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**Chip circuit map featuring independent on/off control**
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**Example chip product**
This chip circuit is separated into several areas, and each has an independent on/off control switch.

Renesas Technology Corp. / www.renesas.com
US pulls ahead on 3.5G

HSDPA launches in the US

Staccato pushes for UWB in Europe

Cellular must plan for IPv6

FPGAs offer base-station designers price, performance and flexibility benefits over the traditional ASIC.

WiMAX will revolutionize the fixed-wireless access market, but what is its relationship with 3G? Wireless Europe spoke to some key players.

Could interference between TDD and FDD prevent the collocation of the two UMTS technologies?

Deploying base-station equipment and antennas at the same location is an expensive and out-dated practice.

Mobile operators are looking to build out their own transmission networks to support data-rich services.

SDR offers benefits and challenges to handset makers ● Dynamic optimization eliminates the wait between the clicks

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John Diehl of Freescale explains that operators are embracing HSDPA because it offers exceptional value for money.
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UK in-building spectrum auction is imminent
The UK telecoms regulator Ofcom is expected to auction a significant slice of RF spectrum at 1800 MHz in March 2006. A maximum of 12 licences could be sold, each having a bandwidth of 200 kHz. Aimed at in-building services, the licences are for low-power operation with maximum in-band emissions in the 200 mW to 1 W range depending upon the air interface. Licensees will be responsible for ensuring that interference between services is controlled. Outdoor antennas may not be located higher than 10 m from ground level. Ofcom is taking a technology-neutral approach to spectrum use and therefore licences could be awarded to GSM, CDMA or TETRA operators. Ofcom is also considering the auction of one licence at 400 MHz, which could be used to provide wide-area cellular services via GSM or CDMA.

Radioplan launches North American division
Germany’s Radioplan has opened a North American division in a bid to expand the uptake of its network-optimization products in that region. Based in Reston, Virginia, the division will be headed by Tim Brooks, who joins Radioplan from PCTEL’s RF Solutions Group. The company, which recently launched an automatic mobile network optimization system for HSDPA, counts several major North American 3G operators as customers.

Ericsson will manage 3’s UK network
UK operator 3 has handed over the management of its UMTS network and IT infrastructure to Ericsson, while retaining ownership and strategic control of the equipment. Ericsson will also supply equipment, additional technology and related services as part of the deal. The 3G equipment was originally supplied by Nokia and NEC. Ericsson already manages 3’s networks in Australia and Italy and is keen to grow this aspect of its business.

IMS is the key to profitability
European network operators are embracing IP Multimedia Subsystems (IMS) as the standard network architecture for deploying new services across both mobile and fixed networks – claims a study by the analyst firm IDC. The firm predicts that sales of IMS equipment and related technical services in Western Europe will total $5.6 million in 2010. However, it also warns that IMS is still in the early stages of development, with major equipment vendors starting to announce IMS strategies and product roadmaps. The study is entitled Western European IMS 2005–2010 Forecast and Analysis.

Qualcomm joins the WiFi Alliance
Qualcomm has strengthened its commitment to non-cellular wireless broadband technologies by joining the WiFi Alliance, which is a trade organization that promotes the use of the IEEE 802.11 wireless local area network standard. Qualcomm, which focuses on the development of chips and related technologies for CDMA and other cellular standards, recently announced that it will add dual-mode WiFi/cdma2000 and WiFi/UMTS chipsets to its line of MSM chipsets for mobile phones.

InterDigital and Lucent settle patent dispute
Lucent Technologies and InterDigital have settled a patent dispute involving technology used in Lucent’s cdma2000 infrastructure equipment. Lucent has agreed to pay InterDigital approximately $14 million over five years to license seven US patents owned by Tantivy, which is a wholly owned subsidiary of InterDigital. In a statement to the US Securities and Exchange Commission, InterDigital said that it would cooperate with Lucent on advanced technology programmes and the two companies would begin negotiations regarding patents not covered in the licensing agreement.

US pulls ahead on 3.5G
Cingular’s launch of commercial HSDPA services has taken the US from cellular backwater to the cutting edge of UMTS technology in a few short years (see page 10). The US operator has also managed to make good use of EDGE – something that its European cousins have yet to do in any meaningful way. Indeed, it seems that Cingular has created a textbook example of what a multigenerational UMTS network should look like, with GPRS, EDGE, UMTS and HSDPA all working together to deliver data services at the right place and ahead of schedule.

While the UMTS industry should be proud that this most European of technologies has been embraced by a major US operator, it must be slightly embarrassed that HSDPA did not make its commercial debut on this side of the Atlantic – even if the Cingular launch only involves two HSDPA data cards. One could argue that Cingular got there first because it rolled out its 3G network later than many European outfits, and therefore could benefit from newly available HSDPA equipment. This is unlike many European networks, which will have to upgrade equipment that is already installed.

However, it is the commercial pressures of cdma2000 EV-DO and the Centrino effect that ultimately drove Cingular to HSDPA. Unlike Europe, where UMTS is the only 3G game in town, Cingular competes with live EV-DO networks, which can offer higher data rates than old-fashioned UMTS. Thanks to Intel and a proliferation of WiFi hotspots, Americans are used to high-speed wireless data services for laptops and PDAs. It would have been sheer folly for Cingular to launch its 3G network in the half-hearted way that we have come to expect in Europe. And with early launches of WiMAX possible later in 2006, keep your eyes peeled across the Atlantic for the first implementations of HSUPA.

WiMAX friend or foe?
Of course, WiMAX is still in its infancy compared with HSDPA and it’s not clear what impact, if any, it’ll have on the cellular industry. Its supporters have taken great pains to play down the potential for WiMAX to compete with 3G cellular services. They describe the early 802.16d incarnation of the technology as an alternative to wireline broadband services (see page 20). Later versions of WiMAX, however, are expected to offer full mobility and will also include two technologies that many see as defining features of 4G cellular: pure IP transmission and an OFDMA air interface. Be it friend of foe, the cellular industry has taken notice of WiMAX, and major players throughout the supply chain are busy evaluating the technology. After several years of relative quiet, the wireless telecoms market can look forward to more exciting times.

Hamish Johnston, Editor
Agilent spins out Avago Technologies

Agilent Technologies has spun out its semiconductor division in a long-awaited deal worth $2.7 bn. The new Avago Technologies is privately owned by Kohlberg Kravis Roberts & Co. and Silver Lake Partners. It will have headquarters in both San Jose, California, and Singapore. It has 6500 employees and major facilities in eight countries worldwide. Avago’s products include RF components and customers include Nokia, Sony Ericsson and Samsung.

HP veteran Dick Chang will have a go at running the new company.

HSDPA launches in US

Cingular Wireless has launched commercial HSDPA services in the US. The service is delivered to laptop computers via HSDPA modem cards and is currently available in 16 major cities. This is the world’s first commercial launch of HSDPA and the first simultaneous launch of 3G and 3.5G technologies.

Called BroadbandConnect, the service can also be accessed via UMTS and GPRS/EDGE. Cingular claims that the HSDPA link can achieve typical downlink data rates of 400–700 kbit/s. The operator already has a nationwide EDGE network in place that can deliver data rates of about 100 kbit/s.

Subscribers have a choice of two modem cards: the Merlin U730 from Novatel Wireless, or the AirCard 860 from Sierra Wireless. Both cards operate on UMTS/HSDPA and GPRS/EDGE networks at 850, 900, 1800 and 1900 MHz, which means that they can be used worldwide – at least for GPRS. Both cards are based on Qualcomm’s MSM6275 chipset. Cingular’s UMTS/HSDPA network was supplied by Lucent Technologies, Ericsson and Siemens. Cingular has promised to launch new services – including high-quality video and audio streaming – that take advantage of HSDPA data rates.

Fujitsu makes PA breakthroughs

Fujitsu Laboratories has developed gallium nitride (GaN) and carbon nanotube technologies that could improve the performance of the power amplifiers used in base stations.

Fujitsu has unveiled a GaN transistor that promises to lower the power requirements of next-generation base stations. Based on a high electron mobility transistor (HEMT) with insulated gates, the device is capable of output power levels in excess of 100 W.

Traditional GaN HEMT designs do not use insulated gates, which results in high leakage currents and prevents the devices being run efficiently at power levels greater than 100 W. The device was used with digital predistortion circuitry to demonstrate that it can amplify a W-CDMA signal without leaking significant power into adjacent channels. The device delivered 110 W and 13 dB of linear gain at 2.14 GHz.

The device was unveiled by Fujitsu researchers at the recent IEEE International Electron Devices Meeting in Washington, DC. The company also presented a paper on the use of carbon nanotubes as heat sinks for transistors used in base-station power amplifiers.

Fujitsu researchers developed a technique to grow carbon nanotubes as long as 15 µm on the wafer substrate by using an iron catalyst coating. According to Fujitsu, these are long enough to be used as a bump in the flip-chip process. A technique to connect the bump to the flip-chip has also been developed.

The nanotubes have a much higher thermal conductivity than traditional metal bumps and can be located near to heat generating elements. The improved heat dissipation allows the transistor to be run at frequencies of up to 5 GHz and an increase of at least 2 dB in gain.

