Mobile networks beyond 3G

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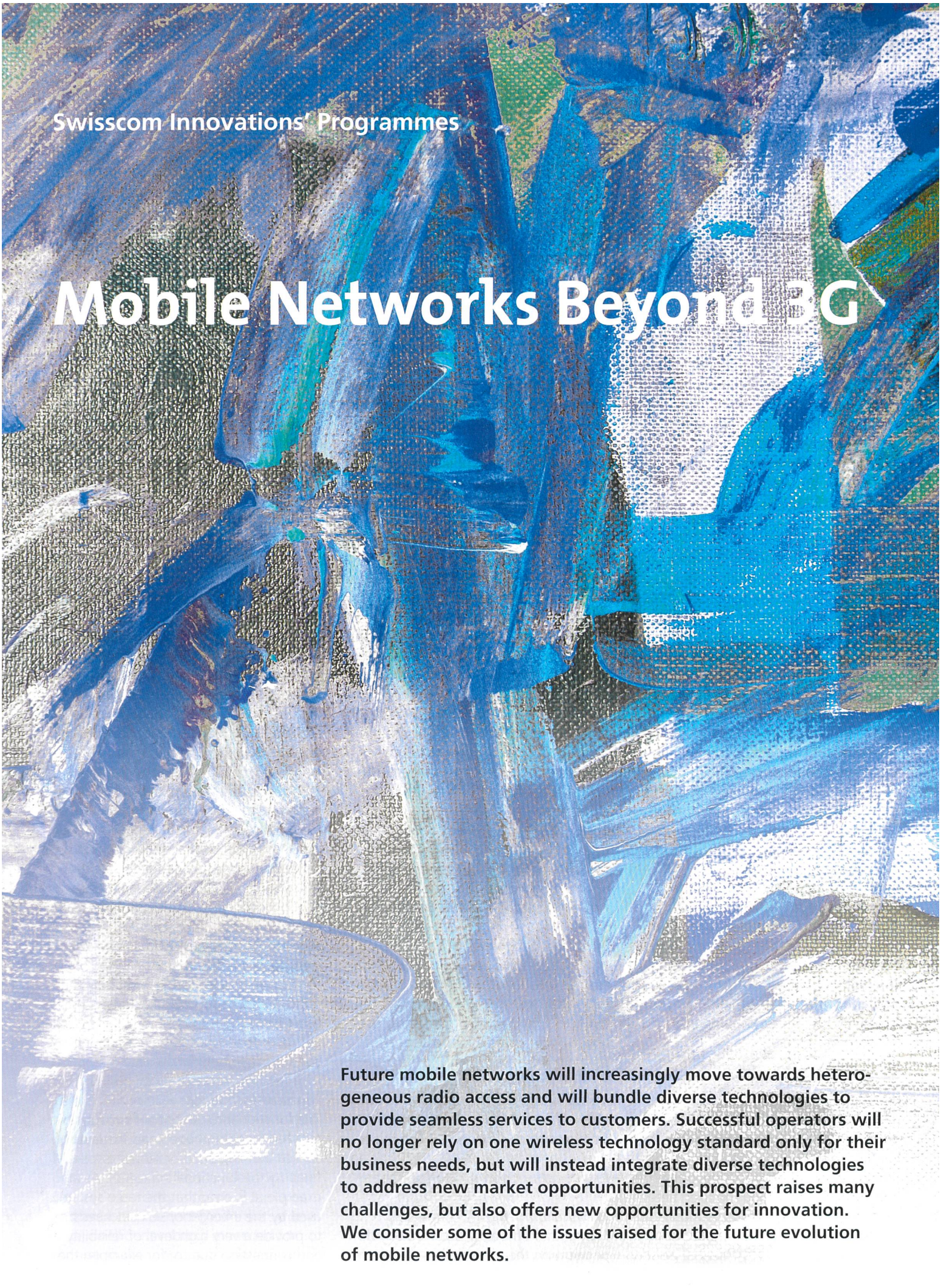

Future mobile networks will increasingly move towards heterogeneous radio access and will bundle diverse technologies to provide seamless services to customers. Successful operators will no longer rely on one wireless technology standard only for their business needs, but will instead integrate diverse technologies to address new market opportunities. This prospect raises many challenges, but also offers new opportunities for innovation. We consider some of the issues raised for the future evolution of mobile networks.

