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GOV LAB

Smart Cities

How rapid advances in technology are reshaping our economy and society

Version 1.0, November 2015

Preface

Navigating the challenge towards a smart city

The world is facing increasing urbanization while, simultaneously, major cities have become a magnet for talent and a driver of economic growth. At the same time, cities are experiencing persistent societal challenges: unemployment and crime demand solution, the need for energy efficiency is becoming urgent, increasing population puts higher pressure on the urban infrastructure and public authorities need to do more with less permanently.

Technology has been incorporated by cities for many years. However, the pace at which this adoption takes place is increasing rapidly as disruptive digital technologies have the potential to solve major metropolitan challenges. As a consequence, urban areas transform into 'smart cities'. In this transformation, disruptive technology is only one of the drivers. The second ingredient of smart cities is *data*, the lifeblood of smart solutions. The challenge is to use the power of data to create smart solutions that address real needs of city users and are perceived as meaningful by them. Their intuitive design causes them to be adopted naturally, resulting in changes of behavior that are lasting. In the end, smart solutions are all about human behavior. Finally, the third cornerstone of smart cities is smart *people*. Focus on employability and winning the 'war on talent' is vital for sustainable economic growth.

This transformation from a traditional city to a 'smart city' does not just happen. Success depends on the quality of the decisions that are made and the way these decisions are executed. What is needed to be successful? What are the "do's" and "don'ts" and what can be learned from cities that are early adopters? This report provides a joint point of view of Deloitte and the City of Amsterdam on this important theme that will shape the next decade.

Smart cities exist on the intersection of digital technology, disruptive innovation and urban environments. They are an exciting place to work and live and the breeding ground for new ideas.

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This report is intended to be a **living document**. New releases of this report will be issued frequently to reflect advances in technology and new examples of smart solutions. Check www.deloitte.nl/govlab

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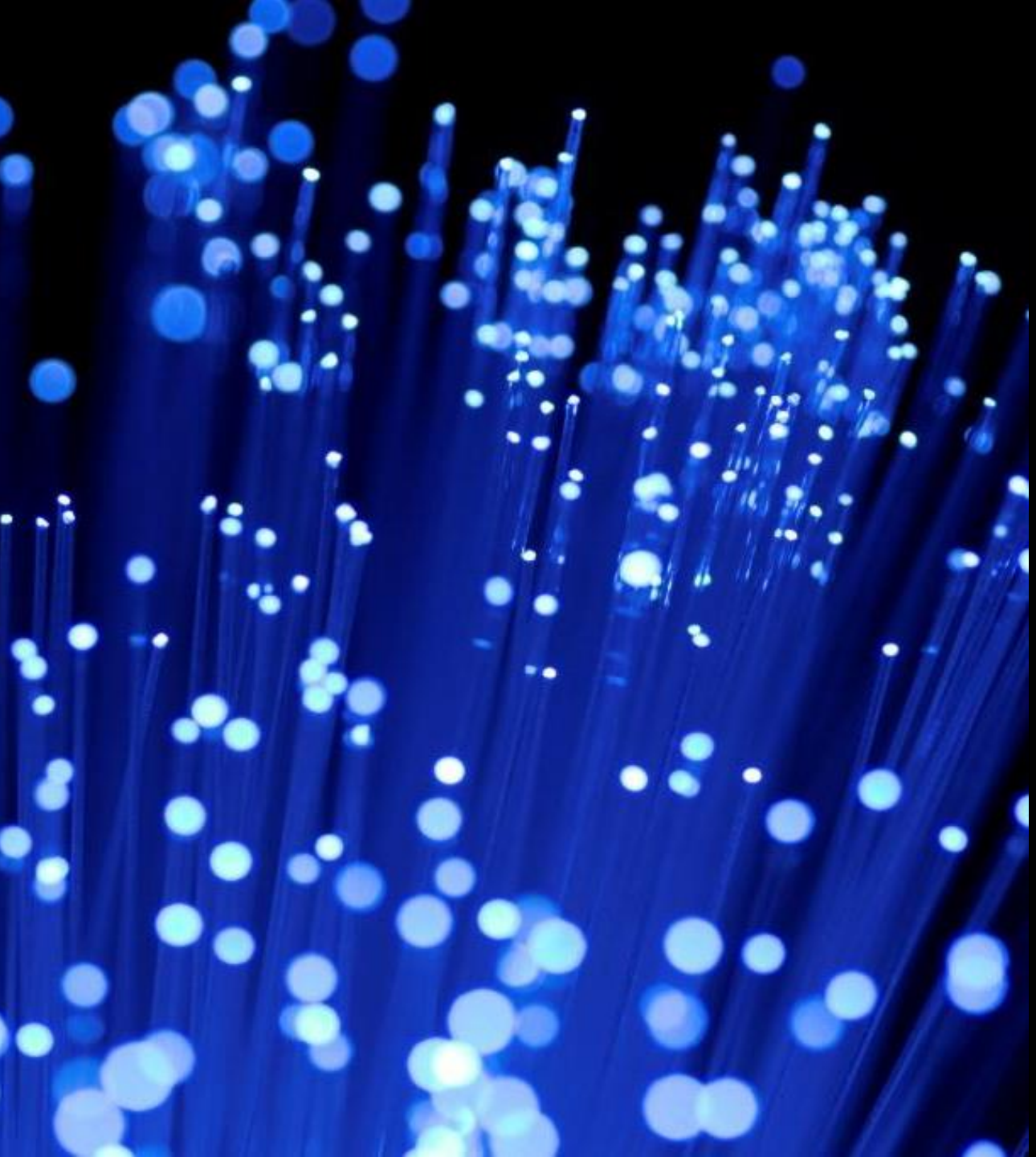
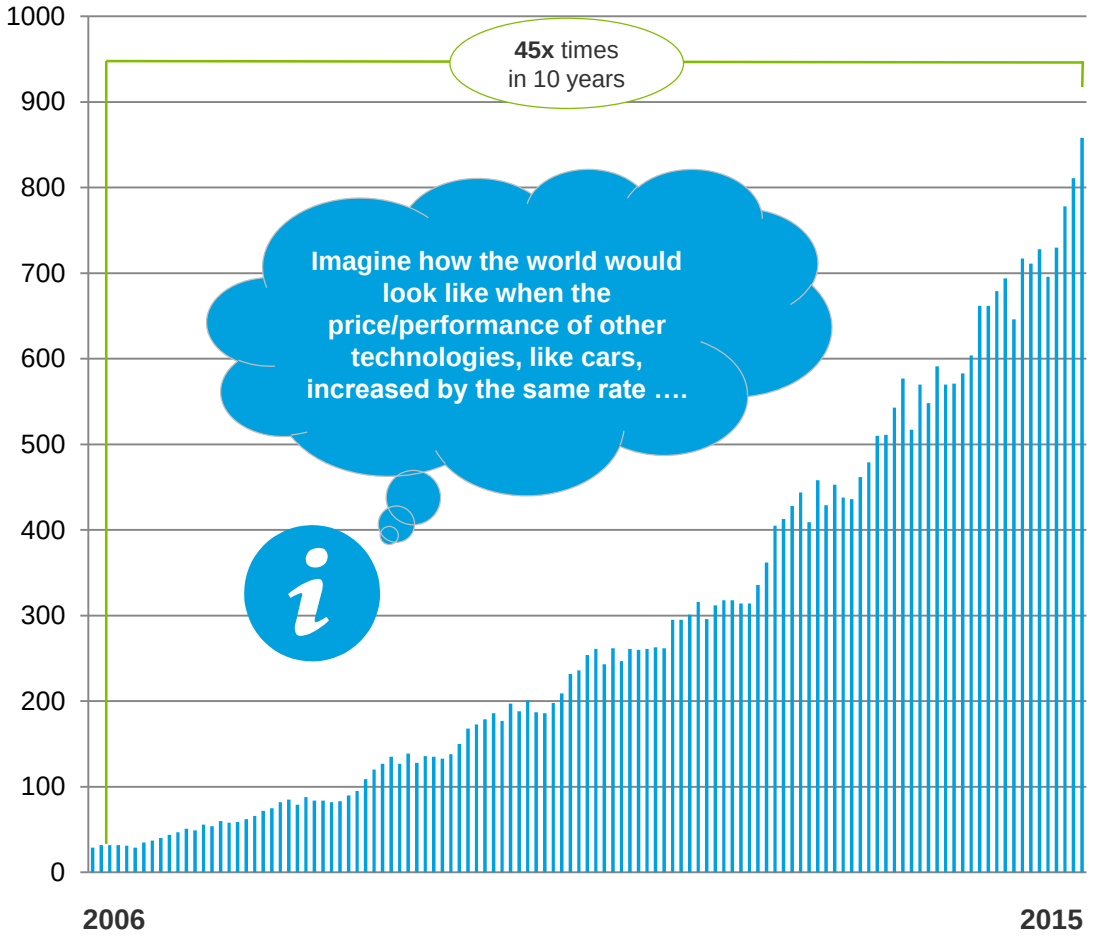


1. The Digital Economy

Continuous advances in technology are driving the digital economy

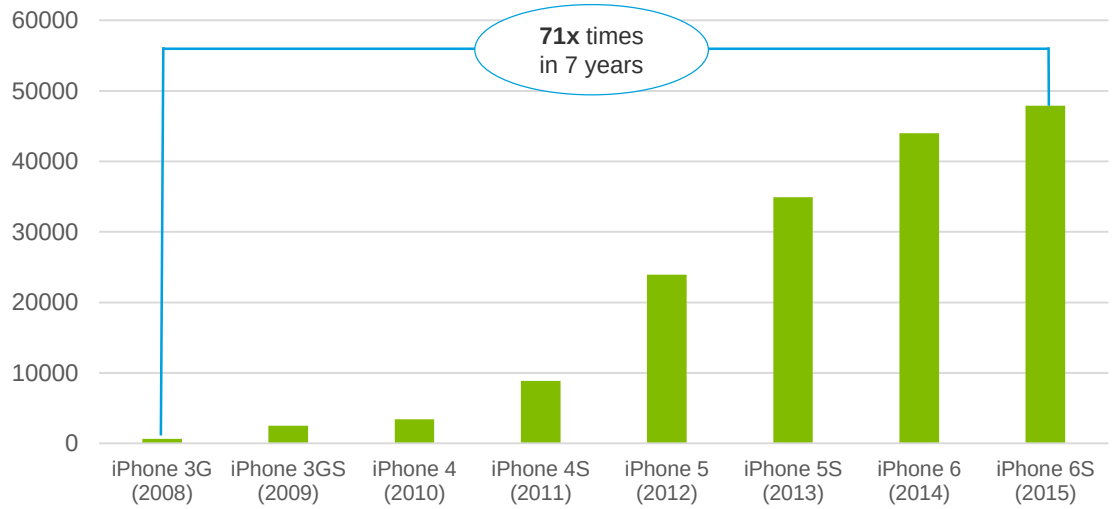
Digital technology shows a spectacular growth in capacity and price/performance, for example in internet bandwidth and traffic, processor speed and storage capacity. This pace of this growth outperforms any other technology.

Monthly volume (in Peta Byte) of AMS-IX Internet Traffic



Source: https://ams-ix.net/technical/statistics/historical-traffic-data

Processor speed benchmark of iPhone generations



Source: iphonebenchmark.net

Gordon Moore's Law: Computing power doubles every two years, and decreases in relative cost. The law fits data from 1970 to 2014.

Jakob Nielsen's Law of Internet Bandwidth: The speed of a high-end user connection grows by 50% per year. The law fits data from 1983 to 2014.

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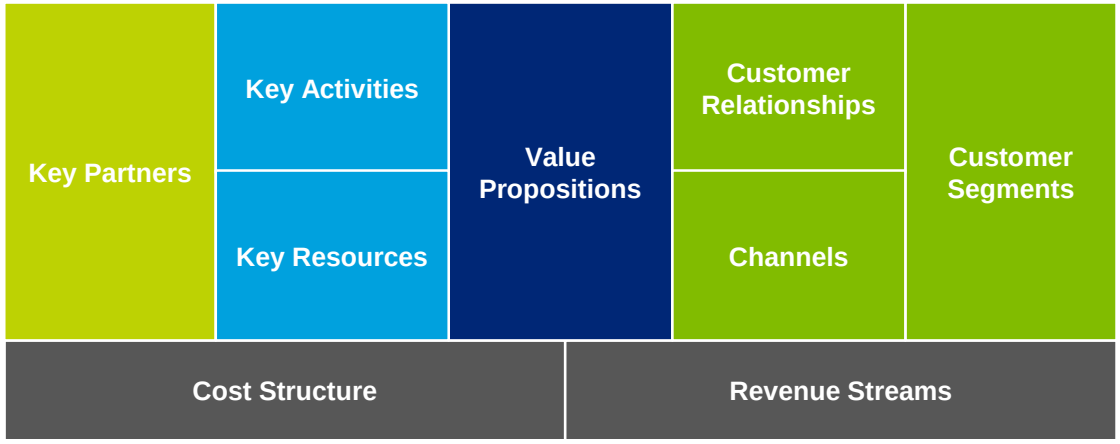
Digital technology is enabling big shifts in the economy (1/6)

Smart cities are not an isolated phenomenon but an integral part of a broader transition towards a digital economy.

Smart Cities: part of the broader Digital Economy

This report contains a point of view on Smart Cities. In order to establish a deep understanding of the concept however, it is important to notice that Smart Cities are not an isolated phenomenon but are part of a broader transition towards a digital economy. Therefore, this first chapter outlines the major shifts that are associated with this digital economy. To structure the big shifts, we have clustered them into five domains (each related to one or more domains in the business model canvass):

- Value Propositions
- Customers, Channels and Relationships
- Activities and Resources
- Partners
- Costs and Revenues



"Digital technologies are doing for human brainpower what the steam engine and related technologies did for human muscle power. They're allowing us to overcome many limitations rapidly and to open up new frontiers with unprecedented speed.

It's a very big deal. But how exactly it will play out is uncertain"

– Andrew McAfee

Source: Harvard Business Review, June 2015

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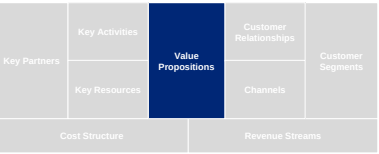
Big Shifts in the Digital Economy (2/6)

Big Shifts related to cluster ‘Value Propositions’



✓ Everything that can be digital, will be digital

Physical products are transforming into digital products in three different ways:

- First, there is a class of products which will be entirely digitized. Music and video are well known examples. In 2014 already, the world wide music industry collected more revenues from digital music than from traditional carriers like CD’s and DVD’s. The shift is not limited to these typical examples. Digital navigation, for example, has replaced physical maps in only a couple of years. Digital currency is replacing the use of cash money at a high pace too.
- A side effect of this trend is the dematerialization of an array of physical devices to an app on the smartphone. Years ago, one needed separate devices for a video camera, photo camera, music player, navigation device, etc. Nowadays, these have become an app on a smartphone at a fraction of the costs of the physical devices.
- Second, a much larger class of products becomes hybrid; part physical and part digital. The Tesla Model S is a good example. These hybrid products make it possible to change the product features by only updating the software in the products. In October 2015, the Tesla Model S received a software update which augmented the functionality of the car with an autopilot.
- Third, products can be augmented with digital apps to provide digital services. For example, a smart scale can be used in conjunction with an app that analyzes the results and gives the user personalized advice on weight control.

✓ Shift to subscription based business models

Closely linked to the trend towards digital products or digital augmented products is the shift to subscription based revenue models. Suppliers of full digital products like Spotify and Netflix are already providing their services in a 100% subscription based model. But also suppliers of products that are not fully digital are looking for business models in which they provide value added services on a subscription basis. This generates new revenue streams in addition to the one-off revenues from the sale of the physical product.

✓ Shorter product life cycles

The impact of rapidly developing digital technology influences both adoption times and product life cycles. On one hand, the pace at which new products are adopted (number of years until x% penetration has been reached) increases. It took almost a century for landline telephones to reach market saturation. For smartphones and tablets, this took only a couple of years. At the same time, product life cycles are shortening. With technology products even to three or six months. In our current economy, a large part of company revenues is from products that were launched during the last year. Due to this shorter product life cycles, companies have a rather narrow window of opportunity to profit.

✓ From possession to use

In the traditional economy, possession of a product was necessary to secure the use of it. The digital economy changes this in two ways. First, fully digital products – like streaming music - need not to be owned in order to be used. Consumers are moving from ownership rights to access rights, often in subscription based models. The second disruption relates to physical products, where digital technology lowers the barriers to shared use. Digital platforms are used to match demand and supply and organize sharing of products. Sensors can be used to track the location and status of shared products in real-time. Market disruption comes from new platforms who don’t have the assets themselves and are therefore very flexible.

✓ Ultra personalization

In the traditional economy, the production paradigm was based on mass production of identical products. New digital technologies like 3D printing allow ultra personalization of products. Furthermore, digital enabled products can be configured to provide functionality and behavior that match personal preferences. Finally, personalization not only applies to the product itself, but also to the delivery process which allows much more flexibility for the customer.

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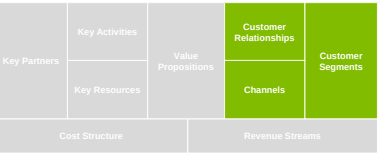
Big Shifts in the Digital Economy (3/6)

Big Shifts related to clusters ‘Customer Segments’, ‘Customer relationships’ and ‘Channels’



✓ **Information transparency**

The Internet provides an unlimited source of (product) information to customers. Not only originating from the producer, but also from other consumers on e.g. online rating sites. The disruptive effect is in the market transparency it creates. It becomes possible for consumers to be even better informed than sales persons when they enter a shop. The downside of the development is an information overload. No single individual is able to keep up with information that is generated.

✓ **Digital is the new normal**

In the digital economy, information, products and services are available through the online channel. However, customers expect more than just online, they expect the experience to be easy and interesting, with personalized and intelligent interfaces. There is zero tolerance for digital failure, every step in the process is a make or break moment for the relationship with the customer. This requires online channels to be completely redesigned with the customer journey in mind, instead of being just the digital version of the traditional physical process.

✓ **Trust and reputation**

In the online world, trust and reputation are vital but are always at risk. Social media and online rating sites give each individual consumer a voice that can be heard by all. Protecting trust and reputation in the digital world has become a vital activity for large firms. Reputation is however not only relevant to big firms, but also for micro entrepreneurs on platforms like Airbnb, Peerby and Etsy. In the digital era, technology is used to build trust between strangers, resulting in a digital reputation which is the expression of how much a community trusts a person. Rachel Botsman summarizes this as: “The currency of the new economy is trust”.

✓ **On-demand**

In the digital economy, customers expect full flexibility in the time and place at which they consumer products and services. This causes a shift towards an on-demand model, threatening traditional models. An example is television broadcasting, which broadcasts contents to every subscriber alike, that are threatened by on-demand video providers.

✓ **Disintermediation**

In the traditional economy, intermediaries like travel agencies were necessary to connect demand and supply in an economically viable way. In the digital world, transaction costs have dropped dramatically and full information transparency exists. The online channel favors a direct-to-consumer strategy, eliminating intermediaries from the value chain.

> “Thanks to digital technologies, we’ll be able to produce more: more health care, more education, more entertainment, and more of all the other material goods and services we value. And we’ll be able to extend this bounty to more and more people around the world while treading lightly on the planet’s resources.
> – *Andrew McAfee*

Source: Harvard Business Review, June 2015

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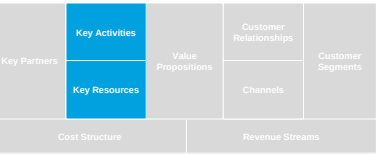
Big Shifts in the Digital Economy (4/6)

Big Shifts related to clusters ‘Key Activities’ and ‘Key Resources’



✓ **Manual work is automated / robotized**

In the digital economy, every business activity that can be automated will eventually be automated due to its advantages: no human errors, 24*7 operation and lower costs. This trend started with automation of administrative routine work, but as technology advances other activities that require more complex skills are automated or robotized too. This requires a huge transition of the labor market as large parts of the existing jobs virtually disappear and new jobs with new skills and competences emerge. Employability of the work force has never been such important as it is now.

✓ **Processes become data-centric**

In the digital economy, data has become a fundamental production factor next to capital, resources and labor. The power of data and analytics is in the ability to make evidence based decision making. The company that is best enabled to create insight from its data has the competitive advantage.

✓ **From ‘push’ to ‘pull’**

Traditionally, businesses created multi-year business plans and used this planning to bring the required workforce and assets at the right time in the right place. In the digital economy however, it becomes harder and harder to predict accurately and this ‘push’ approach is no longer successful. The digital economy requires a different ‘pull’ approach. In this new approach, companies organize themselves in such a way they are able to put the right people and assets in place with short lead times. They do so, for example, by replacing tapping into flows of assets provided by other companies and by replacing manpower by digital power.

✓ **Mobile processes**

Digitization of information and products, in combination with digital communication and collaboration tools make business processes independent of physical location. Mobile solutions cause information and processes to be available at the time and location they are needed. The disruptive effect of this is in the ability to make complex and time consuming processes simpler and faster.

✓ **From efficiency to fast learning**

Until recently, central coordination of activities in order to establish maximum efficiency was a successful strategy. Due to shorter product life cycles, however, this strategy has become less effective. In the digital economy it has become more important to be able to adapt products and services quickly in order to stay ahead of competition. Successful organizations are the ones that are able to learn fast and to implement this learning in new products with very short cycles. Clearly, this requires either completely digital or partially digital (hybrid) products. Tesla, for example, has been able to augment the functionality of their Model S through an automatic software update, in contrast with traditional car manufacturers that require years to redesign a car.

“If man and machine work side by side, which one will make the decisions?”

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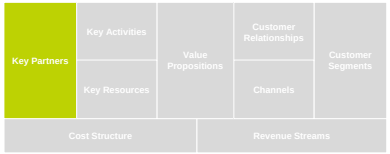
Big Shifts in the Digital Economy (5/6)

Big Shifts related to cluster ‘Key Partners’



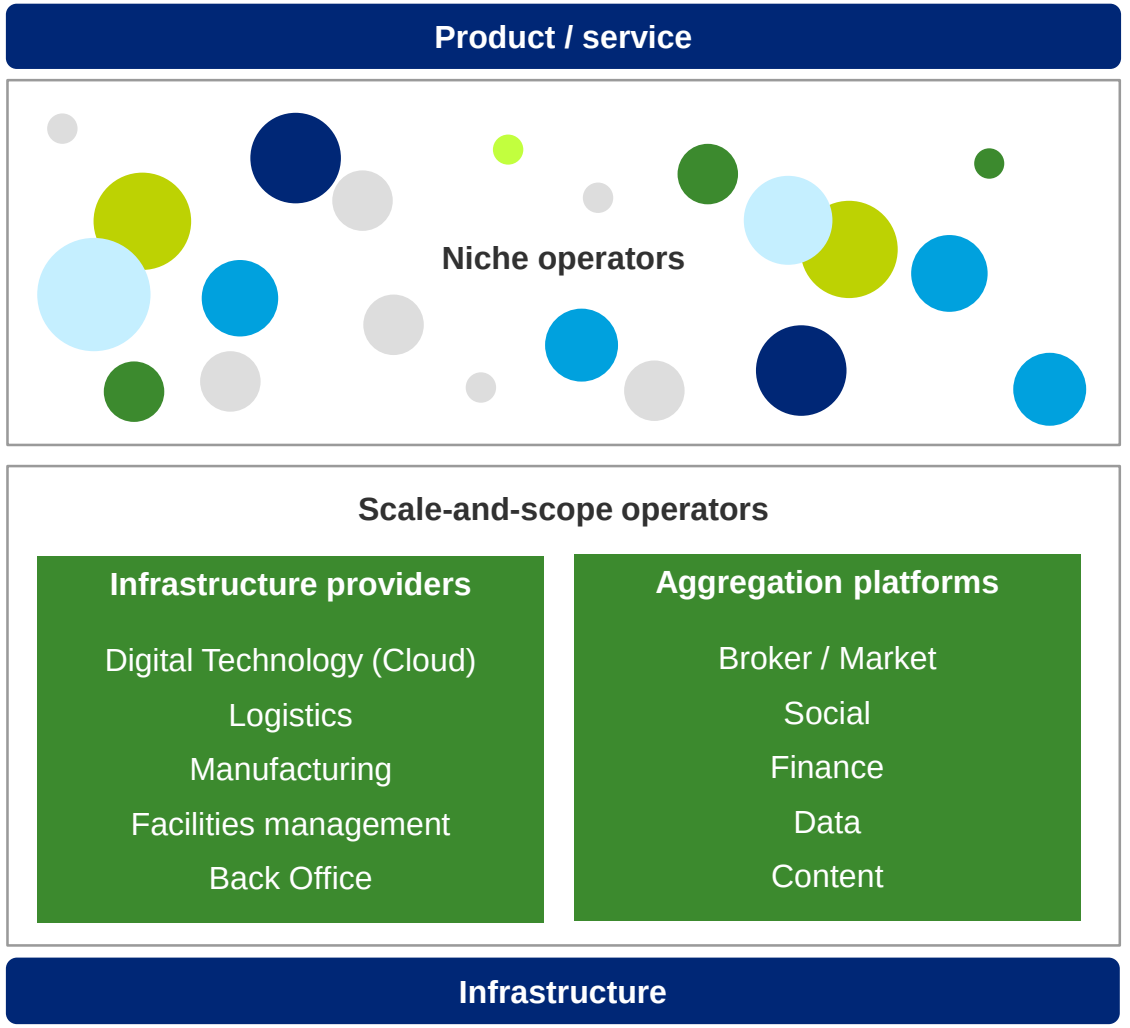
In the digital economy, a new economic landscape is emerging. This new landscape is characterized by two trends: concentration and fragmentation. Both are taking place at the same time and are reinforcing each other.