China’s ZTE collaborates in France and India

ZTE has joined forces with France Telecom and Bharat Sanchar Nigam in separate collaboration deals. The Chinese telecoms equipment supplier has signed a long-term R&D agreement with France Telecom covering a wide range of technology sectors. The first collaborative effort will focus on the development of a Linux-based client interface for 3G smart phones.

The agreement furthers ZTE’s ambitions to become a major player in the European market and France Telecom’s desire to increase its presence in China, where it already operates an R&D facility and collaborates with China Telecom.

ZTE’s chief executive Yin Yimin said: “This agreement strengthens ZTE’s strategy in Europe. It will enhance ZTE’s competitive position.” France Telecom owns Orange, a pan-European GSM/UMTS operator.

Meanwhile it has been reported in the Indian and Chinese media that ZTE will form a joint venture with India’s Bharat Sachar Nigam (BSNL). BSNL provides a range of telecom services including cellular and also manufactures infrastructure equipment. The deal is reported to include the manufacture of one million CDMA handsets at BSNL’s facility in Kolkata. Technology and machinery will also be transferred between the companies, which will each own 50% of the joint venture.

Earlier this year ZTE opened a facility in Delhi that manufactures CDMA and GSM infrastructure equipment and mobile phones. ZTE currently supplies CDMA wireless local loop equipment to BSNL.
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Staccato pushes for UWB in Europe

Staccato Communications has opened a European office that will focus on the development of ultra-wideband (UWB) standards and regulatory frameworks within the region. From its office in London, the US-based UWB chipmaker will work with the European Computer Manufacturers Association, European Telecommunications Standards Institute (ETSI), the International Telecommunications Union (ITU) and the UK’s telecoms regulator Ofcom.

“Regulatory and standardization work on [UWB] in Europe has intensified in recent months,” said Staccato’s chief executive Rick Cornfield, adding “we are committed to ensuring that European UWB policy enables the commercialization of the technology as soon as possible while providing protection for incumbent spectrum services.”

UWB is a very-short-range and low-power wireless communications technology that provides high-speed data links between electronic devices including mobile phones. The technology is currently approved for use in the US and Japan.

Alcatel promotes TD-CDMA in Asia and A-GPS in Europe

Equipment vendor Alcatel will design and roll-out a TD-CDMA network in Jakarta, Indonesia, that will deliver commercial broadband data services. Services will be delivered via a desk-top modem or PC card. Base-station and user equipment will be supplied by US-based IPWireless and the network will be operated by the Indonesian broadband operator PT Solusi Aksesindo Pratama. The three companies currently operate a trial TD-CDMA network in Jakarta and the commercial service is expected to launch in January 2006.

Meanwhile in Europe, Alcatel will supply assisted-global positioning system (A-GPS) technology to Orange as part of a trial of location-based services. The A-GPS will be based on Alcatel’s 8608 A-GPS server and subscribers will be supplied with the iPAQ hw6515 Mobile Messenger personal digital assistant, which has GSM voice, EDGE data and GPS capabilities.

Qualcomm defends patent licensing programme

Qualcomm has defended its controversial intellectual-property licensing policies after a Korean newspaper described its royalties as being prohibitively high.

Qualcomm has issued a statement saying its licensing programme “has promoted worldwide competition and rapid growth of CDMA services”. On 1 December the Korean Times claimed Korean handset makers pay up to 5.75% of the price of each phone to Qualcomm, which declined to comment on specific royalties.

Qualcomm – which owns a large portfolio of CDMA-related patents – also stated that it will continue to charge royalty fees that are excessive and disproportionately high.

While continuing to charge royalty fees to handset makers, Qualcomm has also been accused of excluding others from entering the market. Qualcomm is also accused of “charging royalties for its W-CDMA essential patents that are excessive and disproportionately high.”

Rick Cornfield of Staccato wants Europe to embrace UWB sooner rather than later.

Smart Telecom and Huawei buy last Irish 3G licence

The Irish telecoms operator Smart Telecom has bought Ireland’s remaining 3G licence for €114 million. Smart’s bid was backed by the Chinese equipment maker Huawei, which will supply network infrastructure equipment. This is a major breakthrough for Huawei, which is very keen on breaking into the western European market.

Ireland has four 3G licences, three of which were bought in 2002 by 3 Ireland, Vodafone Ireland and 02 Ireland. The remaining licence received no bids and has been in limbo until the Irish regulator Comreg reopened the auction earlier this year. The licence was offered for a fixed price and Smart Telecom was chosen over other bidders (Eircom and Meteor) on the quality of its business plan.

Smart and Huawei must cover 53% of the Irish population with 3G by 2011. This is expected to cost as much as €400 million.
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Cellular must plan for the transition to IPv6

Steve Rogerson reports from the IMS Global Congress in Budapest, where network operators were warned against delaying the migration to IPv6.

While most cellular operators agree that they should migrate their networks to Internet protocol version six (IPv6), IPv4 works well today and operators have enough on their plates already without worrying about making the transition. Indeed, IPv6 has been around for 10 years and has yet to enjoy any significant application—despite the endless debate that surrounds its implementation.

This conflict came into sharp focus at the recent IMS (IP Multimedia Subsystems) Global Congress, which was held in Budapest, Hungary. Karim El Malki, a consultant with the IPv6 Forum, found himself preaching to a room of sceptical operators. He said that operators should not look at IPv6 simply as a technology that is either good or bad. Instead operators should consider how IPv6 could make life easier for application developers. “That is why IPv6 was developed,” said El Malki. “There is a lot to be gained from new applications with IPv6. I see IPv6 as a service enabler.”

IMS without IPv6

While some operators are wary about making the move to IPv6, they still want to introduce new services that IMS can provide. Operators see IMS as the way to fulfil the promise of 3G by bringing integrated and easy-to-use data services to subscribers.

Günter Pospischil, the IMS lead architect at Mobilkom Austria, said that IMS could be introduced on the 3G operator’s existing infrastructure. “The standards say we should use IPv6—but we haven’t got IPv6,” he said. Pospischil said that he did not know whether IPv6 will be necessary for IMS, adding “we will have to wait and see”. He said that Mobilkom may implement IPv6, “but not for the time being”. Instead, Pospischil is focused on implementing IMS on IPv4, although he admits, “some parts of IMS don’t fit with IPv4”. This does not worry Pospischil because these services will not be mass-market over the next few years and therefore there is no rush to move to IPv6.

Pospischil believes that this reluctance to move on IPv6 is related to the fact that operators have set IMS as a more urgent priority. Ultimately, both technologies must be embraced—but they are both large projects and operators simply could not do both in parallel. Clearly, operators are not rushing into IPv6 because they fear that the transition could cause serious upheaval and the risk of network downtime. Pospischil explained: “The infrastructure has to be ready to support IPv6—and you do need a migration strategy.”

Transition strategy

Karim El Malki believes that these problems can be avoided if mobile operators develop an appropriate transition strategy for IPv6 sooner rather than later. He argued that eventually all networks will be based on IPv6 without legacy support for old standards—and that could cause conflicts. “We have to think mobile for the future,” he said. “We can’t think fixed. Mobile has already passed fixed on the number of subscribers.”

Although mobile subscriber numbers continue to increase, voice revenues are experiencing downward pressure thanks to stiff competition. Operators are therefore looking to data services as a way to boost their income. To do this effectively, more IP addresses will be needed and IPv4 is unlikely to be able to deliver the required number—although some believe that it could. El Malki says that IPv6
The implementation of IPv6 requires the deployment of compatible routers. This router from Juniper Networks supports both IPv4 and IPv6.

The killer applications will come from third-party developers, so let’s give them the chance to start developing.

Windows, which is expected to have IPv6 enabled by default, as something that will bring many users into the fold. Mobile-phone makers are also coming out with IPv6 products, which will create a demand for enabled networks. Indeed, the emergence of Skype, which provides peer-to-peer voice over-IP (VoIP) calls, has reminded operators of how quickly IP-based technologies can catch on with consumers. El Malki believes that IPv6 has the potential to deliver more reliable VoIP with better quality of service than currently offered by Skype.

There are several ways that IPv6 can be introduced into a mobile network. One way is to run both IPv6 and IPv4 on the same point-to-point protocol (PPP) link. Alternatively, IPv6 can be tunnelled through an IPv4 network. The latter strategy involves some losses in transport efficiency but this should not make that much difference to end users. Perhaps the easiest route to IPv6 is a box that converts IPv6 to IPv4 and vice versa. Though this could work in the short term, it is not likely to be an appropriate long-term solution because it suffers from scalability, reliability and security problems. A less painful method is a dual stack, whereby the network is gradually migrated to support both versions. According to El Malki, this strategy allows operators to continue to offer existing services on IPv4 while putting new services on IPv6.

While El Malki conceded that the difficulties in deploying IPv6 should not be understated, they can be overcome if operators devote sufficient time to put a proper plan in place. For example, one operator took six months to develop a strategy and then found the transition relatively easy, said El Malki. He believes that success will come to operators that make an early move towards the rapid introduction of IPv6. “Start deploying and experimenting,” he said. “Think about the personal area networks. The killer applications will come from third-party developers, so let’s give them the chance to start developing. And then we can get the new revenues that are out there. There are no technology barriers – we just need to work out the business models.”

