Consistently delivering innovation in network planning and optimization

NPO innovation journey
Innovation is happening right now at Nokia

Many of the innovations from previous years described in this document are still relevant today and have been developed to support the optimization of mobile broadband networks and services.

Looking ahead, Nokia will continue to focus on innovation and we will be updating this document to reflect the latest developments.
Two decades of continuous innovation in network optimization

Innovation is a hallmark of success in mobile telecoms. One of the most consistently innovative Services business areas at Nokia is the Network Planning and Optimization (NPO) organization. Since the earliest days of digital mobile communications, the NPO unit has delivered multiple breakthroughs, from advanced GSM/EDGE network design and optimization tools during the 1990s, to today’s mobile broadband performance and revenue optimization. Such innovation has given many of Nokia Networks mobile operator customers a substantial competitive advantage.

Over the years, Nokia Networks has continuously developed network planning and optimization to support the needs of its customers and their subscribers, changing market and technology trends, and subscriber behavior and usage demands in four broad areas:

**Network optimization**
The conventional approach during the 1990s was to focus mainly on the network and improving its Key Performance Indicators (KPIs). Nokia Networks helps operators to manage the mobile data explosion by providing solutions that achieve the maximum network potential, reducing their Operational Expenditure (OPEX) and delaying their Capital Expenditure (CAPEX).

**Service optimization**
The first decade of this century added greater emphasis on the service layer and raising the Quality of Service (QoS) delivered by the network. Service optimization enables the operator to provide a better Quality of Experience by prioritizing and improving the performance of different services like online browsing and streaming and the performance of applications and devices. This way Nokia Networks helps operators to manage the data explosion in a smarter and more targeted way.

**Experience optimization**
More recently, since around 2010, innovation has focused on the customer experience, aiming to deliver differentiated services that capture new revenue for mobile operators. Experience optimization enables operators to give each individual user the experience they want and steer away from flat fee pricing by helping them implement and assure QoS differentiation. In experience optimization, Nokia Networks also looks at maximizing end user revenue through modules that will help predict churn and maximize the end user experience.
Technology evolution

As networks continue to evolve to the latest technologies, the level of complexity in networks becomes an increasing challenge. Nokia Networks helps its customers to upgrade to new technology only when and where it is really needed.

Over the last two decades, Nokia Networks has created a consistent stream of innovation, illustrated by Appendix A which lists some major patents.

Importantly, every innovation from Nokia Networks has been created to meet a business or technical challenge facing mobile operators, from enhancing network capacity for satisfying customer demand, to improving call handovers for more reliable services, to boosting smartphone performance on networks, and more. Nokia Networks NPO innovation is driven by a deep understanding of the needs of mobile operators, by anticipating their future requirements and by running a major R&D program.

Describing in detail all of these and other Nokia Networks inventions would require a substantial document*, so instead let’s look at some key innovations over the years and the benefits these have brought to mobile operators.

Fig. 1. Network Planning and Optimization (NPO) has evolved over the years with innovation in three key areas: Experience Optimization, Service Optimization and Network Optimization, supported by innovations in technology.

*NB: Nokia Networks would be pleased to provide more information on any of the innovations listed in this document.
Innovations in network optimization

Addressing the optimization of the network layer, Nokia Networks innovation has focused on creating more advanced methods and tools to enhance coverage, spectral efficiency, average and peak bit rates, latency and many other KPIs.

**Network modeling using a digital map-based simulation**

In 1994, Nokia Networks filed a patent application for the planning of a cellular radio network by creating a mobility model of subscribers on a digital map. Properties could be added and parameters optimized using statistical simulation based on network data.

Part of the Network Planning System (NPS/X), this interactive network design software creates the structure of the network and its actual radio environment on a digital map. The map includes the topography (height of terrain), type of terrain, and roads/streets. The software enables an operator to position base stations and calculate the subsequent coverage using the software's mathematical propagation model.

Network operators were able to take the guesswork out of planning a network, minimizing expensive rework and the addition of more sites, making the plan much more reliable. An additional benefit was that the plan could be created in days with one person rather than weeks with a team of people.

