BSG
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The broadband requirements of small businesses in the UK

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About the author

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Disclaimer

BSG Foreword

This report focuses on the connectivity requirements of small businesses in the UK today and in ten years' time. It is crucial to understand that they are not a homogenous group. The small business could be a dry stone wall builder in West Wales or a 40 employee games developer in New castle. The bandwidth requirements of small businesses are as diverse as the businesses themselves. Providing nearly half of all private sector employment and a third of private sector turnover[1], small businesses are crucial to the UK's economic growth and well-being.

For the past three years, a key theme of the BSG's work programme has been to inform and raise the profile of demand side issues in the broadband policy debate. Our work has seen us quantify the bandwidth requirements of households and qualitatively examine the demands placed on mobile and public WiFi networks. Last year, we focused on the demands of small businesses with *Capitalising on Connectivity* and our *Micro-Business Broadband Usage Survey* serving to both highlight this issue and build the evidence base that has allowed us to commission Communications Chambers to undertake this report.

We chose to focus on small businesses as we know that they were a poorly understood segment of the market by both industry and policy makers. We know that small businesses are generally slow adopters of digital technology either through a lack of awareness of, or their attitude to, the services available to them or having insufficient in-house digital skills to take advantage of technology[2]. This is despite evidence highlighting that if they made full use of technology it would lead to boosts in productivity and unlock up to £18.8 billion[3] in incremental growth.

Model

This report replicates the bottom up quantitative forecasting of our earlier domestic work onto small business premises. This starts by making assumptions about the applications used by employees and visitors. Bandwidth requirements for these applications are based on real world evidence wherever possible and then projected out to 2025.

[1] Department of Business, Innovation and Skills, *Statistical Release*, November 2014
[2] Lloyds Bank, *UK Business Digital Index 2015*
[3] Booz & Co, *This Is for Everyone: The Case for Universal Digitisation* November 2012

Employees are then defined by job type into four broad categories of low, medium, high and high+media users. Communications Chambers have then determined the mix of these employee categories for different industry sectors. The model treats 50 such sectors, and within each sector a range of different premise sizes, from 1 to 49 employees.

This leads to 2450 premise types; each with their individual usage profile. Three sample profiles are a 1 person food manufacturer, a 20 employee construction company and a 49 person computer software business. These three usage profiles are, understandably, quite different. It is important to remember that premise in the context of this report could equally mean branch or office – that is, a number of business premises could be located within a single location, significantly increasing the demand for bandwidth to that building or location.

In determining the bandwidth requirement for a premise we take a 'four minutes excluded monthly' approach, meaning that the headline figure is what is required to deal with the fifth busiest minute in the month. The 2025 downstream results for the 1 person food manufacturer, 20 employee construction company and 49 person software businesses are 6, 84 and 193 Mbps respectively.

As with any model, we have made a number of assumptions that are open to interrogation. All assumptions are published in the report, together with sensitivities to show the impact of varying them. The model itself has been published alongside this report.

Results

The model shows that the median downstream demand for small business premises rises from 5 Mbps in 2015 to 8.1 Mbps in 2025. Whilst this may appear low, it is important to remember that over 90% of the firms have between 0-4 employees, putting the 5 Mbps estimate in line with industry rules of thumb of under 1 Mbps per employee. At the upper end, 95th percentile demand rises from 12.9 Mbps to 41.1 Mbps.

The report also considers bandwidth demand weighted by employees rather than premises. Although 20% of small business premises will have a demand of at least 32 Mbps by 2025, 38% of employees work in such premises, since it is generally larger premises which have greater demand. However whilst the number of employees on a premise is an important factor, there is still a wide degree of variance of demands. For instance the top 1% of 49

employee premises requires 189 Mbps or more whilst the bottom 1% needs 32 Mbps or less.

Which industrial sector a company is in is also an important factor in driving bandwidth demands. For instance, the average business premise in the postal and couriers sector will need around 11 Mbps in 2025, whilst the average premise in the food and beverage industry will require 57 Mbps. Interestingly, the majority of this latter demand is driven by customer use of WiFi rather than employees using the connection themselves.

Upload, which we know is increasingly important for businesses, was also modelled. The report estimates that the median upstream demand is 1.3 Mbps today and will grow to 2.7 Mbps. This contrasts with a 95th percentile upstream demand of 7.2 Mbps in 2015, growing to 36 Mbps by 2025. Again, this varies substantially depending on the number of employees on each premise and the industrial sector that the company operates in.

The sensitivities to the model are clearly presented and the report outlines the impact of changes to these sensitivities. Combining the downstream 'high case' sensitivities increases 95th percentile demand in 2025 to 74Mbps and 13% of employees working in premises that require over 100 Mbps. On the upstream, the sensitivity with the greatest impact is increasing or decreasing the file transfer volume. Increasing it led to nearly 20% of business premises requiring over 70Mbps by 2025.

The report matches small business premise demand against the broadband technologies currently available. We see that some small businesses are already capacity constrained if they only have access to ADSL or 'standard broadband' with upload much more of a constraint than download. By 2025, we see that about 20% small businesses premises, the vast majority of whose needs are currently being met by available next generation FTTC / DOCSIS3.0 technologies, could, if they remained limited to today's speeds, be constrained by them. The portion of employees constrained in some way would be larger.

Fortunately, by 2025, in addition to the continued development of FTTC and DOCSIS3.0, we also expect to see G.fast and DOCSIS 3.1 technologies deployed in much of the country and this would likely meet the demands of all small business premises. Fibre to the premise would clearly provide ample bandwidth, today and into the future, for small businesses.

Next steps

We therefore make the following recommendations:

- Government and industry to work together to **ensure that virtually all small business premises have availability to superfast connections** as quickly as possible. On top of commercial deployments, Government should consider how best to ensure that suitable levels of connectivity are available for businesses in areas currently without access to superfast connectivity, given the productivity gap that would develop between businesses there and in the rest of the country, as well as continuing to develop successful initiatives such as the SME Connection Voucher Scheme. The harder to reach these premises are, the greater the need to bear in mind technological neutrality when looking at solutions.
- Government and industry should continue to work closely together to lower the costs of infrastructure deployment to **facilitate the commercial rollout of technologies capable of ultrafast speeds to as much of the country as possible**.

If Government wished to intervene to drive ultrafast deployment beyond the commercial footprint – i.e. through some sort of intervention – then it and industry will need to address some of the questions that have been thrown up by the report. Do increases in bandwidth always have a productivity benefit for a business, or only if its current bandwidth is insufficient? Following this, should the policy objective for the UK to enable any business, in any sector and of any size, to be located anywhere? If so then who should bear the burden of providing this connectivity – should it be in a pure on-demand case with the cost falling onto the business or should the Government set a threshold that meets the demand of even the most intensive premise?

Furthermore, what does anywhere or universal mean in practice? Should universal then be to every premise or village or should it be to a reasonably local 'island' of higher bandwidth – such as a business park? This could be significant in light of the discussions on whether it would be appropriate to establish a Universal Service Obligation for broadband and at what level that should be set. If it were the latter then it would certainly be cheaper in terms of network deployment and depending on the productivity boosts of higher bandwidth, may be more cost effective in the long run.

In order to help answer these questions and ensure that policy and commercial decisions are made with the best possible evidence:

- Government should **gather and publish evidence from companies who have used the SME Connection Voucher Scheme** in order to further improve that scheme and determine the economic and productivity gains those firms have witnessed.

For many employees, the next 10 years will undoubtedly see work become more of a function than a destination. This will see them become increasingly mobile and therefore dependant on mobile broadband connections. Whilst we wished to examine this, the quantitative data was not available to incorporate this dynamic.

It is important to remember that this model is a study of technical requirements; small businesses may demand and expect to be supplied with more. Conversely they may prioritise a highly reliable connection which is bandwidth constrained to a degree depending on a willingness to pay. What we do already know is that businesses connectivity requirements are becoming increasingly complex and will therefore require holistic communication solutions with improved customer support to go alongside higher levels of quality of service and reliability[4].

This report brings new insights to this policy area and the BSG looks forward to continuing this debate.

[4] Analysys Mason, *Understanding the demand for communication services by SMEs*, April 2015

Contents

1. Executive Summary

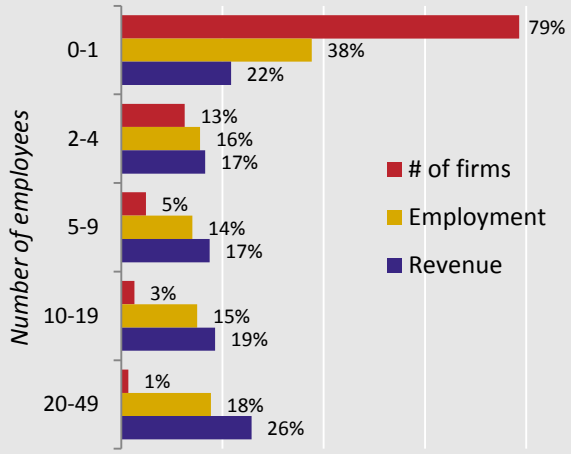
This paper considers the broadband needs of small (less than 50) employee businesses in the United Kingdom. In particular we provide a forecast of their fixed bandwidth requirements.

UK small businesses provide 48% of private sector employment, and there is wide agreement on their importance to the economy. As with all organisations, broadband is a critical input for many small businesses, and thus ensuring adequate provision for them is an imperative. To forecast their needs, we build on an analysis of the 'landscape' of small businesses, and the developing evidence of how they use the internet.

Small business landscape

Most small businesses are very small. Almost 80% have 0-1 employees (in addition to the proprietors). Over 90% have four or fewer employees – comparable in size to typical households. Such firms represent 54% of small business employment.

Figure 1: Splits of small businesses by size[5]



Clearly firm size (or more precisely, premise size) is an important driver of bandwidth requirements – all else being equal, more employees means a heavier requirement. Also important is industry sector. A farm may have very different per-employee bandwidth needs to a photography business.

The leading sectors amongst small businesses are specialised construction (plumbers, painters and so on), retail and food & beverage. However, these groups represent only a quarter of small business employment, and there is enormous diversity.

Broadband services used

Amongst sole traders 67% use fixed broadband, rising to 94% of 20-49 person businesses.

Half of the single employee businesses without fixed report that then use mobile broadband instead.[6] Overall 65% of small businesses make use of smartphones, and half of all users rate mobile as 'absolutely vital'.[7]

[5] BIS, *Business population estimates 2014*, 26 November 2014
[6] Ofcom, *SME experience of communication services tables*, November 2014
[7] Ofcom, *SME experience of communication services tables*, November 2014

Amongst micro-businesses (1-9 employees) the median report fixed broadband speed was 12 Mbps (although over 60% stated that they did not know their speed.[8] This relatively low figure is likely a result of both choice and availability – superfast broadband is available to only 51% of small and 58% of micro-businesses, compared to 75% of residences.[9] That said, only one-fifth of small businesses report that they are unhappy with their broadband speed.[10] Further, while superfast is somewhat limited in its availability, other business products such as leased lines are more widely available, albeit at a price premium.

As for consumers, issues of speed (and reliability) are more acute in rural areas, and have constrained local businesses. The Superfast Cornwall/BT trial provided greatly improved speeds to small businesses which has previously been struggling with less than 2 Mbps, and the effect for these companies was transformative.

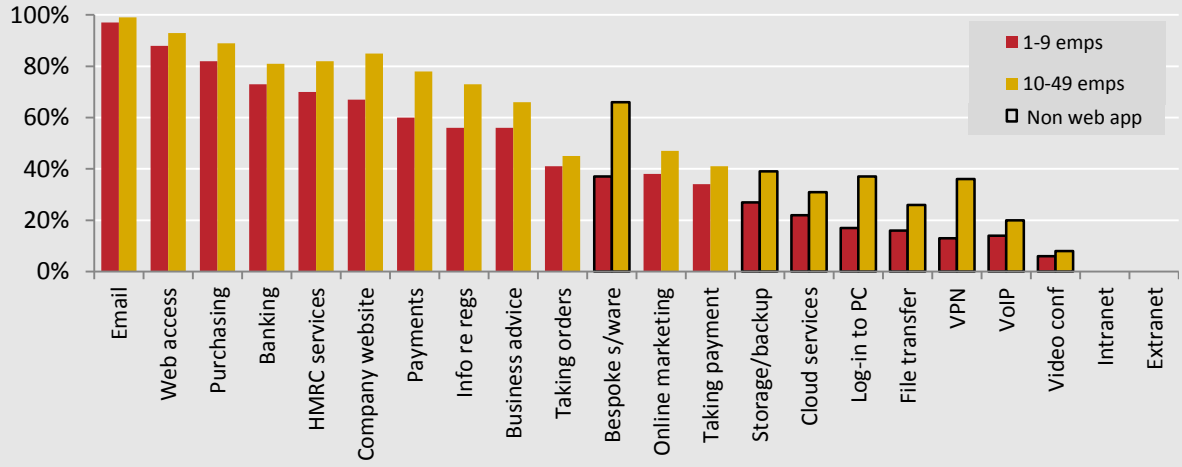
Intensity of business usage

While broadband is clearly critical for many companies, per capita bandwidth and traffic requirements appear to be lower than in the home. (A vital application such as email or online payments need not involve heavy traffic). Based both on Cisco traffic mix figures and on analysis of traffic patterns by time of day, we estimate the traffic intensity of a person at home is 2-3x that of a person at work.

Applications used

This is partly because many of the applications used by small businesses require low bandwidth (many are forms of web use).

Figure 2: Small business application use (Ofcom)[11]

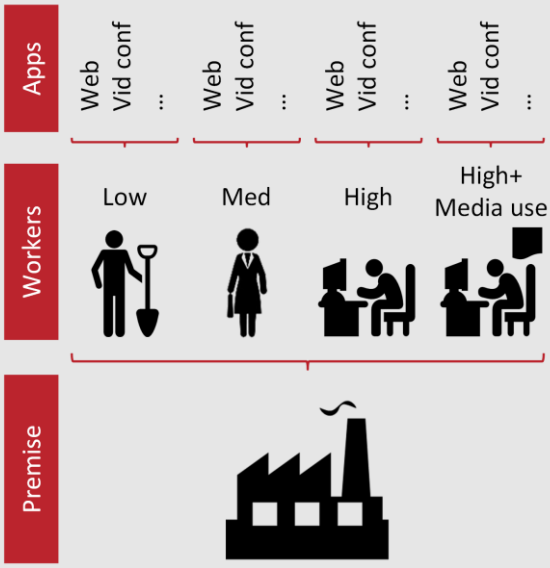


[8] ComRes (for BSG), *Broadband Usage among Micro Businesses*, November 2014
[9] Ofcom, *Infrastructure Report 2014*, 8 December 2014
[10] Ofcom, *SME experience of communication services tables*, November 2014
[11] Ofcom, *SME experience of communication services - a research report*, November 2014

Model structure

In order to forecast the future bandwidth requirements of small businesses, we take a bottom up approach. We start with assumptions about the applications used by employees. We then combine these to build profiles of usage for individual employee types. Finally these employee profiles are then in turn combined to build profiles of premise usage.

Figure 3: Modelling approach



The model treats seven different employee application types explicitly. These are web usage, file transfer, email, cloud storage, video calling, streamed video and BitTorrent. (Not all of these will always have a business purpose, but they are nonetheless part of workplace usage). For each, we base our assumptions on volume of use and bandwidth requirements on real world evidence wherever practical. We project both bandwidth and usage out to 2025 for each application.

We also include non-employee traffic. We add guest wifi for hotels, food & beverage and residential care businesses. We also allocate bandwidth for Internet of Things traffic for all premises.

We vary employee usage volumes by job type. A graphic designer, a tax expert and a shelf filler will have very different patterns of consumption, with the latter perhaps making little or no use of the internet at work. (Overall only 54% of employees have workplace web access).[12] The model allocates 369 'standard occupation codes' such as the three above into the four employee categories: – low, medium and high users, and 'high+media' users (those making use of particularly large files).

Based on tables of occupation mix for different industry types, this in turn allows us to determine the mix of L/M/H/H+M employees for different industries. The 'Computer programming and related' sector has a large number of media-using employees, the 'Manufacture of food products' sector almost none, for example.

The model treats 50 different sectors, and within each a range of premise sizes, from 1 to 49 employees. In aggregate this means the

[12] EC, *Digital Agenda Scoreboard* (accessed 26 April 2015)

model provides forecasts for 2450 different premise types, allowing a rich picture of the diversity of small business demand.

In combining usage of applications and employees to build to premise usage, we take a probabilistic approach. If, for example, employee A is streaming video for 10% of the busy hours, and employee B is doing so for 20%, then their overlapped usage is taken to be 2% of the busy hours (during which period a double bandwidth allocation will be required). We focus on the busy hours since this is when peak demands are likely to occur.

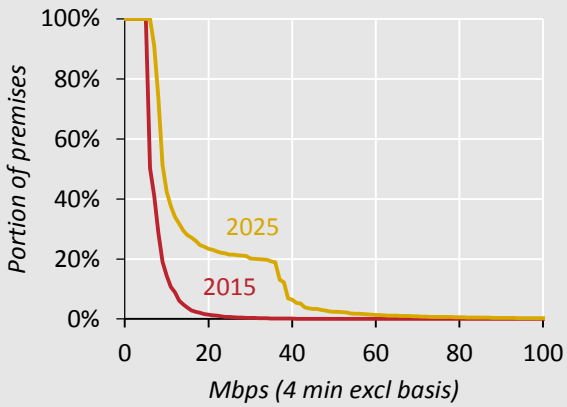
In determining demand for a particular premise, we take a '4 minute excluded' approach. That is to say, we determine which level of bandwidth would be sufficient to meet all but the busiest four minutes per month for a premise (or one per week). This is a practical approach, recognising that infrastructure is almost never built to handle extreme peaks of demand, and that a minute per week of congestion is unlikely to have a material impact on a firm's productivity.

