communications industries. For over 20 years, NRC has been exploring and developing new mobile technologies.

At NRC, our research focuses on four areas identified as: Rich Context Modeling, New User Interface, High Performance Mobile Platforms and Cognitive Radio. Together, these focus areas explore the experiences people will have in the future, the technology and interfaces they will need, and the infrastructure required to seamlessly bring it all to life.

Now with ten locations worldwide, NRC is a truly global organization. We have research centers in Bangalore, Beijing, Cambridge UK, Cambridge USA, Helsinki, Hollywood, Lausanne (Switzerland), Nairobi, Palo Alto (California, USA) and Tampere (Finland). Being a part of such a wide variety of cultures, environments and skill-sets across these diverse geographies, lets NRC empower Nokia to develop products and services that meet the needs of all our customers.

Additionally, by strategically locating our teams around the world we are optimally positioned to collaborate with world-leading universities and research institutions in the mode of open innovation. This allows us to co-create value for all the organizations involved and ultimately for our end-customers.

Open innovation is truly successful when we all contribute our thoughts and inspirations. That is true of the organizations involved, as well as for this newsletter. I encourage you to contact us and contribute your story ideas, and to share your successes with others in our innovation network.

For more information please visit our website at http://research.nokia.com where you can find information about our research, job openings, internships and other opportunities to interact with us at Nokia Research Center.

Regards,
Henry

Research Focus Areas

Rich Context Modeling is characterized by the use of a wide range of sensed and historic information, aggregated into a coherent model of a user's state and surroundings, including things like their location, motion, weather, connectivity options, and proximity to others.

New User Interfaces will combine the personalization and adaptive aspects of a device with data-sharing enabled by future back-end infrastructures and the seamless integration with Internet services, seamlessly blending the physical and virtual worlds.

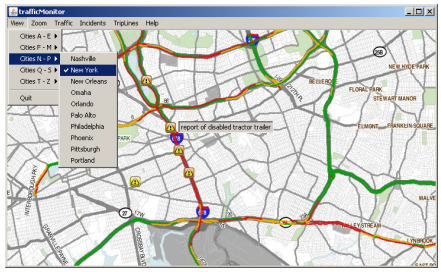
High Performance Mobile Platforms are devices that adapt to you and your environment. We want to drive to radically improve the performance to power ratio, enable new sensing capabilities, and extend the platform and architecture beyond the physical boundaries of a single device, resulting in a superior mobile platform.

Cognitive Radio is focused on empowering a new realm of devices and services through optimized connectivity, where mutually-conscious intelligent devices leverage awareness of environmental circumstances and user needs to determine how to communicate on the fly via dynamic spectrum use for improved connectivity and capacity.

On the road from intern to researcher

In early 2007, Baik Hoh had a problem – common to many PhD students as summer approaches – he wanted to intern at a world–class research organization in an area aligned with his doctoral work, but didn't have any direct industry contacts to help make it happen. Originally from South Korea, Baik was finishing up his doctoral thesis at Rutgers University focusing on the intersection of privacy and location. He thought that a company in the computer or automobile industries would be the right place for him to continue his work over the summer and allow him to get valuable experience in a corporate research department, but only if he could track down the right opportunity.

Without knowing the right people, Baik did what many people would do in his situation, and visited the research websites of leading companies such as Nokia, HP and Microsoft, and filled out online forms to apply for open intern positions. Students such as Baik with very focused research interests many times struggle to find an ideal match in job or research opportunities when they look beyond their PhD. A typical result is the need to adapt and change their research focus. In



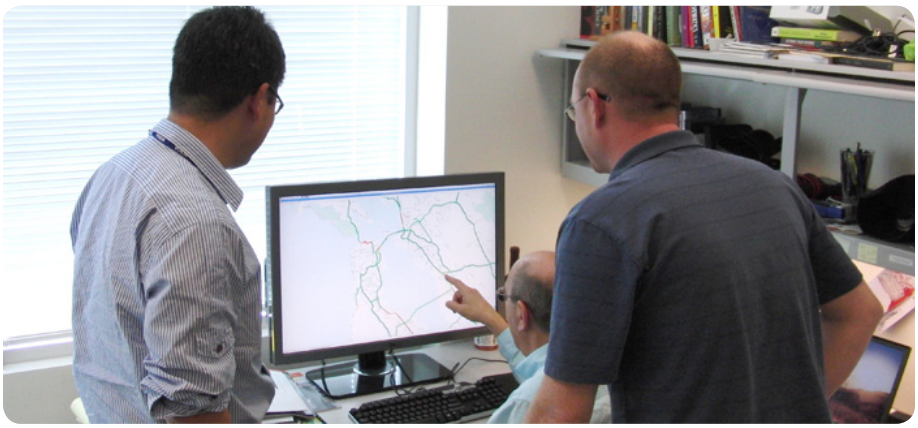
Traffic Works is a free public traffic-information system that uses the power of communities to provide the public with real-time traffic conditions.

