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Technology, Media & Telecommunications Predictions 2015

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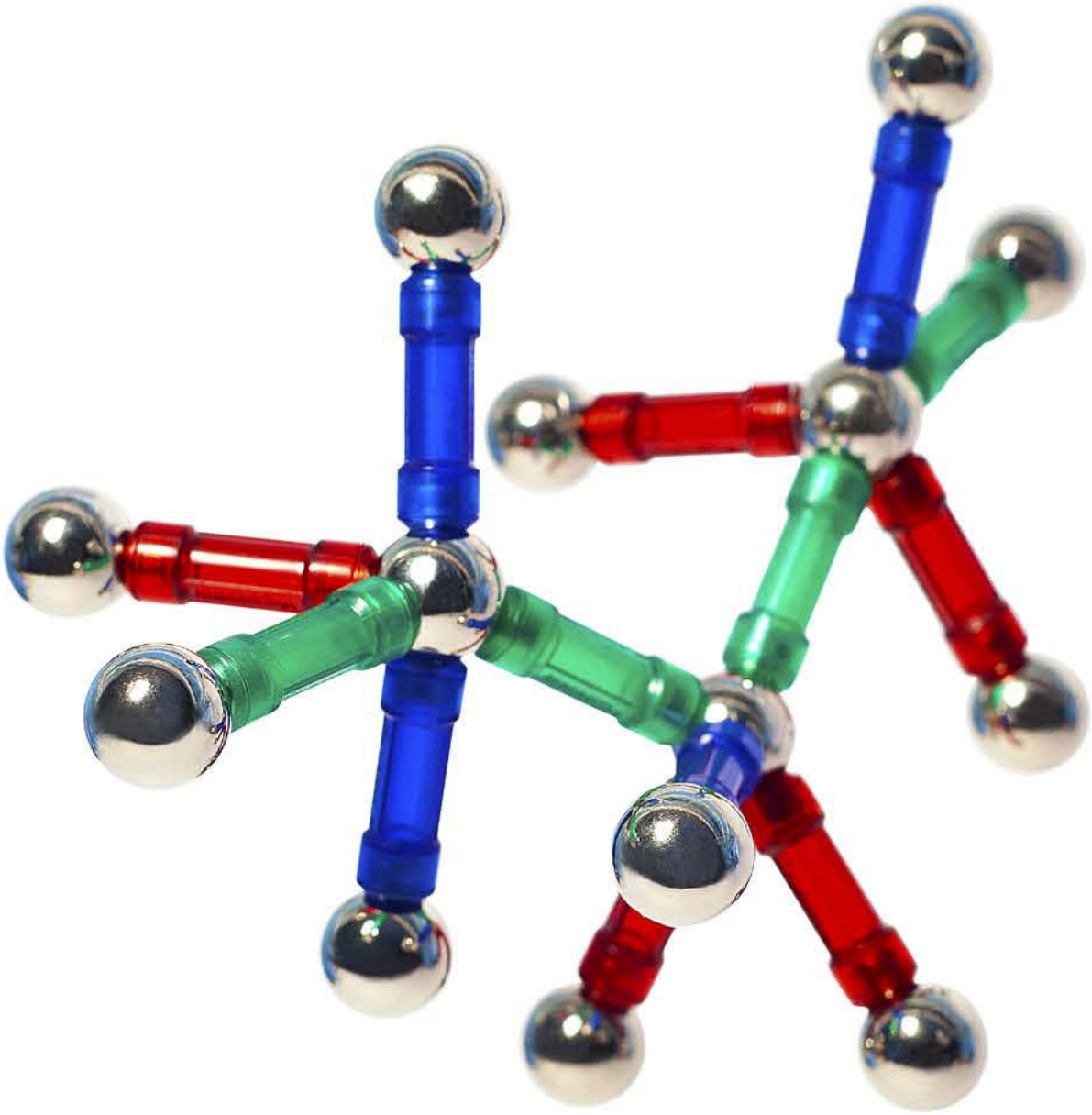

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Foreword

Welcome to the 2015 edition of Deloitte's predictions for the technology, media and telecommunications (TMT) sectors.

Our objective with this report is to analyze the key market developments over the next 12-18 months. Our points of view are built around hundreds of meetings with industry executives and commentators from around the world, as well as our proprietary programs of research with tens of thousands of consumers worldwide.

Our endeavor is to provide a considered point of view on key industry trends. In some cases we seek to identify the drivers behind major inflection points and milestones, such as the first billion-unit year for the smartphone sector, or the take-off of contactless mobile payments.

In others our intent is to explain why we are not expecting fundamental change, such as in the use of drones for home deliveries, or in smartphone battery technology or the deployment of miniature satellites, known as nanosats.

We also consider it critical to examine sub-trends. For instance, broadband speeds are, on average, increasing at a double-digit pace, but in many markets the average is being lifted by significant performance improvements among the fastest connections, while slower connections remain sluggish.

There are few other industries as 'mercurial' as TMT. It delivers constant, significant change, with the decades of sustained processor power and connectivity speed increases being the best examples. These changes can provoke massive disruption, but can also strengthen existing industries. And this is where predicting gets really interesting.

Arguably the bigger challenge in making predictions about the TMT sector is not about forecasting what technologies will emerge or be enhanced, but in how they will be adopted.

Music has gone digital, but consumer demand for physical books remains robust, with millenials at the vanguard. Indeed 18-34 year olds, counter to some perceptions, remain significant consumers of media content.

Technological advance has enabled e-commerce, but customers are increasingly choosing delivery to bricks-and-mortar stores. 3D printing offers a factory in every home, yet it is enterprise that is driving spend. The Internet of Things (IoT) offers us the capability to remote control multiple aspects of our lives from our smartphones, but we expect companies to reap most of its value in 2015.

We wish you all the best for 2015 and trust that you and your colleagues will find this year's predictions a useful stimulant in your strategic thinking. We look forward to discussing them with you.

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As used in Predictions, "Deloitte" refers to the Deloitte Touche Tohmatsu Limited member firm TMT (Technology, Media & Telecommunications) Practices.

Technology

The Internet of Things really is things, not people

Deloitte predicts that in 2015 one billion wireless Internet of Things (IoT) devices[1] will be shipped, up 60 percent from 2014,[2] and leading to an installed base of 2.8 billion devices.[3] The IoT-specific hardware (which could be a more expensive cellular modem, or a much cheaper Wi-Fi chip) is likely to be worth $10 billion,[4] and the associated services enabled by the devices worth about $70 billion.[5] Services include all of the data plans that may be necessary to connect a device over a network, the professional services (consulting, implementation, or analyzing the data) and then things like an insurance policy discount for a telematics device in a car or a wearable device for health purposes.

IoT hardware and connectivity revenues are growing at about 10-20 percent annually, while the apps, analytics and services are growing even more rapidly at 40-50 percent.[6] While the press may focus on consumers controlling their thermostats, lights and appliances (from washing machines to tea kettles), Deloitte predicts that 60 percent of all wireless IoT devices will be bought, paid for and used by enterprises and industries. And over 90 percent of the services revenue generated will be enterprise, not consumer.[7]

The Internet of Things is also referred to as the Machine-to-Machine (M2M) market, and is often used interchangeably (see: A brief history of Internet of Things terminology).[8]

A brief history of Internet of Things terminology

Many devices and sensors have been able to communicate with each other, normally through wires and using technologies such as SCADA (supervisory control and data acquisition).[9] Occasionally they have been connected through wireless radio signals over certain broadcast frequencies. As cellular phone systems were rolled out in the 1980s at different frequencies, they generally transmitted voice conversations but not data for machines. As 3G was deployed from 2001, it became relatively easy to have a machine or sensor communicate over the now-data-friendly cellular network. Industry analysts needed to distinguish between the two types of traffic, so everything involving voice calls was put in one category, and every data-only device into another, called Machine-to-Machine or M2M. Over time, M2M became a broad category encompassing all telematics over cell networks on trucks, smart utility meters, eReaders, tablets and PC modems, but not smartphones.

Even today, many M2M industry forecasts include eReaders, tablets and PC modems; but this seems inappropriate. Although there is the occasional automatic update or download, most of the traffic via these three devices is human-initiated and human-observed; and they often use cellular for only some of the time, and Wi-Fi (or other short range wireless technologies such as Bluetooth, or ZigBee) for the majority of traffic. Finally, with the advent of Voice-over-IP technology, putting these three devices into a different category from smartphones is not helpful, nor is lumping them together with telematics, machines, or sensors. Following a 2014 Deloitte report on the IoT ecosystem, we are going to "focus more on 'machines' and less on 'people'".[10] The Internet of Humans is an important topic, but a different one.

While the press may focus on consumers controlling their thermostats, lights and appliances, Deloitte predicts that 60 percent of all wireless IoT devices will be bought, paid for and used by enterprises and industries.

Modern wireless technology, whether cellular or Wi-Fi, allows a consumer with a smartphone to perform multiple useful tasks remotely: from controlling appliances to home security, climate control and lighting. But Deloitte is forecasting that the total consumer demand in 2015 for this kind of solution will be 90 percent smaller than the enterprise market. Why?

In the consumer context, M2M usually solves only part of the problem. Turning a washing machine on remotely, being notified when the cycle is finished offers some level of convenience compared to pushing a button on a machine in the basement. But the clothes still need to be sorted, carried to the laundry room, pre-treated, placed in the machine and soap added. In other words, the portion of the task that M2M improves is trivial.[11]

The cost saving from using an appliance during off-peak hours is real but minimal. Starting a clothes dryer in the evening rather than noon takes advantage of lower electricity rates where offered. But even if a dryer is used daily, this only saves about $50 per year.[12]

Sometimes the cost is prohibitive: one connected home lighting kit, consisting of a controller and two bulbs, costs $150, with each additional bulb costing $60.[13] A connected living room lit up by six IoT bulbs would cost nearly $400; six halogen bulbs and a dimmer switch cost about $50.

Full IoT is sometimes overkill. For example opening a garage door or starting a car remotely is a binary on/off tasks. A simple radio remote control, costing about $40,[14] accomplishes the same job at a fraction of the price.[15]

Or the task that an M2M device may perform is 'low touch:' the majority of homeowners seldom change their climate settings, and their on/off patterns are predictable, as most of us have predictable routines. The conventional programmable thermostat is adequate for most homes, and is already installed, understood, and paid for. In addition, the ecosystem for connecting and controlling devices is highly fragmented, which limits opportunities for higher-value cross-application uses.

Finally, the powerful customization and data analysis that is possible through IoT is not of interest to most consumers: they are not looking for numbers, they are looking for insights. Even then, behavior is a limiting factor: humans are resistant to modifying their behavior to fit with systems; they prefer that systems adapt to meet their needs with minimal change in human behavior. As an example, an electrical utility installed smart meters in millions of homes, expecting that (among other benefits) consumers could look at an online dashboard of their monthly usage, and modify their behavior to save money and benefit the environment. Three years after the meters were deployed, about six percent of households had viewed the dashboard at all, and fewer than two percent had done so more than once.[16]

So if consumers do not need them, should we bother installing M2M smart meters at all?

We should, because enterprises can benefit. For example, deploying smart meters in the UK has been estimated to generate annual savings of just over $40 per household, or $2 billion for households across the whole country.[17] For the electric utilities, the combined savings from the other benefits of IoT could be multiples of this amount. The savings from automated meter reading, short-circuit detection, and better real-time diagnosis/location of power outages comes to over a billion dollars annually, or about the same size as the aggregate consumer savings. But the most significant benefit comes from the analytics about consumer demand for power around peak power periods. This could save billions of dollars annually by obviating the need for between one and three new power plants, each of which could cost up to $37 billion.[18] The total saving for the utilities could be five or even ten times as large as the savings for consumers.

As discussed earlier, the direct benefit to most consumers from remote control of their washing machines is likely to be marginal; but the value to the machine manufacturers is enormous, not just for the information about reliability and advance warning of when a failure is about to occur, but for real-time information on which features are actually being used and how. The insights revealed by this stream of data could be worth hundreds of dollars per machine over its life,[19] recouping the cost of making IoT-enabled washing machine tens of times over.

In a real-world example, a manufacturer spent millions of dollars and several months building a low-energy automation feature that required customer opt-in. IoT data from users showed that less than one percent of customers actually used it; this prompted the company to change it to a self-learned energy management feature that deployed automatically, translating into customer cost-savings benefits.

Annual sales of cars with embedded telematics are expected to exceed 16 million units in 2015,[20] but it is unclear how many consumers will actually use all those features. As one example, millions of cars have buttons to summon roadside assistance, but in an era of ubiquitous smartphones many drivers never use this service. But insurance companies have interest in the driving data, and offer discounted insurance rates to drivers who opt-in and have after-market devices installed.

Sales of 22 million units including after-market are expected in 2015,[21] and this is likely to save money from discounted insurance and reward safe driving.[22]

Despite all the media excitement around consumer uses for the Internet of Things, most items are selling in their hundreds of thousands as connected devices, sensors or controllers; very few are selling in their millions. Meanwhile enterprises are buying and using tens or even hundreds of millions of IoT devices. Smart meters, smart grids, smart homes, smart cities and smart highways are just some examples. Factories, mHealth, shared transportation solutions (such as car and bike rentals) or resource industries can all benefit too.

Bottom Line

In 2014, the IoT analytics market is primarily descriptive ($800 million), a little bit of predictive ($180 million) and minimally prescriptive ($14 million). Over the next four years, while IoT analytics revenues of all three types is likely to grow by 500 percent, the prescriptive subset is likely to grow over 3,000 percent.[23]

IoT vendors may want to extend cost-reduction and risk management deployments to explore revenue and innovation potential. Often, IoT is seen as a technology that is driven by the CIO. Since CIOs are not typically focused on revenue growth and innovation, providers who sell only to the CIO will usually revert to talking about lowering transaction and maintenance costs. Cost reduction is not bad, but it also is not enough and the potential for adoption and business value may be broadened by reaching out to CMOs, CFOs, major line managers, and even CEOs.[24]

Growing IoT may mean focusing on product and/or customer lifecycle. The retail sector offers examples of how companies can benefit from using real-time data to move beyond transactions and understand their customers and products better. For example, a UK-based retailer used their loyalty club card to track customer visits, buying behavior, payment modes, and inventory. By paying close attention to customers (customer lifecycle) and product sales (product lifecycle), the retailer was able to adjust merchandise dynamically to suit local tastes, customize offers to customers, manage inventory volume based on demand/purchases, and plan inventory refresh as needed. The result? Sales, customer loyalty, and coupon redemption rates all increased.[25]

We expect many firms to target early deployments to maximize impact. This seems counter-intuitive, since the power of IoT grows exponentially as the number of connected devices increases. But in the early days, enterprises may want to find the single biggest pain point or revenue opportunity, and roll out an inexpensive solution, such as a sensor network, which will simplify the ROI justification.

Connecting devices that were unconnected before creates opportunities, but also requires a fundamental shift in business model. A connected product is no longer just a product; it is a service. For example, a connected coffee machine is an insights tool for restocking and usage profiling to optimize coffee pods supply chain and increase customer lifetime value. However, connectivity also introduces new risks, and enterprises need to develop security that is both preventative and responsive in order to lower costs and increase operational efficiency.

Customers have concerns about privacy: what data is an enterprise collecting in M2M, and what are they doing with it? It will be important for companies to maximize transparency in order to enhance user trust: there will likely be a balance between perceived costs and benefits by customers, and the willingness to share information by consumers will vary by application.

Drones: high-profile and niche

Deloitte predicts that in 2015, the active base of non-military drones costing $200 or more should exceed one million units for the first time. We expect sales of non-military drones (also known as unmanned aerial vehicles or UAVs), to be about 300,000 units in 2015, with the majority being bought by consumers or prosumers. We expect total industry revenues to be $200-$400 million dollars in 2015 (equivalent to the list price of a single, mid-sized passenger jet). In short, while we believe that UAVs have a tremendous range of applications, particularly for enterprise and government, we are not foreseeing a breakthrough year for drones in 2015.

This prediction focuses on three categories of UAV, defined by price and performance (we have excluded toys, due to lesser range and potential impact):[26]

- Entry-level hobbyist models, typically priced at $300 – $500 per kit (including the drone itself, additional batteries, chargers, GPS modules and spares). These have four rotors, a range under direct control of up to fifty meters, and can fly for up to about 20 minutes on an extended battery. Basic models can fly at about 15 kilometers per hour (km/h) horizontally. They weigh less than half a kilogram, are about half a meter in length, incorporate a basic camera, and are typically controlled via smartphone or tablet apps.[27]

- Prosumer devices cost from around $750 per kit.[28] These have four to six rotors and a flying range of up to a kilometer. They can fly at 50 km/h (about 15 meters a second) and can remain airborne for up to 25 minutes. They weigh about a kilogram and usually have a separate controller.

- Enterprise models, costing from $10,000 and up. These usually have six or more rotors, large blades, and multiple motors and are capable of lifting more than three kilograms. Some units have wings and propellers. These units can be designed to maximize payload or range. Some models are capable of an hour's flying time.

The UAV market has benefited over the past decade from the surge in demand for consumer electronics, particularly at hobbyist level. For example, a key appeal of drones is their ability to capture high-definition (HD) video: the billions of sensors and lenses produced for devices such as smartphones each year have enabled better quality and lower prices for applications, such as drones.

Also, a smartphone or tablet can be used to control a drone, removing the cost of a separate controller. Routes can be defined using online maps and GPS positioning. The accelerometers and gyroscopes used in drones are bulk-produced for smartphones. Wi-Fi can be used to control the drone, and also to relay images.[29]

For consumers, UAVs blend the appeal of remote-controlled vehicles, high-definition photography and kite flying. The primary application by consumers of drones seems to be for aerial photography.[30] There are UAVs that are designed for "follow-me" footage: the drone is programmed to track and film from the air the progress of someone skiing down a slope.[31] As smartphone camera quality improves, this will be incorporated into UAVs, enabling ever more spectacular footage.

UAVs are also being deployed in a widening range of professional contexts. Drones provide some of the observational or sometimes transportation functionality of a helicopter from $1,000 a unit, and without the cost of an onboard pilot, or even a pilot at all. They can undertake tasks that were previously too expensive to consider. Farmers can survey crops, without needing to visit their fields.[32] Livestock owners can undertake aerial searches for lost animals or even herd them.[33] Police forces and rescue units can use them to complement search and rescue missions, especially by using infra-red cameras.[34] Geologists can use them to map unchartered territories, or to survey for oil.[35] UAVs can inspect wind turbines, which reach several hundred feet in the air, removing the need for someone to climb up a structure.[36] Off-shore oil rigs can be similarly inspected.[37] Archaeologists have used drones to create 3D images of sites, and also to patrol for looters.[38] Finally, they can be used to distribute medicines, in the absence of viable roads, as part of disaster relief or other humanitarian campaigns.[39]

Aerial news footage no longer requires a helicopter or a trained pilot.[40] Some wedding photographers have used drones to capture the ultimate crowd shot.[41] Drones' newsworthy ability to film footage that would otherwise be hard to reach – from the sides of skyscrapers to the backyards of celebrities to the tops of power stations – has raised their profile significantly.[42]

Drones offer fantastic possibilities for enterprises and consumers, and will be used for an increasingly diverse range of observation applications. But it is unlikely that in there will be a surge in demand for UAVs, such that they become a mass-market (multiple millions of units) global market.

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Three key factors are likely to constrain demand in the short – and medium-term.

Drones crash

First, flying drones consistently well is challenging and crashes are common. We expect this will dissuade many from spending a few hundred dollars on a fast, hobbyist UAV in 2015.

An individual can fly a drone within minutes of assembly; but even an experienced pilot can suddenly lose control even in everyday conditions, that is with occasional gusts of wind and with cloud.[43] Piloting a drone, which can attain 50 km/h, but which travels in three dimensions, and which is readily buffeted by the elements is tricky. Even flying indoors can be challenging.[44]

Plotting the course for a drone is simple using an online map and GPS. But GPS can readily be lost – for example if a building blocks the signal, or simply due to dense cloud. Once contact is lost the drone would be flying blind. A lost drone might land safely in an unpopulated area; or it could crash into a building, or worse, land on an individual, with rotors still spinning.[45]

Drones' propensity to crash – either due to pilot error or mechanical failure – is reflected in the fact that drone kits often come equipped with a full spare set of rotor blades.

Someone considering what to spend a few hundred dollars on would likely purchase a new smartphone, which could be used every day, ahead of an equally-priced UAV, capable of taking awesome footage, but constrained by a fifteen-minute battery range, and with an odds-on chance of crashing.

A further constraint on consumer UAV usage is that it may be considered anti-social, particularly if used to capture images of areas of outstanding beauty.[46] The sight and noise of a single drone could tarnish a perfect sunset for hundreds sightseers in the vicinity, as well as affect the behavior of wildlife.[47] Some people may consider a camera-equipped drone flying over their heads as an invasion of privacy – even if the camera is not turned on.

Regulation is uncertain

UAV regulation is likely to constrain their use. In some markets, regulation is imminent, while in others, drones come under the same rules as apply to remote controlled aircraft.

In the US, the Federal Aviation Administration has published an initial plan to integrate unmanned vehicles into US airspace.[48] In the European Union, the Commission has set out its views on "how to address civil drones, or remotely piloted aircraft systems (RPAS), operations in a European level policy framework which will enable the progressive development of the commercial drones market while safeguarding the public interest".[49]

Controls can cover a range of UAV actions including the height drones can attain, the distance they can fly from the operator, the required distance between the vehicle and people and the qualifications the pilot needs. For example in the UK, the Civil Aviation Authority permits UAVs of under 20 kilograms in normal airspace so long as they are 150 meters from crowds, 50 meters from a person or a building and within line of sight (defined as within 500 meters' distance and under 122 meters' height). Commercial use of drones requires a license, for which there is a test commensurate with the demands of flying a UAV: as well as a theory test, the practical test requires demonstrating competence in flying figures of eight, or descending at a specific angle.[50]

In the US, there were 25 reported near misses involving UAVs and piloted planes at altitudes of several thousand feet between June and November 2014, some involving large passenger planes.[51] Hobbyist UAVs tend not to have anti-collision systems as these add cost, bulk and weight, reducing the vehicles range.[52] Because of this potential danger, it is likely that most markets will regulate the use of drones.

A likely outcome in many markets is that UAVs will be integrated into current flight control systems.[53] This will likely require an upgrade of current systems to allow for significantly increased capacity.

