ANALYSIS

Closing the coverage gap — a view from Asia

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Digital Inclusion

Executive summary

1. **Mobile coverage has expanded to near ubiquitous levels; 90% of the population are covered by at least a 2G signal, and 70% by 3G. Despite this, the reciprocal implication is that there remains a significant share of people who live in a coverage gap, 10% on 2G (and therefore lack access to voice and SMS) and 30% on 3G (and therefore lack access to the internet). The majority of these unconnected individuals are low income, living in rural regions of Asia and sub Saharan Africa, and make up the majority of the 4.8 billion not yet on the internet.**

   It is hard to understate the prevalence of mobile networks: worldwide, 90% of people live within range of at least a basic 2G signal, putting mobile above all other universal communication media except radio. 3G networks now cover 72%, and while this masks significant regional variation (the US, Europe, Australia, Japan and Korea are above 95%), the increase from 50% in 2012 has been driven by rises in China and other emerging markets in Asia. However, these rises have mostly been in cities, which by virtue of Asia's size and wide population dispersion means that many in rural areas remain unreached.

   The story in absolute number terms illustrates the dual-pronged challenge of affordability and network coverage in growing the mobile internet base. Within Asia as of 2014, there are around 1.2 billion people that actively use the mobile internet (a third of the population), but this is less than half of the 2.9 billion *covered* by a 3G or 4G network, implying that around 1.6 billion live within range of a fast enough network but are still not online – probably because of cost, with literacy, awareness and perceptions of relevance also challenges. The remaining 1.1 billion (28%) are not yet covered by a 3G or 4G network, mostly in rural areas.

   Continued investment from mobile operators will help shrink the latter number; we estimate capex investments of nearly $600 billion cumulatively through the end of the decade in the region, fully one-half of the global total and representing average annual growth of 1.6% from the 2014 level of investment of $93 billion. This translates into 3G and 4G population coverage levels of 93% and 69% by 2020, with most of this driven by reaching previously uncovered sub-urban and rural areas. But even with that investment, with a population exceeding four billion this still leaves many hundreds of millions of people unconnected and unable to access the benefits of mobility and the internet unless more innovative solutions are broadly adopted to reach those in rural and remote areas.

2. **The impetus for expanding mobile to rural regions has never been in doubt: providing access to communications, services (such as mobile money, health or education information) and the internet to individuals for whom physical channels and fixed line infrastructure are largely absent. The challenge is in overcoming an uneconomical cost-benefit equation where high infrastructure investments and fixed running costs are spread over thinly populated areas.**

   Network economics are based on scale, where high infrastructure investment and running costs are spread across many potential customers in order to make a return that can, in turn, be reinvested. This network-led investment model has worked well in cities and

sub-urban areas. Expanding network infrastructure to rural regions is considerably more difficult. On the supply side there is a lack of road and electricity access, exacerbated by harsh terrain and often vast distances between communities. On the demand side, rural communities are generally low income and thinly distributed. These factors mean investments are often uneconomic.

We focus on Asia in this report for two reasons. It makes up the majority (55%) of the 4.9 billion people worldwide who are not yet connected to the internet, and second, its countries have socio-economic and geographic characteristics that make them microcosms that illustrate the challenges in overcoming rural coverage gaps.

There is much happening in the way of new approaches to rural coverage being deployed by mobile operators, infrastructure start-ups and even internet players. Voluntary network sharing among mobile operators has become the most favoured approach to rural expansion, with at least 64 agreements[1] in place within Asia alone as of 2014. Within this category, passive sharing – combining sites, masts, fuel and in some cases backhaul – has become most popular given that it offers cost savings (up to 20–30% in opex and 40–50% in capex) while preserving the network as a differentiated asset to compete on given that spectrum holdings remain separate (in theory, active sharing – which extends to the radio access network and core – offers more scope for cost savings, but in practice these have proven difficult to realise given integration complexities, with this model also encountering regulatory discouragement given perceived risks to competition). Network sharing has been helped by the insertion of tower companies (towercos) into the value chain. Some of these firms were born from operators spinning off their tower portfolios (such as Indus and Bharti Infratel), and some organically (such as American Tower Corporation). In either case the key advantage is that the risk of infrastructure expansion is transferred to the towerco, which can bear this given the prospect of multiple operator tenants expanding their services to unconnected populations. India, Pakistan, Malaysia and most recently Myanmar are all examples of markets that have pursued network sharing, helping to drive 3G coverage expansion into unfilled urban and rural areas that otherwise would likely have remained unreached (see case studies in Appendix).

3. **There is no one-size-fits-all approach to closing the coverage gap. Government subsidies and alternative infrastructure plays such as software-based networks and aerial technology can potentially provide access to extra-rural and remote areas beyond the reach of terrestrial network sharing. Few, if any, of the companies behind these solutions intend to become connectivity providers in their own right, instead seeking partnerships with mobile operators (such as by leasing infrastructure or spectrum) in niche situations.**

While we believe voluntary network sharing is the most effective and scalable model for expanding network coverage into rural areas, there is still a role for other forms of support. The use of subsidies by governments pursuing universal access targets (many of which are embedded in spectrum license obligations) is one of these, helping to incentivise investment where there is a void from market-led models. There are a growing number

[1] Source: Analysys Mason

of success stories – Sweden, the UK, Canada and Australia are examples – but relatively few in Asia, where we believe there is scope for governments to increase their support. Smaller-scale innovation has come from software-based networks (such as Endaga and Range Networks) that use micro-base stations in remote communities to convert GSM signals into IP, allowing cut off communities to access voice, SMS and even mobile data. Finally, innovation in satellite technology and most recently balloons (Google's Loon project) are targeting mobile access to extra-rural areas by providing backhaul support and, in some cases, direct service in the absence of ground coverage. Interestingly, there is a growing list of partnerships between operators and other ecosystem players in these areas – Airtel with Thuraya (March 2014 targeting rural areas in 17 African markets via satellite), and Telstra, Vodafone New Zealand and Telefonica Latin America with Google's Loon are examples – underlining the importance of information and innovation sharing across the ecosystem in tackling the rural coverage challenge.

Pervasive mobile networks, but still a gap

There are well-documented socio-economic benefits from increasing mobile penetration, particularly mobile broadband penetration (3G and 4G), which for many residents of rural areas and especially in less-developed countries will likely be their primary and probably sole means of internet access. The World Bank estimates that the mobile internet has a higher positive economic impact than fixed-line broadband, particularly in developing countries, and that a 10% increase in mobile broadband penetration drives a 1.4% increase in GDP for low-to-middle income countries. This GDP growth, coupled with stimulation of the job market, helps fuel a virtuous circle that reduces poverty, improves infrastructure and services, and further increases internet access and usage.

In order to obtain the full benefits of mobility, there are certain core requirements: affordable devices and service plans, awareness, relevant local content and services, and network coverage underpinning all of these. Operators globally have invested both in coverage and capacity most heavily in densely populated regions given that, in many countries, the majority of the population live in cities. However, there are many large emerging markets where a majority live in rural areas. These carry more challenging economics for network expansion, but the opportunity cost of not having mobile and internet connectivity is no less than for urban residents. The need for innovative approaches to covering these unconnected populations is therefore high.

We focus on Asia in this report because it comprises most of the world's unconnected individuals, and because its countries have geographic and socio-economic characteristics that make them ideal case studies illustrating the coverage challenge. Most economies in the region are high growth (even with recessionary impacts), and while much of this is driven by cities like Mumbai, Dhaka and Manila, over 64% of Asia's population still live in rural areas (vs. 30% and 17% for Europe and the US, respectively, for comparison). It is these primarily rural dwelling individuals with growing but still low purchasing power that make-up the majority of the 4.9 billion people worldwide not yet connected to the mobile internet, of which Asia accounts for the majority (55% or 2.7 billion). We show how the world shakes out on the inverse plot between rural dwelling and mobile internet take-up below.

