

Nokia Siemens  
Networks



# Smart connectivity

A vision of tomorrow's connected world

A White Paper on seamless access to  
services in heterogeneous networks

# Resume

Smart connectivity is a key component of the Nokia Siemens Networks vision of tomorrow's connected world. This paper describes how this innovative concept will provide powerful connectivity solutions for heterogeneous networks, thereby enabling easy, transparent and efficient access to services – anytime and anywhere – on the users' preferred device.

Smart connectivity will generate significant benefits for consumers, operators, service providers and enterprises. For example, it will enable seamless access to services and applications using different networks and network technologies. Access will be robust and ubiquitous. And service continuity will be ensured while moving between different network technologies and the different

networks of one or more operators. This is an ambitious objective, but we believe that it is not only doable, but that it is something that has to be done in order to realize the opportunities that arise when around 5 billion people employ broadband Internet connectivity and most of them have a mobile device.

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# 1. Executive summary

We've become a mobile society. Cellular voice gave us the "anywhere, anytime" communications paradigm that we take for granted. But we've moved on as devices are also used to access information and multimedia content. What's now required – and it's something that users expect and will value – is the same paradigm for Internet and data services, i.e. the ability to move between networks and geographical areas, while still being able to enjoy uninterrupted connectivity and a robust, high-quality service.

Because of different regulations, market environments and usage scenarios, connectivity providers employ different technologies. They're needed to support the trends and services that are enabled by the new, powerful, multi-communication devices. In addition, virtual operators and service providers are competing with the incumbent network operators. Therefore in future, services will be accessed using different network technologies and multiple stakeholders.

This development has started. For example, fixed mobile convergence allows telephony and multimedia services to be accessed via different networks. However, we are heading towards a broadband, Internet-centric era in which data services become more important and new solutions are needed to accommodate the different access technologies.

In this fast-changing communication landscape, user friendliness and an out-of-the-box experience are challenges that smart connectivity addresses. It allows use of preferred devices and provides a consistent experience by tying different networks together in a way that enables intuitive usage of all services, i.e. it's just as easy as making a phone call. It works that way because the concept leverages the synergy of smart devices and smart networks.

Smart connectivity also addresses the fact that traffic is expected to grow 100 fold by 2015. The concept helps meet coverage and capacity requirements in a cost efficient way and it allows optimum use of different networks and network technologies. Smart connectivity also facilitates network interoperability and makes more efficient use of legacy investments.

This paper can only give you an introduction to this innovative, wide-ranging smart connectivity concept. It explains the building blocks and opportunities and also outlines the important issues that need to be addressed in order to realize the vision.

Smart connectivity technologies and solutions are being constantly developed in Nokia Siemens Networks.

## 2. Introduction

We've arrived at a truly historic opportunity. Over the coming years, the majority of the world will be connected using mobile, wireless broadband and fixed broadband systems. As a result:

- We will live in a world, in which five billion people will be connected, most of them with a broadband connection. People will use the services they want, anytime, anywhere, using their preferred devices.
- The Internet will be the pre-dominant source of content and applications. Mobility will dominate in voice services with 70-90% of all traffic, depending on the market.
- Broadband connections will be available practically anywhere in the world, across both developed and growth markets. A combination of wireless and wireline solutions will ensure global coverage, mobility, adequate speed and capacity. In the growth markets wireless will play a crucial role in broadband coverage.
- In the converged telecom, Internet, media and IT landscape there will be a much larger variety of service providers and business models than today. Each provider will compete in a larger market than before, creating both a huge opportunity and increased competition. The providers, who can offer the highest level of simplicity in connecting people, and in connecting people to content, will be the winners.
- We will see a 100-fold growth in traffic. Recently, the traffic has grown 40-100% pa, depending on the service and region, and we expect a similar trend to continue until 2010, after which the traffic will grow even faster, driven by video-related services.

Smart connectivity is an evolutionary concept and one of the technology enablers that will help realize our vision of tomorrow's networks. On today's networks it introduces intelligence via overlay solutions, thereby avoiding modifications to legacy network technologies. Depending on where in a network a certain function is needed, and on which layer it should be operated, smart connectivity will also drive the introduction of intelligence into new network technologies by influencing the relevant standards. This will allow connectivity intelligence to become an integral part of tomorrow's networks and devices.

Although this document is technology oriented, connectivity related trends, opportunities and business aspects related to smart connectivity are also covered.

