



# Connectivity Technology Reviews

- Alternative internet delivery
- Internet of things

## **Algeria, Algiers**

Satellite dishes wall of a tenement building called 'Les Dunes', said to be the longest building in Algiers (300 m). With its sister building, it contains a total of 840 apartments. In the background is the minaret of a mosque.

Credit: Andrew Testa – Panos



URGENT  
DENTISTE



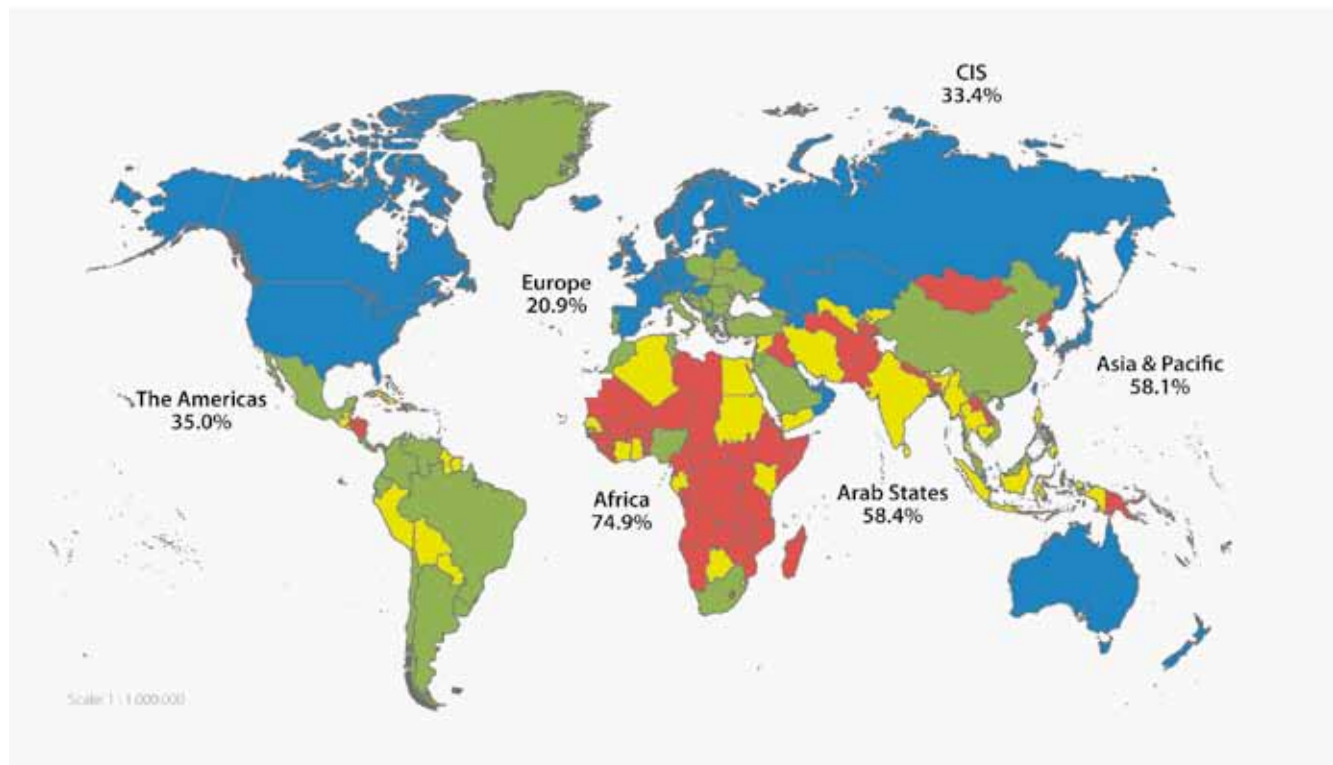
## Alternative internet delivery

### What is the challenge or opportunity?

Affordable access to the internet remains one of the major challenges to getting more poor people online. The poorest people in the least developed countries pay more for internet access than citizens in developed countries in absolute and relative terms.<sup>107</sup> The World Bank's 2016

*World Development Report* estimates that four billion people do not have access to the internet, leaving them unable to reap 'digital dividends' (see figure 7).<sup>108</sup> A 2014 study by the McKinsey Global Institute found that because the internet is increasingly integral to the fabric of local and global economies and societies, those who are not online are likely to be increasingly disadvantaged, and risk falling further behind.<sup>109</sup>

Figure 7 World's offline population, 2016



% of people NOT using the internet

- 0 – 25
- 26 – 50
- 51 – 75
- 75 – 100

At the of 2016, 3.9 billion people – 53% of the world's population – are not using the internet

In the Americas and CIS regions, about one-third of the population is offline

While almost 75% of people in Africa are non-users, only 21% of Europeans are offline

In Asia and the Pacific and the Arab States, the percentage of the population that is not using the internet its very similar: 58.1% and 58.4% respectively

Source: ITU, 2016. ICT Facts and Figures 2016, Geneva: International Telecommunication Union (ITU).

Available at: [www.itu.int/en/ITU-D/Statistics/Documents/facts/ICTFactsFigures2016.pdf](http://www.itu.int/en/ITU-D/Statistics/Documents/facts/ICTFactsFigures2016.pdf) (Accessed October 10, 2016).



## Alternative internet delivery as a frontier technology

One of the major obstacles to expanding affordable internet access relates to the challenge of rolling out or upgrading infrastructure in poorly connected areas. This challenge has a number of facets.

First, infrastructure investment and roll-out tend to be demand driven, shaped by available markets, and typically deployed in areas where telecommunications companies and internet providers see potential profits. As a result, much infrastructure is deployed in more urban and affluent areas, where business and government activity – and therefore potential profitability – are greater.

Second, even when physical infrastructure is in place, the internet may remain out of reach of the majority of people because of the costs of operating and maintaining the infrastructure, which remains high and is often passed on to consumers.