To download the client for your GPS-enabled mobile phone, visit: http://traffic.berkeley.edu/pilot/

this case, with a feeling of predetermination, and a large dose of luck, there was an exact fit between the research needs at Nokia, and the sort of project that Baik was interested in pursuing.

Dr. Quinn Jacobson, Research Leader for the Mobile Internet Services Systems team at Nokia Research Center, was working on what would become the Mobile Millennium project (see sidebar, p.3) in conjunction with the University of California at Berkeley as well as the California and US Departments of Transportation. The project is a traffic-information system that uses the power of communities to provide the public with real-time traffic conditions by using GPS location information from mobile phones as they move around a city. Implicit in a system such as this is the privacy concern that the participants of the project would have about an automated system tracking their location. It fit Baik's research focus perfectly, so Dr. Jacobson contacted him personally and asked him to come out to Palo Alto, California.

"It was perfect for me because I was trying to find work in vehicle location privacy. I had heard that Nokia had bought NAVTEQ and was working on location projects. The harmony of Nokia and my work was perfect," Baik said.



The NRC team-based approach to projects provides an environment where interns are actively mentored and encouraged to make contributions as peers. Here, Baik Hoh, Ken Tracton and Quinn Jacobson review live Traffic Works data.

Over the last half 2007, Baik worked with Dr. Jacobson and students at UC Berkeley on a prototype of the privacy-preserving traffic-tracking mobile client application. To get a novel idea tested and implemented, starting from scratch, it takes a very motivated team, with individuals whose high level of interest for a certain research challenge allows them to overcome the inevitable obstacles they will encounter. The team was just forming at the time, really just an incubator project. But the success of that original prototype helped set the stage for the much larger Mobile Millennium trial which launched November 2008.

Baik returned to Rutgers to complete his PhD. But that isn't where the story ends. Due to the impact of his contribution, and great work with the team, Baik was offered a full time position at Nokia Research Center, which he happily accepted. According to Baik, the transition could not have been smoother. Since interns are treated equal to any other researcher at NRC, he was able to slip back into his old team without any major problems. He plans on continuing his important research in privacy and location at Nokia, ensuring that the company stays on the cutting edge in this increasingly vital area of emerging technology.

For more information about the project Baik is working on, please visit the Mobile Millennium project home page at http://traffic.berkeley.edu/.

For more information about Baik, visit his profile page at http://research.nokia.com/people/baik_hoh/index.html

Selected Readings:

Virtual trip lines for distributed privacy-preserving traffic monitoring. B. Hoh, M. Gruteser, R. Herring, J. Ban, D. Work, J.C. Herrera, A. M. Bayen, M. Annavaram, and Q. Jacobson. MobiSys 2008, Breckenridge, CO.

Automotive cyber physical systems in the context of human mobility. **D. Work,** A. Bayen, and Q. Jacobson. In National Workshop on High-Confidence Automotive Cyber-Physical Systems, Troy, MI, April 3-4, 2008

Also check out: http://traffic.berkeley.edu/publications.html

Facilitating innovation at Demola

At the Information Society Day on March 10, 2009, the Ministry of Transport and Communications Finland presented Demola with the Activator of the Year award. This award recognizes the Demola facility for its contribution to enabling open innovation in Finland, in the Tampere region north of Helsinki.

"What is special about Demola is the way of doing things: anyone and everyone can contribute ideas to a demo which is then built together. The 'Let's do it' attitude without bureaucracy and formal processes makes the atmosphere fruitful."

- Jukka Saarinen, Research Fellow at NRC

Demola is a 'demo factory', a multidisciplinary open innovation environment where researchers and students can co-create to develop new digital products and services with global market potential. Companies provide project ideas, concepts and guidance for student teams, who then develop the ideas further by building demos and test beds, doing trials and analyses, and creating business models.