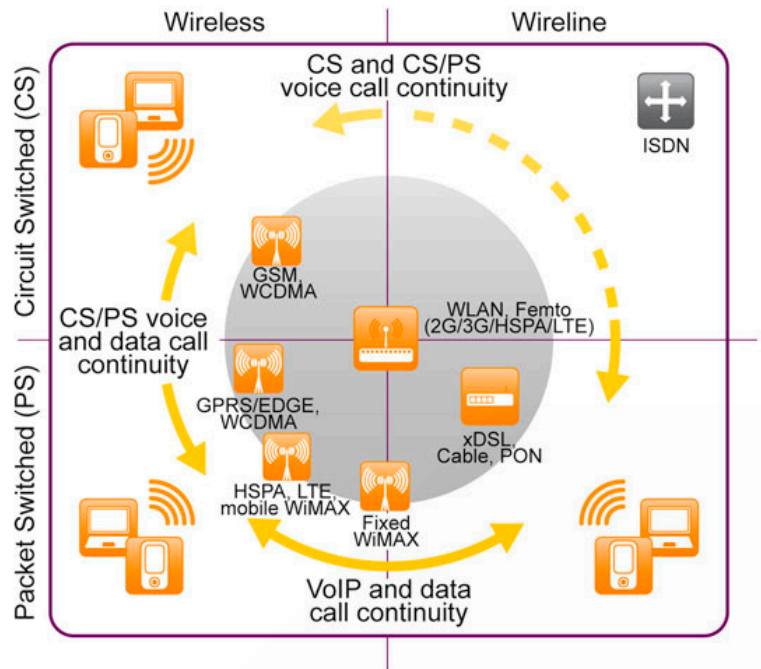
This chapter summarizes smart connectivity drivers and building blocks. Chapter 3 looks at cost-efficient performance. Chapter 4 covers mobility and chapter 5 addresses ease of use, which is a key objective. Services that are easy to use get used and therefore they boost traffic! As mentioned earlier, smart connectivity will generate significant benefits for consumers, operators, service providers and enterprises. This means that we can only cover the individual topics generically.

## The Big Picture

Right now we use wireless and wireline networks, both of which employ circuit- and packet-switched connectivity; something that only makes sense for historic reasons. Developments are taking place in all four sectors and there is competition between different stakeholders, fixed mobile convergence (FMC) being an obvious example. We therefore have a complex communications environment, which is visualized in this schematic. However, by representing these four network types as quadrants we can start to see the value of smart connectivity and the progress that is being made towards the vision of ubiquitous access to all services from a preferred device.

In the wireline sectors xDSL, cable and fiber are delivering broadband connectivity at rates up to 100 Mbps and higher in future. In addition, fixed locations such as homes and offices are employing Wireless LAN hot spots to support broadband data and FMC. Also femto cells are deployed in these locations driven by FMC, FMS (fixed mobile substitution) and broadband data. Developments in the wireless sectors include HSPA, LTE and WiMAX – technologies that enable broadband wide- and local-area connectivity.

Figure 1 – Evolution of connectivity and mobility towards the year 2015.



The key requirement is to enable robust, seamless access to services. We have FMC and the ability to transition from a WLAN to a cellular network and vice versa with certain limitations, but this is just the first step. Operators are providing the all-important voice service at the moment, but devices now handle multimedia content, entertainment and are also used to access information. And in future more radio interfaces and services will be added. Smart connectivity is therefore needed to enable easy, transparent and efficient access to those services from all locations.

## 2.1 Smart connectivity drivers

End users continue to embrace a mobile lifestyle, which now involves anytime, anywhere access to the same services, e.g. in the home, office and outdoors. The gap that smart connectivity fills is the need to retain usage of those services on the preferred device when transitioning between networks and technologies.

Mobile phones have become powerful, multimedia, hand-held computers. They have high-resolution color displays plus ample processing power and memory. In many if not most cases they are the preferred devices since they are carried around all the time. Service retention and improved quality of experience comes via the ability to communicate over multiple radio technologies.

The evolution of communication technologies, particularly those in access networks and the Internet, represents both a challenge and a huge opportunity. The Internet is driving the development of new, innovative services. This model will prevail and the evolution of communication technologies will allow services to be accessed in many different ways.

The need to make access affordable is driving the efficient use of legacy resources. Also partnering and interoperability between multiple stakeholders and networks will stop unnecessary duplication of coverage, capacity and communications functionality.

Voice remains the key service for users and they are not willing to compromise call quality. From a mobility point of view, maintaining voice quality when moving between the networks of different technologies and/or stakeholders will be a challenging task.

Mobile professionals and consumers are increasingly employing data services, e.g. secure email and instant messaging, and they are using the Internet to obtain information. Data applications are therefore becoming an integral part of their life. Broadband access is needed, but data service continuity can tolerate short breaks when moving between different networks. From a mobility perspective, the most important issue is service continuity without any user intervention. Network and device functionality or the application clients will provide this in future.

Figure 1 summarizes connectivity and mobility evolution, which is driving the adoption of smart connectivity technologies and solutions.