Fast forward to today and we find that Nokia Services for HetNets employs a similar, sophisticated approach to analyze and recommend on how to build the most efficient Heterogeneous Network (HetNet) combining the best of all technologies. In 2012, this helped one operator in the US to reduce costs by 20%, whilst boosting customer experience, with 21% more users able to access the highest data speeds.
Identifying traffic hot spots from base station data

In 1996, Nokia Networks filed a patent for planning traffic capacity in networks, an issue that remains highly relevant today. The method provides a system and procedure to locate traffic hot spots by analyzing reports from base stations to identify the cell patterns that occur most often. These cell patterns can be associated with geographical locations which can then be displayed to identify the hot spots.

The method works by storing measurements from the three best neighbors, called triplets, in a hot spot data table. The resulting cell patterns and how they are being used is fed to the Nokia NPS/X network planning system. NPS/X then uses each cell pattern and predicted cell coverage areas to identify a geographical location on a digital map. Areas of high traffic concentration can be seen easily, enabling operators to plan capacity exactly where it is needed. Having the right capacity meant end users could access the network more reliably, suffer fewer dropped calls due to congestion and enjoy a better quality of experience.

Maintaining call quality during indoor/outdoor handovers

A 1998 Nokia Networks patent addresses the issue of improving call handovers between indoor and outdoor cells. The method involves creating groups of indoor and outdoor cells with a gateway cell around each group, and with one gateway cell at the building’s entrance. The gateway cells are each entered on the neighbor lists of each indoor and outdoor cell as well as other gateway cells.
These neighbor lists ensure the cell handover from inside the building to the outdoor cell is carried out through a specific indoor cell, even if a subscriber terminal inside the building is in the outdoor cell’s operating area. The method, which is also applicable to today’s systems, reduces the load on the outdoor cell, because handovers to the outdoor cell decrease.

**Improved antenna tilting to reduce interference and boost QoS**

Enhancing network capacity continues to be a prime goal for most operators and a 2003 Nokia Networks patent helps tackle the issue with an improved way for adjusting antenna tilt based on radio cell interference data.

The technique involves gathering interference information from a radio cell, then organizing and processing that data to determine a tilting factor for the cell according to the interference produced with other cells. It also searches for radio cells with antenna tilting factors that fulfill a set criterion, and tilts the antennas accordingly.

By reducing interference in the network, this method can unlock additional capacity of a multi-technology network, enabling it to deliver higher QoS.

**LTE Stadium DAS Optimization**

Stadia and special venues present a challenging situation with masses of people trying to capture and share images, access websites and social networks, conduct searches and stream video clips all in a very dense environment.

Nokia Networks has used expert system simulators refined over many 3G/4G field projects to address the multivariable optimization of antenna placements, down tilt, power levels, sectorization, combining, and more. Early trials and simulations show significant performance improvements: 36% reduction in interference and as much 60% in difficult conditions. This capability will be used to support a number of high profile sporting events in 2013-14.
Innovations in service optimization

As the world began to adopt 3G systems in the first few years of this century, users’ appetites for new mobile services began to grow and with it came a demand for higher quality services both on 2G and 3G networks. To help operators meet this challenge, Nokia Networks was already evolving its NPO capabilities. In today’s network, the demand still exists with services such as VoLTE where the challenge is to achieve comparable if not better quality.

Classifying user behavior to allocate network resources for high QoS

In 1999, Nokia Networks patented a method that uses network data to classify end user behavior. The method involves filtering user-specific information from the network according to one or more network variables, or combinations of variables defined previously. The filtered data is then used to allocate users into various classes that indicate their behavior on the network.

This enables an operator to set network parameters that are essential for good quality services, such as the QoS threshold values used for allocating resources in a GPRS network.

Reducing the signaling load on circuit-switched and packet-switched networks

In 1999, Nokia Networks gained a European patent for a new radio network access mechanism that defines a method of registration by a multi-mode mobile station (MS) comprising a circuit-switched (CS) and a packet-switched (PS) network.