✓ **Concentration**

Concentration is the trend towards relatively few, very large players that provide infrastructure, platforms and services supporting many fragmented niche players. In the parts of the economy that are subject to concentration, companies can only compete with scale and scope. The value of concentrated players is being a clear leader in their market. Smaller size is always a disadvantage in this segment. Examples of segments where concentration is taking place are: apps stores, cloud computing, social media, payment platforms, etc.

✓ **Fragmentation**

At the same time, other parts of the economy are subject to fragmentation. In these parts of the economy, each entity has a small addressable market, often focused on a niche. Together, all fragmented players address the full spectrum of customer needs. Due to their small scale and influence, no single entity controls the market. Exponential reduction in cost/performance of digital technologies, combined with the availability of on-demand cloud services, lowers the up-front capital investment required to start a business. This is where concentrated players and fragmented players reinforce each other. In general, diseconomies of scale are in play. The extent to which an industry will fragment depends on two elements. First, the degree to which customers are desiring more personalization and uniqueness of their products in terms of price, availability and design. Second, fragmentation is most likely to occur in those market segments where digital technology has lowered barriers to entry most.



Source: The hero’s journey through the landscape of the future, Deloitte Center for the Edge

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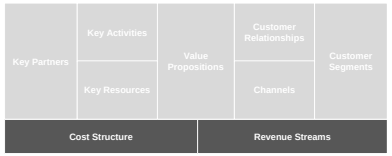
Big Shifts in the Digital Economy (6/6)

Big Shifts related to cluster ‘Cost Structure’ and ‘Value Streams’



✓ **New business models (revenue streams)**

The digital economy allows for other business models than the traditional one where consumers buy a product and ownership of the product is exchanged in return for payment. The four most common business models in the digital world are:

- *Advertising based* – Provide content or services for free in exchange for viewing advertisements (often customized to the personal profiles). Revenue streams are generated by advertisers and not by users. Parties that choose for this business model often focus on building a large user community before they start monetizing the captive user base through advertising. A typical example is Facebook.
- *Subscription (all you can eat)* – Users pay a fixed amount per month in return for the right to consume digital content and services without limitation. A typical example is Spotify and Netflix.
- *Pay-per-use* – Users consume digital content or services and pay a fee per consumed item. Typical examples are in gaming and on-demand video.
- *Data monetization* – Digital businesses collect a plethora of data on consumer behavior and preferences and on product usage. This data has value and can be monetized by selling raw data or derived insights to other players in the market.

✓ **Lower Transaction Costs**

The use of digital technology to support B2C transactions dramatically decreased costs of doing business (e.g. order capturing, invoicing, payment). By digitizing and automating each step in the transaction, it became economically viable for businesses to handle large amounts of relatively small transactions.

✓ **Lower Coordination costs**

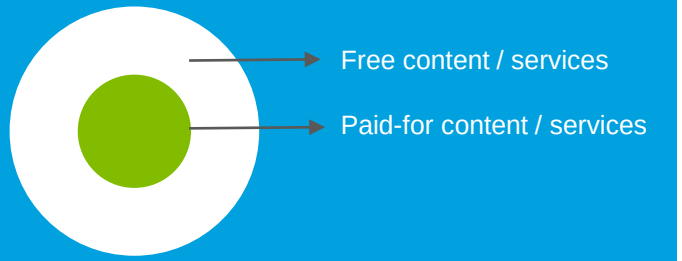
Powerful personal computing, improved communications, information management and collaboration software has significantly lowered the costs of organizing and coordinating complex activities in an organizational and geographically dispersed situation. As a result, business are able to mobilize their experts on a global level to work together on frim projects.

✓ **Higher productivity and asset utilization**

The use of digital technology, e.g. by replacing manual work by computers, costs decrease and productivity increase. Furthermore, techniques like data analysis can be used to make smarter decisions and increase asset utilization, which also decrease cost.

Free content or services

A fundamental difference between the digital economy and the physical economy is the widespread availability of free content and services. Only a part of all value that is created in the digital economy is paid for by users. Two reasons are causing this phenomenon. First, digital content and services have very low marginal costs, i.e. if users consume one extra item, additional costs for the provider are almost zero. That allows providers to provide free content to very large numbers of users. Second, free content is often a key element of the business model. Businesses provide free content to build up a large captive user base and generate revenues by advertising, by selling data they collect from users, or by paid-for premium content or paid-for additional services. The question which content / services is provided for free and which content / services is paid-for is one of the main strategic choices for digital companies.



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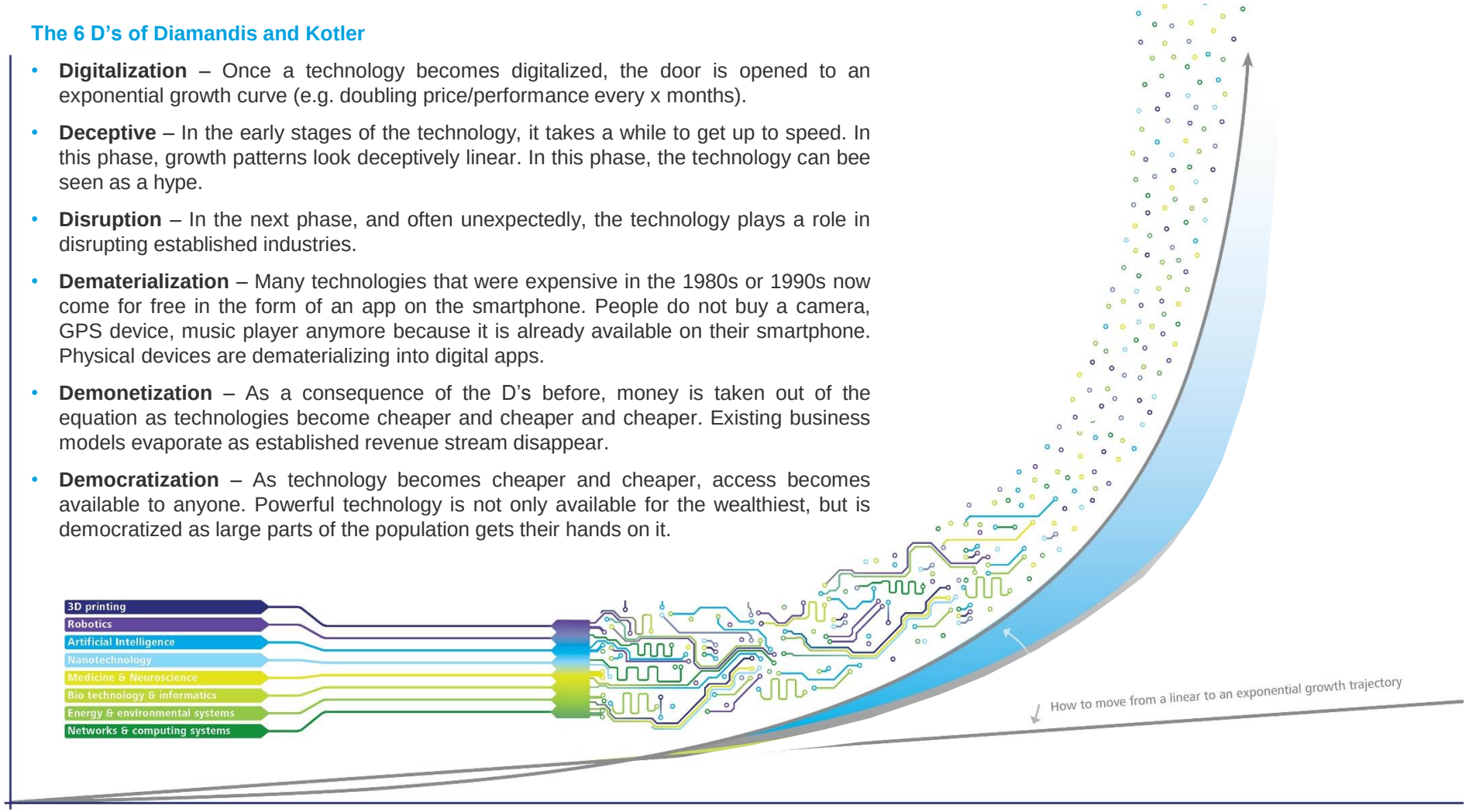
The power of exponential growth

While our minds are stuck in linear thinking, digital technology has the ability to follow an exponential growth track. This creates a huge gap between what we intuitively think to be possible and what technology is actually making possible.

The 6 D's of Diamandis and Kotler

- **Digitalization** – Once a technology becomes digitalized, the door is opened to an exponential growth curve (e.g. doubling price/performance every x months).
- **Deceptive** – In the early stages of the technology, it takes a while to get up to speed. In this phase, growth patterns look deceptively linear. In this phase, the technology can bee seen as a hype.
- **Disruption** – In the next phase, and often unexpectedly, the technology plays a role in disrupting established industries.
- **Dematerialization** – Many technologies that were expensive in the 1980s or 1990s now come for free in the form of an app on the smartphone. People do not buy a camera, GPS device, music player anymore because it is already available on their smartphone. Physical devices are dematerializing into digital apps.
- **Demonetization** – As a consequence of the D's before, money is taken out of the equation as technologies become cheaper and cheaper and cheaper. Existing business models evaporate as established revenue stream disappear.
- **Democratization** – As technology becomes cheaper and cheaper, access becomes available to anyone. Powerful technology is not only available for the wealthiest, but is democratized as large parts of the population gets their hands on it.



Question

When a bacteria colony in a container is doubling in size every minute, and the container is completely filled in 1 hour, when is the container half full?

Answer

Exactly after 59 minutes

59 minutes to fill the first half and 1 minute to fill the second half

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Many breakthrough technologies are only in its infancy

Advances in digital technology have been taking place year after year. There is no reason to believe that growth will stop or even slow down. History shows that predicting technologies that show exponential growth is very difficult.

Quantum computing, Artificial Intelligence, Robotics, Nano Technology and Bio Technology will disrupt the world we live in.

We don't know how exactly, but we are sure it will go beyond what we can imagine today.

"Everything that can be invented has been invented."

(Charles H. Duell, Commissioner, U.S. Office of Patents, 1899)

"I think there's a world market for about 5 computers."

(Thomas J. Watson, Chairman of the Board, IBM, circa 1948)

"It would appear that we have reached the limits of what it is possible to achieve with computer technology, although one should be careful with such statements, as they tend to sound pretty silly in 5 years."

(John Von Neumann, circa 1949)

"640K ought to be enough for anybody."

(Bill Gates, 1981)

"There is no reason for any individual to have a computer in his home."

(Ken Olson, President, Digital Equipment Corporation, 1977)

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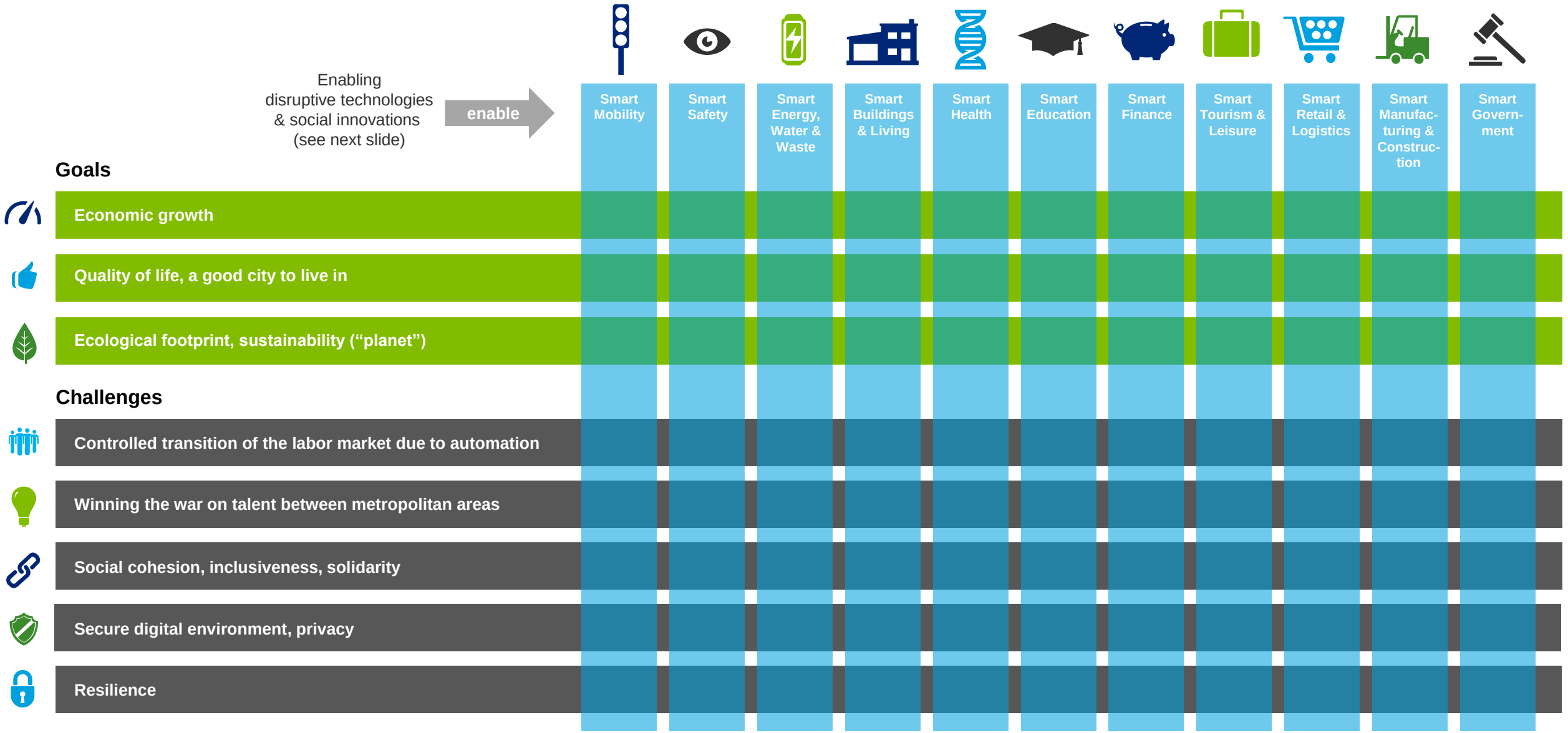
2. Smart Cities: Overview, Benefits and Challenges

What do we mean with ‘smart cities’?

A city is smart when investments in (i) human and social capital, (ii) traditional infrastructure and (iii) disruptive technologies fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance.

Smart cities emerge as the result of many smart solutions across all sectors of society



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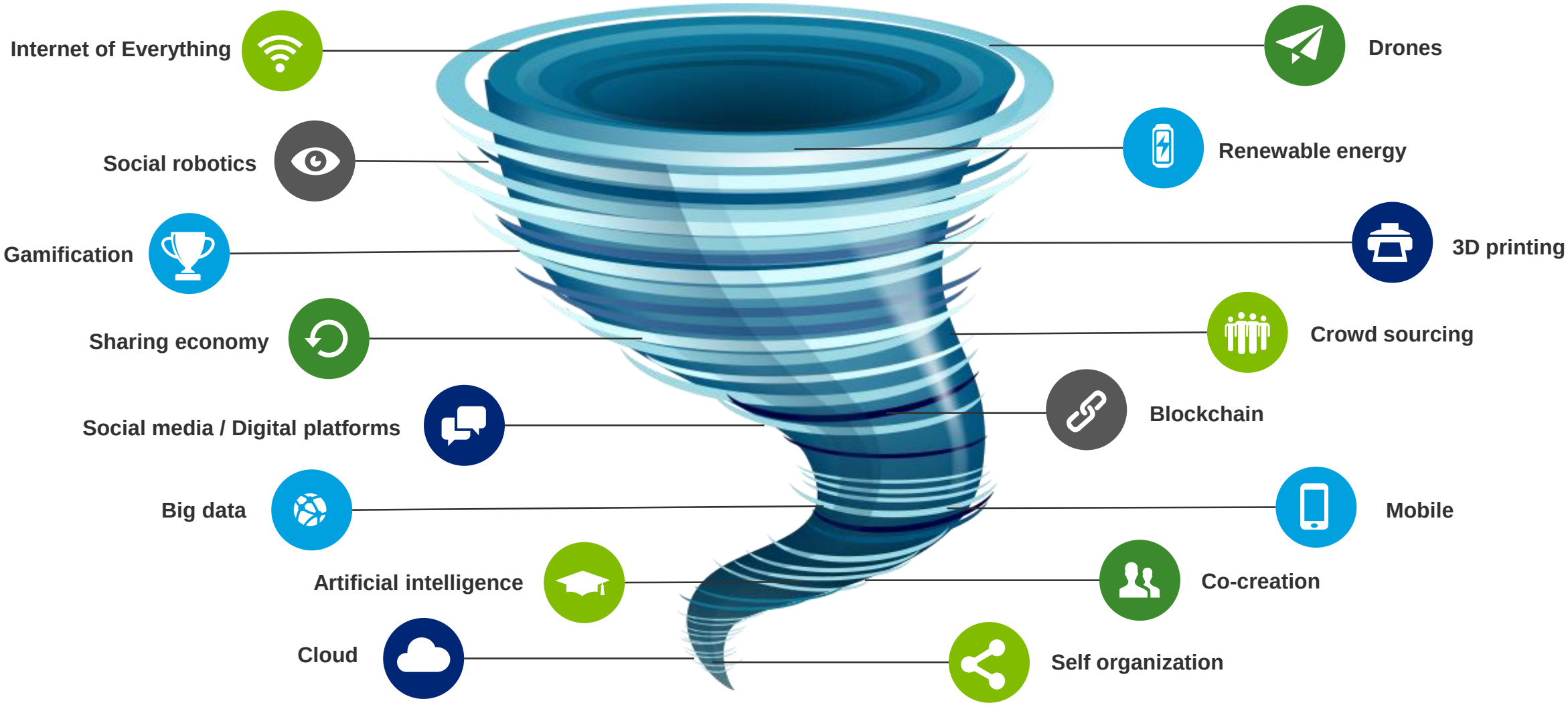
… fueled by a combination of disruptive technologies and social innovations …

Most new technologies and social innovations are disruptive on their own. The combination of them is even more powerful and creates a ‘perfect storm’ of disruption.



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… and combine changing human behavior with the use of data and innovative technology

True smart solutions combine disruptive technological capabilities with changes in human behavior. The latter can only be achieved by simple, intuitive solutions that appeal to real human needs.

Human Behavior Data Technology

Meaningful -
Smart solutions address real needs of city users and are perceived as meaningful

Durable –
The combination of easy to use and meaningful solutions results in lasting changes of behavior

Easy to use -
Smart solutions are simple and intuitive. They are designed to be adopted naturally, even to the extent that people are not aware of them any more

Inviting -
Provide people the right incentives to change behavior voluntary, because they are recognized as beneficial

Always there -
Smart solutions are resilient and always available. People do not have to worry about them

Scalable -
Smart solutions can be scaled from small pilot to city wide use easily

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Typical smart city benefits are already becoming visible …

Each sector contributes with its own unique innovations to the overall success of the smart city. Harvesting the potential benefits from all relevant sectors is the challenge of the city.

Faster reaction to public safety threats by real-time analysis of sensor and surveillance camera video data

Better diagnostics and personalized treatment through artificial intelligence on massive volumes of patient data

People who need care can live in their own home longer through advanced sensoring and health care robotics

Smoothened distribution of tourists (geographical and over time) by analysis of tourist movements and real-time incentives

Lower congestion and pollution through optimal use of transportation infrastructure (roads, parking places)

Exchange of products and services in a peer-to-peer model (sharing economy, from possession to use)

Energy savings through real-time insight in energy usage, combined with gamification concepts

Responsive household appliances react to dynamic energy prices to adjust energy demand to supply

Dynamic groups of citizens organize themselves to work together on collective interests

Co-creation of decision making, new forms of digital democracy and participatory government

More efficient waste collection due to sensors in waste containers

Data-driven policy making leads to more focused interventions and measured evidence of effectiveness

Analysis of data provided by sensors in the water distribution network identifies leakages and allow fast repairs

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… but the imminence of change and the size of impact differs per industry

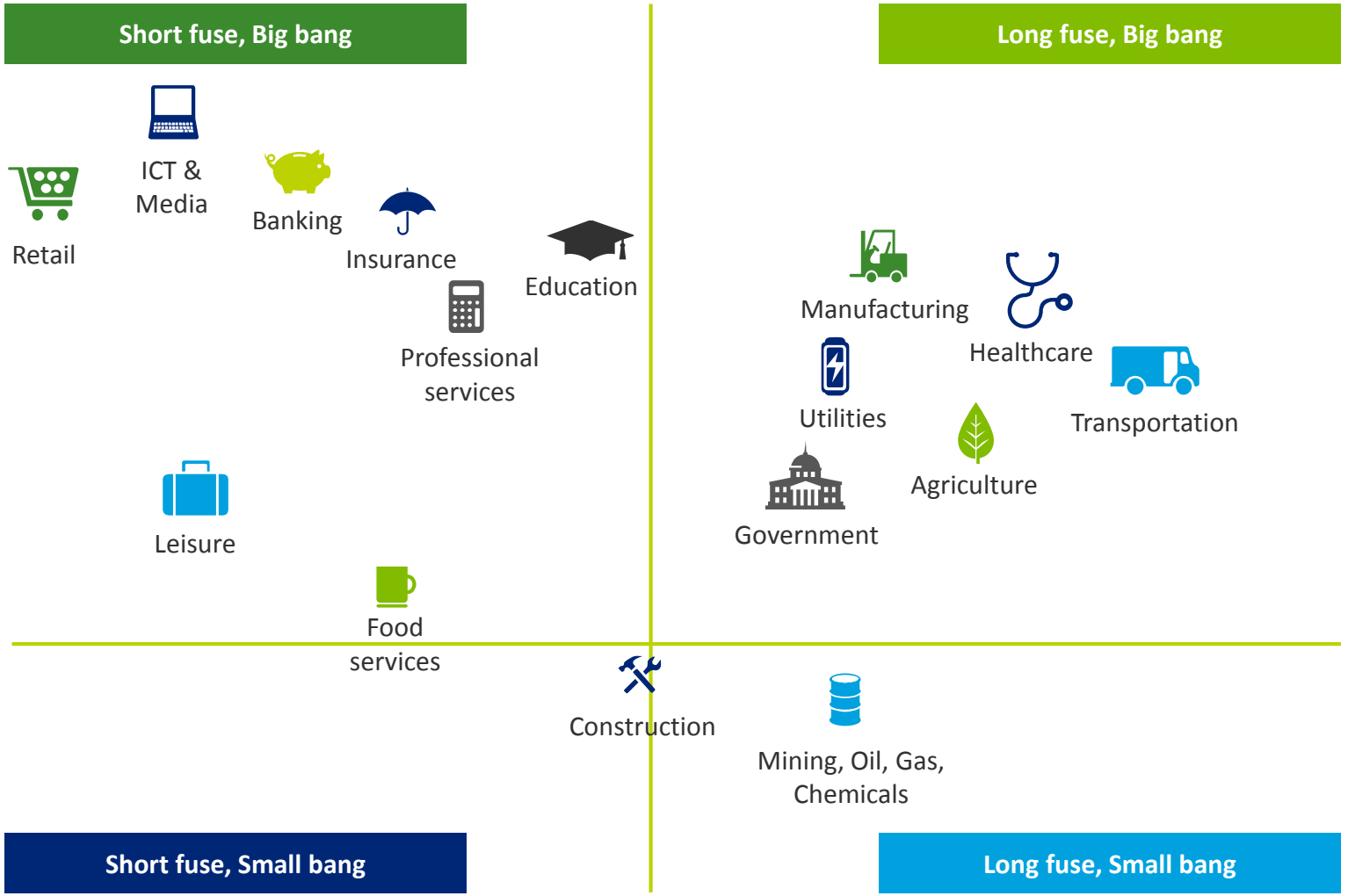
Major disruptions in industries like Retail, Media and Banking are already happening. Other industries are expected to follow later. Ultimately, our entire economy will be disrupted.