Steve Rogerson is a freelance technology journalist.
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Field-programmable gate arrays (FPGAs) play a crucial role in the early phases of base-station development and production. But recent improvements to FPGA technology will see the chips used throughout the lifetime of a base-station design and ultimately make base stations more flexible.

A FPGA is a configurable chip that is used widely in the verification of application-specific integrated circuits (ASICs) as well as in product prototypes. Traditionally, the ultimate goal was to use ASICs in base stations – but not before the design was thoroughly tested. This is done by transferring the ASIC design in software to the FPGA before mass production begins. Within certain limits FPGAs can mimic the behaviour of the final ASIC – which is crucial because producing ASICs requires a significant investment.

FPGAs can also be used as an ASIC substitute in situations where mass-producing an ASIC would be too expensive. While ASICs are relatively cheap to manufacture, they have large development costs. By contrast a FPGA is much more expensive to purchase than its equivalent ASIC, but has little or no up-front cost. Thus FPGAs are much more cost effective for small production runs. Another benefit of FPGAs is short time-to-market. A FPGA can be re-programmed on the bench in minutes whereas an ASIC can take many months to plan, produce, debug and revise.

So FPGAs have always been the choice for first-generation low-volume products as well as for demonstration units and prototypes – and base stations are no exception. First-generation products are usually produced in small volumes and time-to-market is more important than absolute lowest cost. Engineers will use FPGAs for functions that could use an ASIC if time or budget allowed but the ultimate goal is to phase out the FPGA and replace it with an ASIC whenever possible (but often this never happens!).

This is changing as the FPGA price/performance point improves compared to ASICs. FPGAs now offer credible performance in applications where only a few years ago it would not have been a contender. And rather than being a temporary measure, FPGAs are becoming an accepted part of the long-term base-station technology roadmap from the prototype stage all the way through to mass production.

Designers will also take full advantage of the field-programmable nature of FPGAs. Base stations using FPGAs can be reconfigured after manufacture to fix bugs, add new features or ultimately to perform a completely new function. FPGAs could be exploited to develop software-defined base stations that support a range of current and future wireless standards.

So the future looks bright for FPGAs. Better price and performance mean that they are appearing in volume products and long-term roadmaps. Their greater flexibility can be exploited to develop differentiated products in which they’re embedded. FPGAs are a hot topic among manufacturers wishing to make better, cheaper products faster and with lower risk.

Mark Paxman is a managing consultant at PA Consulting’s Wireless Technology Group. He can be contacted at mark.paxman@paconsulting.com.
WiMAX: friend or foe?

While there is no doubt that WiMAX will revolutionize the fixed-wireless access market, its relationship with 3G is less clear. Wireless Europe spoke to various key players (see below), but first, Paul Senior of Airspan explains how the relationship between cellular and WiMAX services will evolve in the future.

As WiMAX establishes itself as the next generation of wireless broadband, the telecoms industry is beginning to consider business models that would maximize the commercial exploitation of the technology. Above all, mobile operators are being forced to decide whether WiMAX is friend or foe. With the first certified fixed WiMAX products becoming available, it is increasingly clear that the new standards-based technology will complement rather than compete with emerging 3G services.

The emergence of WiMAX under the IEEE 802.16 standard takes the broadband wireless access industry to a new stage of maturity, allowing it to address mass markets at last. The first WiMAX products are now undergoing testing and certification and many vendors have already begun bilateral interoperability tests to accelerate this process. As a result, leading players expect to have WiMAX Forum Certified products commercially available by the end of 2005.

The 802.16 standard for fixed broadband wireless is lowering the barriers for entry into the WiMAX space for both handset makers and operators. All Korean WiBro products will eventually be certified as mobile WiMAX and both Samsung and LG have committed to launching products. Indeed, almost all major telecoms equipment manufacturers are developing a WiMAX product.

Although WiMAX is set to make a major impact on the broadband market, it has also been touted for several applications that it is not really suitable for. Much has been spoken of WiMAX as a backhaul solution for 3G networks, but as it is optimized to shift IP packets, WiMAX is not suitable for backhauling this generation of 3G’s circuit-switched traffic. As 3G shifts to become more IP-centric with HSDPA and HSUPA, the situation will improve.

Another popular myth is that WiMAX will debut as an anytime, anywhere broadband technology. While mobile WiMAX for laptops and other devices is certainly part of the industry roadmap, the first commercial WiMAX services will be fixed – a more mundane, but far more commercially viable application.

Faster data rates
WiMAX achieves greater upload and download data rates than HSDPA/UMTS (up to 10 Mbit/s) but it is not really appropriate to indulge in a battle between 3G and WiMAX. Likewise, although WiMAX can allow carriers to

Mobility offers a route to 4G

Wireless Europe spoke to several players in the WiMAX supply chain to discover how the technology is progressing – and the implications for the cellular industry. Naturally we began with Intel, WiMAX’s most fervent and powerful supporter.

Intel’s Gilles Karolkowski told Wireless Europe that interoperability tests for the fixed flavour of WiMAX (802.16d) are going well. Intel launched a WiMAX chipset earlier this year and the company is claiming that 24 WiMAX networks will be up and running by the end of 2005. Karolkowski believes a major challenge facing the industry is reducing the cost of customer premises equipment (CPE).

According to Karolkowski, a pre-WiMAX fixed-wireless broadband CPE costs about €700. The cost of installing an outdoor line-of-sight antenna brings the total cost closer to €1000. He is confident that Intel’s chipset will bring the price below €400 and, perhaps more importantly, 2006 will see the launch of indoor CPEs that can be installed by the customer.

Indoor coverage is a tricky issue in Western Europe, where WiMAX is currently restricted to the 3.5 GHz band, which has very limited in-building penetration. Karolkowski believes that in the short term this problem will be overcome by implementing antenna diversity on the CPEs.

However, 3.5 GHz will not be suitable for mobile WiMAX (802.16e) if the technology is to deliver its promise of full mobility. “The preferred band for mobile and nomadic WiMAX in most of Europe is at 2.5 GHz,” said Karolkowski, “but this is
provide broadband in rural areas where DSL cannot reach, it should not merely be seen as a niche supplement to fixed broadband for incumbent operators.

For wireless equipment makers and operators, the fundamentals are these: WiMAX is an alternative to DSL and cable, but it has the critical advantage of being an all Internet protocol (IP) wireless technology. WiMAX supports WiFi, voice-over-IP (VoIP) and is capable of delivering multiservice bundles—the latter referring to the triple play of voice, video and broadband. WiMAX offers any telecoms operator, mobile or otherwise, the chance to break into the residential broadband market with a competitive and elegant mass-market offering.

WiMAX will also enable operators to add value to their business customers by delivering high-bandwidth services in addition to existing 3G and WiFi services. In other words, WiMAX is simply another part of the technology mix.

WiMAX will only break into the mass residential market if reasonably priced retail equipment becomes available. A handful of WiMAX vendors are already offering self-install plug-and-play units, which are similar to WiFi routers in terms of installation and operation. These devices will act as hubs for WiFi and more in the home, delivering VoIP and, ultimately, Internet television (IPTV).

A handful of wireless broadband equipment vendors will dominate the market and manufacturing agreements are already in place within familiar leading telecoms players such as Ericsson, Marconi and Nortel. While today’s WiMAX devices are stand-alone units that act as hubs, within two years Intel will deliver WiMAX laptop cards that will make the technology a standard option for a wide range of environments from the home to large campuses.

**WiMAX in the home**

3G vendors must look carefully at WiMAX because it offers a viable route into the fixed residential broadband market. Today’s 3G data technology is optimized for handsets and applications that work well on them. While HSDPA holds many promises for 3G services, it will not support the transparent delivery of the majority of IP applications that consumers are demanding from broadband services—such as VoIP and multi-user Internet gaming. Indeed, HSDPA will struggle to deliver the 2 Mbit/s download speeds that consumers expect from today’s fixed broadband experience. Only when HSUPA arrives will 3G finally be an all-IP system and that is clearly several years from today.

At the same time, mobile markets for voice are reaching the saturation point in many markets and operators must consider alternative revenue opportunities that play to their strengths. WiMAX will provide mobile operators with a golden opportunity to exploit their retail channel and consumer knowledge. Mobile operators also have a wealth of experience in designing, installing and operating wireless networks. Indeed, the provision of pre-pay broadband via self-installed user equipment is a cornerstone of any mobile business model.

While many may talk about mobile WiMAX as a 3G-disruptive technology, the reality is that it is the fixed broadband market that is currently dominated by telecoms incumbents worldwide that will be transformed. When the first certified networks go live, it will become clear that WiMAX is a natural part of the operator’s technology and opens up a new market to a mobile industry in search of new revenues.

Paul Senior is Vice President of Marketing and Product Management at Airspan Networks.

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**Laptop integration**

“We are looking to reproduce the success of Centrino for laptops,” said Karolkowski. He expects WiMAX cards to be available in 2007 and by 2008 it will be fully integrated into laptops. He stressed that WiMAX will not replace WiFi, but rather the two will complement each other. Looking further into the future, Karolkowski believes that by 2009 or 2010, WiMAX handsets will be available operating at 2.5 and 2.3 GHz.