Third is the issue of logistics. While mobile telephony infrastructure has overcome many of the obstacles of laying out fixed-line infrastructure – such as the need to lay out hundreds of thousands of miles of cables, and the need to have those cables connected to many homes – setting up and maintaining cellphone towers in hard-to-reach areas is operationally difficult. Given that private telecommunications companies typically drive mobile network expansion, there is little incentive to reach the most remote areas because the potential revenue often does not outweigh the costs. Transportation, materials and personnel are all needed, in places that are often highly inaccessible. This also raises the political issue of the need to secure and manage land rights for new infrastructure, which is seldom a straightforward process.<sup>110</sup>

A large number of proposals and pilots have been developed to overcome these issues through a series of aerial infrastructure innovations. The most advanced have been four efforts designed and backed by large corporate players in digital technology sectors: Google, Facebook, SpaceX and OneWeb. Each initiative claims to have the cutting edge technology that will bring the next four billion online and bridge the digital divide. More details on each approach follow below.

### Project Loon

Google's Project Loon seeks to provide constant wireless internet coverage worldwide, its objective being to 'connect people in rural and remote areas, help fill coverage gaps, and bring people back online after disasters'.<sup>111</sup> This is achieved with a network of thousands of high-altitude balloons working in tandem with drones from its parallel Project Titan initiative. The balloon technology itself is noteworthy, with artificially intelligent sensors continually determining and adjusting the position of the balloons relative to wind currents to give optimum connectivity to people on the ground. Each balloon gives coverage of an area up to 80km in diameter. Through arrangements with telecommunications companies, Project Loon enables users to connect directly from mobile phones and other wireless-enabled devices. The signal is then passed across the balloon network and back down to the global terrestrial internet.

Project Loon's technology was initially piloted in New Zealand, California, Brazil and Australia and found to be both viable and effective. The first commercial deployment was in Sri Lanka in July 2015, with plans to expand to Indonesia and India in 2016. In 2015, MIT Technology Review research estimated that the technology was about two years away from being globally available.<sup>112</sup> Project Loon is the only high-profile alternative internet delivery initiative that has piloted, tested and deployed this form of technology at scale.

---

One of the major obstacles to expanding affordable internet access relates to the challenge of rolling out or upgrading infrastructure in poorly connected areas.

---



One of Project Loon's balloons is displayed at a launch event in June 2013.  Photo credit: Flickr User: iLighter, Creative Commons licence: BY, [https://commons.wikimedia.org/wiki/File%3AGoogle\\_Loon\\_-\\_Launch\\_Event.jpg](https://commons.wikimedia.org/wiki/File%3AGoogle_Loon_-_Launch_Event.jpg)

## Internet.org and drone-based internet

Despite the large proportion of people globally who do not have internet access, a large majority – estimated at 85 per cent of people worldwide – live in areas covered by a mobile internet signal.<sup>113</sup> The untapped potential underpins Facebook's Internet.org initiative. This involves a package of solutions aimed at enhancing the 'accessibility, affordability and relevance' of the internet globally.

The solution that has attracted the most attention – for those who can access an internet signal – has been the Free Basics mobile phone app. This is intended to provide a free demonstration of the internet for the people who do not have internet access, with a series of 'empowering apps' that allow unconnected communities to learn about and engage with the benefits of the internet.

The idea is that after an initial taster, poor users will be incentivised to buy data and begin using the internet. In parallel, Facebook is also running a series of contests and funds seeking to introduce local languages and localised content, and relevant apps to better meet the needs of groups whose interests are underrepresented on the internet.

On the infrastructure side, to reach those not covered by an internet signal and improve affordability, Facebook is placing its bets on a combination of satellites for very remote areas; a network of solar-powered unmanned aerial vehicles (UAVs) or drones that can stay in the air for months at a time for more suburban areas; and laser technology to speed up the strength of internet signals from space.<sup>114</sup> Facebook is also investing heavily in innovations, aiming to bring down the cost of data 100-fold and reduce the cost of mobile phone handsets through partnerships with technology and hardware companies.

## Micro-satellites

OneWeb and SpaceX are betting on planet-wide constellations of low-earth orbit microsatellites to beam continuous internet across the planet. OneWeb is owned by a consortium of actors including Greg Wyler, former CEO of internet satellite company Other 3 Billion (now owned by Google), British entrepreneur Richard Branson, Airbus group, Virgin Galactic, Bharti Enterprises, Hughes Network Systems, Intelsat, Qualcomm Inc., Totalplay and Coca-Cola. OneWeb believes it will achieve global coverage thanks to a network of 648 satellites, along with many small, portable and low-cost ground terminals.<sup>115</sup>

SpaceX's initiative is more ambitious than the other initiatives listed here. In addition to connecting the unconnected on Earth, the company seeks to lay down the fabric for an inter-planetary internet between Earth and Mars with 4,000 proposed satellites. This initiative is part of a larger venture aiming to establish a colony on Mars by 2025.<sup>116</sup>

---

**While the overall potential market size has yet to be estimated, future digital services for the four billion who are presently not online is likely to lead a new market with future value in the order of tens if not hundreds of billions of dollars.**

---

## Potential value generation

The value of expanded internet access is dependent on a number of factors: (1) network coverage and speed; (2) cost of access in relation to income; (3) awareness and literacy (language and digital); and (4) availability of locally relevant content.

Although these will be of varying importance for different socio-economic groups adopting a given technology, 'coverage and cost are arguably the most fundamental'.<sup>117</sup> If these can be addressed, then the initiatives listed here are likely to yield benefits to people living in remote and other hard-to-reach places in developing countries. By bringing connectivity through aerial infrastructure, these initiatives have considerable potential to connect people who were previously never covered by a mobile signal, and overcome the limitations of conventional infrastructure described earlier. If as promised the technologies developed are cheaper to deploy and operate than current land-based infrastructure, these initiatives also have the potential to drive down costs in areas where there is already good

connectivity, thereby making greater internet usage more affordable for more people.

