Forecasting the Take-up of Mobile Broadband Services

As demand for mobile broadband services increases, being able to accurately forecast subscriber take-up becomes a critical skill required to build a business case for infrastructure investment. Furthermore, using these forecasts to accurately predict required backhaul bandwidth will enable mobile operators to meet customers' performance expectations without costly overbuilds.

Executive Summary

With huge investments required to launch, market and grow mobile broadband services, being able to accurately forecast subscriber take-up and revenues is key. An accurate forecast of backhaul bandwidth requirements and costs is also critical to building an effective business case, to profitably pricing the services, and to dimensioning the backhaul network. This paper explores a number of qualitative and quantitative forecasting techniques that can be used by mobile operators to forecast the take-up of mobile broadband.

Qualitative techniques include:

- **Delphi method** converges answers from a panel of experts
- **Scenario planning** envisions multiple possible futures and their implications
- **Qualitative diffusion models** describe a bell curve of innovators, early adopters, early majority, late majority, and laggards and the process of how innovations diffuse from one group to the next

Quantitative techniques include:

- **"S-curves,"** such as the Bass model, provide a mathematical model based on a population of innovators and imitators
- **Causal techniques** use regression testing to identify key variables like GDP, mobile penetration and fixed broadband penetration that determine mobile broadband penetration

This paper also outlines techniques to translate subscriber forecasts into backhaul bandwidth forecasts, based either on contention ratios that have been used to forecast dial-up and fixed broadband for many years, or on translating Gigabytes per month of download.

Finally, this paper identifies mobile broadband forecasts available from market analyst firms such as Infonetics, Analysys Mason and Ovum. These forecasts can be used either as as a starting point or to sanity check internally generated forecasts.

Why Forecast Mobile Broadband?

With the huge investments in spectrum, infrastructure and marketing required to launch, deliver and grow mobile broadband services, accurate forecasting has never been more important.

Accurate forecasts are required for:

- Mobile broadband subscribers
- Mobile broadband Average Revenue Per User (ARPU)
- Mobile broadband revenues
- Mobile broadband market share
- The take-up of individual products and services like music downloads, video downloads and video communications
- Price elasticities (the effects of price cuts and flat-rate bundling)
- Bandwidth requirements (air, backhaul, core)

These forecasts are required to build the business case for investment, to effectively price the service, to plan and build the network, to drive sales and marketing plans, and to communicate with the investment community and regulators.

Can You Forecast Mobile Broadband?

Truly disruptive technologies are notoriously hard to forecast. Evidence of this is often provided in the form of the famous quote from Thomas J. Watson, Sr., then CEO and chairman of IBM, who in 1943 stated that there was a "worldwide market for about five computers."

Truly disruptive technologies tend to fall into two categories:

- New market disruptions
- Low-end disruptions

New market disruptions address needs that were previously unknown. Examples include the television, the VCR, the telephone and the Internet. Low-end disruptions target low-end users at a much lower price point, then attack increasingly higher performance segments. Low-end disruptions include ink jet printers, subsequent generations of hard drive technology, and digital photography.

Disruptive innovations are rare — the majority of innovations are sustaining or incremental improvements on prevision innovations. In developing markets in which mobile broadband delivers Internet access to customers who had not previously had access to broadband or the Internet, it could be argued that mobile broadband is a disruptive innovation. However, in developed markets mobile broadband is typically delivered to subscribers already experienced with fixed broadband and/or narrowband mobile Internet and thus is best categorized as an incremental innovation.

The amount of time, money and effort spent on forecasting should be proportional to the cost required to develop and launch the product or service in question. A major capital investment in mobile broadband infrastructure will justify a much larger investment in forecasting than a new mobile web application that requires minimal investment. In the latter case, an informal "back of the envelope forecast" together with low-cost market experimentation may prove a better option.

Finally it is worth bearing in mind that Mr. Watson's famous forecast on the size of the global computer market actually held true for ten years.

Forecasting Techniques

Fortunately, a number of forecasting techniques are available to accurately forecast mobile broadband. Forecasting techniques fall into two major categories, qualitative and quantitative, though there can be significant overlap between the two (Figure 1).