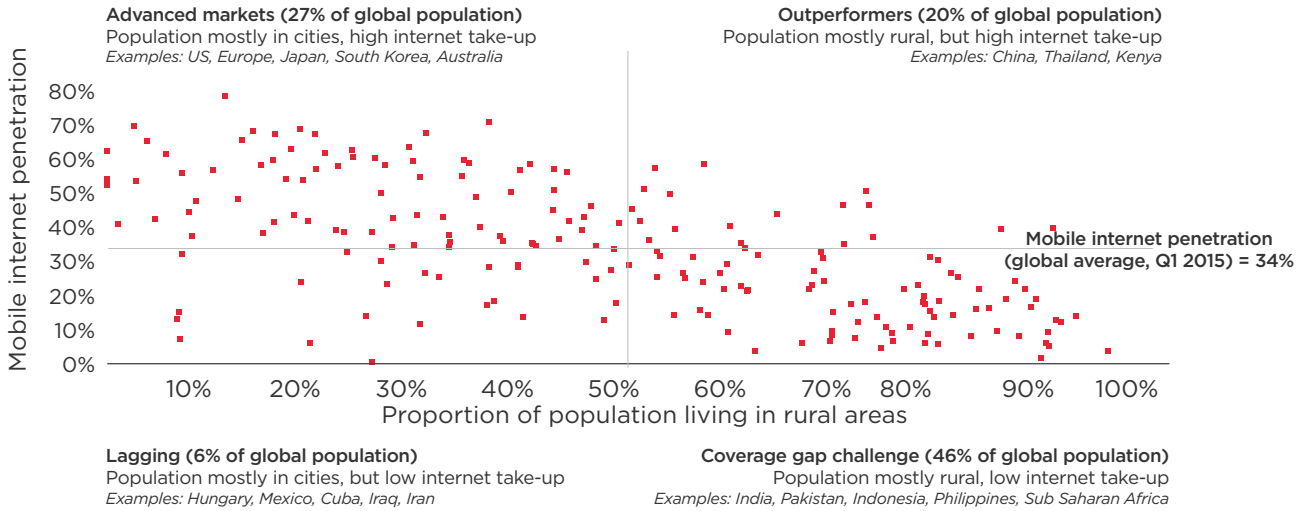


Figure 1: Most people *not* yet on the mobile internet are in rural Asia and Sub Saharan Africa
Source: GSMA Intelligence

Rural areas, globally, lag behind urban areas for a whole host of reasons. Spectrum allocations in the lower-frequency coverage bands, under 1GHz, may be inadequate to provide economically viable network build options for some regions with conventional technologies. Many ideal locations for base stations are likely to be unconnected to the electricity grid, requiring alterative power sources. The IEA estimates that 30% of developing Asia's rural population, amounting to around 650 million people, have no access to electricity.[2] The most commonly-used alternative, diesel-fuelled generators, however, not only increase operating costs, they are environmentally damaging and therefore discouraged to a greater extent.

Moreover, in the Asia-Pacific region specifically, while home to some of the largest and fastest-growing conurbations in the world, the geography and demographics outside of these clusters can be very challenging indeed. The terrain of many rural areas in Asia presents challenges that are probably more extreme and certainly more disparate than anywhere else in the world, including the world's tallest mountain ranges, low-lying flood-prone regions, vast deserts, and far-flung archipelagos. For example, negotiations between the Pacific Island nation of Kiribati, which has a population of 103,500 (at its 2010 census) spread over 3.5 million square kilometres embracing 34 islands, and a potential new entrant failed after a year of discussions in 2009, due to "concerns about the feasibility of having two mobile operators serving a country with a population of only tens of thousands of inhabitants."[3]

The closer ubiquity becomes, the harder it gets

The positive story is that mobile network coverage has improved, with capital investments by operators globally of over $200 billion in 2014 alone, and operators in the Asia-Pacific region representing 43% of this sum. Thanks to these investments, 2G coverage has expanded to around 85% of the Asian population at the end of 2014, with 3G networks reaching 72%, albeit with significant variance by country; complete coverage has been achieved in the more advanced countries in northeast Asia and Oceania compared to much lower levels in India, Vietnam and the Pacific Islands (see Figure 2).

The story is unfortunately starker in absolute number terms, and illustrates the dual pronged challenge of coverage and affordability to growing the internet base. Within Asia now, there are around 1.2 billion people that actively use the mobile internet (a third of the population), but this is less than half of the 2.9 billion *covered* by a 3G or 4G network, implying that around 1.6 billion live within range of a fast enough network but are still not online – probably because of cost, with literacy, awareness and perceptions of relevance also possibilities. The remaining 1.1 billion (28%) are not yet covered by a 3G or 4G network, mostly in rural areas (see Figure 3).

It is this latter group that is the focus of the approaches to rural coverage analysed in this report. Continued investment from mobile operators will help shrink the number; we estimate capex investments of nearly $600 billion cumulatively through the end of the decade in the region, fully one-half of the global total and representing average annual

[2] Source: International Energy Agency, World Energy Outlook, 2011
[3] Source: ITU, The Role of ICT in Advancing Growth in Least Developed Countries, 2011

growth of 1.6% from the 2014 level of investment of $93 billion. This translates into 3G and 4G population coverage levels of 93% and 69% by 2020, with most of this driven by reaching previously uncovered sub-urban and rural areas. But even with that investment, with a population exceeding four billion this still leaves many hundreds of millions of people left unconnected and unable to access the benefits of mobility and the internet unless more innovative solutions are broadly adopted to reach those in rural and remote areas.

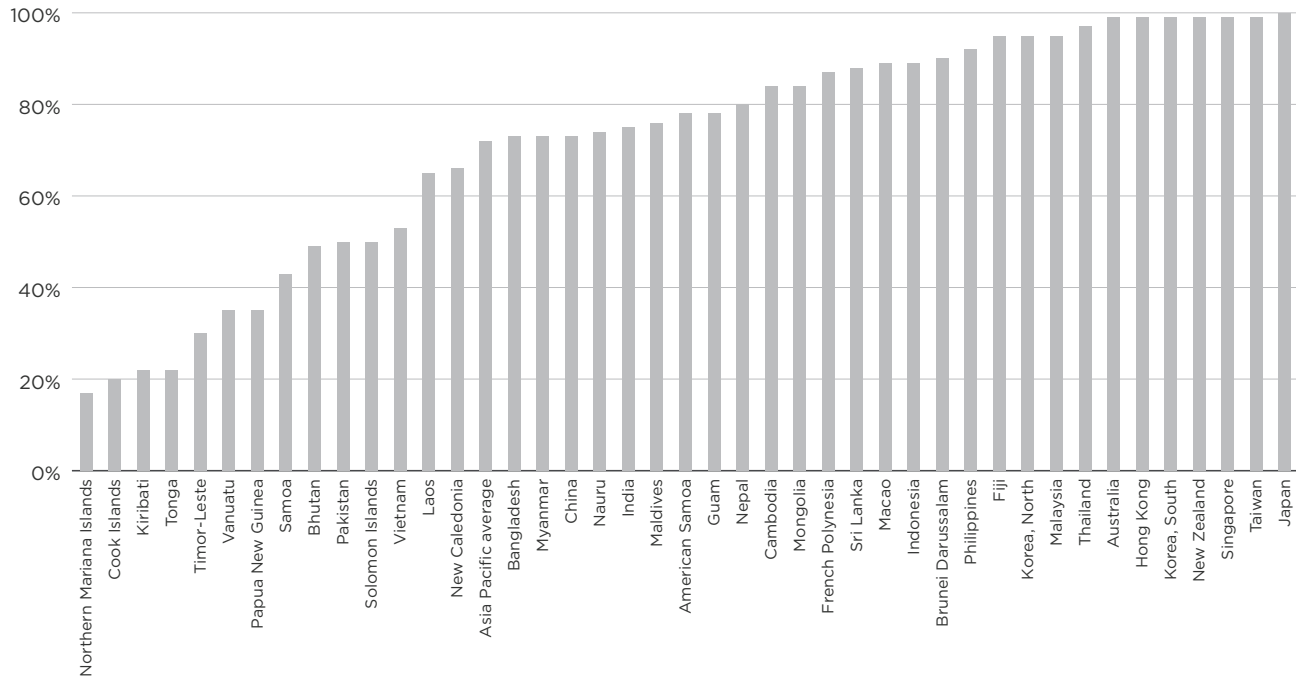


Figure 2: Mobile broadband coverage (3G or 4G networks)
Note: Coverage is of population
Source: GSMA Intelligence (December 2014)

