

## ENABLING DIGITAL DEVELOPMENT

# Six digital technologies to watch

This Report looks at what countries can do to get more out of the internet and other digital technologies. Although it looks ahead to a world in which the internet is universally available and affordable, the analysis largely takes the technology for granted. But technological change is continuous and frequently disruptive. This spotlight examines a range of technologies, identified in the technology forecasting literature that promise to be far-reaching in their impact on development.<sup>1</sup> They are at different stages of the “hype” cycle (figure S6.1). Like the internet, they are likely to be encountered first in the developed world, but will spread quickly to the developing world, where their impact may be even greater.<sup>2</sup>

### Fifth-generation (5G) mobile phones

The development of cellular mobile phones from the earliest incarnation of commercial service in the late 1970s has proceeded in generations. First-generation (1G) analog cellphones were replaced with 2G digital phones, starting in Finland in 1991, while 3G phones, which provide faster internet access, were launched at the opening match of the 2002 FIFA World Cup in the Republic of Korea. By the end of June 2015, there were 2.33 billion 3G mobile subscriptions worldwide, and a further 757 million subscribers to data-optimized 4G, or Long Term Evolution (LTE), technology.<sup>3</sup>

5G wireless networks are the next generation of mobile networks. 5G networks are expected to out-

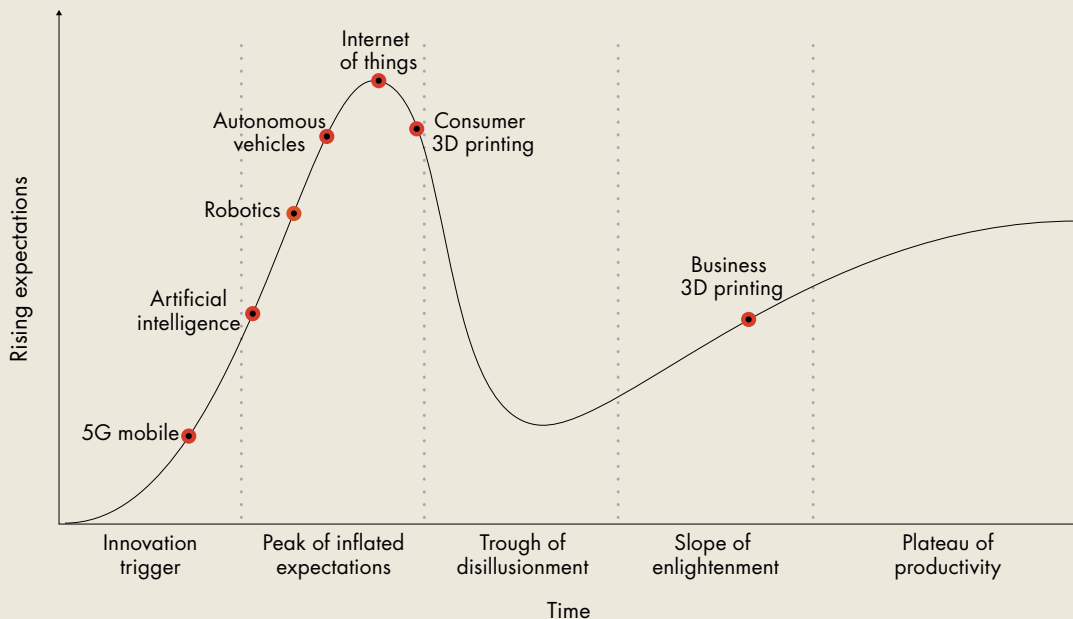
perform current 4G networks by providing data at a speed several hundred gigabits per second (Gbit/s). In 2015, researchers at the University of Surrey’s 5G Innovation Centre (5GIC) managed one terabit per second (Tbit/s) during their speed tests—many thousands of times faster than current data connections.<sup>4</sup>

Accommodating 5G will require using parts of the spectrum that have not previously been considered commercially useful, in particular above 3 gigahertz (GHz), and in the millimeter band that stretches from 30–300 GHz. It will also require new kinds of antennae.<sup>5</sup> Developments in smartphones have increased capabilities about 25 percent per year in the past five years. Even though mobile itself is hardly a new technology, it is its combination with the internet that makes it a disruptive force and one of the technologies with potentially the greatest impact for the developing world. Developing countries will need to closely follow developments taking place in 5G and start preparing for its eventual rollout.

### Artificial intelligence

Definitions of artificial intelligence (AI) differ widely, but generally refer to computer systems that can perform tasks that normally require human intelligence—including visual and speech recognition, decision making, and language translation. Faster computing, “big data,” and better algorithms have helped propel recent breakthroughs in AI.<sup>6</sup> Algorithms are now better able to recognize language and images, for example, thanks to the availability of huge torrents of data from interconnected phones, tablets, and computers. Firms like Narrative Science have automated the writing of financial reports using AI.

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**Figure S6.1** Gartner “hype” cycle applied to selected digital technologies

Source: WDR 2016 team, adapted from Gartner 2015.

