ANALYSIS

Mobile access — the last mile

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Mobile for Development Impact

OMIDYAR NETWORK™

The MasterCard Foundation

Contents

About

GSMA Mobile for Development Impact

GSMA supports the digital empowerment of people in emerging markets through its Mobile for Development Impact programme, used to inform investment and design decisions for mobile services. Our work is freely accessible through support from Omidyar Network and in partnership with The MasterCard Foundation at gsmaintelligence.com/m4d

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Executive summary

1. Despite the growth and increasing pervasiveness of mobile networks over the last decade, there is still a section of the population with minimal or no coverage. While there are real geographic and economic reasons for this, it raises questions in the wider debate on the ways and means of providing 'universal' access to mobile and the internet.

Mobile networks are pervasive. 2G coverage now reaches more than 90% of the population in most mature markets and in many emerging ones, and while 3G coverage is generally lower (60-70%) we expect this to rise to similar levels off the back of continued investment by the mobile operators of around $250 billion per year to 2020. However, there remains a section of the population — perhaps 10–15% — that still has little or no coverage. These individuals are largely distributed in emerging markets and based in rural regions, in many ways representing the final frontier of connectivity. This is a result of an unfavourable cost-benefit equation faced by the mobile operators in which geographic impediments, vast distances and the lack of electricity grid access collectively create a significantly increased cost base for the rollout and maintenance of networks which is not compensated for by incremental revenue from a predominantly low income customer base.

We expect an additional 1.1 billion people across emerging markets to subscribe to mobile services for the first time over the 7 year period to 2020. While the majority of these are in rural regions, there is also an opportunity to connect non-adopters in cities who are covered by mobile networks but lack the income to use them. The increasing desire of governments to mandate 'universal' access to mobile and the internet therefore raises the question of how to extend network coverage to the population tail and help to improve affordability. And, who should bear the financial and operational responsibility given the positive socio-economic impact of bringing mobile connectivity to the previously unserved or unconnected? These are fundamental challenges in realising a digital future whose benefits are felt up and down the income ladder, and it is clear that collaboration between government and private sector players is necessary to achieve this.

2. The final frontier has also become the most publicly visible platform for a raft of experiments with alternative connectivity technologies backed and promoted by big internet players, with aerial networks and the use of white space in the TV spectrum most prominent. So far, these alternative technologies appear to be targeting potential use cases to expand connectivity beyond existing mobile infrastructure to help drive socio-economic impact in emerging markets — such as expanding internet access to remote rural regions and disaster response zones.

However, their viability and disruptive potential on a wider commercial scale in the short to medium term is harder to see. Short of heavily subsidising the cost of internet service and end-user devices (such as handsets or laptops), the significant outlay and increased ongoing cost base of a full-scale network present the risk that access through such means could become more, rather than less, expensive as a share of income than it already is. This matters because affordability is often a larger hurdle to adoption than coverage – a reality seen in many emerging markets where 2G mobile coverage (itself capable of handling low speed internet access) is well above ownership, particularly for low-income rural regions. In addition, there are several operational and technical challenges, and regulatory uncertainty.

Expanding networks to the sky through balloons, drones and satellites has the advantage of providing a wider range of ground coverage, which can help in serving remote rural communities, supplementing efforts to aide disaster responses, and in some cases facilitating backhaul capacity. The use of TV white space (TVWS) has a limited rural use case, with some (albeit very limited) application in urban centres at lower capacity. However, the increasing public visibility of these technologies and promotion from their formidable backers — principally Google, Facebook and Microsoft – prompts the question of whether these could cause disruption at the wider connectivity layer of the mobile sector value chain.

On their merits, we believe this is unlikely, at least in the medium term. Rolling out a scaled network entails an outlay and cost base that is much higher than the current pilots in localised areas and, while the business models to monetise this are not yet clear, it is hard to see how these solutions would not make the cost of accessing the internet more, rather than less, expensive as a share of income than it already is. Second, the technological characteristics make their scaled use in cities very difficult. Finally, they appear to rely on the use of unlicensed models for connectivity and lack of regulatory frameworks, raising questions around quality of service and the risks of planning and investing both for their principal backers and for the ecosystem that would need to form around them to catalyse scale beyond experimentation.

3. We see the more likely intent as part of a wider campaign by the large internet players to gain greater public policy influence. Alternative connectivity strategies are indicative of the increasing pace of innovation in the wider mobile ecosystem. If the first phase of this centred on the service layer (challenging SMS in particular), it now appears to be expanding to target the access level. This time, however, operators are in a stronger position given existing network scale, continued investment and demonstrable innovation of their own.

It is, of course, a difficult and often fruitless task attempting to predict the next move of a serial innovator, and from this the question of whether Google or Facebook harbours ambitions to become a full-scale connectivity provider will likely continue to circle regardless of viability. Indeed, for Google it is not the first foray into telecoms access, with it having laid high-speed fixed fibre broadband networks in three US cities and plans for nine others, as well as a local fibre build in Uganda's capital. However, we believe the real intent here is more pragmatic, with alternative access trials being used as a tool of influence with policy makers and the mobile operators, and potentially to strike licensing partnerships (as Google's recent public indications suggest). While innovative business models can play a role, the fundamental economics of network deployments to more marginalised populations that are primarily shouldered by the operators cannot be ignored.

It is in this space where a lot of innovation is coming from the mobile operators at the network level in an effort to expand coverage and lower the cost of access. Network share agreements at the passive level (sites, towers and power) have grown over the last several years, with early adopting markets such as India and Pakistan now being joined by wider-scale engagements – the recent infrastructure agreement between eight operators accounting for 551 million mobile connections (or 46% share) across Africa and the Middle East being a prominent example targeting mobile broadband access to unserved rural communities. This sharing has also started to deepen into the Radio Access Network, underpinning savings from build out capex and maintenance opex that can be re-harvested into investment. Finally, where operators have reached remote rural communities, their presence has increasingly attracted energy service companies (or ESCos) through a symbiotic micro economy. Operator demand for powering base station sites incentivise ESCos to build distributed small scale power plants serving the telecom tower and local communities either through a minigrid or energy hub model, which in turn allows consumers to charge mobile phones (among other things). All of these are win-wins for consumers and a positive influence on the take-up of mobile given that coverage expands and investment rises (it is investment, not the number of competitors, most closely linked with lower unit prices for voice and data).

Mobile and the internet — a coalescence in adoption

The expansion in access and ownership of the mobile device over the last 10 years has been significant and widespread across many regions. Subscriber growth has averaged 4% annually over this period in mature high-income markets, with this running higher at 14% in developing regions. Despite this heady rise, penetration on a unique subscriber basis is still under 45% across emerging markets — in contrast to the often-cited, but misleading SIM card penetration figure of 90%- compared to the plateauing levels of around 70-80% in mature regions such as the US and Europe (see Figure 1). Even after distilling down to the adult (15–64) population, this implies headroom for further subscriber-led growth, with the bulk to come from emerging markets. Given that these underpenetrated regions are also the most populous, the translation into absolute numbers is vast — we estimate that over the 7 year period from 2014 to 2020, an additional 1.1 billion new (i.e. incremental) individuals will acquire a mobile for the first time, or 155 million per year.