This, of course, should be a matter of concern for cellular operators, many of which have been caught off-guard by the sudden interest in WiMAX. Carlton O’Neal of the broadband-equipment supplier Alvarion, however, sees WiMAX as a natural evolution of the broadband fixed-wireless industry: “We have been deploying pre-WiMAX equipment for almost 10 years now, so the sudden interest is no surprise to us.”

O’Neal believes that the fixed-wireless industry is at a key juncture, moving from proprietary technologies to the WiMAX standard. “This never happened in cellular because roaming required standards from the beginning,” he said. O’Neal believes that this standardization will transform fixed wireless from being a niche product to being a complementary technology for broadband service providers. “The current fixed-wireless equipment market is about $500 million, but standardization will take it to, say, $5 billion over the next couple years.”

O’Neal conceded that fixed WiMAX is not likely to unseat incumbent wireline technologies such as DSL: “WiMAX will always have a radio component and therefore the cost will always be higher.” However, he believes that the WiMAX market will fundamentally change with the introduction of indoor desktop modems, which will make WiMAX a nomadic technology. “It’s not the mobility that is crucial,” said O’Neal. He
believes that this nomadic feature will encourage people to connect all of their electronic devices: “This takes us to the realm of personal broadband.”

This is good news for the cellular industry: “I don’t think that there will be a battle between 3G and WiMAX, because personal broadband will span so many applications that 3G and WiMAX will struggle to support them all.” O’Neal also pointed out that WiMAX will be deployed later than 3G – or even 4G – and therefore WiMAX operators will be racing against the clock to get services to customers.

Reza Ahy of the broadband-equipment supplier Aperto believes that 3G operators have shown a significant surge in interest in WiMAX for two distinct reasons. Some 3G operators are looking at WiMAX as a complementary technology to future cellular technologies such as HSDPA, HSUPA and EV-DO. “We are engaged with several large 3G operators and one is evaluating our technology as an overlay to EV-DO,” he said. Others are interested in using WiMAX as a backhaul solution and Ahy said WiMAX is an attractive backhaul technology because it is non-line-of-sight and can emulate one or more E1 Links.

WiMAX offers different benefits to 2G operators – particularly those that must choose whether to buy a 3G licence or have no access to 3G spectrum. “WiMAX gives them a way of getting into high-speed data services,” said Ahy, pointing out that current broadband 3G services are nomadic rather than mobile.

Chipmakers
The challenges surrounding the development of WiMAX handsets are immense and many rest on the shoulders of chipmakers such as SiGe Semiconductor, which has an RF transceiver in production. SiGe’s Andrew Parolin told Wireless Europe: “All our customers are designing fixed CPE equipment for either indoor or outdoor antennas.” According to Parolin, many companies that produce WiFi user equipment are moving into WiMAX.

Parolin believes that compatibility issues remain for those developing dual-mode WiFi/WiMAX CPEs if WiMAX is operating at 2.5 GHz. “It will be challenging for filter manufacturers,” he said, but he believes that any obstacles will soon be overcome. “It’s really no different than WiFi and UMTS operating on the same platform.”

“The industry has progressed in the development of chips for mobile WiMAX,” said Parolin. “Our chipset is definitely portable – it has low power consumption, about half a watt in receive mode.” Parolin also noted that many WiMAX baseband chips are also meeting size and power requirements for portable applications. He predicts that WiMAX PCI cards will debut in late 2006 and will cost about twice as much as a WiFi card.

Parolin sees truly mobile WiMAX appearing in 2008 or 2009 and, beyond that, he believes that WiMAX or a similar technology will form a good basis for a 4G standard. “The cellular industry thinks WiMAX is a good technology.” He believes that most major equipment makers are looking to support WiMAX in their base stations. “They see its potential as a 4G technology and the cellular industry will try to steer the future development of WiMAX,” he warned. However, Parolin reported that there is currently very little interest in standards meetings, with all participants focused on getting the technology to work as quickly as possible.

Michelle Pampin of Harris Microwave told Wireless Europe that WiMAX itself is a rapidly evolving concept. “Initially WiMAX was defined as a point-to-point technology, but in the last 18 months it has changed completely into an access technology,” she explained. WiMAX is now generally seen as a point-to-multipoint technology, which Pampin said is not ideal for celluar backhaul: “If the hub goes down, several cells are taken out with it.”

Harris makes point-to-point backhaul equipment, so it is not surprising that Pampin is pleased with the shift to point-to-multipoint access systems. WiMAX base stations will have very high backhaul requirements and she believes that they will not be able to backhaul themselves. “They will need point-to-point radio,” because backhauling with leased lines would be very expensive, particularly in Europe.

Like many in the industry, Pampin believes that the first generation of WiMAX – 802.16d – will be short lived. “Many chip vendors have stated that they will do one revision of the d chip and then go straight to e.” She pointed out that some major players such as Motorola are skipping d altogether and going straight for e. This means that significant economies of scale may not be achieved until 2007/08 when the mobile version of WiMAX arrives.

Some believe that mobile WiMAX will arrive much sooner in South Korea – in the form of WiBro. Rupert Baines of base-station chipmaker PicoChip was adamant: “WiBro is the first deliverable of 802.16e. It is incredibly important and is very much the leader.” He described WiBro as only marginally different from WiMAX: “WiBro is to WiMAX what FOMA is to 2GCDMA.” Baines said that WiBro will have forward compatibility with WiMAX.

Baines believes the WiBro standard has advanced much further than 802.16e, which he described as “an awful document that needs major editing”, whereas “the English translation of the WiBro specification is actually much clearer”. WiBro was expected to go live in April 2006, “but that has slipped a few months but it will be next year”.

Baines is adamant that WiBro is “truly mobile in the sense of a cellular service” and agreed that it is a stepping stone to 4G: “WiMAX matters because of 4G and that is why major players such as Samsung and Intel are taking it very seriously.” WiMAX could be a precursor to 4G cellular for two reasons. There is currently a general consensus within the wireless community that any 4G air interface will be based on OFDM or OFDMA, which are the very technologies being developed for WiMAX. In addition, 4G will most certainly be an all-IP network, which is also the plan for WiMAX. However, Baines stressed that WiMAX is not 4G: “In theory, 4G should deliver data rates of 1 Gbit/s for static users and 100 Mbit/s for mobile users and the current version of WiMAX won’t do anything like that.”

By Hamish Johnston, editor of Wireless Europe.
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Could interference between TDD and FDD prevent the collocation of the two UMTS technologies? Peter Relph investigates.

As 3G systems and services slowly grows in popularity across Europe, the prospect that time division duplex (TDD) W-CDMA technology could enjoy widespread deployment moves closer to reality. For many, particularly in Europe, the TDD system is thought of as supplementary – providing additional 3G bandwidth or hotspot data services that are similar to 802.11 WiFi.

Others see TDD as a true alternative to frequency division duplex (FDD) UMTS systems, which already provide 3G services. This is true in East Asia, where the TDD flavours TD-CDMA and TD-SCDMA – along with variants of 802.16 and 802.20 – are under serious consideration as real alternatives to mainstream 3G technologies.

TDD systems offer several well known advantages. A single carrier frequency is employed for both the uplink and downlink connections – the connections being split in the time domain. The time allocated to the up and downlinks can vary according to traffic requirements. This means that TDD can provide asymmetric data services such as Internet browsing without a loss in the spectral efficiency. Moreover, TDD protocols are adaptive, such that the relative proportion of uplink and downlink time can change dynamically to meet the demand.

Interference problems
However, having the transmitter and receiver on the same frequency causes interference problems with the systems operating within adjacent frequency bands. For example, if the adjacent frequency is occupied by an uplink allocation, the receiving base station can expect interference from a TDD base station that is transmitting. Similarly, if the TDD frequency is adjacent to a downlink, the receiver for the TDD system experiences the interference. An identical argument is true for the mobile units.

Indeed, the situation for handsets is arguably worse, because there is no control over the minimum separation between units or the antenna orientation.

This interference issue is well understood and a great deal has been done to try to quantify and solve the problem. An excellent example is the Third Generation Partnership Project (3GPP), which has developed specifications for equipment that is used in the “same geographical region” or in “collocation with other services”. These define progressively more demanding requirements and equipment that is collocatable must achieve a level of performance that is almost impossible, or uneconomical, to implement.

Collocation specifications
Collocation specifications are derived using an interference calculation, which considers the unwanted noise from the interfering transmitter in terms of adjacent channel leakage ratio (ACLR) or wide band noise. The receiver’s ability to reject other signals that are not in the channel of interest are also considered in terms of adjacent channel selectivity (ACS) or blocking immunity. For the base-station equipment, the calculation must consider the coupling between the on-site antennas. A more statistical approach is required for mobile phones in order to calculate the probability of coverage for a particular service. There are many software tools available to do this type of calculation, including Opnet and SEAMCAT.

The problem with such calculations is that they assume that the interference behaves as Gaussian noise and is continuous in time. This is clearly not true for interference from a TDD system, where in practice the interference will either come from the base station or the mobile, but not both at the same time.