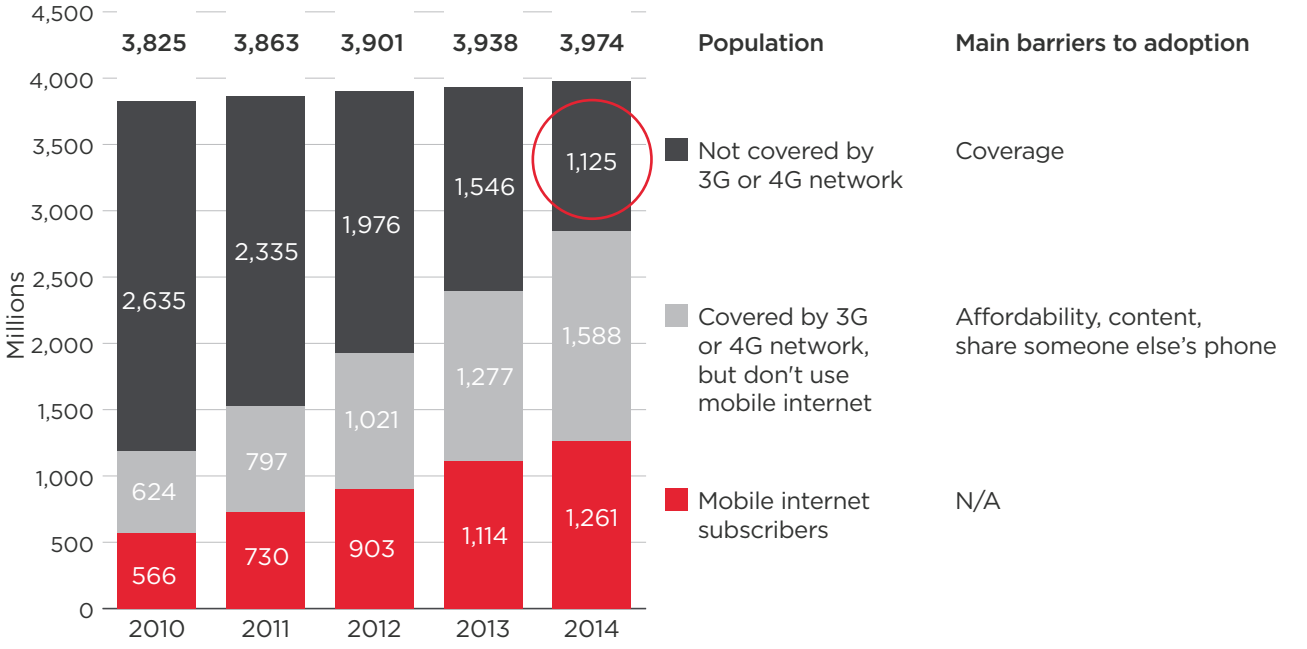


Figure 3: In Asia, 3G coverage is now over 70%, but this still leaves 1.1 billion out of range
Source: GSMA Intelligence

Filling the gap – multi approach, multi stakeholder

How can mobile networks capable of supporting internet access be expanded at an accelerated rate to drive access among unconnected populations but that mitigates the unfavourable cost-benefit equation faced in applying urban network economics into rural areas?

For operators, while the market-led business model has proved effective in expanding coverage to its current levels, going further into rural and remote areas is often uneconomic. This is due to two factors in conflict with one another: lower population density in rural areas, by definition, which makes these areas more expensive to cover on a per-capita basis, and lower household income levels which limits consumers' purchasing power and therefore demand for mobile handsets, service, and commerce – something visible in some of the biggest Asian countries with high rural dwelling rates such as India, Bangladesh and Myanmar (see Figure 4). The best potential network rollout solutions revolve around the interplay between these two factors. Lacking the ability to directly influence household incomes, the converse becomes the lever which can be used to improve the economics of increasing coverage: lowering the cost of doing so. Ultimately, this will produce a virtuous circle as the economic benefits of access to mobile technology increase household incomes.

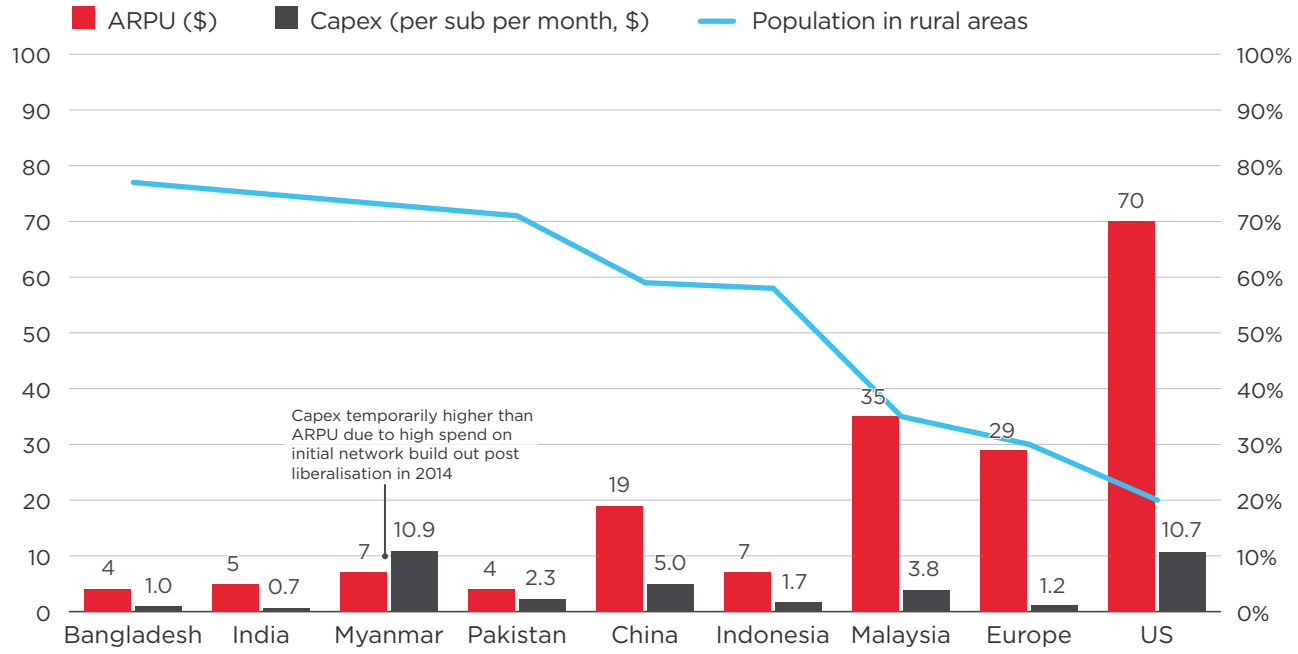
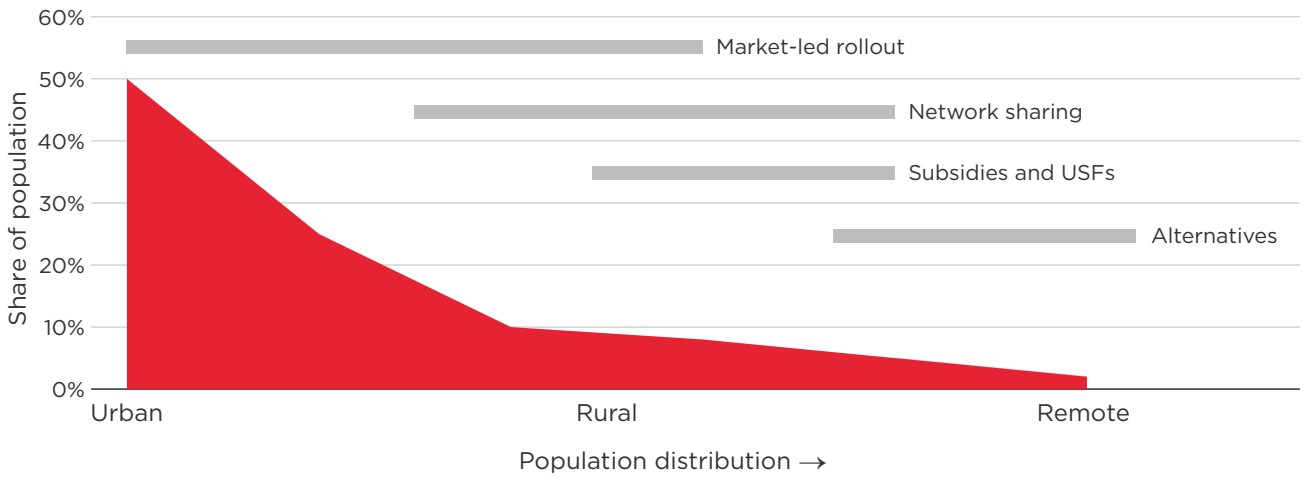


