Content for All - The Potential for LTE Broadcast/eMBMS

White Paper

January 2013

Executive Summary

As smartphones and tablets reach saturation levels in many markets, mobile operators are challenged with meeting the increased demand for mobile data while minimizing capital and operating expenditures. *iG*R's own forecasts show massive growth in the world's mobile data traffic in the next five years from about 432,000 terabytes (TB) of mobile data per month in 2011, to approximately 6.6 million TB per month in 2016 – this represents an increase in monthly data consumption of more than 15 times. Not only is the amount of data being used increasing, but also the mix of types of users is shifting such that more data is being consumed by many more subscribers, not just a few business users.

LTE Broadcast or eMBMS (evolved Multimedia Broadcast Multicast Service) provides an answer to part of the mobile operators' challenges. Simply put, LTE Broadcast (eMBMS) enables a Single Frequency Network (SFN) broadcast capability within LTE, so that the same content can be sent to a large number of users at the same time, resulting in a more efficient use of network resources than each user requesting the same content and then having the content unicast to each user. eMBMS was originally defined in Release 8 and 9 of the 3GPP standards and has been enhanced in Releases 10 and 11.

LTE Broadcast can be used for distributing content such as live events and media to a wide audience, as well as for background file and software delivery and group information distribution.

Based on interviews conducted by *iG*R for this paper, there are several benefits of LTE Broadcast from the mobile network operator's (MNO) perspective:

- No changes required to consumer devices with compatible chipsets and middleware
- No hardware changes required to the LTE RAN
- Part of the standard LTE ecosystem
- Simple business cases and applications
- Vendors knowledgeable and able to provide support.

Of course, there are some concerns and issues with LTE Broadcast as well:

- Business cases are understood but benefits are not yet quantified

- Undecided about how LTE Broadcast should be deployed
- Changes required to backend systems for device software and firmware updates.

On balance, the MNOs appear to see the fact that the LTE Broadcast ecosystem is already defined, supported and growing as a major benefit. While none of the operators *iG*R interviewed for this paper have firm LTE Broadcast implementation plans at this time, future deployment was not ruled out. MNOs appear to be currently preoccupied with deployment of their first LTE networks and optimizing operation of those networks and increasing the penetration of LTE devices in their subscriber bases. LTE Broadcast is seen therefore as a capability to be deployed after the initial LTE networks rather than part of any initial service.

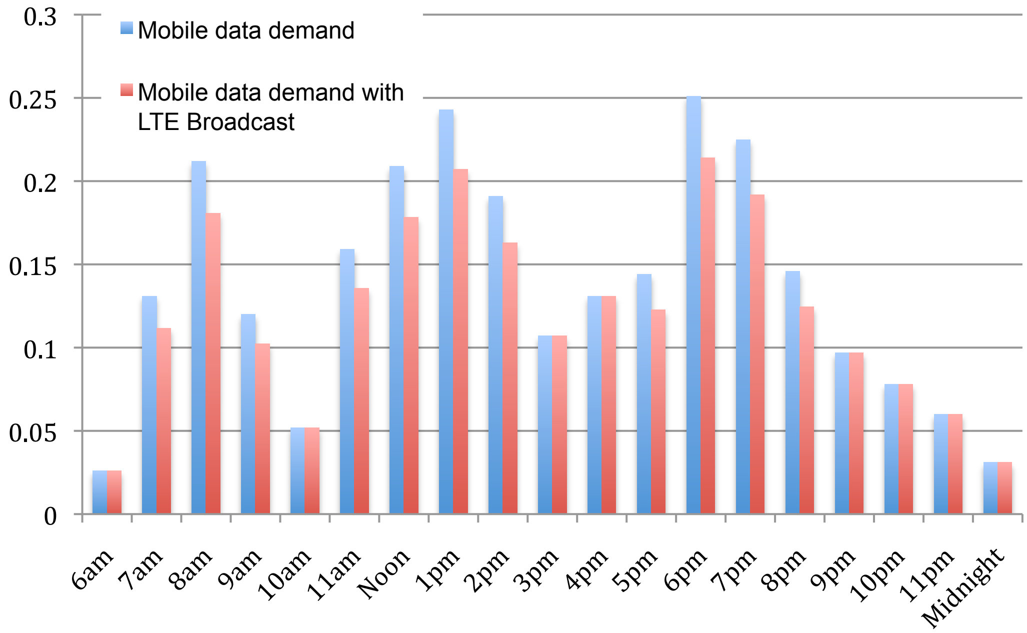
Estimating the impact of LTE Broadcast on a mobile market is complicated by the fact that no trials have to date been conducted and that no specific user data is available. However, *iG*R has built detailed models on the use of mobile data in various metro markets (described in more detail later in this paper) and has applied this modeling to LTE Broadcast.

To assess the impact of LTE Broadcast on the metro market, *iG*R assumed that the amount of video traffic will continue to grow and will reach just over 71 percent of total mobile data network traffic in 2016, while audio will comprise 9 percent. *iG*R's calculation then shows that LTE Broadcast can off-load 12.5 percent of the video data traffic from unicast overall and 15 percent during peak hours. Similarly, *iG*R's model shows that much of the audio demand in 2016 will be for streaming music services and that LTE Broadcast would off-load 30 percent of the total mobile data network traffic attributed to audio overall and 45 percent during peak hours.

