The Technology Book

The technology trends
KPN has on its radar

5G

kpn

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Your accountmanager will be delighted to put you in touch with the right people. You can also send an email to
info-grootzakelijk@kpn.com.

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Foreword

Dear reader,

Welcome to the KPN Technology Book.

I'm pleased to present our overview of the most relevant innovative technological developments that affect us, society and - most likely - your organization or business. For us as a leading telecom operator in the Netherlands, it's crucial that we identify and monitor new technological developments at the earliest possible stage. We use this information to determine our road ahead. We're keen to share our vision on technology with our clients and other stakeholders since we strongly believe that, in this fast-moving and interconnected world, meaningful new products and services can best be developed in partnership with others. By sharing our view on new technology, we also hope to help our partners design their plans for the future.

Since we published our first Technology Book at the end of 2016, a great deal has changed. The pace of technological development continues to increase. For instance, the volume of data transported over networks in the Netherlands has grown as much in the past 15 months as it did during the entire previous 15 years (see graphic). Many of the technologies discussed in the 2016 book have moved closer to implementation. Technologies such as Internet of Things and artificial intelligence have entered the mainstream and are on virtually every company's agenda. And new technology topics have emerged, several of which we've included in this edition.

Past 15 months saw the same amount mobile data volume growth as 15 years before.

Mobile data volume per Month (in TB)

14.000	
12.000	
10.000	
8.000	
6.000	
4.000	
2.000	
0	

2000   July 2016

Sharing information on new technology and developing ideas about how to use it are crucial to our business success – not to mention fascinating and fun. I feel privileged that we at KPN are at the center of new technological developments reshaping our society. I'm proud that over the past seven years, KPN has invested nine billion euros in futureproof telecoms infrastructure, which is a crucial enabler of new technological applications.

Only by sharing our views and experience with clients,
peers and other stakeholders can we realize the full potential of
technological innovation and address the challenges it represents. With this KPN Technology Book we aim to contribute to this dialogue and exchange of ideas. I'm keen to hear your thoughts on what these technological trends mean for you.

Tom Poelhekken
CTO KPN

April 2018

Introduction

The technology topics selected for this second edition of our Technology Book are interconnected, reflecting the growing trend of combining different technologies to create new applications. Some of the topics themselves comprise a mix of technologies. Data-driven society, for instance, is a concept that hinges on technologies such as the Internet of Things, blockchain and artificial intelligence. Likewise, automated driving will not be possible without 5G and IoT.

The topics can be presented along this timeline:

Data &
Services

Identity management

Artificial intelligence

Data-driven society

Mixed reality

Blockchain

Connected and automated driving

Managed
Infrastructure

APIs

Infrastructure

Internet of Things

Next Generation Infrastructure

Quantum Technology

5G

Photonics

Time
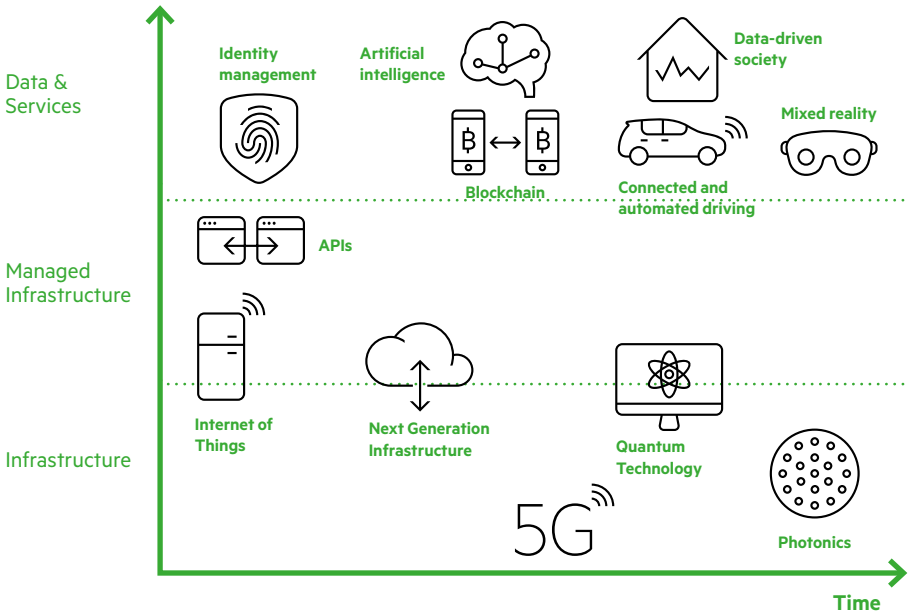
This edition gives updates on a few topics covered in the first edition. Some other topics have been merged into a new chapter in this new edition. We have also added new subjects: quantum technology, mixed reality, identity management and connected and automated driving..

Developers of new technologies, especially those related to the use of personal data, sometimes run into ethical issues that hinder or complicate their activities. The technology and ethics chapter describes the latest developments in ethics and privacy regulations.

KPN continues to monitor a wide range of technology trends. Whenever appropriate, we will update you in a new edition of this Technology Book.

Next Generation
Infrastructure

1

1   What is next generation infrastructure and why does it matter?

Remember how slow first-generation dial-up modems were and how much they lagged? Imagine using one today to stream a movie or live chat with friends.. Technology has advanced, enabling us to live our lives online in the way that we do. And this is only the start. Soon our digital and physical lives may be totally integrated. To keep them synchronized we'll need access that is fast, seamless and available whenever, wherever and from whatever device or channel we choose. This will require next generation infrastructure: smart networks capable of delivering an ultra-high performance that is far superior to today's networks.

This infrastructure (such as 5G, or fiber access) should offer a connection speed of at least one gigabit per second, while being cost and energy-efficient. It will combine existing physical networks with virtual networks driven by software-enabled technologies like network function virtualization (NFV) and software defined networking (SDN).

Virtual networks will be more flexible to meet different user demands. They can be programmed to provide extra mobile capacity when people are commuting, for example, and more streaming capacity to watch a film at home. Businesses will be able to instantly add new connections when they expand, or add temporary capacity during busy periods.

One way to realize this is with 'edge computing' – virtual networks running on edge servers in data centers closer to users. For example, rather than streaming the same film to 100,000 users from a central data center, it can be distributed to a cloud on an edge server and accessed by local users in near real-time. Edge computing will be particularly important for intelligent new applications such as transport control systems, live gaming, augmented reality and the Internet of Things.