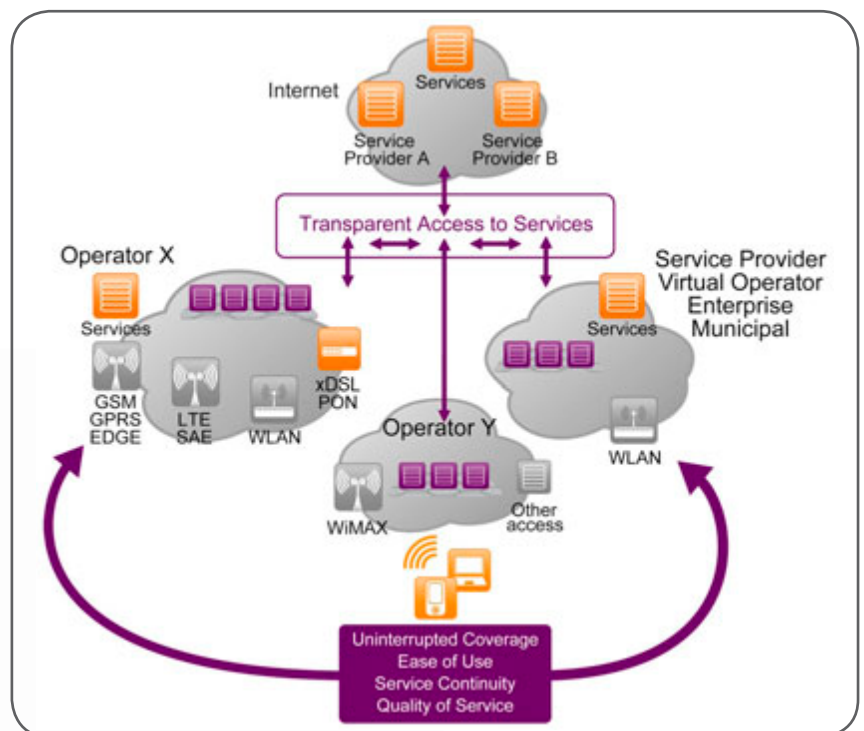
## 2.2 Smart connectivity building blocks

Figure 2 indicates the location of the high level building blocks (shown in purple). They include; network discovery, network selection, policies, IP mobility, CS/PS mobility, inter-network handover control and assistance, service based handover, dynamic roaming assistance, and more in the future. They provide control, coordination and value added functionality, thereby allowing heterogeneous network environments to operate in a smart way. These building blocks may be common to multiple networks or located within a specific network, e.g. an LTE network. One may deploy only a subset of the building blocks, according to needs.

The building blocks are not described in detail. Their use is explained only on a high level in the latter part of this paper. Note that smart connectivity works together with other important functions such as security, identity management, session control, QoS and OSS/BSS. And last but by no means least, it works with the devices.

Although deploying smart connectivity technologies and solutions there is no OPEX impact. The building blocks have a self-organizing capability, which enables automated configuration and optimization. Moreover, smart connectivity facilitates the configuration and optimization of networks, as explained in chapter 3.3.

Figure 2 – Smart connectivity building blocks (shown in purple) allow heterogeneous network environments to operate in a smart way.



# 3. Cost efficient performance

By 2015 there will be 5 billion subscribers, more bandwidth-hungry applications and connection costs will be lower as flat-rate data pricing schemes replace price-per-bit based schemes. This will result in Internet traffic growing 100 fold, which will therefore require a huge amount of additional wireless and wireline coverage and capacity. At the same time virtual operators, service providers and public authorities are reshaping the communication landscape. Therefore the growth in traffic volume will not map to a corresponding growth in revenues for the network operators. Staying in the game will therefore require cost-efficient ways of extending coverage and capacity.

The current infrastructure will normally determine the network evolution path, while local market conditions will define the total cost of ownership of the connectivity solution. In most cases the key driver for network investments is the forecasted feature set of end user devices. While the number of radio access technology options is increasing in the high end of the mobile device market, volumes in the new growth markets are driven by cost. Different end-user solutions that provide the best perceived value for money are therefore required.

Costs are related to markets. There are wide variations in labor costs; legacy investments and network footprints also vary; and the expected subscriber density and ARPU are directly dependent on the demographics of the particular area. This means that in some areas OPEX is more important than CAPEX, while in some other areas it's the reverse.

As the value chains in the telecommunications market become horizontal, end-users have more connectivity options. We are already seeing a distinction between network operators and service providers; new players are also entering and creating alternative business models.

The following chapters describe how smart connectivity helps to manage both OPEX and CAPEX while still providing performance levels that match user expectations.

## 3.1 Capitalizing on network interoperability

The transition from circuit- to packet-switched services has enabled the development of alternative access technologies, both wireless and wireline.

On the wireless side, GSM/GPRS/EDGE provide wide area coverage for voice services and reasonable capacity for data services. However, networks utilizing technologies like HSPA, LTE, WiMAX and WLAN are being increasingly deployed to provide higher speeds and more capacity.

On the wireline side xDSL and cable have been widely deployed in the developed markets. Many homes and small offices have Wireless LANs. DSL lines are being upgraded to VDSL2, making higher connection speeds available to consumers. And Passive Optical Network build-outs provide even more bandwidth.

In order to minimize churn and grow their customer base, operators and service providers have to keep up with network development and periodically upgrade their access offer. This means that a mix of different technologies must be supported.

To avoid making unnecessary network investments, the legacy network has to be leveraged. While traffic shaping, admission control and QoS management continue to be important, in future the resources of different networks will have to be harnessed in a way that allows the most cost-effective available bearer to be used (see figure 3). In a nutshell, smart connectivity will facilitate the distribution of devices to the best available network, e.g. a WLAN for indoor broadband data.