As a result of the audio and video off-load, *iG*R's model shows that LTE Broadcast can off-load up to 11.5 percent of the total daily demand per subscriber and 14.7 percent during the peak hours. The amount of traffic off-loaded to LTE Broadcast is higher in the peak traffic times simply due to the type of content being consumed.

Figure 1 shows the results of this analysis. The blue bars show the expected demand for mobile data in a metro market throughout the day in 2016. *iG*R's model assumes that mobile bandwidth/usage shifts to specific points in the day, essentially making the "spikes" more pronounced - the trend towards more powerful smartphones and tablets with large, high-resolution displays encourages end users to sit and view (or work, etc.) rather than move and talk.

Figure 1: *iG*R Model of Potential Impact of LTE Broadcast on Mobile Data Demand (U.S. metro market in 2016; GB/Hour/Pop)



Source: *iG*R, 2012

As part of its ongoing wireless and mobile industry research, *iG*R forecasts the amount of capital expenditure on LTE network equipment – these models have been applied to the LTE Broadcast modeling (details are late in this paper).

*iG*R expects that much of the LTE spending will be between 2012 and 2014 as each of the major operators deploy LTE and build out the necessary coverage. In 2015 and 2016, the total spending drops such that by 2016, *iG*R expects that total U.S. LTE infrastructure CapEx will be $4.33 billion, down from $7.25 billion in 2015.

*iG*R forecast a reduction in busy hour bandwidth of 9.8 percent if LTE Broadcast were deployed. For the mobile operators, this means the amount of network capacity built in 2016 could be reduced by 9.8 percent, equivalent to an overall potential saving of $4.21 billion. For the larger operators in the U.S., full deployment of LTE Broadcast could equate savings of $60 to $100 million in 2016 alone. Obviously, the benefits of LTE Broadcast would continue in subsequent years for the MNO.

Finally, there is also the potential benefit of ARPU from new services that can only be enabled by LTE Broadcast. Just as mobile broadband led to previously-unforeseen revenue sources for the MNOs, so the same can be expected with LTE Broadcast.

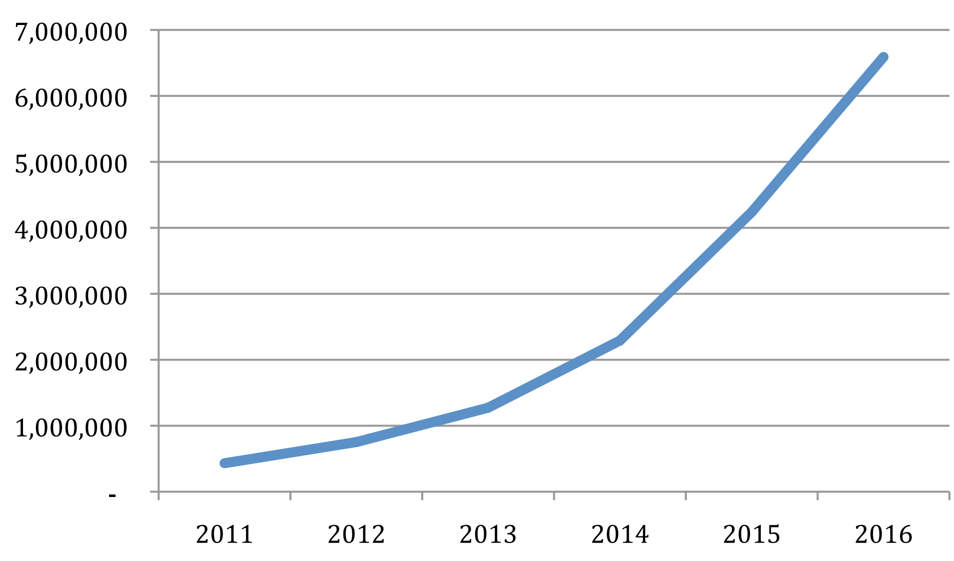
The Growth of Mobile Data

*i*GR expects massive growth in the world's mobile data traffic in the next five years. In 2011, our model suggests that mobile users consumed about 432,000 terabytes (TB) of mobile data per month over cellular networks. By 2016, we expect the world's consumption of mobile bandwidth to increase to about 6.6 million TB per month, an increase of more than fifteen times.

Although we expect developing markets' consumption of mobile data to grow faster than in more mature markets, the growth is significant in every region. In developing regions, there are several drivers behind this growth: network rollouts and upgrades, more advanced, data-centric devices at reasonable price points (including smartphone and tablets), increasing mobile device and data usage, more sophisticated content and many new cellular data connections and subscribers.

In more mature markets, the drivers include: network upgrades to 4G (LTE), super-saturation of smartphones and tablets (multiple mobile devices per user), increasing mobile device and data usage, "bigger" content, and an increasing trend toward consuming content stored in the cloud via mobile devices.

Figure 2: Mobile data usage per month per region, 2011-2016 (TB per month)



Source: *i*GR, 2012

To create the traffic forecast, *i*GR built usage profiles based on our primary and secondary consumer and enterprise research over the past several years – note that *iG*R built the model 'bottom up' by first profiling user behavior with respect to mobile devices, applications and services. *iG*R's bandwidth model uses population and demographic data from various governmental census bureaus, the World Bank, the OCED, and the United Nations, as well as from *iG*R's own mobile connections forecast report.

We have also conducted extensive primary research (including *iG*R's own Web-based surveys of consumers and businesses) in North America, Europe, Latin America and Asia Pacific for the bandwidth model. This has provided us with an understanding of how data is consumed in developed markets and how that consumption has evolved over the past 10 years. This primary research data includes which applications mobile subscribers use of specific devices, the length of time applications are used for, the frequency of use and the time of day at which devices and applications are used.