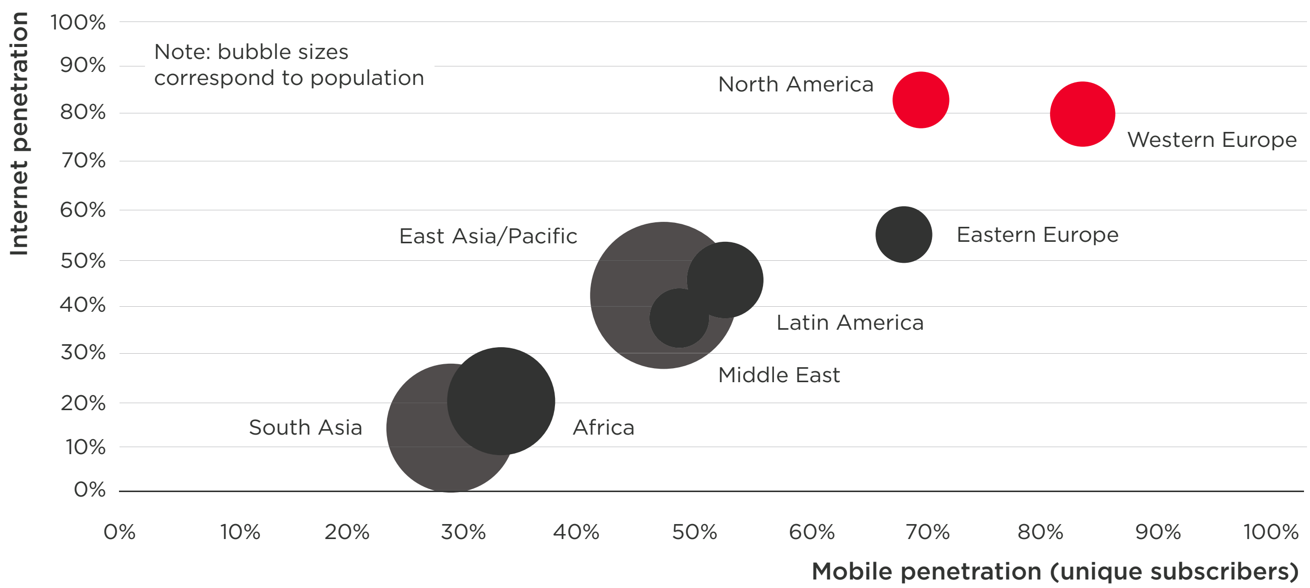


Figure 1: Growth in the mobile internet will come from emerging markets (2012)
Source: GSMA Intelligence, ITU

The rise up a single technological adoption curve is significant because of the catalytic impact the transformation has on economies and social behaviour. It is for this reason that the next 5–10 years present a unique situation given that a significant chunk (more than two-thirds) of the global population is poised to ascend two adoption curves in parallel — mobile and the internet. While in mature regions the bulk of these adoption cycles have already occurred over the last 10 years, this has largely been through two independent devices — PC first and mobile second. In emerging markets there is a general absence of widespread fixed broadband infrastructure, meaning that mobile will be the main and only gateway to the internet for the majority of currently unconnected individuals – in effect a coalescence of technology adoption (see Figure 1).

A striking reality of this opportunity is that the majority of unconnected to the mobile internet are of a different demographic to technology adopters of the west. This means lower income users of a younger age profile, most of whom are on prepaid mobile connections and who are particularly attuned to the value of social media (see Figure 2). Taking Latin America, GDP per capita is around $12,000, the median age is 27, 79% are on prepaid mobile connections and around 50% of adults (15-64) use a social network. Smartphone adoption is still relatively nascent (generally under 30%), and while we expect this to rise as prices decline, a majority of people will continue to access mobile data and the internet through feature phones for the next 3-4 years (see Mobile platform wars).

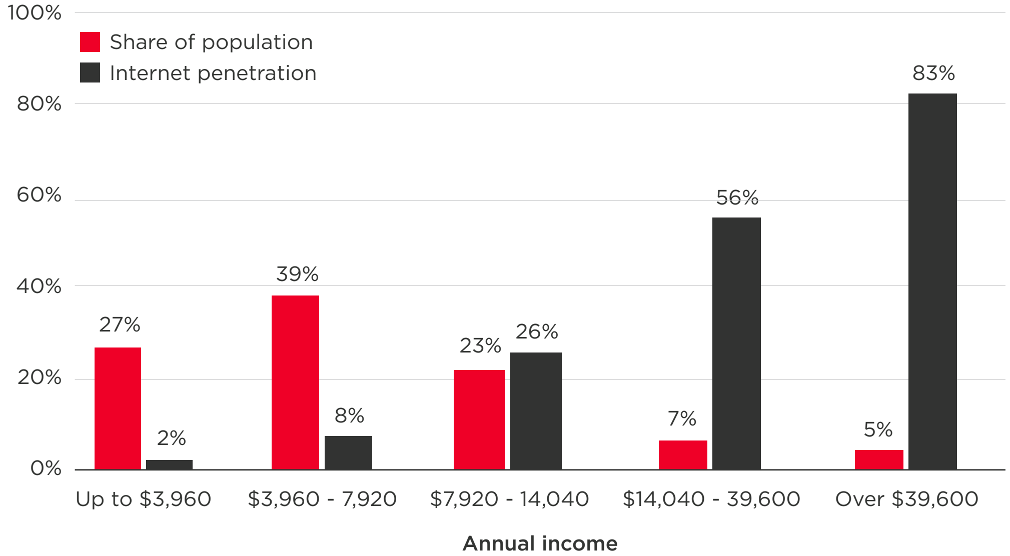


Figure 2: Internet penetration by income band, Colombia (2010)
Source: GSMA Intelligence, ITU

Given these different rules of engagement, the question for those in the mobile ecosystem is less in the opportunity, more in how to realise it. Driving access to the mobile internet is a multi-faceted evolution, with four main barriers for consumers: i) the availability of network coverage (and charging facilities), ii) cost of access in relation to income, iii) awareness and literacy (language and digital), and iv) availability of locally relevant content. While these factors will pose varying degrees of importance in the adoption process for different demographics, coverage and cost are arguably the most fundamental – regardless of how much someone wants to use the internet on a mobile phone for its socio-economic benefit, if the technology is neither available nor affordable then this desire becomes moot.

Mobile network coverage is already pervasive. 2G GSM networks now reach over 90% of the population in many markets. While 3G is lower at around 50–80%, operators are heavily investing to support further rollout — in Sub-Saharan Africa we expect average annual capex growth of 5% out to 2020, with this running at 5% in Asia Pacific and 9% in Latin America. However, in many emerging markets, sections of the population are widely dispersed in (often far-flung) rural regions, with geographic impediments to the rollout of traditional mobile network infrastructure and large distances placing limits on the value of the spectrum as its signal decays. In addition, local economies in rural regions are often off the electricity grid (placing a premium on charging solutions, which in Africa can run to around $3 per home per month) and, in some cases, off the road network (placing a premium on supply chain and distribution management). In other words, it is this final frontier with either no or limited coverage (perhaps 10–15% of the population) that has the most challenging economics for network rollout.

The increasing advocacy from government and internet firms in establishing the internet as a 'universal' service raises an obvious challenge – how to connect for all, not just some? As an extension, who should bear operational and financial responsibility for this? Challenging economics mean that effective policy support and incentivisation is important, particularly given the high opportunity cost of some failed mechanisms that have been used in the past. Universal Service Funds (USFs) are a good example, set up to invest the proceeds from taxing operators into coverage expansion but which in reality have left these funds unspent – a particularly hard hit for rural economies (see Figure 3).