The Deloitte Digital Disruption Map compares 16 industries on their vulnerability to disruption from two perspectives: the size of the impact and the imminence of change. The assessment considers factors including:

- The extent to which products and services are delivered physically
- The propensity of customers to use digital channels
- The importance of broadband and computing infrastructure in business operations
- How mobile a company's customers and workforce are, and their average age
- The significance of social media and innovations like cloud computing
- How digital innovation might be inhibited by government regulations or other factors.

Companies that stand to experience significant digital disruption within the next three years are said to be on a 'short fuse'. Those that can expect major change in four to ten years are on a 'long fuse'.

The size of the impact, or 'bang', is described as the expected change in percentage terms across a range of key business metrics. Companies that can expect to see a 15–50 per cent change in their metrics, such as mix of revenue channels or cost structures will experience a 'big bang'. Below 15 per cent, companies will feel a smaller 'bang'.



Source: *Digital disruption - Short fuse, big bang?*, Deloitte Australia

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Challenge 1: Disruption of the labor market (1/3)

One of the challenges related to smart cities is the imminent disruption of the labor market, due to progressing automation and use of robotics to replace manual work

The Challenge

Disruption of the labor market is the major concern. Due to disruptive technologies, many existing jobs will disappear with (frictional) unemployment as result. Many people will have to be retrained in 21st century skills more quickly to remain employable. New jobs will have to replace vanishing old jobs. The challenge for the city is to make this transition as smooth as possible by renewing fast and making the turn rapidly. A city which does not make the turn fast enough will be confronted with an increasing number of long-term unemployed, leaving no money for addressing social challenges.

Research

Researchers of the University of Oxford have analyzed the impact of computerization on 700 jobs. For each job, the researchers estimated the change of that job being fully computerized in the next 10 to 20 years. The results were clear: 47% of total employment has a high probability of disappearing due to computerization. Many of those jobs are in the categories Office and administrative support, Sales and Service.

The Impact

The disruption of the labor market is going to happen and brings two major challenges:

- **Unemployment** – The pace at which automation and robotics impact the labor market increases. As a result, the pace at which existing jobs disappear and people become unemployed also increases. If people do not adapt their skills to the changing environment, large structural unemployment will be the result.
- **Income inequality** – The benefits of computerization of human labor will be reaped by owners of companies, building, machines and computers who will see higher productivity. Human labor becomes a less important factor, due to which the pressure to increase wages decreases. As a result, inequalities between people are likely to increase if no compensating measures will be taken.

Bottlenecks to computerization

The extent to which an occupation is at risk to be computerized is determined by the Oxford University researchers by scoring occupations on the most important bottlenecks for computerization. Occupations that score low on these bottlenecks have a high risk of being computerized.

Bottleneck variable		Description
Perception and Manipulation	Finger dexterity	The ability to make precisely coordinated movements of the fingers of one or both hands to grasp, manipulate, or assemble very small objects.
	Manual dexterity	The ability to quickly move your hand, your hand together with your arm, or your two hands to grasp, manipulate, or assemble objects.
	Cramped work space	How often does this job require working in cramped work spaces that requires getting into awkward positions?
Creative intelligence	Originality	The ability to come up with unusual or clever ideas about a given topic or situation, or to develop creative ways to solve a problem.
	Fine arts	Knowledge of theory and techniques required to compose, produce, and perform works of music, dance, visual arts, drama and sculpture.
Social intelligence	Social perceptiveness	Being aware of others' reactions and understanding why they react as they do.
	Negotiation	Bringing others together and trying to reconcile differences.
	Persuasion	Persuading others to change their minds or behavior.
	Assisting and caring for others	Providing personal assistance, medical attention, emotional support, or other personal care to others such as coworkers, customers, or patients.

Source: *The Future of Employment: how susceptible are jobs to computerization?*, Carl B. Frey and Michael A. Osborne, September 17, 2013

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Challenge 1: Disruption of the labor market (2/3)

An illustration of the imminent transition of the labor market is given by a top-20 of common occupations that are most at risk compared to a top-20 of common occupations that are least at risk

20 common occupations least at risk (probability < 0.1)	20 common occupations highly at risk (probability > 0.9)
1. First line supervisors of mechanics, installers and repairers, production workers	1. Telemarketers
2. Dentists, orthodontists and prosthetists	2. Insurance underwriters, Insurance claims clerks, Insurance appraisers
3. Child, family and school social workers	3. Cargo and freight agents
4. Physicians and surgeons	4. Packaging and filling machine operators
5. Teachers and instructors	5. Procurement clerks
6. Mental health counselors	6. Bookkeeping, accounting and auditing clerks
7. Human resource managers	7. Real estate brokers
8. Recreation workers	8. Counter and rental clerks
9. Training and development managers	9. Cashiers
10. Computer systems analysts and computer systems administrators	10. Dental laboratory technicians
11. Registered nurses	11. Electromechanical equipment assemblers
12. Mechanical engineers	12. Administrative assistants
13. Pharmacists	13. Counter attendants
14. Logisticians	14. Office clerks
15. Psychologists	15. Receptionists and information clerks
16. Sales managers, Marketing managers	16. Postal service clerks
17. Training and development specialists	17. Paralegals and legal assistants
18. Public relation and fundraising managers	18. Couriers and messengers
19. Chief executives	19. Accountants and auditors
20. Architects	20. Truck and tractor operators

History repeats…

Disruptions of the labor market are not new. In 1849, a population census was held in Amsterdam, with detailed data on occupations of citizens as result. Many jobs either completely disappeared or diminished to much lower employment rates.

Today, for instance, we do not find any ‘Aschwerkers’, ‘Bezembinders’, ‘Copiisten’, ‘Drijvers’ or ‘Gareelmakers’ any more.

A similar disruption is about to happen again….

Source: *The Future of Employment: how susceptible are jobs to computerization?*, Carl B. Frey and Michael A. Osborne, September 17, 2013

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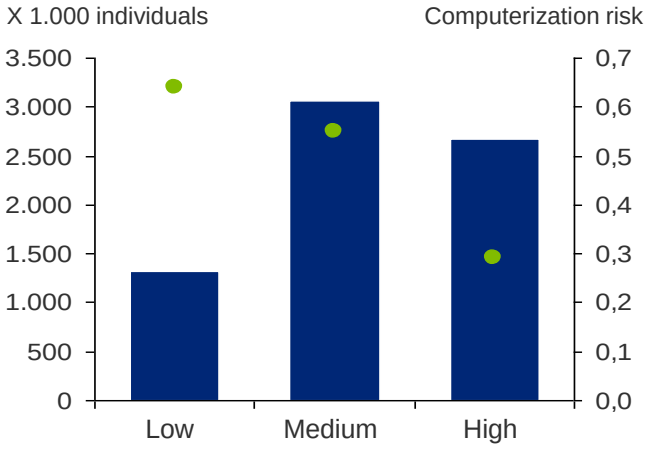
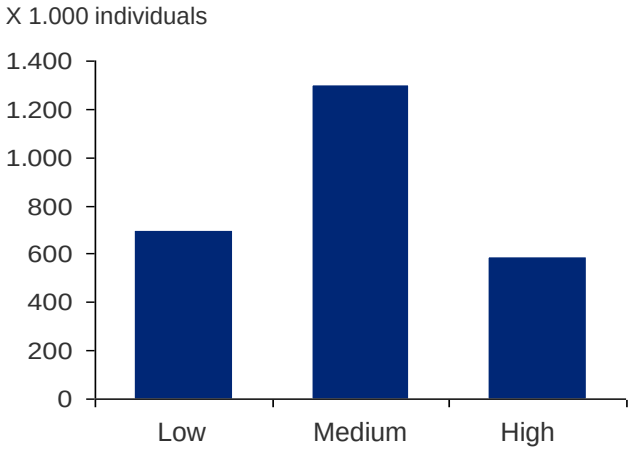
Challenge 1: Disruption of the labor market (3/3)

Deloitte analysis indicates that the disruption of the labor market in Amsterdam is characterized by a relatively high share of higher educated people

Size of the population and risk per education level



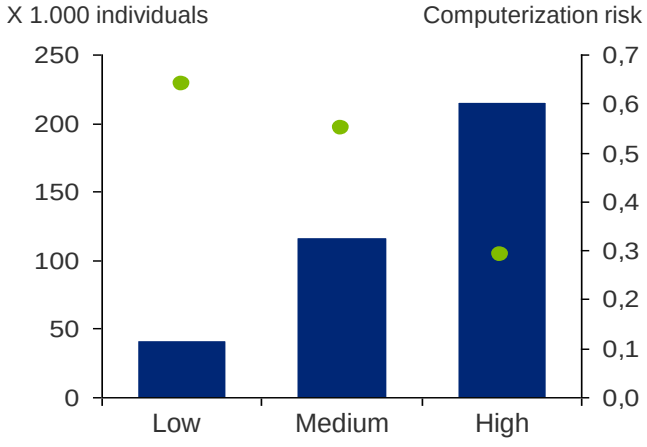
expected # of impacted individuals per education level



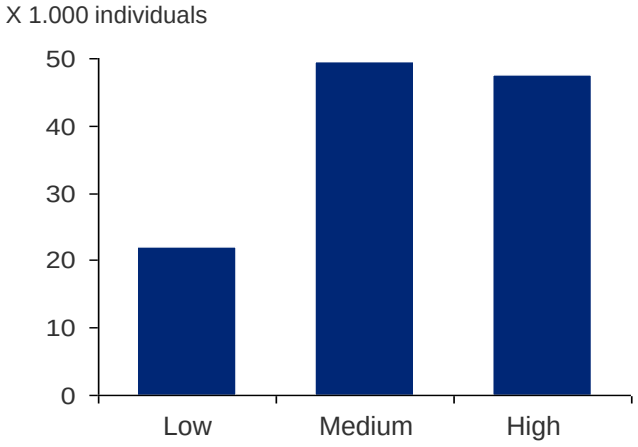
37% of the labor force is expected to be impacted

Size of the population and risk per education level

Gemeente Amsterdam



expected # of impacted individuals per education level



32% of the labor force is expected to be impacted

Conclusion

The impact on the Amsterdam labor force (32%) is smaller than the national average (37%).

The impacted population however has a significant higher share of higher educated people

Source: The probability of computerization per job used in the analysis is derived from *The Future of Employment: how susceptible are jobs to computerization?*, Carl B. Frey and Michael A. Osborne, September 17, 2013

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Challenge 2: Winning the ‘war on talent’

Winning the war on talent is a challenge closely linked to the disruption of the labor market, but related to the other side of the ‘demand/supply’

The Challenge

A Smart City can only exist when it is able to attract and retain high-tech and creative talent. These people are vital for a continuous renewal of the economic infrastructure through creative destruction and innovation. They are the foundation for new initiatives, start-ups and a climate in which innovation can flourish. As traditional jobs disappear, talent is required to be the catalyst in a process that creates new businesses and new jobs. The megacities of the word are therefore competing for this talent.

How to win

The following ingredients stimulates attractiveness for talent:

- An urban 24*7 lifestyle that fits the needs of young professionals to live, work and relax. The spatial planning of a city must be aimed at creating the right conditions. Furthermore, cultural diversity is positively correlated with such a climate.
- Presence of reputable knowledge institutions and research that is able to attract scientific talent.
- Presence of an innovative financial sector provides access to capital in all its forms (classic business banks, venture capitalists, crowdfunding etc.).
- Stimulation of start-ups, for example in the form of incubators where entrepreneurs can rent space in a stimulating environment with other start-ups. This creates a climate where ideas can be exchanged, problems can be solved collaboratively and innovation is stimulated.

“Beneath the surface, unnoticed by many, an even deeper force was at work — the rise of creativity as a fundamental economic driver, and the rise of a new social class, the Creative Class.”
– Richard Florida

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Challenge 3: Social cohesion, inclusiveness and solidarity

Securing that the benefits of smart cities are reaped by all groups in our society alike

The Challenge

Although smart solutions have the potential to connect people and to increase social cohesion, the darker side is the risk of smart city benefits not being reaped by all groups in our society alike. There are three main causes.

- First, some groups have a lack of ‘digital savviness’ or a lack of access to modern digital connections and digital equipment.
- Second, increasing insight in risks (e.g. of becoming ill) due to emerging big data may put solidarity under pressure.
- Finally, smart solutions can be used by groups to organize themselves and to create ‘digital gated communities’, which can become a threat to social cohesion and inclusiveness.

Sustainability and social cohesion are under permanent pressure. It becomes clear that government can not solve these problems on its own. Increasingly, businesses and new collectives of citizens are encouraged to help solve social problems. The search is for smart solutions, the result of co-creation between government and businesses, with scalable business models. To find these, unconventional steps need to be made, for example by organizing a contest for open data driven solutions to social problems.

“Our one confident prediction is that digital technologies will bring the world into an era of more wealth and abundance and less drudgery and toil. But there’s no guarantee that everyone will share in the bounty, and that leaves many people justifiably apprehensive. The outcome — shared prosperity or increasing inequality — will be determined not by technologies but by the choices we make as individuals, organizations, and societies.”

– Erik Brynjolfsson

Source: Harvard Business Review, June 2015

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Challenge 4: Security and Privacy

The use of disruptive technologies has downsides too. Our society becomes more vulnerable for cyber crime as much more data is stored digitally and a plethora of physical objects becomes connected to the Internet

The Challenge

Smart cities are highly digitized cities by nature, characterized by large volumes of data stored digitally and large numbers of physical objects with an online connection to the Internet. This can be used in a positive way, by contributing to societal goals, but it is also possible to abuse the possibilities for criminal purposes.

The Impact

- **Privacy violation** (1) – Almost every aspect of our personal lives is captured in digital data that is stored somewhere in the digital ecosystem. Whether it is data about our purchases and payments, our geographical location and movements, our health records, the websites we visit, the films and series we watch on Netflix, the music we listen to on Spotify, the photos we store in our iCloud, virtually every aspect of our lives creates a digital footprint. Every two days, the world creates more data than in the entire human history up to the year 2003. The threat is in the combination of two aspects. First, digital systems can be hacked with unauthorized access to personal data as result. We have seen many examples of that in the past years. Second, data analytics has become so powerful it can combine data sets to infer someone's lifestyle, habits and more. Even to the point that others are able to know more about a person that the person itself.

- **Hacking of connected objects** (2) – With the Internet of Things, all kinds of machines become connected to the Internet and the role of humans diminishes, even tot the point they are removed from the equation. This will generate huge increases in productivity. But there is also a dark side: connected objects are vulnerable for hacking. For many objects, the risks associated with becoming hacked are limited. However, as objects which are part of vital infrastructures become connected, hacking is a huge threat. Hacking the control system of planes, energy plants, pacemakers, self driving cars and may other connected machines can disrupt vital systems. This goes far beyond the type of hacking resulting in embarrassing privacy leaks, it creates a real threat to life. The implication of these risks is to make these connected objects Secure, Vigilant and Resilient.

- **Future crimes** (3) – The increasing digitization causes a paradigm shift in crime. One of the characteristics of 'future crime' is its almost unlimited scalability. Traditionally, crime was always restricted by physical barriers. The number of victims a pickpocket could make was confined by geographical limitations. When the crime scene shifts from the physical world to the digital world, these limitations no longer exist and crime becomes scalable too. For the first time in history, one criminal organization can rob hundreds of millions of people in one attack.

"More connections to more devices means more vulnerabilities. If you control the code, you control the world." – *Marc Goodman*

"All inventions have unintended consequences." – *Marc Goodman*

(1) Have it all: Protecting privacy in the age of analytics, Deloitte
(2) Safeguarding the Internet of Things, Deloitte Review, Issue 17, 2015
(3) Future Crimes: Everything Is Connected, Everyone Is Vulnerable and What We Can Do About It, Marc Goodman,

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Challenge 5: Resilience

The ability to prepare for and adapt to changing conditions, and withstand and recover rapidly from disruptions due to deliberate attacks, accidents or naturally threats

The Challenge

One of the consequences of digitization is an increasing dependency on digital technologies. If vital digital infrastructures fail or become compromised by malicious attacks, serious disruption of society and economy can be the result. The challenge is to make digital infrastructure and smart solutions resilient.

How to win

City resilience consists of three different aspects:

- **Ensuring continuity of critical services** – Critical services like electricity, water, communication, transportation, etc. are increasingly becoming dependent on smart city technology. City government will have to identify the most critical services to protect and take measures to prevent disruption and, should disruption occur, recover from it rapidly.
- **Incident response** – Critical services like transportation can be disrupted by incidents like traffic accidents. A resilient smart city uses technology to minimize the impact of such incidents and to recover from it as fast as possible. This is done by detecting the incident in real-time, by dispatching emergency services automatically and rerouting traffic while it is needed.
- **Crisis management** – In the early stages of a crisis, information is key to making the right decisions. A smart city supports city government in crisis management by providing detailed and real-time insights in the situation and analysis tools that can help predict the effects of different possible decisions and strategies.

"It is impossible to know what the future holds for New York. But if this plan is brought to life in the years and decades ahead, a major storm that hits New York will find a much stronger, better protected city."

– Mayor Mike Bloomberg about the 'A Stronger, more Resilient New York' initiative

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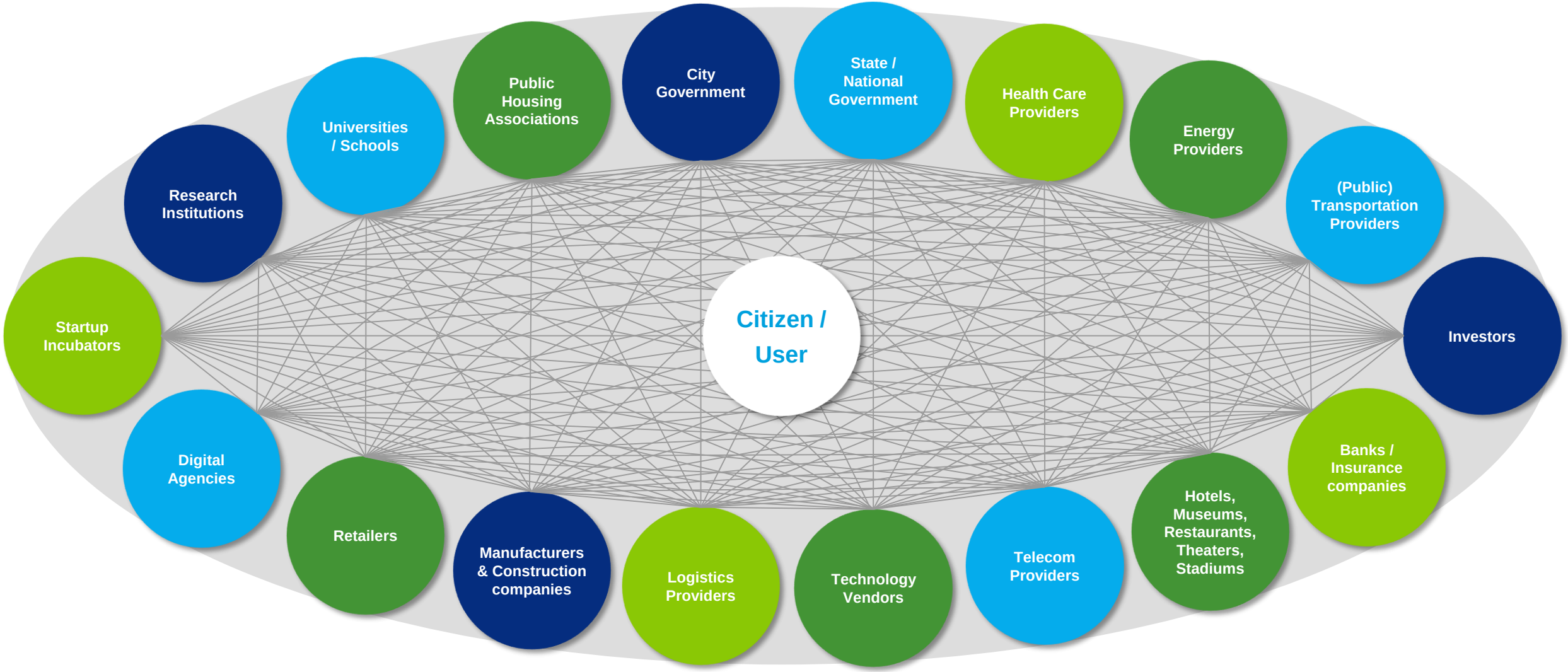
3. Capability Framework and Maturity Model

Smart City actor map

A smart city is the result of the efforts of many stakeholders, working together in partnerships of different shape and form. The citizen / user is at the center of the map, indicating that successful smart cities are always user-centric.



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The six roles of city government

Smart cities require a government that is able to combine six vital roles. To be most effective, city government must make deliberate choices on the mix of roles through which it engages city challenges in the most effective way. Each role must be developed at a mature level.

STRATEGIST & ADVOCATE

Sets out a clear direction for the city: what is our vision and ambition as smart city and how do we want to realize this? Furthermore: be an active advocate of the city as innovative hub for new business.

SOLUTION ENABLER

Build ecosystems by gathering parties that normally do not work together to deliver creative new solutions that neither of the parties could have realized on its own.

DIRECTOR & REGULATOR

Create or change laws and regulations to allow new business models and disruptive entries, and simultaneously protect the interests of citizens and users of the city.

STEWARD

Create an environment in which new businesses and smart solutions can emerge and grow. For example by providing ‘open data’ and by facilitating start ups.

CONNECTOR & PROTECTOR

Secure modern transportation infrastructures, energy grids and digital networks. Set standards and take measures to make these vital infrastructures resilient and safe.

INNOVATOR & INVESTOR

Apply the principles of innovation in the internal organization and processes. Stimulate innovative solutions by acting as launching customer.

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The six roles of the citizen

Smart cities are user-centric and citizens are the main category of city users. They engage with the city government in six different roles. A successful strategy is aware of these roles.

Note: these six roles apply to the citizen. However, citizens are not the only users of the city. Other categories are:

- Tourists
- People that work in the city but live elsewhere
- People that live in the region and use city facilities from time to time

A smart city strategy should address each category of users.

VOTER

The citizen as voter expects to be represented by elected politicians, who have a clear vision and live up to what they promise

TAX PAYER

The citizen as tax payer expects the government to be efficient and spend tax money wisely. The costs of living in the city most match the quality of living in the city.

CUSTOMER

The citizen as customer expects good quality of service: good information, digital channels if possible, favorable opening hours for services provided non-digitally, short waiting times, reasonable prices.

LOCAL RESIDENT

The citizen as local resident expects his living environment to have a certain quality: clean, green and with transportation and other services within reach.

SUBJECT

The citizen as subject expects the government to protect his safety. The right balance between personal freedom and enforcement of law and order is important.

PARTNER

The citizen as partner expects to be taken seriously in the process of creating policy. He expects the government to make sound choices in spatial planning, economic development, social services and education.

Source: Hiemstra, 2003

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Smart City Capability Framework (1/5)

Successfully building a smart city requires a clear strategy and maturity in seven capability dimensions.