We divided connections into four different categories: light, medium, heavy and extreme. These categories are defined as much by the applications that tend to be used, as by their frequency of use, duration of use and the relative mobility of the connection (which has an impact on usage frequency).

Generally speaking, the larger the device, the more bandwidth is consumed on it - a laptop connection will likely generate far more traffic than a smartphone. That said, the advent of streaming video and audio applications (Pandora, Netflix, HBO Go, Amazon Cloud Player, etc.), not to mention YouTube, makes consuming hundreds of megabytes on a smartphone quite easy.

The following, then, describes some of the characteristics of each connection category:

- **Light Connections**: Casual, infrequent data use; a minimal amount of web browsing, social networking, photo sending, email, mapping, etc. In 2012, subscribers in this profile used approximately 169 MB per month. By 2016, Light users are expected to consume 678 MB per month.

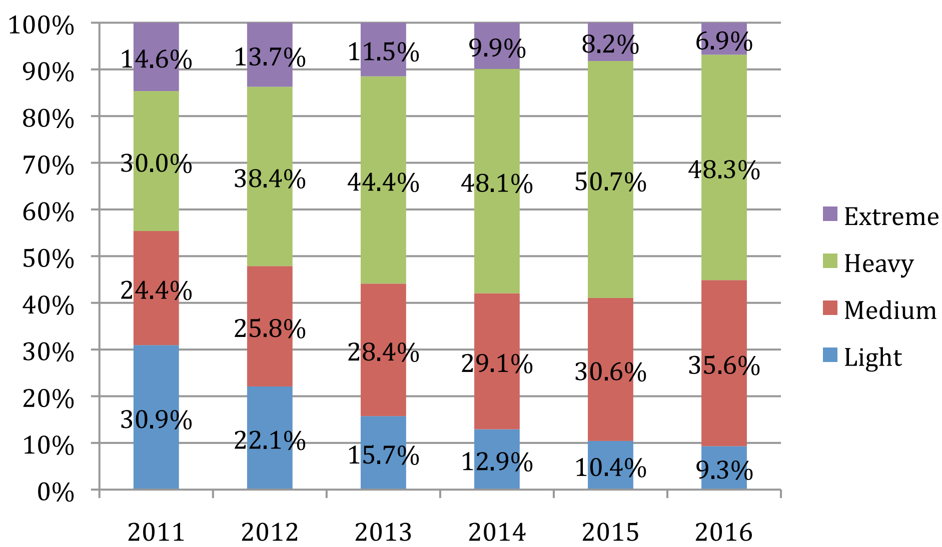
- **Medium Connections**: Less casual, more frequent data use than a Light connection; includes the addition of some usage of audio/video streaming and application downloading. Generally speaking, Medium and Light connections comprise the majority of all connections. In 2012, subscribers in this profile used approximately 358 MB per month, expected to rise to 2.1 GB per month by 2016.

- **Heavy Connections**: Significant and frequent use of the mobile device and a variety of applications – audio and video streaming, application downloads, social networking, email, etc. This type of connection might represent a mobile worker who travels several days per week. In 2012, subscribers in this profile used an estimated 1.19 per month. By 2016, Heavy users are forecast to consume 4.2 GB per month.

- **Extreme Connections**: These are connections that look a more like a wired Internet connection with several gigabytes (GB) of usage per month. This type of connection is likely to be a laptop / tablet tethered to a smartphone or a connection via USB/embedded modem. The person behind the device(s) might be a mobile worker who is always out of the office or a consumer running a BitTorrent client, constantly checking Facebook, or downloading movies or podcasts. In 2012, subscribers in this profile used an estimated 4.8 GB per month. By 2016, Extreme users are forecast to consume 8 GB per month.

Note that *i*GR has assumed that mobile data caps and tiered pricing will be used by the MNO to control usage on the network as a whole but also that the MNO will offer 'multi-device' mobile data plans where many devices share a bucket of data. In addition, *i*GR has assumed that competition will continue to force MNOs across the world to reduce the average cost of mobile data and that the amount of data available for a given price increases.