2   Current status and anticipated developments?

Telecoms networks – wired and wireless – are getting faster. Most households in the Netherlands can access broadband speeds above 100 megabits per second, among the highest in Europe. Around a quarter of Dutch homes are fitted with fiber, which can reach speeds of one gigabit and more. And KPN's 4G network currently offers the fastest possible mobile connection, delivering consistent nationwide coverage of at least 10 megabits per second.

The 5G mobile network will be even faster and able to serve many more users simultaneously as more devices connect to the Internet of Things.

KPN expects all houses and buildings will eventually be connected with optic fiber cables. In the meantime, copper wires and coaxial cables (coax) are getting faster and even wireless technologies such as WiFi are approaching the one gigabit per second speed of optical fibers.

3   Why is next generation infrastructure relevant to KPN?

Edge computing will enable new services such as video analytics, location services and augmented reality. New business models emerge for telecoms operators using virtual networks as a service.

Given its strong position in fixed and mobile connectivity, KPN is well positioned to become the Netherlands' top provider of edge computing. It is converting its former telephone exchanges into local data centers from where it can run edge computing. This close proximity to customers gives KPN an advantage over bigger tech players such as Google. KPN is building a content delivery network to cope with the growth of video traffic and virtual customer premises equipment.

Software-based solutions will enable 'slicing' of the 5G network into multiple virtual networks, each supporting a particular service or business segment. For example, one network slice could connect Internet of Things devices with high availability, reliability and low throughput while another supports an augmented reality service with very high throughput and low latency.

4   What are the key technologies, timings and hurdles?

How fast information is transmitted relies heavily on the quality of the medium transporting it. Fiber is by far the best option. Photonics technology will resolve bottlenecks in fast data transmission in core networks. Access to the fullest possible range of frequencies in the spectrum for wireless transmission is also crucial.

SDN is mainly applied in core networks. It controls traffic flows and can dynamically adjust access requirements in real time. NFV allows networks to run on standard hardware rather than specialized equipment like routers or base stations. It is mainly applied at the borders of the network in data centers and customer premises equipment.

Hurdles include legacy equipment that cannot be upgraded to support new technologies and not enough expertise yet to develop, build and run this new architecture. Suppliers are developing SDN and NFV independently with no standardization as yet. Finally, it will take years to roll out the next generation access network and transition to virtual networks.

5   Who are frontrunners in this area?

Telecom suppliers such as Huawei, Ericsson, Nokia/ALU, HP and Cisco are building portfolios of SDN and NFV solutions. It is being implemented by telecoms like AT&T and Telefonica. Tech companies such as Amazon and Google are using the same principles to deliver cloud services on an unprecedented scale. Nokia Bell Labs is a leading researcher in this area. Opennetworking.org and the European Telecommunications Standards Institute focus on standardization.

5G

2

1   What is 5G and why does it matter?

5G is the next generation of cellular networking technology that will be available in about 2020. Where 4G was focused on mobile broadband for both consumers and business customers, 5G's focus will be much broader. 4G may have connected people, but 5G will connect society. It will make a big contribution to the digitalization of various industries, such as automotive, utilities, agriculture and transport & logistics. 5G differentiates between three groups of use cases:

1. **Enhanced Mobile Broadband (eMBB):** this is an evolution of the mobile broadband service that we know today. 5G will further increase network capacity, average throughput and peak throughput, enabling new use cases such as augmented and virtual reality.
2. **Massive Machine Type Communications (mMTC):** these use cases focus on low-cost sensors and actuators that send small amounts of data and often require very long battery lifetime, e.g. 10 years or more. These use cases are currently served by technologies such as LoRaWAN and LTE-M. With 5G, the number of connected devices will increase even further and positioning of the devices will improve significantly. Typical use cases in this category are smart meters, wearables and asset tracking.
3. **Ultra-Reliable Low Latency Communications (URLLC):** this category includes use cases where reliability (up to 99.999%) and latency (1-10 ms) play an important factor. Use cases include mission critical services for the public sector, but also robotics and connected & automated driving.

2   What is the current status of 5G and what are the anticipated future developments?

5G is currently still in the process of being standardized. A preliminary version of the 5G standard was published by 3GPP in December 2017, and the first version of the 5G standard will become available by June 2018. Based on this standard, various parties in the ecosystem will start to develop their 5G products. These parties include chipset manufacturers, network vendors and module makers. The first 5G applications were demonstrated at the 2018 Winter Olympics in South Korea. In early 2019, the first 5G pilot networks will be set up around the world. Commercial 5G networks on a larger scale are expected from 2020 onwards. Of course, not all functionality will be available from day one. Analysts expect the first 5G deployments to be an evolution of today's 4G networks, focused on eMBB.

3   Why is 5G relevant to KPN?

From a networking perspective, 5G is needed to handle the exponential growth we're experiencing year on year. 5G will not only introduce a new radio technology but will also introduce the next generation of networking equipment that is much more powerful, flexible and energy efficient than the current network. In addition, 5G will provide lots of new business opportunities, especially in the area of URLLC, but also in the area of eMBB and mMTC. 5G will be one of the key technologies in the digitalization of various industries.

4   What are the key technologies, timings and hurdles?

The beauty of 5G is that its flexible architecture allows all these different use cases to run on the same physical network, but with their own parameters for quality of service. That means, for example, that public safety networks, which have very stringent requirements on availability and capacity, are no longer required to be physically separate from the rest. 5G allows these use cases to run on the same physical infrastructure, but still be logically separated from the rest of the traffic. This concept is called network slicing.

5G will also see some revolutionary changes in the radio network. Antennas will become much more powerful by hosting multiple transmitters and receivers inside the same antenna. This concept is called multiple-input and multiple-output (MIMO). The number of antennas will also increase with

5G; they will be in radio towers and on rooftops, but also on street furniture, such as lampposts and bus shelters.

5   Who are frontrunners in this area?

The best way to become familiar with 5G is to start reading white papers from equipment vendors, such as Nokia, Huawei, Qualcomm and Samsung. For another interesting angle on 5G technology, check out the white papers from standardization bodies, such as NGMN and 3GPP. NGMN's March 2015 5G Whitepaper is regarded by the industry as one of the fundamental vision documents on 5G networking technology. KPN is a member of the NGMN and has contributed to this and other working documents.