There will also be benefits for middle- and high-income groups. One major group is likely to be air and sea passengers and transportation workers, who will benefit from internet at affordable rates when thousands of miles from terrestrial infrastructure.<sup>118</sup> Value is also likely to be generated through strengthening connectivity in times of network saturation – for example, at big sporting events or festivals – as well as providing connectivity when ground-based infrastructure has been damaged or destroyed, such as during natural disasters and extreme weather conditions.<sup>119</sup>

Some of the largest benefits from alternative internet delivery initiatives will no doubt accrue to the corporation that proves most successful and captures the greatest market share for its systems. GSMA estimates that 1.1 billion people will connect to the internet for the first time using a mobile phone between 2014 and 2020.<sup>120</sup> It has been estimated that because of the centrality of its search engine for internet users, Google could add over a billion dollars in revenues to its search business for every 42 million users that come on to the internet.<sup>121</sup>

While the overall potential market size has yet to be estimated, future digital services for the four billion who are presently not online is likely to lead a new market with future value in the order of tens if not hundreds of billions of dollars.

Leaders of the firms and initiatives in question have made bold statements about the potential of these innovations to bridge the digital divide and thereby alleviate poverty, decrease inequality, improve education, empower women and minority groups, democratise knowledge, and stimulate economic growth. However, in almost all of the cases, an over-simplistic set of assumptions underpins these claims: that access to the internet in itself will almost inevitably lead to the positive outcomes described.<sup>122</sup>

Although these initiatives are likely to contribute to partially bridging the persistent digital divide, with the possible exception of Facebook's work, they seem to assume that the offline status of individuals is primarily about technological access. However, evidence increasingly shows that connectivity is just one of the reasons that often dictate whether or not an individual is going to benefit from digital dividends. Other factors include:

- Access to and autonomous use or ownership of adequate internet-enabled hardware devices and related software tools;



- Levels of language and digital literacy; and
- Socio-economic status (e.g. age, gender, education, class).<sup>123</sup>

Because digital access is interdependent with broader development challenges it cannot be fully tackled in isolation from wider contexts. For example, in rural and often patriarchal societies, the deployment of better aerial internet infrastructure is unlikely to overcome social norms that act as a barrier for women to access the internet.

## Enablers and barriers

The development policy context is changing, with a growing awareness of the importance of digital access, and the scale and scope of the problem in relation to lack of such access. Influential reports such as the 2016 *World Development Report* are likely to create a positive context for these initiatives to develop and expand, and for their development contribution to be put centre stage.<sup>124</sup> For this to be a true enabler of positive development, a clear and transparent way of assessing the benefits that are being generated by the pilots and subsequent attempts to scale is needed.

Demand for internet access is growing among excluded groups, and this market potential is likely to drive the expansion of these initiatives. A better understanding of this market and of the nature of the demand are urgently needed.

Legislation concerning UAVs and flying objects has not kept up with the speed of technological innovation. Airspace legislation and sovereignty are likely to prove to be major barriers that prevent these initiatives from fulfilling their potential. Specifically, international law dictates that airspace belongs to the country that it covers. Failure to consult or abide by agreements with sovereign nations regarding flying objects in their airspace could result in the taking down or confiscation of those objects.

Besides the legal barriers, there are also issues of national permissions for use of airspace.<sup>125</sup> Some governments – especially authoritarian ones – may be less willing to promote the spread of the internet.<sup>126</sup> For example, North Korea deliberately keeps its population offline, while China blocks full access to certain high-profile platforms such as Facebook, Wikipedia and Google to control the content its citizens can access. More generally, governments may prefer to control infrastructure within their borders as it makes it easier to control access and to filter content.<sup>127</sup>

Perhaps unsurprisingly, privacy and data exploitation concerns also accompany these initiatives. There are commercial risks in Western firms accessing and selling data with commercial benefits. But there are also political and security concerns, such as widespread fears that technology companies will collaborate with intelligence agencies to spy on populations.

These initiatives are not wholly new, but instead build on past initiatives seeking to provide a global internet. A number of these failed, such as Bill Gates satellite-based venture Teledisc in the 1990s, or Motorola's Iridium, widely referred to as the single biggest business failure of its decade.<sup>128</sup> It is not clear that lessons from these failures have informed the design of new initiatives.

These initiatives also collectively propose to add hundreds of thousands of flying objects to an already over-crowded airspace and near-earth orbit. They will increase the likelihood of collisions in earth's orbit and could also lead to signal interference with other satellites already in orbit.<sup>129</sup>

All of these initiatives need access to the limited telephony spectrum to beam mobile internet access from the sky. Only OneWeb has rights to use part of the spectrum, as these were allocated to company founder Greg Wyler during a previous satellite venture. Project Loon has circumnavigated the need to apply for spectrum in Sri Lanka by providing the government with a 25 per cent ownership stake in its operations in the country. All four companies have mentioned the possibility of partnering with established telecoms companies to share spectrum, which is limited and tightly controlled and allocated to entities by governments. Each one of these initiatives will have to have its own spectrum allocated to it to avoid interfering with other telecoms operations on the ground. Project Loon has already encountered spectrum issues in India, where the spectrum it was allowed to use interfered with local mobile networks, leading the government to deny the project access to unused 'white spectrum'.<sup>130, 131</sup>