It is also important to remember that most air interface protocols such as W-CDMA are designed to be immune to burst errors in order to protect the link against fading effects. This is achieved though the link-level coding, that interleaves (or reorders) the data such that a burst of errors appears as random
errors in the data packet. The data are then encoded – usually with turbo or convolutional coding – which adds redundancy so that errors can be corrected. As a result, the effect of interference from a TDD system is not as severe as an equivalent continuous transmission system with the same average power.

Unfortunately, an accurate analysis of bursty interference is quite involved and ideally requires simulation at the link level using a tool such as Cadence’s Signal Processing WorkSystem (SPW). Intuition suggests that the interference effect will be a strong function of the coding performance for the victim’s link – in terms of data rate, data block length, coding rate etc – and the duty cycle of the TDD interferer. In practice the victim and interferer systems will be asynchronous and therefore there will be some statistical element that must be considered. For a complete analysis, a fading channel must be included to quantify the degradation of fading immunity in the presence of bursty interference.

Duty cycle effects
As the duty cycle of the TDD system approaches 100%, the interference model will approach the Gaussian noise model – but this special case is very unlikely. Conversely, as the duty cycle of the TDD system becomes small, the effect of the interference diminishes as the coding of the victim link corrects any resulting errors.

This is particularly true for the case of the TDD mobile device, which is likely to be operating in an asymmetric manner resulting in a low duty cycle. The device could be attached to a laptop computer that is sitting next to a W-CDMA handset operating, say, a voice or video service. In this case it is probable that the W-CDMA user will experience no degradation in service. This is good news for those concerned with mobile-to-mobile interference. This can be troublesome because of the uncontrolled nature of the environment and the fact that handsets are subject to severe size and cost constraints, which limit their performance.

Fortunately for all concerned, the interference from a TDD system is likely to be less severe than a simplistic interference calculation predicts, thanks to the immunity provided by the coding in the victim receiver. A detailed analysis is quite involved and requires link-level simulation, which is dependent on the air interface protocols for both victim and interferer. However, the benefit of proving that interference is manageable must be of enormous value to the supporters of the TDD standards and could further increase the demand for the flexibility that TDD gives.

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While base-station technology has evolved significantly in recent years, many of the processes related to base-station deployment have changed at a much slower pace. However, the need to boost coverage and capacity to meet growing demands for wireless voice and data services is causing operators to consider more efficient ways to deploy base-station equipment.

There are two major areas where efficiencies can be improved. The first involves the optimal utilization of the large amount of unused capacity that is often available in 3G networks during the first years of operation. The second, and more immediate issue, relates to the enormous challenge of site acquisition and on-going efforts to collocate as many new 3G base stations on existing 2G sites as possible. Collocation is important because operators are finding it very difficult to secure new locations that have all of the required facilities for the radio equipment such as electrical power, building space and air conditioning. It is even more difficult to find sites that also offer an optimal location for the base-station antennas.

The long-established concept of distributed cell site architecture (DCSA) has recently reappeared as a way to address these issues. DCSA extends the distance between a base station and its antennas. This allows the antennas to be placed at optimal remote locations, while the base stations can be located at a convenient location nearby (see figure 1). The immediate benefits of DCSA are shorter time-to-operation and lower deployment and site-hosting costs.

**Transparent performance**

The system performance of a typical wireless DCSA is comparable to a conventional base station, and the equipment is transparent to the rest of the network. DCSA equipment is designed and developed by a range of companies including major wireless-network equipment vendors, companies that make related equipment such as repeaters and distributed antenna systems (DAS) and firms that specialize in DCSA. Major wireless-network equipment vendors provide remote RF modules and remote RF heads. These units usually include a radio module that is placed in a remote location where it is connected to a set of remote antennas. The connection between the radio unit and base station is normally done over fibre-optic cable using a proprietary communications protocol. Other companies have developed equipment that transports the RF signals from one location to another, while others employ optical wireless technology, which is a relatively new way of making the connection.

Fibre-optic cable was once seen as the only way of making the link, but today DCSA can be implemented using a range of technologies including laser-based optical wireless systems, microwave radio systems or various smart repeater systems. These provide RF engineers with more flexibility when trying to locate antennas precisely where capacity and coverage is needed.

UMTS infrastructure can be rolled out in several different ways. In many cases the deployment of entirely new base-station equipment is an overkill solution that is too expensive. A much lower-cost strategy is the use of regular RF repeaters, which typically re-broadcast selected radio channels from an existing base station. Although RF repeaters are an attractive and cost-effective solution for 2G networks, they cannot achieve the appropriate levels of noise immunity, pilot pollution and isolation required for CDMA-based networks such as UMTS. A DCSA based on optical or microwave wireless links is much more suitable for use in 3G networks because the links between the base station and antennas offer much greater isolation than RF repeaters.

In the past wireless DCSA installations employed wireless RF distribution systems, which often suffer performance degradation related to in-band interference and RF isolation. However, several recent and successful commercial deployments of optical and microwave transport links have not suffered from these
problems. This means that the link equipment and service antennas can be located very close together. This is unlike RF distribution equipment, which required a distance of several metres between the link and service antennas to achieve the required isolation.

As well as easing the deployment of new base-station equipment, DCSA allows operators to get the most from existing base-station facilities. For example, DCSA can be used to collocate base-station equipment or to utilize spare capacity in existing base stations. Such strategies have been demonstrated to increase significantly the network efficiency in terms of the utilization of available capacity. And because they can be achieved in a much simpler cell-site deployment process, these strategies have been shown to reduce dramatically the time-to-operation of base-station equipment.

DCSA also allows operators to minimize and consolidate their backhaul transmission requirements by collocating base-station equipment and eliminating the need to backhaul remote antennas. Backhaul is a major operating expense and a reduction in the number of required connections provides a significant cost saving.

**Power saving**

In many cases it is not possible to route the RF cable directly to the antennas. This is especially true in UMTS networks, where RF losses reduce performance as cable distances increase. A wireless or fibre-optic DCSA deployment allows the power amplifiers to be located closer to the transmitting antennas. When compared with a traditional deployment – with the base-station equipment located indoors at ground or basement level and antennas on the roof or a tower – savings of up to 12 dB in output power can be achieved by taking this approach.

By using an existing base-station location to serve antennas in new remote locations, mobile operators can reduce – or even eliminate – various conventional costs. These costs are related to the provision of backhaul connectivity to the new location as well as much of the leasing, construction and facilities-upgrade costs associated with the installation of base-station equipment.

Capacity sharing is an important way that DCSA can be employed by operators. For example, the sectors of an existing base station can be redistributed among two locations to maximize the use of its capacity. A single sector can also be divided to provide capacity for two locations. An illustration of the capacity sharing scenario is shown in figure 2.

Operators continue to struggle with the collocation of UMTS and GSM base stations and DCSA can be used in a configuration that delivers great flexibility. In the initial deployment, DCSA can be used to distribute antennas to remote sectors to reduce the initial number of base stations. This allows the operator to deploy UMTS antennas in optimal locations based on coverage and capacity needs rather than being restricted to the locations of existing GSM antennas. An example of a base-station collocation configuration is shown in figure 1.

**In-building coverage**

Providing adequate in-building coverage and capacity is one of the more difficult RF challenges facing operators. In many cases it is too costly or not even possible to provide the appropriate in-building coverage with a conventional base-station deployment. In these situations, an operator may use DCSA to exploit an existing base station to provide coverage and capacity to an in-building location. This is a good solution both for a wide range of building types and sizes from shopping malls and sports arenas to smaller office buildings. A DCSA can be connected directly to an in-building DAS; a typical in-building application is shown in figure 3.

As DCSA technology continues to develop, it will be able to cover longer distances and will offer more features. For example, a feature called drop-and-insert will allow DCSAs to be deployed in star (point-to-multipoint) or chain (series of consecutive links) configurations. Drop-and-insert will help operators share resources between several sites. It will also offer operators greater flexibility when deploying microwave and optical wireless transport systems that require line-of-sight links. Today, the need for lines of sight limits where remote sites can be located.

In the future, DCSA systems will make it possible to install more than two base stations at a single location. Wireless network equipment and radio technology have evolved to provide new capabilities, lower costs and increased efficiency for mobile operators. The methods used for base-station deployment should also evolve to provide the same benefits.

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To capture significant market share in the race for 3G customers, mobile operators must make substantial improvements to their backhaul infrastructure. However, to remain competitive and profitable they must dramatically reduce their operating costs and equipment expenditures. While these two goals seem contradictory, they can both be achieved if operators move from leasing backhaul transmission capacity to building their own transmission infrastructure.

In the early days of 2G roll out, most cellular operators leased backhaul transmission capacity from local fixed-line providers. The move from analogue to digital required more base-station sites and a need to extend the existing infrastructure. Leasing backhaul transmission facilities – rather than building out networks from scratch – allowed operators to get 2G services to market as quickly as possible and in a cost-effective manner. Fixed-line operators already had terrestrial transmission networks in place so leasing backhaul provided mobile operators with a low-risk solution during a period of rapid growth. By outsourcing transmission requirements, mobile operators could leave maintenance to the fixed-line operator and concentrate on building their specialized mobile networks and deploying new services. Today, however, the leased lines connecting base stations to mobile switching centres are a significant operational expenditure for mobile operators. And these costs will rise as 3G data services put increased demand on cellular networks.