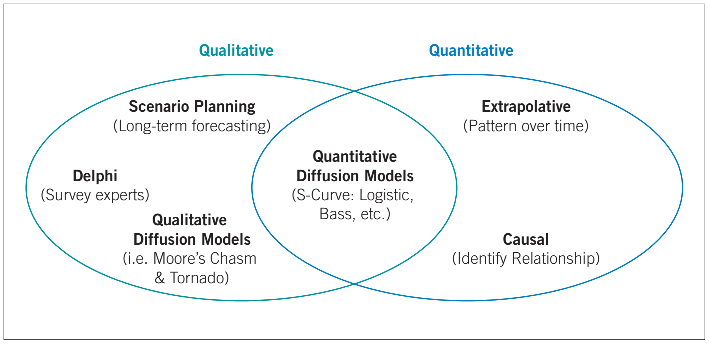


Figure 1. Forecasting techniques

Qualitative techniques include the Delphi method, scenario planning and qualitative diffusion models, such as Geoffrey Moore's technology adoption model as described in his best-selling books *Crossing the Chasm* and *Inside the Tornado.*

Quantitative techniques include extrapolative forecasts, which take historical patterns of growth and extrapolate them into the future, and causal techniques, which use statistical methods to identify causal relationships between different parameters such as price and volume or Gross Domestic Product (GDP) and ARPU.

Falling somewhere between qualitative and the quantitative techniques are quantitative diffusion models and "S-curves," such as the Bass model. These techniques use mathematical models to forecast the take-up of a new innovation. However, the input to these models is often based on qualitative judgments.

The technique most appropriate to a given forecasting situation will often be a function of the current status in the technology lifecycle. As shown in Figure 2, products and technologies go through a well-established lifecycle of launch, growth, maturity and decline. Early in the cycle with limited historical data, qualitative techniques are likely to be most useful; however later in the lifecycle with plenty of historical data available quantitative techniques can be applied.

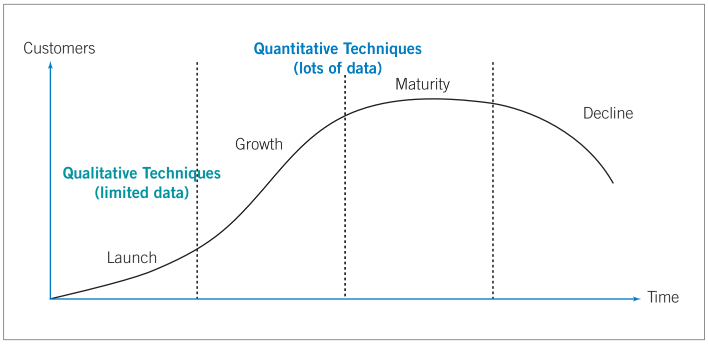


Figure 2. Forecasting techniques and the technology/product lifecycle

The Delphi Method

The Delphi method comprises a panel of carefully selected independent experts. These experts answer questionnaires in two or more rounds. After the first round, a facilitator provides an anonymous summary of the experts' forecasts as well as the reasons they provided for their judgments. Participants are encouraged to revise their earlier answers in light of the replies of other members of the group. During this process the range of the answers will decrease and the group will converge towards the "correct" answer. At the IIR Telecom Market Forecasting event in September 2007, one presentation by a major mobile operator described they had used the Delphi method to forecast the take-up of mobile broadband in the Commonwealth of Independent States (CIS) countries.

Scenario Planning

Scenario planning is a technique used to anticipate the future and prepare an organization for a variety of different but plausible alternative futures. Scenario planning was originally developed by United States Air Force military planners during World War II, but was pioneered in the business world by the oil company Royal Dutch Shell. It came to prominence after Shell was able to anticipate and prepare for the 1970s oil shock. Scenario planning was popularized by Peter Schwartz in his book *The Art of the Long View,* based on his experience in the strategic planning department at Royal Dutch Shell in the early 1980s.

A good example of how this technique can be applied to mobile broadband is the Analysys Mason report "The Future of the Global Wireless Industry: Scenarios for 2007-2012." This report outlines three possible scenarios for the mobile industry:

1. Emerging markets thrive
2. Cellular goes indoors
3. Low-cost data pipes

The term "emerging markets thrive" describes a world in which there is limited growth in developed markets for mobile data revenues and voice ARPUs decline, partly due to the proliferation of discount Mobile Virtual Network Operators (MVNO). At the same time, emerging markets see strong growth in mobile broadband and voice ARPUs.