The impact of regulation on consumers may well be to dissuade usage. In some cases mishaps occurring from drone usage have been met with fines.[54]

The legality of flying drones has already been the subject of litigation, and this may continue through 2015 and beyond. Some drone manufacturers are responding by incorporating safeguards into their devices. For example, one vendor programmed in no-fly zones near hundreds of airports around the world.[55]

Enterprises will deploy UAVs by the dozen, not the thousand

We expect enterprise and government usage of UAVs to be increasingly widespread, where regulation permits, but for each entity to only use a single or a few drones per task. We do not expect drones to be deployed on a massive scale, for example to replace existing vehicles. Drones are cheaper than helicopters, but more expensive than conventional terrestrial vehicles for many enterprise tasks.

Drones will occasionally be used for transporting goods, but this will not be commonplace. For example a delivery company is using a UAV to deliver urgent packages, such as medication, to Juist, a small island 8 kilometers off the coast of Germany, and which otherwise can only be reached by boat at high tide.[56]

Drone delivery is unlikely ever to be viable for anything aside from high-value, lightweight and compact packages, as the cost of per delivery of up to 10 kilometers would be between $8 and $12. (see: Estimating the cost of drone delivery).[57] These costs are unlikely to decline markedly over the next five years, as there are few forecast technology advances in the medium term that would enable prices to fall significantly.

Estimating the cost of drone delivery

The key capital costs in provisioning a drone suitable for delivery of packages are:

- The UAV, at about $10,000-$50,000 per unit. The $10,000 price-point assumes a bulk order or self-assembly. Each drone can make up to 5,000 round-trips of up to 10 kilometers length. Some drones may get stolen, lost in transit or damaged;[58]
- Rechargeable batteries, at about $200-$400 per pack. At this price, batteries would have a range of ten kilometers with a two kilogram pay load. A battery lasts about 100 charges and its range declines following each charge.
- A system control unit which would control the flotilla of UAVs, provide air traffic control and log flight paths. This unit would cost from $30,000.

These costs exclude operational costs, which could be significant. An autonomous UAV that can rely entirely on satellite navigation for guidance should need no piloting, however if the GPS fails the drone is basically blind. In some markets, this would not be legal, and a pilot would be required to guide the device. Other individuals may be required to perform flight control. One other task that a person would need to do would be to swap out exhausted batteries and replacing them with fresh ones.[59]

Drones can convey a package but cannot deliver it.[60] The package may require a signature; it may need to be re-routed to a neighbor. An unmanned UAV needs a lot of human support around it. The trial of delivery of goods to Juist is only to a reception area.[61] A worker receives the goods, and then delivers it to the recipient. This may seem convoluted, but at present it is the only approach, and may remain so for the foreseeable future.

Bottom line

Individuals have long been fascinated of the possibility of replicating our bustling terrestrial highways above ground: the notion of personal or unmanned vehicles flying around the sky in vast quantities has long been a feature of science fiction. A future in which fully-automated UAVs deliver packages to our homes is a compelling one; however it is not at all likely in 2015.

This is not to say that drones are not useful or compelling. Any invention that counters gravity is a marvel; one that combines flight with other recent innovations, such as lightweight high definition cameras and accelerometers should be lauded.

We expect drones will have multiple industrial and civil government applications, building upon the diverse uses they are already being put to. Any task requiring aerial inspection could be undertaken by a camera equipped drone, transmitting footage to ground staff in real time.

The global aerial imaging market was worth about $1 billion in 2014.[62] Hollywood chase scenes make up a small part of that; the majority is for aerial imaging in construction and development, geospatial technology, and natural resource management. Much of that is from helicopters and drones which will capture a percentage of this market. But some of this market will remain inaccessible as drones are not for purpose for all current aerial imaging work. UAVs have lower ranges, lesser tolerance of adverse weather, and smaller payloads than helicopters: the lightest stabilized camera, for example, weighs around 20 kilograms.[63]

This implies a ceiling for sales of drones for the aerial imaging market, but it is also the case that the lower cost of drones will widen the aerial inspection market. If a drone can do a better job of inspection of building sites than sending a team up with ladders and ropes, then the usage of visual inspection will broaden considerably.

Regulators considering how best to incorporate drones into existing air space will need to balance the many positive contributions they can make, as well as the obvious negative externalities they can inflict. An irresponsibly piloted semi-professional two kilogram drone, whose battery expires in mid-flight above a crowd, may cause serious injury. A drone deployed on search and rescue missions may save lives.

Enterprises should examine every potential application of UAVs while recognizing their limitations: these are lightweight, battery-powered devices, many with modest payloads and short ranges.

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3D printing is a revolution: just not the revolution you think

Deloitte predicts, in line with the industry consensus, that in 2015 nearly 220,000 3D printers[64] will be sold worldwide, with a dollar value of $1.6 billion,[65] representing 100 percent unit growth and no more than 80 percent growth in dollars[66] versus 2014. But there won't be a 'factory in every home':[67] although 3D printing can be seen as 'the next Industrial Revolution'[68] the real revolution is for the enterprise market, not the consumer.

By 2017, about 70 percent of units will be sold to consumers,[69] and they are likely to be a majority of units in 2015, but almost all of these will be small units with relatively limited capabilities for producing functional parts.[70] Dollar value and usage will be heavily skewed to the enterprise market. Deloitte estimates that enterprise (rather than consumers) will account for just under 90 percent of the value of all 3D printers;[71] over 95 percent of all printed objects by volume; and 99 percent by economic value.

Deloitte also predicts that rapid prototyping and the production of 3D-printed objects that fit into existing manufacturing processes (such as creating a mold, die, cast or tooling that will be used to make final parts) will represent 90 percent of the 3D objects made by enterprises. Although likely to be the fastest-growing component of 3D printing, final-part manufacturing[72] will still represent less than ten percent of 3D objects printed.

The relative insignificance of the consumer 3D printing market is due to several factors. One is the unit price. Home devices for under $1,000 have now been available for eight years; they print fairly small grapefruit-sized objects out of limited-performance materials and with relatively coarse features. High-end industrial machines are capable of producing finer details, are faster and can print larger objects; but the largest units can cost almost a million dollars, and even smaller machines cost on average hundreds of thousands of dollars each.[73]

But that's only part of the problem holding back the consumer market. In the near term, the less-expensive home devices have some crucial limitations. They can be extremely difficult to calibrate, maintain and use.[74] If the heated bed on which the plastic material is being extruded is even one or two degrees too cold, the object won't form properly; while a degree too hot can cause it to stick to the plate. This deters many consumers from buying a device, and those that do often abandon their machine after producing only a few objects. And this won't be changing soon: according to one forecast, only ten percent of home machines under $1,000 will be 'plug-and-print' by 2016.[75]

3D printers for the home are slow; even objects a few centimeters high can take many hours to print. Printed objects usually require final finishing; materials are expensive at $50 per kilogram or more; the software tools are not easy to learn; and objects tend to be small and have very low-strength properties. The most significant limitation is that most home printers produce objects made from just one or two plastics,[76] and there just aren't that many useful consumer devices made solely out of low-performance plastic.[77]

Many of these limitations will improve over time. Early PCs were hard to use; similar improvements in ease of use are likely for 3D printers. Costs for both machines and materials should continue to decline; printing will get faster; and new materials (different kinds of plastics, or maybe even metals) that currently can only be printed by enterprise-grade machines may make it into the home.[78] But this won't happen in the near term. Even by 2020 home 3D printers will likely be more similar to power tools than PCs: 10-20 percent of homes may have one, or want to have one, but they will be far from ubiquitous; and even owning a 3D printer may be like owning a power drill. Unlike a PC, a 3D printer is a device that most are likely to use only rarely, and not daily.

In contrast a cross-industry survey found that in 2013, one in six enterprises in developed countries owned or were planning to acquire a 3D printer.[79] Deloitte's view is that by the end of 2015 the ratio will be one in four, although it will vary considerably by industry.[80]

Given that 3D printers are now widely used by enterprises, varying by vertical (with manufacturing and medical leading the way) why are we predicting that the finished part share of 3D printer output will not be larger in the next year?

First of all, the manufacture of finished parts is limited by the small number of 3D printers that can actually produce metallic components. Although there are some end uses that may need plastic, glass or other substrate objects, metal remains the most useful 3D-printed end material, but only 348 metal printers were sold worldwide in 2013.[81] The installed base at the end of 2014 is likely to be under 1,000 units globally. Even when the right machine is available, and the finished part has suitable materials properties (such as strength and resistance to cracking), 3D printing of these parts seldom makes sense. For the foreseeable future, printing parts will take 10-100 times longer, and cost 10-100 times as much as manufacturing by stamping, casting, or other traditional manufacturing techniques.

The most significant limitation is that most home printers produce objects made from just one or two plastics,and there just aren't that many useful consumer devices made solely out of low-performance plastic.

In a 2014 survey of industrial manufacturers, 62 percent of respondents were either not implementing 3D printing technology or only experimenting with it. Of those who were actually using 3D printing, two-thirds were using it for prototyping and marketing purposes only; a quarter were using it for a combination of prototyping and production; seven percent were building products that couldn't be made using traditional methods; and only two percent were using their machine only for production of final products or components only (and even then, only for very low volume products).[82]

These trends seem likely to continue in 2015. 3D printing is ideal for prototyping when a fully-functional part is not required. Traditional prototyping requires skilled artisans in machine shops and can take days or even weeks; and each object can cost tens of thousands of dollars – all to create (for example) a plastic rear view mirror housing that a designer looks at and needs to change again. An enterprise-grade 3D printer can take the CAD (Computer Aided Design) file the designer is using and build, layer by layer, a physical sample in eight hours for a materials cost of $100. The designer can then look at the part, tinker with some aspect in the CAD software model, and print out an iterated version by the next morning.

There will be some highly complex parts that are better made through 3D methods (such as certain aerospace components like turbine blades),[83] or unique situations where there is no room for a machine shop and the nearest parts depot is far away (such as the International Space Station).[84] But for many manufacturers, issues around cost, speed, material availability and consistency of outputs remain barriers to using 3D printers; and "customers have yet to put their full trust into these products."[85]

There is a difference between mass manufacture and producing spare parts. Many enterprises may have a potential need for thousands, or even tens of thousands, of replacement parts, any one of which could be critically important. It is impossible to hold that kind of inventory; and delivery of a part from an overseas manufacturer can take many hours or days, even using air freight. Even when a company that owns a 3D printer can manufacture a part that would normally be ordered from a parts manufacturer or distributor, and that part that meets all the required specifications, there are significant legal questions around intellectual property and manufacturers' warranties.[86]

In the near term however we expect some parts manufacturers to embrace a 3D printing business model, where customers are given the option of downloading an approved file, printing a legal and authenticated part,[87] and installing the part without violating copyright or warranty provisions.

In the long term 3D printing will be used increasingly for making finished goods. Already its use for this purpose appears to be growing faster than the 3D printing market generally.

Even here, adoption may take longer than some of the more optimistic expectations. For example the automobile industry is often cited as an early adopter of 3D printing technology: in 1988 Ford bought the first 3D printer ever made,[88] and the auto industry is the single largest buyer of 3D printers, with over 40 percent share.[89] Virtually all global auto manufacturers and many parts makers[90] have purchased one or more 3D printers; but over 90 percent of them are used for prototyping of non-functional parts, and only about ten percent are used to make functional prototypes or casts or molds to help in conventional manufacturing. As of January 2015, the major North American auto manufacturers and parts makers are not using 3D printing for the direct manufacture of even a single final part for a production vehicle, and are not planning to do so in the next two years.[91]

The medical vertical is about 15 percent of the 3D printer market, and is often discussed as one of the bigger markets for finished part manufacture. Although 3D-printed hips and skulls are getting the most press, the less-glamorous use cases are almost certainly the main drivers of medical 3D printed devices, both in volume of parts and in value. The audiology and dental markets are often cited as examples where 3D printing is ubiquitous: "Virtually all hearing aid shells and dental copings are made using 3D printing." That is true for the hearing aid market: there are likely to be over 15 million 3D printed hearing aids in circulation today.[92] But although 3D printing is used for some part of the coping manufacture process, in many cases only 15-20 percent of all finished part copings are made exclusively with a 3D printer.[93] Equally, while 3D printers are used occasionally for making temporary teeth, almost all permanent teeth continue to be milled: it's faster, cheaper, and produces better quality objects.

Bottom Line

Although 3D printers are unlikely to be the 'factory in every home', they may become the factory in every school. Learning how to use 3D printers (and the software tools needed to operate them) will be like learning woodworking or metalworking for past generations of students: enormously useful for those who will end up using 3D printers in their jobs, and still a positive learning experience for the rest. It is still early days, but one study found that hundreds of US primary and secondary schools are already including 3D printers in their annual budgets.[94]

Outside of schools, and for the near term, 3D printing technology may be used best as only part of the manufacturing process: 3D printing dovetails well with many existing production techniques. New technologies that work with existing processes are almost always adopted more rapidly than those that require entirely new ways of doing things.

By lowering the cost and dramatically accelerating the time-to-market for both prototypes and tooling, 3D printing solves particular pain points in some manufacturing chains, and levels the playing field between large manufacturers and the start-up in the garage, just as PC technology narrowed the gap between the mainframe computer makers and the kids in the Silicon Valley garage. Large jewelers used to be the only ones who could maintain in inventory hundreds of mocked-up rings in all the various sizes needed: now small ateliers can produce customized samples at low cost and within hours.

3D printers are used widely in rapid prototyping of mainly non-functional components, but this usage is unlikely to result in material cost savings for the R&D process. Although building traditional prototypes is usually more expensive than using a 3D printer, prototyping is typically only a small fraction of overall R&D costs. The speed and low cost of iteration means that more versions of a given part will be tried; outcomes and timelines will be improved, but dollars won't be saved.

In addition, 3D printing makes the supply chain more flexible and agile. Product life cycles are shortening, which puts a premium on speed to market. Since the initial costs can be lower than those of traditional manufacturing, 3D printing can offer competitive per-unit costs at levels below the scale required by traditional manufacturing.[95]

Deloitte Predictions normally looks at only the next 12-18 months. At the furthest limit of that time frame, there are likely to be new multi-material 3D printers from major manufacturers, targeted at the enterprise market and not the consumer. Full details of these devices are unavailable yet, but they are likely to increase the market for finished parts, due to multi-materials capacity, higher speeds and greater precision.

Although 3D printers are unlikely to be the 'factory in every home', they may become the factory in every school.

Click and collect booms in Europe

Deloitte predicts that the number of click and collect locations in Europe will reach half a million in 2015, a twenty percent increase on the previous year. Click and collect, whereby online orders are picked up from a physical location rather than delivered to the purchaser's home, is likely to become an increasingly fundamental part of the e-commerce offer and should help maintain its growing share of retail spend. Rising e-commerce revenues should have a commensurate impact on Internet advertising revenues, as well as driving website creation and increasing bandwidth usage.

The appeal of e-commerce is well documented, and volumes continue to rise two decades on from the launch of the first Web shopping sites.[97] About half the people in Europe currently shop online, and annual spend is continuing to rise at double-digit rates in some markets.[98] The key friction point in e-commerce has been delivery. Every year, online orders trigger billions of individual deliveries in Europe alone.[99] Delivery timings on most products bought online to be approximate so as to keep costs affordable, and recipients are not always home to receive the goods. There are workarounds to the distribution challenge: parcels can be left with doormen or porters; they can be re-routed to neighbors, assuming they're in; packaging can even be re-designed to fit through letter boxes.

But these options are not always available. And the consequence is that recipients may have to travel to a central depot and wait in line to pick up parcels, cancelling out a key element of the convenience of shopping online. The direct cost to retailers of failed first-time delivery is over a billion dollars per year in the UK alone.[100] The indirect cost may be consumers taking their business to other retailers with more flexible delivery options. During peak shopping periods, it may be that there simply is not enough delivery capacity to cope with the volume of e-commerce orders, and so click and collect has to take up some of the slack.[101]

In the UK, home-delivery volumes are expected to flatten out in 2015, suggesting that growth in e-commerce has to come from alternative delivery options.[102]

Click and collect, whereby products can be delivered to another physical location, offers the best of both worlds: a wealth of choice in selection and flexibility in collection.[103]

There are three main types of location that consumers can collect their purchases from: in-store (including, for larger venues, the parking lot), at a third-party location (such as a post office or a train station), or at a locker (often located on a commuter route). In 2015 we expect that, of the 500,000 pick-up locations: about two-thirds will be individual lockers, some of which will be in clusters of hundreds; just over a quarter will be third-party locations; and the remainder (about 37,000) will be stores. Third-party locations will be a blend of mixed-use sites, such as post offices offering an additional collection service, and dedicated sites, including changing rooms.[104]

In Europe, the UK is currently the most mature e-commerce market, with 13 percent of all retail revenues from online in 2015, of which about a third will be click and collect. Revenues from click and collect more than doubled in the UK between 2012 and 2014, reaching $8.7 billion from 140 million orders.[105] As of Q4 2014, about 95 percent of those online stated they planned to use click and collect for some of their holiday shopping.[106]

We expect e-commerce share of retail to grow in most other European markets, and click and collect to become an increasingly common offer.

Click and collect's impact is likely to vary by retail segment, with non-grocery representing the majority of sales. In the UK in 2013, non-grocery was estimated at 95 percent of sales.[107] For some major non-grocery retail chains, click-and-collect already represents close to half of online orders.[108]

For retailers, the ideal outcome from offering click and collect would be to increase the propensity to purchase from the website and, additionally, in-store when the customer is picking up his or her package. Click and collect may be driving aggregate online spend, by offering greater convenience. In the UK, click and collect's share of all e-commerce has risen steadily over the past three years, along with a rise in e-commerce's share of all retail spend.

Click and collect won't be limited to bricks and mortar stores. Online-only retailers will also partake, sometimes using third-party outlets and lockers to deliver goods and sometimes using retail stores. For example goods purchased on eBay can be picked up at 650 stores of UK retailer Argos.[109]

However, in most markets click and collect stores are outnumbered by both third-party collection sites and lockers. If a customer uses either of these alternatives, this removes the opportunity for incremental sales, as well possibly diluting the brand impact: the third-party collection point's branding may be distinct from that of the original retailer.

Deloitte expects that for many stores, the provisioning of click and collect will occur simply as a means to remain competitive. The decision to offer such facilities may be a reflex reaction to the launch of a service by a direct competitor. As such, some retailers offering click and collect may initially find that they are not yet fully ready to offer such a service.

Their store layout may not be optimized for click and collect. They may have to improvise a store room for goods to be collected and designate a space where people can queue and wait for their goods to be fetched from a store-room without blocking the passage of customers wanting to use the store in conventional manner. It may take several minutes to process each order, so at peak times congestion of pathways for traditional customers may become problematic.

Their staffing levels may not be sufficient to cope with the service; and they may need to hire additional personnel, particularly at peak times in the day or during busy seasons, to collect goods from the storeroom. Retailers offering click and collect for groceries would need to provision rooms equipped with sufficient refrigeration for safe storage of perishable foods.

Point-of-sales software may only be set up for conventional in-store payments, and may not, for example, treat e-commerce returns as a non-store transaction.

The availability of click and collect is likely to encourage some customers to over-order in the knowledge that unwanted goods can be immediately returned and refunded. This will be particularly the case with clothing. Customers may order a wide range of goods, in a manner similar to how they pick an assortment of clothing off rails to try on in the changing rooms. They may then keep one of the half-dozen items they have tried on. With in-store sales, unwanted items would not be rung up in the till; with click and collect all items selected would be 'sold', and then all unwanted items would be refunded. This may cause sales data to be distorted by the volumes of try-to-buy purchases. Retailers offering a much wider range of goods online may also face rapidly increasing costs in delivering orders to stores and in expanding their reverse supply chain capacity.

This prediction has focused on Europe, as there is a strong dynamic around this aspect of e-commerce. Other regions are also deploying click and collect, but are at earlier phases of deployment. For example, in Canada, retailers, including some of the largest grocers,[110] general merchandise retailers,[111] and entire malls[112] are trialing the service at pilot locations. Some UK-based retailers are exporting their experience of click and collect in other markets they operate in, such as Thailand.[113] In South Africa, one chain is using a UK based sister company's experience in collection to trial a click and collect service.[114]

In most markets click and collect stores are outnumbered by both third-party collection sites and lockers. If a customer uses either of these alternatives, this removes the opportunity for incremental sales, as well possibly diluting the brand impact.

Bottom line

Click and collect is an established feature of the retail market. As of 2015, the proportion of retailers offering click and collect in Europe will vary markedly by country, but we would expect that most markets should see significant increases in the number of merchants offering this facility.

At first glance, click and collect may seem a win-win for retailers and customers alike. Consumers are offered additional convenience, hopefully encouraging them to spend more; retailers avoid the cost of delivery to the home, and can utilize existing space.

But every element of delivery incurs a cost: every square meter of space used for storage displaces space that could be used for display, and any staff member processing a collection is unable to assist other customers. It should only require one trip to visit to a locker, but a retailer may have to pay a rental cost for this.

Making purchasing more convenient for customers may also make it easier to return goods – unwanted items, when seen 'in the flesh', can easily be returned at the point of sale. This could stimulate 'buy-to-try' sales, leading to over-stocking of baskets, causing a surge in the volume of returns. Retailers need to monitor carefully the costs of offering click and collect, and in some cases may need to remove the offer.

Retailers should consider how best to structure accounting for click and collect returns. If sales are made by the online team and returns are debited against the store, this could lead to distorted sales and profitability assessments for certain stores. Further, landlords charging rents based on in-store turnover may see reduced rents in busy locations with a high volume of collections. Sales teams remunerated on sales volumes may also lose out due to returns, if these are debited against the retail outlet.

Grocery retailers should monitor the constituents of click and collect baskets carefully. A sub-optimal outcome would be if customers were to choose free delivery locker of bulky but low-cost goods (such as multi-packs of kitchen roll) to a third-party and then wait several days before picking up their goods. Retailers offering click and collect for groceries should be aware of regulations concerning storage of perishable goods.

The best approach to distributing click and collect orders will vary by retailer. Some could receive goods from a central warehouse, and the local store would simply serve as a collection point. Others, for example fashion outlets, could use shop floor staff to handle collection and packing during quiet times, such as mid-week, in anticipation of collection at the weekend.

Retailers should consider whether to charge for click and collect deliveries, and also for returns. There are costs associated with both which, if not charged for, will reduce margin.[115] Retailers may also need to vary the click and collect offer on a periodical basis. Free collection the day after ordering may be restricted to quiet shopping periods; but during sales, and at events like Christmas or Black Friday, the collection period may need to be extended.[116]

Retailers can also shape collection behaviors, for example by using automated systems to advise customers via e-mail or apps when goods have arrived or by using vouchers to encourage prompt collection during off-peak times.

NFC-enabled phones, linked to consumers' credit card details, may be used in the collection or return process. By generating a unique transaction code, NFC-enabled phones can be used as a proof of identity replacement.