Internet
of Things
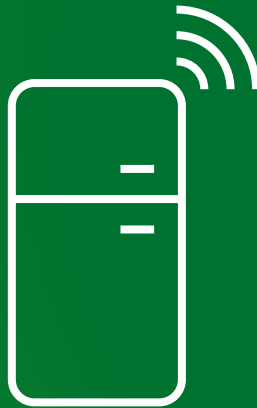
3

1   What is the Internet of Things and why does it matter?

The Internet of Things (IoT) is the network of physical devices, from home appliances to freight containers, embedded with sensors, computer chips and transmitters, allowing them to connect to one another and exchange data. These physical 'things' can also include people, animals and agricultural crops, as well as virtual 'things', such as data.

IoT is expected to impact a range of businesses and public sectors, the idea being that by improving processes, and enhancing efficiency and convenience, IoT will free us up to do the things we value more.

2   What is the current status of IoT and what are the anticipated developments?

Although still in its early stages, IoT is being implemented broadly worldwide. Gartner expects there to be 25 billion IoT-based installed devices by 2020, with 6.8 billion in 'smart cities' alone. So far, it's been most widely used in track and trace services, allowing transport companies to more efficiently use their transport capacity. It's also being used to support predictive maintenance for manufacturing plants and utility networks.

For IoT to get to the next stage, new networks are being introduced. KPN was the first to launch a LoRaWAN network with national coverage in the Netherlands. LoRaWAN is a low-power, wide-area network suitable for transmitting small amounts of data. The newest generation of IoT network is LTE-M, which KPN is rolling out now. A little faster than LoRaWAN, LTE-M can process slightly higher amounts of data and penetrate deep into buildings.

These new networks are a much better fit than the now widely used 2G network. On top of these LP-WAN technologies, there is the faster and higher-capacity network LTE. LTE is a 4G network and also works with SIM cards. It handles larger amounts of data at low latency, meaning there is little or no delay between capturing and processing data.
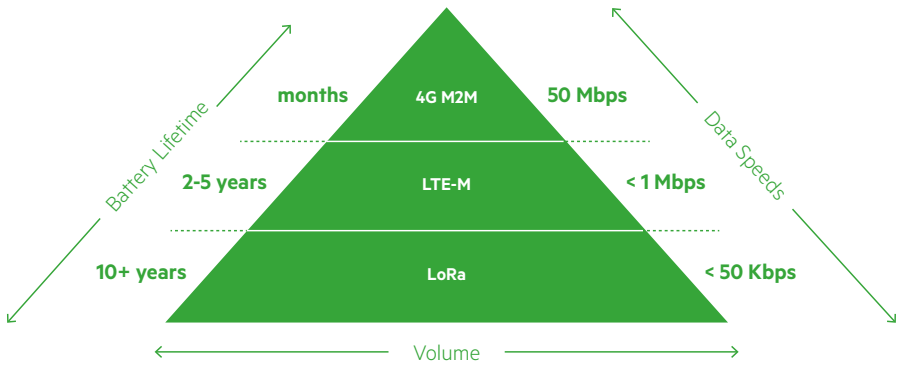
Several companies have already implemented IoT using LTE, with more expected to be introduced shortly in a range of sectors and industries. One example is Tesla: its cars depend on connectivity, for instance to download software updates and route maps.

3   Why is IoT relevant to KPN?

IoT relies on connectivity, one of KPN's core strengths. We were the first to roll out nationwide coverage of the LoRaWAN network, and in late 2017 introduced the first LTE-M network, which enables the further expansion of IoT connectivity at a relatively low cost.

KPN also has an IoT platform suite called KPN Things, which processes the data generated by the 'things' for efficient decision-making. For instance, we're working with a waste container rental company that uses our service to track their assets and optimize their collection schedule. Also, we're working on an 'e-potato' pilot to help farmers manage their business through real-time monitoring of soil humidity, nutrients, temperature of storage facilities, etc.

Our IoT business offering also ensures the security of the data that sensors collect – an important requirement in most IoT business models.

4   What are the key technologies, timings and hurdles?

Networks facilitating IoT concepts are based on technologies such as 2G, 3G, 4G, LoRaWAN, and LTE-M. These need to be further digitized by moving to e-Sim and an API-driven approach. Other relevant technology concerns data collection from sensors, accelerometers or pressure meters, etc.

IoT solutions now usually comprise an ecosystem of different companies, where business models overlap and data ownership and privacy issues can hinder progress. Further integrating IoT in society also means extra security throughout the IoT solution. On top of that, businesses using IoT often need to reorganize to move to a modular 'as-a-service' organization.

The fact that many legacy technologies have a life span of 10-15 years also doesn't help, as it may not be economically viable to replace them with new technologies.

5   Who are the frontrunners in this area?

Microsoft, Google and Amazon are all leading IoT platform players, each trying to distinguish itself in usability and integration with legacy systems. Also, hardware supplier Sierra Wireless has a notable IoT proposition. GSMA – the trade body for mobile network operators – plays a key role in promoting IoT standardization.

Among telecom operators, the frontrunners are AT&T, Deutsche Telekom and Telefonica. KPN plays a leading role in the Netherlands, as a first mover in LoRaWAN and LTE-M networks, among other things.

Data-driven society

4

1   What is a data-driven society and why does it make sense?

A data-driven society is one that uses data for more efficient, decentralized decision-making. Driven by innovation and developments such as IoT, society today produces massive amounts of data from a range of sources. What's still not done very often, however, is sharing these different data sets to create new services, and enable faster, better quality and more efficient decision-making. Doing so on a large scale would create a data-driven society that experts believe could become a reality in a matter of years. Examples could be efficient waste management in cities based on real-time and historical data, or providing tailor-made advice for crowd management, guaranteeing safe and enjoyable mass sporting and music events.

A full-fledged data-driven society would have a huge impact on how governments, cities and businesses design and implement policies and strategies. If citizens could access data that was previously almost exclusively available to their local or national governments, they might feel empowered to draw their own conclusions and develop their own policies to deal with issues in their community. This could lead to new forms of decentralized policies and decision-making. A local neighborhood, for instance, might have its own ideas on how to regulate traffic, based on locally generated traffic data.