The programme "Future network services" explores new broadband service and communication opportunities enabled by the new 10 Gbit Ethernet technology, by managed all-optical networks, the evolution from ADSL to broadband heterogeneous (fixed and mobile/wireless) access networks, and by peer-to-peer network models.
With its Innovation Programmes, Swisscom Innovations follows the objective of recognising early on the impact of technological developments, finding new business opportunities, promoting technical synergies, and developing concrete innovation proposals. Further, the expertise built up enables active engineering support of business innovation projects.

UMTS services are currently delayed in many countries with little revenue being generated. At the same time, operators are addressing an alternative paradigm, WiFi-based hot spots, targeting selected customer

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groups with high-speed data services according to their mobility patterns and communication needs. Reconciling the conflicting goals of ubiquitous service provision with targeted high-speed wireless, argues strongly for a heterogeneous mix of access technologies. In mobile networks beyond 3G (3rd Generation: UMTS), users will be offered seamless access to personalised data and services over diverse radio access technologies, on a wide range of terminal types.

There is mounting evidence that the manufacturer-led evolution to 3G has failed to adequately address market requirements. In future, we will see a move towards heterogeneous wireless access, leveraging successful technologies in innovative ways. It will no longer be possible to rely on one set of standards for a competitive solution.

In this article, key issues for mobile systems beyond 3G are addressed. This includes the evolution of the hotspot paradigm, its integration with the cellular network and leveraging the fixed network infrastructure for future mobile services. The scope includes spectrum issues, seamless access and service personalisation. The foreseen diversity of standards and technologies poses many challenges, but at the same time presents new innovation opportunities for Swisscom. Creatively leveraging the mobile and fixed infrastructure to target specific customer needs in a cost-effective manner is a critical issue.

Swisscom Innovations has addressed the evolution of future mobile systems through the project "B3G" (Beyond 3G) and through participation in the Eurescom P1203 project "The operator's vision on systems beyond 3G". We plan to build on this foundation through participation in the EU 6th Framework project on Open Broadband Access Networks (OBAN). While cooperation within Eurescom has provided an opportunity to suggest a common operator vision for future mobile systems, the planned future cooperation in OBAN will also include vendors to address the technology challenges raised, develop technical solutions and investigate new innovation possibilities for the operator's business.

Key Drivers for Systems Beyond 3G

Spectrum Efficiency

While mobile communication systems such as GSM and UMTS were characterised by new spectrum resources, frequencies over 3 GHz are not easily useable for non-line-of-sight propagation. So there is a physical limit to the available spectrum for cellular systems. Hence, the future focus may be to employ the available, limited spectrum resources more efficiently. Three major themes here are *technical, economic* and *functional* spectrum efficiency [1].

Technical Efficiency

This kind of efficiency is particularly dependent on the service but some main indicators are bandwidth efficiency, frequency reuse and time usage. Normally, a trade-off needs to be found between the first of those two factors since technologies with high bandwidth efficiency typically have a poor reuse factor. For example, GSM can support more traffic channels/MHz than UMTS, however, the spectrum efficiency of UMTS in a network is more than three times better than for GSM due to its reuse factor [1]. Also, different delivery mechanisms provide vastly different efficiency depending on the service required. The convergence of mobile and broadcast technology provides a means of utilising the spectrum more efficiently; it has been shown that frequency sharing between DVB and UMTS based on usage profiles can improve capacity by around 30% [2]. Recent results seem to show OFDM as the optimally suited coding scheme for most mobile channels [3].