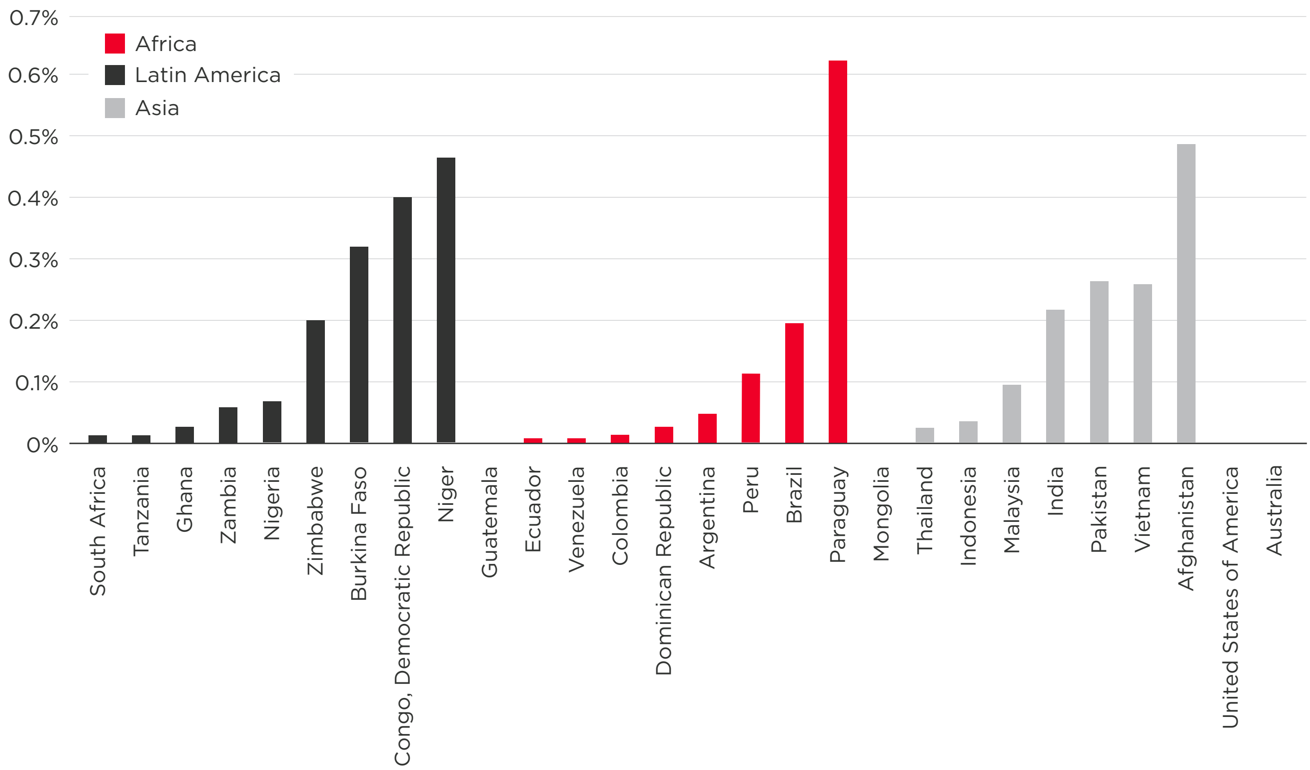


Figure 3: Unspent USF funds as a share of GDP, 2013

Source: GSMA USF study, 2013

Beyond this, there is also a need for innovation in network deployment. Mobile operators are engaged heavily in this space through network sharing and other models of optimising expansion capex and maintenance opex. The final frontier has also been the most publicly visible prompt for the entry of internet players into the connectivity space. Google, Facebook and Microsoft have all entered the fray by trialling alternative connectivity solutions, with aerial networks and the use of TV white space most notable. While these have garnered significant media attention, what of their viability and use cases? And, do they portend wider ambitions in connectivity for players in the internet space? We will assess these in turn, but first it is important to understand what it is these solutions are targeting.

Alternative connectivity 101 — what are these technologies targeting?

While a number of alternative connectivity solutions have been put forth or trialled, we focus on the two most prominent: aerial networks and white space. Aerial networks would include high altitude balloons (e.g. Google's Project Loon), unmanned aerial drones (e.g. Facebook) and satellite solutions. White space targets the use of lower frequency spectrum within the range used for broadcast television, with both Google and Microsoft backing trials in several countries. A summary of these technologies and their capabilities relative to mobile networks is provided in Table 1 below.

		White space	Project Loon	Mobile networks		
				2G	3G	4G
Status		Trials	Trials	In use	In use	In use
Scale[1]		Trials in at least six countries	30 balloons in initial trial (New Zealand); next full trial planned for Chile (flyovers of Brazil, Argentina)	4.6 billion connections	2 billion connections	0.2 billion connections
Voice	**Capability**	Yes (VoIP)	Yes, depends on bandwidth	Yes	Yes	Yes (VoLTE)
Data	**Capability**	Yes	Yes	Yes (GPRS, EDGE)	Yes (UMTS, HSPA/+)	Yes (LTE, LTE Advanced)
Speed (Mb/s)	**Up to**	Not known	20[2]	2	42	320
	In practice	Not known	Not known	0.3	5–7	25–50
Licensing and equipment	**Licensing requirement**	Required for trial use[3]	No	Yes	Yes	Yes
	Licensing authority	N/A	N/A	Regulator or government ministry		
	Devices it works for	Dongles[4], selected others (e.g. M2M)	Device connecting to internal stationary router	Handsets, dongles, tablets, laptops, M2M, other		
	What do consumers need to use it?	White space capable device	Antenna required to receive signal from Google balloons	Cellular capable device (e.g. handset)		

Table 1: How do alternatives compare with mobile networks?
Source: GSMA Intelligence, Google, product websites

[1] Mobile connections Q4 2013
[2] Claims to deliver '3G-like speeds' (potentially ranging from 384 kb/s to 42 Mb/s)
[3] Commercial use does not require a paid license, but must be authorised and meet regulatory standards
[4] Handset requires tuning equipment to filter out other TV signals

The first point to note is that both technologies are at a nascent stage characterised by trials to establish proof of concept, with no announcements on firm timelines for any commercial deployment. Google ran a trial in New Zealand in June 2013, in which 30 balloons were deployed to serve around 50 rural premises. It has since announced that Chile will be the second major trial (late 2014), with flyovers having been conducted over Brazil and Argentina. White space trials for mobile use have taken place in at least 6 countries, including the US, UK, Kenya, South Africa, Tanzania and Singapore.

Alternative connectivity solutions sit on opposite sides of the spectrum bands licensed by national regulators for mobile communications, each attempting to align the physical advantages of a given spectrum range with their target use case (see Figure 4).

Trials involving TV white space use unlicensed spectrum in the low-frequency range within the bands currently used for broadcast television. There is variation between and even within regions as to the precise spaces available.

Google's Project Loon is using unlicensed spectrum in much higher-frequency ranges (around 2400 MHz and 5800 MHz). Facebook has made no indication as to the particular type or range of spectrum it will use for its Drone trials. It is not clear whether, in most cases, aeronautical-based services can be delivered under current national rules.

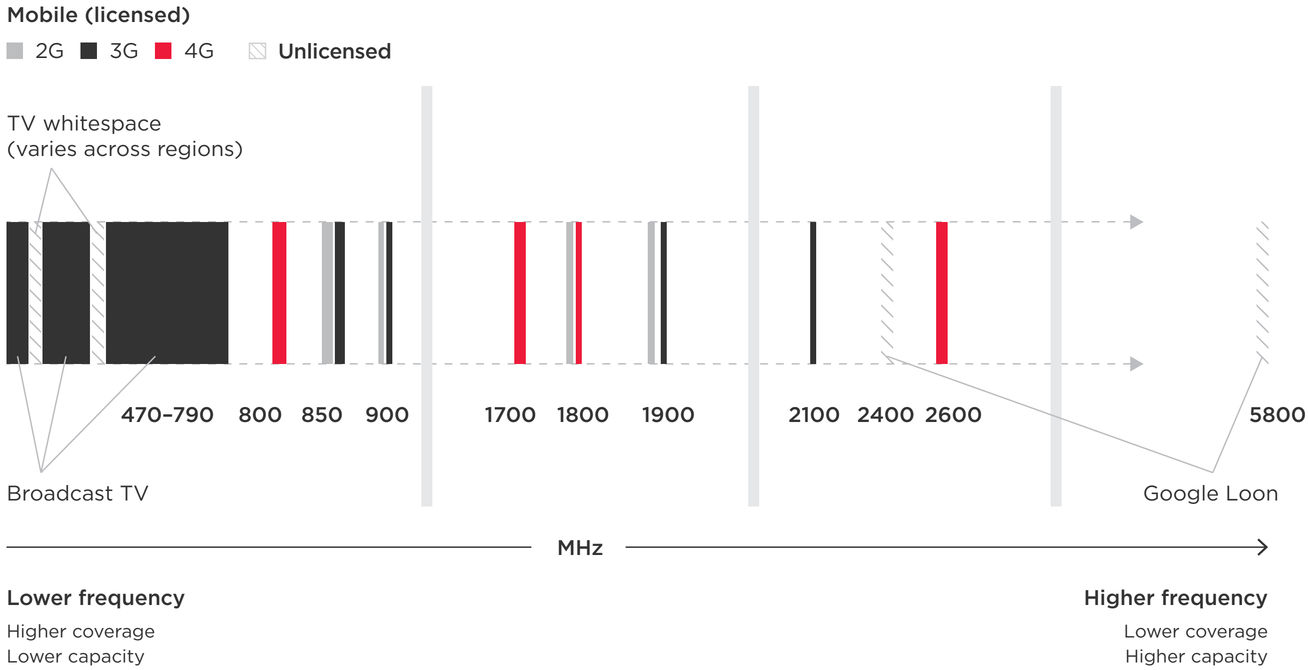


Figure 4: TV whitespace and Loon on the radio frequency spectrum

Source: GSMA Intelligence

Note: Frequency bands across the spectrum not shown to scale. 4G can also be deployed around 700 MHz (not shown)

Aerial networks — use cases

Aerial networks are designed to maximise ground coverage through the advantage of altitude. Google's balloons and unmanned drones posited by Facebook and Google (through their recent acquisition of aerospace firms Ascenta and Titan) cruise at an altitude of 20 km above sea level. This is seen as an ideal compromise to remain above commercial airspace (around 10km up) but not so high up that the signal passing from ground through the aerial network is not severely weakened by distance (see Figure 5). For Project Loon, this amounts to a mesh network of balloons cruising in a latitudinal trajectory within a portion of the stratosphere with favourable trade winds. Consumer users of this type of aerial network require specialised equipment to be fitted to premises on the ground. A user is able to connect to the internet by transmitting signals upwards to a localised balloon, through the mesh network that also connects with ground stations and ultimately back to the original user.