Figure 3: Changing Mobile Data Traffic by User Category, North America

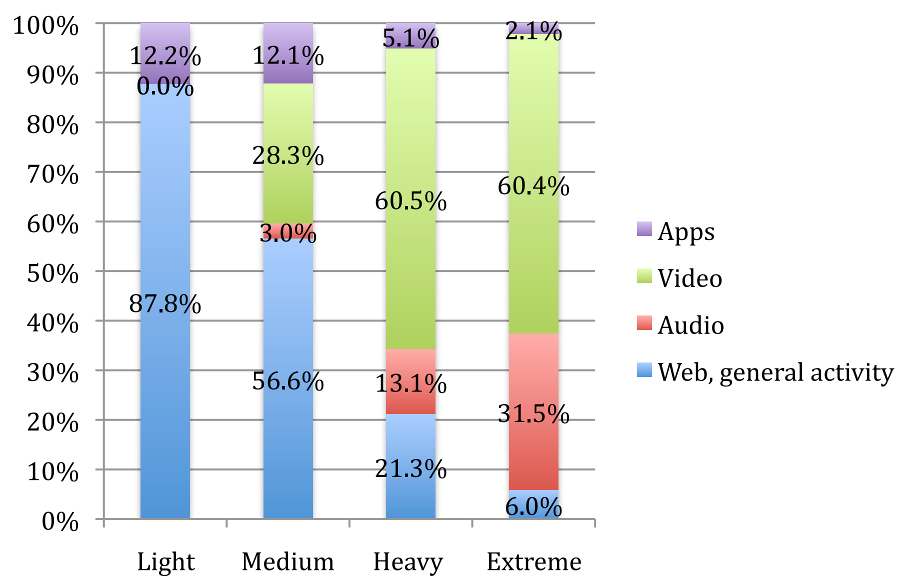


Source: *i*GR, 2012

Not only is the amount of data being used by each category increasing, but the mix of types of users in the market is also shifting. In 2011 and 2012, the majority of the mobile data traffic was consumed by Heavy and Extreme category subscribers. But by 2016, *i*GR forecasts that over 80 percent of mobile data users will fall into the Medium and Heavy categories. In other words, more data is being consumed by many more subscribers, not just a few business users.

In 2011, half of the mobile data traffic in the U.S. was for video – by 2016, video is expected to account for over 70 percent of the traffic on mobile networks in North America. The chart below shows the mix of traffic type for the four user profiles. Since LTE Broadcast is ideally suited to video content and traffic, the majority of the mobile data users would see benefit from the deployment of LTE Broadcast.

Figure 4: Type of Mobile Data Traffic by User Category, North America, 2011



Source: *i*GR, 2012

LTE Broadcast Usage Profiles

For mobile network operators that need to increase the capacity of their networks to meet the ever-increasing demand from consumers, there is no single solution. Rather, the operators are adopting a range of solutions that includes small cells, off-load to WiFi and the acquisition of additional spectrum. Another part of the solution is LTE Broadcast.

Simply, LTE Broadcast enables a Single Frequency Network (SFN) broadcast capability within LTE, so that the same content can be sent to a large number of users at the same time. *i*GR believes this is a more efficient use of network resources than each user requesting the same content and then having the content unicast to each user. eMBMS was originally defined in Release 8 and 9 of the 3GPP standards and has been enhanced in Releases 10 and 11.

As well as distributing content such as live events and media. LTE Broadcast can also be used for background file and software delivery. The following gives examples of the types of content that can be distributed and the benefits.

Live events

Video and audio content for live events can be distributed at the event itself or broadcast to a wider audience outside of the venue. For example, the audience at a basketball game may be able to receive player stats and scoring information via WiFi or a closed broadcast system in the arena itself. And those watching on TV may also get similar information on a dedicated website.

For those in the arena, distribution is usually by WiFi or via a dedicated private system. Using WiFi is inefficient for broadcast since each user is receiving a unicast content stream – capacity is ultimately limited. The private broadcast systems currently offered are relatively expensive, since they use custom end user devices (the consumer cannot use their own smartphone or tablet) and specific wireless transmission equipment (these systems do not use the public mobile networks).

For those outside of the arena wishing to watch the game on their smartphones or tablets, all that is needed is a broadband data connection, such as provided by LTE. The problem for the MNO is that multiple consumers are likely to be asking for the same content in the same metro market and each subscriber will be consuming a data stream on LTE. For example, if 5,000 people in Dallas want to get a live Mavericks game on their smartphones or tablets, that is 5,000 separate data sessions the operator must provide – exactly the same content would be distributed on 5,000 separate sessions.

In this example, LTE Broadcast would enable one video distribution to the 5,000 consumers at the same time – each user smartphone/tablet would simply 'listen in' to the LTE Broadcast channel to receive the content. Thus, demand on the unicast LTE network is off-loaded to broadcast.

The same method could be used in the arena itself – all that is needed is LTE Broadcast. This would then leave WiFi for other applications.

Of course, content includes more than sporting events. Breaking news, entertainment and popular content could all be distributed via LTE Broadcast to standard LTE smartphones and tablets. Note that multiple video channels of live content could be distributed at the same time. For example, one channel may show the presidential State of the Union speech while another channel showed a popular sit-com. Each MNO will decide which content will be broadcast based on the expected demand from the subscriber base – the higher the number of subscribers receiving the broadcast, the more efficient LTE Broadcast becomes.

Media distribution

Prerecorded content can also be distributed by LTE Broadcast. For example, popular TV programs, movies or recorded sports events can be distributed in off-peak hours to smartphones, tablets, media hubs or laptops. This then allows the user to access the content immediately (without having to download the content first) and without using unicast LTE network resources.

For off-peak distribution, the consumer device must be scheduled to 'listen' to the broadcast at the correct time. For example, if a consumer has a subscription for a season of a popular TV program, the smartphone or tablet could be scheduled when the season is purchased to listen in at specific times to receive the content. As long as the device was powered on and on the LTE network, the content would be received.

Since the LTE networks are generally not used between 11PM and about 5AM, LTE Broadcast could be used essentially 'free' to distribute content for caching. Attractive pricing and business models could be used to incentivize consumers to download content in this way, rather than on-demand during peak hours.

Group information distribution

LTE Broadcast can also be used to efficiently distribute content to groups of users at the same time. For example, in the event of a major natural disaster, voice, video and other content could be sent to emergency workers over a wide area. As long as the LTE network was available, emergency personal would be able to receive updates and critical information.