Smart connectivity includes functionality for sharing traffic between networks of different technologies, and even between networks of different stakeholders. This avoids a situation whereby one network becomes congested, e.g. during peak hour, while another network serving the same area has plenty of available resources. It leverages the multi-connection capabilities of connected devices, communication requirements (QoS), policies and available network information. And when required, smart connectivity guides and controls device mobility across the available networks.

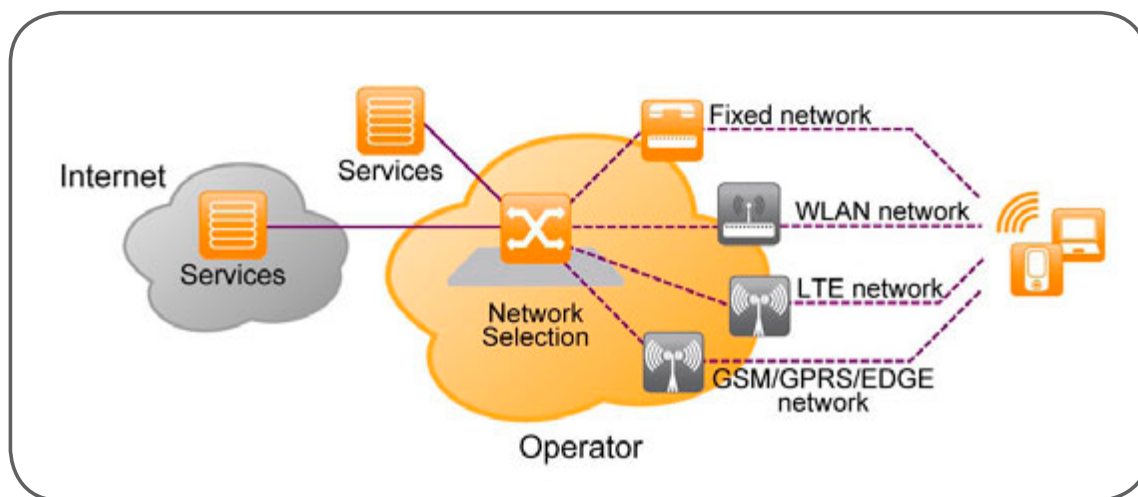


Figure 3 – Smart connectivity using most suitable networks fulfilling connection requirements.

### 3.2 Fast adoption of new network technologies

Network technologies cannot always support new trends efficiently. This is one reason why they need to evolve or be replaced and/or be complemented by new technologies. Thus, the ability to use different network technologies in places where they best fit provides an opportunity for cost reduction and improved customer satisfaction.

The pace of technology development and deployment is accelerating and the life cycle of devices like mobile phones and PCs has shortened. The market is prepared to trade up every two to three years in order to employ the innovative services and applications that new technologies can provide. This represents a virtuous circle for savvy network operators.

Operators that have both mobile and fixed assets are already complementing their cellular network with local wireless networks connected to fixed lines, e.g. WLAN hot spots and femto cells. These local wireless networks are used to provide improved indoor and outdoor broadband coverage and capacity. For example, one of the main reasons for using inexpensive WLAN access points indoors is to enable low-cost tariffs in a local area, i.e. offices and homes. As a result, easy deployment of WLANs in the home combined with low cost is driving the increased usage of data services.

User deployed access is a new phenomenon. Communities are already leveraging the fixed broadband connections of their members to provide extended WLAN coverage for other community members. And operators having fixed assets at their disposal have a similar opportunity to extend wireless broadband coverage and capacity. This is done by deploying local wireless networks and sharing these home and work place wireless network connections with the customers of the operator and that operator's partners.

For example, when visiting a friend your device connects to the local WLAN or femto network instead of using a wide area cellular or WiMAX network. This puts traffic into local, high-capacity networks leaving more wide area network capacity for other users.

People spend an increasing amount of time commuting and traveling. In order to make more efficient use of this time they browse the Internet, read emails, chat and work. This is a market requirement, so we can expect to see the importance of vehicular networks growing in future. For example an airplane, bus or train can have a network to which the users' devices connect and the network's gateway connects to the outside world. This is another development that helps improve connection quality.

Smart connectivity includes network interoperability and mobility mechanisms that tie new networks and network technologies seamlessly to the rest of access and service offers. It also allows devices to discover the new networks. The device management component is used to configure the networks for use by the devices, while the mobility mechanisms ensure service availability and continuity. Together with OAM, device management and service management, smart connectivity minimizes the resources needed to configure the new networks and services for the new networks.

Smart connectivity also allows temporary coverage and capacity extensions by employing the networks of other stakeholders. For example, during a special event such as a rock concert, extra capacity could be introduced by leasing (dynamically) additional network resources. This enables traffic to be offloaded from the primary access networks, which in turn keeps the fans happy while sending video clips to their friends.

### **3.3 Reducing network management effort**

Heterogeneous network environment requires consolidated network management functionalities with process automation capabilities in order to reduce OPEX. This is an important issue that smart connectivity addresses.