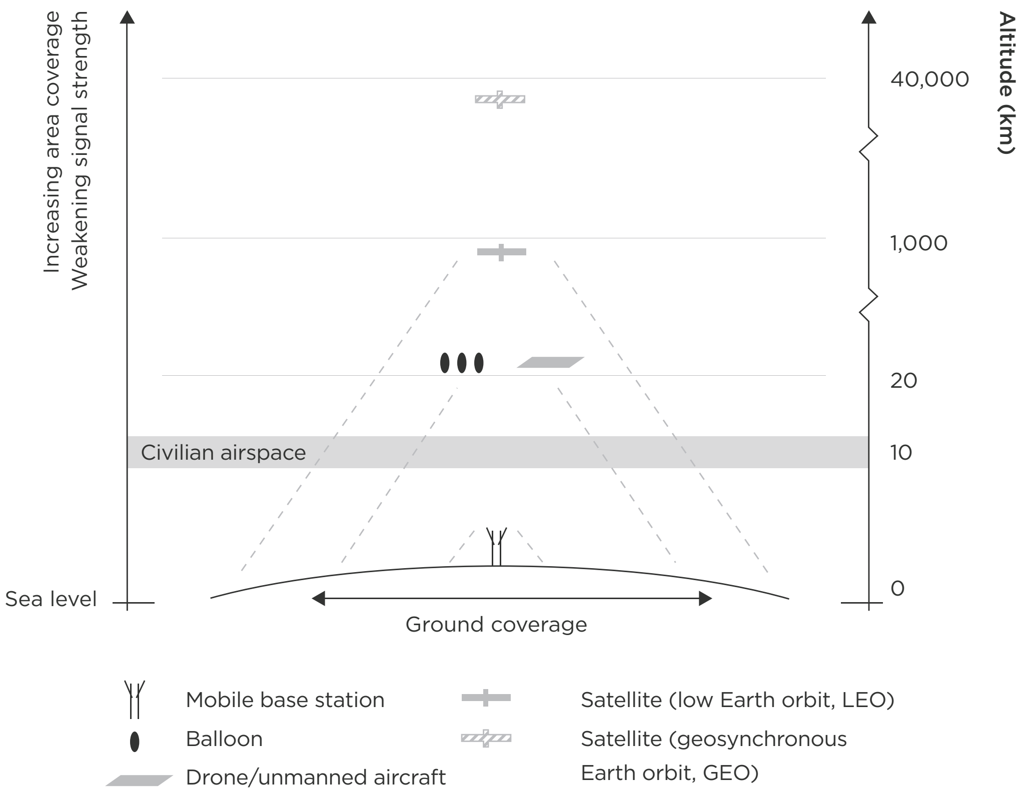


Figure 5: Aerial networks — wider area coverage, weaker signal, lower capacity
Source: GSMA Intelligence

As the networks are free of geographic obstructions on the ground, this presents a niche-use case for connecting individuals in remote rural regions out of range of terrestrial mobile signals. This could include communities situated in mountainous regions, islands or dense forest far removed from roads. While aerial networks making use of a high-frequency spectrum can, in theory, handle both voice and data traffic, they appear to be designed more for the latter (a basic internet browsing experience) given risks around latency and bandwidth needed for VoIP. As such, they are also positioned to act as a source of connectivity in disaster response situations, most likely as a complement to localised mobile network deployments where the predominant communication occurs via SMS.

TV white space — use cases

As global demand for spectrum intensifies, new approaches such as white space are attracting interest and investigation. In recent years, trials using TVWS for mobile communications have been conducted in at least 6 countries. The geographic spread of past and ongoing trials is illustrated below (see Figure 6).

Figure 6: Notable TV whitespace trials worldwide
Source: GSMA Intelligence

Regulators such as the Federal Communications Commission (FCC) in the US and Ofcom in the UK are spearheading white space trials in their countries, while in some cases such as Kenya, the government has been directly involved. In most cases, private-sector players such as Microsoft and Google are leading the trials in partnership with national bodies and other ecosystem players to test the commercial viability of TVWS. Ecosystem players typically participate in trials either as database, device or service providers, offering trial locations or volunteering as pilot users.

The TV broadcasting bands typically occupy the lower end of the radio spectrum that consists of longer wavelengths that can travel further than those in higher-frequency bands. The VHF/UHF TV spectrum enables non-line-of-sight (NLOS) wireless communications, in principle reducing the overall cost of infrastructure (it is less impacted by obstructions, such as masonry and concrete walls, than are Wi-Fi signals). However, trials do not replicate actual commercial conditions. TVWS based services are prone to interference from adjacent frequency bands. In addition, the small amount of spectrum available means that the speed and capacity of TVWS-based services is limited.

From a use case perspective, much as the coverage characteristics of lower frequency make an attractive option for mobile operators, the range of TVWS signals makes it — at least in theory — attractive to internet players for providing access to remote areas. TVWS also requires fewer access points, with supporters linking this to lower infrastructure costs. However, the rural use case along with its potential use in cities is made more difficult because much of the band is still used for broadcast television, which risks interference and lowers capacity. As the technology has not rolled out beyond the trial phase, there is little sense of its speed capability in practice (field trials in Cambridge, UK, have confirmed that up to 8Mbps actual speed can be achieved over 5.5 km links using 8 MHz of bandwidth, but this is under test conditions and would be much lower in practice, given geographic constraints and as capacity demands increase with more people using the technology).

Potential for wider scale disruption?

While the current use cases for aerial networks and white space spectrum are predominantly rural in nature, questions have been asked as to their technical and commercial viability on a wider scale. In other words, could they serve wider ambitions for firms such as Google and Facebook to become connectivity providers if such a desire existed? If they do, could they disrupt the mobile operators?

In order to address this question and its implications, we break down alternative connectivity technologies on the factors that would need to be in place for this to happen.

Scale and cost

Of the barriers to accessing the mobile internet (and mobile in general), affordability and coverage are arguably the two most fundamental. However, it is affordability which shows the strongest link. As a share of income, the cost of mobile ownership (including the device amortised over its usable life and airtime, but excluding taxes in this case) tends to range from around 1–2% in developed economies to nearer 10% in some emerging markets (e.g. Kenya, Tanzania). While there are some outliers to the trend (Eastern European countries tend to show high elasticities above the line, while others such as India plot below), most are tightly clustered along it, with a trigger point around 3% (see Figure 7). In other words, there is a very strong relationship between the cost of accessing mobile and its take up.