Goals

- Economic growth
- Quality of life, a good city to live in
- Ecological footprint, sustainability

Challenges

- Social cohesion, inclusiveness
- Secure digital environment, privacy
- Resilience

- Smart Mobility
- Smart Safety
- Smart Energy, Water & Waste
- Smart Buildings & Living
- Smart Health
- Smart Education
- Smart Finance
- Smart Tourism & Leisure
- Smart Retail & Logistics
- Smart Manufacturing
- Smart Government

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Smart City Capability Framework (2/5)

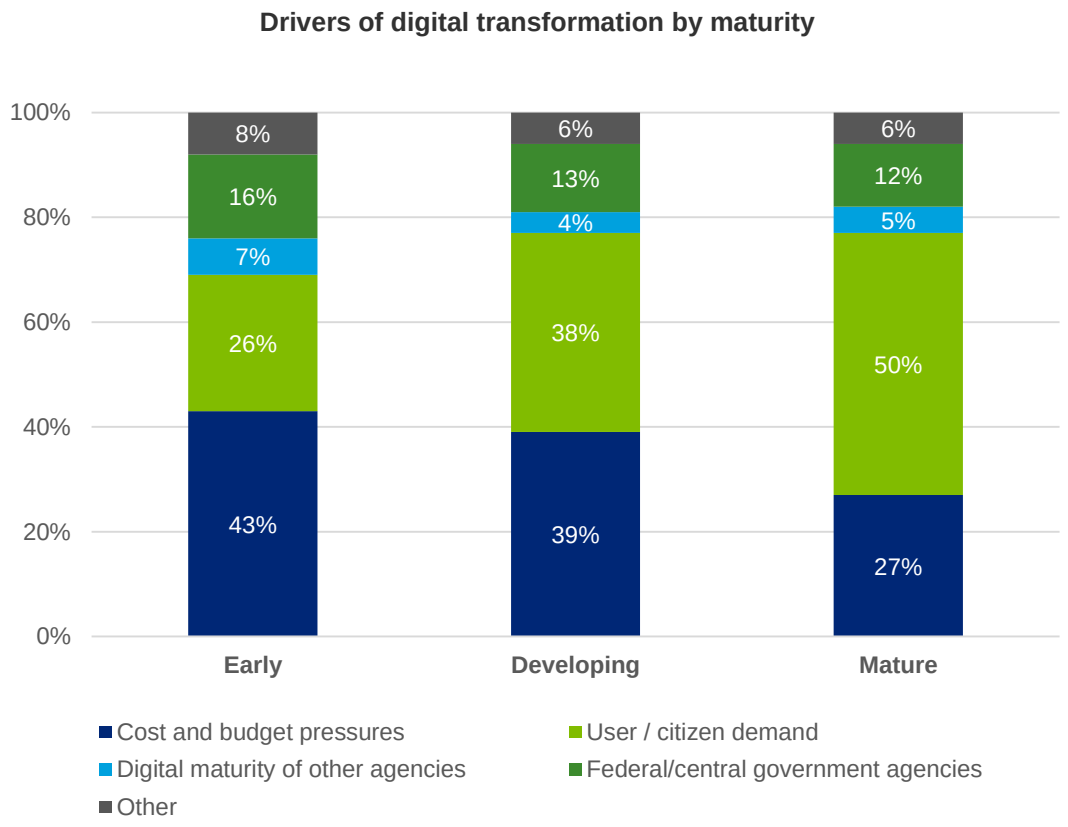
Successfully building a smart city requires a clear strategy and maturity in seven capability dimensions.

Strategy & Vision – Smart cities have a clear vision of what they want to be and a strategy to realize this ambition. Each city has its own strengths, challenges and opportunities. No two cities are alike. A smart city harnesses the power of technology and social innovations to increase existing strengths, to solve persistent challenges and to create new successes by leveraging opportunities. Having a clear economic and social vision allows a city to focus their energy and resources on what brings value to the city most, not only on the short term but also in the long term. A clear vision is the only effective counterweight to the technology push of vendors. Cities that lack such a vision are likely to become a living laboratory for vendor solutions with piecemeal successes.

One of the exiting aspects of disruptive technologies is that no one can predict what the impact of a new technology will be and when it will happen. Although there is a common feeling that something is going to happen, real transformations often have many unexpected elements. For that reason smart cities needs thinkers who dare to ask the out-of-the-box 'what if' questions. What if health care breakthroughs cause people to reach an average age of 120? What if the technology to store electricity becomes 100x more efficient and cheaper. What if the self-driving car really takes of what if no one has a car of his own?

"Smart cities have a clear vision of what they want to be and a strategy to realize this ambition. A clear vision is required as effective counterweight to technology push."

Digitally maturing organizations have greater user focus



Source: The journey to government's digital transformation, Deloitte University Press

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Smart City Capability Framework (3/5)

Successfully building a smart city requires a clear strategy and maturity in seven capability dimensions.

Data – If there is one ingredient that make a city smart, it is data. The combination of various sources of fine grain data allows a city to develop real insight into societal challenges like sustainability, mobility, health and security. This insight can be used to make better, smarter, data-based decisions. The ability to extract data from a wide array of sensors, in public spaces, in transportation systems, in energy grids, in all kinds of consumer devices provides real-time insight in transportation flows, energy flows, pollution and human behavior. It is not sufficient to use these data sources in isolation of each other to create islands of smartness. A real smart city emerges when data is combined from multiple sources that have traditionally not been used in combination.

> “If there is one ingredient that makes a city smart, it is data.”

Technology - Availability of state-of-the-art and open networks for energy and digital connectivity are the foundational infrastructure of smart cities. Energy grids need to be bi-directional, facilitating distributed electricity generation by many small-scale units close to consumers. Networks for digital connectivity are required in three different forms:

1. Fixed broadband networks, facilitating gigabit connections
2. Mobile broadband networks, 4G and 5G networks providing ubiquitous internet access to people using mobile devices
3. Internet of Things networks, characterized by long range (several kilometers), low bandwidth and very low energy usage

In addition to networks, smart cities require massive use of sensors. Increasingly, vendors of objects that are used in public space will equip their products with multi purpose sensors. The challenge for the city is to manage standards and protocols to establish a homogeneous well architecture environment.

Sensors alone are not sufficient though, a city needs a mature software IoT platform to manage the sensors, to receive and process data and to make this data available to smart solutions through application program interfaces.

Refer to chapter 6 for detailed information about the foundational infrastructure and technology on which smart cities are built.

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Smart City Capability Framework (4/5)

Successfully building a smart city requires a clear strategy and maturity in seven capability dimensions.

Skills and competences – The use of disruptive technologies for innovation requires new skills and competences in the city. In particular related to data. The new job of 'data scientist' has been named as the job of the 21st century and smart cities need a lot of them. Furthermore, as smart solutions aim at changing the behavior of people, cities need experts who understand the mechanisms of human behavior and changing human behavior, e.g. by using concepts like gamification.

Openness for innovation and new ideas – Realizing a smart city requires openness for new creative ideas, the willingness to experiment and to take calculated risks. It requires trying new types of collaboration between different departments in the government and with stakeholders outside the government. Only by taking these calculated risks, cities build a deep understanding what really works. In the development phase smart cities are in (beyond the hype, but far from mature), failures are necessary to develop insight and to learn.

> "As smart solutions aim at changing the behavior of people, cities need experts who understand the mechanisms of human behavior."

According to Deloitte Research:

- 90% of Public sector leaders says that workforce issues are a challenging area to manage in their agency's digital transformation.
- Only 34% say their organization has sufficient skills to execute its digital strategy.

Source: The journey to government's digital transformation, Deloitte University Press

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Smart City Capability Framework (5/5)

Successfully building a smart city requires a clear strategy and maturity in seven capability dimensions.

Attractiveness for businesses and talent – Powerful ecosystems can only emerge if the right partners are present in the city. Creativity, deep technological expertise and the ability to execute are vital components. Smart cities need to focus on attracting the right talent and the right companies. Richard Florida calls this the ‘war on talent’ between the megacities of this world. However, cities should be focused and pick their battles. They should focus on the type of talent that fits the long term vision of the city. Talent likes to be around other talent, so make the objective must be to make the city a talent hotspot.

Due to automation and robotics, existing jobs will vanish away. The transition of the labor market requires new jobs and new businesses to appear. Cities must have an active policy to attract those investments and existing businesses that fit the vision of the city. Furthermore, cities must create a climate in which startups can flourish. This requires getting rid of unnecessary and counter productive regulations to pave the way for new and smart solutions. Startups can be facilitated by providing office space and facilities, by financial stimulation or by making available ‘open data’ as foundation for new smart solutions.

Private-public ecosystems – Smart cities require ecosystems of public and private parties to co-create smart solutions that are really new and creative and differ from traditional solutions. In such an ecosystem, neither of the participants has top-down control. Instead, parties are working together to create a result that has value for them all. The ecosystem has the power to deliver creative new solutions that neither of the parties could have realized on its own. In these ecosystems, the role the of government is to identify the areas that have potential but lack sufficient new initiatives and to play an active role to gather parties that normally do not work together in a new creative ecosystem.

Projects & Solutions – Cities should invest both in new disruptive technologies as in human and social capital. A smart city requires smart infrastructure used by smart people. Technological innovations must be combined with social innovations to create sustainable solutions. Examples of such social innovations are: new collectives, self organization, co-creation and the sharing economy. Smart city initiatives typically start as sectoral, small scale and experimental. This phase is necessary to learn, to deepen insight and to iteratively improve the solutions. However, each small scale initiative must be based on a scalable business model that allows piecemeal success to be broadened to city scale quickly and efficiently and without having to change the solution. Initiatives that are not based on a scalable business model will most likely never get out of the pilot phase.

“The ecosystem has the power to deliver creative new solutions that neither of the parties could have realized on its own.”

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Smart City Development Stages (1/4)

Smart cities do not emerge overnight but develop over the years. During this development process, cities grow from early maturity phases to fully developed maturity stages. The maturity model is used to assess the current maturity and to set goals for the aspired maturity.

- Strategy & Vision
- Projects & Solutions
- Data
- Technology
- Skills & Competences
- Attractiveness
- Openness
- Ecosystems

The maturity model on the next pages distinguishes four development stages of smart cities: “initial”, “intentional”, “integral” and “transformed”. For each of the eight domains in the capability model, the maturity model defines typical characteristics for these four stages. In general, the maturity of a smart city can not be expressed as one specific stage for all domains. First, the eight domains are often not developed to the same level of maturity. In most cases, some domains are further developed while others may be lagging behind. Second, the actual maturity of a smart city can have characteristics of two adjacent stages, e.g. a mix of some characteristics of level 1 and some characteristics of level 2.

“Initial” “Intentional” “Integral” “Transformed”

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Smart City Development Stages (2/4)

Smart cities do not emerge overnight but develop over the years. During this development process, cities grow from early maturity phases to fully developed maturity stages. The maturity model is used to assess the current maturity and to set goals for the aspired maturity.

	1 "Initial"	2 "Intentional"	3 "Integral"	4 "Transformed"
Strategy & Vision	• Unconnected fragments of a smart city vision are found in some departments. • Strategy fragments have an operational focus, such as increasing efficiency. • Strategy development is an internal activity of city government. • No clear image of what the city wants to be in the long term. Highly driven by technology push. Act as living laboratory. • Consequences of innovations like Airbnb or Uber overtake city government.	• Cross-departmental vision and strategy emerges with key stakeholders aligned around it. • Strategy focus shifted from internal efficiency to user-centricity. User demands are driving the digital transformation. • Increasing awareness of the need to involve users in strategy development. • Fragmented image of what the city wants to become. Counterweight to technology push is growing but not yet mature. • Partial response of the city to innovations like Airbnb and Uber.	• Integral citywide vision and strategy based on a thorough assessment of strengths, opportunities and challenges of the city. • User-centric strategy becomes increasingly focused on transforming business models. • Users and stakeholders are consulted to provide input for strategy development. • Clear vision on the cities long term future. City priorities are driving the investment portfolio. • Balanced and effective response of the city to innovations like Airbnb and Uber.	• Vision and strategy are subject to continuous optimization in an agile environment, based on measurement/data of realized benefits • Successful realization of the user-centric strategy to transform business models. • Users and stakeholders are actively involved in strategy development through co-creation. • Strategic investments have clear impact realizing the long term vision. • City is able to act pro-active, fast and effective to innovations that impact the city.
Projects & Solutions	• Ad hoc, department based projects driven by technology push and random initiatives. • In general, experimental by nature. • Mainly small scale pilot projects and proof of concepts to prove the business case for further investment. • Project execution and monitoring is subject to classic project-bureaucracy.	• Cross-departmental projects emerge but still in an opportunistic way. • First projects go beyond the pilot phase and scale up to city wide use. • First attempts to execute innovation projects in an agile way.	• A cohesive citywide portfolio of cross-departmental projects delivers recurring success. • City wide foundational technology, processes and standards emerge. • Benefits tracking is in place.	• Initiatives are characterized by agility and focused on innovation. • Continuous improvement of service delivery brings competitive advantage. • Superior outcomes that deliver differentiation.

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Smart City Development Stages (3/4)

Smart cities do not emerge overnight but develop over the years. During this development process, cities grow from early maturity phases to fully developed maturity stages. The maturity model is used to assess the current maturity and to set goals for the aspired maturity.

	1 "Initial"	2 "Intentional"	3 "Integral"	4 "Transformed"
Data	• Data is collected in the context of traditional city processes / responsibilities only. • Data is used for the delivery of a particular service and not re-used for other purposes. • Basic analysis of data in the form or simple reporting on isolated data sets. • Data is stored in disparate systems and is difficult to access and combine. • Some data sets are opened to the public, but only historic data (no real-time data). • Data quality of open data is not guaranteed, no mature data management processes. • Policies for data sharing, privacy, anonymization, authorization, charging & monetization etc. are not in place.	• Small scale pilots to collect (IoT) data specific for smart solutions are in place. • Small scale re-use of data to fuel smart solutions and data analytics. • Pilots with advanced data analytics on city data emerge. • Technical solutions (data platform) to combine and re-use data emerge. • Pilots with providing real-time (IoT) data are being set up. • Initiatives to define data management standards and processes are in place • Partners (city and external parties) have identified the need for such policies and initiatives are in place to define them.	• First city wide collection of (IoT) data specific for smart solutions is operational • Data is combined from multiple sources in new creative ways. • Data analytics is applied on combined data sets to provide new insights • Government services and external partners use the data platform for their open data • First city wide examples of real-time (IoT) data are operational • Data management standards and processes are being implemented. • Partners have agreed a first version of data policies and start using them in practice.	• Data fueling the full spectrum of smart solutions is collected. • Data from various sources is used to create a complete visual overlay of the city. • City wide use of mature advanced data analytics (real-time, big data, predictive). • All data is available through a single "data hub" and via open standards. • Open data encompasses full real-time (IoT) data to be used by smart solutions. • Operational data management standards and processes, data quality is guaranteed. • Data by parties in the ecosystem use is governed by agreed data policies.
Technology	• Fixed and mobile internet broadband networks are in place. • Technology architecture is characterized by point solutions for line of business applications. • Limited investments in sensors and M2M networks.	• Shared architectures are deployed on a limited set of services. • Stakeholders are intentionally investing in sensoring technologies. • Dedicated M2M / IoT networks (low bandwidth, high range) are in place.	• City wide implementation of an IoT platform unifying management of all kinds of sensors. • Joint investments plans for city wide deployment of connected assets with multi purpose sensors. • Standards and policies are in place to create integral architectures.	• Cross organizational technology architectures are in place. • Continuous learning and improvement of the joint architecture to support innovation and transformation. • City wide deployment of connectivity infrastructure and sensors networks for all major smart solutions.

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Smart City Development Stages (4/4)

Smart cities do not emerge overnight but develop over the years. During this development process, cities grow from early maturity phases to fully developed maturity stages. The maturity model is used to assess the current maturity and to set goals for the aspired maturity.

	1 "Initial"	2 "Intentional"	3 "Integral"	4 "Transformed"
Competences	• No clear view on the skills and competences that are needed to execute the digital strategy successfully. • Smart city initiatives are executed with existing skills and competences.	• Required skills and competences are pinpointed and a plan is in place for developing the workforce capabilities. • Efforts mainly directed at equipping existing workforce with new awareness.	• Skills and competences of the workforce are developing but deficiencies still exist at some pockets of expertise. • Efforts are made to develop genuinely new skills: research and analysis, technology skills, agile project management, user experience skills, financial modelling for digital business models and commercial skills.	• City government uses a blend of investment, innovative approaches and external support to secure the right skills and competences. • The next generation of talent is attracted by a workforce strategy that highlights and communicates the impact of the work on the lives of citizens, and by offering employees the flexibility to work creatively.
Openness	• Low appetite for taking risks and experiment. Mechanisms for employee appraisal favor a risk-averse way of working. • Government tends to focus on securing internal buy-in rather than on delivering customer needs.	• Growing awareness for the need to become open for new ideas, experimenting and taking calculated risks. • Government is actively looking for new ideas through competitions, hackathons, etc.	• City wide transition towards an altered attitude to risk and willingness to experiment with new ideas. • New ways of collaboration between departments and with external parties emerge.	• The "fail fast, fail quickly and fail cheap" approach has become part of the organization's DNA. • Ability to learn fast and to adopt new ideas quickly.
Ecosystem	• Siloed internal organization with respect to smart cities. • Private parties purely in the role of technology vendor. • Attempt to match technology push with existing city policies.	• Internal and external collaboration is growing. • Government is still organized in the traditional way, but becomes conscious of its assets (e.g. data) and open for new ways of working together with external parties.	• Government is becoming part of creative public-private ecosystems in which neither of the participants has top-down control. • Parties in these ecosystems are working together to create a result that has value for them all.	• The new way of working in creative ecosystems has transformed the government organization itself. • Government is successfully acting according to its new roles (see page xx)

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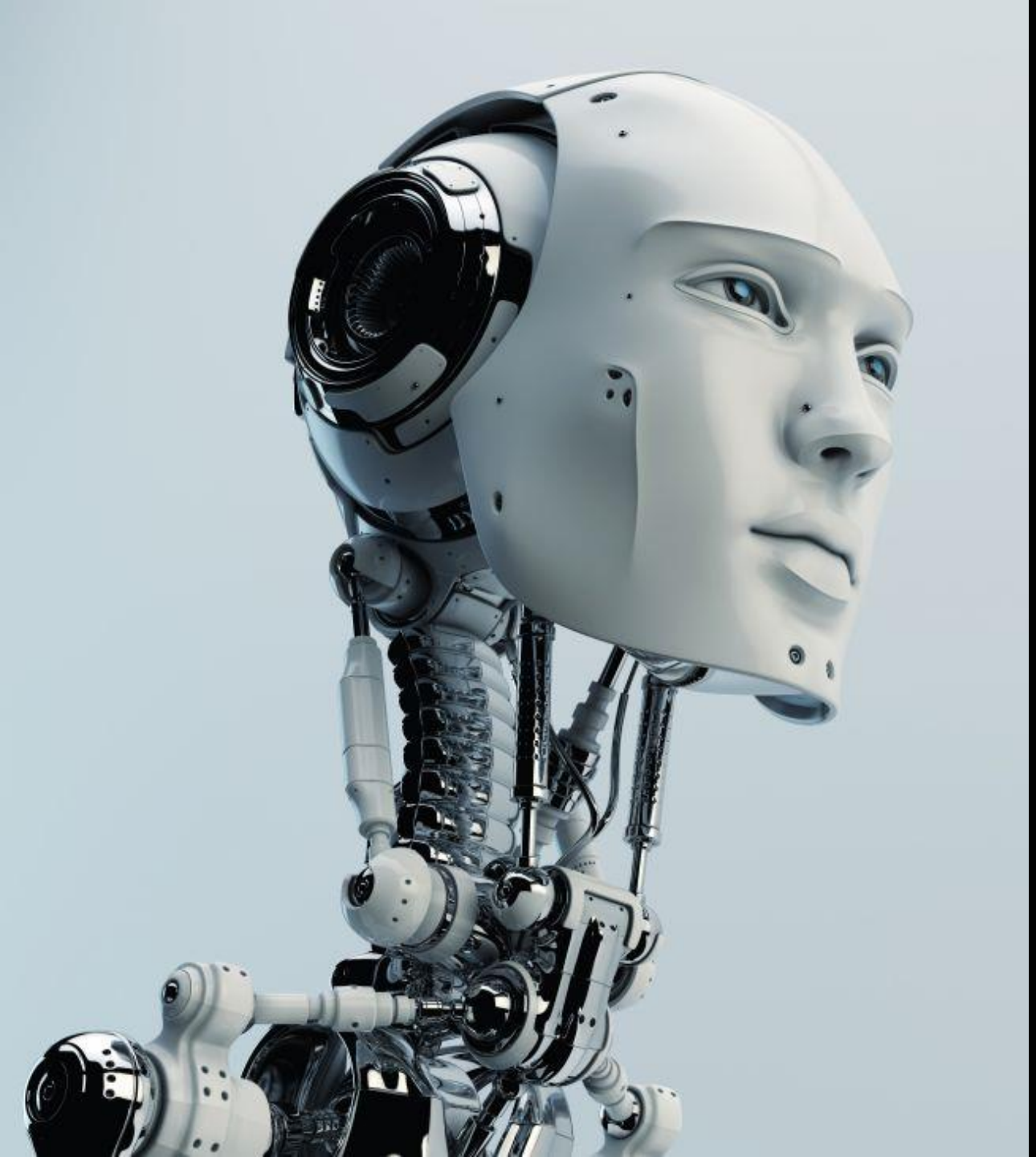

4. Disruptive technologies

Smart solutions are fueled by disruptive technologies and social innovations

Most new technologies and social innovations are disruptive on their own. The combination of them is even more powerful and creates a ‘perfect storm’ of disruption.

Cloud - on-demand access to rich application functionality and computing power allow for exponential scalable solutions in a “pay-per-use” model

Mobile - ubiquitous mobile internet, powerful mobile devices and apps with intuitive interfaces act as front end for many innovative solutions

Social media & Digital platforms – use digital technology to connect people in new and powerful ways forming the basis of new collectives and communities

Big data - large volumes of highly volatile and rich data (structured data, sensor data, audio, video, social media) form the lifeblood of smart solutions

Artificial intelligence - cognitive systems combine machine learning with the ability to interact via natural language and create insight from data

Internet of things - physical objects equipped with advanced sensors and connectivity transform into smart objects and generate a plethora of data

Robotics and drones – social robots and drones replace human labor on a large scale, not only for routine work but increasingly for providing services

3D printing - additive manufacturing allows for efficient production of unique products where and when they are needed

Blockchain - algorithm that facilitates registering transactions in an indisputable way without the use of an intermediary or a central administration

Renewable energy – New sources of energy like photo voltaic cells and energy from wind and water are an alternative to large scale generation based on fossil fuel.

Co-creation - an initiative that brings together parties to jointly create a mutual valued outcome. In the context of smart cities, these are (communities of) citizens, private companies, knowledge institutes and public organizations that form an ecosystem to solve societal problems in a creative way.

Crowd sourcing - the process of obtaining needed services, ideas, or content by soliciting contributions from a large group of people, and especially from an online community, rather than from traditional employees or suppliers.

Sharing economy - using information technology as an enabler to bring together supply and demand in new ways. Use digital platforms to share and reuse excess capacity in a variety of goods and services.

Gamification - the use of game thinking and game design elements (competition, levels, leaderboards, badges, etc.) in non-game contexts. The objective of gamification is to stimulate people to change their behavior. In a desired way.

Self organization - a process where overall order and coordination arises out of the local interactions between people in an initially disordered system. It is spontaneous and not necessarily controlled by any auxiliary agent. The resulting organization is wholly distributed and typically robust.

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Mobile – The second wave in the digital revolution

Mobile devices marked the second wave in the Internet revolution and act as the platform for many smart solutions being the most personal and disruptive of all consumer devices

What is it and why is it disruptive?

Mobile devices marked the second wave of the Internet revolution, after the first wave connected fixed devices. Today, smartphones are the most successful consumer device ever. In 2015, 1.4 billion units are expected to be sold of which more than 1 billion are purchased to replace an older smartphone. The total number of smartphones sold will be greater in units and revenues than PC, television, tablet and game consoles combined.

Of all consumer devices, the smartphone is the most personal one. It is the device that people always carry with them, the device that mostly reflects the users personal choice, the device that contains the most personal information and therefore the least likely to be shared, and it is the device the most frequently looked at. The instant-on, always-connected nature, combined with its form factor and intuitive interface caused smartphone to be among the most disruptive devices ever.

Todays smartphones have unparalleled capabilities. The computing power of a single Apple iPhone 6S is 71x faster than the first iPhone and outperforms the Cray-2 supercomputer built in 1985 many times. But computing power alone is not driving the smartphone as one of the most versatile platforms ever, it is the wide array of sensors that is built in. For example, a Galaxy S6 is equipped with the following sensors:

- *Accelerometer* to sense movement of the device
- *Ambient light* to sense the brightness of the light surrounding the device
- *Barometer* to sense pressure
- *Camera* to visualize the environment of the device
- *GPS* to track the geographical location of the device
- *Gyroscope* to sense the orientation of the device
- *Magnetometer* *to* sense the magnetic field to operate the device's compass
- *Microphone* to sense sound reaching the device
- *Proximity sensor* to sense when someone is close to the device
- *Temperature* to sense the temperature around the device

Source: Deloitte Technology Media and Telecommunications Predictions 2015

Location Aware Services

Mobile applications that use information about the geographical location of a device to provide location-aware functionality. The trend scores high on the transformational impact on the business and companies will use it for new types of services. However, these new types of services require more than just the use of the technique alone. Genuine innovation will spring from the companies' imaginative power.

Bring Your Own Device

A strategy that allows users to select and purchase their own mobile devices from which they can use enterprise applications and data. A major driver for BYOD is Consumerization; the trend of innovations starting in consumer technology followed by companies taking advantage of these innovations by embracing them for enterprise use. Most companies introduce BYOD to achieve higher employee satisfaction and higher productivity.