Investment in technologies like Long Term Evolution (LTE) and IP Multimedia Subsystems (IMS) is limited and the big mobile groups and equipment vendors shift their focus to the emerging markets.

"Cellular goes indoors" describes a scenario in which data services grow rapidly, fixed mobile substitution continues at a fast pace, femtocells and Wi-Fi play key roles in delivering mobile services while at home, and mobile operators rush to offer fixed services.

"Low-cost data pipes" outlines a situation in which the price per megabyte declines rapidly as inexpensive "all-you-can-eat" data plans proliferate, VoIP cannibalizes voice ARPUs, and operators lose control of lucrative services to Web brands such as Skype, YouTube, Facebook and Google. In this scenario, the mobile broadband model closely represents the fixed broadband model in use today.

Qualitative Diffusion Models

Qualitative diffusion models segment the population of adopters based on their propensity to adopt and how they make their adoption decisions, in addition to various psychological and demographic characteristics. The population typically forms a bell curve with innovators, early adopters, the early majority, the late majority and laggard adopter categories.

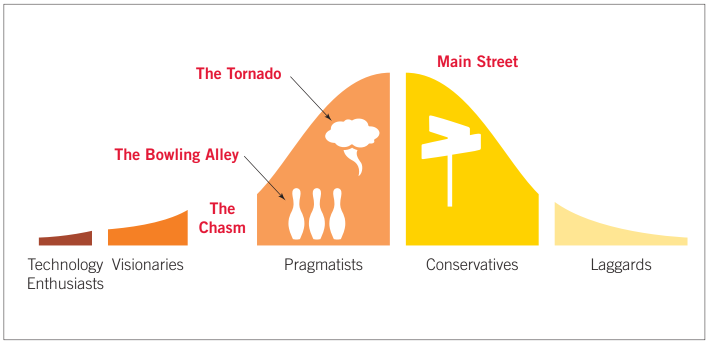


Figure 3. Technology adoption lifecycle

In his books *Crossing the Chasm* and *Inside the Tornado,* Geoffrey Moore described a model for the diffusion of IT innovations in the corporate market (Figure 3) in which adopters are divided into five categories:

1. Technology enthusiasts
2. Visionaries
3. Pragmatists
4. Conservatives
5. Laggards

Technology enthusiasts like to play with new technology regardless of whether anyone else is using it, but do not make big corporate investments. Visionaries talk to technology enthusiasts and other visionaries and will apply a business case to a new technology once they become convinced that it can give their business a significant competitive advantage.

Pragmatists also seek to give their companies a competitive advantage, but they are more risk-averse than the visionaries, whom they view with suspicion, and will only adopt once they see other pragmatists adopting — hence the "chasm" between visionaries and pragmatists. However once pragmatists do adopt, they adopt en masse, typically from the same vendor, creating a "tornado" of demand for the winning vendor (for example, Microsoft for PC software, Oracle for database software, Cisco for routers and LAN switches, etc.) taking those vendors all the way to "Main Street."

Once the pragmatists have adopted, conservatives will follow because they would otherwise be at a competitive disadvantage. Laggards are extremely conservative, adopting reluctantly and only when absolutely necessary.

In Moore's model, the key to crossing the "chasm" between the visionaries and the pragmatists is to build a "whole" product — a bundled solution consisting of hardware, software and services. This can be done for one particular vertical segment (banking, retail, etc.) at a time in the process he refers to as the "bowling alley."

While qualitative diffusion models do have relevance for mobile broadband, Moore's diffusion model probably has more relevance to adoption of mobile broadband in the corporate sector.

Quantitative Adoption Models

Quantitative adoption models use a mathematical model to forecast the adoption of new technology that results in a graph of penetration vs. time that looks like an "S" — hence the name "S-curve" (Figure 4). There are several mathematical variations on the S-curve including Linear, Exponential, Modified Exponential, Logistic, Gompertz and the Bass model.

To keep the discussion focused on forecasting the take-up of mobile broadband services, we will examine in more detail the Bass model, which appears to be the most widely used S-curve in the telecom industry, and the Logistic model, which is a variation of the Bass model.