Economic Efficiency

Spectrum trading is a mechanism that could also enhance spectrum efficiency by pricing spectrum more efficiently. This is called economic efficiency. In other words, the technical efficiency gains of cellular networks have to translate into economic gains to some extent. However, putting a price onto spectrum in advance is not without risk as the 3G auctions have demonstrated. In particular, the economic effects and trade mechanisms are a topic of current research. In order to allow more flexible use of the spectrum and in particular spectrum trading, changes in the regulatory framework are needed. On the other hand, spectrum trading has been possible in some countries, so far to little effect. In fact, it turned out that spectrum users largely just held on to whatever spectrum they had [4]. Instead, some form of spectrum leasing may turn out to be more successful, allowing the spectrum to be 'rented' out for a limited period of time while remaining under the control of the original owner.

Functional Efficiency

The functional value that a mobile system has for its end users and the level of service that is wished or required is defined by the functional efficiency. As an example, it is clear that the radio system used by the emergency services needs to provide a very high level of reliability and congestion due to, for example, the

operator's heavy loading of the system to optimise profits would not be acceptable. Such needs may not be fully met by a cellular service geared towards maximum call capacity. For this reason, private mobile radio (PMR) systems continue to play a vital role for those interested in instant connectivity, tailored coverage and modest, fixed operational costs. Whilst PMR cannot match the technical efficiency of high density cellular services, the functional ability to make almost instantaneous calls, the short duration of calls and the ability of group calls score highly in terms of functional efficiency. Functional efficiency is difficult to quantify as it often involves subjective criteria, like ease of use in difficult situations. However, the benefit of functional efficiency to users tends to be reflected in the value the user places on such a mobile service. Some studies have looked at the difference between what a user would be willing to pay for a service and what he actually pays for the service, reflecting the "consumer surplus". These studies indicate that the average surplus of a PMR user is around 40% higher compared to the average business cellular user, reflecting the value placed on the unique functionality of a PMR system [5].

Seamless Access

Seamless access in B3G will go beyond roaming as we know it today, offering connectivity to the end user across a wide range of access technologies and access networks (Fig. 1). In addition to current technologies such as GSM, EDGE and W-CDMA and WiFi, future technologies may include 802.11g, 802.11a, HiperLAN2 and UWB. GSM roaming based on bilateral agreements or brokerage services has been extended for GPRS by GRXs (GPRS Roaming Exchange). The growing popularity of public hotspots has also introduced a new breed of brokers like GRIC and iPass. In the future, no one roaming scheme will necessarily dominate, but nevertheless user connectivity should be effortless and all but invisible. This implies that the access control must be highly automated with little or no input required from the end user. Moreover, mobile devices such as mobile phones, PDAs and laptops need scalable content according to terminal facilities and available connection. At the same time, intelligent routing is needed for routing to the most appropriate device.

Eurescom Project P1203:
www.eurescom.de/public/projects/P1200-series/P1203/
Project OBAN:
www.telenor.no/fou/prosjekter/oban/

Personalisation

Personalisation is a compelling feature for mobile communication systems. On the one hand, personalisation promises to foster and improve the relationship between the customer and operator, on the other hand an open environment will encourage third party providers to enter the market for personalised services.

Implications for Swisscom

BG3 systems will be characterised by a multitude of market players, thereby increasing competition. A variety of service providers will emerge as network operators meet tough competition through emerging unlicensed wireless access technologies capable of supporting multimedia broadband applications. However, typical users will have a customer relationship with only a small number of network and/or service providers. Wholesale between market players will increase, simplifying the end user interaction. Regulatory bodies will continue to impact development and competition by intervention in operator's businesses, including access to their network infrastructure and by constraints on the usage of wireless technology. However, operators can capitalise on the opportunities for innovation afforded by a heterogeneous wireless environment. Key B3G issues will impact the way business is conducted. Business models for B3G systems will necessarily be complex due to service provisioning, new market players and the diversity of network and support systems. It will therefore become more difficult to predict the return of investments (ROI) for new business cases. Consequently, the ROI will be calculated over a shorter timescale. This implies caution about investments in expensive infrastructure given the need to carefully investigate market changes with regard to services, regulations and emerging network technologies. Greater value should therefore be assigned to the risk taken in investment projects as market issues may dramatically and suddenly change the company business from profitable to near bankrupt in a short period of time. New technologies will quickly replace existing ones, implying a need for rapid business adaptation and technology adoption. To a major ex-