Context Enriched Services

Context-enriched services are applications and services that combine information about the user with all kinds of situational information to offer context aware experiences. It includes proactively pushing content to the user to suggest products or actions that may be attractive to the user in a particular situation.

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Digital platforms – Business model disruptor

Digital platforms connect supply and demand in ways that were never possible before and disrupt markets

What is it and why is it disruptive?

The emergence of digital platforms like Booking.com, Uber and Airbnb caused a disruption in each of their respective markets. None of these digital platforms own assets like hotels, planes or taxis, but they connect supply and demand in ways that were never possible before.

- In the first place, digital platforms provide full transparency in supply (quality, price) allowing customers to find the best matching offer without help from an intermediary. In addition, these digital platforms provide mechanisms for rating the service and giving feedback provides valuable information for potential customers.
- Second, digital platforms provide smooth and intuitive booking, fulfilment and payment processes, taking much of the administrative burden from the hands of suppliers. This makes it easier for new suppliers to become active on the market. For example: the presence of a digital platform like Airbnb lowers the threshold for home owners to rent out their house, hereby increasing the supply significantly.

In short, digital platforms disrupt markets in three ways:

- **Lower transaction costs** – Digital platforms automate the entire process between customer and supplier, making all kinds of traditional intermediaries unnecessary. They provide convenience to both customers and suppliers.
- **Augmented supply** – Digital platforms lower the threshold for new suppliers to become active on the market, augmenting the supply side of the market.
- **Exponential scalability** – Digital platforms do not own assets like hotels and taxis, and are therefore exponential scalable. Parties like Uber, Booking.com and Airbnb have been able to gain relatively large market shares in only a couple of years.

Booking.com

Only ten years ago, people used the services of a travel agency for booking travel arrangements. This market has been totally disrupted by digital platforms like Booking.com, Tripadvisor and Expedia. With only a few clicks, customers book hotel accommodation, plane tickets and rental cars, leaving all administrative handling to the digital platform.

Booking.com

airbnb

Airbnb

Airbnb transforms private homes into hotel rooms. Home owners can rent out their house to travelers from all over the world, leaving all administrative handling and payment processing to the digital platform. In The Netherlands, Airbnb was responsible for 4,2 million nights, compared to 28,5 for all traditional hotels combined.

Uber

Uber provides real time matching of private drivers with citizens looking for a ride. The digital platform and app connect supply with demand and arranges the full payment process and rating process. To balance demand and supply, Uber uses dynamic prices (‘surge pricing’) that are higher when demand exceeds supply.

UBER

Source: ING Economisch Bureau, Hotels en de deeleconomie

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Internet of things (1/4) – The third wave in the digital revolution

A city with a digital overlay generates massive amounts of data to fuel all kinds of smart solutions

What is it and why is it disruptive?

The Internet of Things (IoT) refers to the massive use of advanced sensors and wireless communication in all kinds of physical objects. The wide scale use of sensor technology creates massive volumes of data providing a fine grained digital view on the physical world. This data can be used by smart systems that optimize the use of infrastructure and resources.

The IoT marks the third wave in the development of the Internet. The first wave provided fixed connections to the Internet, the second wave connected a much larger number of mobile devices to the Internet. The third wave connects a plethora of things to the Internet, creating a situation where the vast majority of all IP addresses in the world belongs to objects instead of persons.

Why now?

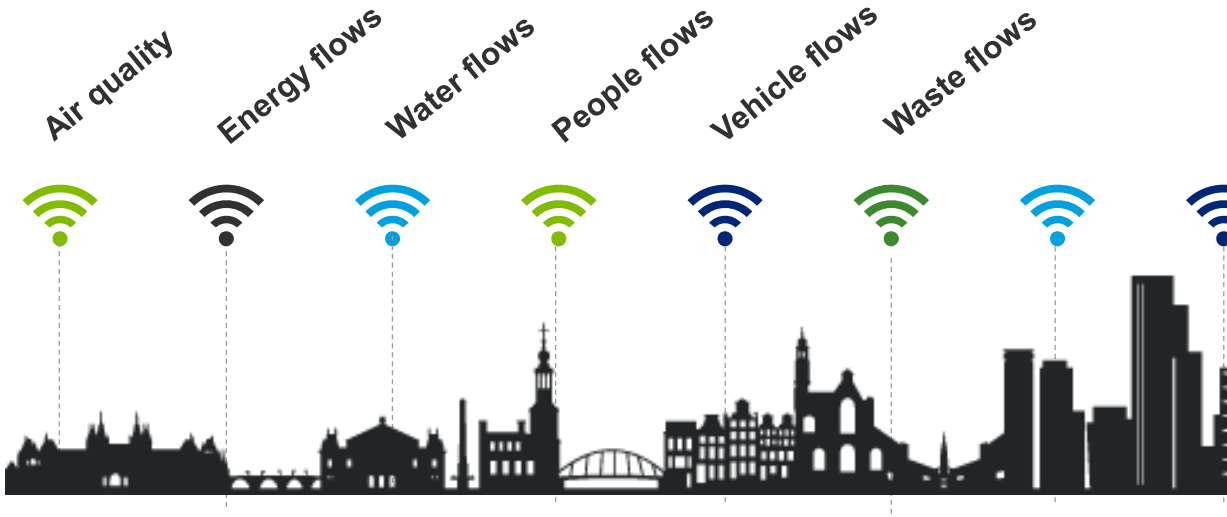
The concept of connected objects is not new, but a number of developments have come together to enable an exponential rise of IoT. These are:

- **Price erosion** – The price of sensors has been dropping in the past five years and is expected to remain decreasing with 5% per year in the next years. This allows large scale use of sensors in an economically feasible way.
- **Ubiquitous wireless coverage** – Sensors require access to wireless networks to make the data available for processing. Ubiquitous wireless coverage is now available, even through different types of networks (WiFi, 3G/4G and LoRa).
- **Abundant processing and storage** – The big data that is generated by billions of sensors needs to be stored and processed. The capacity of processing power and bandwidth has increased and keeps increasing in an exponential way. Due to this, the capacity required for the back end solutions is in place.
- **IPV6** – The newest version of the Internet Protocol allows for an almost unlimited number of unique IP-addresses that can be assigned to identify any conceivable IoT device.

Example: smart lampposts

The lamppost is the most valuable real estate asset in the city for the purpose of installing sensors that form a city wide IoT backbone. Of all objects, lampposts are best distributed across the entire city and they already are connected to power networks.

There are **116.000** lampposts in Amsterdam.



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Internet of things (2/4) – A multitude of sensor types

“Anything that can be connected, will be connected”; 22 examples of sensor use

1. **Air** – Sensors that detect the level of air pollution in urban areas to take appropriate measures that protect peoples health.
2. **Athletes** – Sensors that use an accelerometer and gyroscope are used to detect the severity of a hit to the head, which can be used by the coach to decide to pull athletes off the field to check for concussions.
3. **Buildings** – Sensors that monitor vibrations and material conditions in buildings, bridges and historical monuments provide ‘early warnings’ in case of damages.
4. **Distribution vehicles** – Sensors that detect the geographical location of each vehicle in a fleet are used to optimize routes and create accurate estimates for delivery times.
5. **Energy usage** – Sensors that monitor energy usage can be used to verify the energy efficiency of “green building” and gain insight in further improving this efficiency.
6. **Green houses** – Sensors that detect the micro-climate in terms of temperature, humidity and CO2 level are used to maximize the production of fruits and vegetables.
7. **Gunshots** – Sensors that detect the sound of a gunshot are used to pinpoint the location with an accuracy of 10 meters in real time and dispatch police to that location immediately.
8. **Hazardous gases** – Sensors that detect levels of explosive or toxic gases in industrial environments and indoor locations allow immediate action to secure the safety of people.
9. **Health** – Sensors that measure vital metrics such as blood pressure and heart rate, are used to monitor patients as they live their lives. The data is used to decide when the next visit to the doctor is necessary and to improve patient adherence to prescribed therapies.
10. **Item location** – Sensors that detect the geographical location of an object are used to track objects to save valuable time searching for them.
11. **Machines** – Sensors that monitor the state of machine parts, e.g. by measuring temperature, pressure, vibration and wear generate detailed data that can be used for condition based maintenance; applying maintenance when it is needed instead of in regular intervals independently from the status of the machine.
12. **Noise** – Sensors that monitor noise levels generated by entertainment venues in real-time allow rapid interventions when permissions are violated.
13. **Parking spaces** – Sensors that detect variations in magnetic fields generated by parked cars are used to detect whether a parking space is free. The information is used to guide people looking for a car space to the nearest free space.
14. **Perimeter access** – Sensors that detect people in non-authorized areas are more efficient than human security guards and can trigger immediate action on the right location.
15. **Public lighting** – Sensors that detect motion of people and vehicles in a street and adjust the public lighting to the required level.
16. **Rivers** – Sensors that detect river pollution e.g. caused by leakages of chemical plants in real-time allow for immediate actions that confine the damage to the environment.
17. **Roads** – Sensors that detect the temperature of a road to provide early warnings to drivers in case of slippery road due to e.g. ice.
18. **Storage conditions** – Sensors that monitor storage conditions of perishable goods such as vaccines and medicines measure temperature and humidity to secure the quality of products.
19. **Storage incompatibility** – Sensors that detect objects (e.g. dangerous goods) that are not allowed to be stored together. e.g. inflammable goods and explosives. Or in hospitals, the presence of blood for patient X in the operating room where patient Y is having surgery.
20. **Traffic** – Sensors that detect the speed and the number of vehicles using public roads are used to detect traffic congestion and suggest drivers to take an alternative route.
21. **Waste** – Sensors that detect to what extent a rubbish container is filled, to optimize the trash collection routes and to prevent trash being deposited on the street of a container is full.
22. **Water** – Sensors that detect water leakages in the water distribution network are used to align the maintenance schedule to the actual loss of water.

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Internet of things (3/4) – Example

"The most connected office space in the world" - Bloomberg

The Edge, in Amsterdam, is not only the greenest office building in the world, but also the most connected one. It is a living lab for innovative applications of the Internet Of Things in office environments.

The building has a floor space of 40.000 m^2, houses 2.500 people and is equipped with **30.000 sensors**. The majority of these are integrated in a revolutionary new lighting system consisting of 6.000 luminaires. The LED lighting is connected via Ethernet cables only, providing both Power over Ethernet and IP network connection. Each luminaire has its unique IP-address and is equipped with sensors for infrared, ambient light, temperature and humidity. Smart apps can be used to define personal preferences for temperature and lighting. When the sensors detect a user, the lighting and cooling at that spot is automatically adjusted.

During the day the sensors detect the intensity with which each part of the building is used. At the end of the day, this data is visualized in a heat map used by the cleaning staff to focus on areas that have been used most.

Next to the thousands of sensors in the smart ceiling, sensors are used in all kind of objects, such as coffee machines and towel dispensers. The data that is generated by these objects is used by facility services to refill just in time. All smart solutions contribute to energy efficiency, security and convenience.

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Internet of things (4/4) – IoT at home: smart devices

Sensors and wireless connectivity are installed in all kinds of devices to make them adaptive, responsive and intelligent

What is it and why is it disruptive?

The combination of all kinds of devices with intelligent sensors and wireless communication creates ‘smart objects’ with new functionality that adapt their behavior to the context they are used in. Complex networks of smart objects, communicating with each other and with intelligent cloud systems, emerge. These new possibilities are the source of a plethora of new products. Furthermore, suppliers will try to change their business model to generate new income streams from subscriptions to value added services, provided through intelligent cloud systems (apps) connected to the smart object.

One of the disruptive effects of the Internet of Things is the fusion of information technology with other technologies, like consumer technology, medical devices or vehicles. A self driving car is both car technology as information technology.

Results of a CIO survey

In a Technology Trends survey among leading CIO’s, Deloitte and CIO Magazine (NL) asked the CIO’s to respond to the thesis “*In the future, the Internet of Things will impact our products and services significantly*”.

71% of all respondents answered positively (22%: strongly agree, 49%: agree)

“By 2022, a family home in an affluent, mature market will contain over **500** smart devices.” - *Gartner*

First examples - Nest

Nest, acquired by Google, produces common household objects, like thermostats, that have been made ‘smart’ by a Wi-Fi connection and apps to visualize sensor data and to control the object.

Gartner predictions:

- By 2022, the falling cost of adding sensing and communications to consumer products will mean that a family home in a mature, affluent market could contain several hundred smart objects. These will enable a wide range of new digital business opportunities.
- The number of smart objects in the average home will grow slowly for at least a decade. However, although a mature smart home won't exist until 2020 to 2025, smart domestic products are now being manufactured. The first digital business opportunities they enable have already emerged.
- Any organization manufacturing a domestic product for home use costing more than $20 should brainstorm how it could be differentiated or made more valuable by becoming smart and networked.

Source: Gartner, The Future Smart Home: 500 Smart Objects Will Enable New Business Opportunities

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Big data

Large volumes of rich data (structured data, sensor data, audio, video) form the lifeblood of smart solutions

What is it and why is it disruptive?

One of the most heard buzz-words is ‘big data’. In contrast to the name, this does not simply refer to large data sets. We define Big Data as data too large to be processed by traditional database management and analysis tools. Three characteristics are:

- **Volume** - Too large for traditional databases, data warehouses and analysis tools. Typical examples are: click-stream data, sensor data, location data of mobile devices, surveillance camera data, medical images data, etc. In general, big data requires a distributed approach with parallel software running on large numbers of servers.
- **Velocity** - Rapidly changing data, for example a stream of online sales transactions or real-time data of clicking behavior on websites.
- **Variety** - Heterogeneous content, for example a combination of structured data from enterprise systems, data captured from social media, sensor data and video data from surveillance camera’s. In general, big data is assembled from multiple sources: data that is generated by the own organization, data that is provided by partners and data that is harvested from the public Internet.

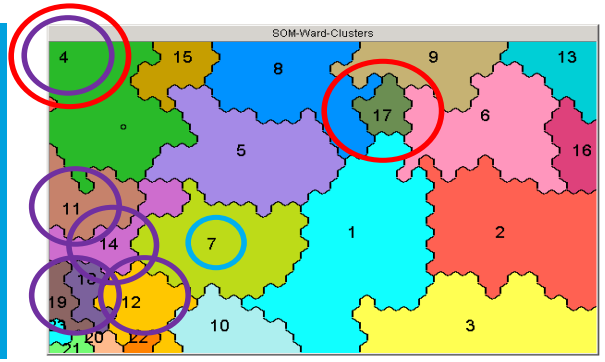
Results of a CIO survey

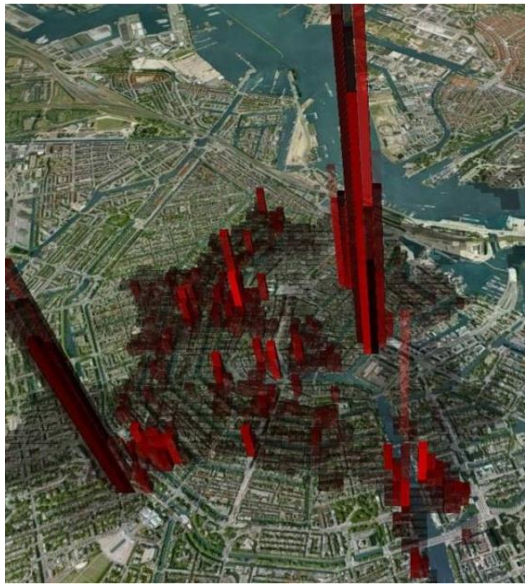
In a Technology Trends survey among leading CIO’s, Deloitte and CIO Magazine (NL) asked the CIO’s to respond to the thesis “*Big Data and Analytics have much more potential for my organization that currently realized*”.

86% of all respondents answered positively (34%: strongly agree, 52%: agree)

Advanced analytics

Advanced analytics on enterprise data is applying statistical techniques on complex data sets to find patterns and correlations between variables. Typical examples are: outlier detection, clustering, pattern recognition and link analysis.





Source: www.flowingcity.com

Advanced visualization

Visualization techniques extending beyond traditional graphs and charts and with interactive features. It combines information technology, psychology, graphic design and art. The approach builds on human qualities like pattern recognition and interpretation of color, brightness, size and motion. Fine grained sensor data of a city can be visualized as an overlay on geographical maps to be interpreted by humans easily. If done in real time, sensor data can be used to identify early warning signals and take the necessary interventions.

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Open data

Large volumes of rich data (structured data, sensor data, audio, video) form the lifeblood of smart solutions

What is it and why is it disruptive?

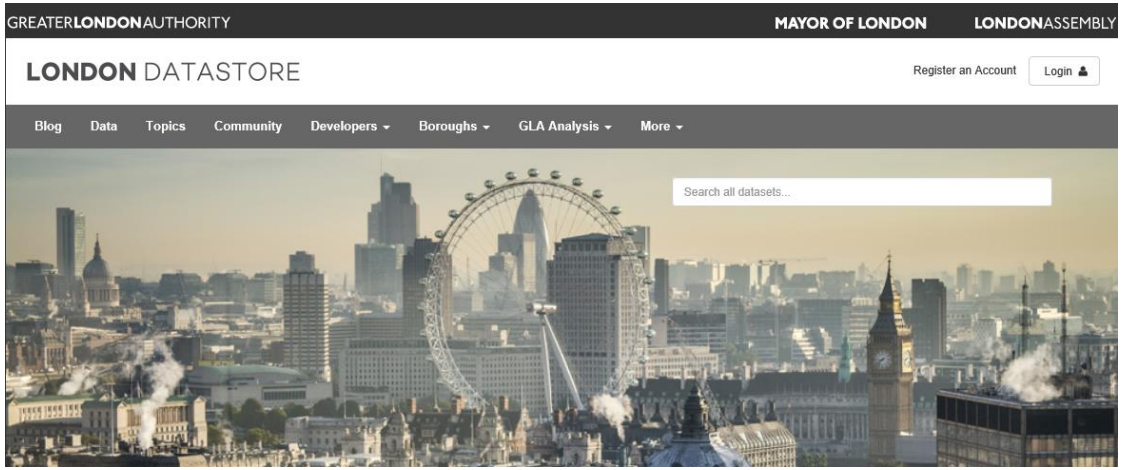
Open data is machine-readable digital data, freely available for everyone to use and republish. The objectives of the ‘open data’ movement are similar to movements like ‘open source’. Major open data initiatives are taken by governments to boost economic growth, for example in the UK (data.gov.uk) and the Netherlands (data.overheid.nl).

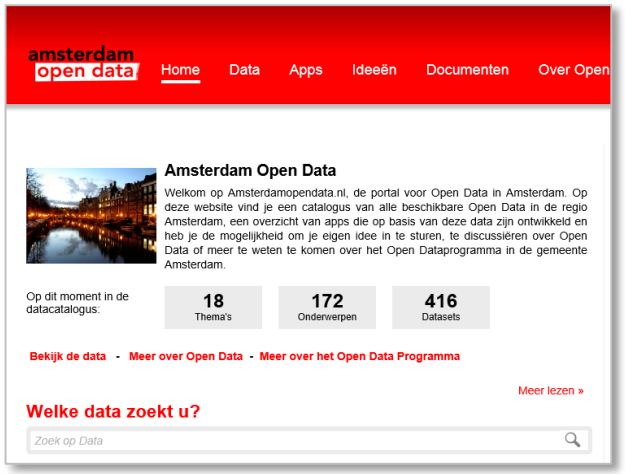
The idea is for companies to improve the quality of their existing services and look for opportunities to develop new services. The trend is not, however, limited to ‘open’ government data. Businesses, too, will open up their data to innovate the way they compete. By releasing parts of their data, companies expect to ignite the creativity of the crowd, to ultimately generate new revenues. This represents a paradigm shift compared to the current practice of keeping all data proprietary.

Data Infrastructure

In a smart city, data is as important as the physical infrastructure. In the past centuries, cities developed carefully thought our mechanisms to manage the physical infrastructure. For data, such mechanisms are either lacking or in its infancy. A data infrastructure is required to maintain data and share data and has the following features:

- **Authority** – The data infrastructure is a credible, authoritative source of data.
- **Transparency** – The data infrastructure is transparent about where the data comes from, how it has been collected and how it has been processed.
- **Openness** – The data infrastructure is open for all users, making the data as accessible as possible.
- **Real-time** – The value of data decreases with its age. The use of IoT generates massive volumes of real-time data which can be made available though the data infrastructure.
- **Agility** – In addition to the previous aspect, agility to update data quickly, the data infrastructure should also be agile to encompass new data sets.





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Cognitive computing

Cognitive systems combine machine learning with the ability to interact via natural language and create insight from massive amounts of data

What is it and why is it disruptive?

Cognitive computing systems interact with humans via natural language. They understand questions from humans and can ask for additional information by asking questions themselves. This allows a whole new type of engagement between man and machine.

- They have *learning and reasoning abilities*, that resemble the capabilities of the human brain. They move beyond calculation based on preconfigured rules and programs.
- With these abilities, cognitive computing systems are able to *deal with ambiguity and uncertainty*.
- They are able to *provide confidence scores*, a quantitative value that represents the merit of an answer. This helps users to make the best possible choice.
- They have the ability to *process massive amounts of data*, which cannot be handled by humans any more. A medical doctor for example is not able to read all medical articles that are published.

Replace or empower humans?

The rise of cognitive systems caused a debate about the impact of these systems on employment. A widely cited article of the University of Oxford estimates that 47% of US jobs is susceptible to being computerized in the next 20 years. However, automating entire jobs or processes is not likely in the near term. More likely is a scenario where parts of jobs are computerized and people will be interacting with cognitive systems, as airline pilots already do today.

The complex decision what to automate

History shows that automation of work is undeniable valuable, but can has unexpected consequences too. Leaving humans with the tasks that could not be automated may create its own problems. People tend to loose their skills if they do not practice them. Here is an analogy with the use of an autopilot in airplanes. If human pilots do not practice flying without the autopilot, they are ill prepared to take over command when the autopilot fails.

The value of human skills changes

As routine tasks will increasingly be automated, the skills required for those tasks will tend to become less valuable and less needed in the workforce. On the other hand, skills that are required for the type of work that can not be automated becomes more valuable. These are the skills to perform loosely defined jobs (common sense, general intelligence, flexibility and creativity) and the skills for successful interpersonal interactions (emotional intelligence and empathy).

Finally, as cognitive systems become able to mimic human skills and automate parts of jobs and processes, the ability of critical thinking becomes more important. Insight always starts with asking the right questions and that is typically a skill that is hard to automate.

IBM Watson

A well known example of cognitive computing is IBM Watson. In 2011, Watson competed on Jeopardy! against former winners Brad Rutter and Ken Jennings. Watson received the first place prize of $1 million.

Source: *Redesigning work in an era of cognitive technologies*, D. Schatsky and J. Schwartz, Deloitte Review 17

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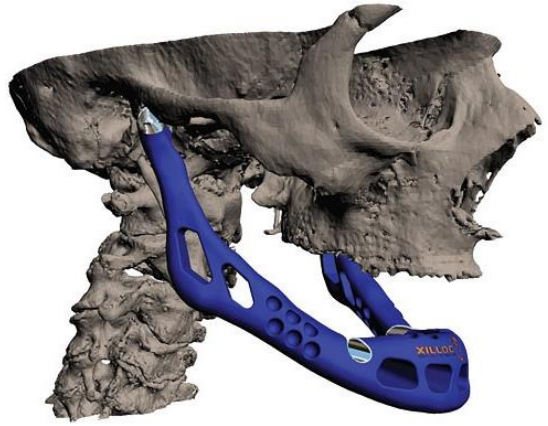
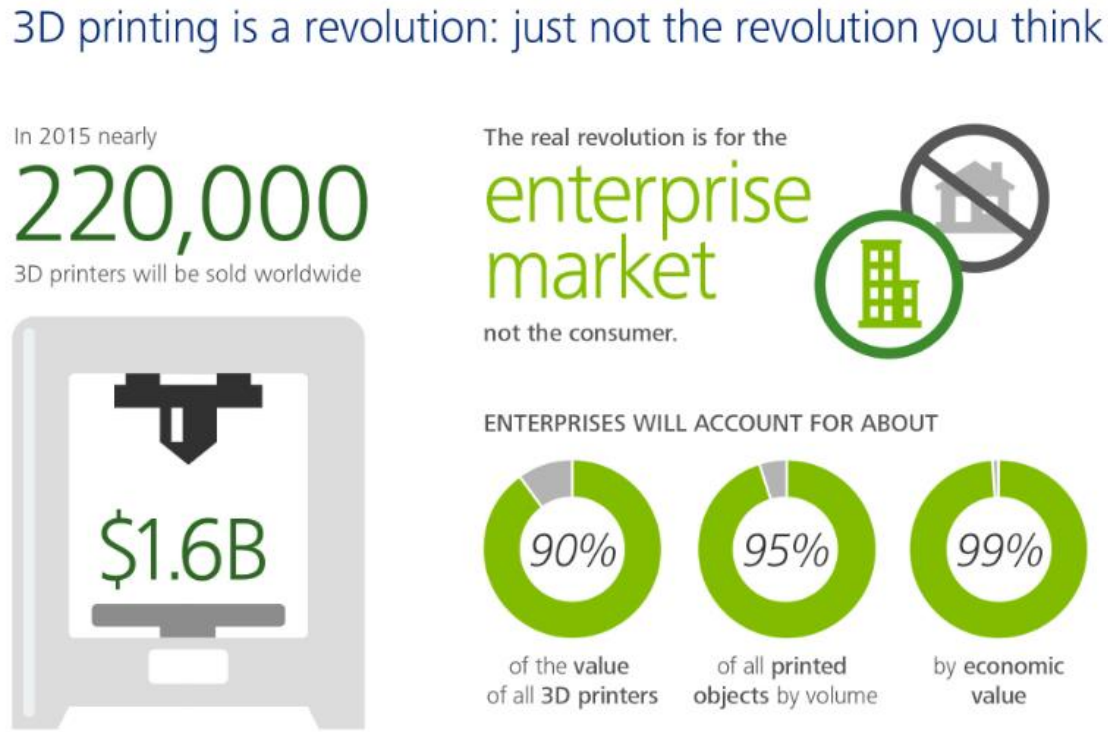
3D Printing

Additive manufacturing allows for efficient production of unique products where and when they are needed

What is it and why is it disruptive?