Model results

Figure 4 shows our results. The median demand for small business premises is moderate, rising from 5.0 Mbps in 2015 to 8.2 Mbps in 2025. At the upper end, 95th percentile demand rises from 13.0 to 41.1 Mbps.

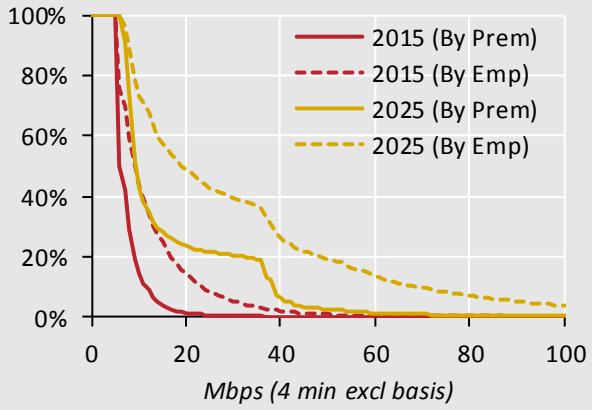
These figures are in part a result of the fact that 80% of small business premises have just one or two employees, and approximately half of small business employees are low users, with limited professional reason to be online at work.

Figure 4: Downstream bandwidth demand distribution



However, considering the mix of premises only risks underemphasising the importance of the higher usage premises – these are likely to be the premises with the most employees. Figure 5 adds the mix of requirements based on employee numbers, rather than premise numbers. Thus while in 2025 approximately 20% of small businesses *premises* have a demand of 31 Mbps or more, 39% of *employees* work in such premises.

Figure 5: Downstream bandwidth demand, premises and employees



On a per-employee basis, the model predicts requirements of 1 Mbps today (for larger firms), rising to 2.5-3 Mbps by 2025. The 2015 figure is somewhat higher than a range of enterprise network 'rules of thumb' for per-employee bandwidth we identified.[13] These were generally well below 1 Mbps, even though they focused on knowledge workers.

The 2025 figure of 2.5-3 Mbps is sufficient for each employee to be simultaneously watching their own HD video stream,[14] with 1 Mbps per employee left over for other for other activities.

Conclusion

Our modelling suggests that today ADSL is sufficient for the downstream needs of the great majority of small businesses. However, its upstream capabilities may be insufficient for the 'unconstrained' demand of many (with consequences ranging from a degradation of video streaming quality to, in some cases, failure of business critical applications). By 2025, ADSL will be insufficient for a third of businesses' downstream needs, and virtually all their upstream needs.

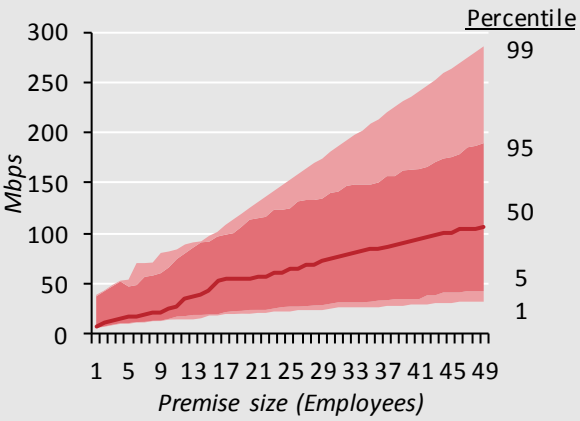
Current superfast products such as FTTC and DOCSIS 3.0 meet the needs of virtually all businesses today, and will continue to be sufficient for the great majority until 2025. FTTP and next generation technologies such as G.fast and DOCSIS 3.1 will be ample for all small businesses, even in 2025.

[13] See page 15
[14] Allowing for the benefits of ongoing improvements to video compression

Beyond these headlines, the model suggests small businesses have highly diverse bandwidth needs (Figure 6). Even for a particular premise size, there is enormous variation, driven by industry type.

This suggests caution with any 'one size fits all' approach to small business broadband policy. Some small firms may find standard residential products more than adequate. Others will need much more, both in terms of bandwidth and service levels.

Figure 6: Range of 2025 downstream bandwidth demand by premise size



Caveats

As with any model, ours depends on a range of assumptions, all of which are (legitimately) open to debate. However, we feel the analysis of small business needs will be better founded if it based on:

- An understanding of the size mix of small businesses
- Reference to job and industry types, and their divergent bandwidth needs
- Recognition of the lower per-person bandwidth requirements of business use compared to residential

2. Introduction

The importance of small businesses (those with fewer than 50 employees) is widely recognized. The new government's manifesto referred to them as 'the lifeblood of our economy".[15] Small businesses provide 39% of UK employment and 32% of UK turnover.[16] These businesses are heavily skewed to the private sector, and thus provide 48% of UK private sector employment.

There is increasing focus on broadband (fixed and mobile) as a vital enabling technology for small businesses. The Federation of Small Businesses (FSB) has referred to broadband as 'the fourth utility', and called for ambitious targets for broadband provision.[17] The government's manifesto highlighted the existing Broadband Connection Voucher scheme,[18] which provides grants of up to £3,000 to SMEs to acquire faster broadband. It also promised to do more to improve availability and speeds of fixed and mobile broadband.

However, while the needs of residential users of broadband have been subject to detailed discussion and analysis, there has been relatively less knowledge of small business needs. The last two years have seen some important quantitative and qualitative research in the UK, from Ofcom,[19] the FSB,[20] BT TSO/Plymouth University[21] and the BSG itself[22] seeking to fill this gap.

This paper builds on this evidence base, and seeks to provide a holistic and quantified picture of small businesses broadband needs. In particular it provides forecasts of fixed bandwidth requirements of different types of small businesses – to our knowledge these are the first such forecasts to be published globally.

[15] Conservative Party, *Our Small Business Manifesto*, 27 April 2015
[16] BIS, *Business population estimates 2014*, 26 November 2014
[17] FSB, *The fourth utility: Delivering universal broadband connectivity for small businesses across the UK*, July 2014
[18] DCMS, *Connection Vouchers* (accessed 22 May 2015)
[19] Ofcom, *SME experience of communication services - a research report*, November 2014; Jigsaw [for Ofcom], *SME Experience of communications services*, 18 June 2015; Analysys Mason [for Ofcom], *Understanding the demand for communications services by SMEs*, 27 April 2015
[20] FSB, ibid
[21] Dr Hazel Lacohée & Prof Andy Phippen, *SME Benefits and Business Opportunities with Superfast Broadband: the Virtuous Circle of Connectivity*, 15 September 2013
[22] BSG, *Capitalising on Connectivity*, March 2014; Comres for BSG, *Broadband usage among micro businesses*, 17 November 2014

Understanding the range of broadband requirements of small businesses is important for a number of policy questions. For example:

- What should be an appropriate minimum speed for policy makers to pursue for small businesses?
- Are higher speeds widely required and are best provisioned broadly, or might point solutions (providing 'oases' of very high speeds, or targeted demand-side subsidies) be more appropriate?
- Can we identify which types of business are most likely to need higher speeds, to target our interventions?

This paper seeks to provide the analysis to answer such questions.

We first set out the characteristics of UK small businesses, looking at firm size and sector. We then look at the broadband services they currently use, the limited evidence on business bandwidth requirements, and the range of applications which are most important to them. We then turn to our forecasts of bandwidth requirements, setting out our evidence, methodology and results.

While we consider the needs of small businesses broadly, the bulk of our work is on fixed broadband speed requirements. This needs two important qualifications.

Firstly, mobile services (voice and data) are clearly vital for many small businesses and in some cases will be more important than fixed services. For example the largest sector within small businesses is 'specialised construction' – for these plumbers, electricians and so on, mobile connectivity on site may well be indispensable. This paper's focus on fixed is not intended to downplay the importance of mobile. In part it is a result of the lack of data and evidence on small businesses' use of mobile – this is a potential area for future investigation.

Our second qualification it that in focusing on bandwidth, we do not mean to minimise the other characteristics of broadband, such as reliability. Of small businesses online, 94% report that a reliable connection is critical to the success of their business,[23] but this is an area where a significant minority of small businesses – particularly in rural areas – remain dissatisfied.[24] Analysys Mason, in a study of a number of SMEs for Ofcom, found that "most of [them] attach great

[23] FSB, *The fourth utility: Delivering universal broadband connectivity for small businesses across the UK*, July 2014
[24] FSB, *Response to Ofcom's call for inputs relating to Communications Services and SMEs*, December 2014

importance to resilience, which is, in some cases, as important as [their] growing bandwidth needs."[25]

This report builds on our previous work for the BSG forecasting residential bandwidth demand, [26] and similar work for the Australian government.[27] While some disagreed with the results of these studies, there was not substantial criticism of our methodology, and consequently we reuse that methodology for this forecast with increased confidence.

That said, we repeat the caveat we offered to our initial residential forecast. This forecast is certainly open to debate and alternate assumptions. We have sought to provide the sources for our underlying assumptions, or where they were simply a matter of judgement to explain our rationale. We do not intend the outputs to be 'the truth', but rather simply a credible middle case. Indeed, the value of models is more often in the rigorous analysis of a problem that they require, rather than in the results themselves, and we have therefore also set out our methodology. This too is of course open to debate.

We would welcome any comments you may have, either on assumptions or approach.

A note on terminology: we use 'conservative' to mean 'unlikely to lead to too low a bandwidth forecast' - that is, an assumption is conservative if it leads to higher bandwidth than the alternative.

We thank the Broadband Stakeholder Group for commissioning this piece of work, and thank its members and other groups such as Ofcom, DCMS and the FSB who provided valuable data or commentary. However, the conclusions of this report are Communications Chambers' own, and do not necessarily represent the views of any of these organisations.

[25] Analysys Mason [for Ofcom], *Understanding the demand for communications services by SMEs*, 27 April 2015
[26] BSG, *BSG publishes new model for analysing domestic demand for bandwidth*, 5 November 2013
[27] Communications Chambers (for the Vertigan panel), *Domestic bandwidth requirements in Australia A forecast for the period 2013-2023*, 26 May 2014

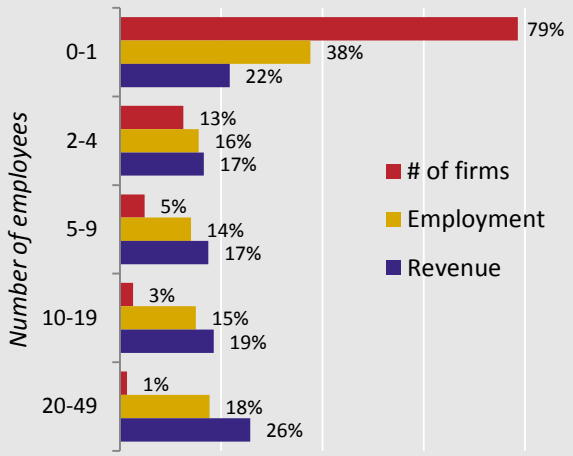
3. Small business 'landscape'

In this section we consider the small business 'landscape' – the mix of small businesses by size, industry and so on – and how, at a high level, it relates to bandwidth needs. As will be evident, small businesses are extremely heterogeneous, covering everything from the sole-trader painter to the 49 person biotech firm. Appreciation of this diversity is fundamental to an understanding of the broadband needs of small businesses.

Firm size

Most small businesses are *very* small. As Figure 7 shows, almost four out of five small businesses have 0 or 1 employees. Note that 'employee' excludes owner-proprietors. Including such individuals, the average number of people working in each '0 or 1 employee' firm is 1.1. This suggests that approximately 90% of these businesses, or over 70% of all small businesses, are sole traders.

Figure 7: Splits of small businesses by size[28]



Of course, these very small firms represent a much lower percentage of employment, at 38%. Firms with 2-4 employees represent a further 16% for a total of 54%. Put another way, over half of those working in small businesses are in a group of employees comparable to the number of residents in typical households.

Premises

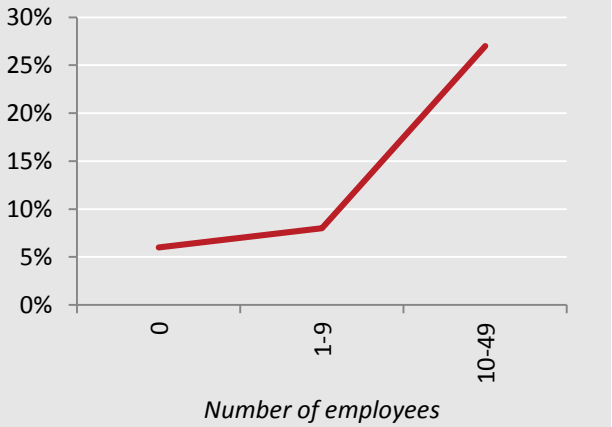
In understanding bandwidth requirements, the ideal focus is premises rather than firms, since this is how bandwidth is bought. A firm with 40 employees and three premises needs to know how much bandwidth to acquire at each site, rather than its aggregate requirement.

[28] BIS, *Business population estimates 2014*, 26 November 2014

In practice, the great majority of small businesses operate from only a single site (Figure 8). Overall, just over 7% of small businesses have multiple premises, and even amongst firms with 10-49 employees, only 27% operate from more than one premise.

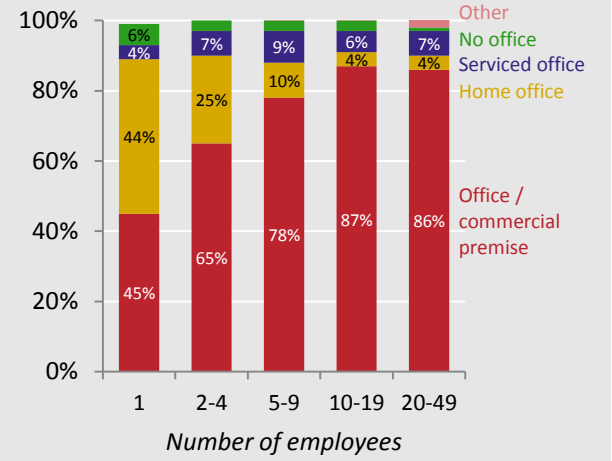
'Premise' here includes home, if that is used for business purposes. For 70% of businesses without employees, and for 37% of those with 1-9 employees, home is the main work premise. Beyond 10 employees, less than 10% of businesses operate from home.

Figure 8: Portion of multi-premised firms[29]



Ofcom's recent survey of small businesses provides further evidence on the type of premises small businesses operate from. This data again highlights the importance of home offices for smaller businesses. Note though that the distinction between a home office and a separate location is not particularly important for the purposes of understanding the level of *business* bandwidth needs – types and intensity of usage are likely to be the same in either case. That said, for a home business user, his or her bandwidth requirement may be additive to the residential bandwidth requirements of other family members online at the same time.[31]

Figure 9: Main executive working location[30]



Approximately 7% of small businesses operate out of serviced offices, and thus may share their connection with several other businesses. In some cases the serviced office provider may cap the bandwidth available to each tenant.

The Ofcom survey also shows that 6% of sole traders have no office at all, presumably because they are entirely mobile.

Industry sector

Figure 10 shows the mix of small business employment by industry sector. This is highly diverse, with the largest single sector

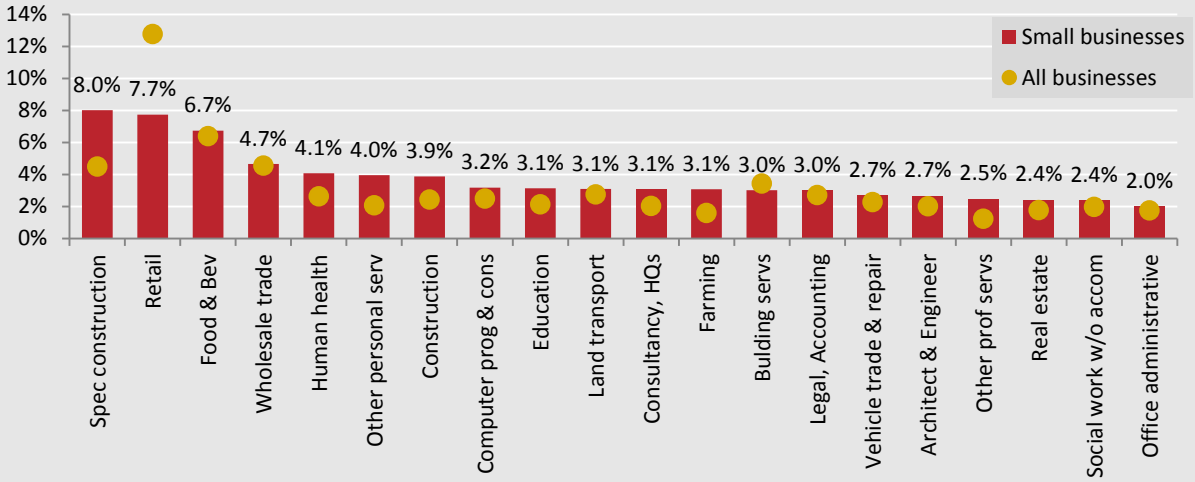
[29] BIS, *Small Business Survey 2012: Businesses With No Employees*, April 2013; BIS, *Small Business Survey 2014: SME Employers*, March 2015

[30] Ofcom, *SME experience of communication services tables*, November 2014

[31] Note that this combination of business and 'pure' residential use was implicitly captured in our previous residential bandwidth forecast for the BSG, which forecast usage from the home, regardless of whether it was for domestic or business purposes

representing just 8.0% of employment. This is 'specialised construction', which covers electricians, plumbers, painters, decorators and so on. This category is significantly over-represented amongst small businesses – such firms represent just 4.5% of overall employment.