The legal implications of click and collect should also be considered. For example there are trials to deliver to people's cars.[117] This is fine if the car trunks are secure, otherwise delivery companies may be blamed for any missing goods.

Smartphone batteries: better but no breakthrough

Deloitte predicts that the rechargeable, lithium ion (Li-Ion) battery technology used in all smartphones will improve only modestly in 2015. We expect a 2015 Li-ion battery to have no more than five percent greater unit charge or milliampere hours (mAh) compared to a 2014 model of the same dimensions and voltage. Longer battery life is likely to remain a key factor for those choosing their next smartphone.[118]

However, most new smartphone owners may still get a 15 percent increase in battery life, but this will mostly be due to other factors. New devices will benefit from efficiency improvements in the components that draw power from batteries (principally processors, radio transmitters and screens) as well as from better software. Further, we expect that the mAh of the average battery shipped in smartphones will increase by up to 25 percent in 2015,[119] due to the increase in average size of smartphones sold, with battery capacity rising at a greater pace than screen area.[120] (Battery life will not increase by the full 25 percent: larger screens use more power and newer phones typically offer increased functionality, leading to more intensive usage).

The smartphone has benefited from Moore's Law – the consistent, significant increase in performance at the same price point – with processor and connectivity speeds seeing the biggest increments.[121] Consumers have often yearned for a similar breakthrough for battery. However since the introduction of Li-Ion technology, which predates the arrival of the smartphone, they have continually been disappointed.

Indeed, there is unlikely to be anything more than a modest improvement from Li-Ion in 2015 or at any time in the future. At most it may yield just a further 30 percent performance before hitting a ceiling, with perhaps a 20 percent improvement by 2017.[122]

So any major inflection in battery performance would require the use of different technology. Li-Ion batteries are currently based on a common chemistry, and use a variety of lithium salts, organic solvents and electrodes. New batteries could use different physical structure of an anode or cathode (or both) such as a nanostructure. Alternatively they could vary the material used in the electrode(s), vary the anion that makes up the salt with lithium, or vary the electrolyte chemistry or material. Or they could move away from lithium chemistry completely, perhaps by using graphene.

Across all of these possible innovations, we do not foresee any breakthrough battery technologies being in the market in 2015 – or, regrettably, before the end of this decade.

The challenge of formulating a better battery

The lack of progress in smartphone battery capacity is not for lack of trying, but simply because it is extremely difficult to identify a battery chemistry that is better and suitable for use in the highly diverse operating environments in which the billions of consumer electronic devices we own are used. Many private companies and public organizations are and will likely remain focused on inventing a better battery chemistry – the reward for the inventor is enormous – but the need to optimize the many different characteristics that define what a 'good' battery is makes the task a challenging one (see: Formulating a better battery).

Internal combustion engine vehicles, of which there are currently over a billion in use,[123] still use a 12 volt lead acid battery whose fundamental design is over a century old.

We are not aware of any breakthrough battery chemistry in commercial development in 2015 that offers significant improvements across a sufficient range of these characteristics. But even if there was such a breakthrough, there would be further, time-consuming hurdles to pass: it is highly unlikely that a replacement for current Li-Ion batteries that could be 'dropped in' to existing devices and form factors will be available within the next three years.

Formulating a better battery

A battery suitable for use in everyday consumer-electronics devices needs to balance the following properties:

- Specific energy. It needs to concentrate as much total energy into as little weight as possible (measured in watt hours per kilogram).[124] Low device weight is a key source of competitive advantage among device vendors.[125]

- Energy density. As much total energy should go into as little volume as possible (measured in watt hours per liter).[126] There is a relentless race among vendors to make ever-slimmer devices;[127] bulky devices are typically regarded as being of lower value.

- Specific power: how much peak power (measured in watts per kilogram) can be delivered per unit weight.[128]

- Cost per energy unit. There are some emerging technologies, which have fantastic performance in terms of specific energy, or energy density, but whose cost is currently prohibitive. For example, one very promising field of battery research is graphene, but this nanomaterial currently costs over $100 per gram to manufacture. The price will fall, but as of 2015 a graphene battery in a smartphone would add about $1,500 for the raw material alone. In contrast, a $20 smartphone battery contains less than $0.02 worth of lithium carbonate.[129]

- Self-discharge: the rate at which a battery loses its power with no usage. This can affect the stand-by life of a device.

- Operating temperature. Devices need to function between zero and forty degrees Celsius. There are some battery technologies that only function at very high temperatures, making them unsuitable for use by the public, but which may still have industrial applications, such as large-scale energy storage. Other technologies are badly affected if left in a hot car for only a few minutes.

- Output current. The stated capacity of a battery (in watt hours) is usually dependent on the current (in amps) it is expected to deliver. A battery must be able to satisfy the current requirement of the device in which it is installed and still offer sufficient capacity.

- Safety. There are some battery-like technologies that have existed for many years, such as hydrogen fuel cells which are used to power public transport and are being trialed in passenger vehicles. However they are unsuitable in devices for safety and practical reasons: the fuel for fuel cells is often flammable or even explosive, and therefore may not be allowed on aircraft.

- Durability: the number of charge/discharge cycles that a battery can undergo; both full charge/discharge cycles as well as partial discharges.

- Efficiency. The amount of power needed to charge the battery compared to the amount of power the battery can store is important, because all ‘wasted’ power is manifested as heat, and heat usually damages batteries. A compact battery must be efficient or it will overheat, especially during fast charging.

- Complexity of the charge system. Current smartphones house the charging circuitry. (What most people refer to as the charger is just a power supply). A battery with a complex charging system requires more electronics, resulting in increased cost and bulk.

A manufacturer would need to run extensive tests on any new battery technology that is being positioned to replace Li-Ion. Will the batteries last as long as expected, when used by consumers, in ways in which the designers may not have anticipated? Is there any risk of the new batteries catching fire if improperly charged, for example through the use of unapproved third-party chargers? Would mistreatment of the device – whether intentional or not – present a potential hazard to the user? Battery engineers can test a product extensively, but may not be able to replicate consumer usage fully. Further, batteries are expected to last a minimum of 2-3 years for almost all consumer devices, and therefore require reliability testing for at least that long, if not longer.

The new battery type would likely require a different charging technology, or may need different packaging, or other system design considerations. An advantage of Li-Ion is that the shape and format of the battery can be varied considerably to meet the needs of the system designer. This would not be the case if, for example, a battery required a metallic container. Similarly, a new chemistry may produce a voltage significantly different from the 3.65 – 3.7 volts of a Li-Ion battery which would require the smartphone to include voltage conversion circuitry, or, perhaps, reengineering the underlying semiconductor technology, which would be non-trivial.

Device component advances will reduce power consumption

While the batteries themselves are unlikely to experience a greater than five percent improvement in 2015, improvements in overall device design can enable – assuming steady state usage – more hours of usage between charges.

The three main drains on battery life for the typical smartphone are: the screen, the processor and the radio. Improvements in processor and radio design are likely to yield the biggest improvements in getting the most minutes out of each milliwatt.

The screen is a key differentiating feature and power drain of devices. Unfortunately we anticipate only modest improvement in display power consumption in 2015, although we do foresee significant change possible by 2020. A smartphone with a four-inch screen might consume about 0.75 watts and its battery would have about 5-6 watt hours' capacity. In real-life conditions, assuming concurrent usage of the screen, processors and radio, this would allow for only about four to five hours of constant usage.

We expect that power consumption by the display is unlikely to improve markedly in 2015: most smartphone displays are transmissive LCDs, which incorporate a backlight.[130] Lower-power display technologies are on the market, the most advanced of which is OLED (Organic Light Emitting Diode).[131] The key constraint on wider adoption of OLED screens in 2015 is cost. We expect OLED displays to displace backlit LCDs over time, but it may be five years before they predominate even in high-end phones.[132]

In the past year, the average size of smartphone screens has increased – and this has indirectly improved battery life. A larger screen drains the battery more and also permits a larger battery to be included, with battery capacity increasing at a greater pace than the screen size. A version of the same phone that has a screen 20 percent larger (with identical components aside from display dimension and battery volume) may last up to 40 percent longer.[133]

The processor used in many 2015 smartphones should be significantly more efficient than 2014 models, delivering a 30-40 percent increase in processing power per watt, in line with Moore's Law. Most processors used in devices – from smartphones to PCs – have experienced annual improvements in power efficiency over the past 40 years.

To illustrate this point, consider that in the mid-1980s, PCs operated at about one MIPS (millions of instructions per second) and consumed about 100 watts.[134] A 2015 PC with a high-end processor such as an Intel Core i7 typically delivers over 100,000 MIPS, but still consumes the same 100 watts. For more information on how processor design can reduce power consumption, see the side bar: Chip design and power efficiency.

Although processors are becoming more energy efficient compared to an equivalent device from last year, smartphones are incorporating ever more powerful processors, which require more energy. It is likely that the first smartphones with 3 GHz processors will launch this year. Software and hardware designers, anticipating consumer demand, will inevitably find applications for increased performance. For example, current leading games designed for smartphones feature far more complex, 3D graphics and video than the 2D games popular with the first smartphones.

Side bar: Chip design and power efficiency

Chip design is a major contributor to greater efficiency. Smartphones are built around a "system on a chip" (SOC), which combine much of the electronics of the mobile device onto a single integrated circuit.[135] One of the benefits of this approach is the ability to shut down parts of the SOC which are not needed at the time. If a user shuts off smartphone display, the graphics and display controller of the SOC may also be shut down and the processor itself put to sleep, only to awaken occasionally to check for user input (via the touchscreen or buttons), receive or transmit via the radio, or use Wi-Fi or Bluetooth. Power consumption of a 'sleeping' processor in a smartphone is a fraction of when it is awake: about 1 mW (0.001 Watts) versus 100 mW. Integrating faster processors reduces power consumption. A slower processor may take 0.5 seconds to complete a task, and consume 50 mW; a faster processor doing the same task in half the time would consume a little over 25 mW.

The radio, which enables data to be transmitted and received, is the third most significant drain on power.[136] Over the past two decades, the energy required to transmit or receive each bit of data has fallen steadily and significantly, by about 30-40 percent per year.[137] Sending a 100 KB photo using a 4G phone should use less power than using a 3G phone, and significantly less than with a 2.5G phone. This is because 4G phones transmit at a faster rate, meaning that the radio is used for less time. Sending the same photo over 4G may take a quarter of the time it would take over 3G.[138] Further, the technology behind 4G is significantly more efficient in terms of coding, which allows for additional power savings.

However faster transmit rates are likely to change user behavior; the ability to send a photo faster is likely to prompt the sending of more and/or higher resolution photos, or the posting of video in place of photos.

As for voice calls, early analogue mobile phones required a continuous signal at one watt power when making a call: today's 4G phones can deliver up to several hours of continuous talk time for that same single watt.

A further reason for the reduction in the drain by the radio on the battery for every voice minute or megabyte sent is decreasing transmit distance. As the number of cellular network base stations has increased, cells have become smaller, meaning a reduced distance between the phone and the base station, and shorter distances mean that transmitting from the phone to the tower requires much less power. The recent proliferation of private and public Wi-Fi routers has enabled a further decrease in transmit power. Smartphone users who predominantly connect to Wi-Fi, should experience longer battery life than those relying mainly on the mobile network.

Smartphone users who predominantly connect to Wi-Fi (presently mostly for data, but increasingly for voice), should experience longer battery life than those relying mainly on the mobile network.

Bottom line

Battery life is becoming an increasingly primal anxiety among digital natives. This anxiety is to an extent self-inflicted: more frequent use of more power-hungry applications on larger devices consumes more power. Our devices would last longer if we used them less, or used them differently. But the rapid progress in smartphone capability looks likely to continue in 2015, which means that the smartphone users will use their phones more frequently, and for a wider range of applications. The gains from new or larger batteries are likely to be balanced out by greater usage.

Phone users who started using mobile telecommunications back in the mid-90s or earlier will be familiar with predecessors to Li-Ion, such as nickel metal hydride, which had markedly inferior performance. These individuals may yearn for a similar step-change increment in performance from batteries. The good news is that one day there is likely to be a new formulation that offers a significant improvement, but that day is unlikely in 2015. In the interim, see our suggestions on how to improve battery life in the side bar.

Frustrations with battery life present many opportunities for vendors.

Smartphone vendors may differentiate their devices in terms of processor design, battery capacity and fast-charging capability.

Network operators with high-density networks and/or a large network of public Wi-Fi hotspots may advertise the fact their network can reduce battery consumption, due to lower transmission drain on their customers' batteries. When a network is overloaded, the phone can spend a lot of time on unproductive tasks, such as waiting for the file to download, or pinging the network to ask whether it can download packets. A congested network can cancel out all the improvements in battery chemistry or semi-conductor efficiency.

Component vendors can offer a range of different external power supplies.

Public venues and public transport facilities can differentiate their facilities through the offer of charging units. There are likely to be ever more locations offering opportunities to recharge, from airport lounges, to planes, trains and automobiles.[139]

Side bar: How to improve smartphone battery life

- Replace the battery with a fresh one, as it will typically have a greater ability to retain power. Over time, with successive recharges, batteries lose their ability to charge.
- Charge frequently and never let the battery drain completely. A Li-Ion battery that is typically discharged by 25 percent before being recharged should last about twice as long as a battery which is half depleted before being recharged.[140]
- Use a phone with a larger screen, as it will likely have a larger battery.
- Keep the display backlight as dim as practicable.
- Use the phone on a relatively uncongested network.

Nanosats take off, but they don't take over

Deloitte predicts that by the end of 2015 over 500 nanosatellites (nanosats) will be in orbit. Nanosats have a mass of between one and ten kilograms,[141] compared to hundreds or even thousands of kilograms for the average commercial satellite. They also tend to be sized in increments of ten centimeters (cm), with a 30 cm x 10 cm x 10 cm configuration being the most common, whereas most commercial satellites measure at least one meter or more in every dimension.[142] Prior to November 2013, only 75 nanosats had ever been launched, and another 94 were put in orbit in the three months ending January 2014, for a total of nearly 170.[143] Our prediction calls for a nearly 300 percent increase in the installed base. Nanosats are attractive for many reasons: they are cheaper than conventional satellites, lighter, easier to build and test, easier to launch, and (as a result of Moore's Law exponentially adding to the functionality of the electronics) increasingly capable of more complex computational tasks.

Students of technology history may wonder whether this is another case of innovative disruption. Although nanosats are currently much less capable than traditional small, medium and heavy satellites, will they follow a similar path to personal computers, MP3 players and camera phones – come in at the low-end, keep improving and eventually dominate the market?

Deloitte predicts that the answer is probably not. Although taking something the size of a small house and replacing it with something that fits on a desktop worked for the PC industry disrupting mainframe computers, nanosats are likely to be additive, and not disruptive for the commercial satellite market, and not just in 2015 and 2016, but in the medium-term. There are specific barriers related to the laws of physics that will likely prevent nanosats from capturing significant parts of the markets that the larger satellites now dominate: in this case, it is 'rocket science'.

The global commercial satellite industry generates about $200 billion in revenues annually.[144] Services (such as satellite pay-TV subscriptions) are the largest part at $115 billion;[145] ground equipment (mobile terminals, dishes, gateways and control stations) $55 billion; launch is 'only' about $7 billion;[146] and the satellites themselves $15 billion.

A $200 billion market should present significant opportunities: that's about the size of the entire US fast food restaurant industry or more than double global tablet sales.[147] If nanosats could capture a significant part of the market from larger satellites, it could be a game-changer. So why is this unlikely to happen, especially when media articles trumpet the potential of nanosats?[148]

Price and processing performance matter a lot, both in space and on the ground. However over 90 percent of the commercial services currently delivered by satellites of any size require certain fundamental characteristics: the ability to stay in their correct position in orbit; the ability to transmit enough power back down to Earth that even small receivers will find usable; and the ability to sense relatively small features.

Staying in their correct position in orbit is a potential problem for nanosats. At less than ten kilograms, and ten centimeters on a side, they have very little internal capacity. Larger satellites use gyroscopes and reaction wheels to make sure they are always pointed in the right direction (attitude control) and have between four and 12 thrusters, powered by propellant (such as hydrazine or xenon) which allows them to maintain a stable orbit (station keeping) given the perturbation effects of gravity or drag from the tenuous upper atmosphere.

Nanosats can use miniature gyroscopes and reaction wheels for attitude control, but they generally have no room for thrusters[149] (or propellant for that matter) for orbital maintenance. This means that some are likely to have usable lives no more than 12-36 months and so require more frequent replacement launches.[150] Most proposed nanosat applications involve Low Earth Orbits (LEO), below 2,000 kilometers; and the inability to stabilize orbits is most severe for LEOs with orbits from 160 to 500 kilometers.[151]

Further, one of the principal potential advantages for nanosats in communications is extremely low latency. Most communications applications involve geostationary (GEO) satellites with an orbital radius of about 36,000 kilometers.[152] Although radio waves travel at the speed of light, the round trip still takes about 250 milliseconds, which can be an unacceptable delay for some communications services. A constellation of nanosats in very low earth orbits would have very low latency, but would also have more severe station keeping needs.

Power is another problem, not so much in terms of processing the data (due to the effect of Moore's Law), but with taking the output of that processing, whatever it might be, and beaming it back down to Earth. Whether a TV satellite is distributing a show, or is one of the GPS constellation of satellites emitting a timing signal that allows a smartphone to determine its location, the signal received by the consumer device on Earth is often only microwatts or even nanowatts in signal power. But as with all radiofrequency transmissions, there is an inverse square law in effect, which means that the satellite needs to transmit down output power of tens, hundreds, or even thousands of watts, even from the nearest Low Earth Orbits, for most home or consumer applications. Depending on footprints, antennas and frequency bands, small receivers on Earth require more power density to come down from space, and even ten watts is a large amount of power to transmit: that's about 40 times as much as the maximum output from a 3G smartphone.

Luckily, there is a free power source in space: the Sun. A few square meters of super-efficient gallium arsenide solar panels provide up to thousands of watts of power,[153] more than enough for GPS, sensing or communication satellite needs. Add another 30-50 kilograms of Lithium Ion batteries for those periods[154] when the Sun is behind the Earth, and all is usually well. But nanosats (which weigh up to ten kilograms) don't have enough room for solar cells or batteries of the requisite capacity. Although both solar and battery technologies are improving, they are doing so slowly. Even a decade from now, although some nanosats should be capable of beaming a signal to Earth that is detectable by the average consumer receiver, they are unlikely to be competitive with larger satellites.

An associated problem is that size also matters for antennas, even assuming equal power. Bigger antennas are better for sending information down to Earth or receiving signals from a ground station. There are various kinds of antennas on satellites: reflectors, horns and phased arrays. Large satellites can use unfurlable mesh reflectors that are up to 12 meters across; solid antennas are up to 3.2 meters in diameter; and even the LEO Iridium constellation of voice and data satellites have phased array antennas that are 188 cm by 86 cm. Nanosats, at least a couple of whose dimensions are no more than ten centimeters, must use antennas that (even if unfurled) are commensurately smaller than for larger satellites resulting in decreases in gain, taper or coverage area, depending on frequency).[155] There are articulated antennas with a 30 cm diameter on satellites today, but this stretches the definition of nanosat.[156]

Many of the commercially useful things that satellites can do require sensitivity. Any kind of observation satellite needs to look down hundreds of kilometers or more, through a turbulent atmosphere, and accurately resolve and image features (optically or with radar) that can be less than a meter across. This is very difficult. Or they need to pick up Earth-originated signals that may be one or two watts in strength on Earth but have attenuated in their journey and are now only picowatts in strength. This is also very difficult.

Either the sensors needs to be ten centimeters or more across, or there need to be optics and filters in front of the sensor that are usually 10-100 cm long. Neither sensor nor optics will fit on a nanosat. There is a useful analogy with cameras on smartphones. Although improvements in semiconductor technologies allow manufacturers to put a ten megapixel sensor chip on a smartphone, it is typically only about 15-25 millimeters square, and the lens is usually no more than four millimeters away from the focal plane.[157] Professional photographers who sell their pictures for money use cameras with physically larger sensor chips that can be up to 2,000 mm square (about 100 times larger) and telephoto lenses that can be 500 mm or more in length (once again, over 100 times longer.) In the same way, any satellite trying to capture Earth Imaging at sub-meter resolutions will likely require devices (lenses, mirrors, and sensors) that won't fit in a cube 10 cm on two of its sides.

Although stability, power and sensitivity are the most important challenges for nanosats, it is worth mentioning some other issues briefly. There are decades of experience with processes and procedures for launching, deploying and even servicing large satellites. There is no similar knowledge base at present for nanosats, especially for some of the proposed large constellations of dozens or even hundreds of them. It is not an insuperable problem, but it isn't trivial either. Next, just like down on Earth, there are only certain slices of the electromagnetic spectrum that are suitable for transmitting information, and that spectrum is finite and needs to be allocated. This constraint is most severe for satellites in LEOs (which will include almost all nanosats) and those using lower frequencies. Finally, there are already concerns about the amount of space debris in orbit: there are nearly 20,000 objects larger than five centimeters being tracked at present.[158] With potentially thousands of nanosats being launched into orbits, with some failing to be deployed and others going out of service over time, the problem will get worse.

It needs to be stressed that nanosats are an important innovation in satellite technology. Their low cost and flexible design will likely make possible many kinds of scientific experiments, or Earth Imaging at more frequent capture rates but lower resolutions. Tracking ships at sea requires neither particularly large sensors nor high power transmission:[159] another ideal market for nanosats.

But if we look at the $200 billion existing satellite market, roughly 80 percent is almost certainly not addressable by any space-based device smaller than ten kilograms – either today, or even by 2025.

Bottom Line

In the short or even medium term nanosats may not be able to capture or disrupt many of the market segments currently served by larger satellites but they do lower the cost and challenges of getting a useful object into space; they will likely attract investor attention and get the public more interested in the satellite market. They will almost certainly enable testing of new technologies on low cost and 'disposable' platforms, which in turn may foster the emergence of new applications or services.

It is also worth noting that the many technologies that improve nanosats, and make them feasible in the first place, also make the larger satellites better, lighter and cheaper too.

The price of satellites and associated costs for most applications will not be disrupted downwards. Based on the announced plans for nanosats to date, over half will be technology prototypes or for the science and education markets, and 40 percent will be targeted at the military and commercial Earth Observation market, but with the limitations noted above (power, station keeping and sensitivity.) Only five percent of nanosats are even trying to compete in the communications satellite sector, which generates over 80 percent of the annual $160 billion in the services and ground equipment satellite markets.