IBM’s Watson computer uses AI to provide diagnostic assistance to doctors, providing customized medical advice. Virtual assistants with voice recognition capabilities like Apple’s Siri and Microsoft’s Cortana are increasingly used in personal and business contexts. A venture capital fund based in Hong Kong SAR, China, Deep Knowledge Ventures, has even appointed an algorithm to its board of directors!<sup>7</sup>

Rapid advances in AI have also resulted in concerns about machine intelligence overtaking human intelligence, and becoming a threat to the future of humanity itself. An example is Nick Bostrom’s 2014 book on superintelligence, which considers AI to be potentially an “existential risk” for mankind.<sup>8</sup> Luminares like Elon Musk, Stephen Hawking, and Bill Gates have weighed in on the dangers of AI. While recognizing the potential risks of AI, such technologies can provide important insights and generate value in virtually every sector relevant to development. The benefits of AI are beginning to be seen in education, with personalized learning; in health, with deep diagnostics; in agriculture, with crop planning, precision farming, and optimized resource application; and in banking and insurance, in areas like customer service, risk management, and compliance.

Advances in AI will prove to be disruptive, resulting in new opportunities for collaboration between humans and machines, as well as a loss of traditional jobs such as legal analysts, financial and sports

reporters, online marketers, anesthesiologists, diagnosticians, and financial analysts.<sup>9</sup> Similarly, a large number of call centers previously offshored to developing countries could be affected by increasingly sophisticated natural language processing systems that can substitute for human workers. The Spanish Bank BBVA, for example, has introduced Lola, a virtual assistant capable of handling many routine customer requests previously handled by call center agents.<sup>10</sup>

## Robotics

*Robotics*, which refers to machines or mechanical systems that can automatically handle tasks, can be generally divided into industrial robots (automotive, chemical, rubber, plastics, and food industries) and service robots (logistics, medicine, assisting the elderly, agriculture, floor-cleaning, civil construction, and exoskeletons). Robots can provide benefits through their computing power, precision, strength, and sensing capabilities. The worldwide stock of operational industrial robots at the end of 2014 was up to 1.5 million, with around 4.7 million service robots sold for personal and domestic use.<sup>11</sup>

While robots have been primarily used in physically difficult or dangerous jobs, they are now becoming more advanced and gaining senses, dexterity, and intelligence. They are more compact, adaptable, and

intelligent, have manipulation capabilities, and are increasingly able to work alongside humans. Eventually they may displace or augment humans, primarily in low-skilled areas like manufacturing, cleaning, and maintenance, but also in high-tech fields, like surgery and prosthetics.<sup>12</sup> A number of leading information technology (IT) companies have made investments in robotics and are driving development of smart robots. Amazon acquired Kiva Systems and is using Kiva robots for order fulfillment. Google acquired Boston Dynamics and several other robotics companies.

Demand for industrial robotics is driven by the desire to reduce labor costs and by the need for accuracy in undertaking repetitive processes. Robots are not paid, they do not get sick, and they can work as long as there is power. They can also take on dangerous or risky tasks, such as detecting landmines. The take-up of robots is expected to rise as a function of their falling costs and growing intelligence, including in developing countries. China is the world's biggest importer of industrial robots. Guangdong province recently announced a program to automate 80 percent of its factories by 2020, by substituting human labor with robots.<sup>13</sup> Robots have been deployed in the Democratic Republic of Congo, in Kinshasa, to manage traffic.<sup>14</sup>

### Autonomous vehicles

Autonomous vehicles (AV), or self-driving cars, attract major research spending from car companies as well as internet firms. Their proponents argue that they will reduce road accidents (for instance, through lane-keeping systems, auto-parking, and cruise control), ease congestion, reduce fuel consumption, improve the mobility of the elderly and disabled, and free up commuting time for other tasks.<sup>15</sup> But they also threaten the jobs of millions of people currently employed as drivers. They also raise complex legal issues, including for liability insurance, and onboard networked computers would be at risk of hacking. The European project SARTRE is piloting the concept of "autonomous car platoons," which allows multiple vehicles to drive autonomously within meters of one another at highway speeds, guided by a professional pilot vehicle. This approach is expected to reduce fuel consumption and emissions by up to 20 percent, improve road safety, and reduce traffic congestion.

Drones (unmanned aerial vehicles, and a specialized type of AV) are growing in popularity as prices fall. They have many potential applications, including police work, assisting the disabled, home delivery, farming, entertainment, safety, wildlife conservation,

and even providing internet service in remote areas. Rwanda plans to be home to the world's first drone airport, or "droneport," to facilitate the delivery of medical and emergency supplies, quickly and cost-effectively, across geographical barriers.<sup>16</sup>

The introduction of AVs is likely to be gradual, with many cars and planes already incorporating elements of assistive technology. The impact on jobs will ultimately be a function of price (self-driving cars are currently prohibitively expensive), legislation (will they always require a human with manual override?), and time.

### Internet of things

The "internet of things" (IoT) refers to the interconnection of objects to internet infrastructure through embedded computing devices, such as radio frequency identification (RFID) chips and sensors. IoT products can be classified into five broad categories: wearable devices, smart homes, smart cities, environmental sensors, and business applications.<sup>17</sup> Cisco estimates that by 2020, 50 billion devices and objects will be connected to the internet.