- A 3D printer uses a digital model to create a physical product through additive manufacturing techniques.
- The traditional production paradigm is based on large batches of identical products. 3D printing makes it possible to economically create one of a kind products and changes the traditional paradigm.
- This allows rapid prototyping, through which research and development cycles can be shortened.
- In the same way, 3D printing makes it possible to create personalized products that are highly tailored to the needs and preferences of customers.
- 3D printing can be used to create spare parts at the time when it is needed and in the location where it is needed, without having to keep large inventories of spare parts and the logistics to distribute them.





Source: Deloitte TMT predictions

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Social Robots

Robots transcend industrial environments as they become more flexible and acquire social skills. Increasingly, they will appear in our daily life environment

Traditional use of robots

Industrial robots have been used for decades already. They are used for assembling products, handling dangerous materials, welding, spray-painting, etc. The total number of industrial robots is estimated at 1,500,000 and is growing with over 200,000 units per year. About 40% of all robots is used in the car manufacturing industry, which has been completely robotized. China currently shows the largest growth and is expected to have more industrial robots than Europe or the United States by 2017.

In their current environments, robots have been successful because they allow lower production costs compared to human labor. They work 24x7, do not get tired and can work more precise and with less errors than humans.

Innovations and relevance for smart cities

The successful use of robots in industrial environments does not make them relevant from a smart cities perspective. There is however a number of innovations that do make robotics interesting from a smart cities point of view. The common denominator of these innovations is that robots become more flexible and acquire social abilities that make them suited for entering the arena of our daily lives with the potential to increase quality of life.

Machine vision - One of the first relevant innovations is 3D-vision and the ability to recognize 3D objects. Traditionally, industrial robots have a fixed position and require the object they work on and the parts they assemble to be in a fixed position too. Robots with 3D vision are fundamentally different as they are able to operate in semi-structured environments which they interpret through visual abilities. As an example: the US postal service installed some 1,000 robots last year to sort parcels. In July 2015, Amazon organized the 'Amazon Picking Challenge' where teams from universities and research institutions competed with robots that use 3D vision to pick the right consumer items from Amazon warehouse storage facilities.

Cognitive and Social abilities – The second major innovation in robotics is robots acquiring cognitive and social abilities. They use artificial intelligence and speech recognition to interact with people through natural langue. Even more, they recognize and respond to human emotions and express their own emotions too.

Potential

Next to the traditional class of industrial robots, a new class of social / service robots emerges. These robots are designed to operate in the same environment as we live in and to assist humans performing all kind of tasks that increase quality of life. Social robots are only in a premature phase. Unleashing the full potential of social robots will probably take decades of research and development. However, the first real life examples are already there.

F.R.O.G. robot guide

The Fun Robotic Outdoor Guide is developed by the University of Twente and designed to operate in semi-controlled environments like heritage sites and zoos. It is an autonomous robot that spots and approaches people, shows them around, answers questions and then moves on to the next group. The challenge of FROG is to understand social clues: which people form a group, are people having a good time, are people lost and looking for direction? In worst case scenario's, FROG can alert security for assistance.

ZORA care robot

The ZORA ('Zorg Ouderen Revalidatie Animatie') robot is based on the generic NAO robot and has been programmed to perform tasks in environments where care is provided to e.g. elderly and autistic children. For example by demonstrating physical exercises, playing games and quizzes and being a companion in walking around. The robot is intended to augment the work of human staff and not to replace them. In 2015, ZORA was the first humanoid robot that has been used in the interaction wit real people. It won the Health & IT Startup-awards in 2015.

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Self driving vehicles

Transforming the way we transport ourselves, potentially eliminating casualties and traffic jams, while freeing up locations currently used as parking space

What is it and why is it disruptive?

A specific type of robotics is a self driving car. This concept goes far beyond the driver assistance tools that are currently added to existing cars (e.g. adaptive cruise control, automated parking). Self driving cars have the disruptive potential to reduce the number of casualties and damages to virtually zero, to eliminate traffic jams and reduce commuting time and to eliminate the need for parking spaces from the city.

How does it work?

Self driving cars are equipped with a range of sensors and intelligent software. At any moment, the car knows its position using maps and sensor data. The sensors are also used to detect objects around the car, it recognizes other vehicles, cyclists, pedestrians, but also unexpected objects on the road. The software uses this information to predict what all objects will be doing next. For example, it will anticipate on another vehicle to slow down speed and on a pedestrian to cross the street. The software then determines a safe speed and trajectory, e.g. by slowing down to yield the pedestrian. Self driving cars will follow traffic rules themselves, but anticipate on other objects not following traffic rules.

Disruptive type of use

Self driving cars do not just replace the current generation of cars, but require a fundamental different type of use, that differs from the current use where everyone owns a car that is not used – and hence occupying parking space - for 90% of the time. This fundamental change will take time as it needs phasing out traditional cars and changing human behavior. However, the advantages seem too large for not realizing this dream eventually.

If the technology of self driving cars is matched with a shift from possession to use, a pool of self driving cars can be envisaged that constantly roam throughout the city and match demand for transportation with mathematical precision. This would reduce the total number of cars with large numbers. Furthermore, as the fleet of self driving cars find parking spaces outside the city when they are not in use, existing parking spaces in cities will be freed up for other purposes.

Google car

Starting in 2008, Google is working on a fully self driving car. They experimented with existing cars modified to become self driving and with a new car designed from the ground up. These prototypes have already driven over 1 million miles on the road.

Volvo Drive Me

Volvo plans a large scale autonomous driving pilot project in which 100 self driving cars will use 50 kilometers of selected roads in and around Gothenburg (Sweden). The project is endorsed by the Swedish Government and aims at establishing insight in technological challenges and feedback from real users.

"Self driving cars do have benefits, but these are relatively weakly linked to the objectives of most cities. It requires government policies to shape the market to achieve the desired outcomes."

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Drones

Aerial inspection and transportation

What is it and why is it disruptive?

Drones are unmanned aerial vehicles that are available as entry-level hobbyist model, but also as enterprise model. The latter usually have six or more rotors, large blades and multiple motors. They can be designed to maximize either payload or weight, being able to carry up to three kilograms or flying over one hour time.

The drone market has benefitted from a number of advances in consumer electronics. The rapid increase in quality of high-definition video enabled its primary use for aerial inspection. The accelerometer and gyroscopes used in drones are bulk-produced for smartphones. The availability of smartphones and tablets to control a drone removed the costs of a separate controller.

Examples

Typical examples of professional use of drones are:

- Energy companies can use drones to inspect wind turbines, which reach tens of meters in the air, removing the need for someone to climb up a structure.
- Building owners can use drones to inspect their buildings, especially the parts of the construction that are difficult to reach by humans, such as the roof.
- Livestock owners can undertake aerial searches for lost animals or even herd them.
- Police forces and rescue units can use drones to complement search and rescue missions, especially by using infrared camera's.
- Geologists can use drones to map unchartered territories, or to survey for oil.
- Off-shore oil rigs can be similarly inspected.
- Archeologists can use drones to make a 3D model of sites and to patrol for looters.
- Television stations can use drones to film footage that would otherwise be hard to reach.
- Finally, drones can be used to distribute medicines in the absence of viable roads.

Inspection of water ways

In The Netherlands, all water ways are under the responsibility of the Water Board. This Water Board started to use drones for aerial inspection of water ways and nature reserves. These areas are in general difficult to access. Before the use of drones, a team of three experts walked for days in an area to make notes and take photos. With a drone, an inspection can be done in an hour and the video material remains available for later use.

First drone delivery

On July 17, 2015, the first drone delivery authorized by the FAA took place in the United States. It was operated by Flirtey, a startup based in Nevada. The delivery took place during the annual free clinic run in a remote area, serving 1,500 patients. Medical supplies were delivered to an airport nearby, then broken up in smaller packages and taken by the drones to the Wise County Fairgrounds where the supplies were needed.

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5. Transformational changes in economy and society

Smart Mobility (1/2)

Smart mobility solutions aim at reducing congestion and fostering faster, greener and cheaper transportation options. They vary from solutions that optimize the current transportation system to solutions that create whole new transportation systems, based on a different paradigm.

- **Smart Parking 1** – Finding a free parking space in a large city is often difficult. Smart solutions can be used to optimize the use of parking spaces. Each parking space is equipped with a sensor that detects whether a car is parked on it or not. The data is used to provide drivers with real time information on the nearest free parking spaces and their price (alternatives). This eliminates the need for driving around looking for a free parking space. Furthermore, if there is no free parking space at all, drivers can decide to change their plans and look for other options (e.g. other time, public transport).

- **Smart parking 2** – Privately owned parking spaces of offices and businesses are often used only part of the time, typically on working days and during office hours. Outside these hours, there is a great potential for making additional parking space available through smart solutions, based on an online reservation system. This allows new forms of public-private partnerships, e.g. by making the parking space of a business available for visitors of a theater or museum in the evenings and weekend.

- **Peer to peer ride services** – This solution taps into the potential of unused vehicles and uses digital platforms and smart apps to allow individuals to sell rides to people requiring transportation. Typical examples are Uber and Lyft, which have grown exponentially due to their nature of asset less digital platforms. These solutions contribute both to convenience and to reduced congestion.

- **Personalized transport information** – Technology and data can be used to provide real-time and fully personalized transportation guidance. Smart solutions use a combination of time tables and IoT data of public transport to find the optimal way of traveling. Location aware apps calculate the distance and walking time to the train, bus of metro station, to advise the user on the best time to start walking. If the user is not familiar to the route, real-time navigation instructions are provided on the app.

- **Smart traffic control** – Real time and fine grained data of the traffic flow in the city, created by sensors in infrastructure and vehicles, allow intelligent systems to optimize the traffic flow by adjusting traffic lights and other signals. These traffic control systems can also be used to guide emergency services like ambulances smoothly through the traffic by finding the fastest route, keeping bridges closed and adjusting traffic lights.

Smart Mobility (2/2)

- **Adaptive connected cars –** Modern cars are already equipped with many computerized systems to increase convenience and safety. Some of these systems even automate manual actions like parking the car. In the future, autonomous and connected cars can contribute to a smoother traffic flow by optimizing their behavior. When vehicles become automatic, safety distances between cars can be reduced which will increase the capacity of the road.

- **Shared self driving cars** – The use of self driving vehicles can be combined with the principles of the sharing economy to establish a large reduction in the total number of cars and parking spaces in the city. In this scenario, people do not own a car but have a subscription to transportation services. If they need transport, they use a location aware app to arrange for it. An intelligent system allocates the nearest available self driving car to the user and picks up the user. If the demand for transportation is low, the cars automatically park in parking spaces outside the city. This frees up the majority of parking spaces in the city.

Smart Safety

Physical safety is a critical hygiene factor for thriving economies and happy people. New technologies can improve public safety and save lives.

- **Smart street lighting** – Not only can smart street lighting reduce energy consumption, it can also add to the safety of citizens. Street lights could for example become brighter when movement is detected, so it becomes clear from a distance that traffic is approaching. Another example is to use street lights to indicate when an ambulance or fire truck drives through (e.g. by changing the color of the light), which could save time and in turn save lives.
- **Drones for risk assessment** – It is an unacceptable risk to send police officers or fire rescue workers into harm's way without knowing what danger lies ahead. By the use of drone technology, it is possible to gather images to assess the danger before sending in human beings. Drones can also help find fires, stop police ambushes, quickly search accident and crime scenes, and even detect heat.
- **Data-based crime prevention programs –** Big data analysis can be used to determine the most likely causes of increased prevalence of crime in certain areas. These insights can be used by governmental agencies to target campaigns specifically on those neighborhoods and causes. A similar approach can be followed for individuals to prevent recidivism.
- **Predictive policing** – Data analytics, combined with techniques like real-time facial recognition and license plate scanning, can be used to find out where a crime is most likely to take place on a specific day and time. These insights can be used to focus police officers patrols to areas with high likelihoods of crime.
- **Emergency apps** – Smart apps can be used by citizens to send an alert in case an emergency, either medical or criminal, happens. The apps automatically detects the locations, possibly augmented with audio or video recorded by the app. The smart solution connected to the app notifies the nearest safety guards/police officers or the central police station.
- **Identifying gunshots** – A city wide network of acoustic sensors on the rooftops of buildings can accurately detect gunfire. If a gunshot is detected by ten sensors, the exact location of the gunshot can be determined immediately, even before the gunshot is reported by bystanders. Practice shows that actual detection rates can be as high as 95 percent.

Smart Energy (1/2)

Smart energy aims at greener energy generation, lower energy consumption, an energy consumption pattern with flattened peaks, and a resilient distribution grid.

- **Distributed generation with renewable sources** – Traditionally, electricity is generated by large scale conventional plants based on fossil fuel. A proportion of this will be displaced by distributed generation based on renewable energy sources such as solar panels or wind mills. Contrary to the current situation (few plants with very high capacity), this will lead to a situation where electricity is generated by a large number of nodes, of which many have a relatively small capacity. Conventional capacity will still be required as stand-by for situations where renewable power sources cease to generate power though.

- **Smart grids** – Transmission and distribution networks will evolve to what we call smart grids. These next generation electricity grids are designed to be bi-directional; nodes can produce and consume electricity. Furthermore, smart grids do not only transport energy, but also data enabling end-user energy management.

- **Microgrids** – A microgrid is a local grid, with local sources of energy and local loads, that can operate as part of the nation wide grid but also on a stand alone basis, disconnected from the nation wide grid. Microgrids contribute to resilient smart cities and help reducing energy losses in transmission and distribution, increasing efficiency of the energy delivery.

- **Smart metering** – A smart meter records consumption of electric energy in intervals of one hour or less and communicates this data to the utility company. This allows utility companies to introduce price differentiation based on the season and the time of day. This encourages consumers to change their energy consumption especially when demand is at peak level.

- **Lower usage through gamification** – The data generated by smart meters can be used to create detailed insight in energy usage patterns. This data can be used by smart apps that use concepts like gamification to make consumers more aware of their energy usage and influence them to change their behavior to decrease their energy consumption.

- **Responsive devices** – Another solution to decrease energy demand at peak times is to make household appliances responsive. These responsive devices (e.g. washing and drying machines) temporarily stop consuming energy when demand for energy (and prices) increase. This lowers the peak levels in electricity demand, which decreases the need for expensive stand-by capacity that is only needed in case of peak usage.

Smart Energy (2/2)

- **Seasonal Thermal Energy Storage (STES)** – Most office buildings in cities produce excess heat during summer season. This heat can be stored underground in summer season and pumped back up during winter season. This way energy consumption can be reduced by recycling heat which is produced in the past.
- **Excess heat use** – Many facilities in the city create heat that can be used for other purposes. By using this excess heat for to warm water used for heating of buildings, energy can be saved. A typical example is to use the excess heat generated by data centers to heat greenhouses in the vicinity.
- **Electric Vehicle Charging** – The amount of electric vehicles used in cities is growing and expected to grow faster in the future. All these vehicles contain a battery, a high amount of such batteries result in a potentially significant energy storage capacity. This provides an opportunity to store energy during production peaks and to provide additional energy during consumption peaks. Such potentially significant storage capacity enables smart cities to use energy more efficiently.
- **Power of combining** – Even though the impact of each individual aforementioned technological development in energy markets is significant, the true power of them is their combination. Microgrids require distributed energy sources to prevent power failures as a result of consumption or production peaks. Responsive devices and electric vehicle charging will only have a positive effect on consumption patterns if smartgrids tell them when energy surpluses and shortages exist on the energy grid. The list of such interdependencies is endless.
- **Cooperation in energy markets** – In order to achieve the benefits of combining technological developments as effectively as possible companies and governments need to work together. Cooperation between companies and governments is required to develop regulations that supports the transition which the energy market is going through. Cooperation between companies is required to align technological developments. Standardization helps significantly in this regard by connecting companies. (e.g. in connecting a smart meter to responsive devices in a household).

Smart Water

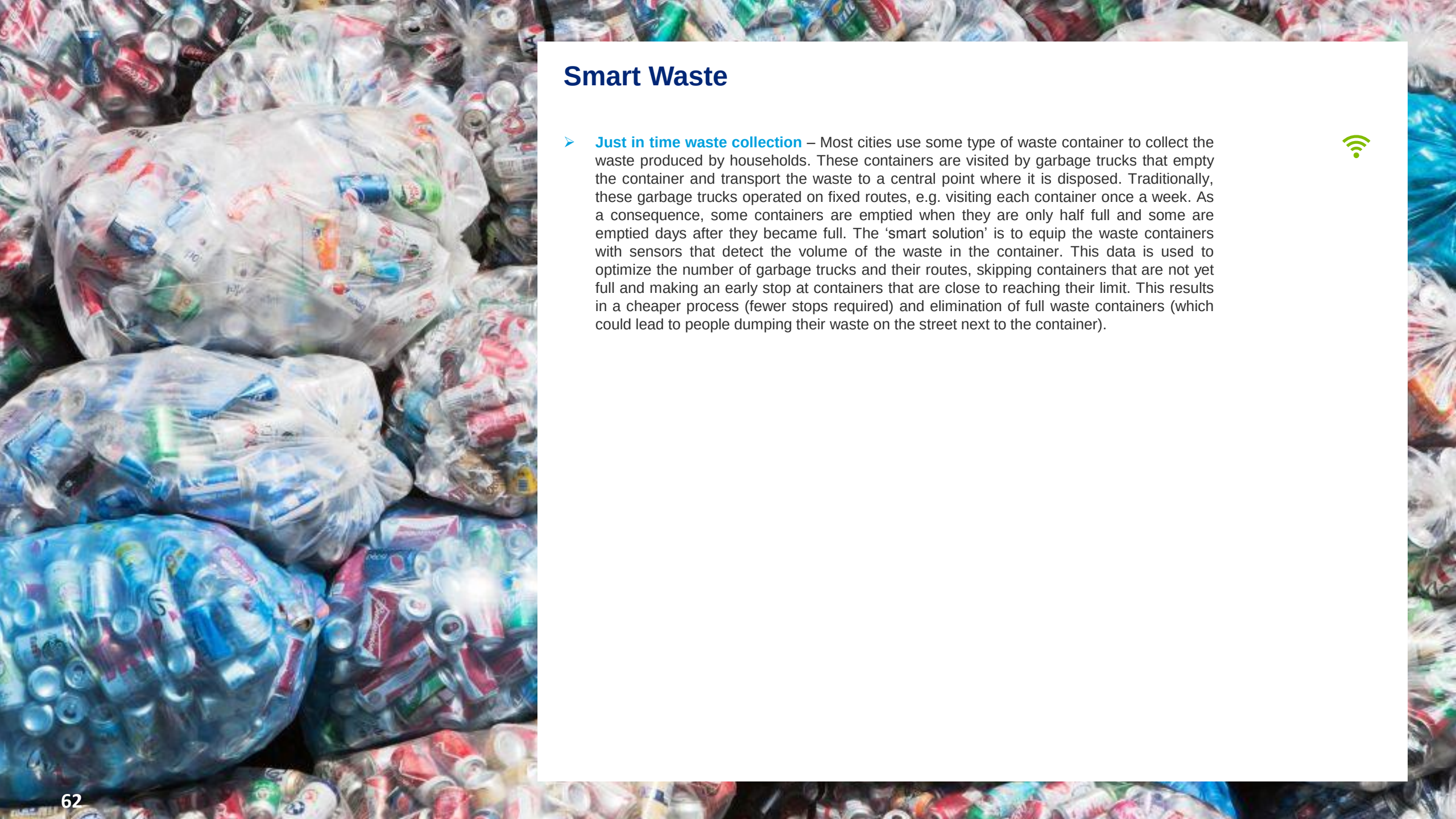
Water (or the lack thereof) will be one of the 21st century's biggest urban challenges. Smart water solutions aim at minimizing waste and securing quality as one of the pillars of sustainability.

- **Leakage detection** – Water loss management is becoming increasingly important due to population growth and water scarcity. Experience shows that the amount of non-revenue water can be up to 25%. To minimize this loss, water providers can equip the distribution network with sensors to provide real time insight in pressure, flows and quality. By analyzing this data, especially the flows during night when normal consumption is minimal, leakages can be detected.

- **Pollution detection** – Sensors can be used to measure the quality of surface water in real time mode. Traditionally, water quality monitoring required manual actions for sampling and analyzing, causing a lag between the emergence of pollution and the detection of it. Real time water quality monitoring, with a network of sensors covering surface water, highly contributes to sustainability of city resources.

- **Advanced warning for flooding** – Cities that are at risk for flooding due to excessive rain or storm can use predictive analytics on weather forecast data combined with geographical data to forecast probable flooding zones and times. This can be used to reroute traffic and preemptively alert the inhabitants of the zones that are at risk.

- **Predictive maintenance planning** – Maintenance on water infrastructure is expensive and has to be planned carefully. Data can be used to focus maintenance on the parts of the water distribution system and sewer system that need it most. Various sources of data should be combined for this purpose. Sensors in the pipes measure flow, pressure and acoustic signals. This data is combined with other data like insurance claims caused by flooding and data from Geographical Information Systems.



Smart Waste

- **Just in time waste collection** – Most cities use some type of waste container to collect the waste produced by households. These containers are visited by garbage trucks that empty the container and transport the waste to a central point where it is disposed. Traditionally, these garbage trucks operated on fixed routes, e.g. visiting each container once a week. As a consequence, some containers are emptied when they are only half full and some are emptied days after they became full. The 'smart solution' is to equip the waste containers with sensors that detect the volume of the waste in the container. This data is used to optimize the number of garbage trucks and their routes, skipping containers that are not yet full and making an early stop at containers that are close to reaching their limit. This results in a cheaper process (fewer stops required) and elimination of full waste containers (which could lead to people dumping their waste on the street next to the container).

Smart Buildings

- **Match energy use to occupancy** – Smart buildings use large numbers of sensors to create fine grained and real-time data about both the occupancy and the conditions in the building (e.g. temperature, humidity and light). The data is used to optimize building systems like cooling, ventilation and lighting with the objective to operate leaner when less people are using the building. On days when fewer people are expected, the system may even close entire sections, cutting costs for heating, cooling, lighting and cleaning.

- **Dynamic power consumption** – Smart buildings are capable of adjusting their power consumption to the real-time scarcity of electricity. If loads are high, the energy grid can send a request to smart buildings to reduce their energy consumption temporarily in order to lower peak load of the grid as a whole. By doing this, the smart building ensures the lowest energy costs possible since energy prices are highest at peak times.

- **Smart refilling** – Facilities like coffee machines and towel dispensers in bathrooms need regular refilling. If this is done too early, unnecessary costs are made. If it is done too late, users will be confronted with unavailable services decreasing their comfort level. Smart buildings use sensors in these machines that are used to detect the optimal time at which a refill should take place.

- **Usage based cleaning** – Smart buildings use fine grained sensor networks to detect the activity level during the day. This data can be used to instruct people and robots responsible for cleaning to focus on the areas that have been used most heavily.