#### **3.3.1 Assisting network configuration**

Smart connectivity introduces mechanisms that interact with devices and they can be used for OAM tasks, e.g. to enable self-organizing and self-configuring networks. When connected, these devices can collect network neighborhood information and send the information to the network, thereby enabling the automated generation of network neighborhood maps. This information can also be used to generate device reports that identify network bottlenecks and thereby enable better management of network resources.

#### **3.3.2 Enabling dynamic roaming agreements**

Right now making roaming agreements between network domains includes manual, administrative paper work.

This will change in future. There will be many more players and the business case for sharing network resources will be compelling. Instead of building out their networks to achieve ubiquitous coverage and increased capacity, operators will achieve that objective via roaming and reusing already available networks.

Smart connectivity, together with OAM, provides dynamic roaming and it facilitates the establishment of interoperability agreements between network operators. If required, this process can be dynamic. Agreements may include the negotiation of parameters like QoS, which is needed to ensure service quality of roaming customers.

# 4. Mobilizing services

The service landscape is undergoing radical changes. In addition to popular services like voice, Web browsing and email we now have video streaming and IPTV. Web 2.0 is facilitating communication and collaboration between users and enabling the sharing of user-created content. Content downloading, e.g. music, movies and navigation maps is taking off along with interactive gaming. These developments impact on network capacity and the quality of the end user experience (QoE).

People have become familiar with the services they reach via fixed broadband connections at home and in the office. Now they are starting to expect the same services and service quality to be provided on their preferred mobile device and it's an expectation that will be fulfilled.

As indicated earlier, a cost-effective way to realize global coverage is to employ a combination of mobile, wireless and landline solutions that are owned and administered by multiple parties. However, the access offering of a single operator or service provider may include different, complementary network technologies and thereby provide the requisite coverage and capacity. In both cases seamless mobility between networks will be a mandatory requirement: it's what the market will expect.

The Internet will be the pre-dominant source of content and applications and IP based mobility solutions will increasingly complement proprietary, cellular mechanisms.

Thus, smart connectivity provides mobility solutions beyond access network specific technologies. It enables robust communication, enables access to services, and provides service continuity when moving between access networks, access network technologies and administrative network domains. The following chapters describe related topics that need to be addressed in future networks.

## 4.1 Robust connectivity over multiple access networks

Today, when people make a voice call, using circuit-switched cellular or fixed networks, it works – first time and every time.

When people make data connections, using various packet-switched networks and IP-based communication, it probably works. But in future, the use of Internet services via multiple access networks will have to be as easy to use and just as robust as a regular phone call today. Otherwise the market won't adopt the heterogeneous network environment and mobile Internet services.

While nothing works without connectivity, other network functions such as security and identity management are critically important as well. The intrinsic benefits of mobility are compromised if the access network cannot authenticate users or provide secure communications.

A deal of work has to be done and industry-wide agreements need to be reached in order to harmonize the communication landscape with respect to mobility over multiple access networks and network technologies.

For example, devices are required to support a number of Internet protocol mobility mechanisms on different layers deployed on networks and other devices. To avoid incompatible solutions and unnecessary complexity, a common understanding must be reached on the best way to support global mobility. This doesn't mean designing a one-size-fits-all solution, but the number of options needs to be limited to a manageable level.

Smart connectivity does not reinvent wheels. If the mobile IP solution specified for WiMAX and LTE can be reused as a more generic solution, then it will be used.

Realizing robust connectivity over multiple access networks can't be done on the network side alone. Users and their devices may have several subscriptions and may utilize municipal and other free networks. In these cases the devices will take overall responsibility for connectivity and network interaction.

## 4.2 Device reachability

Legacy data communication employs the client-server model. The clients are devices such as mobile phones and multimedia PCs and services are implemented in network servers. However, as users are increasingly creating, sharing and storing content, there's a need for peer-to-peer (P2P) communication between end user devices, both mobile and fixed. For example, when visiting a friend, wouldn't it be nice to be able to download some images and home videos from your home PC while retaining secure access to your content at all times?

Network architectures have firewalls and network address translations (NATs) that block incoming unauthorized access from the Internet. This is done to prevent third parties hacking into your PC.

When providing device reachability over multiple access networks, smart connectivity considers the network architectures as well as the communication functionality. For example, when moving to the next version of the IP protocol as part of an IP mobility solution, a routable IP address could be provided to every device. To date IPv6 has not been widely implemented: there has not been enough motivation. However, this will probably change when four to five billion user devices are connected to Internet, many of them running always-on applications.

Mobile phones are becoming powerful hand-held computers and can therefore function as Internet hosts. And sensors are also being introduced increasingly as part of Internet to provide new services and enriching existing services leading to the explosion of the number of connected devices.

Keeping multiple-access technologies active simultaneously increases device power consumption. Smart connectivity coordinates 'paging' via different access networks to ensure constant reachability of user and device on the last mile access with minimized power consumption.

When end user devices become reachable via Internet, users must be able to control the communications process. This is necessary to avoid unpleasant surprises, e.g. increased communication costs when somebody downloads content from a roaming device.

## 4.3 Mobility is taking new shapes

Network heterogeneity, mobile lifestyles and connected appliances are bringing new usage scenarios and requirements into mobility. The following chapters describe mobility scenarios that future networks need to address.