When General Packet Radio Service (GPRS) was introduced by European Telecommunications Standards Institute (ETSI) GSM phase 2+ standards, the GSM network’s dual mode operation was defined as two different networks. This created a need to define the operation of this two network system.
The Nokia Networks patent describes a method by which the Home Location Register (HLR) maintains an access parameter to govern the access type of the MS. This reduces the signaling load across the CS and PS networks, compared to operating just a GSM network. Signaling today remains a key challenge for operators, from predicting the effect that all the different services will have on the network, to understanding the behavior of each device on the network. To solve this challenge, an Application Profiling and Impact capability has been created by combining research from Nokia SmartLabs with real world insight from NPO. This provides an ‘early warning’ system for operators, allowing them to be prepared for the impact of new devices and applications on network performance and customer experience.

**Load sharing manages traffic to improve the quality of services**

A 2001 Nokia Networks patent unveiled a new method for load sharing between multiple radio network cells based on a comparison of the power budgets of two cells. The method calculates a handover margin based on both load and quality performance obtained from the power budget. When a cell becomes congested, its operational size is reduced while the overlapping area between the cells is kept constant. This enables the Base Station Subsystem (BSS) to improve handover priorities and redistribute mobile devices across the cells to reduce the risk of congestion and blocking, thus effectively increasing capacity and improving service quality.

The method was created from Nokia Networks deep understanding of the factors as well as practical knowledge of how to optimize a network for peak performance.
Innovations in experience optimization

As network technology has advanced and brought us into the era of mobile broadband with high data rate WCDMA and 4G networks, Nokia Networks continued to innovate its NPO services with a growing focus on enhancing the customer experience to optimize mobile operator revenues. A wide range of techniques have been introduced to address the complexities of integrating LTE networks and the cost effective and rapid roll out of new technologies and services to help operators achieve profitable growth.

Profiling smartphone behavior to boost the mobile broadband experience

Profiling Smartphone Behavior is a novel service that aims to understand how smart devices interact with the network to help operators proactively plan their CAPEX while improving their customers’ smartphone experiences. Delivered as a service, the innovation is based on tools, data correlation and analysis profiling terminal behavior. This approach helped O2 users in London enjoy faster data speeds, longer battery life and better coverage.

“Nokia Networks reacted swiftly … and then implemented an effective upgrade to enhance the smartphone experience for our customers. This has resulted in a better use of network resources, minimized traffic loss and enhanced the experience of smartphone users.”

Nigel Purdy, Head of Technology,
O2 UK

Catering for high performance applications at events

The use of wireless cameras with HDTV quality at events and the need for high performance communications for machine type applications, for example motor sports, demands the highest bandwidth, lowest latency and shortest handover in mobile networks. To help operators...
capture the revenue potential of these applications, Nokia Networks has created an innovative capability called LTEvent. This enables an LTE network to be set up with specific configurations and parameters to deliver the high performance required, with latency as low as 20ms.

**Delivering high quality indoor mobile broadband**

To improve the customer experience of using mobile broadband services when indoors, Nokia Networks developed its Smart Indoor Management Platform for Planning and Evaluation (SIMPLE) solution. This applies innovative indoor planning principles for different scenarios during the design phase, conducts indoor planning audits, provides real-time health scores and KPI monitoring post-launch, and manages all relevant information in a database format. This allows the operator to tap quickly into the lucrative additional revenue from indoor users while delivering the best quality of service.

**Quality of Experience feedback helps track customer satisfaction**

Smart Experience, or SmartEXP, is a Customer Experience Management (CEM) solution that highlights Quality of Experience (QoE) to help operators deliver a better experience to their subscribers. Comprising an App and Platform to collect and store mass end-user QoE feedback, the system enables an operator to understand their customers’ needs more deeply. Operators can use social networking to share user comments and spread the use of the App.

**QoE Service Modeling for customer experience monitoring**

QoE Service Modeling aims to bridge the gap between the customer experience and network performance by correlating basic network KPIs with service KQIs, and hence to user experience QoE. Being able to implement the QoE model into the live network with real-time data collection, processing, correlation and aggregation enables powerful insight into the customer experience.

Real-time QoE monitoring enables operators to easily identify any performance issue that could affect the customer experience and take action to avoid further degradation of the service quality. Customer satisfaction is increased, churn reduced and the use of services rises, leading to an improved return on network investment for operators.
All the innovations in planning and optimization described above are focused on the continuous evolution of underlying network technologies, from the first analog networks to the current fourth generation. Every day, network operators face the dilemma of when to invest in additional equipment and which steps to take to migrate to newer technologies. The evolution of the network must anticipate end users’ expectations of performance and deliver them as efficiently as possible.