Figure 10: Small business employment by industry (top 20 industries)[32]



Retail trade and food & beverage service (restaurants, cafes and pubs) are the next two categories. The largest sector which might be described as 'data intense' in of itself is computer programming and consultancy (3.2% of small business employment). However, sectors such as food & beverage, while perhaps not requiring significant bandwidth for their own operations, may well provide wi-fi for their customers.

[32] Communications Chambers analysis of data from ONS, *Business population estimates 2014*, 26 November 2014

4. Broadband services used

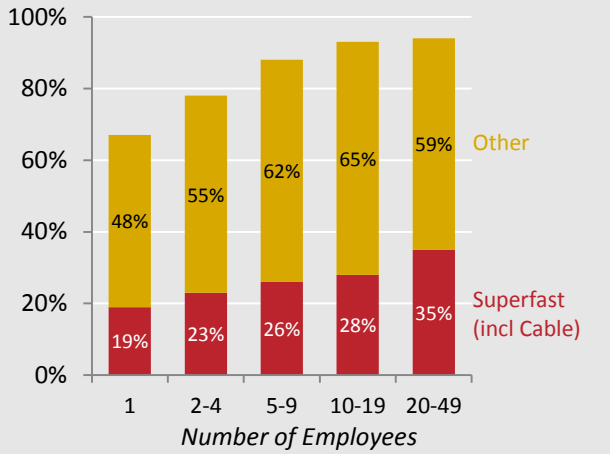
In this section we consider the current broadband services used by small businesses, both fixed and mobile.

Fixed broadband

Adoption of fixed broadband

Ofcom/Jigsaw research has found that only two thirds of single employee businesses have fixed internet access. (Of those without, half reported it was unnecessary since they used mobile internet instead). Fixed internet penetration is higher for larger businesses though, and rises quickly to over 90% for businesses with 10 or more employees (Figure 11). BSG/ComRes found a similar pattern within microbusinesses, albeit with higher levels of penetration – 89% for businesses with less than 5 employees and 95% for those with 5-9.[34]

Figure 11: Internet penetration by business size[33]



These figures compare to an overall level of internet usage of 95% of the working age population.[35] Thus, perhaps surprisingly, the smallest businesses are actually less likely to be online than the average person (of working age). This is doubly significant since, as we have seen, these very small business are such a large proportion of the total number of the total.

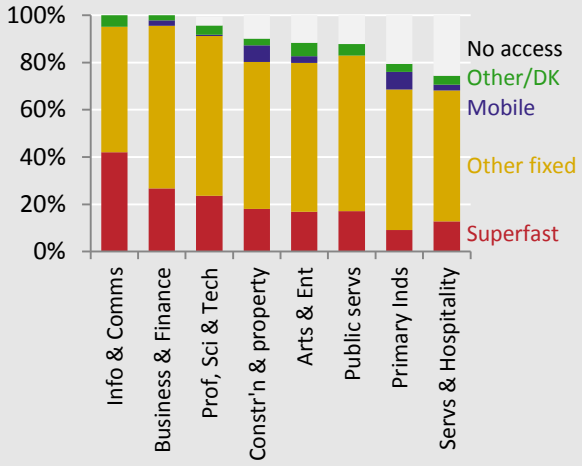
[33] Ofcom, *SME experience of communication services tables*, November 2014

[34] ComRes (for BSG), *Broadband Usage among Micro Businesses*, November 2014. The Ofcom survey asked "Including yourself, which of the following communications services does your organisation use?" BSG asked "Do you have an internet connection that you use at least partly for business purposes?" It is possible that the latter question was more likely to prompt respondents to consider home broadband connections used for business purposes

[35] ONS, *Internet Users 2015*, 22 May 2015

Internet adoption (fixed plus mobile) also varies by sector. Virtually all the micro-businesses (0-9 employees) surveyed by ComRes/BSG in the Information & Communication and Business & Finance sectors use the internet – but a quarter of those in Services and Hospitality do not (Figure 12). Unsurprisingly, more information-intense sectors are more likely to be online.

Figure 12:Micro-business internet adoption and type most used by sector[36]

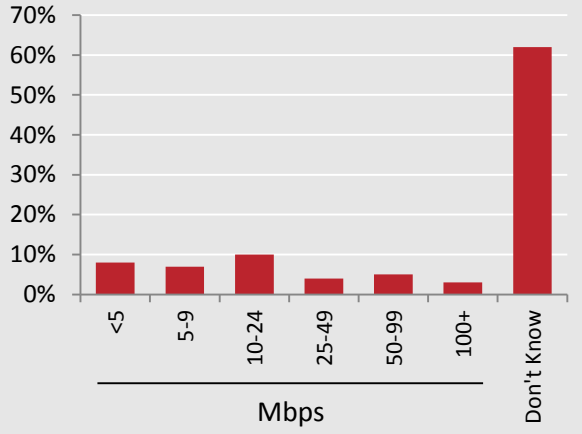


A similar pattern is evident in the type of broadband used by micro-businesses in different sectors – over 40% of Information & Communication businesses use superfast, for example. Mobile is the prime form of internet access for 4% of all micro-businesses and 7% of those in Construction & Property and Primary Industry (though is a secondary form of connection for many more – see below).

Fixed broadband speeds in use

For these microbusinesses, the median speed of connection was 12 Mbps, amongst those who claimed to know their speed. However, much the most popular response to this question, at 62%, was 'Don't know'. This *may* suggest that this group do not feel speed is a critical factor or constraint for their usage.

Figure 13:Micro-business reported broadband speed[37]

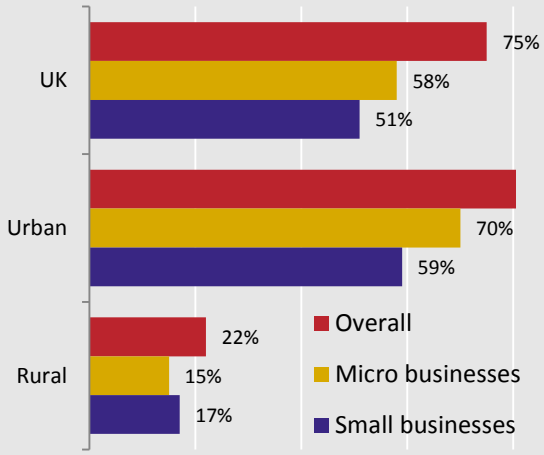


While we are not aware of any technical measurement of the network speeds of UK small businesses, Hong Kong does provide some (surprising) data. Though superfast broadband is widely and cheaply available there, as of March 2015 43% of business lines have speeds of 10 Mbps or less.[38] This compares to a figure of 12% for consumers.

[36] ComRes (for BSG), *Broadband Usage among Micro Businesses*, November 2014
[37] ComRes (for BSG), *Broadband Usage among Micro Businesses*, November 2014
[38] OFCA, *Statistics on Customers of Internet Service Providers ("ISPs") in Hong Kong* (accessed 6 June 2015)

However, in the UK small business superfast adoption is partially constrained by availability, which is appreciably lower for small businesses than it is for consumers. While 75% of premises have access to FTTC and/or cable superfast, just 58% and 51% of micro and small businesses respectively have such access. Ofcom has found that the average download speed in SME-only postcodes is 13.6 Mbps, compared to 23.4 Mbps for all UK premises.[40]

Figure 14: Superfast broadband availability[39]

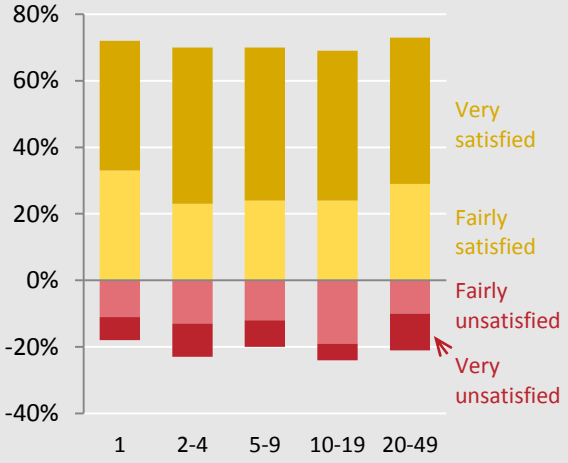


In terms of the type of contract used, a significant number of small businesses use residential broadband – 52% of sole traders do so, and 43% of firms with up to ten employees (though these firms may also use business broadband). Leased line usage is relatively rare amongst small businesses.[41] Even amongst those with 21-50 employees, just 8% make use of leased lines.

Satisfaction with broadband speeds

Ofcom's recent survey, approximately one fifth of small business were unhappy with their broadband speed (Figure 15). By contrast, FSB's survey found almost half to be dissatisfied.[43] However, just 27% of small businesses choose to take superfast or leased line broadband,[44] despite superfast being available to over half, and leased line connections being available to an even greater number.

Figure 15: Satisfaction with broadband speed[42]



This suggests that a significant group of small businesses, while dissatisfied with their current speed, are making the commercial decision not to spend additionally to acquire higher speeds. Leased lines in particular can be appreciably more expensive, typically priced in hundreds of pounds rather than tens (in part because they offer guaranteed, symmetric speeds and higher reliability). Figure 16 shows a sample of BT business broadband products, by way of example. (BT has a

[39] Ofcom, *Infrastructure Report 2014*, 8 December 2014
[40] Ofcom, *Broadband services for SMEs: assessment and action plan*, 25 June 2015
[41] FSB, *Response to Ofcom's call for inputs relating to Communications Services and SMEs*, December 2014
[42] Ofcom, *SME experience of communication services tables*, November 2014
[43] FSB, *Response to Ofcom's call for inputs relating to Communications Services and SMEs*, December 2014
[44] Ofcom, *SME experience of communication services tables*, November 2014

49% share of ADSL provision to SMEs, and a 71% share of fibre broadband provision).[45]

Figure 16: BT Business broadband products[46]

Product	Bandwidth, Mbps (down/up)	Fault fix target	Cost per month (£)
BT Broadband Unlimited	Up to 17 / Up to 1	Next working day	17
BT Infinity Unlimited	Up to 38 / Up to 9.5		32
BT Infinity Premium	Up to 76 / Up to 19		40
BT Leased line	10/10	5 hours	272
	Initial 30/30, Max 100/100		467
	100/100		667

Impact of broadband speeds

However, while some small businesses are choosing not to upgrade their speeds, others may simply not be able to due to a lack of coverage. For such businesses, the extension of improved broadband can be transformative.

For instance, the Superfast Cornwall programme is investing to bring superfast broadband to the county, including to small businesses. A Superfast Cornwall/BT study examined the impact on a number of businesses connected in the early stages of deployment. These participants had all previously been struggling with speeds of less than 2 Mbps and unreliable connections. [47] After deployment, they were receiving between 20 and 74 Mbps down and between 2 and 15 Mbps up. This step up from very poor speeds had a dramatic effect, providing much improved productivity though the ability to transfer large files; make use of video conferencing; use cloud services; use multiple applications simultaneously; and so on.[48] (It is unclear whether the effect of superfast would have been similarly dramatic if participants has already had good basic broadband of, say, 10 Mbps).

Trade press commentary on required speeds

IT vendors and trade press occasionally discuss rules of thumb for enterprise bandwidth requirements, or offer calculators to make estimates based on a company's typical usage. Figure 17 shows a several examples.

[45] Ofcom, *SME experience of communication services - a research report*, November 2014

[46] BT Business, *Broadband & internet* (accessed 24 May 2015); *BT Business, BTnet Leased Line* (accessed 24 May 2015). Prices exclude VAT and line rental. Connection charges apply

[47] For further discussion of the negative impact of very low speeds, see also Jigsaw [for Ofcom], *SME Experience of communications services*, 18 June 2015

[48] Dr Hazel Lacohée & Prof Andy Phippen, *SME Benefits and Business Opportunities with Superfast Broadband: the Virtuous Circle of Connectivity*, 15 September 2013. Interview with Dr Lacohée

Figure 17: Sample bandwidth requirement estimates

Source	Scenario	Requirement (Mbps)	
		Total	Per user
Bandwidth Pool[49]	10 'power users'	14-19	1.4-1.9
API[50]	50 person accounting firm 'in tax season'	38	0.8
Bandwidth Pool[49]	10 'light users'	2-7	0.2-0.7
CII Technology Solutions[51]	'Decent' connections for 10 users	2.56	0.3
Gartner[52]	Connected users (larger sites?)	--	0.2
Arstechnica[53]	Requirement for cloud email, CRM & collaboration	--	0.1
Technibble[54]	Typical office user	--	0.08

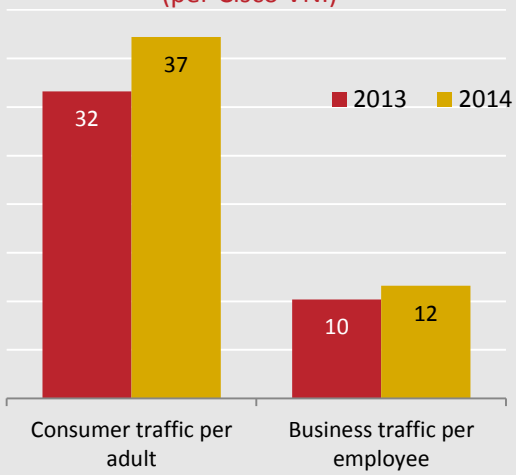
The per-user range is large, from 80 Kbps to 1.9 Mbps. This depends in part on the type of user. The 1.9 Mbps estimate from Bandwidth Pool is for power users, with "intense internet-based application use" and "multiple devices per user". A further factor may be site size. Larger sites have lower per-user requirements because of 'stat-mux' benefits - for larger groups, the probability that all users are online simultaneously is lower, meaning less bandwidth needs to be set aside per user.

We note also that these estimates are typically for office workers, not employees in general. Consequently per-employee requirements may be substantially lower, for instance in a firm with a large number of manual workers.

Fixed internet business traffic

There is limited data on traffic used by small businesses. Cisco's widely used traffic forecasts do however split total traffic between business and consumer. By working out per employee and per consumer traffic respectively (Figure 18), we can compare usage intensity between home and the workplace. For 2014, per adult home usage is roughly 3x the business traffic per employee. There are various reasons for this – employee usage is likely only for five days a week, for example. However the largest single reason is the difference in video. Of the 25GB difference

Figure 18: Traffic per user, GB/month (per Cisco VNI)[55]



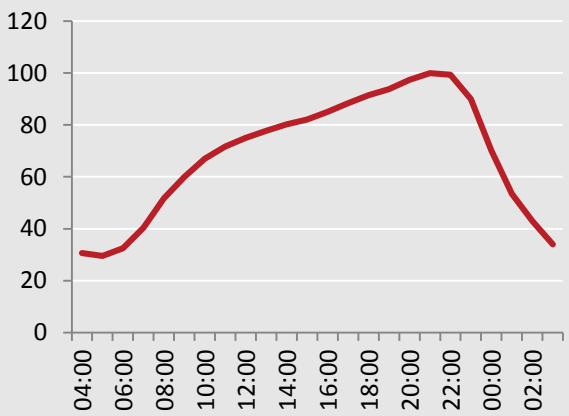
[49] Bandwidth Pool, *Bandwidth Calculator* (accessed 25 April 2015)
[50] API, *Bandwidth Estimator Gives IT Admins the Tool They Need for Better VDI Deployments*, 11 November 2014
[51] Cii Technology Solutions, *What Internet Speed do I Need for my Business?*, 23 January 2014
[52] Gartner, *How Cloud, Mobile and Video Will Increase Enterprise Bandwidth Needs Through 2017*, 22 March 2013
[53] Arstechnica, *Meeting the bandwidth demands of taking your business into the cloud*, 17 September 2013
[54] TechNibble, *How to Estimate Bandwidth Needs for Your Customers* (accessed 25 April 2015)
[55] Cisco VNI, Communications Chambers analysis

between the two figures, 23GB relates to video. This is perhaps unsurprising – major drivers of video traffic in the home, such as iPlayer and Netflix, are unlikely to see much legitimate use in the workplace.

Analysis of internet traffic by time of day

Another way to understand bandwidth intensity at work rather than at home is to consider how traffic varies through the day. Figure 19 shows an index of traffic volume for an average weekday at LINX, a major UK internet exchange. LINX traffic is a good proxy for the shape overall UK internet usage (including mobile, although primarily fixed).