Figure 4: High cost, low ARPU: risk of uneconomic network investments in rural and remote areas
Note: ARPU is per *unique subscriber* (so will be higher than reported connection-based ARPU). Figures are for 2014.
Source: GSMA Intelligence

The 'how' of this objective of expanding coverage by lowering the unit cost of doing so has spawned a number of rollout strategies to complement market-led investments in individual networks from different operators, broadly falling into three groups: i) network sharing, ii) government-support, and iii) alternatives to licensed spectrum-based network rollout. The table below outlines these.

		Description
	Market-led (traditional)	Operators each roll out own networks
Network sharing	Passive	Two or more operators share passive network elements; this could include sites, towers, support costs such as energy and maintenance, and backhaul. 3rd party tower firms may also be involved
	Active	Any passive sharing plus active network elements; e.g. Radio Active Network equipment, core ring, and sometimes actual spectrum sharing. 3rd party tower firms may also be involved
Government support	Subsidies	Monies allocated by government (directly or indirectly, such as tax breaks) to network providers for the specific purpose of extension to uncovered areas
	USF	Universal Service Funds. Capital reserves collected by government, mostly from taxing network providers, for the specific purpose of funding network expansion to uncovered areas
Alternatives	Community networks	Network technology that routes communications over IP and does not rely on licensed spectrum; so far, these have mostly been piloted in remote communities or commercial installations (e.g. oil rigs)
	Aerial	Use of satellites, drones or balloons with on-board signalling equipment to provide ground coverage; these have mostly relied on the use of unlicensed spectrum and been piloted to cover remote communities or disaster areas

Table 1



Key points to takeaway:

- Market-led rollout of individual networks has covered the vast majority of the population up to now (over 85% on 2G and 70% on 3G); its economics breakdown at low population densities with low income in extra rural and remote regions
- There are no silver bullets in these areas; multiple solutions may be used in a single country

- Voluntary network sharing carries efficiencies in high density urban and sub-urban areas, and has also emerged as the most common approach among operators to expanding into uncovered rural areas; in Asia, there were an estimated 64 sharing agreements in place as of 2014, of which 9% involve active network components[4]
- In theory, active sharing offers the greatest scope for cost savings as it potentially involves combining more network elements; however, in practice these have proven difficult to realise given the complexities involved in integrating core networks. Some regulators have discouraged or restricted this practice given perceived risks to competition
- Passive sharing agreements have become most popular given the balance between cost savings (e.g. from network build and maintenance) and speed of rollout, a growing number of visible success stories, and increasing encouragement from regulators
- Government support through subsidies has emerged more as a niche solution for extra-rural and remote regions. USFs remain an option, but limitations from their structure and governance have largely limited success so far (a GSMA survey of 64 USFs in 2012 revealed that more than $11 billion was tied up between them and not yet spent on any rollout projects)
- Alternatives continue to be developed, targeting extra-rural and remote regions. Further proof points are needed to judge effectiveness and scalability in practice

[4] Source: Analysys Mason

Network sharing

Network sharing has emerged as the most viable and economical strategy among mobile operators for expanding coverage to rural and remote areas. Its roots are in joining networks to serve high density urban centres where space for new sites is at a premium, but over the last 5–7 years has become a favoured approach to reaching uncovered rural areas, largely in emerging markets where comparatively high proportions of the population live at low income levels. Most network sharing initiatives are commercially oriented, rather than mandated by regulators, driven by cost reduction pressures, coverage obligations attached to 3G and 4G spectrum licenses and, in some cases, a shift in the focus of competition from the network towards the service layer (such as Bharti in India).

The topographical and socio-economic make-up of the unconnected populations in Asia precipitate these challenges in sharp relief. Indeed, operational costs per tower are estimated to increase by 20% in remote areas cut off from road access and electricity.[5] Most of the network sharing activity in Asia has been of the passive variety, for which cost savings are potentially significant; documented examples from Asia and Europe suggest capex savings of around 40–50% (mostly from combining new sites and towers) and opex of 20–30% (mostly from fuel and other running costs).[6] In theory, active sharing offers even larger savings by making more efficient use of spectrum, and minimising unnecessary duplication of network equipment. It also offers operators improved network capacity and, consequently, quality of service in areas of high demand. In practice, these agreements have proven difficult to materialise because of complexities in integrating core network elements, while perceived risks to competition from spectrum sharing have attracted enhanced regulatory scrutiny. We do, however, believe these concerns will be overcome given the significant scope for cost synergies helping to drive network expansion, with this form of sharing playing a larger role over the next 3–5 years as a complement to passive.

India was one of the first movers, with the regulator (TRAI) modifying license conditions to allow sharing in 2007. Since then, Bharti Infratel, Indus and a host of other tower companies (towercos) have formed as a result of operators spinning off tower assets, with 3G coverage having grown to 75% since commercial services were first offered in 2010. Pakistan followed suit in 2010, marked by a memorandum of understanding between operators and the regulator (PTC). Malaysia has adopted a sharing model across the board and extended this to 4G. Most recently, Telenor and Ooredoo have adopted a tower sharing approach in Myanmar post liberalisation, which has helped extend 3G coverage to around 40% of the population as of the end of 2014 following years of limited and patchy coverage offered by the state monopoly. The below figure illustrates this progression and the corresponding rise in 3G network coverage (see Figure 5; we also profile the 3G coverage expansion strategies used India, Malaysia and Myanmar through in-depth case studies in the Appendix).