Students are encouraged to create a personal profile on Demola's web site and choose the projects they are interested in. Students then contact Demola staff, and together they search for team members in collaboration with universities and colleges. Once a project is started, partner companies give continuous guidance – about two hours a week – to the project team through weekly meetings, workshops and one-on-ones. Demola staff are on hand to provide support as well, about topics such as project management, development models and working methods. Companies will actually implement some of the projects if they are worthy, or the projects could potentially generate new start up businesses.

The shared physical workspace on Demola's premises proved to be an important factor in fostering co-creation and an open innovation community. Demola is not just a work place but also an environment that is beneficial to innovation and provides an atmosphere open toward new working methods and continuous interaction with the various teams, companies and researchers.

Teams are working with unproven concepts, so they might run into unforeseen

technical problems that need novel solutions. This reinforces the importance of a shared space because of how it enables teams to tap into the Demola community for problem solving and creation of new ideas. Best practices can be identified and distributed to other teams as well in such a close working environment.

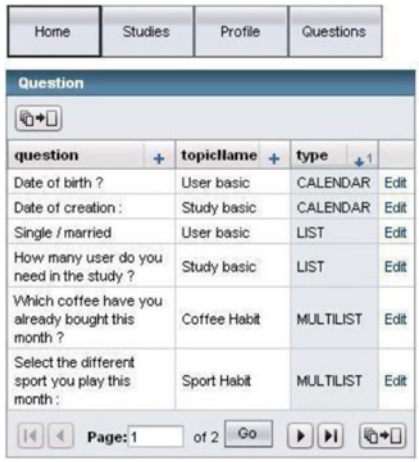
In many teams, there are students from several universities or colleges. Having a neutral location that is conveniently located in the city center has enabled unbiased and constructive collaboration among people from different academies and organizations.

Nokia Research Center (NRC) is a co-founder and a major collaborator with Demola. Collaboration with a variety of companies in dramatically different industries, such as YLE Finnish Broadcasting, promotes diversity in ideas and concepts and fosters innovative activity. In addition this also enables new partnerships between organizations in Demola's network.

Demola is an ongoing example of NRC pursuing its mission to lead Nokia into the future by being the global leader of open innovation. By sharing resources with projects such as the ones at Demola, Nokia has an opportunity to leverage outside ideas and expertise, and in doing so, is able to multiply its efforts deriving more value for all the organizations involved and ultimately for its end-customers.

"What is special about Demola is the way of doing things: anyone and everyone can contribute ideas to a demo which is then built together. The 'Let's do it' attitude without bureaucracy and formal processes makes the atmosphere fruitful. This is a return to the fountain of innovation, where work is spontaneous and fun," said Jukka Saarinen, Research Fellow at NRC.

Altogether, Demola had 12 projects during the first five months, all of them involving ICT companies and student teams from three local colleges: TAMK University of Applied Sciences, Tampere University of Technology and Tampere University. To date around 100 students have participated in Demola's projects, and the number is continually growing.



USRA – User Study Recruiting Assistant – is an example of an application developed within Demola. An online tool that assists marketing specialists in building a structured database of end users and in selecting the right candidates for each market study.

For more information about Demola visit: http://www.demola.fi

Harvesting the energy of open innovation

The path from the research lab to market is unpredictable. A mix of serendipity, focus, creativity and method is required to generate commercially relevant innovations. For high-tech entrepreneurs the starting point of a successful start-up is often a lucky research breakthrough or an innovative new approach to a problem. Conversely, for a large high-tech corporation, the launch of a new product or service is usually the result of focused market studies and a structured R&D process.

So, what happens when an academic scientist with a strong entrepreneurial track record engages in blue-sky research in collaboration with a prodigious company such as Nokia? The experience described here shows that innovation can actually be significantly accelerated by such dynamic collaborations. Academic research creativity is enhanced by the addition of industrial research focus, as talent and efforts are directed towards the right questions, prioritized for real-world results. Basic research remains a fundamental pillar of agile innovation, but the results can be greatly enhanced by working together in and outside the lab with commercial partners.

Prof. Gehan Amaratunga is head of the Electrical Power and Energy Conversion Research Group within the Electrical Engineering Division of the Department of Engineering at the University of Cambridge. Not only is Amaratunga a professor, but he is also a successful entrepreneur who has been working with Nokia researchers since 2007. To date this collaboration has produced nano-enabled solutions to increase energy density and shorten charge/discharge cycles in energy storage systems, plus the potential for novel, flexible form factors in batteries and super-capacitors.