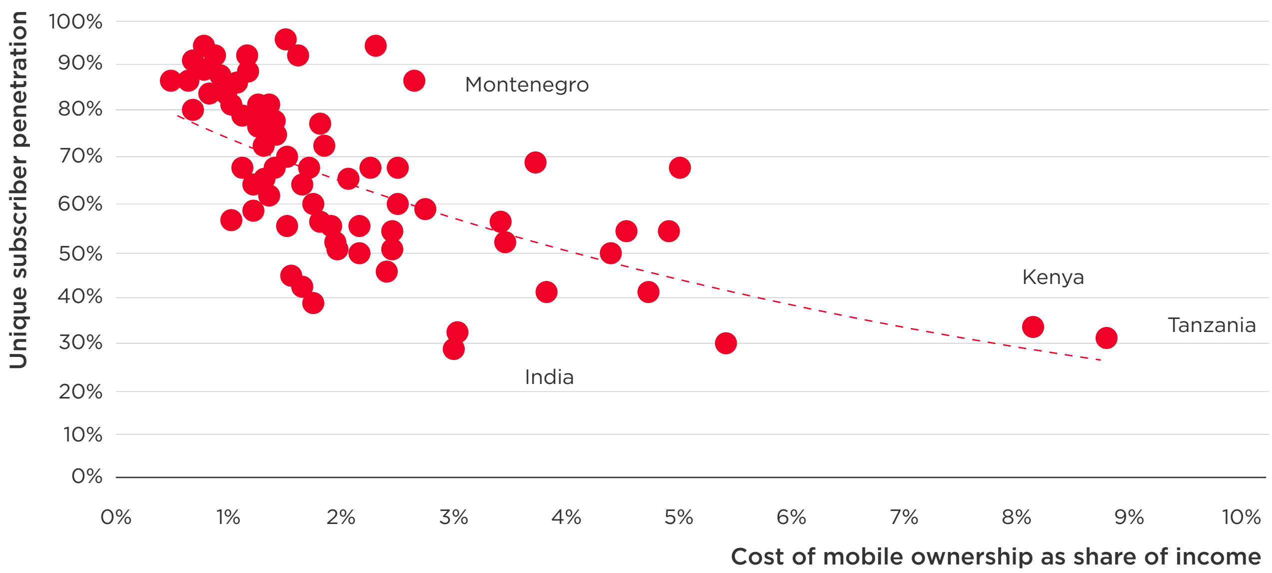


Figure 7: Strong relationship between mobile cost and ownership, 2013

Source: GSMA Intelligence

Note: includes cost of device (amortised over ownership life) and cellular airtime
Expressed as share of income per month

However, the same relationship does not always hold for coverage. Advanced economies generally have both high coverage and high mobile penetration, but the cost of mobile is a much lower drain on disposable income. Several emerging markets have high (if not ubiquitous) coverage but low ownership rates (see Figure 8). This tends to be seen in Sub-Saharan Africa and parts of Asia. While this may also be a result of poor distribution networks in rural and urban areas, the main reason is likely to be the high cost of ownership for low-income individuals.

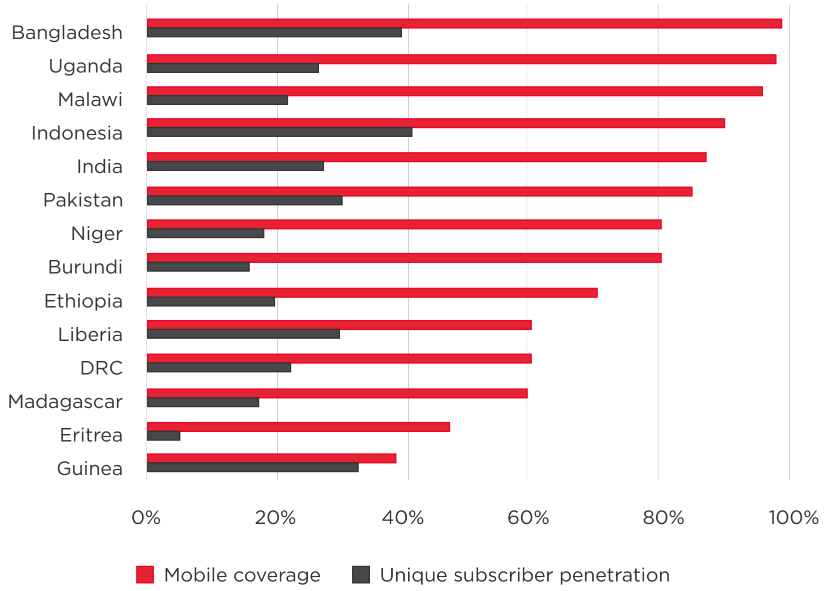


Figure 8: Mobile coverage vs. penetration, 2013
Source: GSMA Intelligence

Internet players may be developing aerial networks and TV white space to expand connectivity beyond existing mobile infrastructure in niche-use cases, but their impact on cost is much less clear (and may have the opposite effect of making access more, rather than less, expensive). Balloons, drones and the use of white space for mobile are all sub-scale technologies, and as such would require new markets to be formed to make them work. Google's mesh network of balloons requires a specialised antennae to be attached to the consumer premises (unless it were to partner with an operator to run over licensed spectrum, in which case service could be accessed through mobile phones). In trials these have been provided for free, but it is not clear whether Google would seek to charge for this or subsidise it in a commercial deployment. In either case, the cost may well preclude widespread deployment in individual dwellings, instead focusing on hospitals, community centres or other points of high footfall. There is also the cost to Google (and any other aerial player) of maintaining the network. Google estimates that an individual balloon would last for 100 days before requiring replacement. However, this assumes there are no technical problems that require on-board maintenance, which would shorten the replacement cycle. Other costs would include ground stations, launch/maintenance facilities and additional balloons in a given area if capacity demands increase.

White space, while deployed on land, makes use of unused blocks of spectrum within the TV bands. The vast majority of handsets currently manufactured and in use are not tuned to this frequency, therefore handset makers would need to insert an additional radio into devices for them to work. Smartphones already carry multiple radios (up to 8–9) to work on 2G, 3G and, increasingly, 4G networks, so incorporating a new radio would pose a challenge in an environment where devices are designed to be leaner and cheaper for a predominantly mid- to low-income user base coming online in emerging markets.

Companies such as Google and Facebook may seek to use a different business model than charging end users for access. Their businesses are based on use of the internet; as such, models that are not direct revenue generators but that increase traffic flow to proprietary web properties and services are, at least in theory, on the table (e.g. cross subsidising from advertising). Regardless of this, it is important to note the scaled nature of networks. It is possible to deploy networks at a local level, with this seen in practice in cases such as mobile micro cells being set up in disaster relief areas or WiFi in cities. The cost structure of this not, however, representative of a full-scale network. The WiMAX experience helps illustrate this point. Back in 2006–07, WiMAX was one of two standards vying to become the global mainstay for 4G, the other being LTE. The promise was based around it being able to handle high data throughput, which would make it ideal for meeting demand driven by rising smartphone penetration. Its failure can be traced to a lack of scale economies following a signalling effect from its key backers that they would move to support LTE. As a result, it never reached a critical mass and has now been confined to relatively niche-use cases, most often as a fixed broadband substitute in rural areas (see Figure 9). The parallel to alternative connectivity solutions is that while niche-use cases can be served relatively inexpensively, to roll out at scale requires a much higher level of investment. While this can be lessened for individual players (particularly those with already large scale businesses), it requires an ecosystem to form around the technology, including standards, spectrum harmonisation and equipment (e.g. handsets), making it difficult to go it alone.