The same approach could also be used for non-critical information such as updates from popular entertainers, sports stars and celebrities. Consumers would subscribe to a channel of video tweets and feeds from their favorite celebrity for example. The content would then be distributed to a wide audience simultaneously, as opposed to having each consumer request the same content and then sent via unicast.

Many types of content could be distributed in this way. Attendees to major trade shows such as the Consumer Electronics Show (CES) or Fashion Week in New York that span multiple venues and locations could receive keynote videos and presentation via LTE Broadcast, while exhibitors would pay to have product demonstration videos and information distributed.

Offload data

The latest smart consumer devices require regular software updates for firmware and operating systems, as well as applications. As consumers use more and more mobile applications, so the number of updates required increases. Updates have traditionally been completed by synching to a PC or Mac, but increasingly the new smartphones and tablets sync over-the-air. While this may be by WiFi in the home, the LTE network may also be used thereby increasing the load on the network for simple device 'maintenance'.

LTE Broadcast could be used to distribute software and firmware updates at off-peak hours to multiple devices at the same time. Obviously, this is a far more efficient use of network resources than having each user update during peak hours on a unicast LTE connection.

One possible issue with distributing updates via broadcast is that the mobile operator support systems would likely have to be modified since each update today requires confirmation from the device of each download and successful install. Devices would also have to be scheduled to 'listen' to the distribution broadcast. Thus, use of LTE Broadcast for software updates would likely have to be incorporated in a complete update eco-system to be fully effective. That said, once the necessary integration is complete, LTE Broadcast would be an extremely efficient method of distributing mobile device software and firmware updates.

Operator view of LTE Broadcast

As part of the research for this paper, *i*GR interviewed several mobile operators (who had already deployed LTE networks) to assess their interest in and understanding of LTE Broadcast. Interviews were conducted with technical staff knowledgeable of the operator's LTE deployment plans.

In general, the mobile operators *i*GR interviewed were knowledgeable about the LTE Broadcast/eMBMS technology and the applications it enabled, since the broadcast technology has been defined as part of the 3GPP LTE standards. In addition, it appears that most operators have discussed deployment options with multiple LTE infrastructure vendors; although none of the MNOs *i*GR spoke to confirmed deployment of LTE Broadcast.

Perceived benefits of LTE Broadcast

From the mobile operators' perspective, the benefits of LTE Broadcast can be summarized as:

- **No changes required to consumer devices with compatible chipsets** – since LTE Broadcast is defined as part of the 3GPP LTE standards, no hardware changes are required to the subscriber device hardware that use an eMBMS-compatible chipset. Further, a common LTE Broadcast service layer middleware can be utilized across all devices to simplify broadcast application development, provide consistent user experiences, and minimize interoperability testing with LTE infrastructure. An LTE Broadcast application would likely be needed initially, but this could be offered as a simple download from specific websites. This is seen as a major advantage by the mobile operators since LTE Broadcast could be of benefit to the entire LTE device portfolio.

- **No hardware changes required to the LTE RAN** – while LTE Broadcast does require an additional server in the EPC and a new software load on the eNode B, no hardware changes are required to the LTE eNode Bs. This obviously minimizes deployment and maintenance costs.

- **Part of the standard LTE ecosystem** – LTE Broadcast is supported in the main 3GPP standards and therefore operators can benefit from a worldwide ecosystem and economies of scale for FDD and TDD LTE.

- **Simple business cases and applications** – in order to benefit from LTE Broadcast, the MNO really does not have to develop any new applications or content, or change subscriber behavior. Simply, a user just has to keep consuming content on their smartphones and tablets for the operator to see a benefit from LTE Broadcast.

- **Vendors knowledgeable and able to provide support** – it appears that the major LTE RAN vendors have discussed deployment of LTE Broadcast and presented technical proposals to the MNO. Since no changes are required to the RAN hardware, the vendors are able to provide implementation and operating support.

In summary, the MNO appear to see the fact that the LTE Broadcast ecosystem is already defined as a major benefit. Since new subscriber devices and specific content formats are not required, LTE Broadcast could be deployed and be effective very quickly across the entire LTE subscriber base.

Concerns

The interviewees also raised a few concerns and issues with LTE Broadcast:

- **Business cases are understood but benefit not yet quantified** – while the mobile operators understand the business cases for LTE Broadcast, the impact and economic benefit has yet to be calculated and confirmed.

- **Undecided about how LTE Broadcast should be deployed** – this issue is tied to the fact that the expected benefits for LTE broadcast have not been quantified. MNOs are undecided about how broadcast should be deployed – at specific locations and venues or across every eNode B in a metro market? Obviously, this decision impacts the costs and expected benefits. *i*GR believes that the MNO simply need more information on the business case for LTE Broadcast in order to make this decision.

- **Changes required to backend systems for device updates** – the current OSS for software and firmware device updates require specific responses from the devices. From the interviews, it is clear that the MNO believe that changes would be required to the OSS to accommodate distribution of update via LTE Broadcast.

Outlook for LTE Broadcast

While none of the operators *i*GR interviewed for this paper have firm LTE Broadcast implementation plans at this time, future deployment was not ruled out. Rather, it seems that MNOs are currently preoccupied with deployment of their first LTE networks, optimizing operation of those networks and increasing the penetration of LTE devices in their subscriber bases.

LTE Broadcast is seen therefore as a capability to be deployed after the initial LTE networks rather than part of any initial service. From an economic point of view, the operator is challenged with providing LTE coverage initially as opposed to network capacity – the benefits of LTE Broadcast are therefore unlikely to be realized until the LTE network is loaded.