We recently had the opportunity to chat with Amaratunga about his research, working with Nokia, and his thoughts on the power of open innovation when done effectively.

Could you give us an overview of what you are researching, and what you are doing in partnership with Nokia Research Center?

I specialized in electronics and nanotechnology for energy. With Nokia what we are particularly looking at is the application of nanotechnologies for energy harvesting and energy storage. So, that means enhanced battery-life through supplementing the battery by harvesting energy from the environment around the mobile device, including the magnetic spectrum, as well as the light, then being able to store that efficiently in devices which have as good a performance or better than existing batteries. One of the key things we are concentrating on is

"Our project has been very productive because of the fact that Nokia Research Center has established a presence in Cambridge to work on Nanotechnology."

- Prof. Gehan Amaratunga, head of the Electrical Power and Energy Conversion Research Group at the University of Cambridge.

trying to break away from the form factor limitations that are caused by existing battery technologies, such as cube and rectangular shapes. If you could shape the battery into any form you wanted, then you would have more flexibility in the form factor that a telephone takes.

Back in his old stomping grounds of Liverpool (where he used to hold an academic position), Prof. Amaratunga relaxes with his Nokia and academic collaborators, as he re-traces the steps taken by the Beatles on the now historic 'Penny Lane'.

When did you start this project in collaboration with Nokia?

We originally started this as part of the strategic alliance between Nokia and Cambridge University in nanotechnology and nanoscience, which was signed in April of 2007, so approximately two years ago.

How is the progress going so far?

We've made some really interesting progress. We've had a number of blue-sky ideas that we wanted to explore, which still had some practical element to it in terms of getting to some quantifiable results. Some of the ideas we had on nano-structuring surfaces for enhanced energy application have worked out as we thought they would, with some new material elements. We demonstrated some really quite exciting results on super capacitors, for example, for rapid charge and discharge applications.

How is it working with Nokia? Have you been able to accelerate research by working together?

I think the initial research would not have been enabled of course unless Nokia funded it. Though, it's more than just the funding. You could argue that someone else could have funded it such as the British equivalent of the National Science Foundation, but I think we wouldn't have had the focus and we would not really have understood what the important problems were without Nokia's input. Essentially, it gave us the targeted focus in addressing the big problem, rather than the problems we thought were important. Our project has been very productive because of the fact that Nokia Research Center has established a presence in Cambridge to work on Nanotechnology. We've had researchers from the Nokia

Nano-enabled energy storage solutions with novel form factors and increased energy density will allow Nokia to power future mobile devices. A device's thickness and flexibility in shape, as well as its performance, will no longer be constrained by limitations with energy storage solutions.

For more information about the Nokia Morph Concept illustrated above, check out this video online: http://www.youtube.com/watch?v=IX-gTobCJHs

Research Center here working intimately and in a very integrated way with the university researchers.

Cambridge UK is one of Europe's hot-spots for high-tech entrepreneurship. You and your research group have a distinguished entrepreneurial track record, having spun out several companies (e.g., CamSemi, Nanoinstruments, Enecsys). How does working with a company like Nokia help foster this entrepreneurial drive that you have developed?

I think when we engage in research, with Nokia for example, none of us really knows. We never really do research expecting it to be a company or that it's going to be entrepreneurial. If that's the way it evolves, then at some point it makes sense for the research to go forward and for it to be spun out into a company at a certain point. If that happens, that's okay, but it doesn't happen with every research project.

Now with the work we're doing with Nokia, one could argue that looking at the energy systems for the phone is crucial to Nokia, but Nokia doesn't necessarily make components for batteries or super capacitors. At some point it may make sense for Nokia to do that, or to spin out something jointly with the university to make that happen, or enable one of their suppliers to do it. Whichever makes sense, that's what will happen, I think.

Looking ahead, what do you think are the key future challenges or opportunities in your technology area?

The challenge for the particular technologies we're developing under the Nokia program is that it is speculative. It builds upon the material system which we worked on for the best part of 15 years, so we're not coming in cold. But to make it applicable to a storage device requires a degree of engineering as well as innovation and understanding of science which doesn't exist, or is not well understood at the nano-scale.

The opportunities of course are that we already have results that are very encouraging and that show the potential, and if we could bring it to the point of a correct performance level, there's a future for some paradigm changing applications.