Launch or deployment risk will be much the same for nanosats as for larger satellites. Regardless of the size of satellite, an exploding launch vehicle will continue to be a risk, and deploying nanosats once they are in orbit is likely to carry similar risks to larger satellites.

Although this prediction focuses on nanosats, there are microsats (10-100 kilograms) and minisats (also known as small satellites, and weighing 100-500 kilograms) which are bigger than nanosats but smaller than the majority of satellites deployed today. Over time, these categories of small satellite are almost certain to have more disruption potential than nanosats.

Nanosats are an important innovation in satellite technology. Their low cost and flexible design will likely make possible many kinds of scientific experiments.

The re-enterprization of IT

Deloitte predicts that in 2015 the impetus for IT adoption will swing back to the enterprise market following a decade of consumer-led technological change.

From the 1950s until about ten years ago, new technologies and advanced versions of technologies were usually adopted by the enterprise first: the mass-market consumers would then take years or even decades to catch up. Early mainframe computers were only useful or affordable for large companies; they cost $750,000 in 1951 ($7 million in 2014 dollars) and had to be lifted into the building with a crane.[160] Touch-tone phones were in offices long before the average home.[161] Electronic calculators in 1972 were business tools, costing several hundred dollars (thousands of dollars in today's money), so too expensive for the home as for students.[162] Early PCs, aside from tech hobbyists and the curious wealthy, were purchased overwhelmingly by enterprises. Who needed to do word processing or use VisiCalc at home? Early cellular phones cost thousands of dollars – the price of a compact car, or a quarter of the average salary at that time – when they went on sale in 1984. Users would pay $50 a month just to be able to use the service.[163]

When PC manufacturers launched new models, boasting bigger hard drives, more RAM and faster CPUs, they were marketed and branded as 'Pro', 'Office 'or 'Enterprise'. Meanwhile, the lagging edge of technology was marketed as 'Home'. While consumers were buying their first bulky cell phones, businesspeople were lining up for sleek flip-phones, and later for early smartphones incorporating full-sized keyboards and 'giant' 2.0 inch monochrome screens.

But in the last ten years there have been several examples where the exact opposite has been true, and the consumer has led the way.

Large touch-screen smartphones were adopted first by consumers. Enterprises were not only slow in taking to these now-ubiquitous devices; in many cases they tried to ban or restrict their use for work purposes. It was much the same with tablet computers. In the early days, enterprises tried restricting their use, and although they are now common in the work place, this only came about after millions of units had already been bought by consumers.

It isn't just technology that has experienced this trend towards consumerization; it affected telecommunications too. Accessing work functions and email on a smartphone works relatively well at 3G wireless speeds; but consumers wanted to watch high definition video or play games, and wanted the advances provided by 4G LTE networks. Most businesses are only upgrading their wireline ISP provisioning gradually, while it is consumers watching tens of hours of high bitrate over-the-top (OTT) video who are looking into getting fiber-to-the-home services.

There have been a number of other technologies that reflect the consumerization trend. Voice-over IP telephony is common in many large enterprises today, but was largely a consumer-driven product initially. Desktop video conferencing was also consumer-led. Many enterprise laptops had their cameras disabled by the IT department. Storing your emails on a web service was a popular consumer service, while enterprises continued to own dedicated email servers.

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Not surprisingly, observers tend to extrapolate trends based on what has happened in the last couple of years: it's called the 'recency bias'.[164] Since the most recent examples of technological adoption have been 'consumer first; enterprise after' (also known as the consumerization of IT)[165] it is not surprising that many believe this will become the dominant model of technology and telecommunications adoption from now on.

There is strong evidence that the pendulum is swinging back to enterprise-first adoption, or at least a world where the consumer doesn't always lead the way.

Predictions 2014 discussed the wearables market: smart headsets and smart watches such as Google Glass and Samsung Gear, and hundreds of other models from various manufacturers. The media hype in January of that year suggested these would be an enormous consumer success,[166] and our prediction was the same: "Usage of smart glasses in 2014 is likely to focus on consumer applications, with enterprise usage becoming more prevalent later as the product specification improves."[167] Consumer acceptance of these devices has been much lower than the four million units we predicted. Although exact numbers have not been disclosed for many head-mounted devices, the combined total of units sold is almost certainly under 500,000.[168]

However, Deloitte member firms' ongoing client interactions over the course of 2014 suggest that the enterprise market may be a sweet spot for the wearables industry. The security, medical, materials handling and warehousing industries are all eagerly exploring the potential of devices that offer hands-free use, augmented reality display, and easy-to-use video camera capability.

Predictions 2015 features three more examples. 3D printing (also known as Additive Manufacturing), drones (also known as Unmanned Aerial Vehicles or UAVs), and the Internet of Things (IoT, also known as Machine-to-Machine communications) seem to be primarily enterprise driven (for the full stories and supporting endnotes, please read each prediction in this report). The consumer market may possibly dominate in terms of units sold, but will be less important in the near term in terms of usage and value.

3D printing has been around since 1988, but more recent media interest has focused on the idea that these devices will become the 'factory in every home'. With a proliferation of sub-$1,000 machines, the concept of widespread home use looks plausible: if many homes have their own laser printers, why not 3D printers too?

The reality is that the home devices are still hard to use, and make small objects out of plastic only. While there is a growing 'Maker' community, the household penetration is well under 0.007 percent,[169] and the total dollar value of all consumer 3D printers is equivalent to less than four hours of smartphone sales.[170]
The media hype is obscuring the more important fact that enterprises are spending ten times more than consumers on 3D printing machines. They buy them and use them frequently: we estimate that the economic value of goods being produced by enterprises is over 100,000 times higher than output by consumers.
In contrast to plastic-only consumer printers, enterprise 3D printers are operated by experts who are good at design, and produce objects from a range of much more useful materials, including metals; and the machines fit into existing production work flows and processes such as the manufacture of molds, forms, jigs, and dies. The most-heralded new 3D printers from large manufacturers are not aimed at the home market, but the enterprise.

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Drones (UAVs) have been widely used in military applications since 2001, but the last few years have seen UAVs gaining traction in the consumer and enterprise markets. Although the majority of the 300,000 drones expected to sell in 2015 will be purchased by consumers, we predict they will not be used extensively. Those that are priced for the consumer or even prosumer can't carry much, go very far, or fly even in light winds; and they are suitable only for experimentation and limited aerial photography. They are also becoming more heavily regulated, and are often difficult to fly safely.

In contrast heavier and more expensive enterprise drones, guided by trained, licensed, and insured pilots, will be better able to comply with the new regulations. Drones will not become the norm for delivery or many other mass market uses, but will have growing utility in niche enterprise applications such as crop surveying, finding lost livestock or people, distributing lightweight medicine during disaster relief, surveying for resource extraction, inspecting wind farm turbines, and a variety of professional photography and videography uses.

The media is also focusing on the consumer aspects of the Internet of Things (IoT); but many of these are trivial applications, with low ROIs; and while they are technologically possible, they often do not meet real mass-market consumer needs. Consumers don't need a washing machine that sends a message to a smartphone when the cycle is finished: they already have loud buzzers to do that.

However, washing machine companies do want a connected device, which can provide information about real-world usage. And in the future, predictive analytics from a connected machine could warn of an impending break down, and which parts need to be stocked for the service call. Although consumers will also end up benefiting from connected devices, they will not be the ones pushing for the functionality or paying for it. Enterprises will, and consumers will piggyback.

Deloitte isn't predicting that all tech trends in future will be pioneered by the enterprise. But it seems likely that the consumerization model will not be the only game in town, in 2015 and beyond.

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Bottom Line

The 're-enterprization of IT' may be an inelegant term, but it is likely to be a boon for the CIO, who tolerated consumerization, but largely found it posed significant challenges. Consumerization and the associated 'Bring Your Own Device' trend offered some benefits for the enterprise, but attempting to procure, pay for, provision and secure tens or even hundreds of millions of consumer devices has been a nightmare for most corporate IT departments. The sheer diversity of operating systems and form factors has been a challenge, and if enterprise use of wearables, 3D printers, drones or the Internet of Things were being primarily driven by consumers the headaches would only be worse.

As an example, head-mounted wearables aimed primarily at the consumer market would be unlikely to be secure enough from an intellectual property perspective for many enterprises. It is too easy for employees to intentionally or inadvertently record trade secrets or other proprietary information. But a device that was enterprise-oriented from inception can have 'IP integrity by design' built in: the pharmaceutical industry would almost certainly be interested in secure enterprise wearables, and not interested in a consumer version of the technology. Equally, consumer wearables are not usually rugged enough, or safe enough (they can emit sparks) to use on an oil drilling rig; but an enterprise version would have to go through the Mil-Std safety tests, and pose lower risks.

The Internet of Things offers significant promise: but the billions of widely-dispersed sensors and various networking standards also pose a security risk that is potentially even larger than with PCs or mobile phones. If IoT were primarily consumer-led, it seems unlikely that security would have been the most important feature. Enterprise-grade IoT seems more likely to protect corporate networks and data, and is likely to do a better job on privacy too.

New technologies – whether adopted first by consumers or enterprises – do not sit in splendid isolation: they need to fit into an ecosystem. Consumerized devices were designed to be inter-operable with consumer networks, software, connectivity and services. In some cases the technology worked adequately with enterprise software, supply chains and networks. But, as an example, where smartphones and tablets work nearly perfectly in synching music libraries or sharing photos on social networks, they are not nearly so perfect in synching ERP workflows or sharing spreadsheet versions.

Media

Short form video: a future, but not *the* future, of television

Deloitte predicts that in 2015 total time spent watching short-form (under 20 minutes' duration) video online will represent under three percent of all video watched on all screens. Short-form revenues will be about $5 billion: by comparison long-form TV content will generate over $400 billion from advertising and subscription revenues alone.

These ratios may appear surprising, given that short-form is often proclaimed as the future of television. A brief foray on the Internet reveals many articles, with eye-popping numbers to accompany, arguing that short-form is already dominating over long-form, mostly at the expense of traditional TV.[172]

Some stats seem to suggest that short-form could usurp traditional long-form television. One of the most successful TV shows in the US at present, *Big Bang Theory,* attracted an average audience of 17.5 million viewers in its most recent season, with each episode broadcast in a 30-minute slot.[173] In comparison, Korean star PSY holds the title for the most-watched video on YouTube, *Gangnam Style,*[174] which has amassed over two billion views since its release in 2012.[175] PSY's official channel has had almost four billion views.[176]

It is not just professional music videos that can generate billions of hits: the home-made, low-budget clip can do even better. By December 2014 PewDiePie, a UK-based Swede, had amassed seven billion views and 32.5 million subscribers,[177] and was adding a further 350 million views per month.[178]

His videos, mostly voiced-over video game play, typically get a few million views each, and since 2010 he has accumulated billions of views by posting over 2,000 clips.[179] To place that number of clips/episodes in context, the longest-running current TV show is the Simpsons, with a 'mere' 560 episodes and counting.

Opening children's toys on camera can also generate billions of views. DisneyCollectorBR is a non-Disney affiliated 'channel' (a collection of uploaded videos) whose core output is to show new Disney-branded children's toys being taken out of their box and used, accompanied by a voice-over.[180] About fifty new videos are posted a month.

The top 100 YouTube channels generate over ten billion views per month globally.

Yet despite these successes – and there are many more – short-form generates a small percentage of all screen-based viewing time, and an even smaller proportion of revenues. How can short-form's numbers be so big, and at the same time also so small?

The answer lies with metrics: comparisons of short-form and long-form are often based on similar-sounding but unequal metrics. Short-form is measured in views; long-form in viewers (see side bar: Views and viewers). Short – and long-form both have subscribers; but for the former the marginal cost is a click; while for long-form it is a commitment of at least a month, and sometimes several years.

Side bar: Views and viewers

Television viewing is typically quantified by viewers (live or within seven days) and online video by all-time views. There are fundamental differences between these two metrics, which are occasionally overlooked when comparing traditional TV with newer forms of video format.

In mature television markets, over $2 billion is spent globally measuring TV viewing among a representative sample of respondents every year. Whenever anyone in the sample is in front of a TV set, their viewing habits are recorded and aggregated. The approach is typically agreed by all key industry players, and acts as the 'currency' that underpins the $200 billion global TV advertising industry.

With online video, the definition of a view is typically any request made to a server to play a piece of video. There is no agreed measurement of what constitutes a view, and a view could be anything from a millisecond to the entire clip. According to comScore's data, the average length of a 'view' is about four minutes.[181] There do not appear to be any industry-wide or national standards for measuring online video views.

There is no certainty that a video is actually visible on a screen when it is playing; it may well be playing 'under the line', on a part of the page that is not visible on a screen. There is no data on how many people may be watching each view. There is also no way of knowing for sure how each online video is used. Music videos, like music stations on TV, may be used more as a jukebox, playing music in the background, rather than as a conventional video service where viewers predominantly look at a screen.[182] Of the top ten all-time views on YouTube, which together have amassed billions of views, nine are music videos.[183] Up to 40 percent of all online video views may be views of music videos.[184]

While harmonizing different metrics is never entirely straightforward, comparing on a like-for-like basis reveals a distinct consumption pattern.

We estimate that 10 billion hours of aggregate online short-form video per month should be shown on screens, but not necessarily watched, in 2015.[185] This is a spectacular achievement for a format that barely existed a decade ago, but it is equivalent to only 20 hours' worth of global consumption of long-form video (television programs and movies). Deloitte estimates that in an average month over 360 billion hours of long-form video will be watched,[186] principally on television sets, and mostly live.[187] We do not expect this total to vary substantially over the coming years.

Online short-form content should generate about $5 billion of advertising revenue in 2015.[188] This compares to about $210 billion from long-form advertising on television.[189] We expect short-form subscription services to be in experimental phase in 2015 and to generate trivial revenues; turnover for long-form pay-TV subscriptions should be approaching $200 billion.[190]

The production values, monetization, genres, devices and consumption patterns for short-form are likely to differ markedly from long-form.

In 2015 long-form television shows are likely to have budgets of up to several million dollars per hour, and tens of millions of dollars per series.[191] We believe that short-form production budgets are typically in the thousands to tens of thousands of dollars per clip. They can't be much higher: a short-form video that gets a billion views at a $2 CPM may leave a little over a million dollars, after deducting the platform's commission.[192] And fewer than a couple of dozen on-line video stars are likely to generate in excess of a billion views in 2015.[193] For most, a billion views would likely require dozens, and often hundreds, of videos to be created.

The available budget influences the most popular genres on short-form aggregation sites, namely: music; how-to clips (predominantly of make-up and video games); video game play; clips from traditional TV programming (such as individual comedy sketches and sports highlights); unboxing (mostly children's toys being opened); movie trailers; and entertainment news.[194] Original content is mostly low-cost relative to long-form, with recording equipment usually consisting of a single modest camera, no special lighting, and often self-shot. The exceptions to this rule are music or movie trailers and TV excerpts.[195]

These popular genres of short-form video differ entirely from the most-watched types of television program in 2015: drama, soap operas, family entertainment, sport and reality. The reason these types of program may never become major hits on short-form sites is down to budget – premium global TV sports rights alone are expected to be over five times the value ($28 billion) of short-form revenues ($5 billion) in 2015.

The two formats are unlikely to encroach on each other's screens. Short-form is consumed mostly on laptops, smartphones and tablets, and is often watched in short bursts, to fill gaps during the day, when waiting for a friend, or to 'graze' or when distracted. The brief length of a short-form view is a factor in the challenge in monetizing directly the format: a viewer may only tolerate watching a single, brief video ad prior to watching a two-minute clip.

By contrast, television is watched predominantly in the evening, is often 'appointment-to-view' (that is, time is scheduled and set aside to consume those programs) and long-form is primarily watched for several hours per session. In many homes the TV is turned on a regular time, and left on for 3-4 hours every night. Long-form viewers are more tolerant of advertising breaks with multiple ads, if this comes after 15-20 minutes of program.

Many viewers may well also prefer long-form content as it reduces the need to choose. Short-form, by contrast, can require multiple choices to be made every hour.

We expect short-form only rarely to be watched on a television set (under five percent of all short-form viewing). This is partly because the age group with the highest consumption of short-form content is the under-30s, who are more likely to consume video content on a laptop, and also less likely to own a television set. But another reason is because short-form content is usually optimized for smaller screens; low-production values feel edgy on small screens, but may irritate on larger screens.[196]

Online short-form content should generate about $5 billion of advertising revenue in 2015. This compares to about $210 billion from long-form advertising on television.

Bottom line

We do not expect short-form online content to usurp long-form traditional television.[197] It is a future, but not *the* future, of screen-based entertainment; and it is unlikely ever to be the predominant video format, as measured by hours watched or revenues. Short-form's success should be respected, but it needs to put in context. Any claims about short-form usurping traditional long-form content should be analyzed carefully, using comparable metrics (see side bar: Big Bang Theory and Gangnam Style: a comparison).

Short-form should not be considered as a direct competitor to 'traditional' long-form content, but rather as an additional screen-based medium, addressing needs that were previously un-served or which were catered for by other media, such as magazines, guides to playing video games, or cookery books.[198]

Stars are likely to emerge from short-form, but they may well have to diversify to monetize their fame as advertising to increment revenues. For example Zoella, a UK-based video blogger (vlogger), has signed make-up and book deals on the back of her online ubiquity.[199] Zoella's first book holds the UK record for first-week sales, at 78,000. Vloggers looking to increase their revenues should observe product placement regulations carefully; as short-form gets a higher overall profile, it is likely to come under closer scrutiny.[200]

Multi-channel networks, set up to aggregate vloggers, may also need to look to additional revenue streams, such as taking cuts from ancillary deals with brands that are looking to tap into vloggers' reach.

A charge often made of traditional TV advertising is that some of this is ignored or skipped over. Digitally served advertising is often assumed to be more precise. However, is also the case that short-form videos may also be skipped, ignored, muted, or even be played out 'below the line', that is outside of the current field of view.

Regardless of whether the ads on short-form are watched all the way through, the most popular short-form videos are often ads in themselves. A toy being unboxed should promote interest in that toy; someone watching a video of games play is more likely to purchase the game; music videos can stimulate demand for paiddownloads and concert tickets.

Side bar: Big Bang Theory and Gangnam Style: a comparison

At first glance short-form's billions of views make television's mere millions of viewers look meagre. *Big Bang Theory,* averaged 17.5 million viewers in the 2013-2014 season.[201] By comparison, as of end-2014, Korean star PSY's hit *Gangnam Style*[202] had amassed over 2.1 billion views since 2012.[203]

If we convert both viewers (of *Big Bang Theory*) and views (of *Gangnam Style*) to total hours viewed, we estimate US residents have spent, in aggregate, 38 million hours watching *Gangnam Style* since 2012. This is equivalent to the total viewing time for four-and-a-half episodes of *Big Bang Theory* in the US market, or one fifth of a 24-episode series. We have assumed that the average view of *Gangnam Style* is 200 seconds (80 percent of the total time), and that a third of all global views have been in the US.[204]

The ‘generation that won’t spend’ is spending a lot on media content

Deloitte predicts that US and Canadian millennials[205] will spend over $62 billion on media content in 2015. This is greater than the total spend on Internet advertising in the US and Canada,[206] and as such represents a significant contribution to the media sector from the generation of 18-34 year-olds often accused of defaulting to unpaid sources of content.[207] There are 83 million millennials in the US and Canada, and $62 billion of spending on media content equates to $750 each.

These numbers may surprise given other trends and perceptions: haven’t millennials stopped buying CDs, subscribing to newspapers, or paying for cable TV? So how can 18-34 year-olds in these two countries spend an average $750 on media in 2015?

The reality is that millennials are spending less on traditional media than they did in the past, and less than older generations, but they are still spending (see Figure 1).

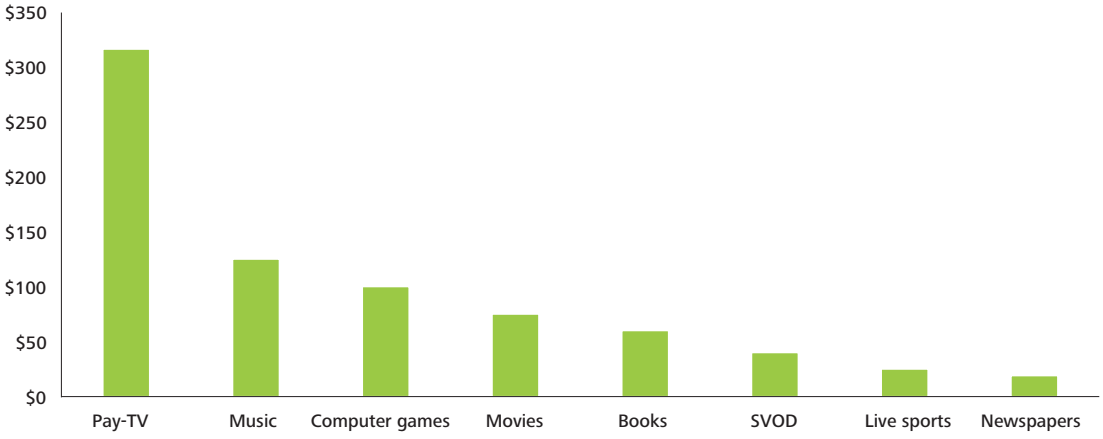
The biggest media expenditure for most households in the US and Canada is pay-TV. This is also true for millennials, almost half of whose annual media spending ($316 of the expected $750 total) is on traditional pay-TV. About 70 percent of 18-34 year-olds live away from the parental home, and 80 percent of those are in a household that will pay for TV in 2015, with each subscription shared by 1.7 people who are 18+, for an estimated $316 spend on TV.[208, 209] About four-fifths of all 18-34 year-olds have access to pay-TV bundles, at an average cost of $80 per month.[210, 211]

Of the remaining 30 percent of Americans 18-34 who live at home,[212] even though their parents may be opting for premium services to keep the kids happy,[213] we assume millennials are not paying or contributing to subscription costs.

Turning to music, while millennials purchase little physical content, music is still a big part of their budget, at $125 in 2015. We estimate that 80 percent will attend a live event, and that most would like to spend more on live music than in prior years.[214] This reflects the long-term trend across all age groups: between 1990 and 2010, spend on music concerts, performing arts and sporting events doubled from a quarter to a half of a percent of total consumer spending.[215] We also estimate average spending on live music among 18-34 year-olds will be about $100, which is more than double the average $48 per capita in the US as of August 2014.[216] Additionally, we forecast that millennials will spend $25 on average on digital music downloads and streaming in 2015. Younger consumers represent a significant proportion of streaming service subscribers; an estimated 40 percent of Spotify’s 50 million monthly active users and 12.5 million[217] premium users are 18-24.[218]

We expect that US and Canadian millennials will spend about $100 on video games in 2015, or $8 billion in total. This age group over-indexes among video gamers: two-thirds of 16-34 year-olds describe themselves as ‘regular’ or ‘avid’ gamers, compared to only a third of non-millennials. We estimate that millennials will account for about a third of the $22 billion spend on computer games in the US in 2015.[219]

Figure 1. Millennials’ $750 spend on media content in 2015



Source: Deloitte, 2014, based on multiple sources

While they are the group most likely to watch movies on different screen sizes, appetite among millennials for the movie theater should remain strong.