2   What is the current status and what are the anticipated future developments of a data-driven society?

Most initiatives are still at a stage where the technology is being explored to see what sort of pilot applications could be launched. One exception is social media; it's using the cloud and the latest technology to share huge amounts of data real-time without authorities intervening. An obstacle to developing more applications, however, is our society's current general lack of trust. Although people acknowledge the opportunities access to data could offer, there are concerns about security and data being used unethically. As a result, it can be difficult for companies that want to develop new applications to convince parties to indeed share their data. There are

also practical concerns about the scalability of data-related services. One of the first projects in the Netherlands to address these issues is the Dutch Partnership Talking Traffic, where multiple stakeholders, in some cases competitors, cooperate to develop ways to better streamline traffic and reduce traffic jams by 20% by sharing data. KPN plays a crucial role in this initiative, facilitating data sharing through its specially built Data Services Hub.

3   Why is a data-driven society relevant to KPN?

A data-driven society requires networks that enable trusted exchange of information between people, things and organizations. As a leader in 'connectivity' in the Netherlands, and based on our potential role as a neutral intermediary and experience with analyzing and securely storing data, KPN is well-positioned to provide products and services to support a data-driven society.

We already provide crucial building blocks for a data-driven society through our Data Services Hub and our networks such as LoRaWAN and LTE-M.

4   What are the key technologies behind a data-driven society, the expected timeframes and the main technological hurdles?

The technological building blocks for a data-driven society, such as connectivity, the cloud, robotics, big data and data science, are all available. We also have the technology enabling the use of applications in different IT systems, which is crucial when different parties want to cooperate and share data. Blockchain is another technology that could enable data-driven societies.

A major hurdle is that we still need to develop regulation to balance privacy and security considerations with the opportunities that big data offer to businesses and governments. As long as parties involved don't know exactly what they may or may not do with data, there will be uncertainty. This makes it difficult for them to build trust.

Another hurdle is an intolerance among the public and regulators of errors in gathering or processing data. Becoming a data-driven society will be a process of trial and error for at least the next five years. But if even the

slightest mistake in dealing with data can lead to major reputation damage, many companies will be hesitant to invest in new applications.

5 Who are the frontrunners and which world-leading companies, institutes, experts and publications should readers invest time in?

Social media players are leaders and all the big tech companies (e.g. IBM, Cisco and Ericsson) have a vision and plans for a data-driven society. The World Economic Forum is very invested in this topic, particularly in how to boost confidence in this kind of concept.

The city of Toronto is a frontrunner among cities and is building a neighborhood designed as a model for urban life in the 21st century, with high-speed communication networks and connectivity to collect data from sensors in public spaces and buildings to report various environmental data.

Estonia is a leader among countries in implementing technologies and taking steps to entrust data-based decision-making to local communities. It claims that use of IT tools and data in the security services (e-Police, emergency services) has halved the number of deaths by accidents in Estonia over the last 20 years.

Artificial intelligence and machine learning

5

1   What are artificial intelligence and machine learning and why do they matter?

Artificial intelligence (AI) is an area of computer science centered on using data to solve complex tasks that only people could do before. Activities computers with AI are designed for, include speech and face recognition, and predicting traffic jams. Machine learning (ML) and robotics are central to AI. For machines to learn unsupervised requires an algorithm or 'neural network', which some experts say works like the human brain, to be able to identify patterns in big data streams. Generally, the more data an algorithm processes, the more accurate its predictions. In some cases, scientists calculate the minimum amount of data an algorithm requires for an acceptable accuracy.

AI is already transforming the way we interact with machines through the applications available, both in R&D environments and commercial consumer products. Further AI and ML progress will change our lives, offering new and better products and services in a range of sectors.

2   What is the current status of AI and ML and what are the anticipated developments?

AI is already being used for things like traffic information, image recognition for medical diagnosis, lip reading, machine translating and text creation. Some tech companies also already offer AI products. For instance, Microsoft has Azure Machine Learning for building predictive models, while Google has built a system that learns to speak by analyzing recordings of human voices.

Most available AI and ML applications can only perform specific tasks, and a future where robots can do practically any task is still far off. Taking the technology to the next level will take time and considerable financial investment. This is being driven by the continuous increase in computer power and the availability of more and more data.

One could say that AI & ML do overlap
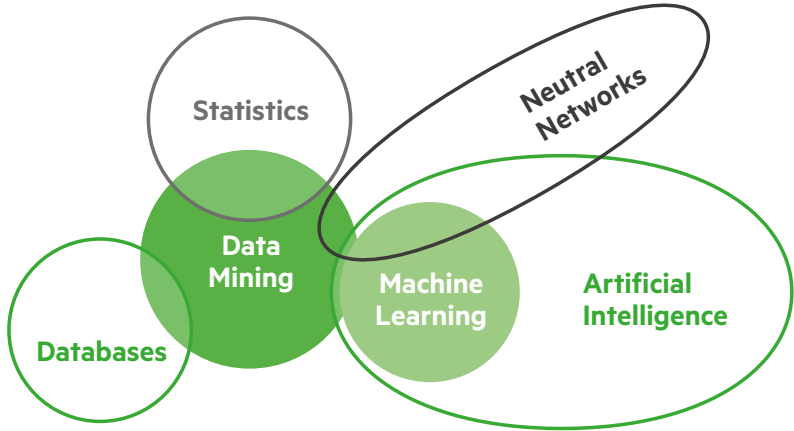
Algorithms can only learn if they're being fed vast amounts of data, and the amount of unstructured data currently available is increasing rapidly. The gaming industry has been a big driver behind greater computer power. For instance, the graphics processing units designed by U.S. tech company Nvidia to help render complex images for games also proved very useful for neural networks.

3   Why are AI and ML relevant to KPN?

We connect people and organizations, and by doing so we generate a large and growing amount of data on logistics and other processes. With AI and ML, we can use these data to enhance our existing services. Data from our networks could be used to identify incidents quicker and respond to them more efficiently, and data from our interactive TV services could enable us to make viewing or other entertainment recommendations. AI technology and platforms are readily available, but a key differentiator is who has the most relevant data and can turn them into useful applications, balancing privacy and added value. Trust is very important in this regard.

KPN is already using AI and ML technology to detect cyberattacks on our systems and to decide when to offer our website visitors webchats. We also use automatic learning from webchats and email.

4   What are the key technologies, timings and hurdles?

AI and ML are based on complex algorithms and data science. The technical ingredients needed are already available.

One of the hurdles to AI is the ethical discussion surrounding it. The more we can do with data, the more pertinent it is for people to decide what kind of use they are comfortable with, especially when it includes sharing personal data. These discussions and the resulting legislation will also determine the pace that more sophisticated forms of AI progress.