Figure 19: LINX Traffic by time of weekday (index)[56]

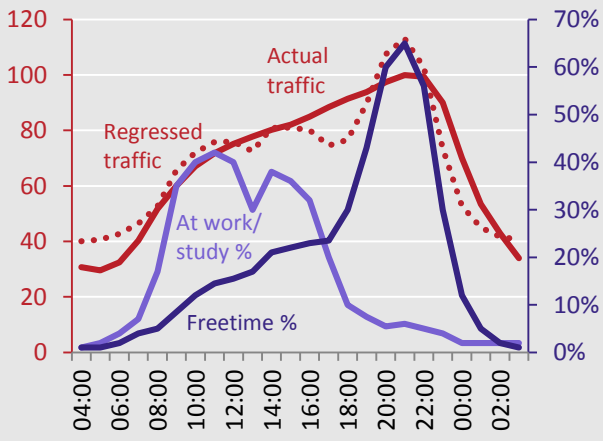


Usage rises steeply in the morning as people awake and get in to work. It then rises steadily through the day until an evening peak at approximately 9pm.

Clearly whether people are awake is an important driver of internet traffic, but it is notable that traffic is lower during working hours than it is during evening hours. This is suggestive that time spent at work is less bandwidth intense than time at home.

ONS time use data tells us how many people are at work (or study) through the course of the day, and how many have free time (predominantly at home). By regressing total traffic against these two input variables, we can understand how important each of these activities is to driving total internet usage throughout the day.[58]

Figure 20: Traffic and time use[57]



The regression coefficient for free time is 2.2x that for work/studying Time. Thus suggests that free time is 2.2x more bandwidth intense than work time. By extension, per employee bandwidth during the workplace peak is likely to be lower than per resident bandwidth in the evening home peak (consistent with the Cisco results).

[56] Communications Chambers analysis of data from LINX, *LINX combined bit rate* (accessed 25 May 2015). Data is average for Monday 18th – Friday 22nd May 2015

[57] Communications Chambers analysis of data from LINX as above, and ONS, *Time Use Survey 2005*, July 2006. This is dated data, but at a high level patterns of time usage are unlikely to change rapidly

[58] $R^2 = 0.86$

Mobile

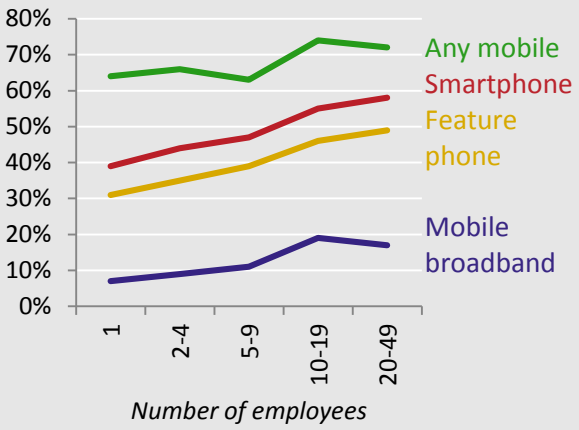
Finally in this section we turn to small business usage of mobile (voice and data). This is in area where there is relatively little data available in the public domain.

Amongst small businesses in Ofcom's survey, 44% report providing smartphones, and a further 21% say that their staff use personal devices for business purposes.[60]

Half of all users rate mobile's importance for the business as '10 – Absolutely Vital', with a further 21% rating it 8 or 9 out of ten. Mobile is particularly important to sole traders, with 59% saying it is vital, compared to 48% for those with 2-49 employees.

The importance of mobile services to micro-businesses is also highlighted by the fact that 9% of such businesses have no landline at all.[61]

Figure 21: Small business use of mobile[59]



FSB's survey had similar results, with 71% percent of small businesses say that mobile phones are crucial or very important to their business.[62]

For mobile data, a majority seem (for the time being) to be continuing with 3G. A Vodafone survey found that just 24% of small businesses were making use of 4G, compared to 39% of larger businesses.[63]

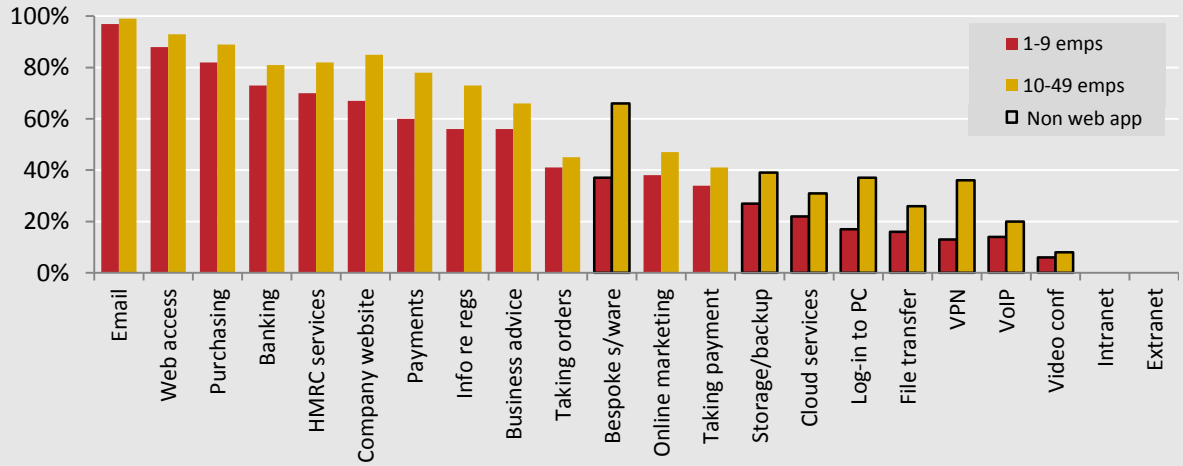
[59] Ofcom, *SME experience of communication services tables*, November 2014
[60] Ofcom, *SME experience of communication services tables*, November 2014
[61] Ofcom, *SME experience of communication services tables*, November 2014
[62] FSB, *The fourth utility: Delivering universal broadband connectivity for small businesses across the UK*, July 2014
[63] Vodafone, *Businesses stifling future performance by not adopting 4G technology*, 14 May 2015

5. Applications used

In this section we consider the applications used by small businesses. There are however two important limitations to the data. Firstly, while there are various surveys as to which applications are used, there is little information about how *much* those applications are used. Secondly, the survey evidence asks about business productivity applications (email, banking and so on). It does not address personal applications, such as Bittorrent, which may well be used over small businesses' broadband connections.

Figure 22 shows the results of Ofcom's survey regarding internet applications used by small businesses. While the survey covers a wide range of activities, many have similar bandwidth requirements, being conducted through a web browser and based primarily around text and pictures. For example, the bandwidth needs for banking, purchasing and HMRC services are all likely to be much the same

Figure 22: Small business application use (Ofcom)[64]



Conversely some categories cover a wide range of bandwidth requirements. 'Taking orders', for instance, could be receiving emails from customers; operating an e-commerce site hosted in the cloud, or even hosting a site on the business' own premises. The last could require substantial bandwidth, but we assume this is a relatively rare scenario – most small businesses are likely to rely on cloud-based hosting, which is generally cheaper, more reliable and simpler (especially for businesses lacking in specialist IT expertise).

The most widely used 'non-web' application in Ofcom's survey was bespoke software. The bandwidth needs of this are uncertain.

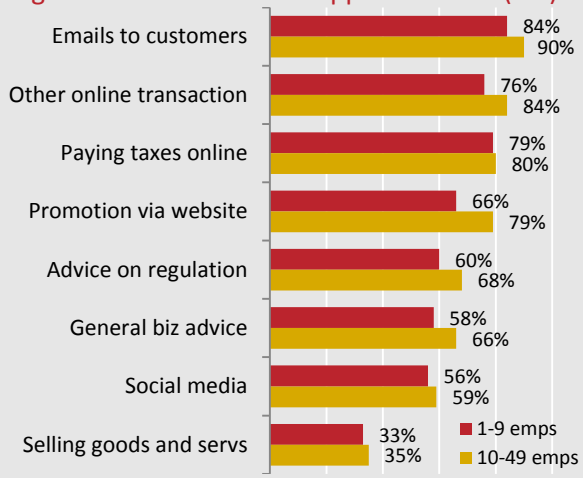
[64] Ofcom, *SME experience of communication services - a research report*, November 2014

Online storage and backup is used by 27% of firms with 1-9 employees and 39% of those with 10-49. This has the potential to use material bandwidth, which we discuss more below. File transfer, in some ways parallel in its technical characteristics to backup, is used by 16% and 26% respectively. Both these applications are likely to generate material upstream traffic.

Remote login to work PCs or servers (VPN) are used by a third of 10-49 employee businesses, though this is a relatively low bandwidth application. Videoconferencing is used by less than 10% of small businesses.

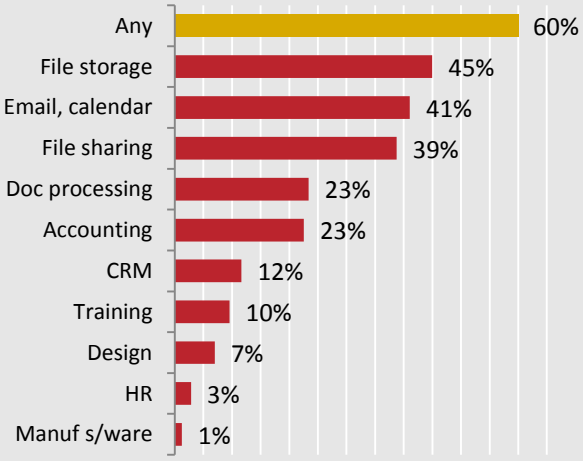
Figure 23 shows the results of BIS' survey of application use (for small businesses with employees). The results are similar to Ofcom's survey. As with that survey, across all applications, larger businesses are somewhat more likely to participating than smaller.

Figure 23: Small business application use (BIS)[65]



Looking specifically at cloud services, a 2014 FSB survey found that 60% of small businesses were using such services (Figure 24). File storage & sharing and email were the most widely used.

Figure 24: Small business use of cloud services[66]



The finding of 60% usage compares to a 2013 ONS survey which reported that 21% of businesses with 10-49 employees were *purchasing* any cloud services, with file storage again being the single most important category.[67] Of course, many small businesses may use cloud services without paying for them – services such as Dropbox and Gmail provide fully featured, free versions.

In general, small businesses are more likely than large ones to use cloud services – 16% of businesses with fewer than 20 employees report that their primary approach to IT is cloud-based, compared to 6% of those with more than 200 employees.[68]

[65] BIS, *Small Business Survey 2014: businesses with employees*, 3 March 2015
[66] FSB, *Cloud computing survey*, 18 February 2015
[67] ONS, *E-commerce and ICT Activity of UK Businesses, 2013*, 28 November 2014
[68] Vision Solutions / Cloud Industry Forum, *The Normalisation of Cloud in a Hybrid IT Market UK Cloud Adoption Snapshot & Trends for 2015*, August 2014

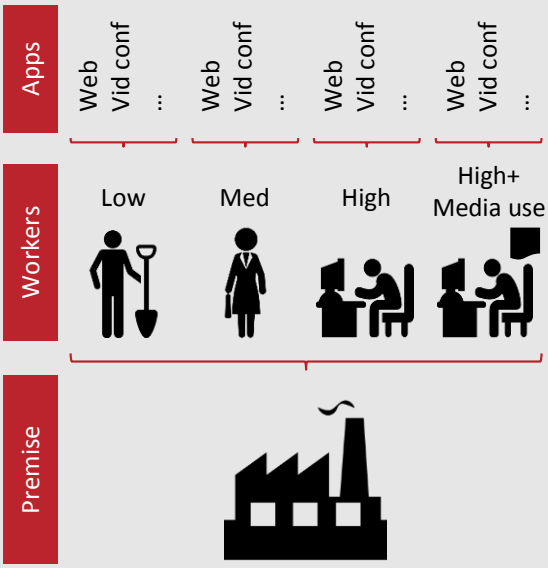
6. Forecast model structure

In this section and the next we set out our approach to forecasting small business fixed bandwidth requirements. We start in this section by describing the model structure, and then turn to the key assumptions which drive the model.

Introduction

To estimate small business bandwidth usage we have taken a 'bottom up' modelling approach - starting with a set of applications used by employees, combining these to build a profile of employee usage for a variety of employee types, and then combining these individual profiles to get a picture of small business usage. We undertake this analysis for a range of premise sizes (1-49 employees) and for a 50 different industry types.

Figure 25: Modelling approach



Scope of the model

The focus of the model is small business fixed bandwidth requirements. Specifically, it considers requirements in the busy hour for business premises. One small business may have multiple premises, and bandwidth is bought and provisioned for the premise, not the firm as a whole.

The model does not explicitly treat devices – our focus is on the usage (for instance, web browsing) rather than the device on which that usage happens. We believe that this approach is preferable, since it is the person that is likely to be the constraint in the system. The number of internet-capable devices may carry on rising, but as a practical matter a person is only going to be able to use a certain number simultaneously.

Note that while we believe the model addresses the vast majority of small business types, a small number of rare or extreme cases will fall outside its scope.

Applications as building blocks

The basic building block of the model is the application. We set out here our broad approach to applications. Later in this section we discuss our thinking and assumptions for each application type in detail.

The model treats seven different application types explicitly. These are web usage, file transfer, email, cloud storage, video calling, streamed video and BitTorrent. We have treated explicitly those applications that are likely to have the biggest impact on bandwidth demand. Note that we have included two applications, streamed video and BitTorrent, which may have less relevance to business productivity, but which nonetheless consume material bandwidth.

Some activities requiring little bandwidth, such as VoIP and telemetry have been grouped under 'low bandwidth' applications.

Focus on the busy hours

In forecasting bandwidth requirements, the model focuses on the busy hours (those when the internet is being used most intensively), since these will be when peak demand occurs. The model begins with monthly usage per person of the various applications, but then assumes that for each application, 33% of usage will take place within the two busiest hours each day.

By concentrating the traffic, we greatly increase the likelihood of overlapping usage of applications (both for an individual and across individuals), thereby upping the peak bandwidth requirement.

Note that the model is agnostic as to *which* two hours in the day are the busiest – for a typical office, it might be 9-11am, but for a builder mostly working away from the office, it might be 7-9pm. We are interested in the busy period for each premise, not the overall network busy hour, which is not relevant for access bandwidth requirements.

Employee types

The model combines application usage into four different profiles of employee usage – low, medium, high and high with media use. We start from ONS's 4-digit standard occupation codes (SOCs). These categorise workers into 369 different jobs, such as shelf fillers, telecommunications engineers, graphic designers and taxation experts. We take each of these jobs and place it into one of our four profiles above.

Low users are those who are not knowledge workers (though they may be highly skilled, who likely do not have a desk. Internet usage is likely to be incidental. Examples of jobs in this category include sales assistants, care workers and cleaners. Approximately half the labour force is in this category.

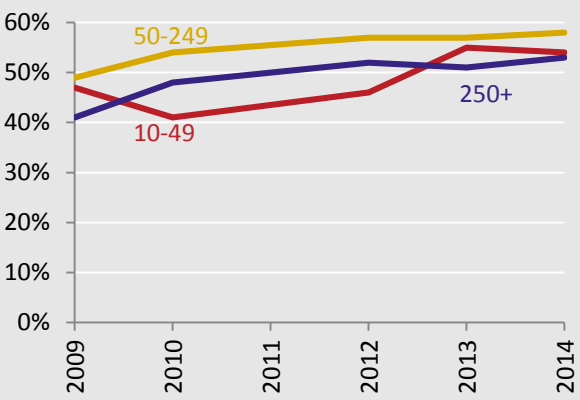
Medium users are knowledge workers who spend material time away from their desk and/or engaged with human interaction rather than a screen. Teachers, sales executives and shop managers would be examples. Such roles certainly involve internet use, but the hours of usage will be less than some more desk-bound roles. Approximately a third of the labour force are medium users.

High users are knowledge workers who spend much of their time at a screen. Book keepers, personal assistants and legal associates are in this category. The types of applications they're using are likely similar to those for medium users, but their levels of usage are higher. High users comprise 16% of the labour force.

High with media users are those whose job involves the manipulation of large files – video, statistical, software and so on. Like high users they spend much of their day at a screen, but are perhaps using Photoshop or SPSS as well as or Word or Excel. Examples of occupations in this category are programmers, graphic designers and photographers & AV equipment operatives. Such occupations are relatively rare, representing just 3% of the total.

The EC's Digital Agenda Scoreboard provides figures to cross check our finding that half of small business employees are 'low users'. The Scoreboard includes figures on the proportion of UK employees who use computers with web access at work (Figure 26). For firms with 10-49 employees, 54% are in this category. (Figures for smaller firms are not provided).

Figure 26: Employees with workplace web access, by firm size (UK)[69]



Certainly there may be employees outside this 54% who make use of the internet for work, particularly those who are mobile. However, it seems likely that the great majority of those making use of workplace fixed broadband will have a computer available to them to do so.

The 54% figure is for firms with 10-49 employees. As we have seen, smaller firms are less likely to have web access, which suggests that for all small business the portion of employees with web access is likely somewhat below the 54% figure. In other words, around half of small business employees do *not* have web access – consistent with our finding that approximately 50% of employees are in the 'low

[69] EC, *Digital Agenda Scoreboard* (accessed 26 April 2015)

user' category – non-knowledge workers with significantly less need for workplace internet access.