[5] Source: Capgemini
[6] Source: Accenture

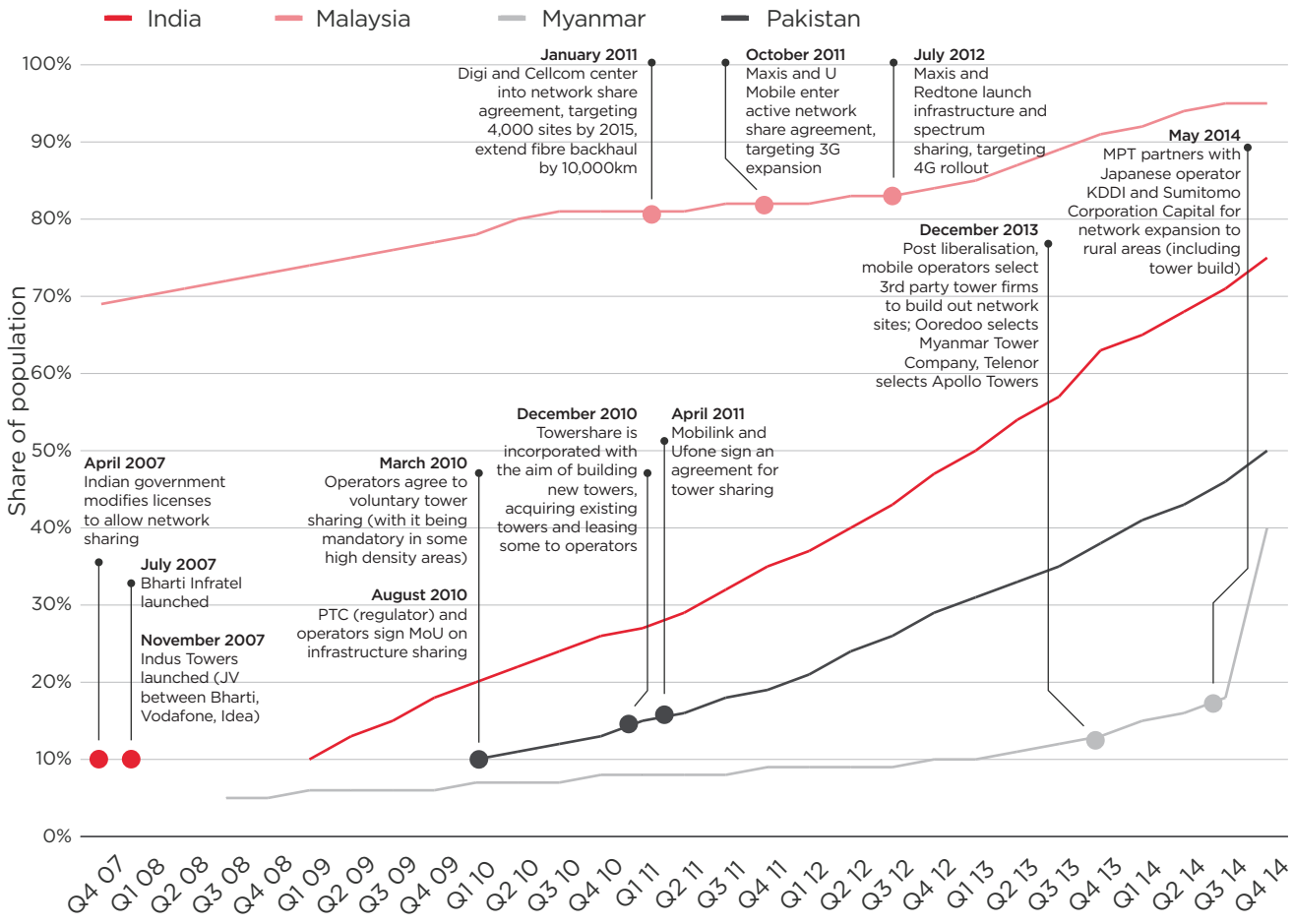


Figure 5: Network sharing has helped drive 3G coverage into rural areas
Source: operator reports, GSMA Intelligence.

Much of this has been helped by the insertion of towercos into the value chain. Traditional network-led rollout relies on medium to high density areas to spread investment and the large ongoing fixed cost base across. Rural areas are much lower density, with towercos able to spread the investment return risk of new infrastructure and running costs (fuel is 60% of the cost base) in previously uncovered areas over multiple operator tenants. For this reason, a growing share of towercos in operation are diversifying to develop and offer lower cost energy solutions, either solar or hybrid solar-diesel. On the other side of the coin, operators are able to offer service into new areas that would not otherwise have been reached, or at least not nearly as fast, with competition on network quality preserved because spectrum holdings remain separate. India is by far the biggest market in this respect, with four of the top five global tower firms (Indus, Reliance Infratel, Viom and Bharti Infratel) active and 70% of towers now owned by 3rd parties (see Figure 6) but the towerco influx is also accelerating in other markets such as Cambodia and Sri Lanka. China, of course, has the largest tower estate for conversion although is a relatively recent mover. The big 3 operators – China Mobile, China Telecom and China Unicom – recently formed a joint venture called the China Tower Company, which launched operations in December 2014. It plans to build 1 million new towers in the next two years with a strong focus on rural expansion, and in addition take over ownership of a further 1 million towers currently owned by the operators, with target savings of $12.5 billion over the next 5 years.

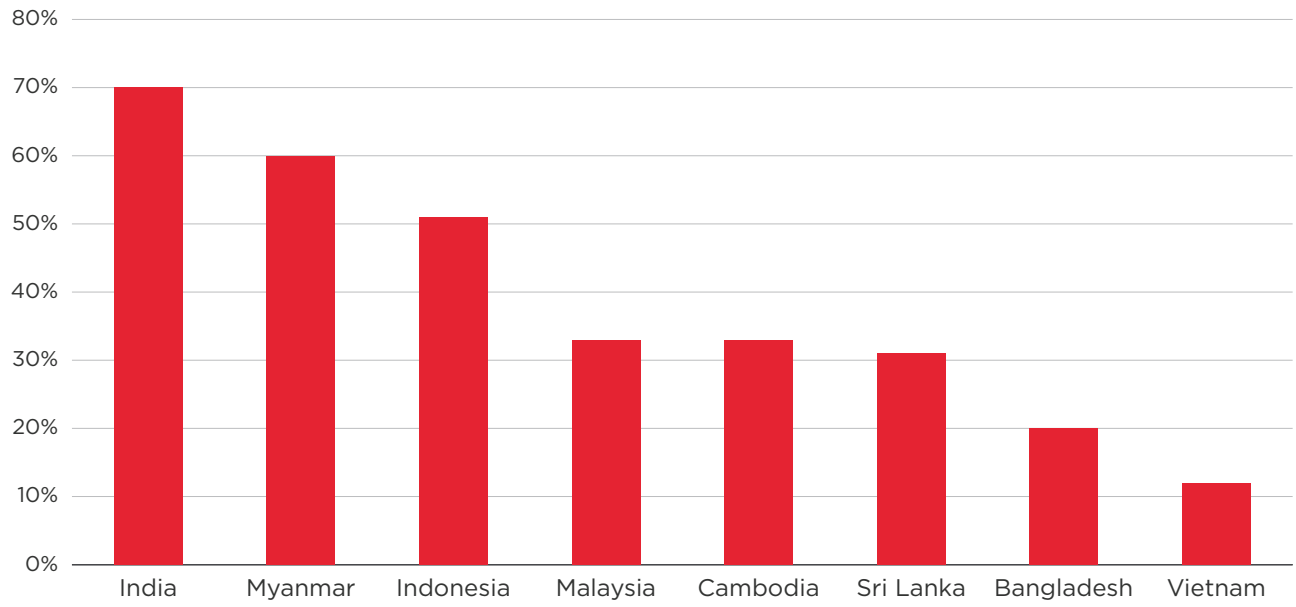


Figure 6: Proportion of towers owned by towercos, 2014

Source: GSMA, Towerxchange.

Government support

Many countries have adopted universalist policies that aim to make telecoms services available, affordable and accessible to all citizens. To this end, governments have been taking an increasingly active stance on closing the coverage gap by incentivising network providers to extend services to previously unserved areas. We highlight two approaches, subsidies and USFs.