Millennial spend on movies should average a little more than $75 in 2015. While they are the group most likely to watch movies on different screen sizes,[220] appetite among millennials for the movie theater should remain strong. We expect the youngest millennials, 18-24 year-olds, while just a tenth of the population, will purchase about a fifth of all movie admissions in the US and Canada in 2015, equivalent to eight movies.[221] We estimate that on average, the overall millennial population of 18-34 year-olds will watch 6.5 films per year, and pay an above-average ticket price of $12: they will attend on busy Friday and Saturday nights[222] and pay more than the average ticket price of $8 in the US which is lowered by the reduced rates for children, seniors, and students.[223]

Spending on books is likely to be about $60 of the $750 total. The typical millennial reads books, both print and digital, with a median consumption of five per year in the US. We assume that 18-34 year-olds will pay $12 per book on average,[224] with textbooks often costing tens of dollars.

Streaming video on demand services (SVOD) will likely add another $40 in 2015. In both the US and Canada, SVOD services such as Netflix are used by 43 and 35 percent of 18-34 year-olds respectively.[225] At $9-$10 per month per service, or over $110 per year, this suggests an average expenditure of at least $40.

As for live sports, we estimate millennials will spend an average $25. North American live sports gate revenues are estimated at $17.8 billion in 2014[226] or nearly $50 per capita. Although millennials may be less devoted fans of major league sports than older generations, the difference is minimal: 93 percent of all North Americans watch TV sports, compared to 86 percent of 18-34 year-olds.[227]

A sixth of US millennials, or over 12 million, is likely to subscribe to a print newspaper in 2015, paying about $120 per year, which means the average millennial will spend nearly $20. American 18-34 year-olds are half as likely as the national average to subscribe to a print newspaper,[228] but spending has declined rather than ceased. Assuming a $10 monthly average spend per newspaper consumer, for ad hoc purchases as well as subscriptions (and not even counting digital subscriptions)[229] that would be $120 per year for those younger readers, and $1.4 billion in annual revenues for the US newspaper industry, or about ten percent of all circulation revenues.[230]

Cumulative media spend of $62 billion for this age group in the US and Canada is a significant amount, but this is less than five percent of their total expected spending of $1.45 trillion.[231] It may seem that 18-34 year-olds are allocating less of their spending power to content than people of similar ages did in the past. However spending less on content is surprisingly expensive: consuming news, video and music for free requires expensive hardware and high-speed wired and wireless Internet access. The typical millennial owns one or more new smartphones and has a big monthly data plan. Streaming video over a wireline connection requires a fast service (at least 5 Mbit/s to stream high definition video)[232] with either a big cap or unlimited consumption. Millennials who replace their PC and tablet every four years and their games console every five would spend about $3,000 per year on technology hardware and connectivity.

The $750 annual content spend by millennials in the US and Canada is all well and good. But how is that figure likely to compare with other parts of the developed world, specifically Western Europe and Japan?

We expect pay-TV to be the largest segment of spend, as in the US and Canada, at about $100 annually. Spend however is highly variable. Japan is the third-largest pay-TV market in the world, but at $8 billion in 2013,[233] it is less than a tenth of spend in US and Canada of almost $90 billion.[234] Pay-TV spend in the UK is higher than the rest of Europe, but penetration at 57 percent and spend per month about $60 are both lower than in the US and Canada.

Our estimate is that the other major components of spending may be lower than in the US and Canada, by a similar proportion. 18-34 year olds in other countries go to concerts, listen to music, attend sporting events, go to movies, and even read books. The rates vary, and the price paid can be very different, but we expect that non-TV spending is at least $200-250 in the rest of the developed world compared to over $400 in North America, suggesting that their total spend is on the order of $300-350 annually. Across over 110 million millennials in those countries,[235] that is another $33-38 billion in content spending. Taking all countries in the developed world together, that gives a total of $100 billion.

Bottom line

Millennials are expected to generate $750 on average in direct spend on content in the US and Canada. But we should also consider their indirect and ancillary spend.

For example 18-34 year-olds watch over 24 hours of television per week in the US,[236] and 17 hours in Canada.[237] Both figures are lower than the national averages for all viewers 18+; but millennials represent an attractive demographic, and represent billions of dollars of the nearly $75 billion North American TV advertising.[238]

Further, in addition to the $200 in annual spending on movie tickets, live sports events, or concerts, millennials spend on concession snacks, sports jerseys and concert merchandise, all of which add to the profitability of the sector as a whole. The licensed sports apparel industry in the US and Canada was worth $13 billion in 2013,[239] equivalent to 70 percent of gate admission revenues.

Monetizing millennials sometimes requires a content provider to offer new services that may not directly be linked to the original media proposition. As an example, college-age fans of American college football often leave games at half-time, not because of a disappointing sporting event, but because they can't get online or upload photos to social media.[240] As a result, hundreds of college and professional stadia are upgrading connectivity. Equally, movie theaters, concert halls and even outdoor music festivals may want to invest in Internet access to meet the needs of a generation where one in three consider Internet access as important as air, water, food and shelter.[241]

Although we estimate that millennials are paying for TV services and attending live sporting events, the leagues and individual teams have a strong interest in making sure that they continue to do so. The revenues from the media rights for sporting events are rising quickly, as we wrote in Predictions 2014.[242] The 18-34 year olds of today who attend sporting events are more likely to be the part of the sports TV audience of the future, supporting the prices of those video rights. There need to be ongoing efforts by leagues and franchises to make sure that sufficient affordable seats are available for younger audiences, in order to create devoted fans in the future. 70 percent of Americans 13-29 year olds say that the biggest deterrent to them attending more games are ticket prices.[243]

Devices are the new status symbol, and these don't work unless they are connected to a fast network. Therefore 18-34 year-olds are likely to continue to spend heavily on tech hardware and telecom services at high levels. That may come at the expense of media and content spending. 18-34 year-olds will still spend on content, but they may be choosier and more-price sensitive than young audiences in the past.

Oddly enough, the fact that millennials who won't spend on traditional media are willing to spend on other kinds of content is not bad news for the traditional media industry. If they weren't willing to spend at all, then there would be no hope. But the experience of the book, computer gaming, OTT providers, cinema and music industries establishes that millennials will open their wallets for certain types of media.

Print is alive and well – at least for books

Deloitte predicts that in 2015 print will represent more than 80 percent of all book sales in dollars worldwide.[244] In the US, the world's largest book market, the figure is lower at just under 80 percent,[245] but the percentage of print is higher in other developed world countries, and even more so in the developing world.[246]

A decade on from the launch of the eReader,[247] print will dominate book sales even in markets with high digital device penetration. Over 30 percent of Americans own an eReader, over 40 percent have tablets,[248] and ownership of smartphones is likely more than 60 percent by the start of 2015. As can be seen in Figure 2, eReaders are not as popular in other countries, and there are some differences when we look at device ownership by millennials (generally defined as 18-34 year olds, although there are other definitions).

Print is likely to generate the majority of books sales for the foreseeable future: eBook sales volumes have hit a plateau, or seen decelerating growth, in major markets including the US, UK and Canada.[249] This has occurred only over the last year, but as of early December 2014, US print book sales were up two percent year over year.[250] The longer-term trend has not been as good. Although eBooks do not make up the majority of the book market, they have taken significant share: in the period 2008-2013 total US book sales were up eight percent to $15 billion and eBook sales were $3 billion. If eBooks are removed from the total, book sales would be down eight percent over that time frame.[251]

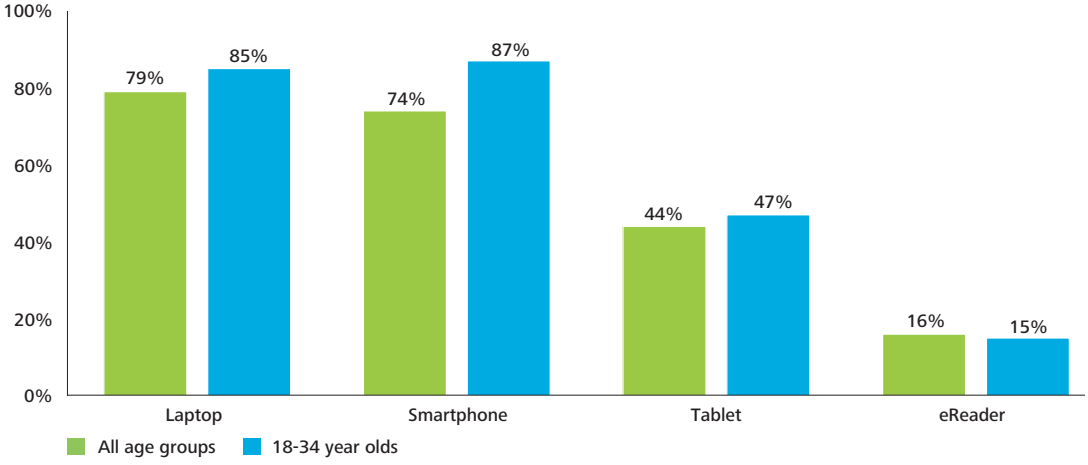
In some print markets, such as newspapers, most of the demand is being driven by older consumers who grew up in a print-only world. This is not the case for books. The aversion of millennials to physical CDs, DVDs, print newspapers or magazines does not extend to print books.

Younger readers are still reading, and in print:[252] 92 percent of 18-29 year-old book readers in the US read in print in 2013, above the average for the population as a whole.[253] Three-quarters of millennials read a print book, but only 37 percent read an eBook. Four-fifths of 18-29 year old Americans have read at least one print book, and their median reading of five titles is the same as for other age groups.

They aren't just reading they are doing so intensely. In a different US survey, a quarter of 16-34 year-olds described books as a 'passion', in line with the average for all ages.[254] Millennials were however more passionate about music (38 percent), equally passionate about movies, but less enthused about video games (16 percent). And just three percent proclaimed themselves passionate about magazines. Not only were younger respondents passionate about books, they were also particularly fond of print copy. Nearly half of 16-34 year-olds agreed that "eBooks will never take the place of real books for me." This was a similar proportion to older readers. Interestingly, 44 percent of 16-24 year-old females strongly preferred 'real' print books, but only a fifth of similarly-aged males felt that way.[255]

Figure 2. Device ownership by millennials and all age groups

Q: Which, if any, of the following, do you own or have ready access to (Laptop, smartphone, tablet, eReader)?



Source: Deloitte Global Mobile Consumer Survey, Developed countries, May – July 2014
Weighted base: All respondents/those aged 18-34: Australia (2,015/659); Finland (1,000/294); France (2,000/595); Germany (2,000/587); Italy (2,000/599); Japan (2,000, 497); Netherlands (2,000/587); Norway (1,000/330); Singapore (2,000/700); South Korea (2,000/670); Spain (2,000/576); Sweden (2,000/614); UK (4,000/1,280).

Why do millennials show a preference for print books? One UK study found that 62 percent of 16-24s prefer buying print books over eBooks[256] because they like to collect, 'like the smell' and 'want full bookshelves'.[257] One recent example of this preference is the mix of physical to digital sales of a book aimed squarely at younger consumers. *Girl Online*, the debut novel of video blogger Zoella with a substantial teen fan base, sold 20 physical copies for every electronic copy.[258]

A key value of print books appears to be their cover. Covers have been shown to drive sales;[259] but they also send a message to those around you about what you are reading and what kind of person you are. As has been noted, "the act of reading a book in public conveys important information to other readers".[260] EBooks don't have covers that are visible to others. A US survey found that 16-34 year olds take more pride in their book collection, are more likely than older generations to buy books that they don't read, and often carry around books even when they aren't reading them. These behaviors don't apply to eBooks, or at least don't apply as strongly.

It may also be the case that physical books are superior when it comes to information retention.[261] Early studies showed little difference in recall between short passages read on a screen and read in print. However for longer passages (even 28 pages, shorter than most books) a more recent study found a significant difference in recall between print and digital.[262] The study consisted of a small sample (only 72 participants), but other research supports this finding.[263] Younger readers read for pleasure or to keep up with current events, but less so than older readers.[264] On the other hand, they are much more likely than older readers to read for work or school, or to research topics of interest. They need to remember what they read: they may be tested on it, or it may help them in their jobs. A preference for print makes sense for them.

As for even younger readers, one US study suggests that 13-17 year olds are even less likely than older age groups to read eBooks rather than print.[265] For even younger readers, over 95 percent of children's picture book sales are in print format, not digital, and that number has been flat for years.[266] This matters, as kids who watch traditional TV or read printed newspapers are more likely than those not exposed to these media to watch traditional TV and read physical newspapers as adults. Toddlers who read printed picture books are more likely to progress to printed easy-reader first books, and then on to physical copies of teen novels.

The future of book retailing is complicated. At the beginning of 2013, the number of high street bookshops in the UK had fallen by more than half in seven years.[267] If eBooks were dominating print, that trend would have continued or accelerated, but that does not appear to have happened: closures of independent bookstores in the US have gone into reverse, with over ten percent growth between 2009 and 2013.[268] But a continued preference for print does not appear to be a panacea for physical bookstores: in the UK nearly 40 percent of all books (print and eBooks combined) were bought from online-only retailers in 2012.[269]

Bottom Line

The essence of this prediction is that eBooks are not replacing print in a big way, unlike other digital form factors; but though they aren't taking over, they are still a large and growing market. It might be expected that smartphones are too small for reading long-form content like books, but some data suggests that the number of books being read on smartphones is higher than on tablets (largely due to much higher ownership of smartphones),[270] and phones are getting bigger with the rise of phablets.[271] Measuring book consumption is difficult: while purchase data is available, many books are gifts,[272] and the technologies that measure TV viewing or Internet usage don't work for print books. Further, most book sales data does not measure self-published books, which tend to be digital rather than print. However, survey data shows that younger readers are still reading, and still reading in print.

Bricks-and-mortar booksellers should not consider the resilience of print to be matched exactly by a similar strength in bookstore sales. Online sales of physical books are likely to remain strong. However physical retailers should extol the value of buying print in person. You can browse far more easily, you can appreciate the font, and you can feel the paper. And you can walk out reading the book, rather than having to wait a few days for the book to be delivered.

With 40 percent of US primary and secondary students using a tablet for at least some of their classes,[273] more research is likely to be needed on the difference between print and screen. If there are differences, they are most likely to relate to content that needs to be retained for years or even decades. The same is likely to apply to tertiary education and the training markets. Other print medium publishers, like newspapers and magazines, might learn lessons from books: how can they duplicate some of the attributes that cause millennials to persist with print?

A preference for print books is likely to have little effect on the trend towards the paperless office. Globally, demand for uncoated free sheet paper (used in printers and photocopiers) is rising, but that is largely driven by the developing world: in North America and Europe demand is declining annually at a rate of 2.6 percent and 3.4 percent respectively.[274] Individual enterprises are shrinking their office printing even faster: between 2011 and 2014 Deloitte Canada reduced the number of pages printed by 22 percent, despite increasing headcount.[275] Most enterprise printing is material meant for only short-term recall, rather than longer-term deep learning.

Telecommunications

One billion smartphone upgrades

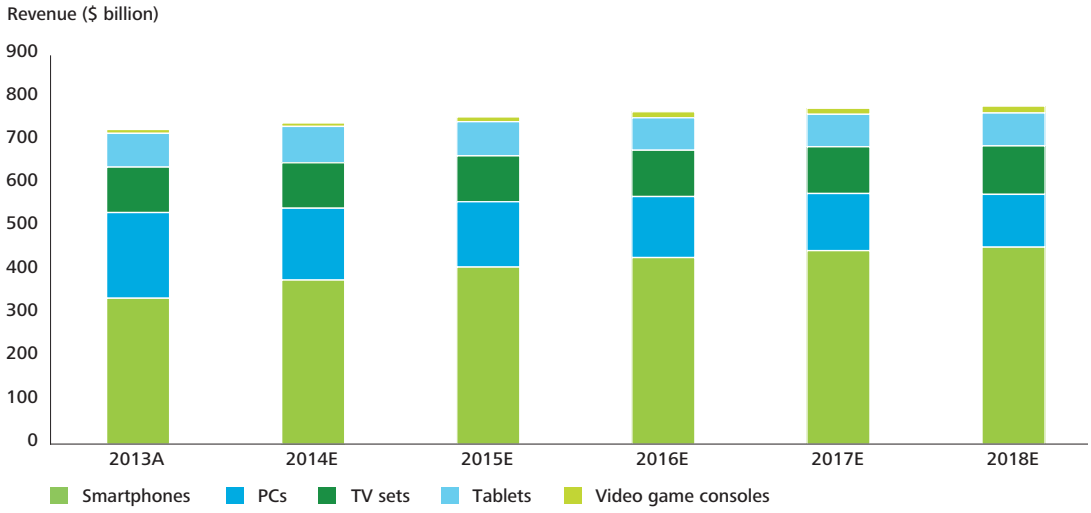
One billion smartphones will be purchased as upgrades for the first time in 2015, generating over $300 billion in sales.

Deloitte predicts that one billion smartphones will be purchased as upgrades for the first time in 2015, generating over $300 billion in sales.[276] We expect smartphone upgrade volumes to continue increasing through 2018, and possibly beyond.

The quantity of smartphones bought as upgrades is unparalleled among consumer electronics devices. In 2015 smartphone sales will be greater in units and revenues than the PC, television, tablet and games console sectors combined (see Figures 3 and 4).[277] The smartphone's share of units and revenue should continue growing through 2018.

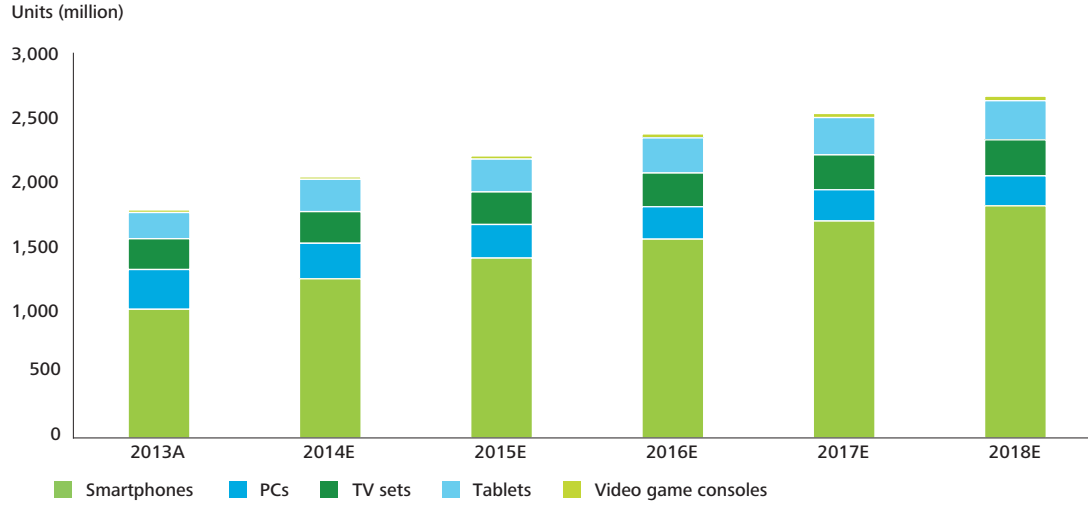
The smartphone's predominance is driven mainly by upgrades. The smartphone base is forecast to increase from 1.8 billion in 2014 to 2.2 billion this year.[278] We expect smartphone sales of about 1.4 billion smartphones in 2015, which implies that just over a billion (about three-quarters) will be upgrades. According to Deloitte's research, undertaken in May-June 2014, about seven in ten smartphone owners in 14 developed markets had upgraded their phone in the previous 18 months.[279] This is more frequent than for any other consumer electronics device, which may surprise in view of the fact that in 2015 most smartphone owners are likely to spend more time looking at TV screens, and information workers and students may spend more time looking at PC screens.[280]

Figure 3. Combined global sales revenue of PCs, smartphones, tablets, TVs and video game consoles, 2013-2018



Source: Deloitte, 2014, based on multiple sources

Figure 4. Combined global sales units of PCs, smartphones, tablets, TVs and video game consoles, 2013-2018



Source: Deloitte, 2014, based on various industry sources

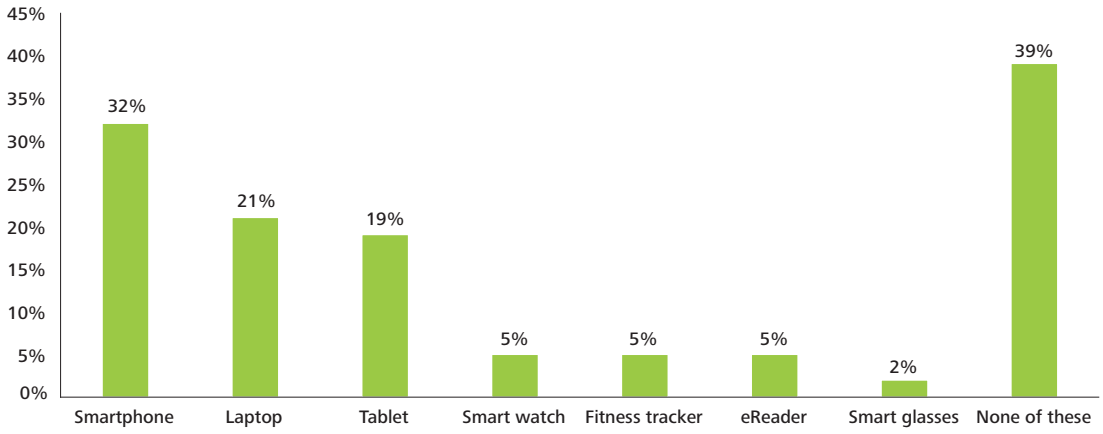
However the smartphone is the most personal of consumer electronics devices: the most constant companion, the most personal of choices, the most customized and reflective of the owners, the least likely to be shared with other users, and the most frequently looked at.[281]

Indeed, our research found that respondents in many countries chose the smartphone as the device they were most likely to purchase in the next 12 months, with a third expecting to buy a smartphone, compared to 21 percent for laptops and 19 percent for tablets (see Figure 5).