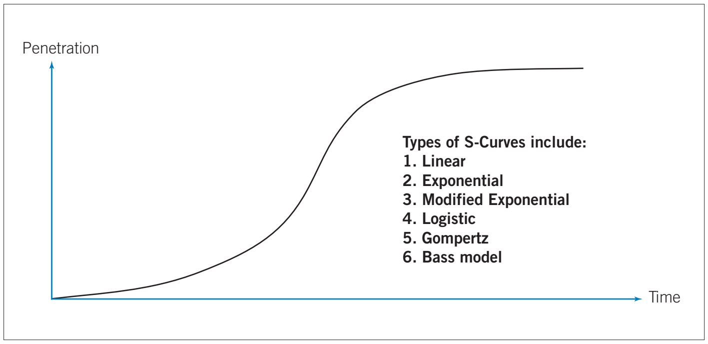


Figure 4. The S curve

The Bass Model

The Bass model, as shown in Figure 5, was developed by Frank Bass and published in 1969 in his paper "A New Product Growth Model for Consumer Durables."

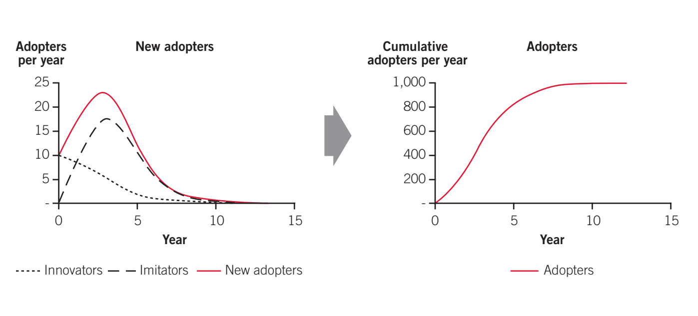


Figure 5. The Bass Model

The Bass model divides the population of potential adopters into two groups:

- Innovators
- Imitators

Innovators will adopt based on a function of how attractive the product is while imitators will adopt based on a function of how many others have adopted. The Bass model is therefore defined by three parameters:

1. P coefficient— a function of the attractiveness of the innovation to innovators
2. Q coefficient — expresses how quickly imitators will adopt based on the number of other people who have already adopted
3. M — maximum market penetration

The Logistic model is a variation of the Bass model with the Q coefficient set to zero. In other words, it only considers the innovator population.

The Bass model is described by complex mathematical formulae. Fortunately, it is not necessary to understand the equation to use the Bass model as several free Bass model Excel tools can be found on the Internet. These tools will enable you to plug in P, Q and M values and calculate a Bass model curve based on these parameters. The challenge is determining which values to assign to P, Q and M.

Applying the Bass Model to Mobile Broadband

So what values should we use for Bass model parameters when applying the Bass model to mobile broadband take-up? Choosing the Bass model parameters based on limited historical data requires a judgment and is where the qualitative meets the quantitative.

There are three primary options for estimating these parameters:

1. Simple questions
2. Product analogy
3. Country analogy

The "simple questions" option requires the forecaster to answer a number of simple questions such as:

1. % of customers that will own the product in the first year
2. Number of years until 95% of the potential market will own the product
3. % of customers that will ultimately own the product

Free Bass model tools are available that will calculate Bass curve and parameters based on these inputs.

The "product analogy" method uses historical data from Bass model parameters for similar products. These parameters are widely available on the Web — some examples are shown in Table 1. The key is to identify a product with the most similar adoption characteristics.

	P	Q
Telephone	0.000009	0.354672
Mobile Phones	0.000472	0.436508
Answering Machines	0.00000013	0.522121
Color TV	0.000046	0.634301
Cable TV	0.000005	0.499277
VCR	0.000228	0.637107

Table 1. Historical P & Q values for various innovations

The third method, "country analogy," recognizes that different countries historically have different Bass model parameters. Different countries tend to adopt at different times and at different rates. Countries with higher GDPs and less risk-averse cultures tend to adopt earlier, while the late adopters tend to adopt faster as the technologies are more mature and they are able to observe the experiences of early adopting countries.

Culturally similar countries tend to adopt in similar ways. Key cultural dimensions that influence the ratio of innovators to imitators include Authority Orientation, Collectivism vs. Individualism, Masculinity vs. Femininity and Uncertainty Avoidance (Table 2).

