The Internet is now firmly part of our everyday life. We perform many common tasks online, such as banking, grocery and gift shopping and purchasing travel or cinema tickets. Plus we get a growing portion of our entertainment from online sources: entertainment and social networking are two of the largest growth areas. We have seen the beginning of basic quality video from the likes of YouTube and the development of social networking sites such as MySpace or Facebook, which are enormously popular among younger generations of consumers. If we are to continue doing more online, our need for bandwidth will increase. And that bandwidth demand may become more symmetrical; in future we might expect to generate appreciable content ourselves, for upload onto the Internet, as well as continuing to download content. But that is not all; our need for Internet availability and quality will also increase.

The Way Forward
It might be very convenient if future Internet access were wireless. Given that it is likely that fixed and mobile Internet access will remain quite different areas, as indeed they are now, we have restricted our initial interest to fixed wireless Internet access, i.e. the local loop or ‘last mile’, which serves businesses and homes. We wish to consider whether there is a way forward to offering economic, ubiquitous broadband wireless access. We know that previous solutions for a wireless broadband last mile have had marginal business cases. Our time scale covers the next 10-20 years, in other words the long-term future.

The first specific question to answer is: ‘What is the future last mile broadband requirement? This really is a key question over the long-term scale of the quality and resolution of the source, at the highest quality and resolution, loss coding gain is available. Taking all such factors into account, 10-15Mbps of bandwidth is likely to be required, per channel, for HD services in 10-20 years’ time. In a home where there are three active users, this would amount to 30-45Mbps.

Peak Rate Congestion
At first sight it may appear that the present-day ADSL service is close to what is required by HD services. This could not be further from the truth. In fact, examining a typical ADSL service advertised at ‘up to’ 8Mbps results in two immediate problems. Firstly, the bandwidth of 8Mbps may only be available at up to two miles from the exchange. But only 20 per cent of customers are this close. At five miles from the exchange, the rate will have fallen, perhaps to only 2Mbps or even 128kbps. Secondly, the present day ADSL service is a contended service, which means that when more users try to access the service, each will get less bandwidth. BT Wholesale provides two contention levels: they are 20:1 and 50:1. Even a home user close to the exchange, who may access 8Mbps peak rate, may access only 144kbps when the system is working hard to support the maximum number of users. A recent survey by Oftel revealed that most home users...
The Internet is now firmly part of our everyday life. We perform many common tasks online, such as banking, grocery and gift shopping and purchasing travel or cinema tickets. Plus we get a growing portion of our entertainment from online sources: entertainment and social networking are two of the largest growth areas. We have seen the beginning of basic quality video from the likes of YouTube and the development of social networking sites such as MySpace or Facebook, which are enormously popular among younger generations of consumers. If we are to continue doing more online, our need for bandwidth will increase. And that bandwidth demand may become more-symmetric; in future we might expect to generate appreciable content ourselves, for upload onto the Internet, as well as continuing to download content. But that is not all; our need for Internet availability and quality will also increase.

The Internet is now firmly part of our everyday life. We perform many common tasks online, such as banking, grocery and gift shopping and purchasing travel or cinema tickets. Plus we get a growing portion of our entertainment from online sources: entertainment and social networking are two of the largest growth areas. We have seen the beginning of basic quality video from the likes of YouTube and the development of social networking sites such as MySpace or Facebook, which are enormously popular among younger generations of consumers. If we are to continue doing more online, our need for bandwidth will increase. And that bandwidth demand may become more-symmetric; in future we might expect to generate appreciable content ourselves, for upload onto the Internet, as well as continuing to download content. But that is not all; our need for Internet availability and quality will also increase.

The Internet is now firmly part of our everyday life. We perform many common tasks online, such as banking, grocery and gift shopping and purchasing travel or cinema tickets. Plus we get a growing portion of our entertainment from online sources: entertainment and social networking are two of the largest growth areas. We have seen the beginning of basic quality video from the likes of YouTube and the development of social networking sites such as MySpace or Facebook, which are enormously popular among younger generations of consumers. If we are to continue doing more online, our need for bandwidth will increase. And that bandwidth demand may become more-symmetric; in future we might expect to generate appreciable content ourselves, for upload onto the Internet, as well as continuing to download content. But that is not all; our need for Internet availability and quality will also increase.

The Internet is now firmly part of our everyday life. We perform many common tasks online, such as banking, grocery and gift shopping and purchasing travel or cinema tickets. Plus we get a growing portion of our entertainment from online sources: entertainment and social networking are two of the largest growth areas. We have seen the beginning of basic quality video from the likes of YouTube and the development of social networking sites such as MySpace or Facebook, which are enormously popular among younger generations of consumers. If we are to continue doing more online, our need for bandwidth will increase. And that bandwidth demand may become more-symmetric; in future we might expect to generate appreciable content ourselves, for upload onto the Internet, as well as continuing to download content. But that is not all; our need for Internet availability and quality will also increase.