### 4.3.1 Service continuity between access networks

In order to provide adequate capacity for future wireless broadband services, cell sizes are decreasing in order to limit the number of potential users. In addition, the use and reuse of available spectrum drives this development, as does use of higher frequencies. In customer premises, fixed access networks are often equipped with wireless network extensions, e.g. WLAN or femto cell. Decreasing cell size and increasing network heterogeneity lead to increasing mobility events within a single network and between different networks.

Service continuity between access networks enables seamless continuation of a service during and after device transition, i.e. there is no user intervention. Voice calls or video streaming continue and secure email connections to corporate networks stay active.

Smart connectivity provides a wide range of service continuity mechanisms that support different customer needs and business models. Today's circuit switched networks (GSM and WCDMA) will co-exist with packet switched networks (HSPA, WLAN, WiMAX, LTE, DSL and cable). The concept also provides service continuity mechanisms between circuit and packet-switched domains, and between packet-switched networks (see Figure 1).

For example, the subscriber shown in figure 4 has both mobile and fixed assets at his/her disposal. The operator is providing low-cost, home zone pricing via WLAN/DSL, i.e. the user is connected to a WLAN network and receives and makes VoIP calls. Before leaving for work, the user receives a phone call. The operator has implemented IMS based services, so when our hypothetical user goes outside, voice call continuity (VCC) mechanisms convert the call into a circuit-switched 2G/3G call that is transmitted over the cellular network. Service continuity mechanisms for data connections ensure that data services continue to operate the same way.

Although the operator provided voice call continuity in this example, WLANs that connect via DSL or cable allow applications service providers and ISPs to provide a VoIP service. The service could also include service continuity (no IMS) as well as roaming between the networks of different stakeholders (see 4.4) when moving out of the home environment.

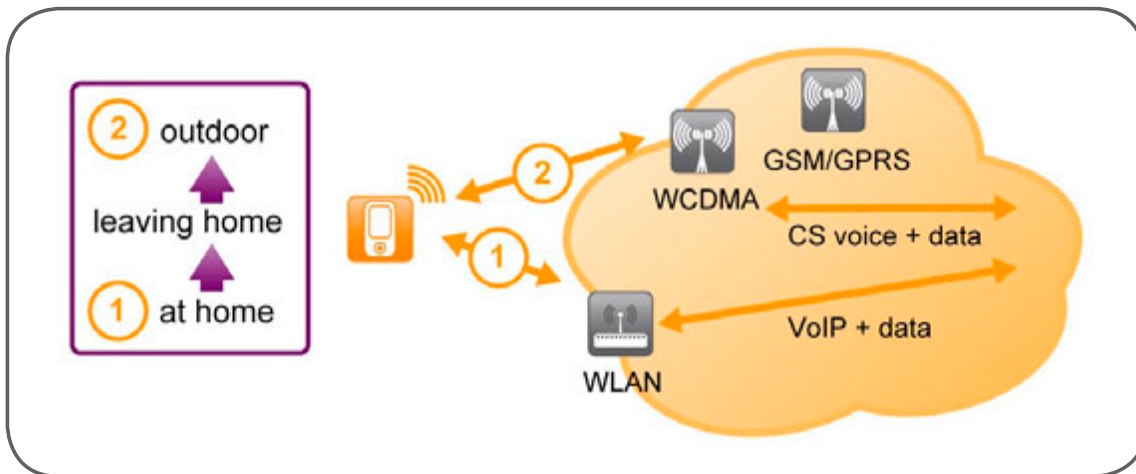


Figure 4 – Voice and data service continuity between home WLAN and operator cellular networks.

#### 4.3.2 Seamless service continuity

Seamless service continuity is an intrinsic function of cellular networks. Handover between two cells is seamless because communication resources are reserved in the new cell before the transition is made. However, as described earlier, seamless service continuity is a complex issue in networks and devices when network heterogeneity increases and service continuity involves different access network technologies.

Many data services tolerate short breaks in communication without impacting on the user's experience, assuming these breaks don't occur frequently. Therefore when transitioning between different access networks, one of the goals of smart connectivity is to balance the quality and robustness of the service against the level of complexity needed to provide it, i.e. there is a pragmatic trade-off. Smart connectivity uses elements from the rigorous cellular world as well as the looser IP domain to realize this objective.

#### 4.3.3 Service based handover

Different access networks target different usage scenarios. Cellular networks like GSM/GPRS and WCDMA are optimized for voice, while WLAN and DSL networks are optimized for broadband data – today often with best effort quality. As a result, cellular networks usually have spare voice capacity with guaranteed voice quality, but their broadband data capacity might be limited.

Smart connectivity enables service-based handover for multi-connection capable devices when network capacity is limited. For example, leaving voice calls on the cellular network and moving broadband data to the WLAN network might provide a better result than using the WLAN for VoIP. Calls would continue to benefit from voice-optimized wide coverage while data connections would get higher WLAN bit rates. This would also free up cellular capacity for other users.