	More Innovators	More Imitators
Authority Orientation	Low	High
Collectivism vs. Individualism	Individualism	Collectivism
Masculinity vs. Femininity	Masculine	Feminine
Uncertainty Avoidance	Low	High

Table 2. Impact of national culture on innovators and imitators

Authority Orientation describes the level of equality in a society and the respect for authority in less equal societies. Societies with a high level of acceptance of top-down authority tend to have more imitators and fewer innovators. Countries that value individualism, such as Anglo-Saxon cultures, tend to have more innovators compared to countries with a communist past, where collectivism is more widely valued.

Masculine cultures tend to focus on achievement and success and have more innovators compared to feminine cultures, that are more focused on caring and quality of life. Finally, cultures with a low tolerance for risk and ambiguity tend to contain more imitators and fewer innovators.

	Year	p	q	m
Scandinavia & Central Europe	1985	0.00018	0.45	0.99
Anglo-Saxon Cultures (UK, USA, etc.)	1986	0.00072	0.64	0.68
South America & Eastern Europe	1990	0.00097	0.39	0.77
Rapidly Developing Asian	1990	0.00060	0.70	0.58

(Source: "The effects of country characteristics, cultural similarity and adoption timing on the diffusion of wireless communications", Sundqvist, Frank and Puumalainen, 2002)

Table 3. Adoption of cellular technology

As an example, a 2002 study on the adoption of wireless communications found that nations clustered in their year of first adoption and Bass model parameters (Table 3). GDP influenced both the market penetration and year of adoption, while cultural factors influenced both the year of adoption and the rate of diffusion.

Causal Techniques for Benchmarking Mobile Broadband

Another technique that can be applied to mobile broadband forecasting is to use causal analysis to benchmark mobile broadband by comparing a basket of countries and identifying any causal relationships between mobile broadband penetration and mobile penetration, fixed broadband penetration, per capita GDP, population density, price of mobile broadband, mobile market competition, and any other variables that might have a causal relationship with mobile broadband penetration.

The data for a number of countries is fed into a software program, which runs regression tests to identify the key variables and co-efficients. The resulting equation can be used to predict mobile broadband penetration for a new country or to forecast the impact of a change in one of the input variables (price, level of competition, etc.).

Translating Subscriber Forecasts into Backhaul Bandwidth Forecasts

While forecasting subscribers and revenues for mobile broadband and specific applications is key to analyze the top line of any business case, translating these forecasts into traffic and bandwidth forecasts is required in order to effectively plan the network and analyze the impact on the bottom line.

Contention Ratios

The simplest way to achieve this is to use the same techniques that have been used to forecast backhaul requirements for dial-up and fixed broadband Internet access for many years — the concept of "contention ratios." A contention ratio describes the percentage of subscribers that will be receiving traffic simultaneously at peak times. In the days of dial up and the early days of broadband access, this ratio was typically pegged at 50:1, based on one in ten subscribers being online and one in five of these receiving traffic simultaneously.

	Year 1	Year 2	Year 3	Year 4	Year 5
INPUTS					
Total number of subscribers	15,000,000	15,000,000	15,000,000	15,000,000	15,000,000
Number of cell sites	10,000	10,000	10,000	10,000	10,000
Mobile Internet penetration	**15%**	**20%**	**25%**	**30%**	**35%**
Bandwidth per user (Mbps)	**1.2**	**1.2**	**1.2**	**1.2**	**1.2**
Contention ratio (X:1)	**50**	**45**	**40**	**35**	**30**
Number of E1s for R99 3G (Voice)	1	1	1	2	2
Number of E1s for 2G	1	1	1	1	1
OUTPUTS					
Subscribers per cell sites	1,500	1,500	1,500	1,500	1,500
Internet subscribers per cell sites	225	300	375	450	525
Backhaul bandwidth per cell for Internet (Mbps)	5.4	8	11	15	21
Total backhaul bandwidth per cell (Mbps)	**9**	**12**	**15**	**21**	**27**
Total backhaul bandwidth per cell (# of E1s)	5	6	8	11	14