While 3G promises to boost revenues by introducing a wide range of data services, operators must develop a robust and flexible network architecture that can deliver 3G at the relevant service and performance levels. In particular, the evolution to 3G requires a further increase in base-station density in any given geography. To support high-speed data services, each base station requires more backhaul capacity.

The backhaul requirements of 3G are putting increasing strain on the capital and operational expenditure of mobile operators. To ensure long-term scalability and profitability of the network, this growth must be achieved using a cost-effective backhaul architecture that meets capacity requirements while carrying all traffic types in an optimal manner. And operators must expand 3G backhaul capacity without jeopardizing existing revenue streams coming from 2G networks.

**Transmission networks**

These requirements have encouraged operators to begin building wholly owned transmission networks. By owning the transmission part of the backhaul connection, mobile operators have greater control over their network infrastructure. It also allows operators to ensure that they have the capacity needed to deliver data-intensive 3G services, especially when networks are upgraded to support HSDPA, which will further increase 3G data rates in the downlink.

Taking control of radio access network (RAN) backhaul transmission can be a costly exercise for mobile operators, and any decision to take backhaul transmission in-house must be driven by two main factors: economics and capacity. In recent years, the installation of transmission backhaul infrastructure has become a much more cost-effective exercise because the price of equipment has stabilized and fibre infrastructure is more widely available. As mobile operators rapidly approach the maximum capacity of current leased networks, they must either rent more backhaul circuits or begin to build their own. Renting clearly attracts an annual fee, which can be much more expensive than ownership in the long term.

Beyond the need for greater capacity, the nature of transmission requirements is also changing. As Internet protocol (IP) becomes prevalent in 3G, it will become possible to build an access network based on packet technology. This will ensure great flexibility to support further growth and compatibility. Privately owned infrastructure will provide the mobile operator with significantly more control over their own IP transmission.

Although the initial investment may be expensive, the long-term benefits of ownership are extremely compelling. In order to enjoy a competitive edge, a mobile operator must maintain up-to-the-minute services, competitive tariffs and, perhaps most crucially, subscriber interest. Service quality and differentiation are also crucial to success because they generate revenue and boost the reputation of the mobile brand.

The ability to provide a range of service packages is dependent upon the quality of the backhaul network. A 3G service that allows several video downloads per month will require more net-
Another benefit of ownership is that operators can perform more detailed analysis of network traffic. Another key benefit of ownership is that operators can perform more detailed analysis of network traffic. This makes it easier to identify patterns of usage and forecast shifts in bandwidth demand - which is more difficult on an outsourced network.

As HSDPA handsets appear on the market, operators will need to support increased data throughput. Owning the transmission network will allow mobile operators to respond quickly to demands for significantly more bandwidth and ease the overall burden that data-intensive services will place on the network. Ownership also strengthens the mobile operator's position with regards to fixed-mobile-convergence (FMC), which is becoming available across Europe. FMC links mobile and fixed-line services and will ultimately allow subscribers to access voice and data services regardless of their location, access technology or terminal type. If a mobile operator outsources its transmission network to a fixed-line operator, then it is less able to choose partners in the provision of FMC.

Managing convergence
Once an operator has decided to build their own transmission network, they must ensure it supports the technological demands of evolving 3G networks as well as existing 2G networks. This migration from 2G circuit-switched TDM networks to 3G packet-switched networks raises new challenges for the mobile operator. In particular, the cost, suitability and availability of platforms must be evaluated with regards to the expected increases in capacity and their ability to manage the complexities of converged voice and data.

There is a risk that mobile operators could end up with several different RAN architectures, each supporting a specific type of traffic. This can be avoided if operators implement core networks that can aggregate simultaneously 2G and 3G backhaul traffic. This architecture offers flexibility, scalability, efficiency, resiliency and economics that will help mobile operators meet their customers' rising expectations while converging the voice and data services of 2G and 3G.

By developing a converged network architecture that supports TDM and packet technologies, operators can move forward in their bid to offer the latest data-rich content services while controlling costs. There are significant benefits in building out backhaul transmission networks to increase service offerings. However, due to the complexity of convergence and the migration to packet infrastructure, mobile operators will need to carefully review their backhaul strategies before making strategic investments.

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SDR offers benefits and challenges to handset makers

By Guenter Weinberger of Sandbridge Technologies

It is becoming increasingly clear that the convergence of future wireless data services will not involve a single global network standard. Instead, convergence will be driven by flexible user devices that can access a continuously evolving patchwork of wireless networks, which are optimized for specific applications. These networks include various flavours of 2.5G, 3G and 3.5G; WiFi, WiMAX, 802.20 as well as audio and video broadcast networks. All of these technologies will combine to deliver a wide range of applications and features – and will ultimately create the “convergent lifestyle” of the future.

Network-agnostic terminals will play a crucial role in delivering converged services and although such devices have yet to appear, the reward for their development will be great. Convergent terminals will expand the business opportunities for mobile operators, applications developers, content providers and other related industry sectors. A truly convergent device must support virtually any mode of connectivity. It must also run a wide range of applications including voice and video communication and messaging, general Internet access, music, video and games. Terminal makers must also overcome the challenge of integrating new user interface technologies. These could include very sophisticated speech recognition and virtual screens that provide a big-screen viewing effect using advanced video eyewear.

Semiconductor innovation

Convergent terminals will also require significant innovation at the semiconductor device level. Hardware designs that employ software-defined radio (SDR) are getting a great deal of attention for very important reasons: because all features are implemented in software, SDR is a reusable platform that can take advantage of future developments in system-on-a-chip (SoC) architectures.

Any credible SDR technology must first meet the two key requirements for use in today’s handheld devices – low cost and low power. Only after meeting or exceeding industry benchmarks in these two categories will it be considered for future applications. Power consumption is a difficult parameter to quantify because it is a proprietary characteristic of an individual SDR implementation. Cost comparisons, however, can be done at a more generic level – and the flexibility enabled by SDR can also be quantified.

While industry incumbents like to describe their GPRS/W-CDMA modems as multimode systems, these are not the target market for early SDR technologies. Instead, there are two independent areas of multimode development that will pave the way for SDR. One is the ongoing addition of new, complex features to handheld devices; the other is the increasing diversity of network standards such as cellular, WiFi, WiMAX and broadcast. The pressure to keep pace with this accelerated evolution of features, systems and standards presents daunting challenges to handset manufacturers.

Figure 1 illustrates the benchmarking of the cost-effectiveness of SDR compared to a traditional hardware-based application-specific integrated circuit (ASIC). The plot shows the cost (in terms of chip area) as a function of the number of features supported by both traditional hardware ASICs and flexible ASICs such as Sandbridge’s SB3010 flexible baseband processor. The intersection of the two plots shows where the SDR device is on a par with a typical hardware ASIC. Beyond this point it is cheaper to implement additional features on the SDR platform than on the hardware ASIC. This intersection point is a key parameter describing the cost-competitiveness of a SDR device and it is a major advantage for cross-over to occur at the lowest possible cost. The maximum cost-benefit is realized by using a highly flexible architecture that allows for the complete reuse of resources for entirely different processing requirements.

Scalability is also an important issue surrounding SDR because the wireless world is moving rapidly towards higher bandwidth interfaces such as WiMAX and HSDPA and the implementation of multiple-input multiple-output (MIMO) antenna diversity schemes. Creating a multimode system based on these technologies will be challenging for any technology – but is essential to establish future-proof credibility.

Flexibility must also be a key feature of any SDR implementation. While total software flexibility is desirable, other approaches offer partial flexibility based on reconfigurable hardware architectures. In theory, very low power consumption is the primary benefit of a reconfigurable-architecture approach. This is because the data-path structures used are similar to those implemented in the hardware-based ASIC approach. This, however, has yet to be demonstrated in a real chip, and

Fig. 1. While software-defined radio is not really appropriate for GPRS/W-CDMA handsets, it will achieve significant cost savings in feature-rich terminals that support a wide range of wireless technologies.
questions remain about the reconfiguration speed and its potential impact on the actual reuse. And given the large bandwidth requirements of typical applications such as communications, multimedia, speech recognition and gaming, it may turn out that a hardware reconfigurable design carries too much overhead to cover all different applications in a hardware-like data flow.

Another benefit of SDR is the short lead time required to ready the platform for the next function. Complete software flexibility offers a great advantage because it requires only a function call and a few clock cycles to load the first lines of software from memory — effectively reconfiguring itself on-the-fly. By contrast, hardware-reconfigurable architectures must load the entire configuration file before any execution of new algorithms may start. Furthermore, more than one hardware block may be involved in implementing a new feature, adding to the lead time.

The software-development environment for designing complete implementations is an important facet of the SDR approach. Communication systems are usually designed using a top-down approach that employs the C programming language at an early stage in the development process. While C is an industry standard that is highly desirable for design-level programming, it does not enjoy widespread use in SDR development. The implementation of efficient and intuitive C programming environments is essential because the fundamental benefits of a flexible platform can only be realized if it can be programmed with relative ease — particularly by third-party developers.