From *iG*R's perspective, LTE Broadcast is likely to provide significant value in a market where there is significant LTE device penetration and subsequent benefit to the MNO.

Estimating the impact of LTE Broadcast on a mobile market is complicated by the fact that no trials have to date been conducted and therefore no specific user data is available. However, *iG*R has built detailed models on the use of mobile data in various metro markets and has applied this modeling to LTE Broadcast.

*iG*R's modeling of the potential impact of LTE Broadcast on a major metro market takes into account the following:

- How mobile data demand changes during the day across the metro market
- How LTE Broadcast changes the demand for LTE unicast in the subscriber base
- How the use of LTE Broadcast changes the LTE unicast capacity available.

This section describes how the model was created by *iG*R, the major assumptions made and the estimated impact LTE Broadcast would have on a market.

Mobile data usage during the day

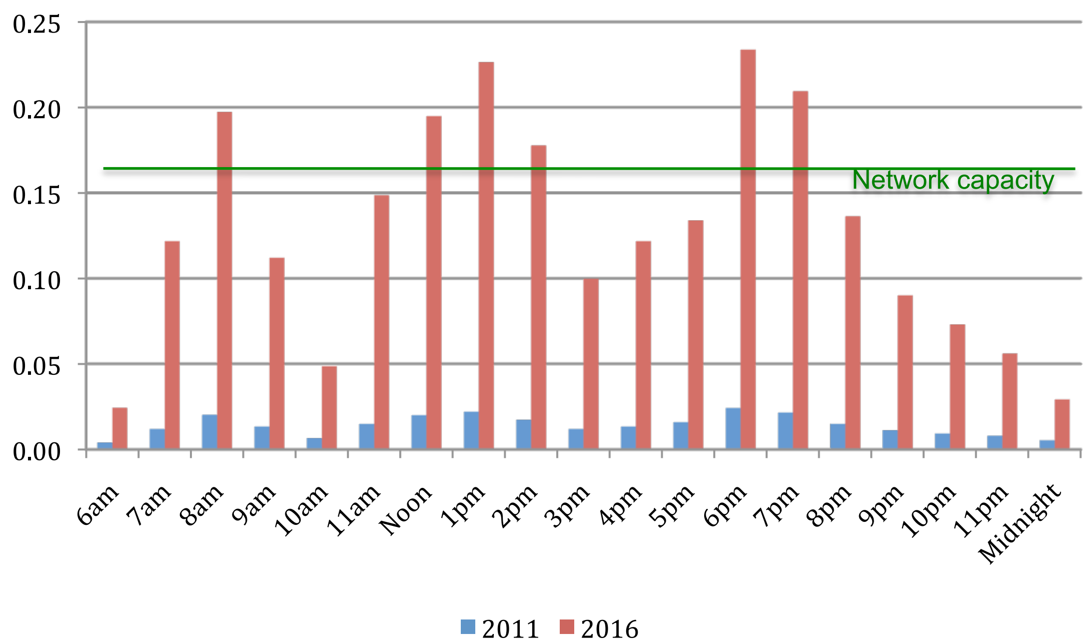
Figure 5 below shows *iG*R's estimate, based on *iG*R's own primary research (including Web surveys of mobile subscribers across the globe), of how an average individual's cellular data use might be spread throughout a hypothetical weekday, for 2011 and 2016. Essentially, there are three peak usage times: morning (commute); mid-day (lunch) and evening (commute):

- In the early morning, commuters might be on a train streaming morning TV or radio shows to their phones. Or, maybe they're doing the same thing in a gym.
- During the midday lunch hours; users might be doing any number of Internet-related activities on either a smartphone or a tablet.
- In the evening hours, people might be commuting, exercising and/or socializing. Any and all of these activities involves the use of cellular data.

*iG*R is assuming that mobile bandwidth consumption during the day shifts over the forecast period and that the overall amount of bandwidth consumed increases each year. Remember, as well, that bandwidth consumption per person per month is also increasing over the forecast period – from 466 MB/month/user in 2011 to an anticipated 2.4 GB/month/user in 2016. So, even in the off-peak hours more bandwidth is consumed. Again, note that this is the average amount of bandwidth per hour and is based on our per-month forecast. (Full details on the model and methodology can be found in *iG*R's market studies: *Global Mobile Data Traffic Forecast, 2011 – 2016: Up, up and up some more* and *Localized U.S. Bandwidth Demand Forecast, 2011 - 2016*).

The green line shows the estimated ***mean network capacity throughout the day*** in 2016 for this market. Note that the mobile data demand exceeds the estimated capacity at multiple times during the day. At 8 AM, for example, *iG*R expects that in 2016 demand will exceed average capacity by about 32 percent or 0.05 GB/Hour/POP. These peaks are those times when usage exceeds the average of what the network can handle at a given point in time. Such peaks equate to no service, bad service, or slow service. Consistent poor service could lead to higher churn.

Figure 5: Mobile Bandwidth Demand by Time of Day (GB/Hour/POP)



Source: iGR, 2012

Note that this forecast assumes the deployment and increasing availability of LTE – and adoption by consumers – throughout the forecast period. By 2016, ***iG*R has assumed that 70 percent of the total mobile data demand in the market will be carried by the LTE network.** In reality, macro cellular networks in 2016 will probably be a mix of LTE Advanced, LTE and 3.5G – with LTE probably being the majority deployment in a (sub)urban environment.