The huge production volumes of smartphones manufactured also make this the most competitive market among devices, undergoing the most substantive improvement on a year-by-year basis. Our view is that the device replacement cycle for smartphones is the shortest relative to other devices (see Figure 6).

Figure 5. Device purchase intent in the next 12 months

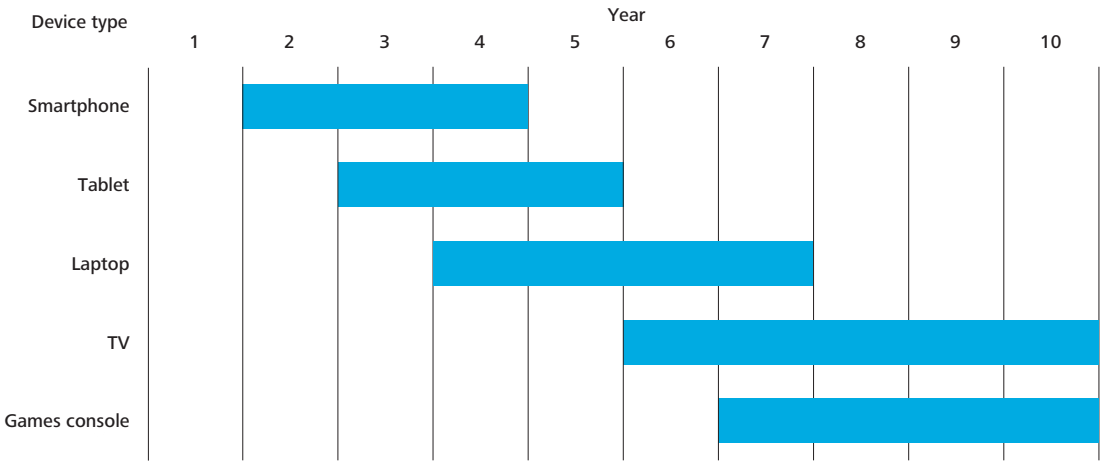
Q: Which, if any, of the following devices are you likely to buy in the next 12 months?



Source: Deloitte Global Mobile Consumer Survey, Developed countries, May - July 2014

Weighted base: All respondents: Australia 2,015; Finland, 1,000; France 2,000; Germany 2,000; Italy 2,000; Japan 2,000; Netherlands 2,000; Norway 1,000; Singapore 2,000; South Korea 2,000; Spain 2,000; Sweden 2,000; UK 4,000; US 2,001

Figure 6. Device replacement cycle, by type of devices (years)



Source: Deloitte, 2014

There is a wide spread of motivations, practical and emotional, which will drive the billion upgrades we anticipate for 2015 and the 1.15 billion for 2016.

Some may question the need for users to swap one small rectangular and expensive slab for another.[282] Arguably there is little perceptible benefit in upgrading from a quad-core to an octa-core device;[283] 3G is good enough and 4G unnecessary; there is little noticeable difference between a 12 MP (megapixel) and 20MP photo, or between a high definition and 4K screen;[284] wide-angle lenses that take better selfies aren't needed; and square corners are not superior to rounded ones (or vice versa).

Assessing the smartphone upgrade market from a purely technical perspective, it might be concluded that most existing owners do not 'need' a new device. But this assessment is too narrow; there is a wide spread of motivations, practical and emotional, which will drive the billion upgrades we anticipate for 2015 and the 1.15 billion for 2016.

In the near term smartphones will offer both an ever-wider range of functionality (such as a fingerprint sensor) and enhancement in existing functions (such as a better camera).

At first glance, fingerprint readers may appear superfluous. They enable us to do things (such as unlock phones, authenticate an in-app payment, gain access to enterprise email, or authorize an in-store contactless purchase) that we can already do with passwords and PINs.[285]

But fingerprint readers make each step faster and slicker: a single touch of a reader is, for some users, more elegant than multiple taps of a touchscreen. This is also where one-upmanship comes in, and envy may drive the decision to upgrade. A fingerprint reader enables people do things slightly differently from others whose phones lack a reader, as well as being superior from a practical perspective.[286]

The camera is a core functionality of smartphones, as well as the feature phones that preceded them. We expect that a common (but rarely ever sole) reason for upgrading a phone will be to take *and* share better photographs, from anywhere in the world.[287]

Every year the photographic capability of smartphones improves. 4G enables faster sharing;[288] better sensors enable improved low-light photos; wider lens apertures let in more light, making possible the shooting of slow-motion video. Faster processors and micro-actuators reduce the blur from camera shake. The latest flashes offer a more natural light, lessening the chance of 'bleached' faces, or washed-out balsamic glaze on the second course of a fancy meal. Filters change the mood.

All these enhancements result in photos more worthy of sharing; and faster connectivity speeds enable and encourage us to distribute them more frequently and in higher resolution.[289] A panoramic photo is about eight megabytes in size, and takes mere seconds to share at 4G speeds. A generation back, holiday snaps could only be inflicted on friends and family post-vacation.

Better cameras may trigger upgrades to get more memory. Although this may seem logical, it is arguably irrational, if we exhaust memory only because we are averse to deleting un-needed snaps. A 64-gigabyte (GB) phone can store over 30,000 high definition photos, few which will be looked at again.

Some of the practical motivations for upgrading may not be picked up by standard, questionnaire-based market research. A common reason for upgrading in 2015 will be to get a larger screen, ostensibly to browse more easily, or watch more video. Few might admit however that the principal benefit of a larger screen is to avoid the need to put on reading glasses.[290]

This year, a common complaint among smartphone users will be that their device 'feels slow'. This will be fact as well as perception: smartphones used frequently for data applications tend to last about four years before becoming too slow to operate.[291] Phone hardware is locked down and generally can't be upgraded; but the software used on the device, including the operating system (OS), is upgraded at least annually. New software, be it an OS or an app, is designed for the majority of phones likely to use it and pay for it. Every year, the newest smartphones incorporate faster processors and more random access memory (RAM); so over time, as software becomes more complex, the processor and memory in a device increasingly struggle to undertake existing and new functions.

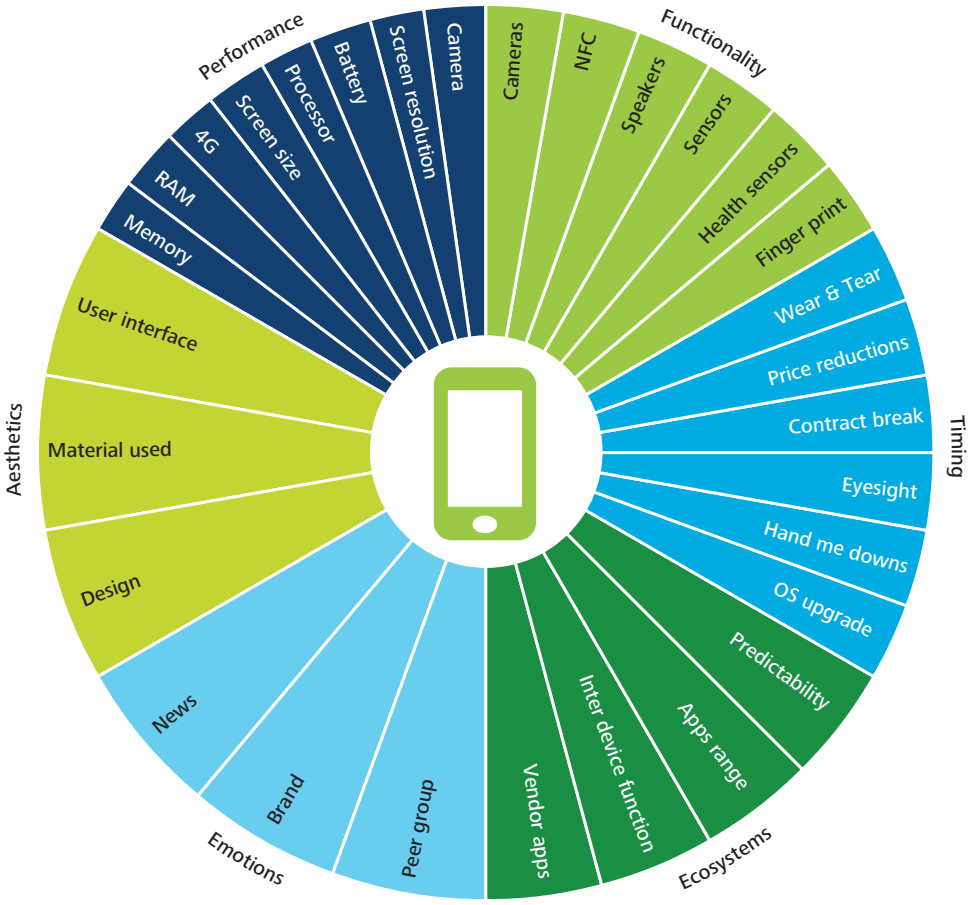
Upgrading a smartphone on the basis of looks may seem superficial, but this decision can also be rationalized. Better-quality materials – whether metals, plastics or even bamboo – are now being used, and these can make devices more durable as well as more eye-catching. New screens tend to be stronger, and also to have better viewing angles, as well as superior visibility in sunlight.[292] Many smartphone models are now dust – and water-resistant.[293]

Peer pressure is likely to be a factor in many decisions to upgrade. It's not just the envy invoked from seeing friends and family with pristine new devices, replete with brand new functionality; it's also the news flow, with some new smartphone launches dominating the tech sections of websites and also national news bulletins.

Added to that is pestering from children, eager for their parents to upgrade so as to get an upgraded hand-me-down smartphone for themselves.

In many cases, the timing of an upgrade will be linked to the expiry of a contract, a price reduction, or a sales promotion. But the decision to actually upgrade a phone, and the choice of which model to upgrade to, will likely have been driven by many of the aforementioned factors, as well as many other impulses, summarized in Figure 7. Vendors and carriers should be aware of them all.

Figure 7. Drivers for phone upgrade



Source: Deloitte, 2014

Bottom line

The smartphone is the most successful consumer device ever: the landmark of a billion upgrades in a single year is testament to this.

Just being in the smartphone industry, however, is no guarantee of success, and the market is becoming increasingly competitive. The challenges for smartphone vendors: retaining loyalty, taking share in a maturing market, maintaining margin, and determining which functionality their customers want at each point in time, are likely to get steadily more acute over time.

In addition to optimizing hardware, vendors will need to increment the range of intangible factors used to enhance their devices' appeal. These range from the availability of technical support, to the ease of transferring data between the old and new devices and from the perceived security of client data to the caliber of the accompanying app store.

Vendors need to ensure that all functionality addresses current needs and anticipates latent ones. Incorporating superfluous functionality, or technology that is hard to use, will diminish profitability.

Offering cameras with ever-higher resolution may offer quality increments that few owners would be able to discern;[294] whereas incorporating better low-light capability may have wider appeal, as the improvement would be more immediately noticeable.

Smartphone vendors should continue to work closely with carriers. In markets with subsidies and two-year contracts, upgrades have both advantages and disadvantages for carriers. They need to fund the upfront device cost, or offer the ability to pay in installments, but the upgrade also gives them a chance to lock in a customer, reduce churn and perhaps even sell them upgraded service levels. In markets with no subsidies, the vendors need to optimize pricing and features in order to appeal to retailers and consumers.

For purchases of the few hundred million smartphones by enterprises, the selection process can be more complex than for consumers. CIOs are unlikely to care too much about the need for a smartphone optimized for sharing holiday snaps; but the HR department may want to offer such devices to attract and retain staff. In some cases, phones that are more resilient and waterproof may be perfect for field workers; and for companies needing additional security, fingerprint readers and NFC chips may be of particular interest.

Smartphone vendors should continue to work closely with carriers. In markets with subsidies and two-year contracts, upgrades have both advantages and disadvantages for carriers.

The connectivity chasms deepen: the growing gap in broadband speeds

We expect the global number of broadband homes to have grown by about two percent to 715 million by the end of 2015.[295] Average broadband speed obtained in most markets should increase by between 15 and 25 percent.[296] This average, however, obscures significant differences between households. In many markets the top decile of homes are likely to enjoy ten times or greater the average speed of those in the bottom decile. Countries with ubiquitous fiber to the premise (FTTP) are likely to have the most consistent broadband speeds.

In short, the term 'broadband' is now a blanket term which describes an ever-widening range of different performance levels, from a few megabits per second (Mbit/s) up to a few hundred Mbit/s. When broadband was first rolled out to homes in the late 1990s, services started at about 512 Kbit/s.[297]

We also anticipate a further variability in broadband speed, dependent on each home's circumstances. A diverse set of factors, from thickness of walls to age of router, from time of day to browsing habits of household members and neighbors determine the actual speeds that are attainable at each broadband-connected device.

The variability in speed attained at the device has major implications for the addressable audience for any online service.

There are two main factors that determine broadband speeds attainable.

One is location: typically, the further a home from an exchange, the lower the speeds. Rural homes are more scattered, and so typically, due to the distance from the exchange, have lower broadband speeds. For example in Germany, as of mid-2013, about 80 percent of urban homes had access to 50 Mbit/s services, but in rural areas, under a fifth had access.[298]

A second issue is technology: there are four main types of broadband technology, each of which offers a different range of speeds:

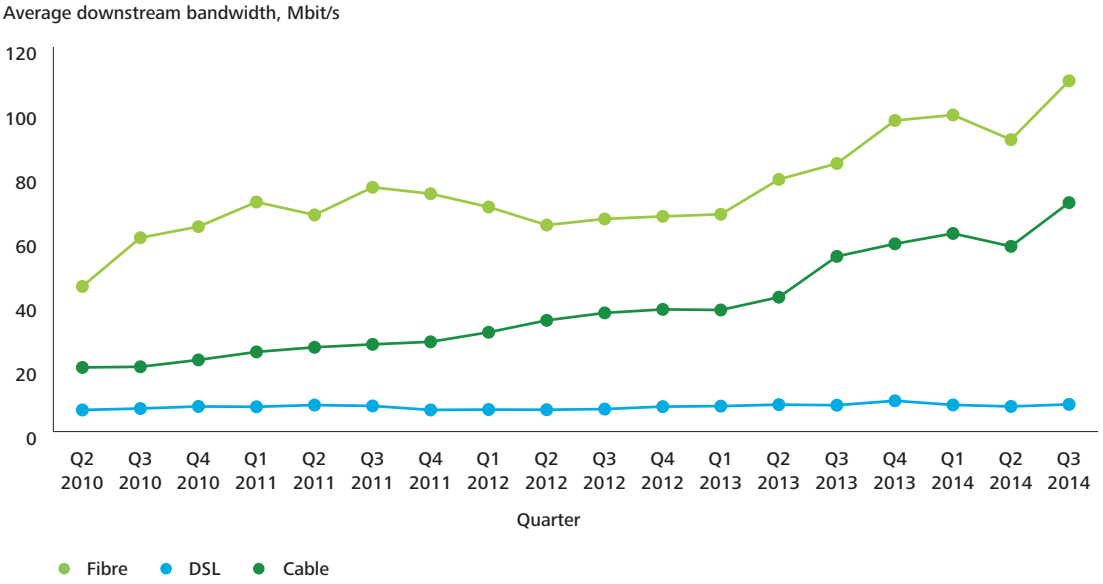
- Standard ADSL – the original broadband technology – offers a maximum speed of 8 Mbit/s. An enhanced version of the technology, known as ADSL+ offers treble that. We forecast 280 million ADSL homes (40 percent of the total) as of the start of 2015.[299] ADSL works over existing copper lines, and requires an upgrade at the telephone exchange.
- FTTC (fiber to the cabinet), the most commonly deployed upgrade to ADSL, is forecast to be in about 175 million homes (a quarter of all broadband homes) as at the start of 2015.[300] FTTC extends a fiber connection to a street-side cabinet; thereafter the connection is via the existing copper wire. FTTC is typically advertised at 30-40 Mbit/s downstream, with 70 Mbit/s and faster services also available for an additional fee. Speed declines by about half within 800-1000 meters from an exchange, by 75 percent within 1.6-1.8 kilometers.[301] By 2020 FTTC will be able to reach 100 Mbit/s, which should be sufficient for the majority of current online services.[302]
- FTTP (fiber to the premise)[303] is forecast at 110 million homes (16 percent of broadband homes) as of Q1 2015.[304] FTTP extends fiber all the way to the home.[305] FTTP speeds are currently up to 1 Gbit/s.
- Cable is in about 135 million homes (19 percent of broadband homes). Cable broadband providers with DOCSIS 3.0 networks market services starting at 50 Mbit/s. Peak speeds offered are in the hundreds of Mbit/s. The technology allows for faster speeds, but few websites today can cope with them. About 80 percent of cable broadband is DOCSIS 3.0; other networks are much slower. DOCSIS 3.0 based cable broadband speeds have increased significantly in recent years: in the UK, they rose from 11.7 to 43.3 Mbit/s between December 2010 and May 2014.[306]

Each technology currently supports a different set of applications. ADSL should always be good enough for general browsing and e-mail, but may be insufficient for streaming to a television set, depending on the distance from the exchange. FTTC should be sufficient to streaming video to a 40 inch TV set during prime-time, but speeds vary by distance from the exchange, as well as by grade of service chosen. DOCSIS 3.0 cable and FTTP can cope with most broadband applications, including simultaneous high definition television streams.

Over time, at a global level, the speed of each of these technologies has increased, with cable and fiber broadband technologies getting faster, but ADSL has remained at approximately the same speed (Figure 8).

Distance and technology are, however, just two of the factors affecting broadband speeds in each home. A further issue is affordability.

Figure 8. Changes in standalone residential bandwidth offered by technology in Mbit/s (Global)



Source: Point Topic, 2014

The variation in speeds by technology may increase in the near-term. For example a planned upgrade to FTTC, known as G.Fast, offers up to 1 Gbit/s speeds over existing copper connections, by increasing the range of frequencies over which broadband signals travel.[307] The drawback with this approach is that it works over very short distances – ideally 100 meters or less. This is an acceptable distance in neighborhoods packing in dozens of homes within 100 meters of a cabinet, but in some rural areas homes may be over 100 meters from the road, and many kilometers from the exchange.

There is also a planned upgrade to the cable broadband technology standard, called DOCSIS 3.1. This is being introduced in response to the faster speeds being offered over FTTC and FTTH networks. The new cable standard offers speeds up to 10 Gbit/s down, and 1 Gbit/s up. These enhancements will again further extend the gulf in broadband speed by household.[308]

Broadband providers could deploy cabinets in close proximity to every home wanting high speeds, but as private businesses in the absence of subsidy, they will inevitably tend to focus on upgrading connections in cities, as they offer the highest potential return.

Another approach could be to deploy fiber to every home, or to extend the reach of cable networks, but both would require significant investment.

FTTC is the most likely technology to be deployed in markets with ubiquitous pre-existing copper networks: it is a fraction of the cost of extending fiber to the premise. However its performance is markedly affected by distance from the exchange, so it may increase speeds for those with existing access to fast broadband, rather than bring slow broadband speeds more in-line with the average.[309]

Distance and technology are, however, just two of the factors affecting broadband speeds in each home. A further issue is affordability. In most markets, broadband pricing varies by technology deployed; the faster the service, the greater the cost. For some homes, paying an extra $20 per month may be immaterial, whereas for homes below median income levels, this additional cost may be unaffordable. The premium payable for faster broadband is a principal reason behind its relatively slow take-up. In the UK, as of March 2014, only 14 percent of homes passed had subscribed to either FTTC or FTTP.[310]

Affordability means that variation in broadband speeds will also exist within the same neighborhood, based on income levels, as well between urban, suburban and rural households.

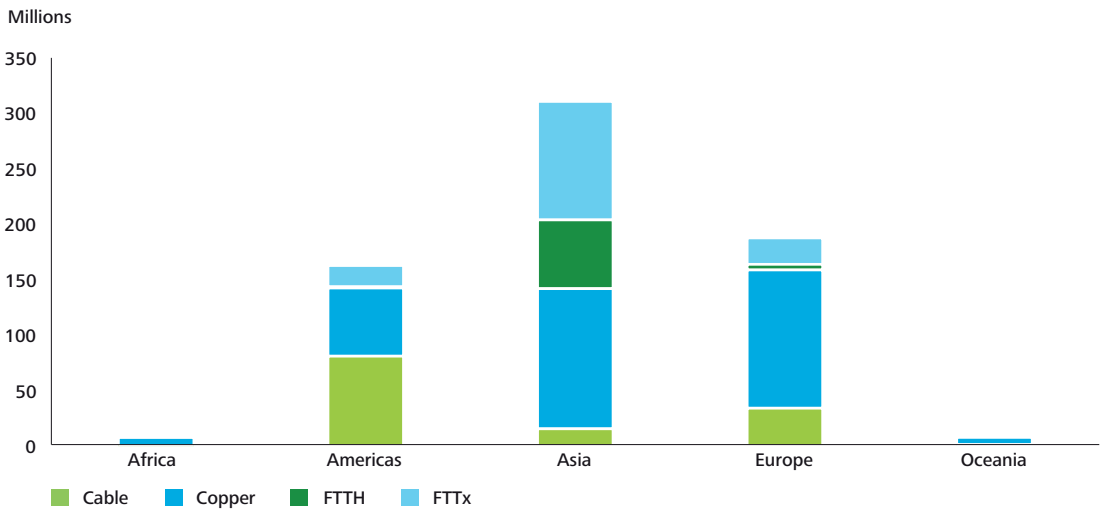
So far we have focused on broadband speeds to the home. Once within the home, there are multiple factors which deplete the actual speed obtained at the device. One is whether wireless or wireline is used. A wireless router is easier to use, requiring little installation. But using Wi-Fi can result in a 50 percent drop in speed. Providing a wired connection is too complex for most households. An intermediate step uses power line adaptors, which run broadband signal along the power supply. This can work if the electrical cabling in the house is sufficiently modern, and the power line adapters used are compatible with the router provided by the ISP. The age of the router affects speed too – the older the router, the slower the throughput. Construction materials used can also determine performance. Older houses with thick walls block wireless signals, as do newly renovated homes with layers of foil-backed plasterboard.[311] Underfloor heating based on coils of hot water pipes also deflects signal, as does anything metallic. The highest speeds within Wi-Fi home are generally closest to the router; but in some cases the device needing the fastest speeds (typically the television) may not be adjacent to the router.

The speed obtained at the device is further affected by other members of the household. Broadband is a shared resource, and a high-speed connection shared among bandwidth-hungry family members may still result in modest speeds at the point of consumption.