5   Who are the frontrunners in this area?

Tech companies with large databases, e.g. Facebook, Alibaba and Booking.com, are investing in AI and ML. Microsoft is a frontrunner in tools based on unstructured data, while Amazon leads the way in ML tools and services. IBM's Watson computer is also still considered an inspiring frontrunner. Fintech startups are among those to use AI technology, mostly open source, helping them compete with established companies.

NASA and many universities are running programs to further develop AI- and ML-related technology. University of Amsterdam professor Max Welling is a leading authority in the Netherlands on deep learning, i.e. a class of ML algorithms. Together with the Jheronimus Academy of Data Science, KPN is conducting research on applying transparent, predictive models, linking data science with research into decision-making, privacy and compliance. Internationally, telecom operators such as AT&T, Verizon and Telefonica are frontrunners.

APIs

6

1   What are APIs and why do they matter?

Just like people interact with applications using graphic interfaces such as icons, applications use application program interfaces (APIs) to communicate with each other. APIs allow one system to access another and add new functionalities or services. Think of how Google Maps provides information on restaurants, places to stay, public transport, etc. This information is added by third parties using APIs. Uber, for example, uses communication APIs to generate virtual numbers that protect the identity of its drivers and customers and thereby enhance the user experience.

APIs present multiple advantages. They are more flexible than traditional software programs as components can quickly and easily be added or removed; they are often developed in an open environment so there are mostly no license fees; and their functionality can evolve rapidly as developers find new ways to use them.

2   What is the current status and what are the anticipated developments?

McKinsey estimates that APIs will triple over the next 12 months, with an estimated global economic profit of EUR 1 trillion[1] in 2018. APIs are the driving force behind the digital economy, allowing online players to use each other's key assets to improve their user experience at minimal cost. The corporate world is starting to understand this, and more and more companies are establishing API programs to enable multiple participants to connect and interact on digital platforms.

This will require coding from developers other than the parameters that currently need to be set in applications by engineers. In this regard, businesses only use 55% of the software solutions they acquire[2].

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1   Source: What is really takes to capture the value of APIs, Keerthi Iyengar, Somesh Khanna, Srinivas Ramadath, and Daniel Stephens, September 2017, Digital McKinsey

2   Jim Johnson, Conference on Extreme Programming, Alghero, Italy, 2002

With APIs, developers can choose only the functionalities they want e.g. to add different languages or payment options to websites, and adapt these to their specific business requirements.

3   Why are APIs relevant to KPN?

Successful businesses today are data-driven, creating digital ecosystems that connect digital resources to introduce new products and services quickly and inexpensively. To remain competitive and continue to be relevant in this digital world, KPN must develop its own native APIs. These will allow KPN to create its own business-to-developer channel, offering its own software rather than that of third parties. Promising areas for KPN are technologies such as software-defined networking (SDN) and network function virtualization (NFV). Few telecoms operators are venturing into these areas to the extent that KPN is, and if successful, KPN could become a leading player. Other key areas are the Internet of Things and security.

KPN has an internal API platform that is currently available to its own developers and is adding functionalities known as carrier integrated services. These developments will allow KPN to create value for customers from within the network, rather than rely solely on over-the-top (OTT) APIs from third-party vendors, which do not always meet the required quality of service, let alone security. KPN believes a dynamic combination of OTT and native solutions will drive the telecom API market.

One native API KPN will be providing is an SD-WAN one that will allow developers to create their own VPN. But before opening up its network assets to external developers, KPN must ensure its core assets are properly protected. As such, the internal API development of virtual numbers will only be available as a service not as an API. Just consider the legal implications if this API were available to all.

4   What are the key technologies, timings and hurdles?

The key technologies for telecom providers to enable APIs will be SDN and NFV. SDN allows a telecom provider to program network devices rather than change the software controlling these devices. NFV enables the consolidation of network equipment onto generic servers rather than dedicated appliances. These technologies make it possible for companies to access network capacity on demand via a self-service portal.

Slicing the 5G network into multiple virtual networks for particular services or business segments will drive demand for APIs that open up KPN's network. For example, companies like Google or Apple may demand a slice of the network to run their services like virtual or eSIM.

5   Who are the frontrunners in this area?

Many companies have been set up in recent years that specialize in offering APIs, allowing their services to be integrated into existing applications and programs. Nexmo and Genband are good examples: while they use their own data centers, they 'piggyback' on the networks of local telecom providers. Rather than competing with these OTT developments, KPN has chosen to offer their solutions in its API store.

At present, only a few telecom APIs have been adopted, e.g. carmaker Renault is using an API from Orange for the radios in its Twingo cars.

Dean Bubley, Alan Quale and Tsahi Levent-Levi are three leading market observers covering the telecoms API area.

Blockchain
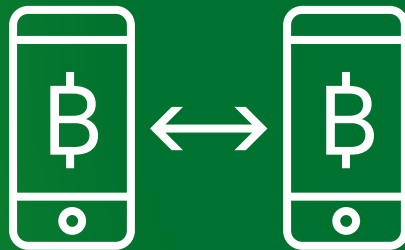
7

## 1 What is blockchain and why does it matter?

Blockchain is a distributed ledger technology that facilitates peer-to-peer transfer of value. The transaction history is stored on a decentralized network of computers, tasked with validating, updating and securing an immutable transaction ledger. Transactions are processed in batches. Each batch of transactions is stored in a block, which is subsequently shared with all computers (i.e. nodes) in the network. Each block is cryptographically linked to the previous block, creating a chain of blocks describing 'who owns what'. This chain can only be altered by a majority vote of the network.

Because blockchain allows for peer-to-peer transactions, it is often referred to as a disintermediating technology: it makes transactions cheaper, safer and more efficient by removing third parties from the transaction process. For example, when storing and transferring money, the trust we put in banks to do this on our behalf is replaced by a trust in the cryptography and economics of blockchain technology that allows us to do it for ourselves.

Blockchain can be used for digitizing many types of assets, such as property deeds, birth certificates and medical records. The decentralized nature of blockchain and its unchangeable ledger means these transactions are tamper-proof.