Subsidies and grants

Government subsidies are directly financed from public funds as opposed to contributions from service providers (see USFs below). In most cases, operators and other service providers interested in a government subsidy participate in a bidding process for a contract to build new infrastructure in rural areas, generally towers and fibre backhaul. We profile several active programmes from across the world in the table below. As short-term, specific interventions with measurable outcomes as opposed to longer term stable funding regimes, subsidies are most effective in reaching the most rural and even remote areas for which traditional rollout models would be uneconomic. In Canada, this is evidenced through a $180 million grant over a 3 year period targeting expansion to remote communities (including the Arctic) with broadband speeds of at least 5 Mbps. Australia has reserved $76 million in subsidies to service providers to improve mobile service coverage in remote areas following more than 10,000 requests for new towers in more than 6,000 locations nationwide (some of the country's regional governments are moving in the same direction. Telstra has secured an $8 million contract from the government of Western Australia to build the first 22 of 85 towers, which form part of a $40 million Regional Telecommunications Project to reduce gaps in mobile voice and data coverage in small communities). These disbursements are, of course, small in the context of overall capex ($2 billion in Canada in 2014 for example), but we believe will continue to play an important role filling a highly specific void in the absence of market-led investment. For these reasons, we believe there is significant scope for Asian governments to increase their support in this area as a complement to operator-led network sharing.

Date	Country	Value	Key details
Feb 2014	Canada	245	- Second tranche of subsidy to extend and enhance broadband connectivity in rural and Northern communities by 2016 - First tranche of CAD225m distributed over the 3 years to 2013 - Project to deliver internet download speeds of at least 5 Mbps to 280,000 households in remote areas
Apr 2014	UK	372	- This is in addition to the £12bn already spent by the central and local government in high speed broadband across the UK - Aim of the investment is to help job creation in some of the UK's hardest to reach rural areas, and ensure that 95% of homes and businesses are connected by 2017 - Government has also committed £10m to find ways to reach those areas in the 'final 5%', with pilots for 4G, fibre optic and satellite technologies
May 2014	Australia	77	- Federal government subsidies aim to improve mobile service coverage in regional Australia - Launched in response to more than 10,000 requests for new towers in more than 6,000 locations nationwide - Mobile operators are invited to participate in a competitive bid for contracts to build the towers
Sep 2014	Sweden	455	- The Swedish Broadband Forum invited applications for a new round of subsidies for fibre optic and wireless broadband in rural districts - The board received one application each from the counties of Sodermanland and Gavleborg, two from Skane and three each from Halland and Vastra Gotaland - Subsidies will help enable fast internet services to around 500,000 residents and businesses in the countryside
Oct 2014	US	191	- Federal government fund to finance 25 broadband and communications infrastructure projects in rural communities in 19 mainland states, Puerto Rico and the US Virgin Islands - Funds disbursed through Community Connect ($13.7m) and Public Television Digital Transition ($2.4m) grants as well as through Telecoms Infrastructure loans ($174.4m) - The fund is provided by the United States Department of Agriculture (USDA)
Nov 2014	Paraguay	6	- Tigo won government tender to deploy new mobile and wireless infrastructure in Western and Eastern areas of Paraguay - 26 locations in the West and 10 locations in the East will see increased access to data transmission, broadband services and high quality voice telephony as a result of efforts to ensure universal access to communication services
Nov 2014	Spain	77	- The industry ministry will be allocating the funds to aid the deployment of fibre optic and wireless broadband technologies in rural areas - €45m in loans and €7m in direct subsidies will be handed out to projects that cover 301,000 households and businesses over the 3 years to 2017 - The remaining funding will be used for backhaul projects for radio networks

Table 2: Government subsidies for rural coverage expansion – gathering pace

Source: GSMA Research

Universal Service Funds (USFs)

USFs are generally financed through some sort of contribution mechanism from service providers, either fixed or calculated as a percentage of gross revenues, often with pre-defined exclusions. In some countries, the USF is a portion of an overall regulatory or licensing fee. Most USF-sponsored projects are delivered by service providers although some are carried out by third-party vendors on behalf of the government. Some successes can be highlighted; in February 2015, Pakistan's USF awarded a contract worth $18m to Telenor to deliver basic telephony and data services in unconnected areas of Chitral, Upper Dir and Lower Dir districts in the country, bringing access to 1.2 million people. In India BSNL, along with other state-backed entities PGCIL and Railtel, are leading the deployment of a USF-sponsored broadband fibre-optic backhaul network, which aims to connect each of the 250,000 Gram Panchayats of India and facilitate connectivity to around 600 million rural dwellers.

However, the underperformance of many USFs in terms of funds disbursements and project implementation and monitoring have largely undermined their effectiveness. Globally as of 2012, the GSMA estimates that of the $11 billion balance held in USFs worldwide, more than 95% was in emerging countries. These monies are collected on top of general corporation tax, which means it risks being a brake on future investment, and actually hits smaller, primarily agrarian economies hardest. We believe USFs remain an option in reaching underserved areas, but at a lower priority than network sharing and subsidies until governance is improved to release funds systematically and much more in time with when they are actually collected.

Alternatives

Finally, a number of alternatives to licensed spectrum-based mobile networks are being trialled to provide coverage in extra rural and remote areas, which we discuss below.

Community networks

These target remote communities cut off from cellular connectivity, road and grid access using micro base stations and a backhaul solution that links into the core network of mobile operators. Technically this functions by using custom software that re-encodes voice calls and data access onto the IP channel, which runs through a gateway onto the internet and interconnects with mobile networks around the world. A number of start-ups have taken root in this space, including Range Networks and Endaga, both of which operate low power sites. There are some proof points from local installations, such as those on oil rigs or other commercial sites, but relatively few from consumer-facing ones. We believe these merit further attention given the potential for expansion into underserved areas but ultimately will remain sub-scale indefinitely in the absence of partnerships with mobile operators given that most of the existing operations in this area run on experimental or unlicensed spectrum.

Aerial

Some of this is new and some is not. Satellites leverage the advantage of altitude to provide a wider ground coverage, with low earth orbit (LEO) satellites cruising at 1,000km above sea level and geosynchronous earth orbit (GEO) much higher at 40,000km up. Signal decay remains a problem, although rain fade has been mitigated through recent advancements in the Ku band. The technology is well established in serving commercial shipping companies and other remote commercial installations, but the move to consumer has struggled to gain traction given high cost and integration complexities. Both challenges remain, although we believe momentum is slowly gathering. The role of satellite systems was recognised by ITU Member States at WTDC-2014, with three Resolutions acknowledging the benefits that satellites provide to remote areas, and in helping bridge the digital divide for remote and rural regions. Commercial activity has also increased over the last 18–24 months; Airtel Africa signed a partnership agreement with Thuraya in March 2014 to provide voice and data access to unserved remote communities across 17 countries, while Intelsat and Gilat have jointly partnered with RuralCom to provide 2G and 3G coverage in parts of Alaska and British Colombia (Canada). We expect investment in the sector will continue to benefit from the halo effect given off by plays from companies such as O3B (of which Google is an investor) and SpaceX.

Apart from satellites, there is growing interest in the potential of other aerial connectivity solutions to facilitate network coverage in remote areas. Google's Project Loon – a network of balloons roughly 20km above sea level utilising unlicensed spectrum designed to provide internet connectivity to people in rural and remote areas – is the most prominent in this space. The company has reported progress on the initiative, with continuous flying time now 100 days before equipment needs to be swapped out, and ground antennas now

compressed into handsets as opposed to the large versions attached to home premises at the time of the first trials in mid-2013. Focus remains in the southern hemisphere, with trials having been completed over several countries, including New Zealand, Australia, Chile, Brazil, South Africa and Argentina. The company also claims to offer '3G like speeds', which could mean up to 42 Mbps, although in practice realised speeds are likely to be nearer 20 Mbps. The technology is not likely to scale to mass market, and nor is Google likely to want to do that (see Mobile access: the last mile). However, its use in niche situations does merit consideration as a supplement to ground mobile coverage, particularly in reaching remote areas or in serving disaster zones. Partnerships with mobile operators are of key importance even on this scale, and those formed with Vodafone in New Zealand, Telstra in Australia and Telefonica in Latam provide implicit recognition of this.