The Internet is now firmly part of our everyday life. We perform many common tasks online, such as banking, grocery and gift shopping and purchasing travel or cinema tickets. Plus we get a growing portion of our entertainment from online sources: entertainment and social networking are two of the largest growth areas. We have seen the beginning of basic quality video from the likes of YouTube and the development of social networking sites such as MySpace or Facebook, which are enormously popular among younger generations of consumers. If we are to continue doing more online, our need for bandwidth will increase. And that bandwidth demand may become more-symmetric; in future we might expect to generate appreciable content ourselves, for upload onto the Internet, as well as continuing to download content. But that is not all; our need for Internet availability and quality will also increase.
Broadband 1.0

- FTTH + VDSL
- FTTC + ADSL2+
- FTTx + xDSL

Broadband 2.0

- Wireless
- 2.4GHz, higher power
- <1GHz, medium power
- PTP uW + xDSL
- satellite
- white space spectrum
- <3GHz: underused rural cellular spectrum
- underused military spectrum
- underused TV spectrum

Meeting Requirements

We returned to our original interest – can wireless address the needs of Broadband 2.0? It would have to do so at a competitive cost, which means preferring self-install, indoor systems and minimising base station numbers, perhaps by working at the lower frequencies of the UHF band.

But before evaluating specific wireless technology approaches, we sought benchmarks for broadband access technologies from other countries. It was quickly apparent that countries leading on bandwidth to the home are all using some form of fibre system. While Japan/Korea are doing this with government sponsorship, Verizon and AT&T in the US have recently begun fibre roll-outs on a purely commercial basis. This is a watershed development for fibre in the local loop. Interest in fibre is high in the EU too, but some operators have halted their roll-out plans due to the absence of an FCC-style forbearance on fibre unbundling within the EU.

Benchmarking against upcoming wireless standards showed these were biased towards small screen mobile content delivery, i.e. they are not attempting to address the challenge of Broadband 2.0 requirements for delivery of HD services to the home.

Our evaluation of wireless technology approaches began by looking generally at the capacity-coverage trade-off involved in all point to multipoint wireless systems. We also looked in detail at WiMax and 802.22 capacity planning. This provided a profound, if not entirely unanticipated result – the practical, economic capability of wireless, while adequate to provide today’s Broadband 1.0, is very clearly inadequate for the very much more demanding Broadband 2.0. The capacity shortfall is nearly two orders of magnitude. For example, to provide even only an SDTV-capable uncontended streaming capacity to all subscribers would need 50 more base station resources is needed to provide Broadband 1.0. This would either require 50 more spectrum allocation or 50 more base stations would need to be deployed. To provide HD services, this factor becomes 500.

The basis of the 50 and 500 factors is contained in the fact that most radio systems, like ADSL systems, are not designed to service the maximum number of users at maximum bit rates, simultaneously. To do so requires an increase of resources. Such an increase may come from either more spectrum for the same number of base stations, more base stations within the same spectrum, or any point in between. Wireless is a rule of thumb that HDTV requires 10x more bandwidth than SDTV and noted that 802.22 intrinsically has 50:1 contention built into its design. In fact the radio system capacity estimates are really based on physics rather than any specific system. We assumed an efficiency of 95% for HD. This figure of merit is quite good for an affordable radio, and while some radio standards may do better, they will not do 50x better, so our overall conclusion is valid independent of radio system.

Seeking Solutions

So why does the Internet work as well as it does present? Because we make quite small demands upon it, on average. We can use fast ADSL to our advantage when we download a huge file over a few minutes, as long as our neighbours are not doing the same thing at the same time. And this is the point, mostly our neighbours are not doing this at the same time. But the situation is so different for video. We might watch a TV programme for an hour, and fear that whole hour we will require a high bandwidth. On the whole, our neighbours will also want a high bandwidth for their TV at the same time as we are watching our TV. It is the long-term streaming nature of video which demands more of the Internet capacity than legacy applications, such as email, web browsing, file downloads etc. A video stream addresses the issue that the contention for resources occurs in the backbone, rather than the ADSL line itself.

Today’s bandwidth is limited. At present video over Internet solutions such as YouTube are kept well below standard video quality and picture size. Try to imagine YouTube picture quality shown on an HDTV display if you can.

So why does the Internet work as well as it does present? Because we make quite small demands upon it, on average. We can use fast ADSL to our advantage when we download a huge file over a few minutes, as long as our neighbours are not doing the same thing at the same time. And this is the point, mostly our neighbours are not doing this at the same time. But the situation is so different for video. We might watch a TV programme for an hour, and fear that whole hour we will require a high bandwidth. On the whole, our neighbours will also want a high bandwidth for their TV at the same time as we are watching our TV. It is the long-term streaming nature of video which demands more of the Internet capacity than legacy applications, such as email, web browsing, file downloads etc. A video stream addresses the issue that the contention for resources occurs in the backbone, rather than the ADSL line itself.

Today’s bandwidth is limited. At present video over Internet solutions such as YouTube are kept well below standard video quality and picture size. Try to imagine YouTube picture quality shown on an HDTV display if you can.