IoT is quickly redefining service delivery and unlocking opportunities in multiple areas. Smart fitness sensors and trackers are transforming health care and improving personal fitness and health. Embedded sensors accurately relay moisture, air and water pollution levels, and resource levels, allowing for closer monitoring of environmental problems. Factories and supply chains use smart sensors to improve the efficiency of manufacturing and distribution of goods. Globally, there has been a rise in spaces where people can gather to build and learn with electronics, software, and digital fabrication. Known as makerspaces, these spaces have democratized access to tools and empowered participants to build and learn on their own.

One of the key applications of IoT is in combating climate change and its effects. Farms in developing countries can use intelligent sensors to monitor soil conditions and guide autonomous irrigation systems. Smart traffic synchronization systems in cities save on travel time and fuel consumption. Countries such as Singapore are deploying smart networks that use global positioning systems (GPS), sensor information from monitoring cameras, and other sources to sense population movement, ease traffic congestion, and re-route traffic in the case of special events and emergencies.

Some experts believe that the IoT will mark a new stage of the internet's development, since it has the

### Box S6.1 Using cellphones for medical diagnosis, thanks to 3D printing

Doctors in developing countries often lack the necessary equipment to diagnose diseases, but they do have smartphones. Dr. Aydogan Ozcan, an engineering professor at the University of California Los Angeles (UCLA), has created software and hardware that can convert smartphones into microscopes and diagnostic machines. He uses 3D printing to create a fluorescent microscope device that can be attached to the phone. The device includes an app that connects the smartphone to a server at UCLA and transmits raw images of DNA molecules to detect

and diagnose cancer, nervous system disorders such as Alzheimer's disease, and drug resistance to infectious diseases.<sup>a</sup> Similarly, a 15-year-old girl from Cupertino, California, has designed a spirometer, a device that can diagnose respiratory illnesses such as chronic obstructive pulmonary disease and asthma. She designed this tool using open hardware and 3D printing, at a fraction of the cost of a commercial spirometer.<sup>b</sup>

a. <http://newsroom.ucla.edu/releases/ucla-engineers-first-to-detect-and-measure-individual-dna-molecules-using-smartphone-microscope>.  
b. <https://cogito.cty.jhu.edu/43295/maya-varma-final-device-and-app-design/>.

potential to revolutionize the way people live, work, interact, and learn. However, there are still significant barriers to full commercialization of IoT, such as the fragmented landscape of standardization, which is preventing interoperability; and the relatively high cost of embedded devices. The maker movement offers a possible solution for the standardization challenge, empowering individuals to adjust devices to fit the local context. There are also significant privacy and security concerns. As more devices are connected to networks, hacking unsecure devices could have repercussions that far exceed the damage posed by conventional security threats.

## 3D printing

3D printing, a process whereby machines can print objects from digital files or scans, consists of adding successive layers of material to make a three-dimensional (3D) object. This technology has transformational potential for manufacturing, since it enables users to create smaller batches of highly customizable products at declining prices. In recent years, 3D printing has advanced to printing of body parts (titanium jaws, spines), exoskeletons, rocket parts, and even food.<sup>18</sup> As prices have fallen, consumer-oriented devices have appeared on the market in recent years, allowing individuals to make three-dimensional solid objects locally, often using a computer-assisted design (CAD) file that can be downloaded from the internet. The “ink” used in the printer is usually plastic, but other materials—including epoxy resins, silver, titanium, steel, and wax—are also available.

The revolutionary aspect of 3D printing lies in its digital nature: physical objects become digital information that can be remixed, reformulated, improved, and shared. However, desktop 3D printers are still relatively expensive, and use between 50 and 100 times more energy per unit of weight than conventional injection molding. Other concerns include potentially negative uses such as gun and drug printing, and infringement of intellectual property.<sup>19</sup> However, as the performance improves and the cost of the printers and their inputs decline, 3D printers could be adopted more widely (box S6.1). The most relevant immediate progress may be in industrial printers for highly customizable objects that are relatively expensive and require replicable results. This is most suited to the construction industry, where 3D printed buildings can provide lower-cost housing solutions.

3D printing is expanding in developing countries. In Uganda, for example, the technology is used to create 3D-printed prosthetic limbs. The startup Proto-print, a social enterprise in Pune, India, helps waste pickers turn the waste plastics they collect into 3D printer filament. iLab Haiti has used 3D printing to design basic medical supplies for local clinics (such as umbilical clamps, finger splints, and casts) and produce them using on-demand manufacturing.<sup>20</sup>

## Notes

1. Sources used in the analysis of technology trends include Gens and IDC Predictions 2015 Team; Deloitte Consulting 2015; McKinsey Global Institute 2013; and Meeker 2015.
2. Munte-Kunigami and others 2015.

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4. <http://www.bbc.com/news/technology-31622297>.
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7. <http://www.bbc.com/news/technology-27426942>.
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19. <http://www.techrepublic.com/article/the-dark-side-of-3d-printing-10-things-to-watch/>, accessed March 2014.
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