## What next for development actors?

- **Research and analysis** – More and better targeted research investments by development actors could help enhance and deepen understanding of the needs of the four billion offline, potential markets and the range of possible solutions. It could also identify positive and negative impacts and work to mitigate these, and bring more objectivity to the claims being made. Development actors could use better research to set specific standards and targets for alternative internet delivery, and thereby drive more ‘pro-poor’ innovation. A particular role for evidence is to clarify the potential of existing initiatives. Because these initiatives tend to overlook the wider, non-technological factors that might keep the four billion offline, they tend to make bold statements about having the capability to ‘bring everyone online’ – rather than making measured projections about how many people their initiatives might in fact reach. An independent assessment of these initiatives is needed that takes into account all the factors that stop people from getting online; and makes realistic assessments of how many people will come online because of these initiatives, and how many are likely to remain offline, who will require other kinds of interventions.
- **Collaboration with development actors** – For the most part, none of the cited initiatives – with the exception of Internet.org through its Free Basics app – involves much collaboration with development organisations. These initiatives are largely deploying simple, top-down technocratic solutions – what Evgeny Morozov has termed ‘tech solutionism’<sup>132</sup> – to complex, often non-technological problems. Technology companies would have much to gain from interacting and collaborating with development actors that are more familiar with the ‘beneficiaries’ they are attempting to reach, in terms of prior engagement, access and being an trusted and honest broker.
- **Cooperation across initiatives** – Some collaboration is already happening; for example, Google invested \$900m in SpaceX in 2015. Development actors may be able to drive greater operational collaboration between competing firms to enhance pro-poor innovation, helping the initiatives to assess their own strengths and weaknesses and identify new partnerships that can drive access growth among those most in need.

---

Technology companies would have much to gain from interacting and collaborating with development actors that are more familiar with the ‘beneficiaries’ they are attempting to reach, in terms of prior engagement, access and being an trusted and honest broker.

---





# Internet of things

## What is the challenge or opportunity?

The internet of things (IoT) provides the opportunity to radically improve the efficiency of all kinds of public sector, business and community processes and infrastructure, thanks to a growing network of low-cost sensors, actuators, and data communications technology embedded in physical objects. This IoT enables those objects to be sensed, coordinated and controlled remotely across existing network infrastructure. The technology is instrumental to establishing and integrating a number of new innovative processes and business models, leading to multipliers in the value they might otherwise generate in isolation.

## Internet of things as a frontier technology

The IoT, also known as the 'internet of everything', refers to the interconnection of physical objects embedded with sensors, electronics, software, network connectivity and actuators (see figure 8 for an illustration of the

range of objects connected to the IoT). These enable the objects to collect and exchange data, which can subsequently be acted upon. From monitoring goods trucks as they travel across Germany, to measuring the humidity of the soil in Spanish vineyards, to tracking the output of water pumps in Kenya, the IoT can be integrated into virtually any process and thereby enhance efficiency, responsiveness, timeliness and intended positive outcomes.

The IoT is a frontier technology because of its enabling character. It allows a number other frontier technologies to be combined, thus multiplying their potential generated value. Following the general principles of network economics, the more 'things' are connected and the more services are integrated into the network, the more value can be extracted from the IoT as a whole, and the more its adoption will accelerate. The potential impact of the IoT is therefore enormous. McKinsey Global Institute predicts that if 'policy makers and businesses get it right, linking the physical and digital worlds could generate up to \$11.1 trillion a year in economic value by 2025'.<sup>133</sup>

Figure 8 Range of devices connected to the internet of things



The more things and services are integrated into the Internet of things, the more value that can be extracted from them.  
 Source: Jeferrb on pixabay, <https://pixabay.com/en/network-iot-internet-of-things-782707>

---

The Internet of Things (IoT) allows a number of other frontier technologies to be combined, thus multiplying their potential generated value. Following the general principles of network economics, the more 'things' are connected and the more services are integrated into the network, the more value can be extracted from the IoT as a whole, and the more its adoption will accelerate.

---

Widespread adoption of the IoT is speeding up, thanks to constant improvements in underlying technologies such as miniature sensors, wireless networks and connectivity. It is calculated that currently more than 22.9bn devices around the world are already connected to the IoT, which is expected to exceed 50bn by 2020.<sup>134</sup> However, this widespread adoption is not going to happen overnight in developing countries, where a relative minority of connected objects are present.

### Definition

The IoT refers to the growing trend for data communications technologies to be built into physical objects – from swallowable pill cameras that travel through the human intestines, to wearable gadgets and smartphones, house appliances and smart-city sensors, and drones and satellites. These technologies comprise:

- **Sensors** – Electronic components designed to detect processes and environmental factors; and
- **Actuators** – Electronic components responsible for control or movement.

Together, they enable connected objects to be sensed, coordinated and controlled remotely by both human and automated users across existing network infrastructure. The IoT creates opportunities for the direct integration of the physical world into computer-based systems. The aggregation of information the sensors collect generates high-value big data that can be used by a variety of stakeholders for real-time monitoring and response, or collected over time to perform predictive analysis and improve processes.

The IoT has the potential for the public sector, business, communities and individuals to improve delivery of services, optimise performance, introduce new business models, and achieve goals in a very wide range of different settings. Areas where the

IoT has been widely applied include, but are not limited to:

- Improving the efficiency of manufacturing and logistics;
- Enhancing counterfeit product detection;
- Monitoring movement of people, stock, vehicles and equipment;
- Analysing a wide range of infrastructure investments from water installations to healthcare facilities; and
- Monitoring the environment to ensure optimal conditions and resource allocation in water delivery systems and agriculture.

As well as enhancing existing processes, IoT technologies are increasingly used to establish innovative processes and create novel services. IoT technologies range from simple identification tags that enable tracking of items to complex multi-sensor devices and actuators. Sensors can be attached to items to track their location and condition; embedded in infrastructure to control their surroundings; included in multi-functional gadgets such as smartphones; or integrated into robots and drones to support their movement and activities.