The point is that despite LTE, *iG*R's model shows that the macro network will still be incapable of meeting (on average) peak hour cellular data demand. Put differently, simply deploying LTE to meet this excess bandwidth demand is insufficient. It is unlikely to solve the problem.

Also note that *iG*R's model assumes that mobile bandwidth/usage shifts to specific points in the day, essentially making the "spikes" more pronounced. *iG*R believes that the trend towards more powerful smartphones and tablets with large, high-resolution displays encourages end users to sit and view (or work, etc.) rather than move and talk.

These devices – along with the mobile broadband connection – also encourage new types of content consumption. Netflix works quite well on an iPhone with LTE connectivity; so does Pandora.

Modeling demand for LTE Broadcast

To assess the impact of LTE Broadcast on the metro market, *iG*R assumed that the amount of video traffic will continue to grow and will reach just over 71 percent of total mobile data network traffic in 2016, while audio will comprise 9 percent.

*iG*R then calculated that LTE Broadcast can off-load 12.5 percent of the video data traffic from unicast overall and 15 percent during peak hours. Similarly, *iG*R has assumed that much of the audio demand in 2016 will be for streaming music services and calculated that LTE Broadcast would off-load 30 percent of the total mobile data network traffic attributed to audio overall and 45 percent during peak hours.

As a result of the audio and video off-load, *iG*R's model shows that LTE Broadcast can off-load up to 11.5 percent of the total daily demand per subscriber and 14.7 percent during the peak hours.

Note that the amount of traffic off-loaded to LTE Broadcast is assumed to be higher in the peak traffic times simply due to the type of content being consumed. For example, in the morning and evening commute, a driver may listen to streaming music in the car – today this would be accomplished with unicast but this is an ideal candidate for broadcast. At lunch, an LTE Broadcast user is likely to watch a news update or a popular TV program while having lunch. But between times of peak demand, the consumer is likely to be at work and therefore web browsing or using email, which cannot easily be broadcast.

In addition, several other assumptions have to be made:

- That LTE Broadcast will be deployed over the entire metro area, in all eNode Bs. While LTE Broadcast could be deployed in select areas or venues, this significantly complicates the model since subscriber movement in and out of the LTE Broadcast coverage has to be modeled. Also, *iG*R believes that the LTE Broadcast solution pricing makes deployment over the whole market more attractive and economical.

- That the amount of LTE spectrum dedicated to Broadcast can be varied between 10 percent and 60 percent. In fact, the 60 percent allocation is only required once during the day.

- As the spectrum allocated to Broadcast increases, so the corresponding LTE unicast spectrum available drops and hence the capacity of LTE unicast declines. Obviously, the more subscribers that benefit from a specific broadcast, the greater the reduction in LTE unicast demand.

- *iG*R are assuming a 28 day month since the survey data suggests that in the U.S., mobile bandwidth usage on Saturdays looks more like weekday traffic than it does Sunday usage.

- The model shows the average demand and capacity across the metro market. Since demand is not spread evenly across a metro market, there will be pockets where demand (and network capacity due a higher density of cells) is greater. Hence, LTE Broadcast could have a greater or lesser impact in places across the market but will average to the figures *iG*R has shown.

- The model does not factor in subscriber movement throughout the area and throughout the day but rather looks at an average demand network capacity.

- Finally, the model has assumed that LTE Broadcast would be deployed in 2014 and that capacity would increase through 2016, when all eNode Bs in the metro market are covered.

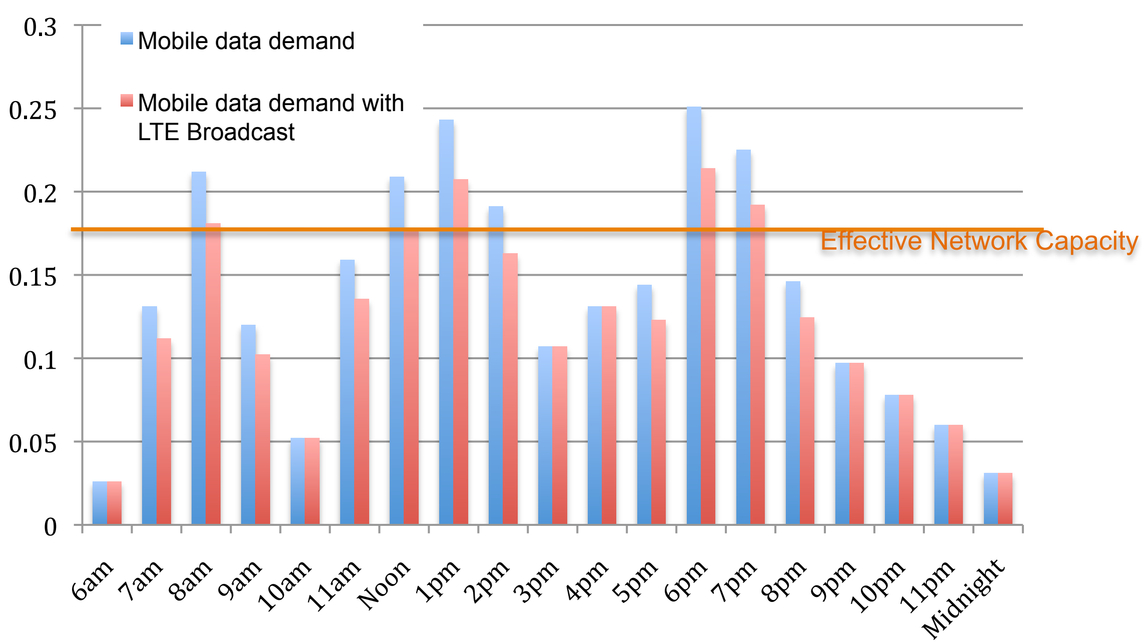
Impact of LTE Broadcast

Figure 6 shows the impact of LTE Broadcast on the market. The red bar is the revised mobile data demand for 2016, assuming that LTE Broadcast is deployed across the metro market. **Demand decreases by 14.7 percent across the busy hours** due to Broadcast since subscribers will be able to receive the same content rather than request a unicast download.