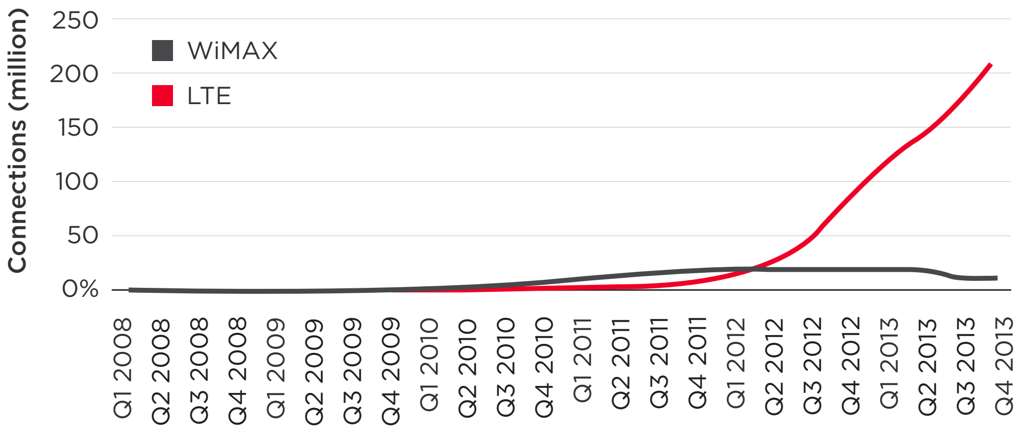


Figure 9: Evolution of 4G take-up

Source: GSMA Intelligence

Licensing and regulatory

One of the attractions of aerial networks and white space to those promoting them is their lack of licensing framework. This is, of course, not surprising for commercial reasons but it does raise questions as to the long-term viability of would-be commercial solutions. 'Unlicensed' does not mean 'unregulated', and restrictions on power output limit the effective use compared to the licenced spectrum such as broadcast and traditional mobile. Aerial trials function as mesh networks that drift over national airspace by virtue of wind currents. Most countries have established agencies to regulate airspace, and indeed have systems in place to, for instance, manage dynamic traffic moving through national territories (commercial air traffic being the most common). Similarly, a telecoms network in the sky would require multiple national regulators to coordinate to develop a system of tracking flight paths of balloons and the process of ascent and descent into different countries – they cannot be stateless. The extension to this concerns the spectrum used in an aerial network. Mobile networks require harmonisation of spectrum to work seamlessly across a country or regional area (and to keep the cost of handsets or other devices low), but this could quickly become problematic in the event that the spectrum used for aerial broadband networks is repurposed for different use, as different countries may have different priorities for the use of certain spectrum bands (for example, the 5.8GHz band is only permitted for aeronautical use in some regions). Lastly, for both aerial networks and white space, agreements would presumably need to be put in place for guard bands to lower the risk of interference with devices using spectrum in adjacent bands.

On a commercial level, unlicensed spectrum is favoured by new participants because of its availability and lack of acquisition cost. However, the converse to this is that national governments miss out on revenue. While this may be an amicable solution in the short term while the technical viability of technologies are being established, it poses a long-term risk. There is no certainty that an unlicensed spectrum band will remain available for an alternative connectivity use over time given that a national regulatory body could decide to refarm or reallocate it to a new use (e.g. licensed mobile broadband), undermining investment planning — white space already faces this risk given that part of the band is reserved for television. Should governments decide to license and charge for the spectrum, those deploying the technology may choose to think twice about continued rollout.

Quality of service

Putting aside considerations on cost and regulation, there is also the issue of how well something works. Aerial networks do have the advantage of a wider coverage area with increasing altitude. To reach communities in remote rural regions or use their dynamic positioning advantages in responding to a natural disaster has clear benefits. However, it is not clear how capacity increases would be managed with increasing use by people on the ground. This is important because mobile signals become weaker with increasing altitude at an exponential rate (see Figure 10), and since unlicensed spectrum generally is used at lower power to reduce the risk of interference. Facebook has indicated the potential use of a specialised technology to mitigate this risk (so-called Free Space Optical, or FSO), but this would take time and faces similar questions as to whether it remains unregulated.

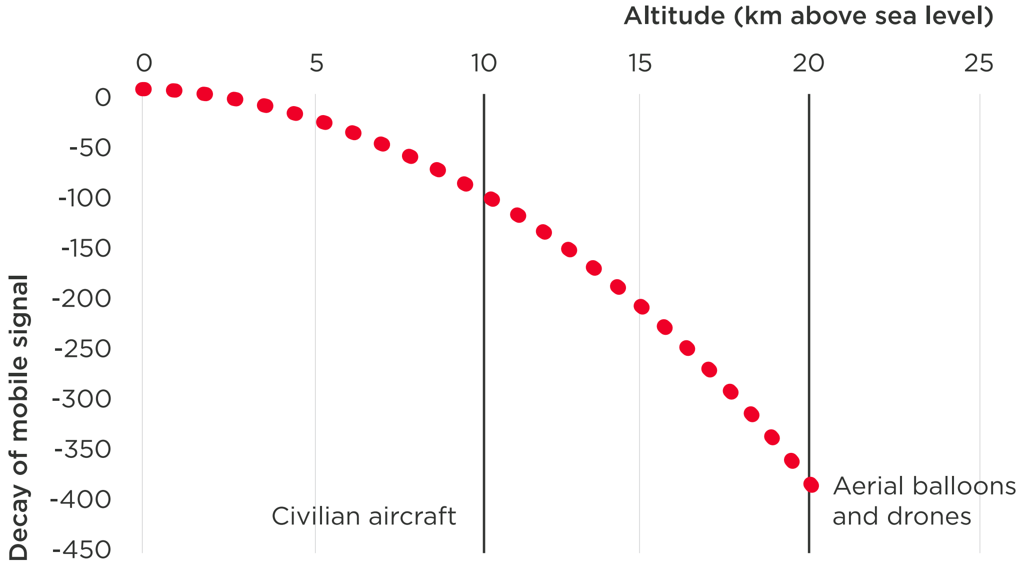


Figure 10: Mobile signals weaken at higher altitude
Source: GSMA Intelligence

The physics of an aerial network are brought into even sharper relief in urban applications. Population densities of major cities tend to be in the range of around 1,000-5,000 people per square kilometre, compared to fewer than 100 in rural areas. While a single balloon or drone cruising at 20 km above sea level would cover a ground area of around 1,250 km^2 (not hugely different to the size of a city itself), this would need to rapidly compress to avoid straining the network given the high population density and demands from people using it. A challenge quickly becomes obvious given that to lower the size of a cell site, aerial craft would need to descend altitude, bringing them below favourable wind currents and closer to the range of commercial airspace – precisely why they are not deployed at that altitude in the first place. There is as yet no indication of any intention to deploy an aerial network over a city. In the event, all of these factors would come into play.

Regardless, innovation is a good thing

The technical, operational and economics challenges these alternatives face mean that disruption to the mobile operators on a wider scale at the connectivity level of the value chain is unlikely in the short-to-medium term future. Market forces will help to drive down some (though not all) of the challenges these solutions face in scaling, but this is more likely to occur over a longer time horizon, perhaps 5–10 years. As such, their use cases appear to be as supplements, not substitutes. Indeed, public indications have supported as much, with Google recently indicating that Project Loon is in place "to complement the business of the service providers, not substitute it". Regardless, there is likely to be continued speculation on the ambitions of the companies backing them. Silicon Valley has been the source of much innovation in the wider tech sector over the last 25 years and in mobile more recently. While attempting to predict the next move of Google, Facebook or Microsoft is a trying endeavour, a history of acquisitions sheds some light on this question. It is clear that, at least among Google and Facebook, many acquisitions are made — nearly 200 known between them since 2001, and a further 300 investments in companies without actually acquiring them (see Figure 11).

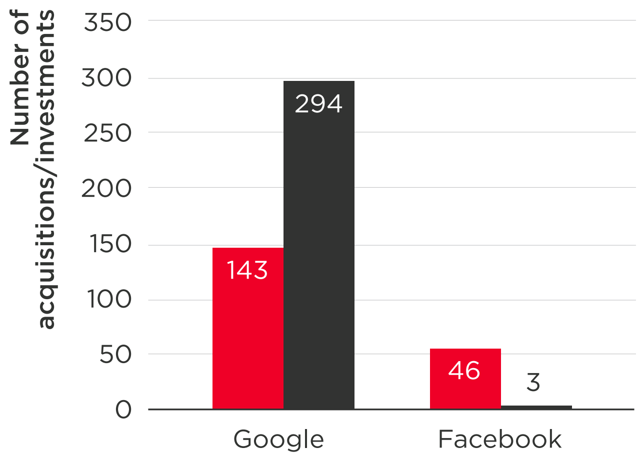
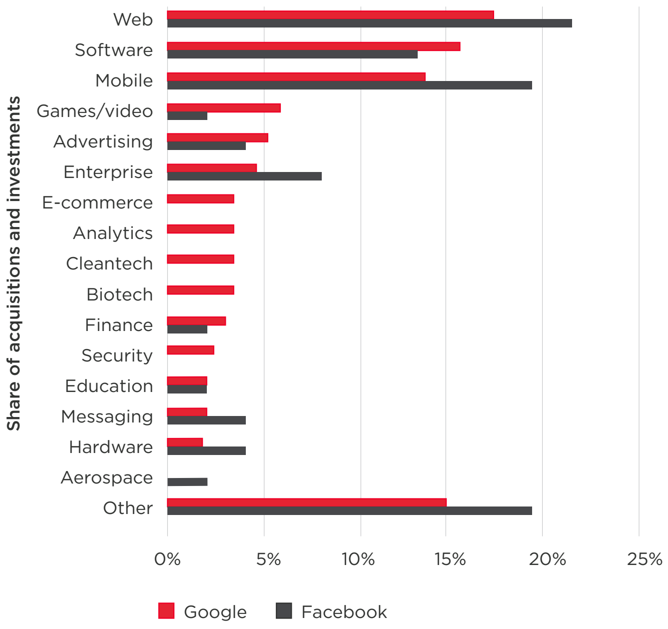