All IoT sensors collect data, which is then transmitted using connective technologies, which include cellular networks, WiFi and Bluetooth. The transmitted data can be aggregated and processed in many different ways, from computerised analysis that triggers automated actions, to dashboard displays that facilitate operational decision making by people, and big data analytics or artificial intelligence/machine learning to support better understanding and navigation of complex problems.<sup>135</sup>

## Potential for acceleration

The IoT is a new but rapidly growing technology, which is widely expected to continue accelerating its expansion as an essential component of the digital industrial revolution. International Data Corporation (IDC), a market intelligence firm, predicts that, in the next 2–3 years, the IoT will reshape business areas as diverse as executive decision making, marketing strategies, product design, customer engagement and aftersales service; moreover, within five years all industries will have launched IoT initiatives and incorporated IoT in their business plans.<sup>136</sup> The worldwide revenues generated by IoT solutions is expected to grow at a steady 20 per cent annually, rising from \$2.7 billion in 2015 to \$7.1 billion in 2020.<sup>137</sup>

---

**The worldwide revenues generated by IoT solutions is expected to grow at a steady 20 per cent annually, rising from \$2.7 billion in 2015 to \$7.1 billion in 2020.**

---

A variety of issues could potentially limit the rate of growth of the IoT, but current trends are positive on most fronts. On a technological level no major barriers are blocking the development of the IoT. Semiconductor components that are central to most IoT applications are showing ever-greater functionality at lower prices and electrical consumption. Sales of sensors are growing rapidly, and technological advances are making more capable sensors more affordable. Miniaturisation and high-volume manufacturing techniques make it possible to install sensors in even the smallest devices. Finally, the spread of high-speed wireless data networks is extending the coverage area of the mobile internet, helping pave the way to greater IoT use.<sup>138</sup>

The increased effort to develop formal and informal standards should facilitate interoperability between IoT applications and technologies, a critical factor in reducing the risk of lock-in that might deter future investments. Companies such as Apple and Google have entered the IoT home automation market and now provide development toolkits, contributing to the emerging ecosystem for IoT app development, which could then spark off further innovation.

The field of digital technologies for international development has seen renewed growth in interest, and many innovations are improving project outcomes and delivering services in developing countries.<sup>139</sup> Adaptations of IoT to

the needs of low-income populations have been identified by scholars at the Berkeley Institute for Globally Transformative Technologies as one of the technological breakthroughs to drive global sustainable development.<sup>140</sup> While many international development actors are aware of the need to leverage the potential of IoT for development, they are still uncertain about the best way to do it. Consequently, most of the experimentation in the IoT for development (IoT4D) field is currently performed in small-scale projects that non-governmental organisations (NGOs), social enterprises and academia are driving, and is still in the nascent or ‘hacker’ phase of development. Nonetheless, interest is growing and the field is expected to accelerate and increase in scale and scope.

## Potential value generation and impacts

The IoT is expected to generate immense value, with deep and long-lasting impacts across all industries and spheres of human interaction. Health care, manufacturing, energy and infrastructure management, agriculture, home automation and environmental monitoring are among the sectors where the impact is going to be most immediate and visible.

As a new universal connecting infrastructure, the IoT will potentially influence every existing domain of human endeavour, while at the same time catalysing the emergence of new ones:

- **In health care**, for example, IoT is already improving efficiency in treating patients with chronic conditions, as wearable sensors alert medical staff about emerging problems. An increasingly widespread example is the incorporation of sensors into cardiac pacemakers to create ‘smart hearts’, which generate and share information about patients’ conditions, enabling better clinical decision making and even automated actions such as recalibrating pacing rhythms in real-time. In developing countries, the IoT is used to ensure that health clinics are always fully stocked with vaccines and anti-malarial medication.<sup>141</sup>
- **In manufacturing**, sensors can be used to track machinery and provide real-time updates on equipment status, decreasing downtime; as well as tracking trucks and pallets to improve supply chain management, reducing inventory levels and optimising the flow of materials.
- **In energy**, smart electrical grids are improving energy demand management and reducing costly peak usage. Grid sensors can monitor and actively diagnose network problems to prevent outages and reduce maintenance costs.





A technician from M-KOPA, a Kenyan based company specialising in low-cost solar lighting, installing and activating a solar lighting system in a rural property. This works thanks to mobile money and sensors connected to the Internet of things. Photo credit: Sven Torfinn – Panos.

- **In agriculture**, sensors measure soil moisture, temperature and stress in plants, and gather information about how water moves through a field to optimise irrigation schedules and fertiliser use.<sup>142</sup>
- **In water delivery systems**, sensors are used to monitor the availability and safety of drinking water. Furthermore, sensors are being used in developing countries to monitor the performance and structural integrity of water pumps.

These technologies will continue to benefit developing countries in driving social and economic advancement by improving services and economic activities. However, the special conditions and limitations that pervade developing countries will shape the extent and scale at which the IoT develops.

Lack of connectivity, limited technological literacy and economic capacity, and the lack of basic infrastructure favour smaller-scale, simpler and more cost-effective solutions. In developing countries, for example, deployments are more likely to be made in isolation and independent of supporting infrastructure, using widespread available technologies such as mobile phones and SMS (text messaging). Much experimentation in developing countries is in the areas of health care, water, agriculture, natural resource management, resilience to climate change, and energy.

A number of promising initiatives are being developed. For example:

- **Health care** – Across sub-Saharan Africa SMS-enabled thermometers help to preserve the freshness of vaccines throughout delivery to remote and rural areas through real-time monitoring of temperatures in cold storage units.<sup>143</sup>
- **Water delivery** – detect usage patterns and failures of village water pumps, helping to reduce their downtime and plan future infrastructure investments.<sup>144</sup>
- **Agriculture** – Low-cost greenhouses equipped with sensors use SMS to send alerts and receive irrigation commands from farmers.<sup>145</sup> IoT apps are also used to track and manage smart multi-functional shareable micro-tractors, available for farmers on demand as a collaborative consumption tool.<sup>146</sup>
- **Resilience** – Mobile phone activity is increasingly used to understand emerging crisis trends such as the sudden mass population movements, and to improve disaster management; for example, by synthesising and providing real-time information gathered from communities during floods.<sup>147</sup>
- **Energy** – Firms such as M-KOPA Solar use IoT-supported financing schemes to provide rent-to-own solar energy products to hundreds of thousands of off-grid households.<sup>148</sup>

## Potential benefits for development

The IoT holds significant promise in delivering social and economic benefits to emerging and developing economies. Awareness is growing in the international development sector of the game-changing role that the IoT – in conjunction with other digital and frontier technologies – could potentially play in development.