The range of speeds obtained is evidenced in many empirical studies. Data from a major content distribution network, found that about half of connections it interfaced with around the world were at 4 Mbit/s or faster, a fifth were at 10 Mbit/s or faster, and just one tenth were at 15 Mbit/s and up.[312]

This prediction has focused on the divergence in broadband speed within specific markets. There are also marked differences in broadband speeds by geographical region which are likely to continue through 2015 and beyond. Figure 9 below shows the number of broadband homes by technology for all global regions.

Figure 9. Broadband homes by region and by technology



Source: Point Topic, 2014

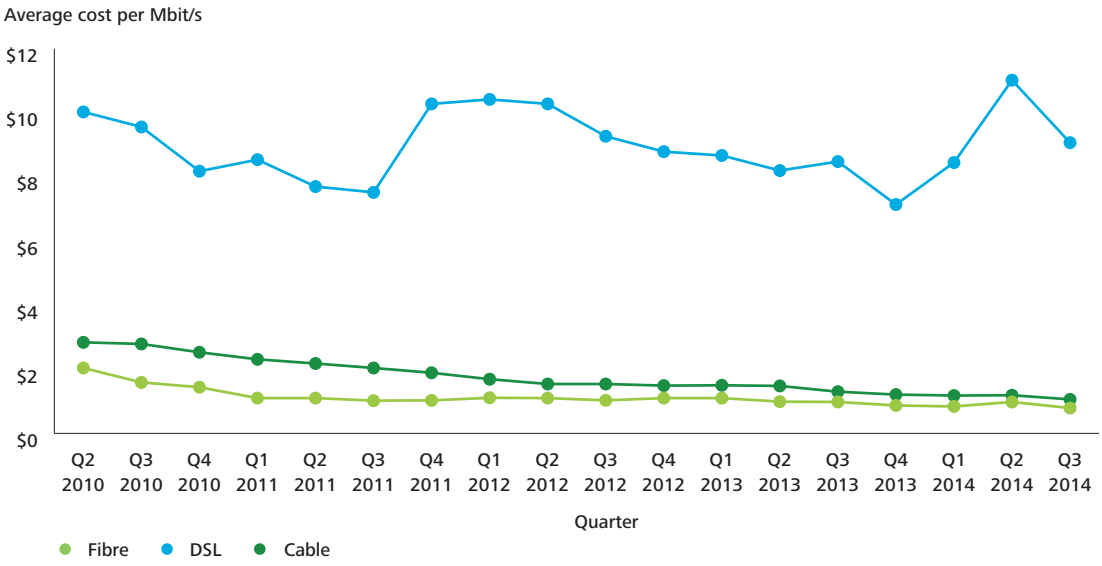
Bottom line

When we talk about broadband divides, this often refers to the gulf between the 'haves' and the 'have nots'. This gap is important, but it is also critical to recognize variations between the 'haves'. The gulf between those with access to the fastest broadband speeds and those on basic speeds has widened over recent years; and in the near term looks likely to increase further.

There are evident implications for regulators. It may not be sufficient simply to call for broadband to be recognized as a universal service, in the same way as fixed line telephony in many countries. The definition of what broadband is needs to be updated regularly. Speed is a key parameter. Historically this has focused on downstream speed, but in future, as broadband usage evolves, upstream speed will become increasingly important as users upload more content.

Regulators should also consider how price per megabit is affected by technology. Households with access only to ADSL broadband, do not just have lower speeds, but are also paying significantly more per Mbit/s (see Figure 10).

Figure 10. Changes in standalone residential average cost per megabit, US dollars, at PPP rates (Global)



Source: Point Topic, 2014

Any private or public entity looking to deliver over-the-top services (OTT), whether this is video-on-demand (VOD) or online tax submissions should consider what ranges of broadband speeds households are able to get.

Video is particularly affected by interruptions to service. Any company, whether a standalone subscription VOD provider, or a broadcaster offering on-line catch up, should monitor closely available speeds. Households that cannot access fast broadband connections but wishing to have on-demand service may need to be offered alternative approaches, such as satellite caching (whereby content is via satellite to a digital video recorder).

Companies offering online shopping ideally want to offer the richest experience possible – but this requires fast broadband connections which are not always available.

This prediction focuses on 2015 and the likely outcomes during this time period. In the long-term there is ample opportunity for more disruptive innovation with broadband delivery, including the use of hot air balloons to deliver high speed connections to rural areas. With this approach, signals are relayed between arrays of balloons before reaching a ground station which is itself connected to the Internet. This approach is expected to deliver 3G type speeds.[313]

Contactless mobile payments (finally) gain momentum

Deloitte predicts that by end-2015, five percent of the base of 600-650 million near-field communication (NFC[314]) equipped phones will be used at least once a month to make contactless in-store payments at retail outlets[315]. This compares with monthly usage by less than 0.5 percent of the 450-500 million NFC-phone owners as of mid-2014[316]. Contactless mobile payment will not be mainstream by end-2015, but niche adoption will be a major progression from near nil in prior years.

Looking further ahead, Deloitte expects the number of NFC-enabled devices being used for making in-store payment should rise steadily over the medium term, as consumers become more familiar with the process, and more banks and merchants in more markets accept this form of transaction[317]. We expect the volume of NFC-smartphone transactions and the range of spend value to increase steadily over time.

While usage of phones to make contactless payments is expected to increase over time, they are likely to co-exist for some time with all other means of payment, from contactless credit cards to cash. It will be a long while before the majority of us can jettison our physical wallets.

The logic of using mobile phones to make in-store payments has long been recognized, and as far back as the late 1990s prototypes of vending machines equipped to take payment via mobile phones and over cellular networks were being exhibited at trade shows. The benefit of using short-range wireless technologies over a distance of a few centimeters to transmit payment information has also long been understood. Speedpass, the first contactless payment device (a key fob for use in gas stations) was launched in 1997[318]. In the same year, the Hong Kong metro system introduced a contactless pre-paid fare collection system.[319]

Indeed, the combination of contactless payment and mobile phones has existed for over a decade. The first phones with any form of contactless technology were launched in 2004 and the first phone with NFC went on sale in 2006.[320] For many years, smartphones have been used to effect financial operations, such as checking balances, transferring funds, and transacting online.

But prior to 2015 the use of phones to make in-store payments using any technology (such as QR codes, or other short-range wireless technologies) has been minimal, with only a small proportion (ten percent or lower) of the smartphone base claiming to have paid in-store via their phone at any time.[321]

Deloitte expects that 2015 will be an inflection point for the usage of mobile phones for NFC-enabled in-store payment, as it will be the first year in which the multiple prerequisites for mainstream adoption – satisfying financial institutions, merchants, consumers, technology vendors and carriers – are sufficiently addressed.

We expect the largest card issuers in the majority of the largest developed countries to have activated NFC-smartphone payments by end-2015, although adoption patterns are likely to vary by region, due to differing economics and technical (e.g. payments processing) models.

For financial institutions (card issuers and banks), NFC in-store phone payments offer continuity and improvement to their business models. They levy a commission on the transaction value, which they may share with a handset vendor or other entity.[322] They underwrite the risk on the payment. Account holders are subject, with one of approaches used, to the same transaction limits as with a physical card and the repayment terms for credit card holders are the same.

The core advantage with any contactless smartphone transactions is the potential for greater security, when payments are made with phones featuring either built-in (via hardware or software) or SIM-based tokenization capability.[323] When someone pays using an NFC-device, the tokenization facility creates a unique code (known as a token) which is sent from the device to the merchant's NFC-enabled till. The credit card number is not transferred which means in the event of a breach, only card information used in traditional transactions would be exposed.[324] The card information is either stored with the issuing networks (such as Visa or MasterCard), or is stored in the cloud (HCE), or in a secure element on the phone. The token is only good for a single transaction and unusable otherwise. A fraudster who intercepted the transaction would only get access to the single-use token but not the card details.[325]

Using a fingerprint, an eye scan or a heart rate sensor as an additional form of authentication makes the payment more secure still.[326] The combination of biometric authentication, an embedded secure element and tokenization may provide more robust security than card swipes or chip and PIN.

We would expect that when offered a choice, about 30 million individuals may opt to pay using their phone instead of a contactless card.

For merchants, NFC-equipped phones can enable fast and, with some systems, high-value transactions.[327] All forms of payment have friction points: cash requires change and credit cards require PINs or signatures; but contactless payment requires only a card or device to be placed on a compatible reader. A fundamental benefit with some contactless smartphone payment systems is that the spending limit can be the same as the account holder's credit or debit card limit.[328] By comparison, contactless cards typically have a payment threshold (typically under US$50)[329] and a transaction limit (the number of contactless payments made) before additional identification is required, so as to mitigate the impact of a stolen contactless card. As one example, the 23.8 million contactless card transactions in the UK in June 2014 had an average value of $11.03.[330] This was about one seventh of the average transaction value of all credit and debit cards in the UK in the same month ($78.52).[331]

Accepting NFC payment requires compatible point-of-sale (POS) terminals, and new POS terminals cost several hundred dollars. As of the start of 2015, there were already millions of NFC-ready payment terminals globally, out of the tens of millions of terminals in use around that world. Over the course of 2015 that base is likely to see a significant increase, particularly in the US where merchants are replacing their terminals to comply with the EMV mandate, these will most likely to be ones supporting NFC.[332]

By end 2015, we expect a minority of merchants to be supporting contactless smartphone payments. These will often be retailers that have already made the investment in replacing POS systems, and will often be stores with a high volume of relatively low-value transactions, such as fast food outlets.

For most of the parties involved in the adoption of NFC mobile payments, the reason to adopt is financial. For consumers it is also behavioral. Using NFC-equipped smartphones to make payments will be adopted only if it can make the payment process simpler, sleeker or provide specific incentive in the form of digital coupons or discounts.

The multiple components that enable NFC-smartphone in-store payments have been falling into place over the last few years. Hundreds of millions of smartphone owners have already submitted their credit card data (one or multiple cards) to a range of vendors so as to be able purchase apps, or download songs, or purchase additional cloud-based storage.[333] Tens of millions of consumers have become acclimatized – over the course of many years – to the idea of contactless payments using their credit and debit cards, and in some markets their contactless transport cards.[334] For most people, using a fingerprint reader is a rare requirement, typically occurring only when passing through border control in some countries. But as of early 2015 it has become an everyday action for approaching 100 million individuals using phones equipped with a fingerprint reader.[335]

So for smartphone users who already have credit card data linked to their phone, have made contactless payments and are accustomed to submitting a fingerprint to unlock their phone or authorize an app purchase, submitting a fingerprint reading to authorize a contactless payment should not feel unfamiliar.[336]

The existence of hundreds of millions of contactless credit and debit cards should not constrain the usage of NFC-enabled smartphones as an additional means of payment. We would expect that when offered a choice, about 30 million individuals may opt to pay using their phone instead of a contactless card.

For some, this will be because they are more likely to be holding their phone than their wallet. A few may decide to pay by smartphone to signal their status as early adopters. With some approaches, a smartphone may offer a higher payment limit than a regular contactless card.

Some NFC-based smartphone payment systems require pre-payment.[337] We would expect these systems to remain popular, and co-exist with approached linked to debit and credit cards. Pre-pay would prevail among the under-banked.

Bottom line

Contactless payment, initially in single-vendor closed-loop systems, has already been available for decades, but it is only in recent years that contactless cards have started to enjoy a surge in adoption. 2015 should see strong growth in contactless mobile and card payments usage, but the rise will be from a small base to a slightly less small base. Customer education and marketing will be essential to increase awareness of the ability to pay using a phone.[338]

While we expect significant growth in usage in 2015 relative to the prior base, many challenges remain before smartphone contactless payments can become mainstream, even in developed countries.

For financial institutions, smartphone contactless payments offer an additional way to transact which also may help maintain the current ecosystem, albeit at a cost in terms of commissions.

Retailers should consider four main benefits: reducing the need to protect customer data, the higher speed of contactless transactions relative to other payment means, the ability to attract consumers with higher disposable incomes, and the opportunity to provide more personalized experiences, for example by integrating loyalty schemes.[339]

Handset vendors can differentiate their devices through the inclusion of components, such as a fingerprint reader, or a tokenization engine, that would enable contactless payments. These functionalities need to be offered as part of a payment ecosystem, and should be easy to use.

Over time, other contactless processes such as premise entry and exit could be incorporated in a handset; and contactless payment is likely to be combined with other processes at the point of transaction, such as collection and redemption of loyalty points.[340]

All players should consider how contactless smartphone payments could be made even more secure. One possible way of doing this would be to use the location data routinely collected by smartphones as a security check.[341] Deviations from a normal purchasing location could trigger a request for further verification, such as PIN entry.

In the medium term the impact of contactless mobile is wide: it provides the opportunity to deliver new customer experiences such as displaying special offers in store to NFC based devices, it may catalyze the removal of point of sales systems for merchants. And NFC may become incorporated into a wider range of devices beyond phones.

Endnotes

1. Deloitte is not including the Information and Entertainment sector in this analysis. We have categorized Smart TVs, game consoles, set top boxes and the like as being part of the Internet of Humans, rather than the Internet of Things. See: Internet of Everything Market Tracker, ABI Research, as accessed on 16 December 2014: https://www.abiresearch.com/market-research/product/1017637-internet-of-everything-market-tracker/
2. Source: Gartner, who estimate device unit sales (excluding Information and Entertainment) for 2014 at 636 million and forecast 2015 sales of 1.015 billion units. See: Gartner Forecast: Internet of Things, Endpoints and Associated Services, Worldwide, spreadsheet download, Gartner, 20 October 2014: http://www.gartner.com/document/2880717 [Registration required]
3. Gartner Forecast: Internet of Things, Endpoints and Associated Services, Worldwide, Gartner, spreadsheet download, 20 October 2014: http://www.gartner.com/document/2880717 [Registration required]
4. We calculate the value of a $10 IoT module within a $40,000 car as worth $10, and not as a $40,000 IoT-enabled device. Deloitte estimates that the average cost of an IoT modules will be about $10, so a billion units are about $10 billion in IoT specific subsystem hardware revenues, although embedded in larger devices worth collectively hundreds of billions of dollars.
5. Gartner has excluded most of the Internet of Humans Information and Entertainment services revenue from their $69.5 billion services forecast: "Video media service revenue and video game ecosystem revenue are excluded from the information and entertainment category, but the revenue from both segments is available in "Forecast Analysis: Consumer Video Media Services, Worldwide, 3Q14, 5 December 2014" (G00269649), and "Forecast: Video Game Ecosystem, Worldwide, 4Q13" (G00246826)." See: Gartner Forecast: Internet of Things, Endpoints and Associated Services, Worldwide, spreadsheet download, Gartner, 20 October 2014: http://www.gartner.com/document/2880717 [Registration required]
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7. Gartner total service revenues for 2015 are $69.5 billion, while consumer services revenues excluding Information and Entertainment will be $5.2 billion, or 7.5 percent. See: Gartner Forecast: Internet of Things, Endpoints and Associated Services, Worldwide, spreadsheet download, 20 October 2014: http://www.gartner.com/document/2880717 [Registration required]
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11. Based on experimental data, five laundry loads were washed and dried. Total time of doing all tasks (not counting the machine time of doing the washing and drying) averaged 180 seconds per load, of which turning the machines on was under five seconds.
12. This obviously varies by appliance power usage and local electricity rates and off-peak discounts. In Ontario Canada, off-peak rates are 7.7 cents per kilowatt hour (kWh), versus 11.4 cents during mid-peak periods. The average dryer load takes about an hour at 3500 watts, or 3.5 kWh; or 27 cents off peak and 40 cents mid-peak. The difference of 13 cents means that even at one dryer load per day, only $47.45 would be saved annually. See: Smart Meters and Time-of-Use Prices, Ontario Ministry of Energy, 30 October 2014: http://www.energy.gov.on.ca/en/smart-meters-and-tou-prices/
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42. For example, see: France probes fresh drone flights over nuclear power plants, Euronews, 1 November 2014: http://www.euronews.com/2014/11/01/france-probes-fresh-drone-flights-over-nuclear-power-plants/. Also see: Attack of the drones: Hollywood celebrities are besieged by paparazzi spies in the sky. Worried? You should be… because they'll soon be a regular fixture over YOUR home. Mail Online, 8 September 2014: http://www.dailymail.co.uk/news/article-2746231/Attack-drones-Hollywood-celebrities-besieged-paparazzi-spies-sky-Worried-You-ll-soon-regular-fixture-YOUR-home.html

43. The majority of reviews of drones read as research for this chapter mentioned crashes during testing. In all the following reviews or other articles, the product reviewers experienced a major crash. See: Review: Using the DJI Phantom 2 Vision+ camera drone with Apple's iPhone, Apple Insider, 3 August 2014: http://appleinsider.com/articles/14/08/03/review-using-the-dji-phantom-2-vision-camera-drone-with-apples-iphone. Also see: I almost killed someone with a drone, The Verge, 13 November 2014: http://www.theverge.com/2014/11/13/7205741/i-almost-killed-someone-with-a-drone. There are also multiple examples of drones crashing, even when controlled by professionals, see: Drone crashes into spectators at Virginia bull run, The Verge, 26 August 2014: http://www.theverge.com/2013/8/26/4659698/drone-crashes-into-spectators-at-virginia-bull-run; A tourist who crashed a drone into Yellowstone has been banned from the park for a year, The Verge, 24 September 2014: http://www.theverge.com/2014/9/24/6838561/drone-pilot-banned-from-yellowstone-after-crash

44. Parrot AR.Drone 2.0 Quadricopter: A Drone Anyone Can Fly, Livescience, 15 February 2014: http://www.livescience.com/43426-parrot-ar-drone-2-0-quadricopter-guide.html

45. Drones can be hard to pilot precisely. For an example of this, see: Drone Quadcopter hits groom in the head // Epic Fail, YouTube, 4 August 2013: http://www.youtube.com/watch?v=ocqB6_y71xE; one drone being used in the Grand Canyon failed while over the canyon, the owners the descended into the canyon to retrieve it, despite the lack of any trails. See: New docs show drone landed on Lincoln head at Mount Rushmore in 2013, ArsTechnica, 27 September 2014: http://arstechnica.com/tech-policy/2014/09/new-docs-show-drone-landed-on-lincoln-head-at-mount-rushmore-in-2013/

46. One drone was stranded on the top of a national monument in the US. See: New docs show drone landed on Lincoln head at Mount Rushmore in 2013, ArsTechnica, 27 September 2014: http://arstechnica.com/tech-policy/2014/09/new-docs-show-drone-landed-on-lincoln-head-at-mount-rushmore-in-2013/

47. In the US, the Director of the National Parks has directed all parks to prohibit drones on grounds of nuisance and safety. See: NPS bans drones over safety, nuisance concerns, EE News, 20 june 2014: http://www.eenews.net/stories/1060001697

48. FAA unveils plan for integrating drones into U.S. airspace, Reuters, 7 November 2013: http://www.reuters.com/article/2013/11/07/us-faa-drones-idUSBRE9A61H220131107

49. This communication is available in a range of languages. See: Access to European Union law, EUR-Lex, as accessed on 8 December 2014: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52014DC0207

50. Behind the mind-boggling shots captured by BBC drones, Wired.co.uk, 12 February, 2014: http://www.wired.co.uk/news/archive/2014-02/12/bbc-drone-journalism

51. Near mid-air collisions with drones, The Washington Post, 26 November 2014: http://www.washingtonpost.com/wp-srv/special/national/faa-drones/

52. One approach to prevent collisions among UAVs is by using radar, but this can be inaccurate. See: Collision-free flying for UAVs in crowded skies, Robotics Business Review, 31 July 2012: http://www.roboticsbusinessreview.com/article/collision_free_flying_for_uavs_in_crowded_skies

53. For example see: Communication from the commission to the European Parliament and the council, European Commission, 8 April 2014: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52014DC0207&from=EN

54. One person in the US was fined $2,200 for flying a drone in New York City: the drone landed twenty feet from a pedestrian having hit two buildings before its unplanned landing. See: Drone operator fined after almost hitting nyc pedestrian, Bloomberg, 3 May 2014: http://www.bloomberg.com/news/2014-05-02/drone-operator-fined-after-almost-hitting-nyc-pedestrian.html. One person in the UK was fine £800 for flying his drone within 50 meters of a bridge and over a nuclear power installation. See: UK's first drone conviction will bankrupt me, says Cumbrian man, The Guardian, 2 April 2014: http://www.theguardian.com/world/2014/apr/02/uk-first-drone-conviction

55. Chinese manufacturer programs Phantom drones with no-fly zones to protect Australian airports, ABC News, 14 April 2014: http://www.abc.net.au/news/2014-04-14/chinese-made-drones-programmed-with-no-fly-zones/5388356

56. DHL launches first commercial drone 'parcelcopter' delivery service, The Guardian, 25 September 2014: http://www.theguardian.com/technology/2014/sep/25/german-dhl-launches-first-commercial-drone-delivery-service

57. The major costs of drones large enough to carry packages are in the parts of which the drones are made of. Motors, propellers, and carbon fiber frames are made in low volumes and require high mechanical precision. Radio control elements, ESC speed controllers, accelerometers, gyroscopes and other components most likely to benefit from the deprecation delivered by Moore's Law are a relatively small part of a UAV's costs and have already benefited from Moore's Law. Large scale manufacturing of parts would enable unit costs to fall significantly (in the region of 30 percent), but this is not likely to happen in 2015.

58. Some consumer drones have been destroyed in flight, for example, see: The future of drones: Getting them shot out of the sky by neighbors with shotguns, Esquire, 2 October 2014: http://www.esquire.com/blogs/news/quadcopticide-100214

59. There are some examples of working battery-swapping stations, however every so often the inspection of a drone health state would still be needed.

60. One approach to addressing the issue of delivery to the recipient is to lower the package using a string. See: Inside Google's Secret Drone-Delivery Program, The Atlantic, 28 August 2014: http://www.theatlantic.com/technology/archive/2014/08/inside-googles-secret-drone-delivery-program/379306/?single_page=true

61. DHL launches first commercial drone 'parcelcopter' delivery service, The Guardian, 25 September 2014: http://www.theguardian.com/technology/2014/sep/25/german-dhl-launches-first-commercial-drone-delivery-service

62. The market was worth $869 million in 2012, and is growing over 12 percent per annum, suggesting revenues in excess of $1 billion in 2014. See: Growth and factor of Aerial Imaging Market 2013 – 2019, LinkedIn, 13 July 2014: https://www.linkedin.com/pulse/article/20140613105811-340063519-growth-and-factor-of-aerial-imaging-market-2013-2019

63. Aerial Filming, Hello Air, as accessed on 8 December 2014: http://www.heloair.com/aerial-tyler_mount.php

64. Also known as Additive Manufacturing, AM, and/or 3DP. For sake of consistency, we will use the term 3D printing throughout.