#### 4.3.4 Using services via different locations and devices

People connect to services from different locations using the same or different devices. In future, when both home and office appliances are connected to the Internet, it should be possible to move ongoing services between devices. For example, transferring a video call from a PC to a mobile device.

The ability to use different devices to access the same services will result in different experiences. The devices have different resources, e.g. screen size, and support for the different access technologies may vary.

Smart connectivity embraces the whole communication environment in order to balance the performance of a specific service against the combined resources of the network and device. As a result, end users can enjoy improved quality of service when the best-available networks and devices are used. Thus, congestion is avoided and the overall use of the networks is optimized.

#### 4.4 Roaming

From a technical perspective national and international roaming is not significantly different to regular mobility across different networks. However, service continuity between the networks of different stakeholders hasn't been a requirement for fixed and cellular networks.

Operators and service providers that employ the networks of other stakeholders are changing the communications landscape. For example a fixed network operator may start offering local wireless access using WLAN hot spots. It's in the interest of the operator to provide (seamless) service continuity when its subscribers move out of the hot spot area and when they move into it. If services are dropped when moving around, usage becomes cumbersome and that can result in a subscriber looking for other communication partners and solutions.

# 5. Ease of use

Heterogeneity in the network landscape increases communication complexity but this must not be allowed to impact on end users. In order to allow users to employ a heterogeneous network environment and the Internet, a user friendly, out-of-the-box experience is required and this is an issue that smart connectivity addresses. The benchmark that future networks and devices have to meet is the way we make voice calls.

Ease of use is highly valued by most users and that parameter may be more important than the cost of the offer. Subscribers are not interested in the underlying technology. They want to make connections in the easiest possible way – after that comes the cost.

The following chapters describe how smart connectivity provides the ability to hide the communication complexity of multiple networks and network technologies. The end result is a stunning, on-the-go, user experience. Smart connectivity therefore provides value-adding functionality by converting complexity into an opportunity for differentiation.

## 5.1 Heading towards a network agnostic user experience

Smart connectivity delivers the perception that there is only one network. Users simply use their services; moving between different networks and network technologies is transparent. Moving between networks is

just like moving between cells in a cellular network even though multiple networks and/or network technologies might be used (see Figure 2). Smart connectivity therefore enables different networks and architectures to co-exist and interoperate.

## 5.2 Discovering networks

In future there will be more networks, network technologies and service providers. Without a concept like smart connectivity, users and their devices will not know which is the best network and access technology to employ. As a result, usage of preferred and trusted network neighborhoods would be limited.

Smart connectivity includes network discovery functionality that enables devices to discover trusted and preferred networks robustly and efficiently, even when roaming. Network neighborhood information assists devices to monitor their network environment efficiently, instead of performing frequent battery consuming scans. The required network settings are provided together with device management and this allows devices to get instant and automatic access after the network is discovered.

Besides improving the end user experience, network discovery also provides networks with better tools for distributing traffic evenly across available networks as and when devices discover them.

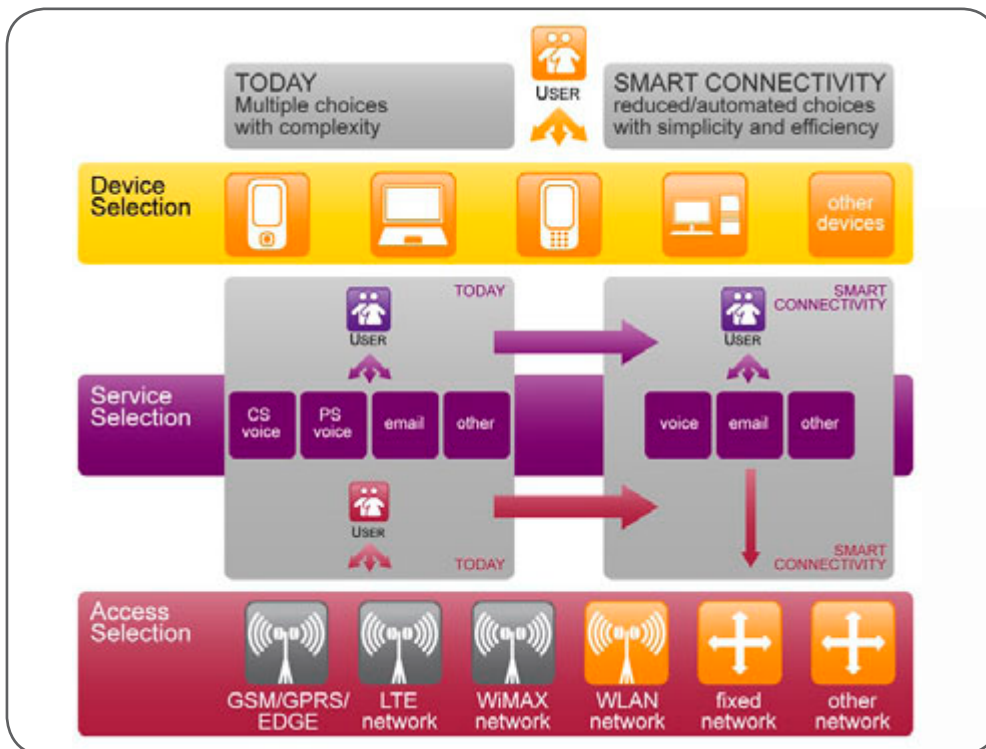


Figure 5 – Transparent and easy to use access to services in heterogeneous network environments – just like using a huge cellular network.