- **Automated garage entry** – At arrival of the garage of a smart building, a camera detects the license plate of the car, matches it with the personnel records and the list of registered visitors and raises the gate. For visitors, LED lights point out the route to the parking place that has been reserved for that visitor.

- **Renewable energy** – Smart buildings use renewable energy like solar panels and thermal energy storage to decrease the net energy usage to a minimum, even to the level where the building creates more energy than it consumes.

Smart Homes

- **Homes are operated by electronic devices** – Smart homes are connected with electronic devices such as smartphones, tablets and laptops. Lights, heating, the television, the coffee machine and other everyday appliances can be operated with an electronic device.
- **Appliance control** – Appliances are equipped with sensors to monitor the state of the appliance. If the appliance needs maintenance, a refill or does not work as it should a notification is send to the smartphone of the home owner to notify him or her about the error.
- **Security** – Home monitoring and security appliances can be viewed and controlled from anywhere in the world by using the smartphone or tablet. Examples include knowing when somebody enters your driveway, accessing in-home security footage and system home-owner recognition so that getting locked out of the house can never happen again.
- **Intelligent feedback** – 'Home automation' machineries provide home-owners with intelligent information and feedback by monitoring routine habits of the home-owners. For instance, a smart home's freezer may be able to register its contents, advise menus, propose healthy alternatives, and order replacements as food is used up.
- **Match energy use to occupancy** – Smart homes use sensors to record real-time data about both the occupancy and the conditions in the home (e.g. temperature, humidity and light). The data is used to optimize ‘home automation’ systems like cooling, ventilation and lighting with the objective to reduce costs.
- **Landscape control** – Landscape system measures and take cares of the optimal environment for plants and pets. The system waters the plants and/or gives food to pets at the optimal time and in the correct portions.
- **Healthcare monitoring** – Wireless sensing technology embedded in the walls can monitor breathing and heart rate in real time. This could benefit any person living in the house, but the effects for being able to observe elderly people or babies as they are sleeping are particularly persuasive.

Smart Health (1/2)

- **Quantified self** – Innovation in sensor technology embedded in wearables and mobile devices brings self-tracking within reach. People start generating their own data about their physical condition. This enables the trend of the ‘quantified self’, people gathering data about themselves with four objectives: self-discovery, self-knowledge, self-awareness and self-improvement. The trend enables people to become more actively involved in getting and staying healthy. Increasingly, ‘health care’ becomes focused on staying healthy instead of focused on curing diseases.
- **Patient empowerment** – Information about diseases and treatments becomes widely available on the Internet, allowing patients to specialize themselves in their own diseases. Patients get online access to their electronic health records maintained by health care providers. As a consequence, there will be a group of patients that want to become in control of the health care process. On the other hand, there will also be a group of patients that is not able to cope with all this information and choices, which gives rise to the need for new roles like a ‘personal health organizer’.
- **Digital platforms connect supply and demand** – The current health care ecosystem is not very transparent and the various links in the chain do not connect well. Currently, the process is centered around the health care provider. There is a need to become more patient centric to establish a smooth ‘customer journey’ through the health care process. Digital platforms allow bringing together supply and demand in new ways (like Airbnb and Uber did in their markets).
- **Personalization of treatments through ‘big data’** – Innovation in medical technologies like DNA sequencing cause exponential increases in price / performance ratio. As a consequence, these techniques will be applied much more frequently. Combined with other advanced medical imaging and analysis techniques, huge amounts of patient data becomes available. Advanced analytics will be applied on this ‘big data’ to determine a personalized treatment plan for each individual patient.

Smart Health (2/2)

- **Artificial intelligence supports the doctor** – The volume of patient data and scientific knowledge increases to a level which can not be understood or handled by humans any more without the help of technology. Increasingly, artificial intelligence and cognitive computing will be applied to assist the doctor in interpreting medical data to establish the right diagnosis and define the most effective treatment. The current ecosystem will be disrupted when non-traditional actors will get access to these systems.
- **From institutions to networks (unbundling)** – In the past, large institutions were necessary to provide health care efficiently. New technologies allow 'unbundling' of specific parts of health care. Increasingly, health care will be provided by networks of smaller actors instead of by large institutions. This will also affect the location at which care will be provided, which will become much more decentralized.
- **3D printing** – The use of 3D printing will disrupt the type of health care which uses prosthetics and implants, by making complete personalization possible. Furthermore, 3D printing can be used by surgeons practice a complication procedure on a real-life model of the patient (e.g. a heart of a brain).
- **Robotics in 'cure' and 'care'** – In the 'cure' part of health care, advanced robotics can be used for highly specialized tasks, which robots can do better than humans. A very different type of application of robotics is in the 'care' part of health care. In that segment, robots will be used to support people at home, allowing them to stay in their own environment as long as possible.
- **Insurance and financing** – Traditionally, solidarity between people was based on a lack of information about the risk of becoming ill which lead to an insurance system where risks are spread over the entire population. New technology however make it possible to obtain a much better insight in individual risks, which potentially creates a new paradigm in health care insurance and solidarity.

Smart Education

Smart cities require smart people. Education is critical for development of talent that is motivated and enabled to drive innovation. New technologies will disrupt the education market.

- **Digitization of education** – Digital technology changes the way education is provided to students. At this moment, thousands of Massive Open Online Courses (MOOC's), provided by world class universities, are available and the number is steadily increasing. These MOOC's can be used for blended learning: a mix of online education with on-campus education.
- **Adaptive learning & counseling** – Digitization of education processes creates valuable data that can be analyzed to create insight in the personal profile of individual students. With this insight, schools and universities can provide the right mix of education and counseling (adaptive learning and adaptive counseling) to maximize the probability of success.
- **Unbundling of education** – Traditionally, schools and universities offer their education as one curriculum, on one location within one period of time, for all students in the same form. Digitization of education allows offering specific parts as an independent service. For example by offering examination training in the form of an online assessment followed by a personalized advice and access to online courses to eliminate knowledge deficiencies.
- **Personalization of education** – The availability of online courses, combined with the augmented supply due to unbundling of education services, allows a further personalization of education. Students combine education services from different education providers to form a learning path tailored to their personal preferences, interests and talents.
- **Life long learning** – The availability of online education will stimulate the trend towards life long learning. Rapid technological advances cause knowledge to become obsolete and outdated in relatively short time. Smart cities are inhabited by a labor force that keeps their knowledge up to date through ongoing education.
- **Corporate universities** – Companies are confronted with an ongoing need for innovation with new technologies and trends. To develop the talent they need for that, there is a tendency towards providing education in house, for example by corporate universities.

Smart Finance (1/2)

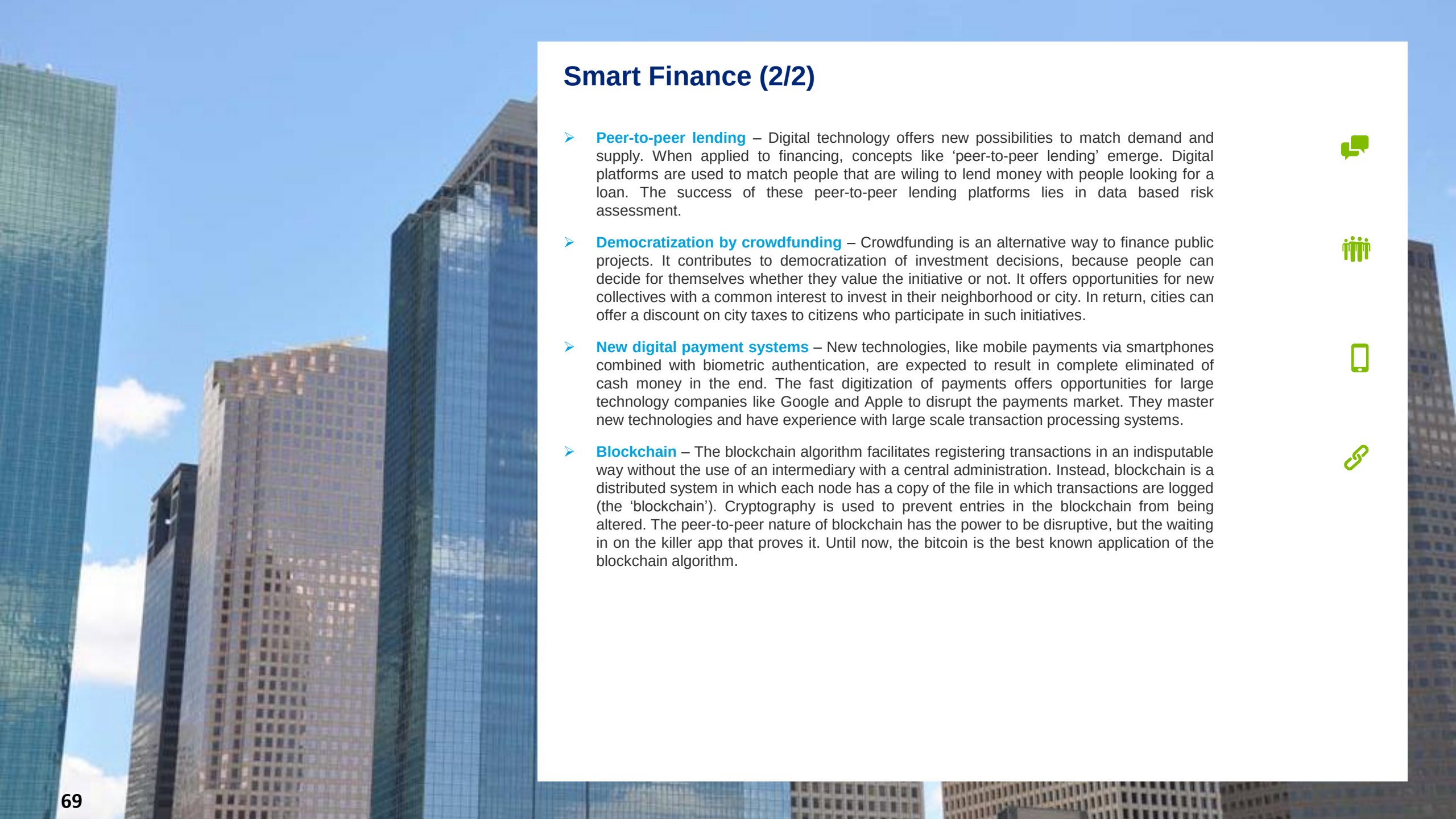
- **Data based risk analysis** – Financial service providers are highly dependent on their ability to estimate risks. The increasing data volume combined with new technologies like data analytics and artificial intelligence creates opportunities for better risk assessment. Access to detailed data of peoples behavior is key to build / maintain competitive advantage. The new job of 'data scientist' becomes a vital one for financial institutions.

- **Data-based insurance** – The Internet of Things can be used to create valuable data about insured objects. In case of cars for instance, IoT data can give full insight in driving behavior. Insurance companies can use this data to make better risk assessments and to offer client personalized offers for insurance products. Clients get the choice to give insurance companies access to their data - to prove they have low risk - to get a discount on their insurance premium in exchange. This data-based insurance principle van be applied to almost any object that can be insured.

- **IoT data + Gamification = Changed behavior** – The IoT data generated by objects can also be used by the owners to get a better insight in usage and risks. Combined with social innovations like gamification, changes in behavior can be established with more efficient use and lower risks as result.

- **Elimination of damages by robotics** – The '*Stichting Wetenschappelijk Onderzoek Verkeersveiligheid*' (SWOV) estimates the annual costs of traffic accidents in The Netherlands at 12.5 billion euro. This is 2,2% of the het Gross National Product. The use of robotics in the form of self driving cars is expected to eliminate most of these costs.

- **Dynamic pricing** – Cities have vital infrastructures with often limited capacity and the pressure on this infrastructure increases due to population growth. Efficient use requires demand to be aligned with the available supply. Pricing can be used as an instrument to stimulate desired behavior of users, but has not always been effective because the technology was lacking to use it in a smart way. Innovation in sensor technology and payments systems now makes it possible generate real-time data about the use of infrastructure that allow real dynamic pricing.



Smart Finance (2/2)

- **Peer-to-peer lending** – Digital technology offers new possibilities to match demand and supply. When applied to financing, concepts like ‘peer-to-peer lending’ emerge. Digital platforms are used to match people that are wiling to lend money with people looking for a loan. The success of these peer-to-peer lending platforms lies in data based risk assessment.
- **Democratization by crowdfunding** – Crowdfunding is an alternative way to finance public projects. It contributes to democratization of investment decisions, because people can decide for themselves whether they value the initiative or not. It offers opportunities for new collectives with a common interest to invest in their neighborhood or city. In return, cities can offer a discount on city taxes to citizens who participate in such initiatives.
- **New digital payment systems** – New technologies, like mobile payments via smartphones combined with biometric authentication, are expected to result in complete eliminated of cash money in the end. The fast digitization of payments offers opportunities for large technology companies like Google and Apple to disrupt the payments market. They master new technologies and have experience with large scale transaction processing systems.
- **Blockchain** – The blockchain algorithm facilitates registering transactions in an indisputable way without the use of an intermediary with a central administration. Instead, blockchain is a distributed system in which each node has a copy of the file in which transactions are logged (the ‘blockchain’). Cryptography is used to prevent entries in the blockchain from being altered. The peer-to-peer nature of blockchain has the power to be disruptive, but the waiting in on the killer app that proves it. Until now, the bitcoin is the best known application of the blockchain algorithm.

Smart Tourism & Leisure (1/2)

- **Crowd management** – Large events in the city can attract up to hundreds of thousands of people in a geographical limited area. Innovative technology can be used to get insight in the behavior of the crowd and provide recommendations for the most effective crowd management measures. The technologies to provide this insight is a combination of WiFi sensors that track individual mobile devices, camera's that automatically count people, social media and GPS trackers. Advanced analytics is used to predict the number of people in an area one hour in advance.

- **Indoor navigation** – Many travelers sometimes worry when transferring to a connecting flight. Schiphol airport installed 2,000 iBeacons in the public areas of the airport. One of the services that uses this infrastructure is the 'gate to gate navigation' of the KLM app. Upon arrival, the app shows a map of the airport with the route to the destination gate and the time needed to walk to the gate.

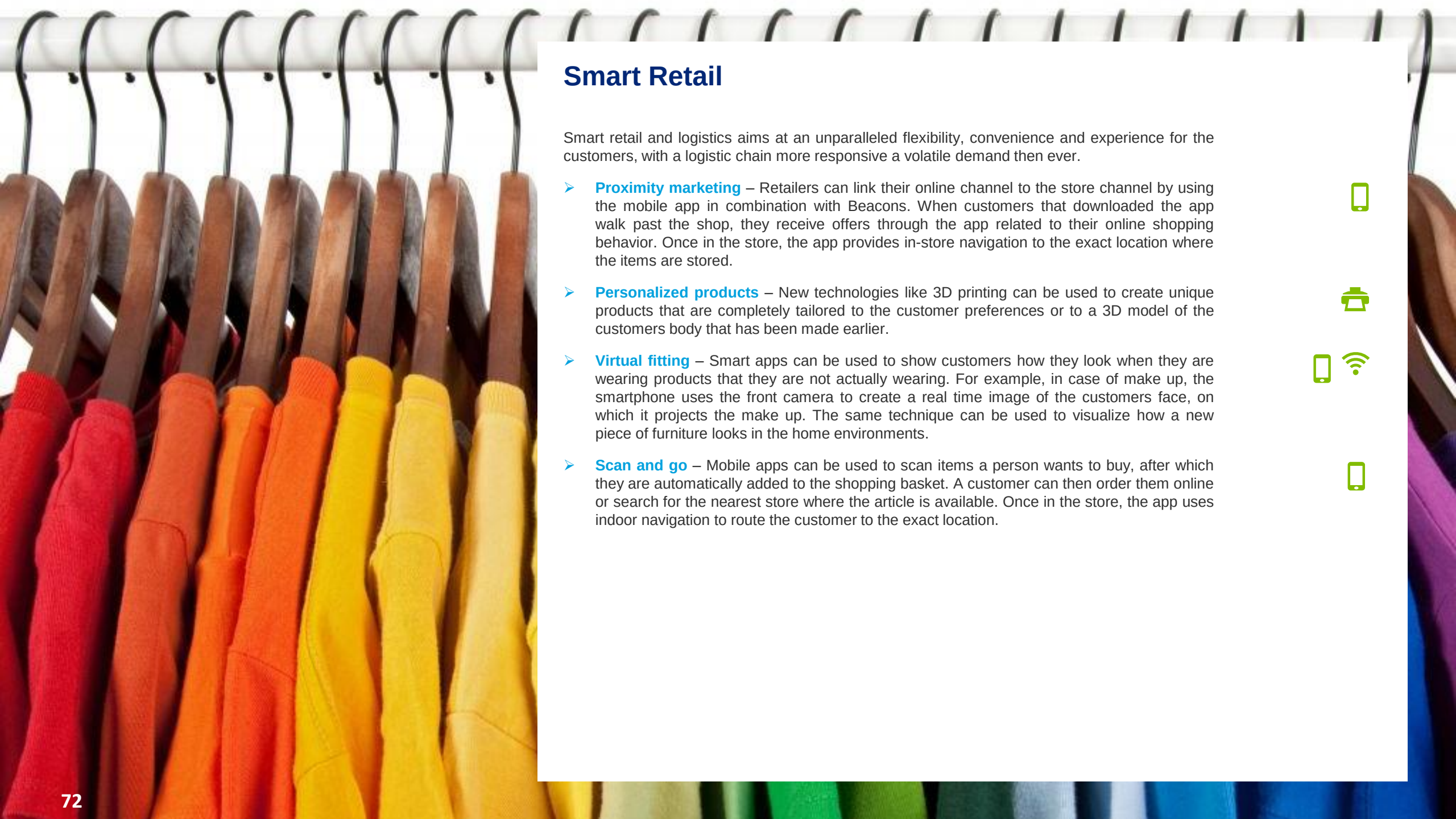
- **Smartphone museum guide** – Mobile apps combined with iBeacons for accurate location information provide museum visitors additional information about works of art on their own smartphone and in their own language. Furthermore, these smart apps can provide the museum with detailed information on the movement of visitors through the museum and their appreciation of specific works of art. This information can then be used to improve the experience of future visitors.

- **Airbnb / Uber** – Airbnb and Uber caused a disruption of the markets for hotel rooms and taxi rides. Both are completely asset less digital platforms that bring demand and supply together in a way that was not possible before. Due to their asset less nature, Airbnb and Uber managed to grow exponentially. In Amsterdam alone, over 11,000 rooms are offered via Airbnb in 2015. In contrast: the largest hotel chain in the Netherlands has 8,400 rooms. In July 2015, the Dutch Government announced that laws and regulations related to these sharing economy initiatives will be modernized to stimulate innovation and at the same time protect public interests and prevent excesses like noise nuisance in rented houses.

Smart Tourism & Leisure (2/2)

- **The iBeacon Mile** – The city of Amsterdam has build an iBeacon Lab of 60 iBeacons covering the 3,4 mile from central station to the former marine base. The intention of this 'Living Lab' is to provide an environment where inventors can test their products, prototypes and ideas.

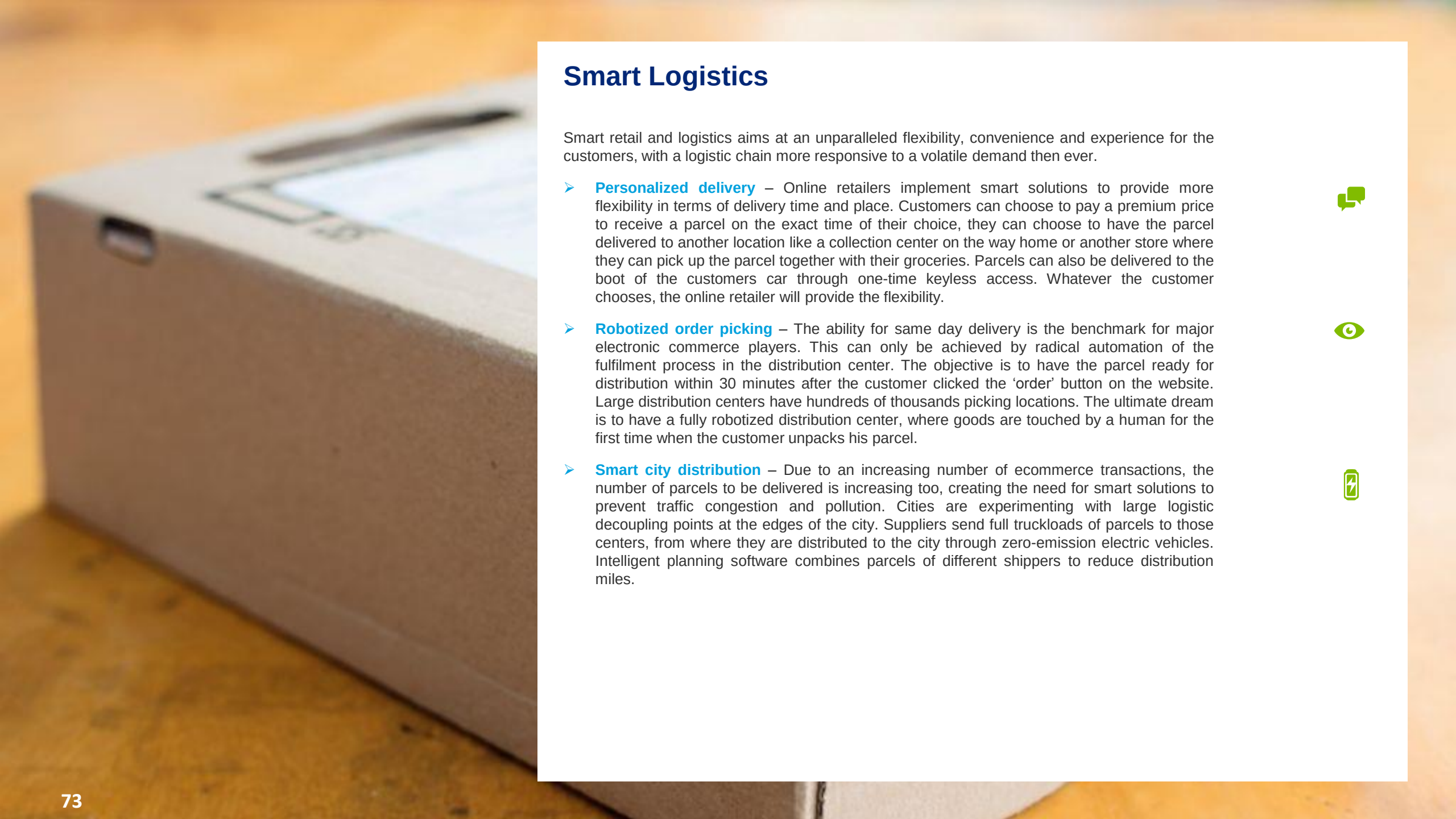
- **Autonomous robotic guides** – Innovations in robotics like machine vision and social capabilities allow autonomous robot tour guides to emerge. These robots approach individuals or groups of people, answer questions and show them around. A first example of robot guides is FROG (Fun Robotic Outdoor Guide), which has been tested in a heritage site in Spain in 2015. As they are further developed, they will show more general use in tourists sites.



Smart Retail

Smart retail and logistics aims at an unparalleled flexibility, convenience and experience for the customers, with a logistic chain more responsive a volatile demand then ever.

- **Proximity marketing** – Retailers can link their online channel to the store channel by using the mobile app in combination with Beacons. When customers that downloaded the app walk past the shop, they receive offers through the app related to their online shopping behavior. Once in the store, the app provides in-store navigation to the exact location where the items are stored.
- **Personalized products** – New technologies like 3D printing can be used to create unique products that are completely tailored to the customer preferences or to a 3D model of the customers body that has been made earlier.
- **Virtual fitting** – Smart apps can be used to show customers how they look when they are wearing products that they are not actually wearing. For example, in case of make up, the smartphone uses the front camera to create a real time image of the customers face, on which it projects the make up. The same technique can be used to visualize how a new piece of furniture looks in the home environments.
- **Scan and go** – Mobile apps can be used to scan items a person wants to buy, after which they are automatically added to the shopping basket. A customer can then order them online or search for the nearest store where the article is available. Once in the store, the app uses indoor navigation to route the customer to the exact location.



Smart Logistics

Smart retail and logistics aims at an unparalleled flexibility, convenience and experience for the customers, with a logistic chain more responsive to a volatile demand then ever.

- **Personalized delivery** – Online retailers implement smart solutions to provide more flexibility in terms of delivery time and place. Customers can choose to pay a premium price to receive a parcel on the exact time of their choice, they can choose to have the parcel delivered to another location like a collection center on the way home or another store where they can pick up the parcel together with their groceries. Parcels can also be delivered to the boot of the customers car through one-time keyless access. Whatever the customer chooses, the online retailer will provide the flexibility.