2 What is the current status of blockchain and what are the anticipated developments?

The huge advances in blockchain technology and the growing number of blockchain projects in 2017 has seen the technology become widely adopted. Some people are still skeptical, noting that the technology has been around for almost ten years without generating many new applications. Most experts, however, say blockchain could have a big impact across many industries and may cause the biggest revolution since the internet.
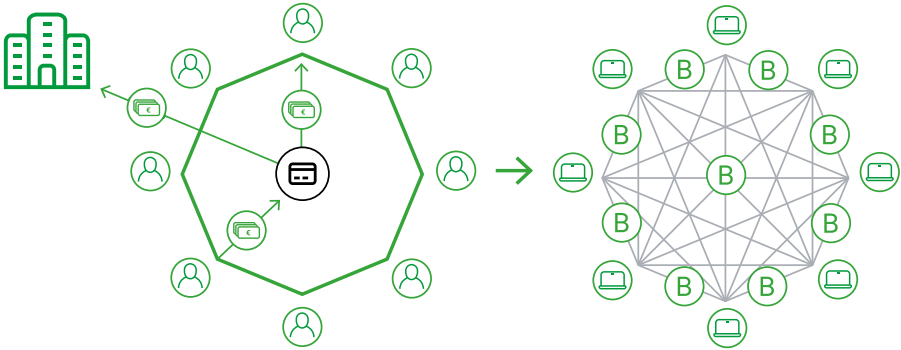
The financial sector remains the biggest blockchain user. A report by Santander estimates that blockchain could reduce banks' infrastructure costs for cross-border payments, securities trading and regulatory compliance by US$ 15-20 billion a year by 2020. ING and Rabobank are said to be ahead of many other financial companies in developing blockchain applications. Also, an increasing number of startups aim to raise funding through initial coin offerings, inviting investors to buy utility tokens that could increase in value as the company succeeds.

The highly volatile nature of cryptocurrencies has prompted skepticism about its applicability as a means of payment. 2017 also saw the emergence of decentralized stablecoins: cryptocurrencies that stabilize their value against the US dollar. This reduced volatility could be what many companies have been waiting for and drive the adoption of cryptocurrencies.

Blockchain opportunities are being recognized in other sectors too, with companies like IBM, Microsoft and KPN already offering services based on blockchain. A large number of Fortune 500 companies have joined forces in the Ethereum Enterprise Alliance, an initiative to further develop Ethereum blockchain technology for enterprise use cases.

3   Why is blockchain relevant to KPN?

KPN believes blockchain technology will bring innovations to the internet. We invested a lot in the 90s to bring fixed and mobile internet innovations (i.e. the 'internet of information') to society. We now see similar innovations with blockchain, and are working with blockchain entrepreneurs, startups and established companies to identify ways to accelerate, scale and validate these innovations as a first step towards the 'internet of value'.

Wider public acceptance of blockchain largely depends on greater trust. As a reliable company people entrust their data to, KPN can play a key role in making blockchain accessible. We're involved in many blockchain projects, for instance a local government initiative to financially support residents using blockchain-based applications. Our New Business unit's blockchain team is exploring new opportunities that we hope to implement as services in the coming years. KPN is also looking at how blockchain could disrupt our existing products and services.

4   What are the key technologies, timings and hurdles?

The first blockchain technology (i.e. bitcoin) was conceptualized in 2008 and implemented in 2009 by Satoshi Nakamoto. Since then, many different blockchain technologies have become available. One of the main hurdles is scalability. Blockchain transactions can take a long time and need a huge amount of computer power and energy. No single active blockchain network has managed to scale up so far, while demand for transaction processing only grows. Scaling solutions are coming though. Ethereum – a blockchain project that strives to be a decentralized version of the web – expects to provide much higher capabilities in the next 2-3 years, with some initial solutions coming in 2018.

5   Who are the frontrunners in this area?

Bitcoin has been a clear frontrunner and Satoshi Nakamoto's original white paper is a good introduction to the technology and its ideals. Ethereum continues to be at the forefront of blockchain development and adoption, and its white paper presents new and potentially game-changing concepts. Startups and established corporations worldwide are also helping drive blockchain use. In the Netherlands, the Delft Blockchain Lab plays a leading role.

Identity management

8

1   What is identity management and why does it matter?

Identity management is the process of verifying who is who in online networks and transactions. It has become a hot topic since more and more transactions are being performed online and the number of identities has also grown, not in the least because an individual can have several identities on the internet. Adding to the complexity is the wide variety of ways in which identities are being verified. Facebook, for instance, has relatively loose ways of verifying a member's identity. This means a low threshold for new members to join, but also makes it quite simple to join under a false identity. Banks on the other hand usually have strict and more complex protocols to verify their account holders' identities, and apply strong authentication processes to verify if a login is valid, for instance through additional verification via a mobile phone.

As the number of transactions, financial or otherwise, on the internet continues to grow, the call for standardization is growing too. At the same time users still expect everything online to be easy, including logging in and closing transactions.

2   What is the current status and what are the anticipated developments?

Ways of verifying identity online are still highly diverse. In the past few years however, several initiatives have made strides towards the standardization of identity management. In 2014 a group of 62 mobile telecom operators, in cooperation with their industry organization GSMA, introduced Mobile Connect: a universal protocol allowing users to log in to websites and applications by matching the user to their mobile phone, without the need to remember passwords or usernames. Mobile Connect also allows the user to authorize transactions. As of early 2018, Mobile Connect was available in 30 countries worldwide and available to more than 3 billion people.

The European Union introduced the eIDAS (electronic IDentification, Authentication and trust Services) ruling in 2014, a binding set of standards

for electronic identification and 'trust services' in electronic transactions in the European single market. eIDAS, which was due to be implemented by all national governments by September 2018, should enable citizens to carry out secure cross-border electronic transactions such as university enrollment, opening bank accounts, filing tax returns and authorizing access to medical records.

KPN and several other companies are doing research into using blockchain for identity management. We are also exploring integrating secure identity management and transaction technology with IoT devices, enabling these devices, such as a refrigerator for instance, to not only automatically order products but also arrange payment.

Experts expect it will take some time for the standardized easy-to-use identity verification applications to spread. Consensus is that we can expect more applications that combine identity verification and online payments services (or closing other transactions) rather soon. However, only after 2020 will identity verification and transaction technology be integrated into IoT devices.

3   Why is identity management relevant to KPN?

Due to our capabilities and track record in mobile security and identity verification, KPN is in a very good position to meet the increasing demand for easy-to-use online identity management applications with a high security level. Growing regulation also boosts our position, as it emphasizes the need for assurance that we are well equipped to provide. We have 6 million clients whose identity we've verified for mobile subscriptions, and manage more than 1 million identities with a very high level of security. Combining this strong identity management expertise with online payment services will be one of our focus areas in the coming years.