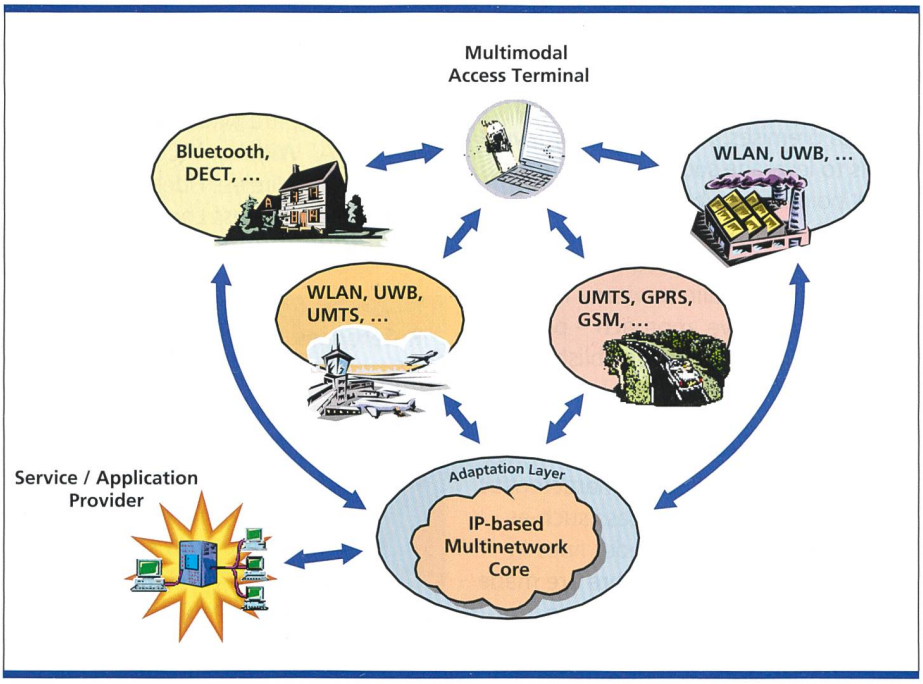

Fig. 1. Illustration of the seamless heterogeneous access concept. Communication with the backbone is offered through wireless access supported by transparent handover between diverse service providers and wireless technologies.