We assume (somewhat arbitrarily) that these low users have one-fifth the usage of medium users, who have average per-employee usage of most applications. We use these assumptions to solve for the level of usage of high and high+media users, to ensure that *overall* average usage is correct – that is, that the extra usage of the high users offsets the lower usage of the low users. In practice this means high users have 3.1x the average usage.

Industry classifications

As we have noted, businesses will vary dramatically in their bandwidth requirements based on their industry type – a food manufacturer is likely to need less bandwidth than a software developer or TV production business.

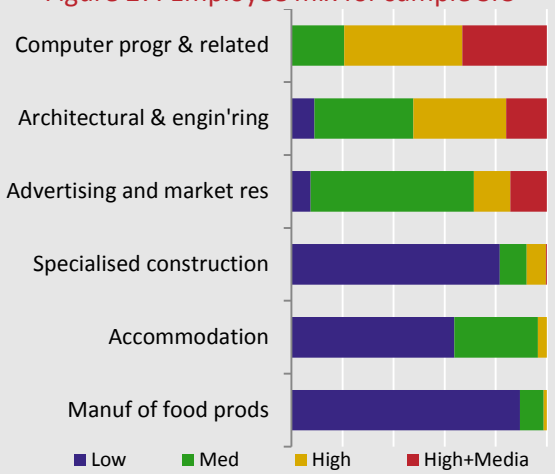
Our classification of employees allows us to explore this, since ONS provides cross tabs of occupation codes with standard industry codes (SIC). For example, we know how many bookkeepers work in TV production businesses. Thus we are able to calculate the mix of low/medium/high/high+media employees by SIC.

We work with 2 digit SIC. Examples of such industries are 'specialised construction activities', 'residential care activities' and 'scientific R&D'. There are 84 distinct 2 digit SIC, though a number have low total employment amongst small businesses. The model treats 49 of them explicitly, and groups the remaining 35 (representing 4.9% of employees) in an 'other' category.

In selecting the 49 SIC to treat explicitly, we primarily chose those with the largest number of small business employees. However, we included some smaller SIC if they were likely to have higher bandwidth demand. 'Programming and Broadcasting' and 'Scientific R&D' are two such examples.

Figure 27 shows the results of this analysis for a sample of six SICs. For 'Computer programming, consultancy and related activities', 33% of staff are media users, and virtually no staff are low users. Conversely, for 'Manufacture of food products' 89% of employees are low users, and virtually no staff are media users. These employee mixes ultimately feed into very different bandwidth demands for different SIC.

Figure 27: Employee mix for sample SIC[70]



Non-employee use

In addition to employees as drivers of bandwidth, we also consider M2M/IoT (machine-to-machine and internet of things traffic) and 'guest' traffic. Guest traffic is, for example, the hotspot usage of customers in a coffee shop or guests of a hotel. (For the Accomodation SIC, such traffic is much greater than employee generated traffic). Detailed assumptions for this 'overlay' traffic are discussed below.

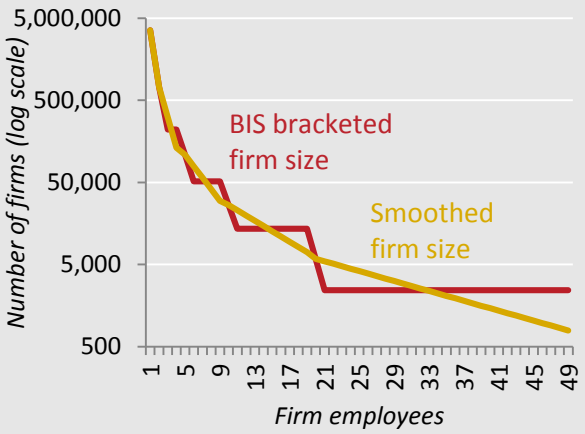
Premise sizes

An important factor in determining the bandwidth requirements of a small business is its number of employees. As we have seen, 79% of small businesses have only a single employee.[71]As the number of employees increases, the number of firms decreases dramatically. BIS provides number of firms by 'brackets' of employees – for instance, 5% of small businesses have 5-9 employees. However, within this bracket there are likely many more firms with five employees than with nine.

[70] Communications Chambers analysis
[71] BIS, *Business population estimates 2014*, 26 November 2014

For the purposes of the model, we have smoothed these brackets, giving the profile shown in Figure 28. (Note the log scale for the number of firms). This gives us the overall mix of firm size, but we also take into account that different SIC have different firm sizes. For instance, firms involved in 'Residential care activities' have an average of 6.4 employees, while those involved in 'Creative, arts and entertainment activities' have an average of 1.4. This contributes to different bandwidth demands for different SIC (in addition to the different employee mix).

Figure 28: Modelled number of firms by size[72]



Having developed a picture of firm size, we the need to adjust this to premise size, since premises are the locus of bandwidth consumption. For businesses with 1-9 employees, 37% report that they work from home.[73] Just 8% of this group report that they had more than one site, and it seems likely this was primarily an office plus home working. Since (say) working from home in the evening has no impact on the daytime bandwidth requirements of the office premise, we do not split premises for the micro firms (a conservative approach).

For firms with 10-49 employees, 27% have more than one premise, and for these larger firms it seems more likely that these will represent a genuine split of staff during the busy hours of the day. For this 27% of larger firms, we split them into two sites, one with two-thirds of the firm's total employees, and one with one-third.

These assumptions allow us to generate a mix of premise size by industry.

Since the model treats 49 premise sizes and 50 different industry sectors, in aggregate it treats 2450 different premise types. This helps to provide a picture of the diversity of demand of small business.

Building premise employee mixes

Our analysis of employee types gives us the average mix for our 50 industry sectors. However, we need to convert this to a specific mix for a premise of a given size. This is particularly relevant for small premises. Imagine an industry with an 80% low user / 20% high with media user mix. Putting the one employee in a single person premise

[72] Communications Chambers analysis of data from BIS, *Business population estimates 2014*, 26 November 2014
[73] BIS, *Small Business Survey 2014: SME employers*, March 2015

in either of one of these categories may lead to under- or over-statement. Further, in reality in very small businesses employees play multiple roles, acting (say) as a graphic designer for some of the day and as a bookkeeper at other times.

Thus for the initial four employees we take a blended approach, combining the usage of the different employee types in proportion to their overall mix in the industry in question. Thereafter, each extra employee is added so as to keep the employee mix as close to the industry mix as possible. For example, if the mix of first nine employees leaves low users most underweight, then the tenth employee will be a low user, and so on.[74]

Combining traffic

Thus we have built a picture of application usage for different types of employees, and how these employee types are represented in different premise sizes for different industry sectors. The next step is to understand how the usage of these employees combines to create the peak bandwidth demand for the premise in question. Critical to this is an understanding of usage overlaps.

If an individual never multi-tasks, then their peak bandwidth requirement will be set by their most demanding application – perhaps video calling. However, if they sometimes access the web while in a video call, then the combined bandwidth of these two apps may set the peak. Similar logic applies when combining the usage of multiple individuals.

To build a profile of this combined usage, we have taken a probabilistic approach.[75] For example, if app A is used for 30% of the time during the busy hours, and app B is used for 40%, then they will (on average) be used simultaneously for 12% of the time –and, for that 12% of time will need will need the summed bandwidth of the two applications. [76]

This approach is used both to combine app usage to build individual user profiles, and to combine user profiles to build household

[74] We do not believe using the blended approach beyond the first few employees is appropriate. Consider an industry with a 50/50 low/high user split, where the low users have no usage at all, but the high users use 5 Mbps all the time. In a ten person premise, the true bandwidth requirement would be 25 Mbps (the total of all the high users). If we used the blended approach, then we would model ten users each using 5 Mbps for 50% of the time, resulting in significant usage of over 25 Mbps

[75] In this regard, this model takes an identical approach to the residential demand model

[76] Note that the model makes the simplifying assumption that bandwidth usage is additive – one stream of X Mbps and another of Y Mbps will together need X + Y Mbps. In practice, two streams can sometimes interact in subtle and unexpected ways (both in the access network and more generally), meaning that even with ample bandwidth performance can be unsatisfactory. See the papers of Predictable Network Solutions for a more detailed discussion

profiles. In practice, this is a complex set of calculations that ultimately embeds all possible combinations of applications, the total bandwidth for each combination and the expected duration.

Note that there are reasons to believe this probabilistic approach may potentially understate or overstate overlapping usage. It may understate it to the extent to which certain applications have a particular 'affinity' for each other. For instance, a user may potentially be *more* likely to browse the web while on a video call than they would be to browse at other times

Conversely, the probabilistic approach may overstate overlaps if applications 'repel' together. For example, a user on a video call is perhaps less likely to simultaneous stream other video.

Applications may also be more likely to 'repel' each other as they 'stack'. This is because of the human limits of multi-tasking. While it is perfectly feasible to (say) browse and consume streaming video at the same time, each additional task becomes harder. For instance, if a user then receives a video call, it is likely (though not certain) that they would either pause the video or their surfing. In other words, this triple multitask is less likely than simple probability (and the model) would suggest. This potential overstatement in the model is particularly important, since it is these app stacks that drive peak bandwidth demand in the busiest minutes of the month. This is one way in which the model is conservative (in the sense of unlikely to understate demand).

Development over time

The model develops a ten year forecast for unconstrained[77] bandwidth requirements. Changes in requirements are driven by a range of factors, including:

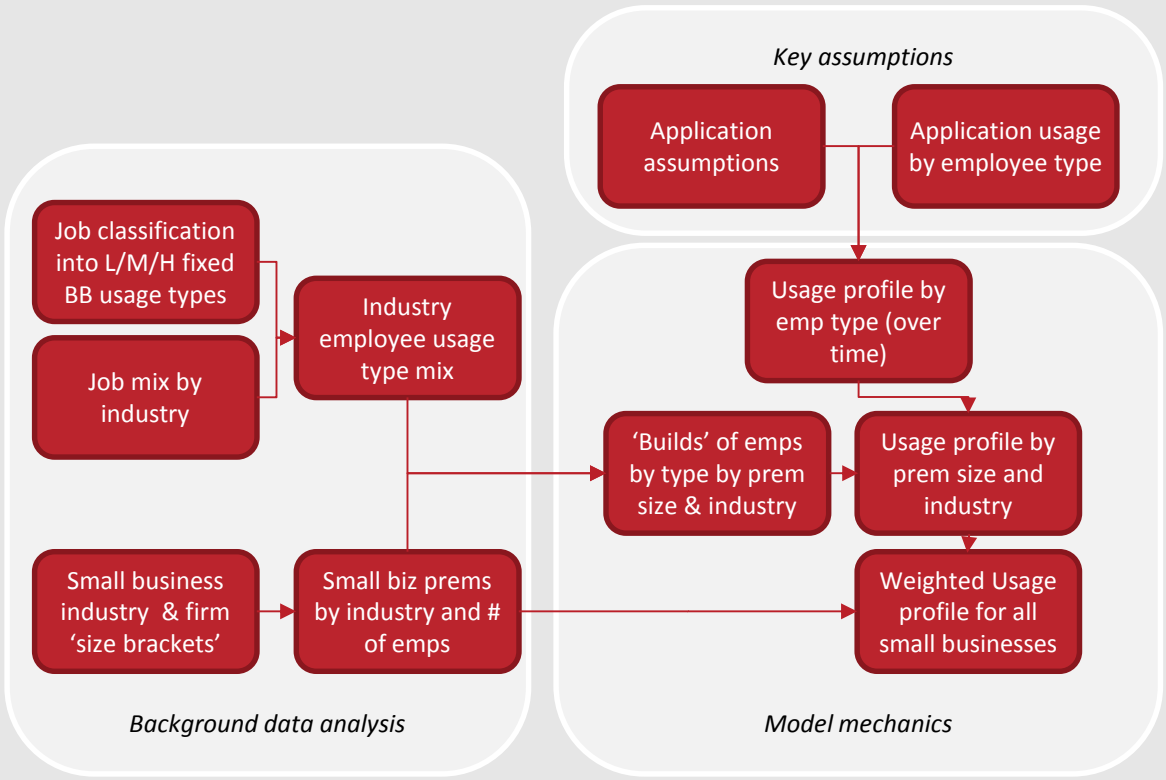
- Increasing time spent using applications
- Varying bandwidth required by individual applications (for instance, rising for web use as web content includes richer images and more video)
- Rising user expectations (for instance, increasing impatience with time taken for software downloads)

Conclusion

At a high level, we can summarise the model structure as follows:

[77] By this we mean that we have not scaled back bandwidth to reflect constraints that may in practice exist in the access network

Figure 29: Model structure



While the modelling of the combination of applications to build premise usage profiles is complex, it is to some extent mechanistic. This aspect of the model is not in itself highly assumption-dependent, but rather depends on the mathematics of overlapping usage.

However, it builds absolutely on the assumptions regarding the usage characteristics of individual applications. We now turn to this vital area.

7. Forecast Model Assumptions

Bandwidth has no inherent value. Rather, it is an enabler of applications – everything from a simple text email to a large video file uplad. Thus bandwidth needs can only be assessed by looking at applications – which are and will be used, how many people will use them, for how long, and how much bandwidth will be required?

In this section we consider both the current state of play, and the prospects for a wide variety of applications.

Wherever possible we have used third party sources for bandwidths and usage. In particular, we have used application providers' own estimates for bandwidth requirements where available.

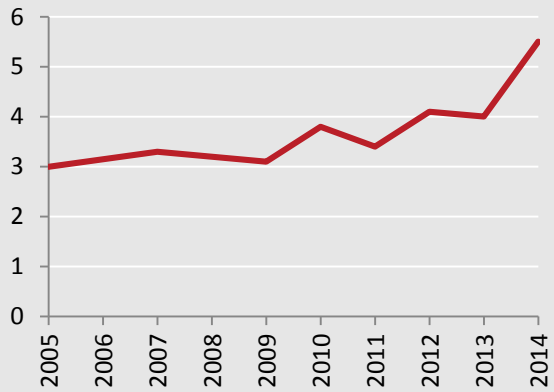
The employee applications the model covers are web usage, email, video calling, cloud storage, file transfer, streaming video and Bittorrent. We first take these in turn, before considering other forms of bandwidth demand (such as guest wifi).

Web usage

Duration of use

Ofcom's Media Use survey has found a steady albeit moderate increase in time spent online[79] at work amongst those online until 2013. However the last year has seen a sudden jump of 38%, to 5.5 hours per week (or 8.8 hours per employee). It is possible this is an anomaly, or possibly a result of increased personal use of the internet at work using smartphones.

Figure 30: Hours per week spent online at work (amongst those online)[78]



By contrast, the Oxford Internet Survey reports declining workplace usage (amongst those employed and online), down from 7.3 hours per employee in 2007 to 5.5 in 2013.[80]

To be conservative (ie to avoid underestimating bandwidth), we take as our starting point Ofcom's higher figure of 5.5 hours per online adult, or 8.8 per employee. We assume usage grows at 3% per year.

[78] Ofcom, *Adults' media use and attitudes, Report 2015*, May 2015. For equivalent US data, see USC Annenberg School Center for the Digital Future, *The 2014 Digital Future Report*, December 2014

[79] Respondents were asked "How many hours in a typical week would you say you go online at work". This seems likely to elicit responses related to web use, rather than (say) time spend on Skype or uploading files to Dropbox in the background

[80] William H. Dutton & Grant Blank, *Cultures of the Internet: The Internet in Britain*, 1 October 2013

In 2015 this implies 2.5 hours of web usage *per day* for our medium users (teachers, sales executives and so on) and 7.6 hours per day for high users (personal assistants, book-keepers and so on). For high users in particular, this is a very substantial part of the working day, consistent with the great majority of their work being conducted though cloud-based applications (online accounting software such as Freeagent, web based email and calendars and so on).

Bandwidth

For bandwidth requirements we take the same approach used in our residential forecast.[81] This is based on three assumptions – page weight (the total size of the files making up a web page); an expected page download time in seconds; and time spent on each page. Together, these assumptions allow us to understand the spikes of bandwidth needed to accommodate page loads, and the pauses between as the user reads the pages in question.

In line with the residential model, we start with a page weight in 2015 of 1.6 MB (for an average 1.4 MB download after the benefits of caching[82] are factored in). We assume this grows by 2.7x over the next ten years.

We assume a maximum page download time of 3 seconds for 'above the fold' content,[83] though in all but the busiest periods, our modelled users will see faster loads than this. We assume above the fold content reaches a maximum of 2MB.

Note that in using UK average page weight assumptions, we are taking a conservative approach, since it is likely that business web pages are lighter than typical consumer pages – they are (generally) likely to be more functional with fewer images, and less video (particularly video advertising, which is increasingly embedded in consumer sites).

Figure 31 Weights of sample business pages[84]

Webpage	Page weight (MB)
HSBC Business internet banking	1.0
Ofcom telecoms	0.9
Salesforce.com	0.7
Freeagent accounts dashboard	0.6
Alibaba	0.6
Google Adwords	0.5
HMRC PAYE	0.4

Figure 31 shows page weights for a range of business oriented sites, which are generally between 0.5 and 1.0 MB. Compare this to the

[81] For a more detailed discussion, see BSG, *BSG publishes new model for analysing domestic demand for bandwidth*, 5 November 2013

[82] When a browser visits a page, it stores in its cache the various component files of that page for potential reuse on a second visit. If a given file is still present on the page on the second visit, it can simply be pulled from the cache, rather than needing to be redownloaded from the network

[83] 'Above the fold' content is that which appears on the screen without the user needing to scroll downwards. This is the most urgent content – off screen content can load in the background while the user is reading the above the fold content, and will be available when the user scrolls down later

[84] Communications Chambers analysis

7MB weight of the Daily Mail home page (though no doubt there is some use of the Daily Mail site from offices).