Finally, the most challenging — and also most important — benchmark parameter for SDR is low power consumption, which must be met regardless of the other benefits that a particular SDR technology offers. Sandbridge Technologies has pioneered the development of SDR silicon that can achieve industry-benchmark power consumption levels for battery-powered devices. The US-based company’s SB3010 system-on-a-chip architecture is a homogeneous multi-processor system based on a proprietary eight-way multithreaded processor. It employs a single-instruction-set architecture to execute DSP, RISC and Java instructions in a highly parallel approach. The technology can also be reprogrammed on-the-fly using industry-standard ANSI-C.

SDR technologies hold great promises for enabling the development of convergent handheld devices. Whatever the technology of choice will be, the wireless industry is moving towards the creation of a new platform device that will bring a broad range of communication and entertainment features into the pockets of wireless subscribers. Advanced technologies such as SDR will enable more features to be delivered at lower cost and ultimately even the low-end phone market will benefit.
Dynamic optimization eliminates the wait between the clicks

By David Nowicki of Bytemobile

Delivering data services to any mobile device is fraught with challenges and cellular handsets present unique problems – and unique business opportunities. As well as delivering data services that are valuable or useful to the subscriber, successful operators must also offer readily available network capacity and a consistently high-quality user experience.

Dynamic data optimization serves both these requirements. Optimized data conserves bandwidth, which extends network capacity and helps to smooth out over time the need to expand network infrastructure. And if done correctly, dynamic data optimization increases data rates and reduces transmission latencies – both of which are important to a high-quality user experience.

Mobile data subscribers have long been frustrated by excessive waiting times between clicks as data are slowly rendered on the screen. While 3G and 3.5G technologies are reducing waiting times, there will still be much work to be done long after these technologies are widely deployed and high-end handsets become commonplace. The reason is that most data services are based on Internet protocols such as HTTP and TCP.

These protocols were not designed for mobile networks and are inherently inefficient. When used to deliver wireless services to mobile devices, delays are magnified with every click. While designers of handset user interfaces (UIs) are working hard to reduce the number of clicks required to get to useful content, little has been done to reduce the time delay between the clicks.

User frustration

Users are also frustrated by the actual utility of browsers and Web-based applications on handsets. Beyond small screens and inappropriate UIs, Web portals that are supposedly optimized for the mobile user fail to deliver any real benefit. The disadvantages of portal optimization often outweigh the benefits because too much utility must be sacrificed in the interests of performance. And if subscribers are forced to endure an unsuitable UI for too long, the quality of the user experience will plummet. This approach also forces many content providers to slim down their content so that it can be delivered over various wireless networks. As well as being expensive, this practice discourages the development of services with richer content.

One of the greatest challenges facing operators is that the demand for mobile-data services is not a simple linear function of quality. Recent studies in Germany suggest that demand increases dramatically when transmission latency declines and data rates increase to certain threshold levels. Greater demand can be a good thing, but problems can arise if it is not easy to predict when these major increases will occur. Sudden increases can severely stress network capacity, which can be very difficult to expand on short notice due to capital constraints. And radio spectrum is a finite and regulated resource, which puts an ultimate limit on the bandwidth available for mobile data services.

Full-featured dynamic data optimization is an important real-time core network tool that can help operators address latency and capacity challenges. It allows operators to make much more efficient use of existing network capacity, buying them more time to consider major decisions about adding infrastructure and bandwidth.

However, the greatest benefit of dynamic data optimization is that it creates a much better experience for mobile device users. Not only does it increase access speeds and reduce latency – essentially solving the frustration problem – but it also makes mobile browsers truly usable, opening the door to true Internet access. Such significant improvements encourage greater usage and boost revenues.

Bytemobile has developed dynamic data optimization products for wireless networks that employ a portfolio of state-of-the-art data-reduction and protocol-acceleration techniques. The techniques have already been deployed worldwide in the company’s Optimization Services Node (OSN) server, which optimizes data traffic for laptop access. The company has released the new OSN Monaco Edition software, designed specifically for a wide variety of mobile devices.

Less data, faster transfer

Monaco improves the speed of access on mobile handsets, reducing the amount of data transferred by two to five times and increasing the data transfer rate by up to ten times for portal browsing. OSN Monaco employs Bytemobile’s Macara Dynamic Interleaving (MDI) technology, which is available in both clientless and client formats. MDI allows OSN Monaco Edition to ensure the very fast downloading of site content in a range of formats including WML, XHTML, and HTML. In most cases, data rates can be increased without adding any additional software to the handset.

The Monaco software operates simultaneously in both clientless and client-server modes. The clientless mode does not require the deployment of software on handsets and can therefore be used in the rapid development of services using phone-based content on mass-market feature phones. Client-server operation offers opportunities for greater speed when using full HTML sites, but the Bytemobile Monaco Client must be deployed on the end-user device.

The success of handset-based data services is linked strongly to dynamic optimization solutions that provide truly usable access to rich web content – at speeds and in ways that users are accustomed to. As operators continue to roll out optimization-enhanced networks and provide a user experience on handsets similar to that on a laptop or PC, data usage and revenue growth will follow.

www.bytemobile.com

Bytemobile’s Optimization Client speeds access to mobile data services by optimizing the quantity of data transferred.
**Hybrid couplers support antenna sharing**

MECA has launched a family of high-power 3 dB hybrid couplers. Designed for use in combining two transmitters to share one antenna, the H705 couplers are available in three bands: 400–520 MHz, 800–1000 MHz and 1700–2200 MHz.

According to MECA, the couplers’ unique air-line construction achieves the lowest possible insertion loss while delivering high isolation values of 30 dB. The H705 series offer a typical voltage standing-wave ratio (VSWR) of 1.10:1 and a maximum phase balance of 3°. The couplers have a maximum power rating of 500 W and are supplied with an N-female connector.

[www.e-meca.com](http://www.e-meca.com)

**Direct-conversion modulator offers high linearity**

A new high-performance quadrature modulator from Linear Technology is optimized for use in 850–965 MHz GSM and cdma2000 base stations. The LT5568 accepts in-phase (I) and quadrature-phase (Q) baseband signals and modulates them directly to the RF transmission frequency.

The modulator has a zero-IF (intermediate frequency) transmitter architecture, which enables base-station designers to attain high performance while reducing the component count.

[www.linear.com](http://www.linear.com)

**FPGA core enables MIMO**

The ChannelCore64 allows designers to replace up to 16 specialist digital down converter (DDC) ASIC devices with a single proprietary core running on a field-programmable gate array (FPGA). Released by RF Engines, the core is said to allow designers to reduce both the size, cost and power requirements of their base stations.

The company also claims that their technology will increase the flexibility of base stations, leading ultimately to interoperability between different radio access technologies. The use of FPAGas will allow the dynamic reconfiguration of band- plans, which could allow base stations to be reprogrammed to operate according to new standards.

The core offers 64 independent down-conversion channels, which may be connected to either of two 16-bit analogue-to-digital converters (ADCs). The core could therefore support future technologies such as multiple-input multiple-output (MIMO) antenna diversity.

[www.rfel.com](http://www.rfel.com)

**Base station saves 70%**

Nokia claims that the use of its Flexi W-CDMA base station can lead to cost savings of up to 70% during the installation and operation phases. Described as a small, modular but high-capacity platform, the Flexi base station is said to allow operators to make more efficient use of their base station sites. As a result, the base station can be installed quickly with less site construction work than traditional equipment. The Flexi also has low power requirements and can be installed both indoors and out.

The platform supports distributed base-station architectures. It can form part of a multi-radio network because its modules can be fitted inside existing Nokia UltraSite EDGE base-station cabinets.

[www.nokia.com](http://www.nokia.com)

**RF synthesizer on two chips**

Texas Instruments has launched a high-performance radio frequency (RF) synthesizer that is designed to maintain signal integrity in wireless infrastructure applications. Described as highly integrated, the TRF3761 RF synthesizer is a two-chip solution that occupies 6 x 6 mm of board space, which is about one-third the footprint of comparable modules.

The TRF3761 eliminates the need for customized modules that integrate phase-locked loop (PLL) devices with voltage-controlled oscillators (VCOs), buffers and passive circuitry. Available for operation in the 400–2500 MHz frequency range, the component can be used in 2G, 2.5G and 3G base stations. At an output frequency of 1.9 GHz, the TRF3761 delivers –138 dBc/Hz phase noise when measured at a 600 kHz offset, and noise floor of –160 dBc/Hz when measured at a 10 MHz offset.

[www.ti.com](http://www.ti.com)

**Portfolio maximizes data throughput on 3G networks**

New from Horsebridge Network Systems, the Next Generation Sync portfolio of products promises to reduce dropped calls and packet-data losses in cellular networks.

Aimed at cellular operators and network-equipment manufacturers, the products are claimed to improve the quality of data transmission and resulting services across 3G networks. Next Generation Sync maximizes traffic throughput and provides operators with a reliable and robust network synchronization technology. According to Horsebridge, the system also increases the accuracy of call handover between 2G and 3G networks.

The Next Generation Sync product portfolio delivers synchronization across 3G and HSDPA mobile networks, WiMAX networks, cellular backhaul links and triple play services. It is available as a stand-alone system for mobile operators or as a card for network-equipment manufacturers.