Figure 11: Google and Facebook investments and acquisitions, 2001–14

Source: Crunchbase, GSMA Intelligence

What is striking is not only the sheer volume, but the range of sectors acquired. Web, software and mobile firms make up around 50% of the companies bought, but beyond this there is a long tail of firms in sectors including gaming, advertising, e-commerce, finance and security among others (see Figure 12). Aerospace is a relatively new category — with Google investing $410m in satellite firm O3B in 2010, and recently acquiring Titan Aerospace and Skybox, while Facebook acquired Ascenta, a British company specialising in drones and other high altitude unmanned aircraft, earlier in 2014. It is, of course, tempting to extrapolate these acquisitions into the commercial intentions of their acquirers, especially if those could disrupt a sector. However, this can be conflated with more pragmatic intentions, and we believe speculation should be tempered against this reality, alongside the challenges such alternative connectivity solutions would face in moving from pilot to scaled commercial options operating as full-scale connectivity plays.



Acquisition/invesment range	Google	Facebook
< $50M	43%	47% [2]
$50–100M	14%	29%
$100–500M	25% [1]	6%
$500M–1B	8%	0%
> $1B	10%	18%
Total	**100%** (51)	**100%** (17)
Price not disclosed	92	29

[1] Includes O3B (investment) and Skybox, both aerospace
[2] Includes Ascenta, aerospace

Figure 12: What verticals are being bought into? (2001–14)
Source: Crunchbase, GSMA Intelligence

Note: other includes: transportation, music, medical, health, social, network hosting, real estate, travel, photo, public relations, hospitality, automotive, news, local, legal, non-profit, manufacturing, fashion, consulting and semiconductors

In the short term, we believe the more likely scenario is to use alternative connectivity solutions as a public policy tool targeted at governments, regulators and the mobile operators, and potentially to strike licensing partnerships. We see both pros and cons to this. On the pro side of the ledger, it is becoming increasingly apparent that there is a need to examine new models of expanding mobile broadband access that go beyond existing mobile infrastructure in a way that adequately balances the goal of socio-socio-economic impact with commercial return. Mobile operators have invested more than $1 trillion globally over the last six years (equivalent to 16% of operator revenues), driven by ongoing network build-outs (including higher-speed 3G and more recently 4G networks) and capacity upgrades to accommodate the growth in data traffic. We expect these trends to continue, with global capex over the period from 2014 out to 2020 forecast to total over $1.7 trillion, equivalent to a growth of around 5% per year (see Figure 13). The growth in network investment is projected to be highest in emerging markets (notably Latin America and Asia), in line with demand both in terms of new mobile users and from existing ones migrating to higher-speed packages.

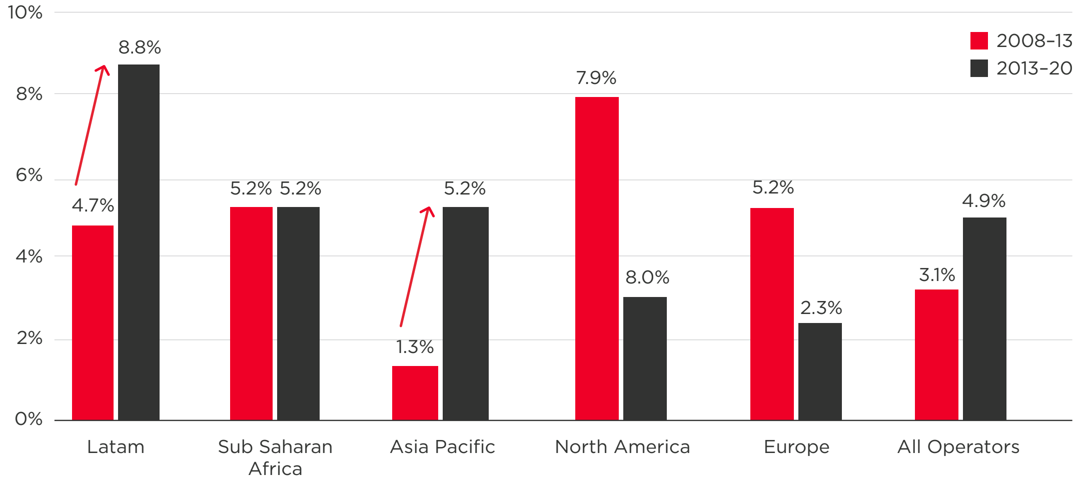


Figure 13: Forecast capex growth from mobile operators, 2014–20

Source: GSMA Intelligence

Indeed, 2G coverage is now almost universal in many markets, with this allowing voice and low speed data access. The challenge comes from the cost and time in extending networks capable of facilitating higher-speed access required for many internet applications, even after allowing for improvements in data compression technology on lower end smartphones. This is particularly the case for laying fibre backhaul in rural regions due to geographic impediments and vast distances. In the absence of traditional mobile networks reaching these areas unilaterally, supplements could well assist. Aerial networks or those using unlicensed white space spectrum arguably have a place in this debate as supplements or aids to more traditional mobile network infrastructure. At a wider level, they are also significant as they represent examples of the type and depth of innovation being tabled to meet the access challenge in a data world, and we expect the pace of this to accelerate across the mobile ecosystem over the coming 2–3 years.

However, we believe priority for low frequency spectrum should be on licensed mobile broadband use. Part of the intrigue around alternative connectivity technologies is that they are seemingly the stuff of science fiction come to real life. But it is also arguably because of a cynicism felt towards mobile operators in certain markets (the US being a good example) fuelled by a perceived lack of competition and high prices. Operators in this light lack the 'cool' factor that is omnipresent in many of the internet companies that have shot to prominence over the last decade, and that is personified by the images of several of their founders. This view is in many ways short sighted (and in some cases self-serving) because it ignores or heavily discounts the cost of investment required to lay and upgrade the networks that underpin the expansion of the internet.

In addition to organic investment, operators are also seeking to improve the economic case for rural deployment and indirectly reduce the cost of mobile services through network sharing deals that reduce expansion capex and maintenance opex. Outside of Europe and the US, a number of operators in Asia and Africa are already sharing passive elements of their networks — India and Pakistan are good examples — with several independent tower companies also in play by leasing sites and capacity (saving operators the heavy capex outlay). The recent infrastructure agreement targeting mobile broadband access to unserved rural communities between eight operators accounting for 551 million connections or 46% share across Africa and the Middle East is a further example. Passive sharing of base station sites and towers has expanded beyond its traditional use case in high-density urban areas to more rural ones given the cost savings on power in particular (many mobile sites in rural areas are off-grid and so rely on expensive diesel generators). At a deeper level, active sharing of the Radio Access Network elements (in addition to site and tower sharing) is being pursued by operators in several emerging markets.

Solar sites have a relatively high up front cost outlay (although this is coming down as equipment prices fall), but lower long-run operating costs given the decreased reliance on diesel (some estimates put the reduction of diesel running hours at around 50-60%). Growth has accelerated over the last three years, with the GSMA now tracking more than 42,000 green power sites worldwide, the bulk in emerging markets (see Figure 14). It is also worth highlighting the emergence of software solutions that extend coverage into rural areas not covered by 2G or 3G networks. These tend to work by converting voice calls into IP for 2G and 3G phones — effectively bringing LTE-style technology to earlier generations of mobile. Range Networks is perhaps most well known in this space, but others using similar technology have sprouted up (such as Endaga). In all of these cases, the solutions are in place to extend coverage to rural areas, and in the case of hyper local networks, also providing micro economies built around sustaining the network itself.