Our page weights are based on the desktop versions of websites. Again, this is a conservative assumption. Many sites may have lighter weight versions for mobile devices – for example, the Daily Mail website is just 1.8 MB when loaded on an iPhone 4.[85] To the extent to which office usage is via smartphones or tablets, this will reduce requirements relative to our assumptions.

Our assumptions imply a web browsing bandwidth requirement from 2016 onwards of 5 Mbps. The portion of surfing time for which this bandwidth is required rises from 5% to 12% over the forecast period, as pages get heavier.

Email

Email use is almost universal amongst small businesses online. Based on data from the Radicati Group, we assume approximately 30 emails sent per day, and 100 received, of which 25% have attachments. We assume these attachments have an average size of 0.5 MB.[86]

A key factor in bandwidth requirements for email is whether it is hosted locally or in the cloud. An email in the cloud must be downloaded each time it is read, whereas a locally hosted email is downloaded a single time to the on-premise server. Moreover, a cloud-based email must be downloaded quickly, since the user is waiting for its arrival, whereas it may be downloaded in the background to an on-premise server.

We assume cloud based emails are each read twice, and even those with attachments must, at worst, download within 5 seconds. We further assume that by 2025, 90% of email is cloud based.

Video calling

Amongst microbusinesses, just 26% report that they currently make use of video-calls or video-conferencing, and only 9% say they do so once per week or more frequently.[87] Of the 74% who do not use it, the prime reason is lack of relevance, cited by 86% of this group. Lack of bandwidth was blamed by 3% of the non-users.

[85] Mobitest for Daily Mail home page. Accessed 27 May 2015
[86] Radicati Group, *Email Statistics Report, 2015 -2019*, March 2015; Radicati Group, *Email Statistics Report, 2009 -2013*, May 2015
[87] ComRes (for BSG), *Broadband Usage among Micro Businesses*, November 2014

However, to be conservative we have assumed growing use of video calls. Based on Ofcom data, we first estimate the volume of business calls (across fixed and mobile) at 63.6bn minutes per year, or about 8 minutes per employee per day.[88] We assume that initially video calling represents 2% of this total, but rises to 25% by 2025.

We initially assume video calls require 1.5 Mbps up and down. This is based on Skype's recommended speed for HD video ('high quality' video requires only 0.5 Mbps, and basic video calling 0.3 Mbps).[89] To this initial bandwidth requirement we apply an annual efficiency improvement of 9%, based on a range of sources discussing trends in video coded efficiency.[90]

An HD video call with this bandwidth would certainly meet the needs of a typical, standard meeting room video conference. However, higher end 'telepresence' systems exist, using purpose-build facilities with a large screen down the middle of a conference table. We have not included these in our forecast, both because per employee use appears to be limited, and we believe they are likely to be very rare in small businesses because of their expense

Regarding usage, Accenture, an enthusiast for telepresence, had an average per-employee usage of just 1.3 minutes per month across its facilities in 65 locations in 2010.[91] This is not to say it wasn't valuable – rather that usage was likely concentrated amongst senior staff, with many employees not using it at all.

Regarding expense, Cisco's current six-seat IX 5000 system costs $299,000, for example.[92] This is approximately equal to one year's turnover for the average UK small business. This sophisticated system requires 10.8 Mbps for 1080p60 resolution video.

Cloud storage

The largest cloud storage services are Dropbox, Microsoft's OneDrive and Google Drive. These all work similarly, mirroring a user's local files, storing them in the cloud, and (if appropriate) copying them to other devices that share the folder in question. This approach limits bandwidth required for file access, since files are 'preloaded' on the

[88] Ofcom, *Telecommunications market data tables, Q4 2014*, 28 April 2015
[89] Skype, *How much bandwidth does Skype need?* (accessed 27 May 2015)
[90] ZetaCast, *Technical Evolution of the DTT Platform*, 2012; Brian Williamson, *Anchor product regulation – retrospective and prospective*, October 2013; Sky, *Beyond HD Masters 2013*, 2013; Motorola, *Opportunity and impact of video on LTE Networks*, 13 May 2013; Cisco, *Cisco Visual Networking Index: Forecast and Methodology, 2012–2017*, 29 May 2013; Orange, *Brainstorm on video coding standards*, 21 October 2014
[91] Accenture, *Telepresence Videoconferencing*, 2010
[92] Brian Riggs (Ovum), "Immersive Telepresence: New Systems for a Declining Market", *No Jitter*, 2 March 2015

local device. Simply accessing a file creates no immediate traffic, since the access is to the local copy. However, each time a file is saved locally, the cloud copy (and other copies on devices) must be updated.

Dropbox, the most popular of the services, uses two techniques to limit the traffic required. Firstly it only transfers the changed component of the file ('incremental sync'), and secondly it applies compression.[93]

Dropbox downloads are performed at the fastest available download speed, and uploads are automatically throttled to 75% of the maximum upload speed to prevent slowdown in browsing[94]. Furthermore, bandwidth requirements are eased by a lack of user awareness – if a file takes longer to upload, the user is unlikely to notice.

To estimate the time and bandwidth requirements of a cloud storage service like Dropbox, we have taken the average downstream and upstream throughput based on analysis by Drago et al[95] (1.26 Mbps and 0.54 Mbps respectively). We note that these are technically 'constrained' figures, in that they are a consequence of available bandwidth today. However, in practice they appear to meet users needs – we are unaware of any complaints about the speed with which Dropbox uploads or downloads files.

For business user volumes, we have drawn on Microsoft's *OneDrive for Business Client Network Bandwidth Calculator*.[96] For a standard user, this assumes an average file size of 2.6 MB, 1 new file generated per day and 5 edits to existing files. We further assume that media-using employees have larger average file sizes, at 10 MB. Both filesizes grow at 10% per year.

For modelling purposes we have assumed usage of cloud services is widespread. However amongst microbusinesses only 41% currently make use of cloud storage,[97] and only 21% of small businesses pay for *any* cloud service (though note that the basic version of Dropbox is free).[98]

[93] Li Zhenhua et al, *Towards Network-level Efficiency for Cloud Storage Services*, November 2014
[94] Dropbox, *FAQs*, accessed April 2015
[95] Drago et al, *Inside Dropbox: Understanding Personal Cloud Storage Services*, 14 November 2012. Similar speeds are noted by Gracia-Tinedo et al, *Actively Measuring Personal Cloud Storage*, July 2013
[96] Microsoft, *OneDrive for Business Client Network Bandwidth Calculator* [Accessed April 2015]
[97] ComRes (for BSG), *Broadband Usage among Micro Businesses*, November 2014
[98] EC, *Digital Agenda Scoreboard* (accessed 4 May 2015)

File transfer

Assumptions around file transfers are both challenging and important. They are challenging firstly because there is relatively little information about data volumes and typical usage, and secondly because we must make an inherently arbitrary assumption about the user's tolerance for delay. Is the architect willing to wait ten minutes for her set of plans to upload, or is a one minute upload essential? This makes a dramatic difference to bandwidth requirements.

Such assumptions are important because file transfers are (for some small business types) likely to be a key driver of bandwidth needs. Many other applications have relatively moderate bandwidth requirements (albeit they may aggregate to higher bandwidths). File transfers in of themselves can trigger a need for superfast speeds.

We begin by considering various sample uses of file transfer (which we do not claim to be exhaustive or even representative):

- Jaybox, a company featured in an FSB case study, manufactures online jukeboxes, and uploads over 1,000 MP3 tracks per month. [99] Assuming a 320 Kbps audio encoding (a very high quality),[100] this would imply a total upload for the firm of at least 7.2GB per month, or approximately 0.3 GB per working day
- DragonFly, a data analysis firm with 7.5 FTE staff which uploads large data sets, reports a cross-firm total of 1-1.5 GB per working day[101]
- Medical images in OsiriX's set of sample files range from 5MB to 0.3GB[102]
- A photographer returning to base and uploading 100 photos of 10 MB each[103] would upload a 1 GB total (though download needs might be moderate)
- A download of a standalone copy of Windows 8.1 requires 4GB[104]
- Ofcom's 429 page 2014 Communications Market Report is 4MB[105]

[99] FSB, *The fourth utility: Delivering universal broadband connectivity for small businesses across the UK*, July 2014
[100] AudioMountain, *Audio File Size Calculations*, accessed 24 April 2015
[101] Network Strategies, *Faster broadband connectivity: the cost-benefit equation for small business in New Zealand*, 31 October 2014
[102] OsiriX, *DICOM sample image sets* (accessed 12 May 2015)
[103] Based on typical JPEG file size for Canon EOS 5D Mark III professional SLR camera. *Techno Buffalo, Canon EOS 5D Mark III Review – A Worthy Successor*, 26 July 2012
[104] Microsoft, *Creating installation media for Windows 8.1* (accessed 5 May 2015)
[105] Ofcom, *Communications Market Report 2014*, 7 August 2014

We have assumed that in 2015 the average media-using employee uploads 1 GB of data and downloads the same amount. We assume these transfers take place in four sessions (two up and two down), with a delay tolerance of 10 minutes each time – so, for example in 2015 the employee would wait 10 minutes to upload 500 MB of data.

This download volume is equivalent to the photographer above, or an individual downloading a full copy of Windows 8.1 every four days (though our assumptions would allow for substantial additional downstream and upstream traffic respectively).

For the future, we assume that traffic volumes grow at 10% annually, implying 2.6 GB of traffic (up and down each) in 2025. We also assume that expectations tighten, with transfer times shortening to five minutes in 2025 rather than ten today.

Streamed video

In BSG's survey of microbusinesses, only 29% reported that they 'create or view videos', and just 12% say that they do so at least weekly.[106] However, it is possible that respondents had in mind 'legitimate' business use of video. It seems likely that recreational use of video from business premises is more widespread.

Indeed, for many enterprises managing such recreational video use can be a challenge – it is perceived as being a 'bandwidth hog', driving up communications costs. A number of vendors offer products to allow IT managers to cap or block video traffic on enterprise networks.[107]

However, regardless of what proportion of video traffic is legitimate, it is a reality for businesses, and we have included it in our forecast.

Based on figures from Ofcom's *Digital Day* study,[108] we estimate that the average employee consumes 6 minutes per day of online video at work (including video within social media sites such as Facebook, and allowing for some video advertising on general sites). We assume that this figure will grow at 10% annually, giving 17 minutes of workplace video per day by 2025. (For heavier users, this implies over 50 minutes of video per day).

The average bitrate for a professional video stream (for example, from OTT TV providers) in the UK was 1.55 Mbps in 2014.[109] We

[106] ComRes (for BSG), *Broadband Usage among Micro Businesses*, November 2014
[107] Including McAfee, BlueCoat and Kerio
[108] Ofcom, *Digital Day 2014*, 13 October 2014
[109] Convivia, *2015 Viewer Experience Report*, 21 April 2015

assume an average downstream bit rate of 2 Mbps, and hold this figure steady. Implicitly this implies improving video resolution, since improvements in video compression would otherwise reduce bandwidth requirements over time. We assume 0.5 Mbps is the upstream requirement.

Bittorrent and other P2P

Bittorrent is another application which enterprise network managers actively seek to control – many of its uses are recreational rather than professional. However, Cisco figures suggest file sharing represents 7% of business traffic.[110]

Data on the nature of workplace usage of Bittorrent is limited. We assume 5% of employees are users, and that the average user downloads two hours of video per month (at work). This assumption gives a volume of traffic roughly equivalent to Cisco's figure.

We assume 2 Mbps encoding of the content, with slower than real time downloads today rising to real-time by 2025. (Some torrenting happens in real time today, but this is perhaps less likely to be insisted on in a work environment).

Internet of things and low bandwidth apps

While internet of things and machine-to-machine traffic are increasingly important, such traffic is generally telemetry and consequently low bandwidth. We group this traffic with other low bandwidth applications, such as VoIP (voice over IP) communications and audio streaming.

We assume a base requirement of 200 Kbps per premise, plus 50 Kbps per employee (both upstream and downstream). This would, for example, be enough for each employee to be having a VoIP call simultaneously. These assumptions are also conservative (high) in comparison to the base level of traffic evident in bandwidth traces we have been given for a 50 person office.

We assume requirements triple by 2015.

Sector specific applications

In addition to the above applications, which we assume are used to some extent in all types of workplace, we have also incorporated the

[110] Cisco VNI

bandwidth needs of 'guest wifi' – that is, bandwidth not for employees but visitors to the premise in question.

Accommodation

For accommodation businesses (hotels, B&Bs and so on), guest wifi is an increasingly vital offering. We estimate 2.5 rooms per hotel employee,[111] and a 2015 requirement of 1 Mbps down, 0.2 Mbps up per room.[112] This implies 2.5 Mbps down for guest wifi per employee. We assume this requirement doubles over the next decade.

Residential care activities

For residential care (for example, old people's homes) we assume requirements at 30% of those for accommodation. The elderly are less intense users of the internet, and there usage is likely to be more evenly spread over the day, rather than compressed into evening hours, as would be typical for guest usage in a hotel.

Food & beverage service

For pubs, cafes and restaurants, wifi is also increasingly expected. US speed tests give an average hotspot speed of just over 4 Mbps for McDonalds, and 9 Mbps for Starbucks, the two most generous outlets.[113] The three other F&B outlets tracked averaged in the range 1-2 Mbps. Note however that such tests measure currently available capacity, net of any capacity being used by other customers in the outlet. Thus, if (say) average utilisation was 50%,[114] such test results would crudely imply a total capacity of 8 and 18 Mbps for McDonalds and Starbucks respectively. Actual demand could certainly be higher or lower than these figures, and Starbucks' bandwidth *may* represent 'over-provision' for today's needs, given that is a significant outlier.

Such metrics are challenging to convert to per-employee metrics, not least because the average UK McDonalds actually employees more people than the average UK Starbucks (over 60 vs 11).[115] However, we assume a base requirement of 7.5 Mbps downstream for even the smallest business, with an additional 0.25 Mbps per employee

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[111] Based on figures from Oxford Economics, *Economic contribution of UK hospitality industry*, September 2010 and *AM:PM Hotels* (accessed 6 May 2015)

[112] Comcast, *The Connected Traveler: What Your Hotel Needs To Know*, 2014. See also Cisco, *Hotel Guests Say Broadband Is Important - Can You Meet Their Expectations?*, July 2011, which suggests dramatically lower figures (albeit now potentially out of date)

[113] OpenSignal, *US Wi-Fi Report*, July 2014. These are obviously not small businesses, but do give a sense for what users might expect from a hotspot, whoever provides it

[114] According to Ofcom, *Infrastructure Report 2014*, 8 December 2014, average traffic per hotspot is 54GB per month. Assuming 25 days of operation and 8 hour days, this implies an average bit rate for a hotspot of 0.6 Mbps. If this applied to the McDonalds and Starbucks hotspot, then our notional 50% utilisation rate is a significant overestimate, and the implied capacity should therefore be appreciably lower than the 8 and 18 Mbps we cite

[115] McDonalds, *What makes McDonalds?* (accessed 6 May 2015);Oxford Economics, *The economic impact of Starbucks on the UK economy*, July 2013

(and 1 and 0.1 Mbps upstream) These assumptions imply 10 Mbps for a ten person business, roughly in line with Starbuck's current provision

Excluded applications

Having discussed the applications included in the model, we now briefly turn to some of the applications we have omitted.

Software updates

We have omitted software patch downloads. These are frequently scheduled to happen in off-peak hours, or rely on systems which deliberately reduce their requirements if the network is busy. For instance, Windows uses a 'Background Intelligent Transfer Service' for patch downloads. This monitors network usage, and transfers only using idle bandwidth.[116] BITS also enables peer-caching – the sharing of a single downloaded patch file across multiple PCs.

Given these characteristics, these patches and updates are unlikely to have a meaningful impact on peak hour bandwidth requirements.

We also have omitted mobile OS updates. Because such files are not particularly large (800 MB is typical for iOS), and released only occasionally, they had only minor impact on our residential model. The impact is likely to be lesser in a corporate environment. Apple typically releases such updates between 1 and 3pm Eastern Time, or 6-9pm in the UK. As such, the main surge of traffic (which can be significant in overall network terms) is likely to hit residential rather than business lines, and certainly sits outside general business busy hours.

Remote server backup

We have reflected in the model the bandwidth requirements of cloud storage services such as Dropbox. However, some businesses keep the primary copies of their files on a local server which is then regularly backed up, typically daily. Historically such backups were to tape, but increasingly they are to servers in the cloud. This can require substantial bandwidth (even when, as typically is the case, only changes are being uploaded, rather than the entire server).

However, such backups are usually scheduled to take place in the early hours of the morning. In some cases they may happen during working hours, but such systems generally deploy network

[116] Microsoft, *Network bandwidth* (accessed 6 June 2015)

monitoring similar to that of BITS, to reduce their bandwidth requirements when the network is busy.

For these reasons, remote server backup is unlikely to impact peak-hour bandwidth requirements.