Experience clearly shows that these technologies can be successfully adapted to developing countries to improve research, public policy, basic service delivery and evaluation of programmes across a range of sectors. Innovators all over the developing world are creating sustainable and successful IoT-based business models that generate enormous value for economically disadvantaged people.

It is not surprising that NGOs, academia and social enterprises drive most frontier innovation, through small-scale, exploratory interventions. The IoT is composed of nascent technologies with a number of unresolved issues (see below) that become especially prevalent in developing countries with precarious infrastructure, sparse network accessibility and uneven purchasing capacity. To reach the untapped potential that the IoT offers to these countries, it is necessary to transition from small-scale experimentation to more systematic, scaled-up use of the technology. Successful pilots will need to find pathways to evolve into sustainable businesses, where corporate or individual customers are willing to pay; or into successful public or civil programmes, where governments and the third sector pay for services because of the social value they generate.

---

**M-KOPA Solar has empowered off-grid households that lack purchasing capacity to directly leapfrog into leasing and financial services, and has also created an emerging IoT network that could lead to further applications and benefits.**

---

With appropriate levels of experimentation, it is entirely feasible for developing countries to use the IoT to leapfrog to new levels of social and economic development. M-Pesa, for example, has allowed 19 million people in Kenya to access banking services via mobile technology, leapfrogging traditional banking networks. It has transformed economic interactions in that country, facilitated the creation of thousands of small businesses, promoted rural development and poverty reduction, and indeed set down an

infrastructure for IoT applications.<sup>149</sup> Building on this, M-KOPA Solar has empowered off-grid households that lack purchasing capacity to directly leapfrog into leasing and financial services, and has also created an emerging IoT network that could lead to further applications and benefits.<sup>150</sup>

Local and national governments, and public service providers in general, need to get involved and take the lead in progressively introducing better, IoT-powered public services. This cannot happen immediately because few countries have the necessary capacity – either on the government side or among commercial providers – to implement reliable, cost-effective, off-the-shelf solutions that can be deployed at scale. But the learning processes leading in that direction should begin, supported and facilitated by international organisations.

## Enablers and barriers

The IoT offers great promise, but to deliver on its potential certain conditions need to be in place and obstacles need to be overcome. Some of these issues are technical, some relate to regulation, and others are structural and behavioural, or are questions of trust and habit. Certain challenges have been identified as the most pressing for the IoT.<sup>151, 152</sup>

### Technology

For widespread adoption of the IoT, the cost of basic hardware – such as sensors, tags, batteries and storage – must continue to fall. For example, the cost of MEMS (microelectromechanical systems) sensors dropped by 35 per cent between 2010 and 2013 and is expected to continue to drop.<sup>153</sup> This is especially relevant for developing countries, where the cost of solutions can be an important deterrent to experimentation. Further development is also needed in analytical and visualisation software, and IoT software development tools that are suited to developing countries and available technologies.

### Security

The security of IoT products and services is fundamental. Users need to be able to trust that IoT devices and related data services are secure from vulnerabilities, as this technology becomes more pervasive and integrated into our daily lives. Poorly secured IoT devices and services can serve as potential entry points for cyberattack and expose user data to theft by leaving data streams inadequately protected. When the IoT is used to control physical assets, such as water treatment plants or vehicles, the consequences associated with a breach in security extend

beyond unauthorised release of information to potentially causing physical harm.

### Privacy

The IoT is dramatically changing how personal data is collected, analysed, used and protected. Concerns about privacy and potential harms might well hold back wholesale adoption of the IoT. IoT providers need to be transparent about what data is used and how, and ensure that users are appropriately protected. This is especially important for groups in developing countries that are already marginalised and subject to abuses of human and other rights.

### Interoperability and standards

Greater collaboration and coordination is needed to address the fragmented environment of proprietary IoT technical implementation. Without concerted efforts, fragmentation is likely to inhibit the anticipated value for users and businesses. Purchasers will remain hesitant to buy IoT products and services at scale if there is lack of integration, high product complexity or lock-in to specific vendors. ITU has estimated that there currently over '115 different protocols used by IoT devices to connect to the cloud today'.<sup>154</sup> Without interoperability, the majority of potential IoT benefits will not be achieved. The use of generic, open, and widely available standards as technical building blocks for IoT devices and services will support greater user benefits, innovation, and economic opportunity. Private and state-led approaches have been proposed in the discussion about how to effectively and safely move towards greater interoperability.<sup>155</sup> There are potential risks (e.g. security and privacy) if interoperability is implemented poorly.

### Legal, regulatory and rights issues

The use of IoT devices raises regulatory and legal questions, as many IoT applications cannot proceed without regulatory approval. This has implications across the areas of licensing, spectrum management, standards, competition, security and privacy. The rapid rate of change in IoT technology frequently outpaces the ability of associated policy, legal and regulatory structures to adapt. For example, there are issues about tensions between law enforcement-related surveillance and civil rights; data retention, sharing and destruction policies; and legal liability for unintended uses, security breaches or privacy lapses.

---

**It is important to nurture pro-poor innovation which develops IoT goods and services for those at the bottom of the income pyramid in the sectors that matter most to these target groups, such as health, education and small-scale agriculture.**

---

### Organisational skills and capacities

The IoT combines the physical and digital worlds, and thereby challenges conventional notions of organisational responsibility. To achieve the vision expounded by champions of IoT, many different functions and departments in government, development organisations and private companies will need to radically increase their awareness of and knowledge about how IoT systems could be put to use in their areas of work. They need the capacity and mindset to use the IoT to guide data-driven decision making; and the trust and willingness to adapt to new processes and business models.