However, since LTE Broadcast is deployed, the LTE unicast capacity also drops at those busy times, since spectrum must be used for broadcast. *iG*R's model shows that the revised mean network capacity across the day drops by 4.9 percent (to 0.152 GB/Hour/POP from 0.16 GB/Hour/POP) in 2016.

Thus the net impact on the market of LTE Broadcast is an increase in effective network capacity of 9.8 percent during the busy hours by 2016 (shown by the orange line in Figure 6). This means that the operator can either reduce the amount of network capacity built in 2016 by 9.8 percent (thus saving capital expense) or could add new subscribers to the market without requiring additional network capacity. In addition, additional ARPU can be expected from new services that can only be enabled by LTE Broadcast.

Figure 6: *iG*R Model of Potential Impact of LTE Broadcast on Mobile Data Demand (U.S. metro market in 2016; GB/Hour/Pop)



Source: *iG*R, 2012

Potential impact on LTE Network Infrastructure Capital Expenditures

As part of its ongoing wireless and mobile industry research, *iG*R forecasts the amount of capital expenditure on LTE network equipment. *iG*R's LTE cost model is based on the amount of data the network is expected to be able to support and deliver. Thus, the cost model is based on the estimated cost required to add 1 GB of data capacity to the network.

Since the capacity of the network is known (based on the network technology), the cost of network build out is dependent on the subscriber growth and the data usage of each subscriber. These known/estimated variables provide the total GB the network is likely able to deliver. (Full details of *iG*R's LTE CapEx model can be found in the market study: *U.S. LTE Network Infrastructure CapEx Spending Forecast, 2011-2016*).

*iG*R fully expects for LTE uptake to grow quickly in the U.S. and in other major markets as it is deployed. And, once the LTE subscriber base starts to grow, more devices become available and usage of the network increases, then the operator increases the network capacity. Operators are continually balancing their network CapEx between coverage and capacity, and with the potential growth in ARPU from new services. The engineers strive to provide sufficient coverage to be competitive and sufficient capacity to meet the needs of the growing subscriber base (and potentially ARPU), while minimizing unnecessary CapEx.

*iG*R expects that much of the LTE spending will be between 2012 and 2014 as each of the major operators deploy LTE and build out the necessary coverage. In 2015 and 2016, the total spending drops due to fewer major deployments, the fact that operators are adding capacity and not building new sites, and due to the lower cost per GB of capacity (driven by increased scale and competition in the infrastructure market). By 2016, therefore, *iG*R expects that total U.S. LTE infrastructure CapEx will be $4.33 billion, down from $7.25 billion in 2015.

As discussed in the previous section, *iG*R forecast a reduction in busy hour bandwidth of 9.8 percent if LTE Broadcast were deployed. For the mobile operators, this means the amount of network capacity built in 2016 could be reduced by 9.8 percent, equivalent to an overall potential saving of $4.21 billion. Note that while the impact of LTE Broadcast is best seen during busy hours, the mobile operators must build their networks to cope with peak demand – for much of the day, the mobile network is underutilized.

For the larger operators in the U.S., full deployment of LTE Broadcast could therefore equate LTE CapEx savings of $60 to $100 million in 2016 alone. Obviously, the benefits of LTE Broadcast would continue in subsequent years for the mobile operator. In addition, there is also the potential benefit of ARPU from new services that can only be enabled by LTE Broadcast. Just as mobile broadband led to previously-unforeseen revenue sources for the MNOs, so the same can be expected with LTE Broadcast.

About *iGR*

iGR is a market strategy consultancy *focused* on the wireless and mobile communications industry. Founded by Iain Gillott, one of the wireless industry's leading analysts, we research and analyze the impact new wireless and mobile technologies will have on the industry, on vendors' competitive positioning, and on our clients' strategic business plans.

Our clients typically include service providers, equipment vendors, mobile Internet software providers, wireless ASPs, mobile commerce vendors, and billing, provisioning, and back office solution providers. We offer a range of services to help companies improve their position in the marketplace, clearly define their future direction, and, ultimately, improve their bottom line.

A more complete profile of the company can be found at www.*iGR*-Inc.com.

Methodology

To prepare this white paper, *iGR* used data from several sources:

- Existing *iGR* research on mobile data bandwidth demand and mobile data usage in metro markets
- Interviews with major LTE operators and specifically those knowledgeable of the companies' plans for network evolution
- Published technical papers on LTE Broadcast and eMBMS.

Disclaimer

The opinions expressed in this white paper are those of *iGR* and do not reflect the opinions of the companies or organizations referenced in this paper. The research and writing of this paper was commissioned by Qualcomm Labs. Although Qualcomm Labs provided input into the topics and technical accuracy of the paper, Qualcomm Labs was not involved in the carrier interviews or in the ongoing research.