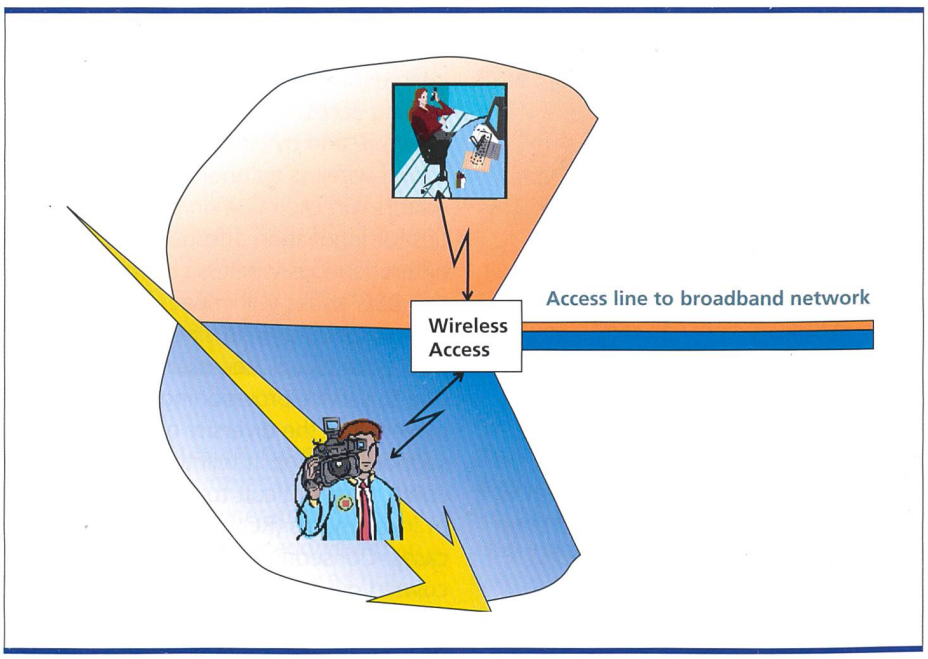

Fig. 2. Illustration of the Open Access Network concept. A private user (orange) and a public user (blue) share wireless access to a broadband backbone network.

tent churn is price driven, so creatively leveraging existing infrastructure and heterogeneous wireless technologies will be key.

Outlook

Within a few years, it may be expected that the majority of private homes and offices will have access to broadband feeder networks such as ADSL, VDSL, fibre and cable, and that wireless technology will be widely utilised for inhouse communication within residential and business premises. A challenge for Swisscom is to leverage such private wireless access points for public use.

The OBAN proposal mentioned earlier leverages privately owned wireless access points for public services. It represents an innovative approach – perhaps the only viable one – to establish a broadband mobile network in line with current B3G visions. The concept is to establish a so-called "Open Access Network" (OAN) whose main characteristic is that private wireless access such as WLAN and supporting feeder lines including xDSL and optical fibre are made available for public use (Fig. 2). In OBAN, private users continue to utilise their infrastructure as before, with the addition that public users can utilise spare wireless capacity thereby enabling high speed public data and conversational services. The sharing of resources between public and private users will be managed according to service agreements among involved parties. In contrast to the conventional cellular mobile network consisting of optimally located outdoor base stations and antenna masts, the Open Access Network foreseen by OBAN will potentially consist of millions of wireless access points randomly located in business and private premises. The intention is to weld such access points together to provide continuity of radio coverage in the public environment. This will enable users to roam seamlessly throughout the OBAN network while maintaining continuous communication sessions. In rural and low density urban environments where Open Access Network coverage is limited, integration with the 3G network (W-CDMA, EDGE etc.) will be necessary to ensure an uninterrupted service. [10, 6, 3]

Abbreviations

3G	3rd Generation (UMTS)
B3G	Beyond 3rd Generation
DVB	Digital Video Broadcasting
EDGE	Enhanced Data Rates for GSM Evolution
GRX	GPRS Roaming Exchange
OAN	Open Access Network
OBAN	Open Broadband Access Network
OFDM	Orthogonal Frequency Division Multiplexing
PMR	Private Mobile Radio
UMTS	Universal Mobile Telecommunication System
UWB	Ultra Wide Band
W-CDMA	Wideband Collision Detection Multiple Access
WiFi	Wireless Fidelity (802.11b WLAN-technology)
WLAN	Wireless Local Area Network

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Zusammenfassung

Zukünftige Mobilfunksysteme entwickeln sich in zunehmendem Masse in Richtung heterogener Funknetze. Verschiedenste Funktechnologien werden dazu dienen, dem Benutzer einen naht- und lückenlosen Dienst anbieten zu können. Der erfolgreiche Netzbetreiber der Zukunft wird sich nicht mehr auf einen einzigen drahtlosen Technologiestandard beschränken, sondern die verschiedenen Technologien integrieren, um neue Märkte zu erschliessen und bestehende besser auszunutzen. Eine solche Vision stellt den Betreiber vor einige Herausforderungen, bietet aber auch neue Möglichkeiten für innovative Lösungen. In diesem Artikel betrachten wir einige der zentralen Fragen für die Entwicklung zukünftiger Mobilfunknetze.