### Emerging economy and development issues

Developing countries have to cope with additional difficulties to achieve the IoT's potential, as they typically lack infrastructure readiness, market and investment incentives, and required technical skills and policy resources. In these settings it is important to nurture pro-poor innovation which develops goods and services for those at the bottom of the income pyramid in the sectors that matter most to these target groups, such as health, education and small-scale agriculture.<sup>156</sup> However, given the ubiquity of mobile phones in many developing countries, IoT platforms that leverage mobile phone coverage – for example, using SMS-enabled sensors to monitor water pumps – provide exciting opportunities to overcome major infrastructure constraints such as connectivity. Other infrastructural constraints and the difficulties mentioned above must also be overcome for such applications to reach scale.



## What next for development sector actors?

The next 3–5 are going to be critical for actors in the IoT field to define the exact nature and scale of its long-term impacts. IoT constitutes new territory, even for those with a high degree of technical expertise; much evolution and continuing development is expected. We are clearly in the very early days of IoT4D, and it is perhaps unsurprising that development sector actors are still unsure about how to approach it.

In such an incipient stage of technological development, it is just as important to trigger learning processes within and across development organisations as to launch new IoT initiatives. Currently, even if a successful IoT project managed to gather significant flows of data for a specific development challenge or area, it is doubtful that there would be sufficient institutional capacity to properly analyse the data and act on it. Moreover, IoT components and infrastructure are still expensive and lack interoperability, leading to higher risk of failed investments.

---

**The best IoT projects do not have a narrow technological focus; instead, they focus on development problems and consider the wider social, economic and cultural contexts.**

---

Therefore, an immediate priority is to continue working to improve enabling factors for the IoT in developing countries, especially in relation to improving connectivity and regulation. At the same time, investment is needed in capacity building to be able to better assess projects, understand the potential of IoT4D, and provide strategic guidance to in-country partners.

Development actors working with the IoT might consider actions in the following specific areas:

- **Increase awareness and knowledge about the IoT in the field** – Development actors need to increase their capacity to integrate IoT technologies into their processes and programmes. This means investing in internal resources, but also fostering cooperation with experts, advisers and researchers, and establishing partnerships with private companies. If the IoT and other digital and frontier technologies are going to be game changers in the development field, people who work in the development sector will need a critical understanding of IoT technology and the skills to use it, across different sectors and departments.
- **Convene a variety of actors to strengthen networking and collaboration** – Networks are of vital importance and should include partners in national civil society and government from the outset. Loose networks, sector-specific communities of practice and more formal cooperation mechanisms all have a role to play. The capacity of IT companies to provide technical training and certify competencies could be leveraged and tailored for the international development sector as a way to disseminate IoT knowledge and foster cooperation in development projects.
- **Incentivise new IoT4D solutions to address outstanding challenges** – A lot of innovation and experimentation are already happening in the field of IoT4D. Challenges and seed innovation funds can provide good instruments to catalyse new ideas and support initial field-testing. Equipped with their knowledge of development contexts and the appropriateness of particular technologies, development organisations could collect evidence and evaluate projects' results and impact potential, as a way to keep replicating and disseminating the best examples. IoT4D projects should have sound business models that promote their sustainability and provide inclusive pro-poor innovation that benefits the most excluded sectors. Moreover, the best IoT4D projects do not have a narrow technological focus; instead, they focus on problems and consider the wider context and alternatives. For example, what makes M-KOPA Solar successful is not that it provides electricity to off-grid households, but its innovative approach to providing them with financial services, using IoT technologies to turn off devices when payments are interrupted. This has led to some of the lowest drop-out rates of any loan programme, while providing a platform to develop more sophisticated products and services in the future.
- **Fund and support the best technologies and innovations** – Development organisations should provide financial and technical assistance to the most promising examples. This cooperation would not only benefit the recipients of support, but it would also allow development organisations to keep learning and improving their knowledge of the IoT. If the technology proves to be useful, pre-commercial procurement could also be used to give the technology a final push on its way to becoming self-sustaining.