Additionally, we will introduce Mobile Connect to the Netherlands and are also exploring ways to integrate identity management and transaction technology into IoT devices.

4   What are the key technologies, timings and hurdles?

E-Commerce currently relies on the SSL certificate (the little green lock) for secure transactions on the internet. A wide range of other technologies are available that enable different aspects of identity verification and online payments with a high level of security. However, so far no one has combined these different building blocks into a single platform or service. KPN has acquired various technologies and is now working with established and boutique companies to combine them in order to develop integrated identity and payment management products and services.

Most of the technology required is available. The implementation is what will take time, and depends on the rate at which consumers and corporations adopt the online verification and payment applications. Trust and ease-of-use will be crucial for these applications to gain wide acceptance.

5   Who are frontrunners in this area?

Companies such as Gemalto, Symantec, the French security and identity specialist Morpho, and high-assurance digital certificate provider Digicert all provide the building blocks for developing an encompassing identity verification and online transaction system. In the Netherlands, KPN has been taking steps towards integrating a wide range of technologies to develop easy-to-use identity verification and online transactions applications.

Mixed reality

9

1   What is mixed reality and why does it matter?

The Pokémon Go game app caught the attention of millions of people worldwide after launching in 2016, and so far it is the best-known example of a mixed reality (MR) application. MR is a combination of augmented reality (AR) and virtual reality (VR). In most MR, AR and VR applications users wear special smart glasses where digital information is presented. These place a visual digital layer between the wearer and the real world. The degree to which this digital layer "interacts" with objects in the actual world and incorporates the context, e.g. locations and activities, etc., determines whether it's MR, AR or VR.

AR projects 2D information onto the glasses, while MR presents information in 3D imaging, providing a more immersive experience. MR can also consider real-world objects when projecting digital information onto the glasses. VR completely replaces physical reality with a computer-generated reality, blocking out the 'real' reality around us. VR gives developers more freedom, allowing them to design a brand new virtual world. VR doesn't, however, enable users to move around and interact with the real world. As such, most experts expect more applications to eventually be developed for AR and MR than VR.

xReality: The difference between AR, MR and VR

Augmented reality
Digital content is
projected on reality

Mixed reality
Digital content interacts
with reality

Virtual reality
Creates a fictional digital
environment, disconnected
from reality

MR is expected to revolutionize entertainment and enhance efficiency in many industries, particularly manufacturing. It could also potentially be used to improve education.

2   What is the current status and what are the anticipated developments?

The gaming industry is currently the biggest AR/MR user. VR also has stunning examples in games, and is being used in the military and healthcare, often for training purposes.

AR is being used by several retailers to help customers. IKEA, for instance, offers a 3D-imaging tool to see how its furniture would fit in a customer's home. Boeing uses AR to train staff to assemble aircraft wings, which it says has led to time savings of 35%[3].

At this stage, all eyes are on hardware manufacturers and their products, such as Rokid Glass, the Microsoft HoloLens and Meta(vison). However, most of these are still 'single solutions', expensive and hard to scale-up because there is no platform. Although Microsoft integrated its HoloLens with Windows, it remains to be seen if it will succeed.

Mobile platforms will be the dominant platform for AR and MR applications and services. All eyes are on Google's AR Core and Apple's ARKit, both aimed at developers rather than end-users. HoloLens could prove nothing more than an experiment, since Microsoft has dropped its mobile initiatives.

Although MR is still in its infancy, some estimate the industry will be worth US$165 billion in 2020. The market seems to be waiting for the fun, functional applications that could see a real MR breakthrough into the mainstream.

3   Why is mixed reality relevant to KPN?

MR depends on massive data transfers, requiring large bandwidth capacity at low latency. This presents opportunities for KPN, primarily in the B2B

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[3] A Manager's Guide to Augmented Reality, by Michael E. Porter and James E. Heppelmann, in: Harvard Business Review, November-December 2017.

market, and we've been exploring business opportunities with parties such as TNO, the Dutch organization for applied sciences. We currently have a patent for 'tiled streaming', a technology to enable streaming images to mobile devices.

More importantly, we can offer several services in the value chain, such as high bandwidth connections for production companies, high-demand storage solutions that use our servers to deliver the processing power needed for MR, and hosting solutions to enable applications for end-users. KPN might also consider offering end-user MR services, such as enhanced ways of teleconferencing. Providing MR devices to further promote MR applications is another consideration.

### 4   What are the key technologies, timings and hurdles?

Technologies enabling MR are sensors, cameras and scanners that map the physical world into a digital 3D picture. The lack of affordable smart glasses is one of the main obstacles to MR growth, as is the limited battery power of MR devices. Technology boosting the speed and capacity of data transfers, such as 5G and quantum computing, will help MR grow.

5   Who are the frontrunners in this area?

The U.S. startup Magic Leap is a frontrunner in MR, although there has been some skepticism in the market because its ambitious plans didn't come to fruition for a long time. In late 2017, Magic Leap announced the launch of its first MR product, a head-mounted virtual retinal display called Magic Leap One. Most of the world's big technology companies (i.e. Apple, Facebook, Microsoft, Google, Samsung, Sony, Nintendo and Huawei) are developing or have already launched VR, AR and MR products or services. Google's plans are mostly centered on AR, while Apple has chosen to focus mainly on AR and potentially MR devices and applications.

At this relatively early stage, a lot of attention is on hardware. Besides Magic Leap and Microsoft, companies to follow are Vuzix, Atheer, ODG, Oculus Rift (Facebook), HTC, Sony, Rokid Glass and Metavision.

Quantum
Technology
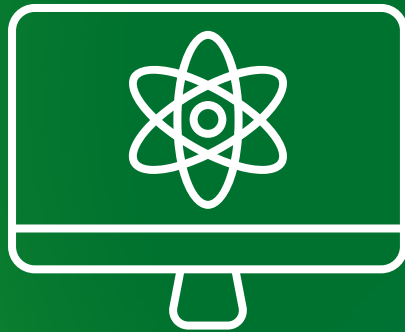
10

1   What is quantum technology and why does it matter?

The second quantum revolution is well on its way. While the first revolution brought us groundbreaking technologies such as the transistor over 100 years ago, the second revolution will again bring transformative advances and changes to society, industry and science. As a result, the lives of people around the world will be changed fundamentally.