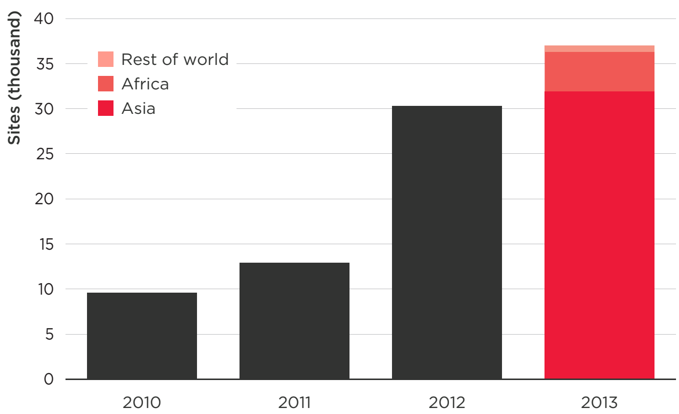


Figure 14: Operator-led green powered sites

Source: GSMA Mobile for Development, Green Power for Mobile

Finally, there are an increasing number of cases where operator expansion into remote rural regions has attracted power companies (many of them ESCOs). The demand from operators for powering base station sites incentivises ESCOs to deploy micro grids to supply this and the local community, enabling consumers off the main country grid to charge their phones locally, as opposed to using a pay per charge model at a community centre (see Figure 15 and Figure 16 for a geographic spread of deployments. Africa and South Asia are hotspots, with OMC Power in India a good example). The advantage of these approaches is that the economics of rural rollout are improved by default, with savings free to be re-harvested into further investment, which is (as opposed to competition) the factor most closely linked with lower unit prices for consumers.

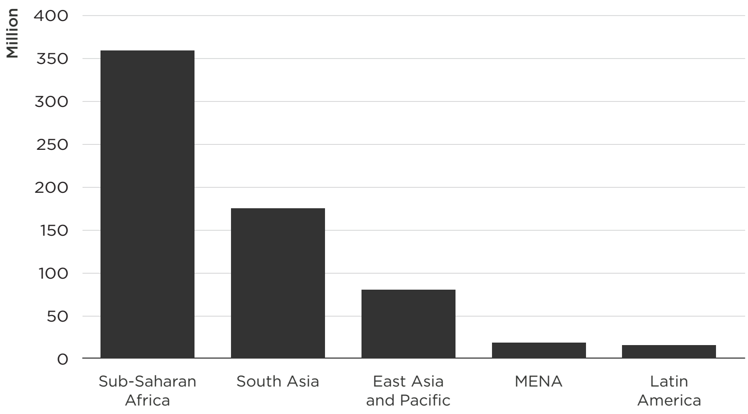


Figure 15: People that lack access to electricity but are covered by mobile networks, 2013
Source: GSMA Mobile for Development, Mobile Enabled Community Services

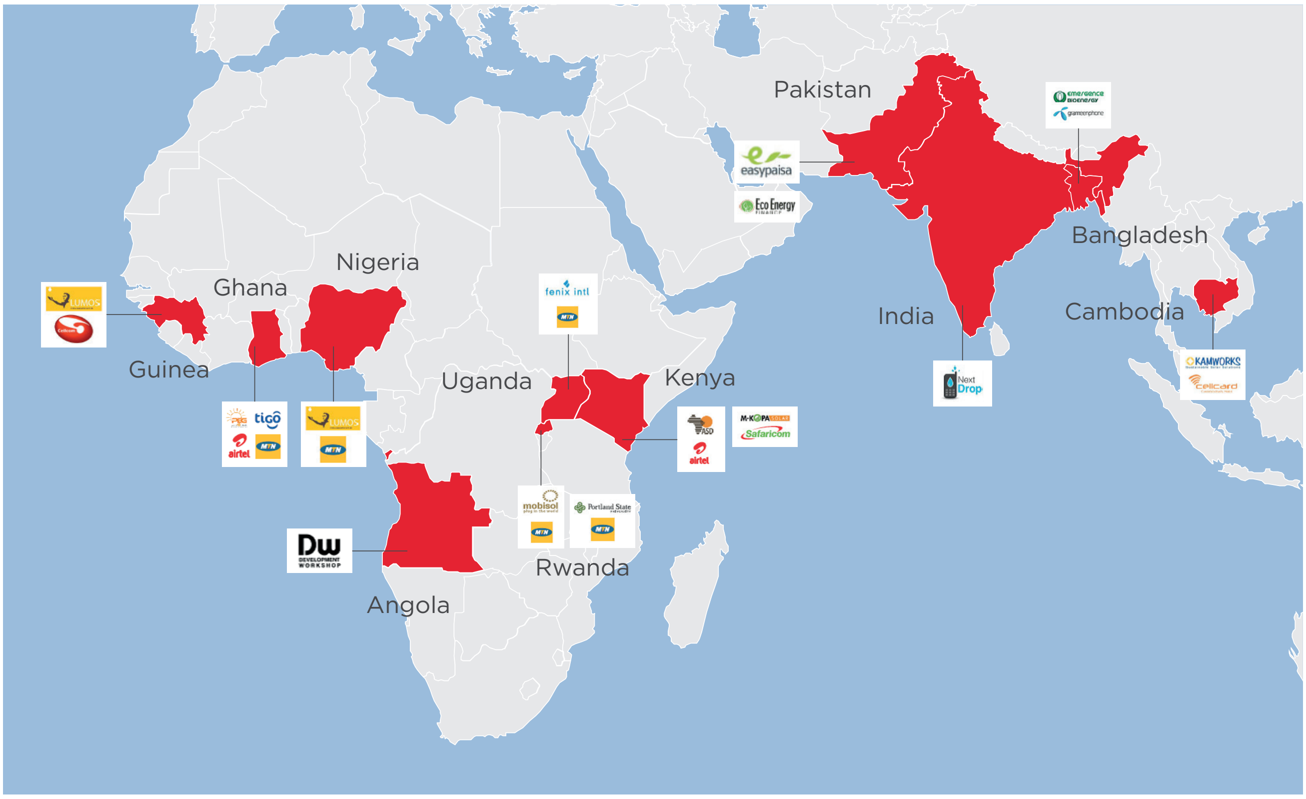


Figure 16: Distribution of GSMA grantees providing mobile-enabled community services
Source: GSMA Mobile for Development, Mobile Enabled Community Services

Outlook

The expected medium-term increase in the number of new mobile subscribers across emerging markets is vast — 1.1 billion between now and 2020. Internet adoption is also poised to scale an adoption curve in parallel, with mobile the primary gateway for this given the absence of widespread fixed broadband infrastructure in regions where most of the unconnected live. Together, these adoption curves are the foundations for countries transitioning to digital societies. Even with continued heavy investment, coverage gaps are likely to persist in some remote rural regions given physical challenges and poor economics. Innovative means of network extension and provision will continue to be necessary to close these.

However, affordability has and will continue to remain a central challenge — indeed, in many developing countries we estimate 30–50% of the population are currently covered by GSM networks (capable of low-speed internet access) but do not own a mobile, underlining an opportunity that, in this case, has nothing to do with expanding coverage. Of course, economic growth and rising incomes will help, but this takes time. Collaboration and effective incentivisation between government and private sector players — including mobile operators and internet players — is key. It is here where we see perhaps the largest scope for gains to be made in shaping pro-investment policy environments that adequately balance improved social outcomes, economic growth and commercial return.

About GSMA Intelligence

GSMA Intelligence is the definitive source of mobile operator data, analysis and forecasts, delivering the most accurate and complete set of industry metrics available.

Relied on by a customer base of over 800 of the world's leading mobile operators, device vendors, equipment manufacturers and financial and consultancy firms, the data set is the most scrutinised in the industry.

With over 20 million individual data points (updated daily), the service provides coverage of the performance of all 1,140 operators and 1,153 MVNOs across 3,505 networks, 65 groups and 236 countries worldwide.

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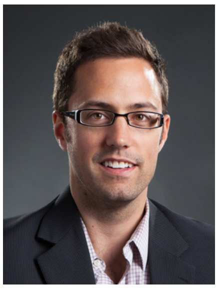

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