Remote access / VPNs

Remote log-in is used by 17% of micro businesses and 37% of those with 10-49 employees.[117] However, we have not explicitly included it in our forecasts, to avoid duplication. Since we do not reduce the number of active employees in a premise to account for those working remotely, it would be double-counting to also factor in bandwidth usage associated with remote access. Such remote access anyway uses little bandwidth – below 150 Kbps (often much below) for most office productivity applications.[118]

[117] Ofcom, *SME experience of communication services - a research report*, November 2014
[118] Citrix, *XenApp and XenDesktop: Bandwidth Showdown*, 10 October 2013

8. Model Results

In setting out the results of the model, we first describe the metrics we will use to describe bandwidth demand. Secondly, we set out the base case results of our model. Thirdly, we provide sensitivities to our base case results, to illuminate the wider range of possible outcomes, and to highlight the most sensitive input assumptions.

While the model provides figures over time, for simplicity we will focus on 2025 and how it compares to 2015

In interpreting these results, it is important to note what they are and are not. They are a forecast of technical bandwidth demand – that is, the actual bandwidth used by a small business premise. This is not necessarily the same as the bandwidth that a business might be willing to pay for, which could be more or less. For example, a business committing to a two-year contract might well buy above its current demand, to allow headroom for growth. Or a small business owner with many demands on her time may choose to over-provision, simply to avoid having to revisit the issue of broadband requirements in the near term.

We also note that some small businesses may buy more or less bandwidth than they need out of lack of technical knowledge. Recent Ofcom research[119] has highlighted that small business decision makers often lack ICT expertise, meaning that they may be unsure of their technical requirement; the range of products available to meet that requirement; and which product is likely to be best suited.

Describing bandwidth demand

Descriptions of bandwidth requirements are often made in broad terms: "typical small businesses will need X Mbps". However, such statements are incomplete in two ways.

Firstly, there is enormous variation in needs, so the requirements of a typical premise may not be particularly illuminating.

Secondly, the duration of requirement is crucial. If a premise's peak need in a month is (say) 50 Mbps, but that demand lasts for just one minute per month, that is a very different situation from having a sustained demand for an hour per day of 50 Mbps.

In the former case, the business may be unwilling to pay for an upgrade to receive 50 Mbps – they would likely rather just wait the

[119] Jigsaw [for Ofcom], *SME Experience of communications services*, 18 June 2015

minute to begin one of the activities, or perhaps live with degraded video quality[120] or slower page loads in that minute (assuming their current bandwidth is sufficient for the rest of the month).

In the latter case, faced with an hour per day of degraded experience, the business might be far more likely to upgrade to 50 Mbps to enable its employees to work efficiently.

Thus (in line with the previous residential demand forecast) we set out the results of the model in terms of '4-minutes-excluded-monthly demand'. A demand of 50 Mbps on a 4 minute excluded basis means that if we ignore the premise's four highest bandwidth minutes of usage per month, 50 Mbps would be enough to fully satisfy the household's bandwidth needs for the rest of the month. (The ignored minutes could require 100 Mbps or 200 Mbps, but in either event this is set aside).

The choice of 4 minutes of congestion per month (or one per week) is arbitrary. Tightening to '1 minute excluded monthly' increases the required bandwidth, loosening to 10 minutes would decrease it.

Some commentators believe that the correct metric is zero minutes - that is, no matter how brief the demand, the network should be built to accommodate it.[121] However, infrastructure is almost never built to accommodate extreme cases – roads are not built to run without congestion at the peak of rush hour, reservoirs are not built to provide the full demand for water in a drought, and telecoms networks are not built to meet all demand at all times. The reason is simple – the cost of doing so would greatly outweigh the benefits.

For telecoms, 'five nines' is often said to be 'carrier grade' reliability. Five nines mean that availability is 99.999% (or all but 0.4 minutes per month). The significance of 'carrier grade' is that carriers are presumed to need far higher reliability than their customers. An outage for a carrier can affect many customers at once, and is obviously more serious than an outage at a customer premise affecting only that one customer.

We also note that degraded internet performance for an end user can be caused by many things – poor performance by a client device, a congested wifi network, congested transit links, problems at the

[120] Most video over the internet uses adaptive bitrate streaming. With ABS, the streamed picture quality adjusts automatically in light of available bandwidth. Thus, in the face of congestion, the viewer might receive SD rather than HD video for a period, but the stream would continue without interruption

[121] See for instance Dr. Alessandro Monti [WIK Consult], *Market potential for high-speed broadband connections in Germany in the year 2025*, 15 January 2013, which says "Optimal user experience has to be guaranteed at any time. No limitations on usability or function"

application server and so on.[122] This suggests that the benefits of extremely high performance in the access link may be 'lost in the noise'. Conversely, lines with very low speeds appear to be particularly likely to have problems in *other* areas, such as wifi issues – perhaps because such lines are likely to have older routers.[123]

Against this background, we have taken the view that '4 minutes excluded monthly' is a reasonable threshold for a business premise's bandwidth – it is equivalent to 99.99% full availability, and as we have noted, even within the four excluded minutes the most likely adverse consequence is a moderate degradation of video resolution or a slightly extended download, rather than anything more serious. By contrast, 'five nines' availability may mean a complete loss of service for 0.001% of the time, not a degradation.

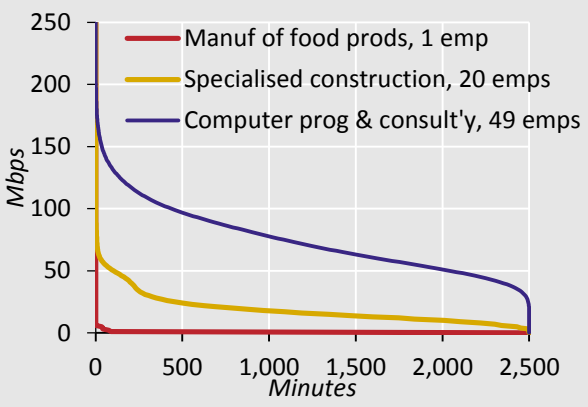
Model outputs

Usage profiles of individual premises

As we have described, the model works bottom up, building from an employee's usage of a range of applications, combining these usages to get overall usage profiles for different types of employee, and in turn combining these to create the usage profile of a particular business premise type. The model develops 2450 such profiles (based on 1-49 employees and 50 different industry sectors). These premise profiles are then combined according to the nationwide small business premise mix to get to a national profile of usage.

Figure 32 shows the results for three sample premise types – a single person food manufacturer, a 20 employee construction business and a 49 employee computer software/consultancy business. Clearly the demand profiles are very different. The software business is using substantial bandwidth throughout the 41.7 busy hours[124] (or 2,500 minutes) in the month. At times demand is above 200 Mbps. By contrast, our solo food manufacturer rarely uses the internet at all, and has very little demand beyond 5 Mbps.

Figure 32: 2025 downstream usage profile, sample premises



[122] Ofcom empirical research in a residential environment found that for access speeds above 10 Mbps, such factors were responsible for virtually all instances of degraded performance, with the access link very rarely acting as a constraint. See Ofcom, *Infrastructure Report 2014*, 8 December 2014

[123] Actual Experience (for Ofcom), *Internet Performance Evaluation*, 24 October 2014

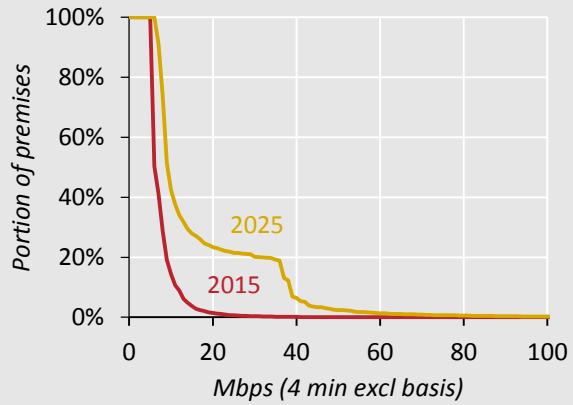
[124] We work on 250 working days per year, or 20.83 per month. We also assume 2 busy hours per day

By 'reading off' the demand in the fourth busiest minute for these businesses, we can determine their '4 minute excluded' demand. They are 6, 84 and 193 Mbps for the food, construction and software business respectively.

Usage profiles across premises (downstream)

By undertaking this analysis for each of the 2,450 premise types we model, and weighting according to the frequency of each of these premise types, we are able to build a picture of overall demand. Figure 33 shows the results, for 2015 and 2025.

Figure 33: Downstream bandwidth demand distribution



In 2025, for example, approximately 20% of small businesses premises have a demand of 31 Mbps or more (on our '4 minute excluded' basis). While this may seem low, it is worth recalling that: 80% of small business premises have just one or two employees; approximately half of small business employees are low users, with limited professional reason to be online; and (in part for this reason) bandwidth intensity is lower at work than at home.

In 2015 we estimate the median premise demand is 5.0 Mbps and the 95th percentile demand is 13.0 Mbps. By 2025 these figures rise to 8.2 and 41.1 Mbps respectively.

Note that we provide median figures for reference only – network planning should not focus on such a metric, since a network designed for the median user would by definition disappoint half the users.

Usage profiles across employees (downstream)

While the mix of demand across premises is important from a network planning perspective (since this is what most closely relates to mix of lines required), it risks understating the importance of those premises which require very high speeds. Such premises are likely to be those with the most employees (and the most economic activity). Thus (say) focussing the 95th percentile of premise demand would ignore 5% of premises, but potentially a much greater share of employees.

To explore this issue, we have analysed the bandwidth demand distribution across employees, as well as across premises. Figure 34 shows the results. As we have seen, in 2025 approximately 20% of small businesses premises have a demand of 31 Mbps or more. However, 39% of employees work in premises with a demand of 31 Mbps or more.

Figure 34: Downstream bandwidth demand, premises and employees

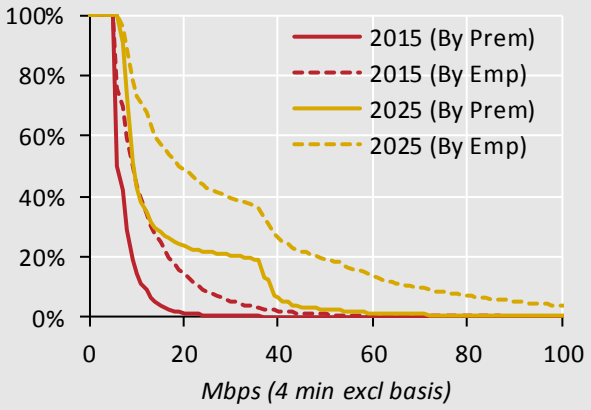


Figure 34 also shows that while there are few premises with a need of more than 50 Mbps, there are substantial minority of employees in such premises. Indeed, over 4% of employees are forecast to work in premises requiring 100 Mbps or more in 2025.

In 2015 we estimate the median employee demand is 8.0 Mbps per premise[125] and the 95th percentile demand is 29.7 Mbps. By 2025 these figures rise to 18.2 and 91.3 Mbps respectively.

Note that the above analysis looks at all small businesses. However a complication from a policy and planning perspective is that many small businesses do not work from business premises. As we have seen, 44% of single person businesses work from home, for example.[126] Such home businesses will benefit from the coverage of residential broadband (though of course it is open to them to purchase pure business products for a residential address).

However the focus of broadband policy regarding SMEs is (to some extent) on the provision of broadband to pure business premises. These premises have somewhat heavier bandwidth requirements than the average small business premise, since it is the smallest small businesses which are most likely to operate from a residential address.

Figure 35: Downstream bandwidth demand, prems and employees (excl home businesses)[127]

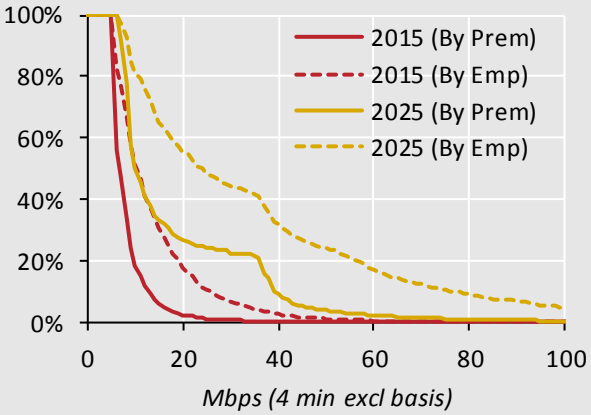


Figure 35 shows the bandwidth requirements of small businesses operating from business premises. For such businesses the 2025 median and 95th percentile premise demand is

[125] That is, the median employee (if all employees were ranked by the bandwidth need of their workplace) works in a premise requiring 8.0 Mbps. This is quite different from a per-employee demand

[126] See page 14

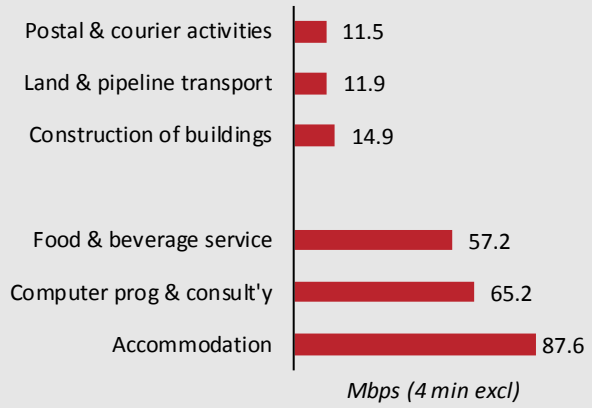
[127] Businesses with no office premises are also excluded

9.0 and 45.2 Mbps, compared to 8.2 and 41.1 Mbps for *all* small businesses.

Demand variation by industry (downstream)

The model also allows us to understand variation across industries, driven by their different employee mixes and premise sizes. As Figure 36 shows, there is wide variation. The average computer programming & consultancy employee will work in a premise requiring 87.6 Mbps in 2025. For Food & Beverage the average requirement is 57.2 Mbps. In both these cases demand is primarily driven by growing provision of wifi for customers.

Figure 36: 2025 downstream bandwidth demand (employee weighted) by industry, top & bottom 3

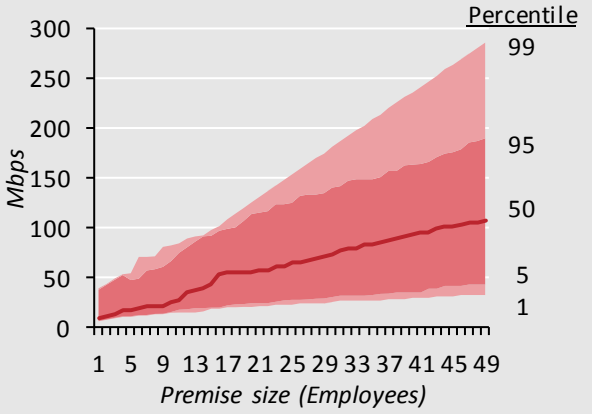


At the other end of the scale, the average postal & courier worker's premise will need just 11.5 Mbps – most employees will spend most of their day away from a desk, reducing bandwidth requirements.

Demand variation by premise size (downstream)

Thus industry type is an important factor in the distribution of requirements, but so too of course is premise size. Figure 37 shows how 2025 median bandwidth demand grows with premise size (the red line). Thus the median 49 person premise requires 107 Mbps in 2025. The chart also shows the variation on either side of this median – caused by the industry type of the premise in question. Thus the top 1% of 49 person premises require 286 Mbps or more, and conversely the bottom 1% require just 32 Mbps.

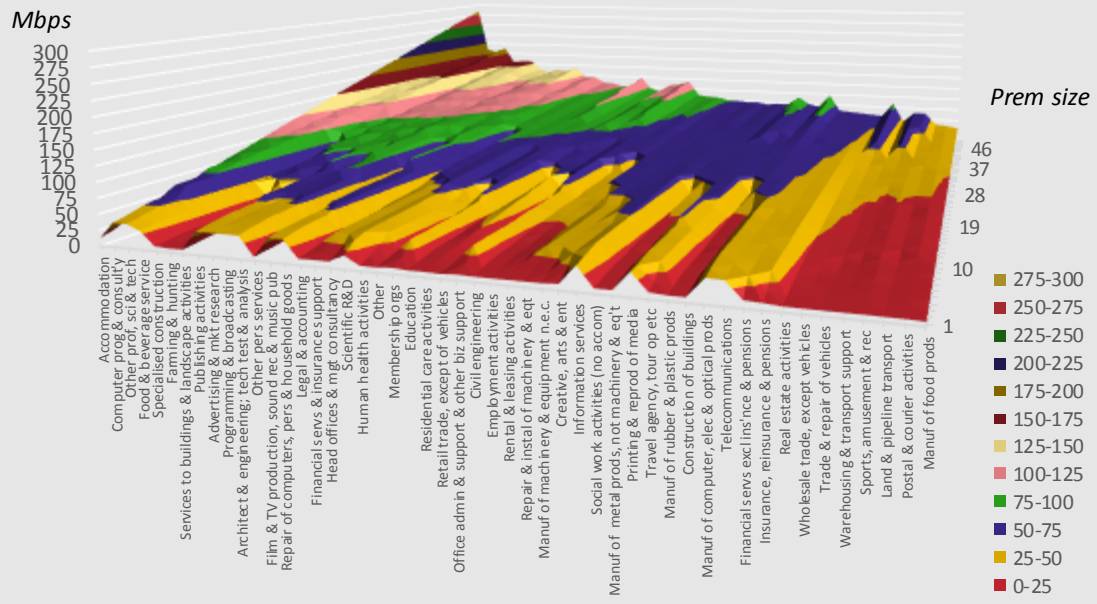
Figure 37: Range of 2025 downstream bandwidth demand by premise size



Demand variation by premise size & industry (downstream)

Figure 38 provides a combined view industry and premise size variation. Higher bandwidth industries are shown to the left, lower to the right. Premise size is shown from front to back. All industries need more bandwidth as premise size grows (the surface slopes up and away), but this rate of growth is different for different industries – ordered as they are, there is also an upward slope to the left. The larger premises of the more demanding industries have a demand approaching 300 Mbps.