- **Robotized order picking** – The ability for same day delivery is the benchmark for major electronic commerce players. This can only be achieved by radical automation of the fulfilment process in the distribution center. The objective is to have the parcel ready for distribution within 30 minutes after the customer clicked the ‘order’ button on the website. Large distribution centers have hundreds of thousands picking locations. The ultimate dream is to have a fully robotized distribution center, where goods are touched by a human for the first time when the customer unpacks his parcel.

- **Smart city distribution** – Due to an increasing number of ecommerce transactions, the number of parcels to be delivered is increasing too, creating the need for smart solutions to prevent traffic congestion and pollution. Cities are experimenting with large logistic decoupling points at the edges of the city. Suppliers send full truckloads of parcels to those centers, from where they are distributed to the city through zero-emission electric vehicles. Intelligent planning software combines parcels of different shippers to reduce distribution miles.

Smart Manufacturing

- **From product to platform** – The strive for personalization and customization is pushing manufacturers to think of products as physical platforms. The product in a platform can be the center of an ecosystem in which third-party partners build add-ons. This change goes beyond simply adding software to products. The design of products is changing to allow for extensive personalization, customization, and to stimulate offerings from third-party companies that increases the function and value of the main product.
- **Additive Manufacturing is become cheaper** – Additive manufacturing (AM) also known as 3D printing comprehends manufacturing technologies that produce objects by addition rather than subtraction, which is used in conventional manufacturing technologies. The price of additive manufacturing is decreasing, which makes AM increasingly competitive compared to conventional techniques. When the production load shifts from the physical world to the digital world, engineers can design complex, previously unthinkable shapes. Also manufacturers can produce more durable and lightweight parts that require a reduced amount of assembly time, decreasing the total cost of production or increasing the value of the final product.
- **Robotics** – Robots in the manufacturing process are automated machinery that can perform routine or dangerous tasks autonomously. Robots will not substitute human labor in the direct future, but they will take on n growing part of the manufacturing floor. The increasing share of activities performed by robots is likely to shrink the quantity of low-skill, low-wage human manufacturing employments while producing a comparatively small number of specialized expert, higher-wage jobs in maintenance and programming.
- **Material Science** – ‘Space-age’ is a term used for describing novel materials that allow the creation of a more capable, advanced and intricate generation of objects. Examples of the first generation of ‘Space-Age’ materials include carbon fiber, nanomaterials, memory foam and optical coatings. Over time, these materials will become ubiquitous. As new materials are generated, older ones, once unreachable to all but the most progressive, big, price-insensitive manufacturers, have begun to trickle down to the mainstream. As manufacturing developments lower costs and other obstacles to access, it is expected to see such materials used in more mainstream applications.

Smart Construction

- **Advanced Construction Materials and Machinery** – New cutting edge materials and machinery come into existence and are applied to construction processes and products. Examples include 1) 'Automated Paving Machines', that after concrete is poured in, can construct roads without human labor; 2) 'Concrete Admixture for Moist Content', which is a product that prevents moisture from going through concrete surfaces and as a result eradicates failures in flooring; 3) 'Concrete optimizer' is a system that measures information from the inside of a truck mixer drum and sends it to technicians and operators to check on the quality of the concrete.
- **Improved Construction Processes** – Construction companies work with new improved and streamlined methods, processes and operations. These progressions enable the construction industry to construct buildings and roads more efficiently with lower costs. For instance the 'Warm Mix Asphalt' is enabled by a mixture of technologies that allow asphalt mixtures to be installed at lower temperatures reducing heating and transportation costs. Another example is the 'Bubble Filled Concrete Deck' technique that links air, concrete and steel in a new method that can eliminate as much as 35% of the structural concrete.
- **Wireless monitoring of infrastructure** – Monitoring can be done by attaching sensors to buildings and infrastructures. The sensors are linked to various nodes, which in turn are linked to a central data repository. All the information collected from the sensors are collected in the central data repository. In this manner monitoring can be done from anywhere. The data can be accessed through software and a proactive approach can be taken on to prevent future problems. This is in strong contrast with the traditional way as that requires a technician on site, and often deals with remediation.
- **Integrated Photovoltaics (BIPV)** – Integrated Photovoltaics provides an alternative for traditional building materials. The benefit of BIPV is that it allows a building to generate their own energy via solar power. Photovoltaic cells can be straightly integrated to the outside assembly of a building in components such as glass, walls and roofs.

Smart Government (1/2)

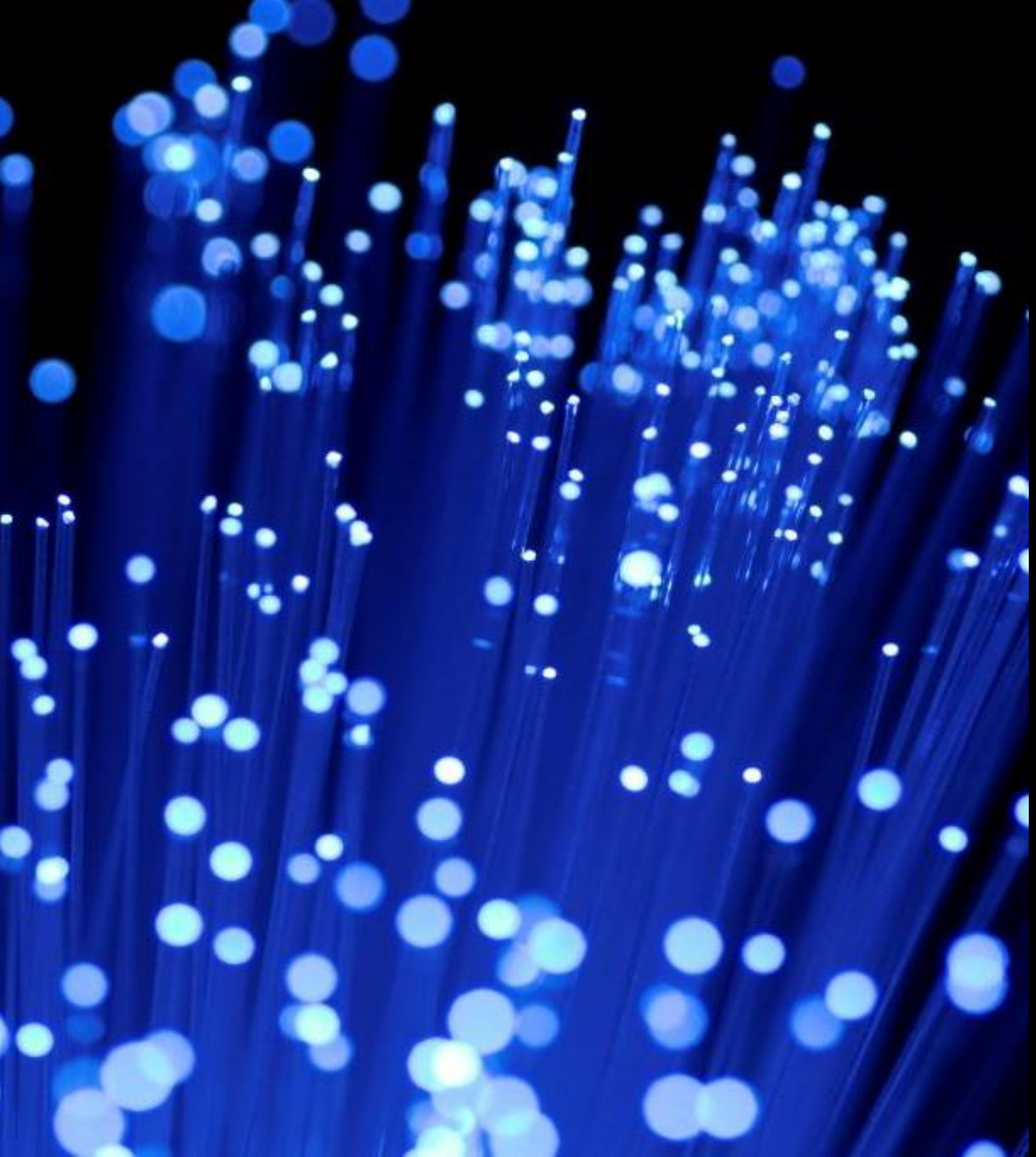
Smart cities require a smart government. A smart government uses the disruptive potential of technology and data to innovate in all parts of the value chain:

- **Analysis** – The government value chain starts with analysis of perceived societal problems, preferably in a fact-based way. The availability of big data combined with advanced data analytics techniques increases the predictive power of these analyses. Furthermore, due to proliferation of data, non-governmental organizations become active in the analyses of societal problems which creates competition in this domain.
- **Policy-making** – The policy making process becomes more complex due to increased transparency, competition in the analyses, combined with new types of digital democracy and co-creation. The result is however more effective policies due to relevant feedback and creative alternatives at earlier stages in the process.
- **Planning** – The use of digital technology allows a shift from public to private in the planning phase. Instead of defining a detailed solution, the government increasingly defines the high-level requirements, and lets the market define creative and innovative solutions.
- **Execution** – At this moment, the services of private companies are often used for the execution of policies, and this will remain. Due to all kinds of social innovation however, new types of market parties, like social entrepreneurs, emerge. These parties distinguish themselves from traditional parties by accepting a different distribution of risks among partners and a different type of financial compensation. An example is the use of ‘social impact bonds’, used to commit an investor to societal goals.
- **Enforcement** – Policy enforcement and supervision on the proper execution of polices increasingly becomes data-based. Responsibility remains with the government, but alternative models like peer-to-peer review emerge.

Smart Government (2/2)

Other developments that contribute to ‘smart government’ are:

- **Distributed government** – Digital platforms and mobile apps allow well defined government tasks to be distributed to actors outside the government. The city of Amsterdam for example has 800.000 inhabitants of which most are carrying a smartphone. Creative solutions to use the power of this crowd extends the reach of government.
- **Online public services** – Citizens have access to smooth online services in many industries already. As a consequence, they expect public services to be accessible in the same way. A smart government uses digital technology to make public services available online in a self-service model, making them independent of location and time.
- **Scope of services** – On one hand, new technologies allow unbundling of government services. New collectives and market parties take on parts of the traditional government tasks, due to which the scope of services provided by government deceases. On the other hand, history shows an increase in government responsibilities (higher in the Maslov Pyramid). Two examples of new responsibilities that have been adopted by the government are ensuring equal opportunities and regulation of markets. If this development continues, combined with unbundling of public services, a new government emerges.



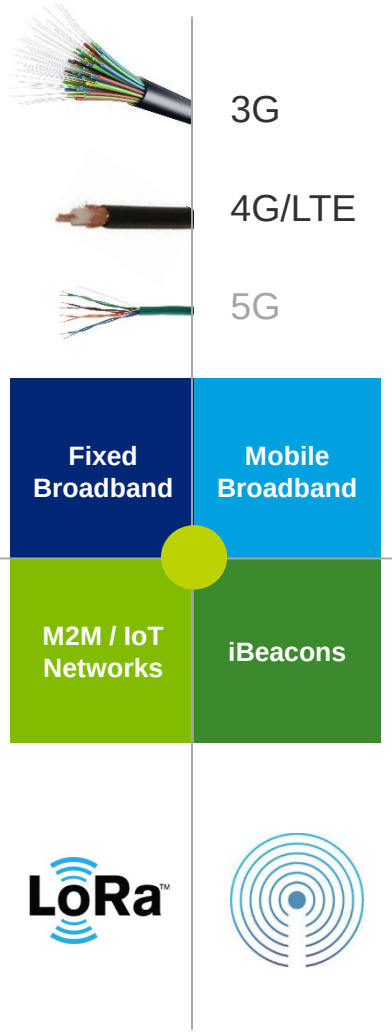
6. Smart City Foundational Systems and Infrastructure

Connectivity networks

Smart city solutions require digital connectivity on various levels: fixed broadband, mobile broadband, M2M / IoT networks and Beacons

Fixed broadband networks

- Fixed broadband networks provide internet access at a bandwidth of 100 Mbs to 1 Gbs and higher.
- In the Netherlands, three types of fixed broadband are available:
  - *Fiber to the Home* is available at 34% of all 6.9 million homes and is extended with 200,000 to 300,000 connections per year. It typically provides up to 500 Mbs and allows Gigabit bandwidths.
  - *Coax* network is available to 97% of all houses. It typically provides up to 200 Mbs and can be upgraded to 1 Gbs and above.
  - *Twisted pair* network is available at 98% of all houses. It typically provides up to 100 Mbs and can be upgraded to several hundreds Mbs.
- AKAMAI measured the average peak connection speed of fixed broadband in The Netherlands in Q1 2015 at 61,5 Mbs, with a growth rate of 28% per year.



Mobile broadband networks

- Mobile networks originated as networks for mobile telephony (voice) but evolved to networks that provide broadband internet data connectivity mainly.
- In The Netherlands, multiple generations of mobile networks are available:
  - 3G networks are available in 99% of the Netherlands and typically provide 5-10 Mbps (stationary) and hundreds Kbps (fast moving vehicles)
  - 4G/LTE networks are available in 96% of The Netherlands and typically provide up to 50 Mbps download speed.
  - 5G networks are expected to provide mobile gigabit connections by 2020.
- AKAMAI measured the average peak connection speed of mobile broadband in the Netherlands in Q1 2015 at 27,5 Mbs.

M2M / IoT networks (LoRa)

- Machine-to-Machine (M2M) and Internet of Things (IoT) communication have specific requirements, for which dedicated networks needs to be in place.
- The key characteristics of these networks are:
  - *Long range* – Typically several kilometers and providing coverage in locations like basements etc. where 3G and 4G coverage is lost.
  - *Low energy* – IoT devices are often battery operated and require communication with very low energy use.
  - *Low bitrate* – IoT devices transmit small amounts of data and do not need broadband networks but only 0.5 kbps to 50 kbps bandwidth.
- These networks are called ‘LoRa’ networks of ‘LoRaWAN’. They are provided by telecom operators like KPN and organizations like ‘The Things Network’.

iBeacons

- iBeacons are small, battery operated, devices that use Bluetooth Low Energy (BLE) to transmit a unique identifier that can be picked up by the operating system of mobile devices (e.g. smartphones). Standard beacons have a range of 50-70 meters.
- The iBeacon signal can be used to determine the mobile device’s accurate physical location and trigger a location based action on the device.
- iBeacons do not push notifications to mobile devices. However, apps on mobile devices can use the identify of the iBeacon and the proximity to the iBeacon to trigger a push notification to its user.
- The iBeacon protocol has been standardized by Apple, but is supported by major vendors (iPhone 4S and later, Android 4.3 and later, Windows Phone).

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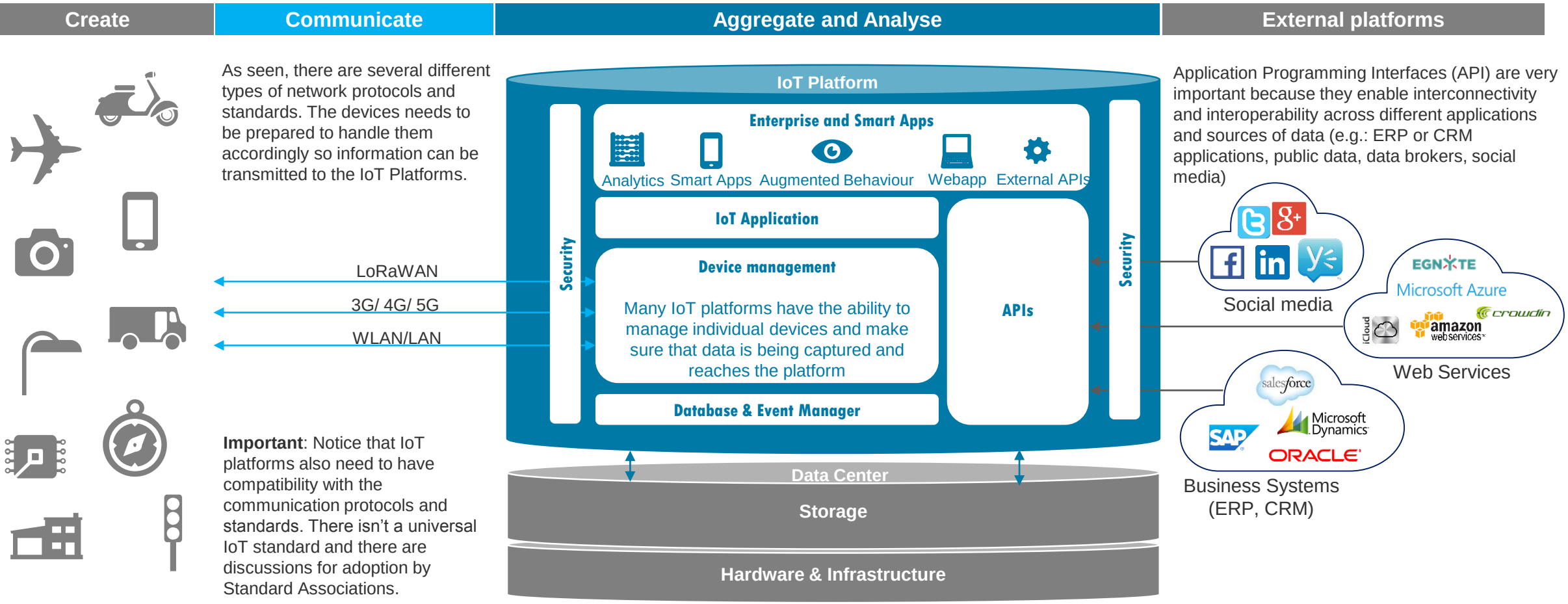
Foundational Infrastructure and Software for IoT are needed for aggregation and analyze

IoT platforms are the software that makes the Internet of Things to work. They use the data captured from the sensors, and creates insight and augmented intelligence through its consolidation and analyse enabling the promised value generation and augmented behaviour.

IoT platform vendors offer different types of architecture depending on their capabilities. On premise or public/private cloud, integration with different communication protocols, storage and APIs are only some of the parts that needs to be thought when deploying IoT use cases. The structure below serves as a guide to understand the complexity of IoT platforms and further information can be taken from your preferred vendor as well as their capabilities when it comes to analytics, storage and infrastructure.



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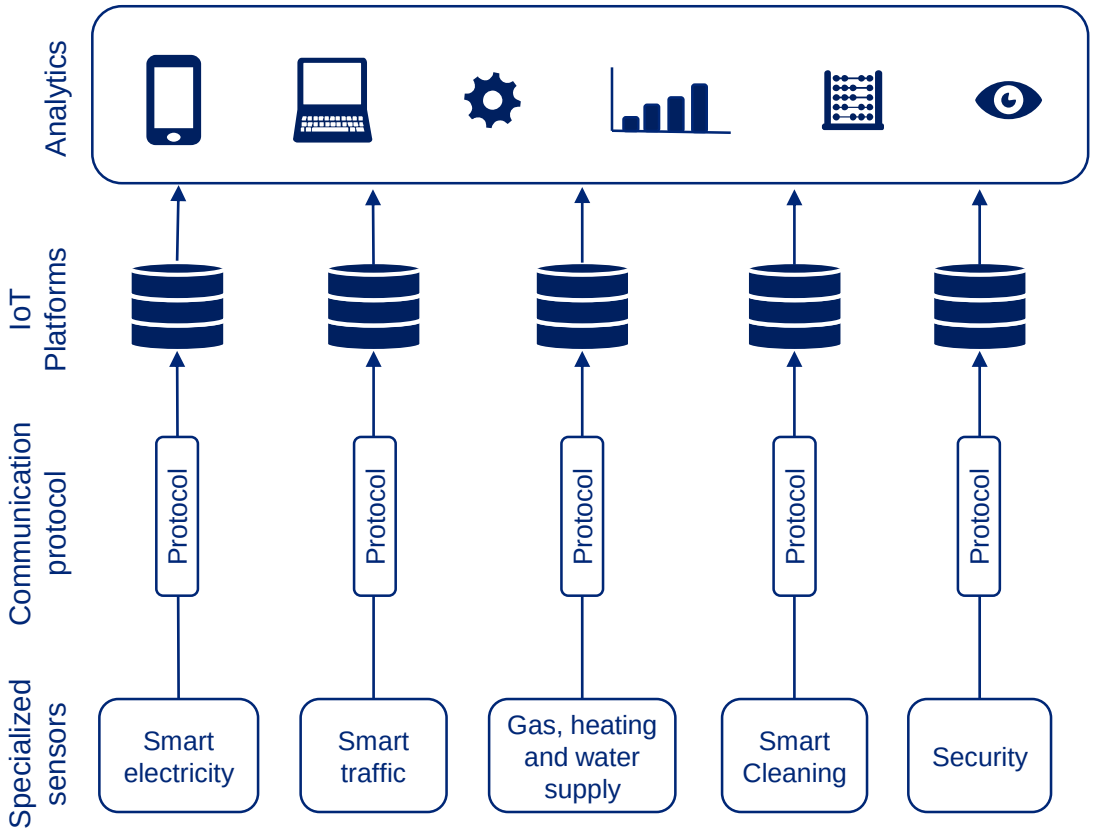
The challenge is to have a solution that is comprehensive and easy to manage

At the moment, devices are created with specific communication protocols that require integration with the IoT platforms. Therefore it is important to understand the technological orchestration behind your IoT solution to make sure that

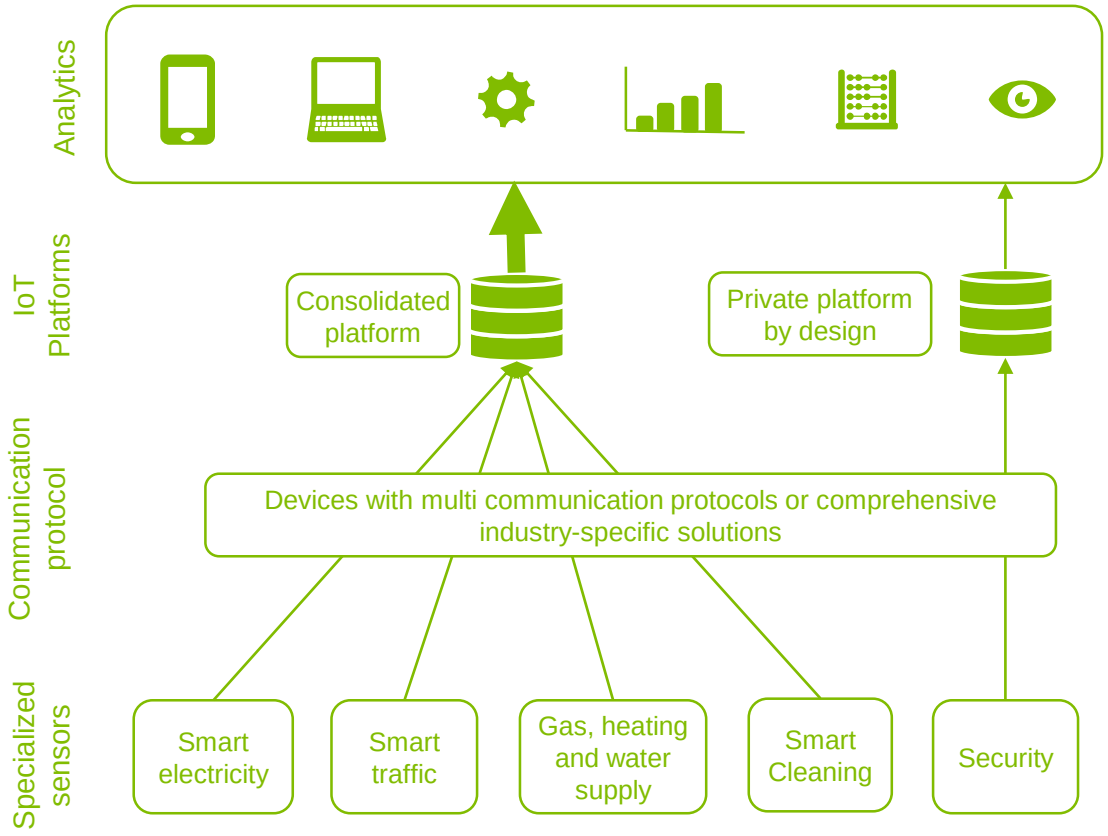
IoT Platforms today

Due to the different protocols and standards, devices are very much specialized to capture information in specific characteristics creating a chain that is hermetic to certain applications although the use of APIs can improve significantly its use. In practice, IoT platforms today are segmented



IoT Platforms in the future

Developments on IoT platforms indicate a more comprehensive connectivity enhancing the data collection to enable true creation of value. Some applications might still require a separated platform but that would be by design instead of lack of options.



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7. Smart Cities of the world

(to be added)

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