### 5.3 Automated network selection

Step back and consider the way that multi-connection devices would normally work in an environment where there are multiple overlapping networks. Today users have to instruct the device: tell it how to get connected using a list of obscure network names. If something goes wrong, the user is expected to fix it even though he/she has no knowledge of the problem. This is not only cumbersome, it's unacceptable. The paradigm that the market will demand is the kind of automatic network detection and selection that users experience in circuit-switched PLMN voice domains.

Smart connectivity automates and hides network selection and its usage. As subscriber involvement is minimized, using services becomes easier and communication becomes transparent. This is also an enabler for efficient use of network resources: without it network selection decisions would be based solely on user intuition rather than facts known by smart networks and smart devices.

The automated network selection process embraces the policies that allow the customization of mobility according to individual needs. These policies also allow dynamic adaptation to changes in the communication environment. They include service QoS requirements, device capabilities, user/operator/enterprise network usage preferences and available network resources. They are all considered when a network selection decision is made. Different network technologies have different characteristics and services have different requirements; network selection needs to take this into account. And in some cases different services might require routing via different networks.

Pricing is an important parameter that needs to be considered when network selection is automated. To date different pricing models have been one of the main reasons for leaving network selection complexity to end users. When a user selects the network to be used, the user takes responsibility for the decision – it's not down to the device or the network. In the future this will change when minute or bit based pricing per network is replaced with a more harmonized pricing model that covers multiple networks.

Location of network selection functionality will be an issue in the future as it provides a degree of control over the network that is selected. To have control over customers and make efficient use of network resources, operators and service providers need to deploy mobility policies and possibly even network controlled handover mechanisms over multiple networks. The device (user) side of the equation will no doubt resist this development: they may want to decide what network to employ. However, as users are expected to have relationships with multiple communications and service partners, a mixture of user and automated control will probably be the final result.

## 6. Conclusions

In future, networks will be heterogeneous: they will involve different network technologies and different stakeholders. This will mandate deployment of the new smart connectivity solutions provided by Nokia Siemens Networks.

Smart connectivity allows network operators and service providers to gear up for broadband Internet era. It provides powerful solutions that allow users to reach operator and Internet services via different networks and network technologies, using their preferred devices.

Ease of use is a key feature. Smart connectivity brings user friendliness and an out-of-the-box experience into heterogeneous network environments. It makes all services as easy to use as a phone call: it hides network and technology complexity from end users. The result is increased user satisfaction, less churn, higher traffic volumes, and easier adoption of new services.

Smart connectivity brings networks together. It provides mobility solutions that unify different networks and network technologies, thereby enabling seamless access to multiple service offers. Users will be able to access their services robustly from any location. Service continuity will be ensured while moving between different networks and network technologies, managed by single or multiple stakeholders.

While providing the ability to tie different network technologies together, smart connectivity also enables coverage and capacity extensions using preferred network technologies. Smart connectivity makes efficient use of legacy network investments: it avoids the duplicating of coverage and capacity: it allows users to take advantage of the neighborhood networks of other stakeholders. In a nutshell it helps reduce operating costs while still enabling the provision of adequate performance for consumers.

Nokia Siemens Networks smart connectivity

**Seamless access to services in heterogeneous networks**

# 7. Glossary

ARPU	Average Revenue per User	OAM	Operation Administration and Maintenance
CAPEX	Capital expenditure	OPEX	Operational Expenditure
CS	Circuit Switched Domain	P2P	Peer-to-Peer
DSL	Digital Subscriber Line	PLMN	Public Land Mobile Network
EDGE	Enhanced Data Rates for GSM Evolution	PS	Packet Switched
FMC	Fixed Mobile Convergence	QoE	Quality of Experience
FMS	Fixed Mobile Substitution	QoS	Quality of Service
GPRS	General Packet Radio Service	SIP	Session Initiation Protocol
GSM	Global System for Mobile Communication	SLA	Service Level Agreement
HO	HandOver	UMA	Unlicensed Mobile Access
HSPA	High Speed Packet Access	VCC	Voice Call Continuity
IMS	IP Multimedia System	VDSL	Very high data rate Digital Subscriber Line
IP	Internet Protocol	VDSL2	2nd generation VDSL
IPTV	Internet Protocol Television	WCDMA	Wideband Code Division Multiple Access
ISDN	Integrated Services Digital Network	WiFi	IEEE 802.11-based wireless local area network (WLAN)
ISP	Internet Service Provider	WiMAX	Worldwide Interoperability for Microwave Access
LAN	Local Area Network	WLAN	Wireless local area network
LTE	Long Term Evolution	xDSL	Digital Subscriber Line technologies
MP3	Moving Picture experts group audio layer 3		
NAT	Network Address Translation		

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