Appendix



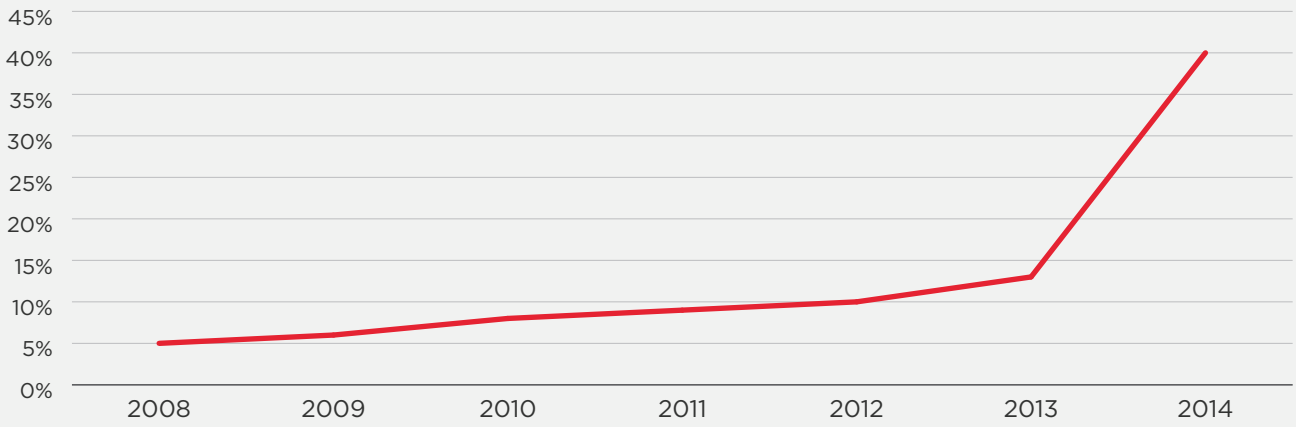
Coverage case study: Myanmar

The Challenge

Before 2013, the mobile network of Myanmar state-owned operator Myanmar Post and Telecommunications Company (MPT) covered only the capital Rangoon and a few other cities in the country. Although the operator had launched 3G service, this was not commercially available to consumers. Indeed, a considerable proportion of the population, mostly in rural areas, did not have any form of mobile service, leaving a large digital divide. In June 2013, Ministry of Communications and Information Technology (MCIT) selected Telenor and Ooredoo to build and operate two new mobile telecommunications networks as part of the government's liberalisation drive in the telecoms sector. The government also set a voice and data coverage target for the operators at 75% of the population within 5 years, a requirement that would involve deploying and running network infrastructure in regions lacking grid electricity and in difficult terrains (mountains, glaciers and forests) amid adverse weather conditions, notably heavy rains and severe flooding during the monsoon season.

Market Structure

The number of unique mobile subscribers in Myanmar reached 10.6 million at the end of 2014, a penetration of 20%. Most of the growth in the previous two years was recorded in second half of 2014 following the launch of commercial services by new entrants Telenor and Ooredoo. The two operators have already established strong footholds on the market, securing a combined market share of 38% – Telenor (23%) and Ooredoo (15%) – at the end of 2014, while the incumbent MPT had a market share of 62% at the end of the same period. We estimate 3G coverage in Myanmar has increased to 40% of the population, a spike from the sub 20% levels of the previous 5 years driven by network expansion from the two new entrants as part of license obligations.



3G Coverage (Population)

Source: GSMA Intelligence

Strategy and players

In line with their coverage obligations, Telenor and Ooredoo set initial voice and data coverage targets of 84% or more within the first 5 years of commercial launch. To achieve their coverage targets, both operators adopted a tower sharing strategy in order to accelerate the rollout of new towers and share inherent risks, including deployment costs, with other investors in the infrastructure market. Ooredoo selected Digicel Myanmar Tower Company (Digicel MTC) to build and manage its first set of towers, while Telenor selected Apollo Towers to build and manage 1,001 towers and Irrawaddy Green Technology (IGT) to build and manage another 2,000 towers.

In February 2015, the MCIT awarded Network Facilities Service (Class) licences to independent tower firms operating in the country, thereby formalising their operations and recognising the activities of towercos as a vital component the country's telecoms infrastructure market. The move removes any uncertainty over the long-term operations of the towercos, at least for the initial 15-year validity of the licences. This should attract more capital to the towercos to finance infrastructure rollout plans and also allay any concerns among the mobile operators about the stability of the towercos or the sustainability of the tower sharing strategy.

Impact and learning

Ooredoo's reported figures indicate its network covered 15% of the overall population at launch in August 2014, but increased significantly to 40% on 3G by the end of year. The operator expects overall coverage to reach 80% of the population by the end of 2015, and 97% within the next 5 years.

By outsourcing the build-out and management of tower infrastructure, Telenor and Ooredoo are able to focus developing a variety of value-added services. Furthermore, both operators have been able transfer some of the cost savings from tower sharing to consumers in the form of lower service tariffs. Voluntary infrastructure sharing can be applied in other markets to drive coverage expansion and optimise the utilisation of network assets. For new entrants, tower sharing provides a useful opportunity to accelerate service rollout and minimise infrastructure deployment costs.



Coverage case study: India

The Challenge

The combination of a difficult terrain, characterised by mountains and sparsely populated farmlands, high energy costs and low income levels made it uneconomical for India's mobile operators to expand coverage to rural communities, despite more than 70% of the country's population living in those areas. In 2007, the total cellular tower count in the country was 100,000, covering 40% of the land area. This left an estimated 500 million people without mobile coverage, according to the Telecommunications Regulatory Authority of India (TRAI).

Market Structure

India's unique mobile subscriber base reached 451 million at the end of 2014, a penetration of 35%. The market is served by 12 active mobile operators, providing services across different 'circles' for which they have received concession. Bharti Airtel was the biggest operator at the end of 2014, with a market share of 23%. Vodafone (19%), IDEA Cellular (16%) and Reliance (11%) round out the top 4. Aircel (8%), state-owned BSNL (8%) and the other 8 operators account for the remaining 31%.

Strategy and players

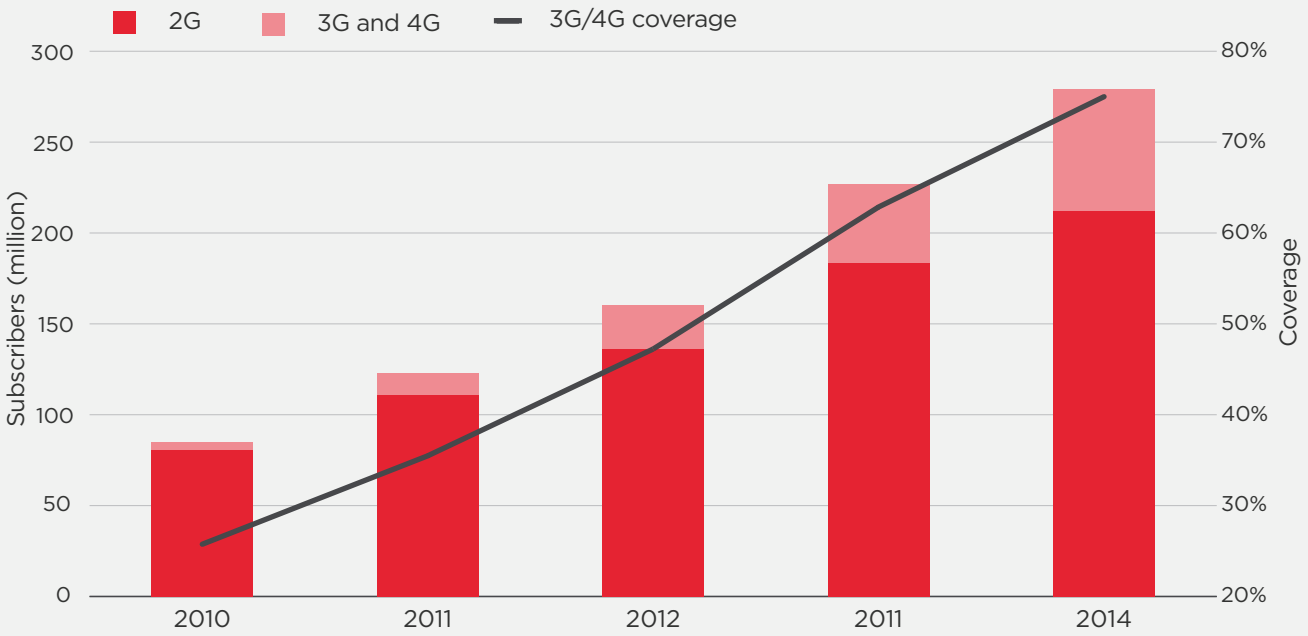
In April 2007, TRAI modified the licence agreements of mobile operators in the country to allow them share passive network infrastructure, such as towers. The regulator also approved subsidies for tower deployment in rural areas using funds from the universal service obligation fund (USOF). Several mobile operators, including Bharti Airtel, Vodafone, Reliance and IDEA spun off their towers to newly formed towercos, such as Bharti Infratel (2007), Indus Towers (2007), Viom Networks (2008) and Reliance Infratel (2008).