65. Gartner Says Worldwide Shipments of 3D Printers to Reach More Than 217,000 in 2015, Gartner, 27 October 2014: http://www.gartner.com/newsroom/id/2887417

66. Deloitte estimate: low cost consumer printers will represent much of the 2015 growth, meaning total dollar growth will be lower than unit growth.

67. What Lies Ahead for 3-D Printing?, Smithsonian, May 2013: http://www.smithsonianmag.com/science-nature/what-lies-ahead-for-3-d-printing-37498558/?no-ist

68. 3D Printing: The Next Industrial Revolution, ExplainingTheFuture.com, as accessed on 9 December 2014: http://www.explainingthefuture.com/3dp_book.html

69. Beyond 2014: Evolving Opportunities in Technology. Wells Fargo, February 2014: https://www.wealthmanagementinsights.com/userdocs/pubs/Beyond_2014_Evolving_Opportunities_in_Technology_ADA.pdf

70. Having an object that looks like an automotive connecting rod but is made of light plastic with the strength of a mediocre child's toy is not the same as having an object with the strength to function as a connecting rod.

71. It was estimated to be 87 percent of the market in 2013, according to Stifel research report from October 29, 2014. See Roundup Of 3D Printing Market Forecasts And Estimates, 2014, Forbes, 9 August 2014: http://www.forbes.com/sites/louiscolumbus/2014/08/09/roundup-of-3d-printing-market-forecasts-and-estimates-2014/

72. Also known as End Product Production.

73. 3D Printer Price, MCAD, as accessed on 9 December 2014: http://www.mcad.com/3d-printing/3d-printer-price/

74. Home 3D printers take us on a maddening journey into another dimension, ArsTechnica, 28 August 2013: http://arstechnica.com/gadgets/2013/08/home-3d-printers-take-us-on-a-maddening-journey-into-another-dimension/

75. Gartner Says Worldwide Shipments of 3D Printers to Reach More Than 217,000 in 2015, Gartner, 27 October 2014: http://www.gartner.com/newsroom/id/2887417

76. Either ABS or PLA using Fused Deposition Modelling, or FDM. See: Fused deposition modeling, Wikipedia, as accessed on 9 December 2014: http://en.wikipedia.org/wiki/Fused_deposition_modeling

77. Why 3D Printing Is Overhyped (I Should Know, I Do It For a Living), Gizmodo, 17 May 2013: http://gizmodo.com/why-3d-printing-is-overhyped-i-should-know-i-do-it-fo-508176750

78. This may be decades away or even further: metal printers emit unsafe fumes and run at dangerously high temperatures.

79. 3D Printing: The Hype, Reality and Opportunities — Today, Gartner, 8 October 2013: http://www.gartner.com/it/content/2589000/2589023/october_1_3d_printing.pbasiliere.pdf?userId=13498280

80. Manufacturing or retailing are likely to be higher than average, while it is difficult to imagine what a bank or software company would need a 3D printer for.

81. The Golden Age of 3D Metal Printing: 75.8 % Growth, 3D Printing.com, 22 May 2014: http://3dprinting.com/materials/metal/golden-age-3d-metal-printing-75-8-growth/

82. 3D printing and the new shape of industrial manufacturing, The Manufacturing Institute, June 2014: http://www.themanufacturinginstitute.org/~/media/2D80B8EDCCB648BCB4B53BBAB26BED4B/3D_Printing.pdf

83. Advanced manufacturing is reinventing the way we work, GE, as accessed on 9 December 2014: http://www.ge.com/stories/advanced-manufacturing

84. SpaceX rocket carries the first ever zero-g 3D printer to the Space Station, ExtremeTech, 22 September 2014: http://www.extremetech.com/extreme/190629-spacex-rocket-launches-to-the-space-station-carrying-the-first-ever-zero-g-3d-printer. It is important to note that due to the danger, size and weight of a 3D printer that can make metal parts, the ISS printer is plastic only. In NASA's words: the 3D printer being used in October 2014 is only "the first step towards establishing an on-demand machine shop in space." See: 3D Printing In Zero-G Technology Demonstration (3D Printing In Zero-G), NASA, 25 November 2014: http://www.nasa.gov/mission_pages/station/research/experiments/1115.html; NASA is 3D printing objects in space, Engadget, 25 November 2014: http://www.engadget.com/2014/11/25/nasa-is-3d-printing-in-space/?ncid=rss_truncated

85. 3D Printing: Cutting through the hype, LinkedIn, 21 June 2014: https://www.linkedin.com/pulse/article/20140721200509-22092049-3d-printing-cutting-through-the-hype?trk=prof-post

86. The lead author on this Prediction was a speaker at the Interlog 2013 conference on spare parts in San Diego. In a room of large enterprise users, about 30 had metal 3D printers, none of whom of had yet used the machine (or at least admitted to using the machine) to manufacture one spare part. See: How 3D-printed Spare Parts Could Save Manufacturers from any Production Interruptions, Interlog, as accessed on 9 December 2014: http://interlog.wbresearch.com/interlog-3d-printing-ml [Registration required.]

87. There is an entire fascinating area around watermarking (or otherwise identifying) a specific 3D-printed object. See: Secretly Tag 3-D-Printed Objects With InfraStructs, IEEE Spectrum, 20 August 2013: http://spectrum.ieee.org/video/consumer-electronics/gadgets/secretly-tag-3dprinted-objects-with-infrastructs

88. Ford's 3D-printed auto parts save millions, boost quality, Ford, 12 December 2013: https://media.ford.com/content/fordmedia/fna/us/en/news/2013/12/12/ford_s-3d-printed-auto-parts-save-millions--boost-quality.html

89. 3D Printing Market Analysis By Application (Automotive, Aerospace, Aerospace, Medical), By Raw Material (Polymers, Metals, Ceramic) And Segment Forecasts To 2020, Grand View Research, December 2013: http://www.grandviewresearch.com/industry-analysis/3d-printing-industry-analysis

90. The auto companies themselves only produce about 20-30 percent of parts in any given vehicle. The parts makers of various levels in the supply chain produce the remainder.

91. We are indebted to Dr. Peter Frise for these insights. He is a Professor at the University of Windsor, consultant to many of the leading manufacturers and ODMs, and CEO of AUTO21, Canada's national automotive research program.

92. 3D Printing Revolutionizes the Hearing Aid Business, Forbes, 15 October 2013: http://www.forbes.com/sites/stevebanker/2013/10/15/3d-printing-revolutionizes-the-hearing-aid-business/ It was ten million units as of October 2013, and 15 million seems a reasonable assumption for January 2015.

93. Interview with European company in the 3D medical printing business.

94. This Year Educational 3D Printing Contracts Averaged almost $32,000, 3D Printing Industry, 21 October 2014: http://3dprintingindustry.com/2014/10/21/educational-3d-printing-onvia/

95. 3D Printing: Cutting through the hype, LinkedIn, 21 July 2014: https://www.linkedin.com/pulse/article/20140721200509-22092049-3d-printing-cutting-through-the-hype?trk=prof-post

97. Amazon launched in 1994.

98. As of 2013, the proportion was 45 percent. In some markets the ratio was far higher, for example 60 percent in Germany.
See: The impact of e-commerce on final deliveries: alternative parcel delivery services in France and Germany (Page 2), mobil.TUM, 2014: http://www.mobil-tum.vt.bgu.tum.de/fileadmin/w00bqi/www/Session_4b/Morganti_et_al.pdf

99. There are over one billion parcels delivered in Germany and France alone. In the UK the volume of deliveries and returns is estimated at two billion in 2017.
See: Paketmarkt: Alles hat seinen Preis, DVZ, 24 January 2013: http://www.dvz.de/rubriken/kep/single-view/nachricht/paketmarkt-alles-hat-seinen-preis.html.
See: Observatoire annuel des activités postales en France, ARCEP, 25 October 2012: http://www.arcep.fr/fileadmin/reprise/observatoire/activ-poste/2011/obs-postal-annee-2011-fr.pdf; UK e-commerce home delivery volumes heading for "plateau"?, Post & Parcel, 8 February 2013: http://postandparcel.info/53743/in-depth/uk-e-commerce-home-delivery-volumes-heading-for-plateau/

100. The Annual Cost of Failed Deliveries, The Delivery Magazine,23 May 2013: http://courier-direct.co.uk/news/index.php/the-annual-cost-of-failed-deliveries/

101. For the months of November and December in the UK, there were an anticipated 3.4 million home deliveries per day, and a shortfall of 60,000 drivers.
See: Christmas demand shines light on driver shortage, Financial Times, 5 December 2014: http://www.ft.com/cms/s/0/b99df890-7bc2-11e4-a695-00144feabdc0.html#axzz3LuTWuIBF

102. UK e-commerce home delivery volumes heading for "plateau"?, Post & Parcel, 8 February 2013: http://postandparcel.info/53743/in-depth/uk-e-commerce-home-delivery-volumes-heading-for-plateau/

103. This is likely to become an increasingly fierce battleground. Same-day delivery is being offered in some markets. See: Amazon launches same-day delivery service in the UK, Financial Times, 15 October 2014: http://www.ft.com/cms/s/0/43878128-5433-11e4-84c6-00144feab7de.html

104. Westfield London launches click-and-collect hub with fitting rooms, Retail Week, 27 January, 2014: http://www.retail-week.com/multichannel/westfield-london-launches-click-and-collect-hub-with-fitting-rooms/5056881.article

105. Click-and-collect – UK, Mintel, September 2014

106. Ninety five percent of UK consumers plan to use click and collect this Christmas, PostcodeAnywhere, 29 October 2014: http://www.postcodeanywhere.co.uk/press-centre/news/consumers-choose-click-and-collect

107. Click-and-collect – UK, Mintel, September 2014

108. Analysis: Will click-and-collect be retail's next Christmas battleground?, RetailWeek, 30 September 2014: http://www.retail-week.com/multichannel/analysis-will-click-and-collect-be-retails-next-christmas-battleground/5064683.article [Registration required]

109. Argos extends eBay tie-up to bring click-and-collect service to 650 stores, The Guardian, 3 July 2014: http://www.theguardian.com/business/2014/jul/03/argos-ebay-click-and-collect-service-650-stores

110. Loblaw gears up for online grocery orders, Global News, 25 September 2014: http://globalnews.ca/news/1582574/loblaw-gears-up-for-online-grocery-orders/

111. Retailers Invest in 'Grab and Go' Lockers and Cages in Stores, USA Today, 3 December 2014: http://www.aol.co.uk/video/retailers-invest-in-grab-and-go-lockers-and-cages-in-stores/518543183/

112. Malls launch pick-up depots to lure online shoppers, The Globe and Mail, 10 September 2014: http://www.theglobeandmail.com/report-on-business/shopping-malls-play-catch-up-to-web/article20524681/

113. Tesco expands click-and-collect in Asia, The Telegraph, 26 October 2013: http://www.telegraph.co.uk/finance/newsbysector/retailandconsumer/10406960/Tesco-expands-click-and-collect-in-Asia.html

114. Retail & consumer goods industry news, Retail Analysis, 14 November 2014: http://retailanalysis.igd.com/Hub.aspx?id=23&tid=3&nid=13236

115. For a discussion on the costs of click and collect, see: Analysis: Will click-and-collect be retail's next Christmas battleground?, Retail Analysis, 30 September 2014: http://www.retail-week.com/multichannel/analysis-will-click-and-collect-be-retails-next-christmas-battleground/5064683.article [Registration required]

116. In the UK's most recent Black Friday, online spending was 50 percent higher than anticipated. See: Parcels surge hits Christmas deliveries in UK, Financial Times, 11 December 2014: http://www.ft.com/cms/s/0/e9086648-815c-11e4-b956-00144feabdc0.html?siteedition=uk#axzz3LuTWuIBF

117. Volvo has demonstrated click and collect delivery to a car. With this service, the delivery company would be assigned a single-use digital key to open the trunk of the car. Once the delivery is completed, the key expires. See: Volvo transforms the car into a pick up and drop off zone, Evigo, 24 February 2014: http://evigo.com/11491-volvo-transforms-car-pick-drop-zone/

118. In a Deloitte survey fielded in 14 developed countries in May to July 2014, 'battery life' ranked, on average, as the second most important factor when choosing a next smartphone, following the option 'To be a smartphone'. In Germany, Singapore and Spain, 'battery life' ranked number one.

119. Deloitte estimate, based on over 40 percent of smartphones sold in 2015 having a five inch or larger screen, and of significant numbers of iPhone mobile digital device users moving from a four inch screen to a 4.7 inch or larger screen. iPhone, Apple Pay, Touch ID are trademarks of Apple Inc., registered in the U.S. and other countries. Deloitte TMT Predictions is an independent publication and has not been authorised, sponsored or otherwise approved Apple Inc..

120. Screen area is a single diagonal dimension; batteries occupy volume in three dimensions. Assuming bezel size and device thickness remain constant, a phone with a five inch screen has 20 percent greater screen area than a four-inch device, but its volume is about 50 percent greater, a proportion of which is likely to be allocated to accommodating a larger battery.

121. Not all the improvements are driven by Moore's Law: some are driven by non-Moore's Law effects such as new standards, software, radio technology, antennas.

122. The rechargeable revolution: A better battery, Nature, 5 March 2014: http://www.nature.com/news/the-rechargeable-revolution-a-better-battery-1.14815#/batt2

123. World Vehicle Population Tops 1 Billion Units, Wards Auto, 15 August 2011: http://wardsauto.com/ar/world_vehicle_population_110815

124. Specific energy, Wikipedia, As accessed on 4 December: http://en.wikipedia.org/wiki/Specific_energy

125. All energy storage is normally expressed in watt hours, but since all smartphone batteries work at the same voltage (3.8 volts) most smartphone battery capacity is described in mAh.

126. Energy density, Wikipedia, As accessed on 4 December: http://en.wikipedia.org/wiki/Energy_density

127. The market demand for ever thinner phones is one of the reasons why the user-swappable battery has disappeared on a growing range of phones. User-replaceable batteries require a battery compartment and a door to be incorporated into the housing to accommodate fool-proof replacement without exposing sensitive electronic components to static discharge, dirt, and so on. Batteries have to be encased in a tough plastic housing to mitigate the risk of puncture by careless users which would result in the destruction of phone as a consequence of leaking electrolyte.

128. Power-to-weight ratio, Wikipedia, as accessed on 4 December 2014: http://en.wikipedia.org/wiki/Power-to-weight_ratio

129. Spot lithium carbonate prices are around $7,000 per tonne, or $7 per kilogram, or $0.007 per gram. A 2000 mAh battery weighs 32 grams, and 2-3 grams of lithium, so roughly 2 cents of lithium.

130. This technology places a heavy draw on the battery as the entire screen has to be lit, even if a significant number of pixels may be dark or "OFF"

131. This is an emissive screen, which combines the display and backlight function.

132. Our current view is that OLED may become the default on high-end phones as of 2020.

133. The iPhone 6 and iPhone 6 Plus mobile digital devices share most components, including the same processor and motion co-processor. The larger model has a larger screen and a larger battery, but can support significantly longer Internet use and video playback. See: Apple Inc., as accessed on 4 December 2014: https://www.apple.com/uk/iphone/compare/

134. A 2015 PC would require about 10 megawatts if performance per watt had remained as it was in the 1980s.

135. An SOC might special purpose processors to handle things like graphics and radio communications or these might remain separate devices for design reasons. Some even include rudimentary processors which exclusively handle a single I/O port, ensuring extremely rapid response time to events, well beyond what would be possible from the "main" CPU running the operating system.

136. For a detailed analysis of power efficiency in LTE smartphones, see: An empirical LTE smartphone power model with a view to energy efficiency evolution, Intel Technology Journal, 2014: http://vbn.aau.dk/files/176790997/An_Empirical_LTE_Smartphone_Power_Model_with_a_View_to_Energy_Efficiency_Evolution.pdf

137. This is in line with Moore's Law

138. Second generation (2G) mobile technology, launched in 1991 is capable of up to 64 Kbit/s transmission; fourth generation (4G), launched in 2009, can deliver speeds of up to 75 Mbit/s. This represents about a 50 percent increase in speeds per year

139. A growing range of taxi cabs in major cities are expected to incorporate USB chargers. See: Next-Gen NYC Taxis to Have USB Ports for Phone Charging, Tested, 5 April 2012: http://www.tested.com/tech/43768-next_gen-nyc-taxis-to-have-usb-ports-for-phone-charging/; London's new Metrocab electric taxi could save cabbies £40 a day, Auto Express, 16 January 2014: http://www.autoexpress.co.uk/car-news/85276/londons-new-metrocab-electric-taxi-could-save-cabbies-ps40-a-day. New fleets of trains incorporate USB chargers, see: On board the new Eurostar, the sleekest under-sea train, CNet, 13 November 2014: http://www.cnet.com/uk/pictures/on-board-the-new-eurostar-the-sleekest-under-sea-train-around-pictures/

140. Note also that the charging circuit, which is in the smartphone and not in the charging unit, will typically power the phone off the charger while the battery is being charged and stop charging the battery once it is fully charged. Therefore there is some advantage in terms of battery life to leave the charger plugged in provided the battery is not overheated, which is unlikely to happen with a smartphone. For more information on how to prolong the life of a Li-Ion battery, see: BU-808: How to Prolong Lithium-based Batteries, battery University, as accessed on 4 December 2014: http://batteryuniversity.com/learn/article/how_to_prolong_lithium_based_batteries

141. Miniaturized satellite, Wikipedia, as accessed on 11 December 2014: http://en.wikipedia.org/wiki/Miniaturized_satellite

142. Satellites are classified strictly by weight, rather than size. However, assuming similar densities, the average 10 kilogram satellite will be not much larger than 3-4 10 cm by 10 cm by 10 cm modules, or less than 5 liters in volume. This is before any components may be unfolded or unfurled: there are three meter satellites that have antennas or solar panels that can extend more than ten meters.

143. Nanosats are go!, The Economist, 7 June 2014: http://www.economist.com/news/technology-quarterly/21603240-small-satellites-taking-advantage-smartphones-and-other-consumer-technologies

144. Report cites gains by U.S. industry in commercial market, Space News, 17 June 2013: http://www.spacenews.com/article/satellite-telecom/35827report-cites-gains-by-us-industry-in-commercial-market

145. The various Direct-to-Home satellite TV services are the majority, at $90 billion or almost 80 percent of services. Ibid

146. Terrestrial GPS receivers are the lion's share, at $32 billion or almost 60 percent of ground equipment. Ibid

147. Revenue of the United States fast food restaurant industry from 2002 to 2018 (in billion U.S. dollars)*, Statista, 2014: http://www.statista.com/statistics/196614/revenue-of-the-us-fast-food-restaurant-industry-since-2002/; The tablet sales revenue are estimated at $80 billion for 2015.

148. Nanosats are go!, The Economist, 7 June 2014: http://www.economist.com/news/technology-quarterly/21603240-small-satellites-taking-advantage-smartphones-and-other-consumer-technologies

149. Although some work is being done on electric thrusters for nanosats.

150. That being said, most nanosats are expected to have relatively short design lives anyway: a few years in most cases, not the 10-15 years that larger satellites are designed for. So orbital stabilization won't be the limiting factor in some cases.

151. Low Earth orbit, Wikipedia, as accessed on 11 December 2014: http://en.wikipedia.org/wiki/Low_Earth_orbit

152. Geostationary orbit, Wikipedia, as accessed on 11 December 2014: http://en.wikipedia.org/wiki/Geostationary_orbit

153. Some future satellites are expected to have even higher power requirements. The Alphabus platform will provide 22 kW. See: High-throughput satellite market still expanding, Aviation Week: 30 December 2013: http://aviationweek.com/awin/high-throughput-satellite-market-still-expanding

154. Depending on the orbit, the Sun may not be visible for some hours out of 24.

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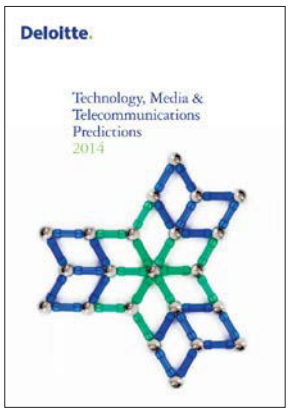

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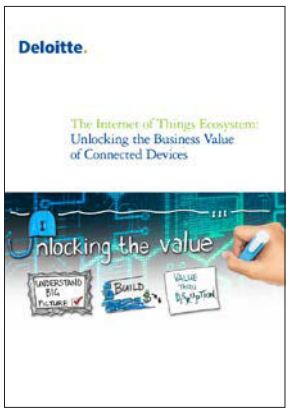

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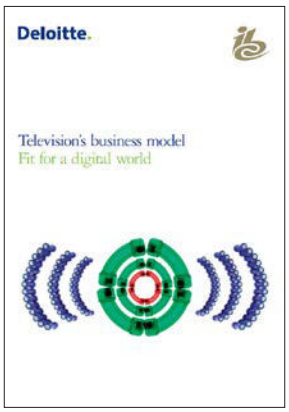

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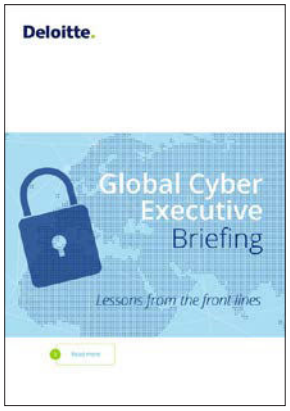
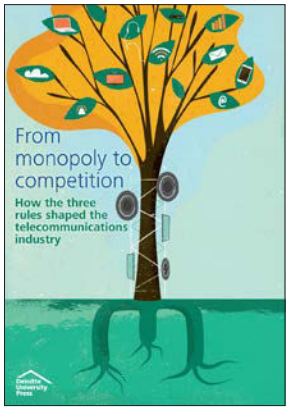


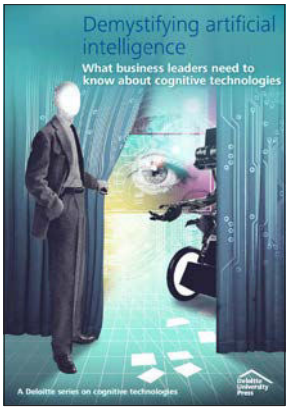
Global Cyber Executive Briefing: Lessons from the front lines

www.deloitte.com/cyberbriefing



From monopoly to competition: How the three rules shaped the telecommunications industry

http://dupress.com/industries/technology-media/



Demystifying artificial intelligence

http://dupress.com/articles/what-is-cognitive-technology/

Other thought leadership

- Tech Trends 2015, The fusion of business and IT: www.deloitte.com/us/techtrends2015
- Global Mobile Consumer Survey, 2014: www.deloitte.com/gmcs

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