Most home users do not realise their Internet connection is shared.
MULTIPLE USERS

Homes of the future will set up bandwidth with each individual requiring his or her own ADSL channel

MEETING REQUIREMENTS

We returned to our original interest — can wireless address the needs of Broadband 2.0? It would have to do so at a comparable cost, which means requiring self-install, indoor systems and minimising base station ownership, perhaps by working at the lower frequencies of the UHF band.

But before evaluating specific wireless technology approaches, we sought benchmarks for broadband access technologies from other countries. It was quickly apparent that countries leading on bandwidth to the home are all using some form of fibre system. While Japan/Korea are doing this with government sponsorship, Verizon and AT&T in the US have recently begun fibre roll-outs on a purely commercial basis. This is a watershed development for fibre in the local loop. Interest in fibre is high in the EU too, but some operators have halted their roll-out plans due to the absence of an FCC-style scheme for ring-fencing the backhaul.

Benchmarking against upcoming wireless standards showed these were biased towards small screen mobile content delivery, i.e. they are not attempting to address the challenge of Broadband 2.0 requirements for delivery of HD services to the home.

Our evaluation of wireless technology approaches began by looking generally at the capacity/cost trade-off involved in all point to multipoint wireless systems. We also looked in detail at WiMax and 802.22 capacity planning.

This provided a profound, if not entirely unanticipated result — the practical, economic capability of wireless, while adequate to provide today’s Broadband 1.0, is very clearly inadequate for the very much more demanding Broadband 2.0. The capacity shortfall is nearly two orders of magnitude. For example, to provide even only an SDTV-capable uncontended streaming capacity to all subscribers would need 50+ more base station resources is needed to provide Broadband 1.0. This would either require 50+ more spectrum allocation or 50s more base stations would need to be deployed. To provide HD services, this factor becomes even greater.

The basis of the 50s and 500s factors is contained in the fact that most radio systems, like ADSL systems, are not designed to service the maximum number of users at maximum bit rate, simultaneously. To do so requires an increase of resources. Such an increase may come from either more spectrum for the same number of base stations, more base stations within the same spectrum, or any point in between. We found a rule of thumb that HDTV requires 10x more bandwidth than SDTV and noted that 802.22 intrinsically has 50:1 contention built into its design. In fact the radio system capacity estimates are really based on physics rather than any specific system. We assumed an efficiency of 85% - 90%. This figure of merit is quite good for an affordable radio, and while some radio standards may do better, they will do not 50x better; so our overall conclusion is valid independent of radio system.

SEEKING SOLUTIONS

But before evaluating specific wireless standard approaches, we sought benchmarks for broadband access technologies from other countries. It was quickly apparent that countries leading on bandwidth to the home are all using some form of fibre system. While Japan/Korea are doing this with government sponsorship, Verizon and AT&T in the US have recently begun fibre roll-outs on a purely commercial basis. This is a watershed development for fibre in the local loop. Interest in fibre is high in the EU too, but some operators have halted their roll-out plans due to the absence of an FCC-style scheme for ring-fencing the backhaul.

Benchmarking against upcoming wireless standards showed these were biased towards small screen mobile content delivery, i.e. they are not attempting to address the challenge of Broadband 2.0 requirements for delivery of HD services to the home.

Our evaluation of wireless technology approaches began by looking generally at the capacity/cost trade-off involved in all point to multipoint wireless systems. We also looked in detail at WiMax and 802.22 capacity planning.

This provided a profound, if not entirely unanticipated result — the practical, economic capability of wireless, while adequate to provide today’s Broadband 1.0, is very clearly inadequate for the very much more demanding Broadband 2.0. The capacity shortfall is nearly two orders of magnitude. For example, to provide even only an SDTV-capable uncontended streaming capacity to all subscribers would need 50+ more base station resources is needed to provide Broadband 1.0. This would either require 50+ more spectrum allocation or 50+ more base stations would need to be deployed. To provide HD services, this factor becomes even greater.

The basis of the 50s and 500s factors is contained in the fact that most radio systems, like ADSL systems, are not designed to service the maximum number of users at maximum bit rate, simultaneously. To do so requires an increase of resources. Such an increase may come from either more spectrum for the same number of base stations, more base stations within the same spectrum, or any point in between. We found a rule of thumb that HDTV requires 10x more bandwidth than SDTV and noted that 802.22 intrinsically has 50:1 contention built into its design. In fact the radio system capacity estimates are really based on physics rather than any specific system. We assumed an efficiency of 85% - 90%. This figure of merit is quite good for an affordable radio, and while some radio standards may do better, they will do not 50x better; so our overall conclusion is valid independent of radio system.

whole solution for the local loop, but it will help get us to Broadband 2.0 from where we are today.

Steve Methley is a consultant in Cambridge UK. Email: sgm2@plextek.com  The author gratefully acknowledges the funding of this work by Ofcom, from whom a complete report is available. However, the views expressed here do not necessarily represent those of Ofcom. The material in this article is drawn from a report commissioned by Ofcom which was performed by a consortium consisting of Steve Methley of Plextech, Peter Harewood of Spectrum Trading Association, Saleem Bhatti of the University of St Andrews and Frank Rowell of LCC. The full report can be accessed at www.ofcom.org.uk/research/technology/overview/ese/lastmile.