- <sup>107</sup> Heeks, R (2014) 'ICTs and Poverty Eradication: Comparing Economic, Livelihoods and Capabilities Models', *Development Informatics Working Paper Series*, 58.
- <sup>108</sup> World Bank (2016), *World Development Report 2016: Digital Dividends*, World Bank
- <sup>109</sup> McKinsey Global Institute (2014) *Offline and falling behind: Barriers to Internet adoption*
- <sup>110</sup> *Ibid.*
- <sup>111</sup> Google.com (2016), *How Loon Works – Project Loon*, [www.google.com/loon/how/](http://www.google.com/loon/how/)
- <sup>112</sup> Simonite, T (2016), '10 Breakthrough Technologies: 01 Project Loon', *MIT Technology Review*, [www.technologyreview.com/s/534986/project-loon/](http://www.technologyreview.com/s/534986/project-loon/)
- <sup>113</sup> Although 85 per cent of the global population live within reach of a mobile signal, this does not necessarily mean they can afford it or that it is a high-speed internet. This figure includes speeds slower than 3G.
- <sup>114</sup> Internet.org (2015) *Connectivity Lab*, <https://info.internet.org/en/story/connectivity-lab/>
- <sup>115</sup> Oneweb.world (2016) *OneWeb*, <http://oneweb.world/>
- <sup>116</sup> Fernholz, T (2016), 'The details behind SpaceX's ambitious satellite internet experiment', *Quartz*, 11 June, <http://qz.com/426158/the-details-behind-spacexs-ambitious-satellite-internetexperiment/>
- <sup>117</sup> GSMA, (2014), *Mobile Access: The Last Mile*
- <sup>118</sup> Oneweb.world (2016) *OneWeb*
- <sup>119</sup> Google.com (2016) *Loon for All – Project Loon*, [www.google.com/loon/](http://www.google.com/loon/); Oneweb.world (2016) *OneWeb*
- <sup>120</sup> GSMA (2014) *Mobile Access*
- <sup>121</sup> Schmidt, J, Chambers, A and Schatz, P (2016) 'Google's Plan for Ubiquitous Internet: Strategy and Impact', *MS&E Leading Trends in Information Technology*, 238
- <sup>122</sup> Hernandez, K (2015) *Connectivity Flying High: Bridging the Digital Divide From the Sky*, MA dissertation, Brighton, United Kingdom: Institute of Development Studies.
- <sup>123</sup> Ramalingam, B and Hernandez, K (forthcoming), 'Busting Digital Myths', in *2016 World Social Science Report* (1st ed.), UNESCO
- <sup>124</sup> World Bank (2016) *World Development Report 2016*; World Economic Forum, (2015), *The Global Information Technology Report 2015*, etc.
- <sup>125</sup> Open Net Initiative (2016) *About Filtering*, <https://opennet.net/about-filtering>
- <sup>126</sup> Pick, J and Azari, R (2008) 'Global digital divide: Influence of socioeconomic, governmental, and accessibility factors on information technology', *Information Technology for Development*, 14(2), pp.91–115
- <sup>127</sup> *Ibid.*
- <sup>128</sup> TIME (2009) 'The 10 Biggest Tech Failures of the Last Decade: Iridium', [http://content.time.com/time/specials/packages/article/0,28804,1898610\\_1898625\\_1898640,00.html](http://content.time.com/time/specials/packages/article/0,28804,1898610_1898625_1898640,00.html)
- <sup>129</sup> *Ibid.*
- <sup>130</sup> Steel, W (2016), An update on Google's Project Loon, *Cleanleap*, <http://cleanleap.com/updategoogles-project-loon>
- <sup>131</sup> *Financial Express* (2016) 'How gov'ts 'no' upset Google, Microsoft plans to connect Indian villages', [www.financialexpress.com/industry/companies/white-spaces-project-microsoft-googleplans-face-blackout/279450/](http://www.financialexpress.com/industry/companies/white-spaces-project-microsoft-googleplans-face-blackout/279450/)
- <sup>132</sup> Morozov, E (2013) *To save everything, click here: the folly of technological solutionism*
- <sup>133</sup> Manyika, J, et al. (2015) *The Internet of Things: Mapping the Value beyond the Hype*, McKinsey and Co.
- <sup>134</sup> Wjellers, D (2015) *Is This the Future of the Internet of Things?*, World Economic Forum, November
- <sup>135</sup> Meier, P (2015) *Digital Humanitarians: How Big Data Is Changing the Face of Humanitarian Response*, Routledge
- <sup>136</sup> IDC (2015) *Worldwide Internet of Things Forecast, 2015–2020*
- <sup>137</sup> IDC (2014) *Worldwide and Regional Internet of Things (IoT) 2014–2020 Forecast*
- <sup>138</sup> Manyika, J, et al. (2013) *Disruptive Technologies: Advances That Will Transform Life, Business, and the Global Economy*, McKinsey and Co.
- <sup>139</sup> Biggs, P, et al. (2016) *Harnessing the Internet of Things for Global Development*, Geneva: UNITU and Cisco
- <sup>140</sup> Buluswar, S, et al. (2014) *The 50 Most Critical Scientific and Technological Breakthroughs Required for Sustainable Global Development*, Berkeley: LBNL Institute for Globally Transformative Technologies (LIGTT)
- <sup>141</sup> Microsoft (2016) *IoT-enabled Smart Fridge helps manage vaccines and saves lives*, Microsoft <https://blogs.microsoft.com/iot/2016/08/16/iot-enabled-smart-fridge-helps-manage-vaccines-and-saves-lives/>
- <sup>142</sup> Manyika et al. (2013) *Disruptive Technologies*
- <sup>143</sup> <http://nexleaf.org>
- <sup>144</sup> [www.sweetsensors.com](http://www.sweetsensors.com)
- <sup>145</sup> <https://illuminguingreenhouses.com>
- <sup>146</sup> [www.hellotractor.com](http://www.hellotractor.com)
- <sup>147</sup> Pastor-Escuredo, D, et al. (2014) *Flooding through the Lens of Mobile Phone Activity*, IEEE Global Humanitarian Technology Conference, GHTC
- <sup>148</sup> [www.m-kopa.com](http://www.m-kopa.com)
- <sup>149</sup> Kikulwe, E (2014) 'Mobile Money, Smallholder Farmers, and Household Welfare in Kenya', *PLOS ONE* 9, no. 10
- <sup>150</sup> Faris, S (2015) 'The Solar Company Making a Profit on Poor Africans', *Bloomberg Businessweek*, 7 December
- <sup>151</sup> Manyika, J, et al. (2015) *The Internet of Things: Mapping the Value beyond the Hype*, McKinsey and Co.
- <sup>152</sup> Rose, K, et al. (2015) *The Internet of Things (IoT): An Overview. Understanding the Issues and Challenges of a More Connected World*, Internet Society
- <sup>153</sup> McKinsey Global Institute (2015) *The Internet of Things*
- <sup>154</sup> ITU (2016) *Harnessing the Internet of Things for Global Development*, [www.itu.int/en/action/broadband/Documents/Harnessing-IoT-Global-Development.pdf](http://www.itu.int/en/action/broadband/Documents/Harnessing-IoT-Global-Development.pdf)
- <sup>155</sup> ITU (2015) 'Interoperability in the digital ecosystem', *GSR Discussion Paper*
- <sup>156</sup> UNCTAD (2016) 'Harnessing Emerging Technological Breakthroughs for the 2030 Agenda for Sustainable Development', *Policy Brief*