Recently, the merging and sharing of networks, the release of new spectrum and the ability to use spectrum more flexibly have brought greater opportunities, but also more complex decisions for network operators. Nokia Networks has always provided support in finding the best options in each specific case by bringing continuous innovation to services for technology evolution.

**Automated network workflows cut optimization costs (SON)**

The Nokia Smart Automation Flow Engine (SAFE) helps operators reduce the cost of optimization while also achieving better results. This simple yet highly intuitive solution uses internal end-to-end, customized workflows to deliver daily network operational improvements and make network changes to integrate new technologies, such as LTE. As well as achieving highly consistent results, SAFE provides a single control and management environment for the highest efficiency.

This helps the operator to tackle rising network complexity and brings the next level of efficiency to the network management process.

**Identifying base station synchronization errors with ease**

Synchronization Assessment Without Probes (SAWP) identifies the root cause of out-of-sync base stations triggered by network problems. SAWP also ensures proper monitoring of frequency accuracy. This
innovation identifies network-related synchronization problems by using an internal parameter of the base station in combination with the known network topology, eliminating the need for external measurement equipment.

**Achieving highly effective mobile backhaul planning**

Rapidly growing data traffic volumes and constant upgrades of existing networks with LTE and Small Cells have raised the importance of effective mobile backhaul capacity planning. With the introduction of all-IP networks, end-to-end QoS requirements have also become critical. The Nokia NPS10, part of Mobile Backhaul Planning Assessment and Planning services, improves the effectiveness of planning backhaul networks by using an iterative approach that considers the busy hours of individual base stations.

**Measuring the progress of ipv4 to ipv6 transformation**

Nokia Carrier IP Migration Index (CIMIX) is an innovative tool and methodology to measure an operator’s progress towards an all-IP network and services infrastructure against an industry baseline. This is the industry’s first benchmark methodology to evaluate such progress and determine whether the IP strategy is aligned to customer experience, revenue generation or cost efficiency.

Operators can also use CIMIX to determine the success of their IP transformation on their strategic goals and create an action plan for improved business performance, helping to ensure a successful transformation journey.
Delivering NPO services with extreme efficiency

To support its innovative tools, platforms and processes for improving operator networks and services, Nokia Networks has put considerable R&D effort into creating new ways to deliver and industrialize all its rollout and optimization services. This gives faster time to results, reduced costs, repeatability and consistent delivery quality.

Common reporting for clear views of network health

The Nokia Platform for Reporting and Optimization Tools for NPO (PROTON) is a flexible and offline data collection and storage platform with a customized feature set and specific functionality to fulfill the needs of different NPO applications and use cases. PROTON consolidates all the reporting information from the full range of optimization projects and wide variety of tools and data sources. This gives a clear view of network health and helps to ensure proactive action is taken to improve operator networks and services.

PROTON also runs offline and independently, allowing Nokia Networks to provide NPO services without needing permanent access to the operator’s OSS.

The platform improves the efficiency of optimization projects by providing predefined and customized applications for faster integration of project demands, and by correlating different data sources to simplify fault analysis. Being a single, centralized platform, PROTON also enables project experiences to be shared and applied to all NPO projects so that customers can benefit fully from best practice.

Automated system log processing helps improve the smartphone experience

LOGOS is an Nokia Networks proprietary tool that enables the automated collection and rapid processing of system logs for call tracing. By providing a statistically relevant amount of call trace data, Logos allows multiple Radio Network Controllers (RNCs) to be analyzed much more efficiently, speeding up the delivery of services such as Smartphone Profiling.

Boosting the efficiency of databuild services

Traditional databuild services often involve considerable and time-consuming manual work to edit and check configuration files, as well as skilled local resources to customize the process. Daisy for Databuild is a task flow system that eliminates most of this complex manual
work for new rollouts and swap services, providing about a 17% efficiency improvement in service delivery.