Selected Readings:

Photoelectrochemical cell using dye sensitized zinc oxide nanowires grown on carbon fibers H. E. Unalan, D.Wei, K. Suzuki, S. Dalal, P. Hiralal, H. Matsumoto, S. Imaizumi, M. Minagawa, A.Tanioka, A. J. Flewitt, W. I. Milne and G. A. J. Amaratunga; Applied Physics Letters, 93 (2008) 133116.

A solid state dye-sensitized solar cell based on a novel ionic liquid gel and ZnO nanoparticles D. Wei, H. E. Unalan, D. Han, Q. Zhang, L. Niu, T. Ryhänen and G.A.J. Amaratunga; Nanotechnology, 19 (2008) 424006.

Flexible, Light Weight Supercapacitors from carbon nanotube thin films, Pritesh Hiralal, Haolan Wang, Husnu Emrah Unalan, Markku Rouvala, Di Wei, G. A. J. Amaratunga, MRS Fall Meeting Boston, December 2, 2008

Producing radical results in mobile computing.

The long-term focus of academic research often contrasts with the industry requirements for a fast prototyping of novel ideas and a quick gathering of end users' feedback. The success priorities of industrial and academic research can also be very different.

These are some of the common challenges faced by any open innovation collaboration between university and industry. Finding efficient and innovative ways of working together can however bear very appealing fruits for all the parties involved. Academia can rapidly expand its research in a variety of new directions. If new breakthroughs are rapidly deployed in pilot services or products, the response from the real world can help steer research in commercially relevant directions. This creates a virtuous circle that enhances the potential impact of new research activities for both industry and academia – in a true win-win scenario.

Dr. Jianwei Niu is the Associate Professor of Distributed and Mobile Computing, School of Computer Science and Engineering, Beihang University in China. He and Nokia Research Center, Beijing have cooperated on more than five projects, including a business card recognition system and the Stroke++ applications (see side bar). With research focusing on multimodal user interaction and mobile computing, Niu's team have published more than 10 joint papers with NRC, and have three graduate students and PhDs from his lab that are now Nokia employees. Niu also collaborates closely with NRC in areas of campus events organization, curriculum building, and Nokia mobile platform technical training.

What makes Niu and his team so productive is that they have become proficient in mobile development as an integrated part of their basic research. By using an in-house framework, the team has been able to create prototypes of their ideas quickly, and begin user testing immediately resulting in a dramatically shortened feedback cycle. The results have been an abundance of innovative mobile applications that Nokia has been able to use, with several having already been pre-installed and sold on consumer devices worldwide.

Such productivity belies the challenges that working with outside companies entails. Like in many projects that involve open innovation style partnering with commercial organizations such as Nokia, it could all result in poor value for academic researchers if their goals were not carefully aligned.

Stroke++ is a revolutionary one-handed Chinese character input method for touch screen devices. Going well beyond the traditional single-stroke input, Stroke++ incorporates the use of character "radicals" to dramatically decrease input time.

"Academia mainly focuses on long-term research, and industry wants to transfer these research results into products as quickly as possible," Dr. Niu said. "Before working together, both parties should have a clear and correct understanding of each other, and know the advantages and disadvantages of their partner, and arrange the cooperation accordingly."

Currently, Niu's team has two ongoing projects in cooperation with Nokia Research Center, Beijing.

The first is the radical new Chinese character input method called Stroke++, mentioned earlier. A new one-handed system for touch screen devices, which provides a quick and efficient solution for Chinese text input. Unlike almost all the language input devices that were designed based on Western linguistic and psychological models, Stroke++ combines the input of radicals and strokes in a new way, and can extend to other character systems as well, such as Hindi and other eastern languages. Started in September 2008, Stroke++ currently runs on Symbian S60, and soon on Nokia's Linux-based Maemo platform as well.

The other project is a novel method of multimodal user interaction based on human face expression recognition and "face sketching", which allows online video conferencing systems to be enhanced with real-time facial avatars. This second project is making exciting progress, and Niu hopes it will be finished before the end of this year. Looking ahead to future research, Niu said, "I think that the key challenges include facial expression recognition and 3-dimension face reconstruction in our technology area."

Originally focused on the compression and transmission of video, as well as mobile computing, working with Nokia has gradually shifted Niu's research focus towards other areas.