[www.horsebridge.net](http://www.horsebridge.net)
Tri-band power amplifier eases handset design

Silicon Laboratories has expanded its family of CMOS power amplifiers to include a tri-band power amplifier (PA). The Si4300T is for use in GSM/GPRS handsets and is claimed to be the smallest, most highly integrated and most reliable PA available for this application.

Unlike PA modules, which comprise multiple chips and discrete components, the Si4300 family uses a single die on a small substrate.

Based on a patented amplifier architecture, the Si4300T performs all functions between the transceiver and the antenna switch module. This includes power control, thermal and load mismatch protection, harmonic filtering and input and output matching networks.

www.silabs.com

EDGElabs.com delivers video

Agere has launched its Vision X115 chipset for use in EDGE handsets. This is the first product to be based on Agere’s Vision mobile-handset architecture and OptiVerse software framework. Together these technologies are said to allow handset makers to develop smaller and cheaper GPRS/EDGE smart phones.

According to Agere, the chipset’s multi-processor supports various services without the need for extra applications processors or multimedia companion chips. Supported services include CD-quality sound, cinema-quality video and a 2 megapixel camera.

When implemented, the chipset can reduce the overall component count of a handset by more than 100, resulting in up to 20% savings in both bill-of-material (BOM) costs and board area.

The X115 comprises two chips: an analogue baseband and a digital baseband. The analogue baseband includes a complete power management solution that also handles the analogue baseband processing, audio mixing and conversion. The digital baseband features three processor cores: an ARM7TDMI-S for communications functions; an ARM926EJ-S for applications processing; and Agere’s DSP16000 core for physical layer and audio signal processing.

The X115 chipset is combined with Agere’s OptiVerse software, which includes reusable and standardized application programming interfaces (API) that provide access to underlying communication and application functions. According to Agere, the APIs simplify the development of customized multimedia applications such as audio and video.

www.agere.com

HSDPA coprocessor is on ASIC

InterDigital’s UMTS Release 5 HSDPA coprocessor is available for implementation on an application-specific integrated circuit (ASIC). The coprocessor is said to be optimized to support all HSDPA service categories up to category 10.

Fabricated using 130 nm technology and designed to be process-independent, the coprocessor complies with Release 5 of the UMTS specification. Other features include low power and MIPS requirements and the ability to support transmit and receive diversity. The coprocessor can be supplied as technology blocks for use in existing UMTS Release 99/Release 4 chips and is scalable to support HSUPA in Release 6.

www.interdigital.com

TI and DoCoMo sample chipset boosts video

Texas Instruments (TI) has produced sample quantities of the OMAPV2230 multimode UMTS chipset, which was developed in collaboration with the Japanese operator NTT DoCoMo. Aimed at the worldwide 3G handset market, the chipset includes a UMTS dual-mode digital baseband processor. It also integrates an advanced applications processor, which is based on TI’s high-performance OMAP 2 architecture.

TI claims the integration of advanced applications and modem functionality in the same device has resulted in a system that offers high performance at low power. The chipset supports worldwide operation on W-CDMA and GSM/GPRS/EDGE networks. It also includes TI’s Advanced Imaging, Video and Audio Accelerator (IVA 2), said to boost video performance in mobile phones by up to four times and imaging performance by up to 150%.

www.ti.com

Extensions support HSDPA and EV-DO future standards

The DO multicarrier multilink extensions (DMMX) and HSDPA multicarrier multilink extensions (HMMX) platforms have been announced by Qualcomm.

The extensions describe standards-based enhancements to cdma2000 EV-DO and W-CDMA HSDPA. According to Qualcomm, the techniques can be used to boost capacity and speed in ways that do not require changes to current or proposed standards. The extensions also support the development of chips and software to enable the concurrent operation of multiple radio links such as CDMA, TDM and OFDM.

Multicarrier multilink technology involves the simultaneous use of multiple wireless transmission protocols in multiple frequency bands.

www.qualcomm.com

Quad-band EDGE transceiver integrated on one chip

The Othello-E single-chip radio transceiver for EDGE handsets is new from Analog Devices (ADI). Based on ADI’s Othello direct-conversion radio architecture, the new transceiver is said to integrate virtually all the components necessary to create a complete quad-band EDGE radio design. These include voltage-controlled oscillators (VCOs), phase-locked loop filters and power management.

The transceiver operates in the 850, 900, 1800 and 1900 MHz frequency bands.

To achieve the increased linearity necessary for EDGE, the Othello-E employs a high-performance logarithmic RF power detector to enable a closed-loop polar modulation transmitter design. According to ADI, this is an improvement over open-loop polar designs that require the close matching of the transceiver and power amplifier.

www.analog.com
HSDPA delivers benefits for incremental cost

Operators are embracing HSDPA because it offers exceptional value for money, explains John Diehl, Director and General Manager of Freescale’s Platform Division.

Why should operators deploy HSDPA?
HSDPA increases the peak data rates by a factor of 10, but only increases the silicon area – which can be thought of as the ultimate cost – by less than 5%. A similar dynamic applies on the base-station side and when we talk to operators there is a universal refrain that they will deploy HSDPA because it is such a small incremental investment for a large increase in capability. HSDPA will follow wherever UMTS is deployed and we expect HSDPA to be deployed in Europe in 2006.

HSDPA will be used to support standard 3G applications, because even operators will admit that some of these services are lacking in terms of user experience. HSDPA should change this and will deliver a user experience that is similar to the wireline Internet. The need to support services such as music downloads is why we have incorporated the ARM 11 processor within our Mobile Extreme Convergence (MXC) architecture. This delivers quite a bit of processing horsepower.

How else is Freescale addressing HSDPA?
Our i.300 platform supports HSDPA in a form factor and level of integration that is similar to the most integrated 3G chipsets on the market today. The changes required to support HSDPA at the silicon level were made predominately in the digital baseband level. Sophisticated signal processing is required to handle the new modulation scheme. We also had to upgrade our protocol stack.

On the radio side, HSDPA uses the same RF chain and frequency band as UMTS. This allowed us to reuse much of the technology that we developed for UMTS. We were able to design our devices in such a fashion that we would not have to re-engineer when we went to HSDPA – which is one important reason why we can deliver HSDPA in our chipset. Freescale is one of a few in the world doing HSDPA, so it is a bit premature to say if others will be able to achieve this.

Does HSDPA boost power consumption?
HSDPA does require significantly more processing power as well as very sophisticated digital signal processing circuits that are dedicated to HSDPA demodulation. We have updated our process and some of our DSP core to reduce power consumption. This has been done in general to improve our overall UMTS performance. We have also increased the processing power that is available on demand to ensure that HSDPA can be delivered.

The other major architectural enhancement is our (MXC) platform, which moves all of the communications processing to a single DSP core. This is an innovative departure from previous architectures. Traditionally, the communications processing has been distributed across a DSP and a microprocessor core. All of the communications processing on the MXC platform – including the layer 2 and 3 protocols – are done on the DSP core. This frees up power on the microprocessor.

When will handsets be available?
I am confident that handsets will be available for the mass market in 2006. Our technology is incorporated in prototype HSDPA handsets that are being used today. There has been great interest in our HSDPA chips not only from our largest customer Motorola, but also from other handset makers. We are very optimistic that in 2006 we will see handsets incorporating Freescale HSDPA shipping in the market.

A commercial HSDPA launch will require a lot of coordination between the operator, technology suppliers (such as Freescale) as well as handset makers. All of these pieces must be in place – but this won’t happen until operators feel that they have a sufficient diversity of devices available for a commercial launch. What we can say for certain is that Freescale is at the forefront of HSDPA development and we are working to expedite the commercial launch of the technology.

Will conformance testing be a problem?
Conformance testing is always a challenge, but operators now understand that a significant part of the solution lies with the chipset suppliers. There is an increasing level of interaction between the chip companies and the operators and as a result we don’t expect HSDPA to have as many problems as UMTS. The entire supply chain is working together and has learned from previous experiences to ensure a smooth launch.

Interview by Hamish Johnston, editor of Wireless Europe.
Emerging Markets for GaN Electronics

Electronic devices based on gallium nitride promise to deliver unrivalled power and thermal performance for RF applications, but widespread adoption of the technology depends on whether manufacturers can produce high-performance devices at low cost.

This new Technology Tracking report, from the publishers of Compound Semiconductor, analyses the challenges facing GaN device makers as they seek to develop commercial products that can compete effectively with existing RF technologies.

The report includes critical information in each of the following areas.

- **Addressable markets**: the technology and commercial drivers at play in the market sectors being targeted by GaN manufacturers.
- **Material choices**: the different substrate technologies being exploited and their impact on cost and performance.
- **Key metrics**: state-of-the-art performance data for devices grown on different material systems.
- **Reliability**: the technology innovations that are needed to ensure long-term reliability of GaN devices.
- **Market evolution**: how continuing technical advances will impact on future market growth.
- **Organizations**: profiles of the leading developers of GaN electronics.

For more information, see [www.technology-tracking.com](http://www.technology-tracking.com)

**LAUNCH OFFER:**
Order *Emerging Markets for GaN Electronics* today and receive a **FREE** copy of the CS-MAX Technical Digest, valued at $150.*

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Thanks to TI 3G technology, you helped Susan conduct a meeting in her bathrobe.