In April 2008, TRAI approved active network infrastructure sharing which allows operators to share RAN, transmission systems and some other active network components to boost network coverage. In 2010, Tata and Aircel sealed a network sharing agreement with MTNL for 3G services, and in 2015 Airtel and BNSL announced a network sharing deal that would strengthen their mobile services in areas where either of them has a weak or negligible presence.

Impact and learning

Tower sharing stimulated investment and competition in India's tower market, with the overall tower count rising to more than 450,000 at the end of 2014, a 4.5× uplift from 2007. As a result, 2G network coverage increased to 87% of the population, making mobile services available to previously unreached communities. Although India only launched commercial 3G services in 2010, relatively late in comparison with other markets in region,

3G network coverage reached 75% of the population in 2014, driven by network sharing. For the operators, tower sharing has resulted in significant capex and opex savings, with considerable improvements in quality of service as passive and active network sharing have helped boost capacity in areas of high demand.



Mobile internet growth helped by expanded 3G coverage
Source: GSMA Intelligence



Coverage case study: Malaysia

The challenge

As part of the National Broadband Initiative introduced by the Malaysian Government and the Malaysian Communications and Multimedia Commission (MCMC), the 'Time 3' coverage plan has called for MNOs to avoid unnecessary infrastructure duplication and efficiently use spectrum in order to address coverage in rural and remote areas by, at least in part, ensuring that network rollouts in these areas are economically viable. The plan aims to ensure that mobile coverage is available in areas where there is a population density of at least 80 persons per square kilometer. 962 (of 1,000 proposed) additional towers to improve coverage have been built since 2010.

Market structure

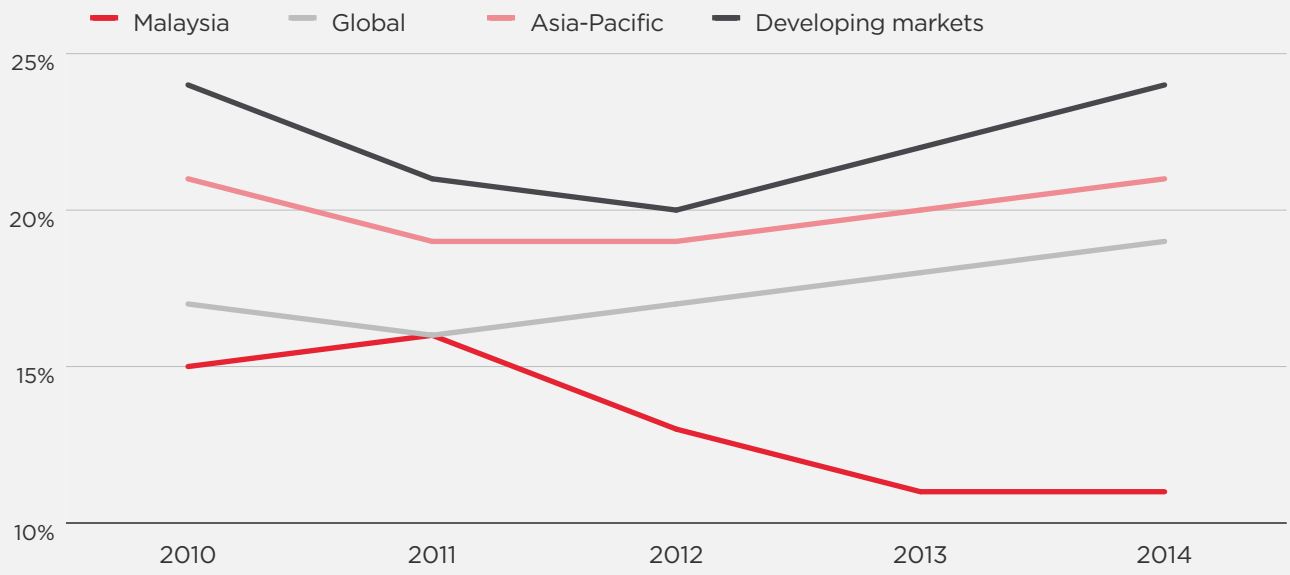
Malaysia has 8 licensed MNOs, however three are dominant with almost 90% of the market. Celcom and Maxis each have about 31% of connections, as of December 2014, with DiGi having around 27%, U Mobile 7%, and others 4%. Unique subscriber penetration is 54%, up from 47% in 2010, while unique mobile broadband (3G and 4G) subscriber penetration is 31%, having grown from 12% in 2010.

Strategy and players

Malaysia has some of the most extensive network and spectrum sharing among MNOs in Asia and globally, with the support of the government. Celcom and DiGi share infrastructure including sites, masts, and backhaul, and Celcom has had a roaming agreement with U Mobile since 2007. Maxis has had a 3G network sharing agreement with U Mobile since 2011, while Maxis and REDtone share, since 2012, infrastructure and spectrum to rollout 4G. Celcom also shares, since 2013, active elements including spectrum with Altel, which is investing US$270 million over 5 years to rollout a 4G network.

Impact and learnings

3G coverage has grown from 77% of the population at the beginning of 2010 to 95% while 4G, which is the focus of most recent network sharing and spectrum pooling agreements, has increased from 10% in at the start of 2013 to 33% by the end of 2014. This has allowed capex as a percentage of revenues for Malaysia, which has historically been lower than regional or global averages, to open up an even wider gap over the past three years. Despite the moderate level of capex, the growing broadband coverage helped to drive mobile broadband penetration to nearly triple since the start of the decade. While network sharing agreements are used in other markets, the scale of these in Malaysia is unique. Sharing of spectrum, given its scarcity and cost, could especially prove useful elsewhere if regulators are supportive and competition concerns can be addressed.



Capex Intensity (capex as a share of mobile revenues)
Note: 2014 data is 12 months to 30 September
Source: GSMA Intelligence

About GSMA Digital Inclusion

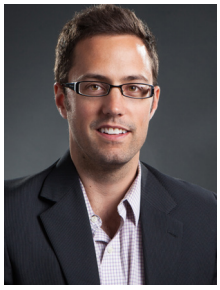
GSMA's Digital Inclusion programme supports the connection of an additional two billion people to the mobile internet by 2020. The programme focuses on working with mobile operators, development organisations and governments to address the barriers to mobile internet adoption through network infrastructure and policy, affordability and tax, digital literacy and local content.

For more information, please visit the GSMA Digital Inclusion website:
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