"After six years of cooperation with Nokia, now our main research work focuses on multimodal user-machine interaction. To some extent, the cooperation with Nokia has both shifted and expanded our research direction," said Dr. Niu.

Selected Readings:

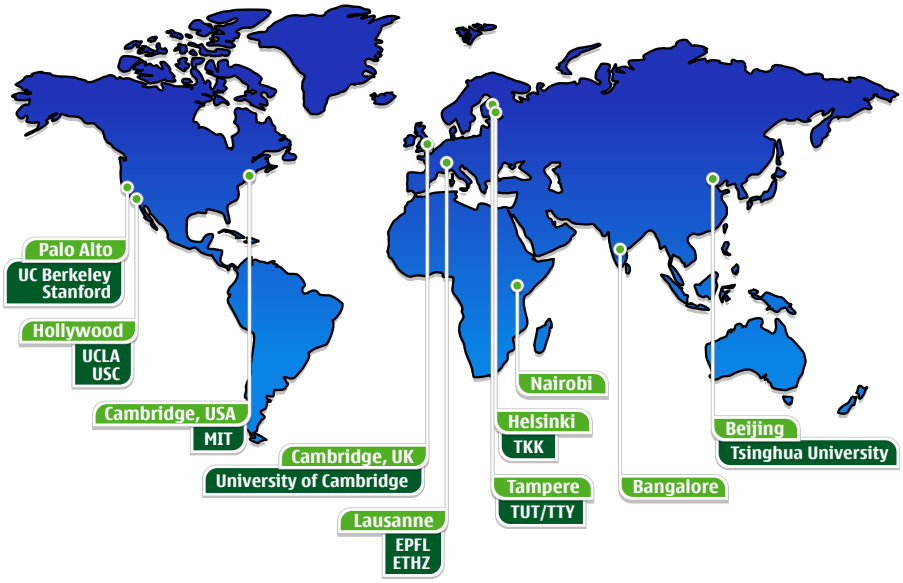
A novel Protocol in Intermittent connected Mobile. NIU Jianwei, MA Jian and etc. IEEE SEC 2008, Beijing, China, pp:155-162..

Rate-Distortion Optimized Stream Switching For Peer-to-Peer Live Streaming. ZHANG Jin-feng, NIU Jian-wei, MA Jian, WANG Hai-la. Journal of Zhejiang University Science-A, 2008, V9(4):445-456.

Opportunistic Networks. XIONG Yongping, SUN Limin, NIU Jianwei, MA Jian. Journal of Software, Vol.20, No.1, January 2009, pp.124−137

Adaptive Multiple-copy Multiple-hop Forwarding In Intermittently Connected Mobile Networks. NIU Jianwei, ZHOU Hang, SUN Limin, XIONG Yongping. SEC 2008, Beijing, China, 2008 Oct, pp:303-308.

The map below shows the location of NRC laboratories, located in close proximity to our strategic academic collaborators. The range of these collaborators is continually expanding and the list of strategic partners with whom Nokia has signed a Framework Research Agreement currently includes institutions such as the University of California at Berkeley, University of California at Los Angeles (Framework Agreement under negotiation), Stanford University, the University of Southern California and the Massachusetts Institute of Technology in the U.S. In Europe there are the University of Cambridge, EcolePolytechniqueFédérale de Lausanne (EPFL), EidgenössischeTechnischeHochschule Zürich (ETHZ), Helsinki University of Technology (TKK - TeknillinenKorkeakoulu), Tampere University of Technology (TTY - TampereenTeknillinenYliopisto). In Asia, the Tsinghua University in Beijing.



Open Threads Editorial Board: Rebecca Allen (Lab Director, NRC Hollywood), Andreas Korczak (Head of Strategy and Operational Excellence, NRC), Zhen Liu (Lab director, NRC Beijing), Claudio Marinelli (Director, Open Innovation and Academic Relations, NRC), Doug MacMillan (Director, Research Promotion, NRC), Jukka Saarinen (Research Fellow , NRC Tampere).

For More Information

Nokia Research Center maintains an active communication with the industry at large. For an overview of our activities, organization and partners please go to: http://research.nokia.com/

For more information specifically on our Open Innovation network and activities, go to: http://research.nokia.com/openinnovation

We also invite you to meet our team and learn more about the people at NRC who are doing amazing research which is shaping tomorrow's mobile technology: http://research.nokia.com/people

You can download this newsletter by going to: http://research.nokia.com/files/OT_1_09.pdf

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