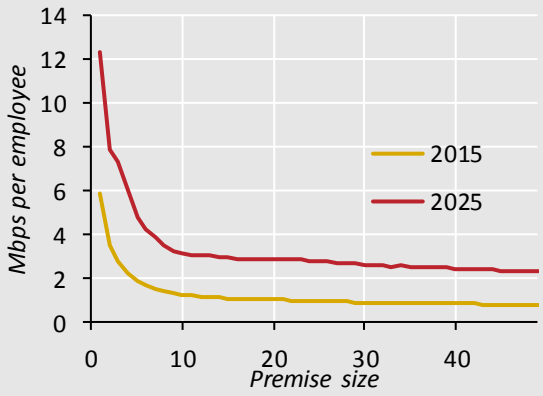
Figure 38: 2025 downstream bandwidth demand by industry and premise size



Per employee bandwidth (downstream)

Another perspective on demand comes from *per employee* bandwidth needs. Figure 39 shows how this varies by premise size. Small premises have relatively high bandwidth needs per employee. However as premise size increases, stat-mux gains come into effect, and the per-employee need drops and then (approximately) stabilises. For larger premises, the model estimates a per employee need of around 1 Mbps today, rising to 2.5-3 Mbps in 2025.

Figure 39: Downstream bandwidth demand per employee by premise size



The 2015 estimate is actually somewhat higher than the bandwidth 'rules of thumb' discussed above.[128] These were generally below 1 Mbps, and typically were for office workers only, excluding the non-knowledge workers included in our estimates.

This 2025 range will be enough for every employee to be simultaneously watching their own HD video stream,[129] with 1 Mbps per employee left over for other for other activities.

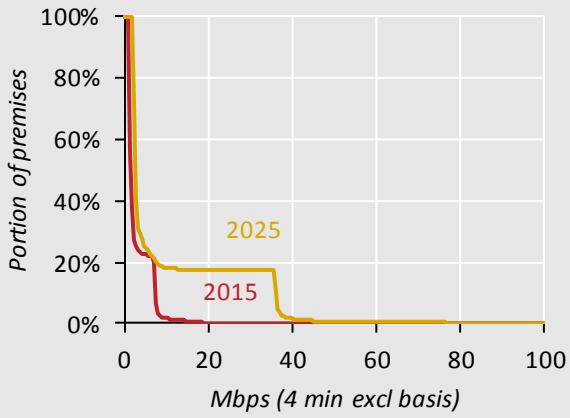
[128] See page 15

[129] Allowing for the benefits of ongoing improvements to video compression

Usage profiles across premises (upstream)

We now turn to *up*stream demand. Most of the applications used by small businesses have relatively moderate upstream demands. Exceptions are file transfer and (to a lesser extent) video conferencing. Figure 40 shows the model's estimates of 2015 and 2025 upstream demand.

Figure 40: Upstream bandwidth demand distribution



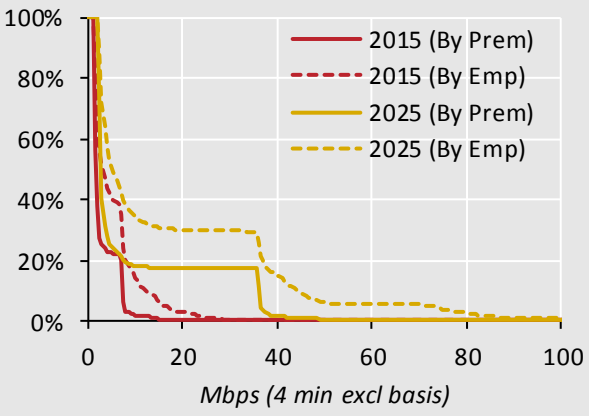
Note the 'shelf' at 18% of premises, particularly evident in the demand curve for 2025. This is caused by file transfers – those premises which have such transfers have appreciably higher upstream requirements than those which do not. In reality, the volume of file transfers would vary in such premises, tapering demand. For simplicity we have taken a standard (high) assumption of transfer volumes, and this results in the shelf.

In 2015 we estimate the median upstream premise demand is 1.2 Mbps and the 95th percentile demand is 7.2 Mbps. (Typical consumer ADSL upstream speeds are around 0.8 Mbps).[130] By 2025 median and 95th percentile demand rise to 2.3 and 36.0 Mbps respectively.

Usage profiles across employees (upstream)

Figure 41 adds the distribution of upstream demand across employees. On this basis, 2025 median and 95th percentile demand is 4.7 and 72.1 Mbps respectively.

Figure 41: Upstream bandwidth demand, premises and employees



Sensitivities (downstream)

As with any model, this one is dependent on a large number of assumptions. Particularly for a model looking out ten years, as this does, there is considerable uncertainty attached to these assumptions. Reasonable people may legitimately disagree with

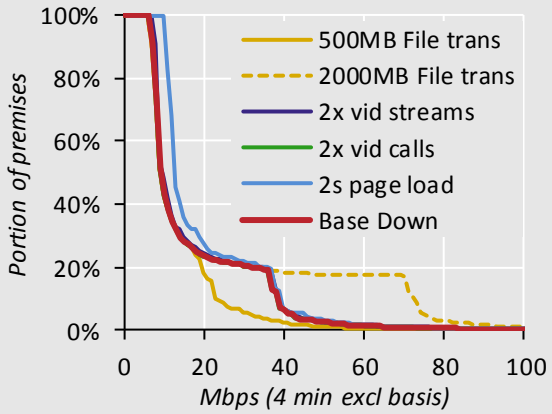
[130] Communications Chambers analysis of Ofcom, *UK fixed-line broadband performance, November 2014 - The performance of fixed-line broadband provided to UK residential consumers (Panellist Data)*, 26 February 2015

some or all of our inputs. Therefore we have undertaken a sensitivity analysis to illuminate the impact of varying certain key assumptions.

Figure 42 shows the results of a range of such sensitivities for downstream bandwidth requirements. The red line is our base case, with other lines showing the results with the respective single assumption changed.

We consider doubling and halving the size of file transfers; doubling the volume of streamed video; doubling video calls; and shortening web page load times from a maximum of 3 seconds to a maximum of 2 seconds.

Figure 42: Downstream bandwidth demand sensitivities



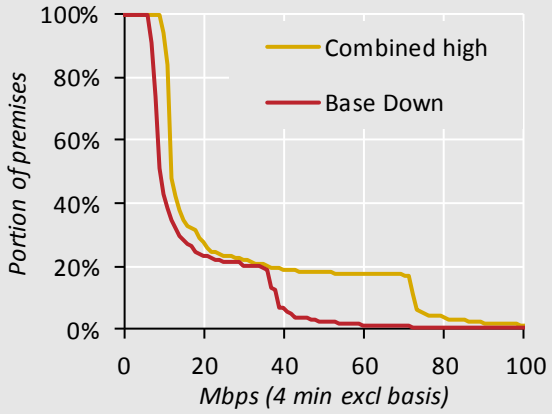
Of all these, only file transfers have a meaningful impact. These are a key driver of peak demand. Doubling the size of transfers increases 95th percentile demand to 74 Mbps from 42 Mbps (and halving it reduces it to 31 Mbps).

The other assumption with material impact is we page download time. Tightening this to 2s increases bandwidth requirements in lower use premises, since in these it is an important driver of peak demand. However, in those premises with substantial file transfers, it has relatively less impact.

Video streaming and video calling have only nominal impact. Neither is particularly high bandwidth, and both are relatively frequent even in the base case – as such, they may well already be included in peak demand.

Figure 43 looks at the combined impact of all the upside sensitivities discussed above. In aggregate, they increase 95th percentile demand to 74 Mbps. In this scenario, over 1.3% of premises (with 13% of employees working in those premises) require over 100 Mbps.

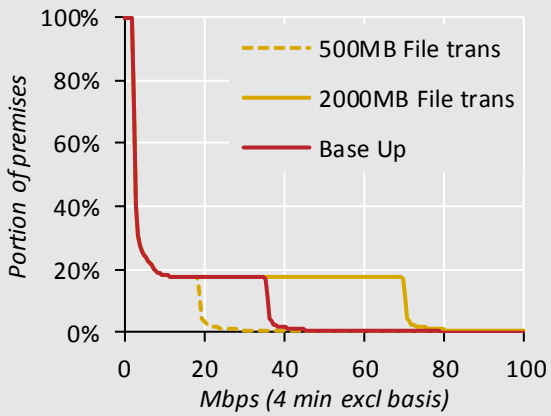
Figure 43: Downstream bandwidth demand 'Combined high' case



Sensitivities (upstream)

The key sensitivity for upstream bandwidth demand is again the volume of file transfers. Since our simplifying assumption is that media using employees have symmetric upstream and downstream file transfer requirements, changes to file transfer volumes drive very similar changes to upstream and downstream bandwidth (Figure 44).

Figure 44: Upstream bandwidth demand sensitivity to file transfer volume



Conservative assumptions

In the discussion of sensitivities and scenarios above, we primarily have focused on sensitivities that would drive increased demand. However, we have done so because we are aware that our base case forecast is lower than some more casual forecasts, *not* because we believe these upside sensitivities are more likely than downside sensitivities. Indeed, we believe that our model is, in a number of regards, highly conservative. Outcomes with lower demand than we forecast are entirely plausible. For instance:

- In considering web usage, we have not taken account of the substantial shift to browsing on a mobile device, which will appreciably reduce effective page weights. We have also used standard page weights, rather than adjusting downwards for the lighter websites typically used in a business context
- We have also taken our estimate of hours of web usage from the top end of the range of available figures, and assumed all this travels via the fixed network. (In practice some will be via employees' cellular connections)
- We assume widespread use of services such as video calling and cloud based storage, even though a substantial majority of small business do not use such services today
- For file transfers we have assumed our calculated average speed requirement (for instance, to transfer a file of a certain size in a given time) is made available throughout the download. In practice, speeds could be lower at certain times, for instance to accommodate some other spike of demand, as long as there was spare capacity later for the download to 'catch up'

- Also for file transfers, we have taken a single, high volume assumption. This will likely represent an overstatement of the requirement for a number of business types
- We have not factored in the human limits to multitasking – for instance, we have not assumed that having two tasks in process makes an additional simultaneous task any less likely
- We have taken no account of shift work – we assume all employees are on duty during the busy hour.

Summary

Downstream

Our forecast highlights the enormous diversity of small business bandwidth needs. While the median business is predicted to need just 8.2 Mbps downstream in 2025, 5% will need 41.1 Mbps and 1% will need 67.5 Mbps.

Figure 45: Summary **down**stream bandwidth demand (Mbps)

	2015		2025	
Percentile	Prem	Emp	Prem	Emp
Median	5.0	8.0	8.2	18.2
95th	13.0	29.7	41.1	91.3
99th	21.7	47.7	67.5	143.9

Upstream

There is similar diversity in upstream demand. The model suggests that in 2025 a majority of premises' upstream requirements will be well within the capabilities of today's superfast offers (typically 6.7 Mbps)[131], there will be substantial minorities for whom this is insufficient.

Figure 46: Summary **up**stream bandwidth demand (Mbps)

	2015		2025	
Percentile	Prem	Emp	Prem	Emp
Median	1.2	2.7	2.3	4.7
95th	7.2	15.6	36.0	72.1
99th	13.5	25.1	43.8	90.5

[131] Ofcom, *UK fixed-line broadband performance, November 2014*, 26 February 2015

9. Conclusion

Demand and the broadband network

The model allows us to estimate what portion of small businesses will have their (unconstrained) broadband needs met by different access technologies.

We look at three technologies – ADSL, FTTC (in the form of BT's 'up to 76 Mbps' product) and DOCSIS 3.0 (Virgin's 'up to 152 Mbps' product). We base our estimates of their capabilities on Ofcom's broadband performance report.[132] We do not provide figures for FTTP, but it would clearly be able to provide ample bandwidth for all small businesses.

Figure 47: Proportion of small business premises adequately served by different technologies

	Average speed (Mbps)		Portion of prems for which bandwidth sufficient			
			2015		2025	
Technology	Down	Up	Down	Up	Down	Up
ADSL	11	1	91.10%	43.65%	65.41%	0.00%
FTTC	60	17	99.96%	99.71%	98.64%	82.47%
DOCSIS 3.0	159	12	100.00%	98.63%	99.96%	82.26%

As of 2015, average ADSL is sufficient for the downstream needs of 91% of small business premises. However, there are two important caveats.

Firstly, there is significant variation in ADSL speed, and those in rural areas or urban not-spots may be receiving much less than the 11 Mbps average. Ofcom research has found that 24% of premises in SME-only postcodes had broadband speeds of less than 5 Mbps.[133]

Secondly, the portion of employees adequately served by ADSL's downstream bandwidth is lower, at 63%. As we have noted, the premises with the highest demand are generally those with more employees.

Moreover, while ADSL provides sufficient downstream bandwidth for a majority, it provides sufficient upstream bandwidth for only a minority of small businesses – 43.7% (using our conservative assumptions). Given only a 1 Mbps upstream capability for ADSL, even limited use of video calling, file transfers and so on can push a small business' upstream need above this capability. This suggests that many small businesses using ADSL today may (for instance) be limited to less than HD quality video calling, seeing slower uploads

[132] Ofcom, *UK fixed-line broadband performance, November 2014*, 26 February 2015
[133] Ofcom, *Broadband services for SMEs: assessment and action plan*, 25 June 2015

for cloud storage and so on. In some cases, business-critical applications may simply not function.

However, we note that the 43.7% figure is sensitive to some of the model's assumptions. For instance, if BitTorrent is excluded it rises to 49%.

Turning to superfast technologies, both FTTC and DOCSIS 3.0 appear to be sufficient for virtually all small businesses today. By 2025, their upstream capabilities will be inadequate for the (unconstrained) demand of a little under 20% of small businesses.

However by 2025 next generation technologies such as G.fast and DOCSIS 3.1 (being tested today by BT and Virgin respectively) are likely to be deployed. These, along with FTTH, will each have ample capacity to meet our forecast demand, in the areas where they have been rolled out.

Today, the model suggests that 14% of small business employees work in premises requiring more than 20 Mbps – for this group, even good ADSL is unlikely to be adequate. By 2025 approximately half of employees will work in such premises. This highlights the importance for small businesses of FTTC, G.fast, HFC, FTTH and other technologies which can deliver faster speeds than ADSL.

Diversity of demand

These figures suggest a wider spread than for residential users, for which our previous model predicted for 2023 19 Mbps median need, and 35 Mbps for the top 1% (compared to 8 and 67 Mbps for business premises). This difference is driven by the lower bandwidth intensity of business use, coupled with the much wider size range of small businesses compared to homes.

The diversity of small business requirements perhaps argues against a one-size-fits-all for broadband provision. An intervention to (say) provide 100 Mbps for all would represent a substantial overprovision for most such businesses. Focussed solutions, such as demand-side subsidies for those with an acute need, or 'bandwidth oases' – business parks scattered across the country with very high bandwidth – may be worth exploring instead.

Small business demand and residential products

A complication in mapping these conclusions onto the market is that the smallest businesses (one or two persons) which make up such a large percentage of the total may not 'present' as business customers to service providers. Many may be home based, making secondary use of a pre-existing residential broadband line, or

perhaps operating off their own line, but making use of a residential rather than a business product. Such business usage is 'invisible' – it appears as residential custom to service providers.

However, a positive consequence of this is that private and public investment to improve residential speeds is likely already benefiting a significant number of small businesses.

Limits of the model

As with any model, this one has limits. Precision must be traded off against complexity, data is often best-available rather than perfect, and so on. Also, as with any forecast, it includes a range of assumptions that are the best guess of the author as of today, but which may prove inaccurate.

Moreover, it is a forecast of a highly dynamic system (the internet) which will continue to be in flux. Highly demanding applications may appear which are outside any of the categories in the model. These represent upsides to our forecasts, and so it may (subject to cost) be sensible to 'overbuild' relative to these forecasts to allow headroom for such potential applications.

As we have noted, the model is also dependent on some highly arbitrary assumptions about expectations of transfer times for file upload and download. Others may (legitimately) take a different view on these inputs.

For these reasons, the outputs from the model are open to debate and we see our modelling exercise only as a contribution to a meaningful discussion about bandwidth needs, rather than its conclusion. However, we feel strongly that this discussion will be better founded if it is based on:

- An understanding of the size mix of small businesses
- Reference to job types, and their divergent bandwidth needs
- Recognition of the lower per-person bandwidth requirements of business use compared to residential

Finally, we note the limits of the model's scope – it is a forecast of technical bandwidth requirements. Businesses may choose to buy more or less bandwidth than they technically require. Moreover, other product characteristics, such as service levels, reliability, latency and so on may all be important to a purchase decision.