Table 4. Contention ratio example forecast

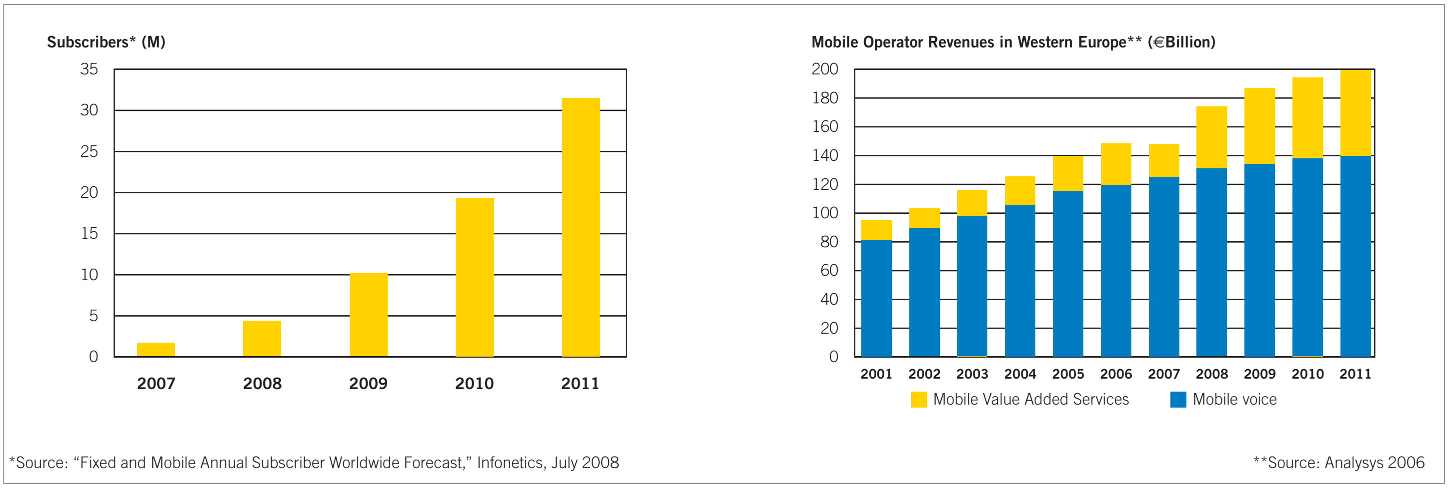


Figure 6. Example forecasts on mobile broadband subscribers and revenues

However, as broadband penetration has increased and come to play such a key role in modern life, broadband subscribers are far more likely to be online at peak times in numbers greater than one in 10. The advent of new applications like video, peer-to-peer and instant messaging, also mean that simultaneous receiving is no longer just one in five. As a result, fixed broadband contention ratios are now typically somewhere between 20:1 and 10:1.

We can apply this technique to mobile broadband, using the example of a mobile operator with 15,000 subscribers and 10,000 cell sites, with 15% of subscribers taking mobile broadband services and peak download bandwidth per user of 1.2 Mbps. If an average cell site has 1,500 subscribers — and therefore 225 broadband subscribers (1,500 x 15%) — at a 50:1 contention ratio 4.5 subscribers would be simultaneously downloading, requiring 5.4 Mbps backhauling capacity for the mobile broadband (4.5 subscribers x 1.2 Mbps). Adding the capacity required for 3G voice and 2G to this figure would equal the total backhaul capacity required at the cell site. An example forecast based on this technique is shown in Table 4.

Megabytes per Month

Another technique is to look at the number of megabytes per month downloaded for individual applications and/or segments. For example with 1 Mbps of backhaul capacity and 2.6M seconds in a month, you could support theoretical maximum of 324 Gbps of download per month. However in reality usage is not evenly spread over 24 hours and tends to peak during the day for business and in the evening for residential. Based on a number of data points from different operators, Tellabs estimates that you need to divide this number by ~8. Therefore as a rule of thumb, every 40 Gbps per month or 10 Gbps per week of download equates to an extra 1Mbps backhaul capacity required.

For example, if an operator with an average of 1,500 subscribers per cell site launches a new video download service that achieves a penetration of 10% and these subscribers downloaded 10 video clips per week with 20 Mbps per clip, this would equate to 30 Gbps per week per cell (1500 x 0.1 x 10 x 20 Mbps) and require an extra 3 Mbps of backhaul capacity.

Market Analyst Forecasts

There will be situations where mobile operators need to generate their own internal forecasts. Reasons include:

1. External forecasts do not exist or lack sufficient detail.
2. External forecasts lack the access to confidential internal data
3. Creating forecasts provides strategic insights that are not available from external analyst reports.