**Automated neighbor relations checks eliminate drive testing**
A method called ‘Neighbor Consistency check through ADA’ automatically creates and validates neighbor relations prior to the deployment of a new or optimized radio network plan. This improves the efficiency of the deployment by eliminating drive testing, resulting in huge improvements in data gathering. The method can be used for all radio technologies.

**More efficient optimization of LTE interference**
A Nokia Networks patented methodology called Irregular Coverage Recognition (ICR) cuts the time to complete one optimization cycle through automation and a simpler tool chain. This reduces the number of iterations needed to optimize interference since the process is more accurate and decreases the number of drive tests needed.

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### Global delivery of NPO services
Nokia Networks has been one of the pioneers of Global Service Delivery in which services are provided remotely to operators. In 2006, the company set up its Service Delivery Center (SDC) for providing network planning and optimization services. The aim is to deliver more efficiently, scale to meet growing demands, automate high volume standardized tasks, deliver more quickly, achieve more consistent delivery, reuse of best practices and efficient use of expertise. SDC was the first to provide virtual and remote delivery of standard NPO services in volume. These services include:

- Benchmark analysis
- Drive Test Post processing
- 2G Radio Network Monitoring and Assessment
- 2G Radio Network Optimization
- 3G Radio Network Monitoring
- IP Planning, IP Backbone Planning
- Core planning (fixed)
- Core R4 Planning (mobile)
- Database planning and data build

The SDC concept enables specialist expertise to be made available to operators everywhere, so they benefit from best practices that are proven globally and tailored to local needs. This not only improves the efficiency of the services but eliminates risk to the operator with investment and accountability resting with NSN.

SDC has been remotely delivering NPO projects to more than 600 operators.
Innovation recognized across the industry

Nokia Network Planning and Optimization (NPO) services are built on continuous attention to innovation, quality, expertise and automation. The services aim to help operators to generate new revenue streams by enhancing the performance of their networks and services, and integrating Customer Experience Management and Mobile Broadband capabilities.

The benefits of this strategy continue to be recognized globally:

• In March 2013, IDC said that Nokia Networks offers a strong NPO portfolio and is a technology leader able to combine multiple service components into one solution powered by strong capabilities and tools.
• In a recent IDC MarketScape report, IDC ranked Nokia Networks as an LTE “Leader” with capabilities to serve operator needs today and with a long-term alignment with operator strategies and with recognition of NPO’s contribution.
• Nationwide testing of South Korea’s LTE networks in 2013 by the Korea Communication Commission (KCC) revealed that Nokia Networks is ahead of other vendors in providing quality LTE access to subscribers. The findings come in the wake of performance figures in late 2012 which also showed that Nokia LTE technology outperformed other networks by supporting the traffic generated by spectators of the Korean Busan fireworks display. The top results are testament not only to Nokia Networks products, but also to its advanced NPO services and expertise.
• In early 2013, Nokia Networks helped Vodafone New Zealand launch the country’s first 4G LTE service. Nokia Networks upgraded the existing 2G and 3G networks to ensure the 4G network benefited from greater network coverage and high-speed services. Nokia Networks further provided NPO expertise in LTE refarming services.

“While our managed services provider was focused on operational KPIs, Nokia Networks bridged the gap between technical measures and the real customer experience. They proactively developed a more comprehensive suite of KPIs that reflected the way end users interact with the service and created Key Quality Indicators (KQIs). These correlated much more closely with the way our customers were actually experiencing our services,”

Petek Ergul, Head of Core Networks, Three UK
Fig. 3. A recent IDC MarketScape report ranked Nokia Networks as an LTE “Leader”

Fig. 4. Nokia Network Planning and Optimization innovation in numbers
## Appendix A

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<td>Feb. 1994</td>
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<td>Monitoring traffic in a mobile communication network</td>
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<td>Method of providing a matrix indicating interference relationships between cells of a cellular communication system</td>
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<td>Method and arrangement for limiting paging load in a mobile communication system</td>
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<td>Adaptive frequency planning in a cellular network</td>
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<td>Radio access network optimization using a diagnostic link</td>
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<td>Method and apparatus for mobile station management and system optimization</td>
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In addition to the above Nokia Networks has multiple positively filed applications for the granting of patents which are currently in the approval process.