However, forecasts from market analysts will often provide a useful starting point and if nothing else provide a useful sanity check on any internal forecasts. Forecasts on mobile broadband subscribers and revenues are available from a number of market analysts including Infonetics, Analysys Mason and Ovum, though more commonly by region rather than individual country (Figure 6). Forecasts for individual mobile applications such as SMS, MMS, email, mobile video, mobile music, mobile gaming, etc. are available from market research firms such as Portio Research (Figure 7) and Juniper Research (Figure 8). *Heavy Reading* also provides a forecast of mobile backhaul bandwidth requirements, as shown in Figure 9.

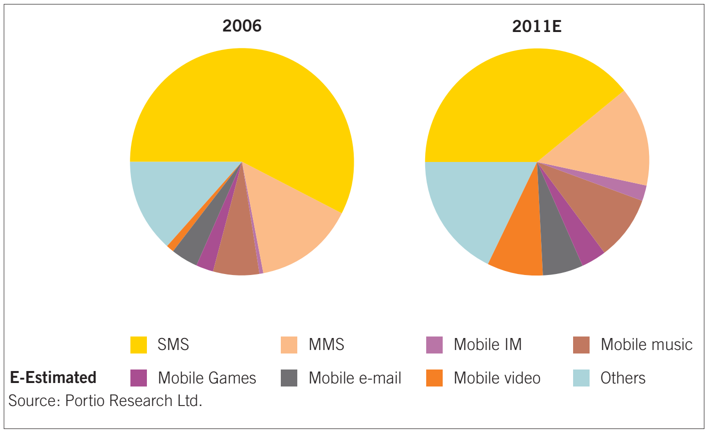


Figure 7. Example forecasts on individual mobile applications

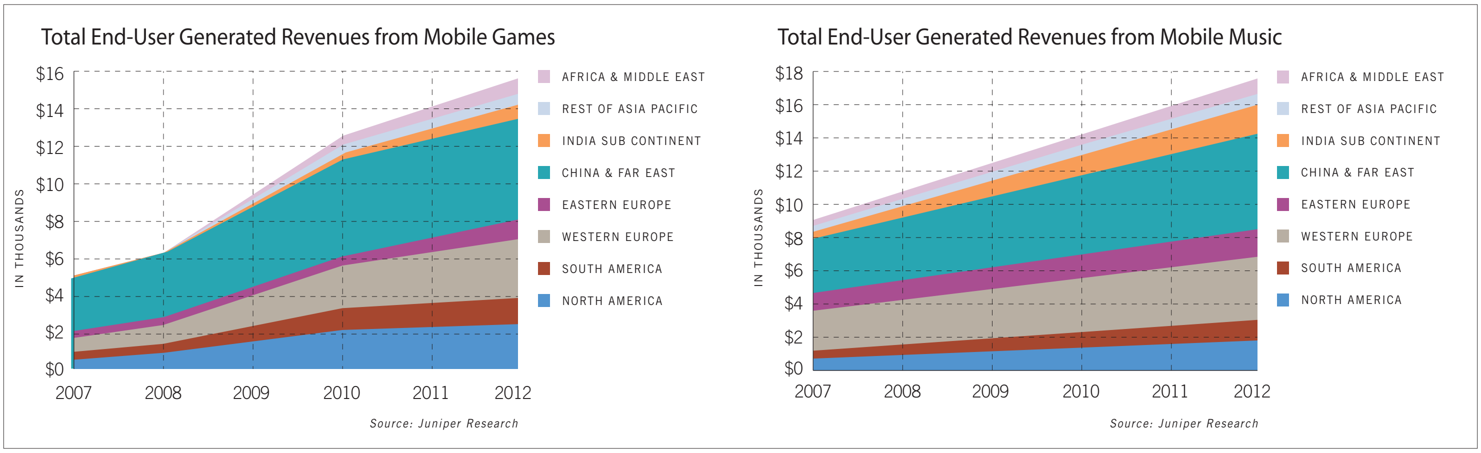
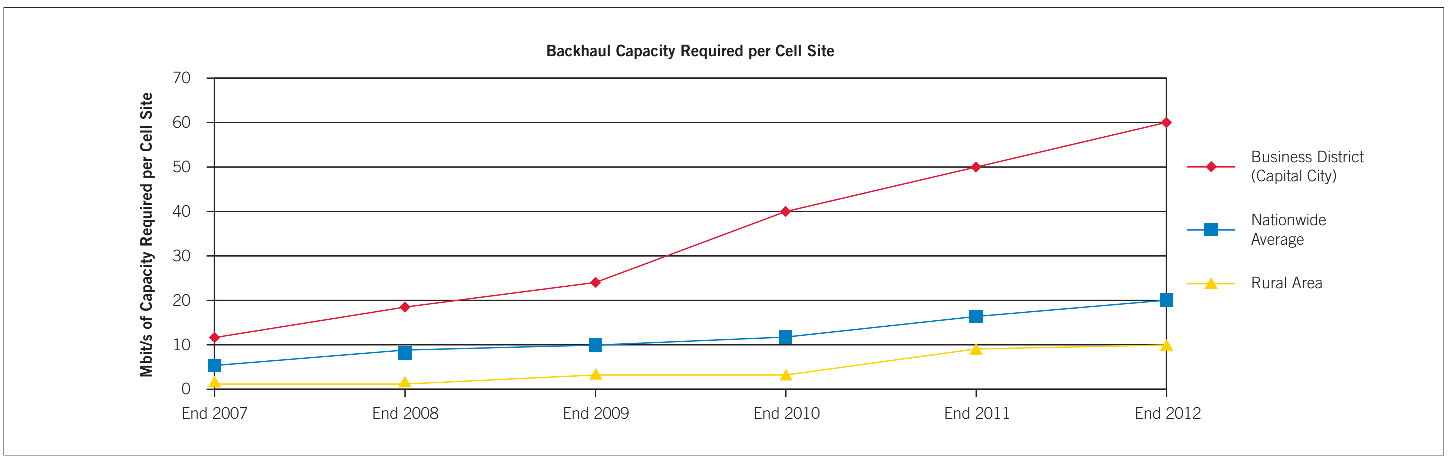


Figure 8. Example forecasts on individual mobile applications by type and geographic region



Source: Heavy Reading Ethernet Backhaul Quarterly Market Tracker July 2008

Figure 9. Example forecast on mobile backhaul bandwidth

Summary

With the huge investment required to launch, market and grow mobile broadband services, accurately forecasting subscribers, revenues and bandwidth requirements is key to both making profitable investment decisions and meeting customer expectations. Fortunately, a number of quantitative and qualitative forecasting techniques are available, many of which are already being used by mobile operators, regulators and analysts to forecast mobile broadband take-up.

Translating these subscriber forecasts into backhaul bandwidth requirements in order to effectively plan the backhaul network and meet customer performance expectations without excessive overbuilds can also be achieved using methods described in this paper. Finally, while forecasting requires significant effort in terms of time and resources and is never 100% accurate, in the words of the late French mathematician Henri Poincare, “It is far better to foresee without certainty than not to foresee at all.”

North America

Tellabs
One Tellabs Center
1415 West Diehl Road
Naperville, IL 60563
U.S.A.
+1 630 798 8800
Fax: +1 630 798 2000

Asia Pacific

Tellabs
3 Anson Road
#14–01 Springleaf Tower
Singapore 079909
Republic of Singapore
+65 6215 6411
Fax: +65 6215 6422

Europe, Middle East & Africa

Tellabs
Abbey Place
24–28 Easton Street
High Wycombe, Bucks
HP11 1NT
United Kingdom
+44 870 238 4700
Fax: +44 870 238 4851

Latin America & Caribbean

Tellabs
1401 N.W. 136th Avenue
Suite 202
Sunrise, FL 33323
U.S.A.
+1 954 839 2800
Fax: +1 954 839 2828

Statements herein may contain projections or other forward-looking statements regarding future events, products, features, technology and resulting commercial or technological benefits and advantages. These statements are for discussion purposes only, are subject to change and are not to be construed as instructions, product specifications, guarantees or warranties. Actual results may differ materially.

The following trademarks and service marks are owned by Tellabs Operations, Inc., or its affiliates in the United States and/or other countries: TELLABS®, TELLABS and T symbol®, and T symbol®.

Any other company or product names may be trademarks of their respective companies.

© 2009 Tellabs. All rights reserved.
74.2065E Rev. A 2/09