The EU created a Flagship project for Quantum Technologies in 2016 and has pledged support of EUR 1 billion. They have divided the work in Quantum Technologies into 4 pillars. These are: 1. Communications; 2. Computing; 3. Simulation; 4. Sensing & Metrology. Within these pillars are diverse innovations. Some examples include: a new quantum internet (that would be impervious to eavesdropping), an universal quantum computer (to solve problems that are not practically feasible with classical computers), quantum simulators (to study quantum systems that are difficult to model even with supercomputers) and even advanced navigation and GPS to gravimeters.

2   What is the current status of quantum technology and what are the anticipated developments?

Quantum computers have already entered their early test phase and the global race to build a bigger quantum computer and unleash its potential is well under way. This race is one in which governments, universities, corporations and national as well as regional institutions are all participating. Google just announced that they have created 'Bristlecone' a 72 qubit quantum processor. They are pinning their hopes on achieving quantum supremacy over classical computing this year.

In the quantum communication domain, China has built the first large scale quantum key distribution (QKD) network. This feat of engineering includes a vast terrestrial network between Beijing and Shanghai, as well as a satellite connection for China.

3   Why is quantum technology relevant to KPN?

Quantum technology will disrupt the way we handle communication, impacting symmetric cryptography, cloud computing and networking. Quantum computers will be able to break through public key encryption schemes and disrupt the way we communicate and trust across the internet. The concept of "capture now, decrypt later" means that all encrypted messages ever sent and stored could be decoded in the future, making them unsafe if we don't add additional measures.

As providing secure networks and improving online security is a top priority for KPN, we are working to adapt our networks and our cryptography to a post-quantum era. This year, we have already embarked on a project to start the Dutch quantum internet backbone by connecting four universities via our network. We have also started working with new, candidate, post quantum algorithms on our networks and systems. We work together with universities like TU Delft, TU Eindhoven, but also with organiations like QuTech and QuSoft to realize our ambitions in this dynamic and engaging area of science.

4   What are the key technologies behind quantum technology, the expected timeframes and the main technological hurdles?

Developments in quantum technology are moving ever quicker and in early 2017 a 49-qubit computer was announced. Up until then, the largest quantum computer was a 20-qubit one. Again Google's Bristlecone just upped the ante to 72 qubit. The challenge will be to create a system with 50 fault tolerant and stable qubits in the next few years. If this is accomplished, the expectation is that in 10 years a computer with thousands of qubits will be possible.

There are many engineering hurdles to overcome, but one of the more practical problems is around achieving room temperature for quantum computers. Currently, for qubits to function well and remain stable, a quantum computer needs to operate near absolute zero, at temperatures that are colder than outer space.

5   Who are the frontrunners in this area?

At the moment, China and the US are spending the most significant sums of money on quantum R&D, removing the EU from its pole position a couple of years ago (see graph). Multinationals such as IBM, Google, Microsoft are building alliances together with both local industry and academics to gain and maintain pole position. The EU still has a prominent position, thanks to the work in key universities which are making leading strides in fundamental research where the Netherlands plays a major role.

Estimated annual spending on quantum-technology research in 2015 (EUR million). Percentages are calculated on an estimated total spending of EUR 1.5 billion.

EU	37%
USA	24%
China	15%
Canada	7%
Australia	5%

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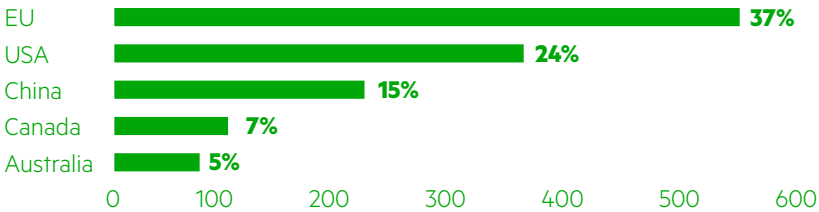
Source: Economist Technology Quarterly 2017

In the Netherlands, QuTech is the most advanced research center for quantum computing and the internet. It was set up by TU Delft and TNO and cooperates with several other universities and industry partners.

Photonics
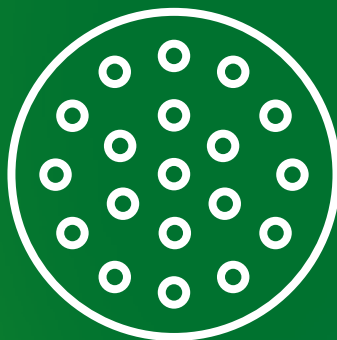
11

1   What is photonics and why does it matter?

Photonics is the science of light, covering a wide range of scientific areas and technological applications. For the telecom sector the most relevant field of photonics is optics technologies, which include fiber optics and integrated optics. These technologies are used in the glass fiber networks providing households with fast internet and to exchange data between data centers.

Fiber optics is a technology where light is used to transport data at high speeds through glass fiber cables. Integrated optics is a technology that manipulates light before it is shot into the fiber cables, so it can transport even more data over longer distances. Integrated optics also focusses on developing photonic integrated circuits (PICs) to perform these tasks more efficiently. PICs are the photonic counterparts of electric integrated circuits, i.e. computer chips. Rather than using electrons, photonic chips use light, making them much faster while using less power. This type of photonics is used in different fields like vivo imaging: the sophisticated technology used in medical research to see cancer cells while they are still in the patient's body. In telecoms, photonics are used to enlarge transmission capacity and speed, while reducing costs and energy use.

Although the electronics industry still underlies most telecom technology, it has nearly reached its speed limit. This is because most of the technologies needed to achieve optimal speed have already been invented and applied. As demand for more speed and higher capacity in data transport increases, the need for photonic systems grows. Photonics is already one of the fastest-growing high-tech industries in the world and will become one of the top 5 key industries[4]. In the Netherlands, it will create some 7,000 jobs in the Brainport region of Eindhoven alone[5].

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[4]   Heiko Jessayan, "Zonder fotonica loopt het internet vast" (Het Financieele Dagblad, April 29, 2016)

[5]   The Institute of Photonic Integration conference (Eindhoven University of Technology, April 25, 2016)

2   What is the current status of photonics and what are the anticipated future developments?

Glass fiber cables have been rolled out in many countries worldwide, including the Netherlands. These glass fiber networks have a relatively high capacity and can meet the current data transport demands. Innovations have increased network capacity over the years. For instance, KPN's glass fiber 'core' network (the network connecting our main data centers and other core locations) had a capacity of 2.5 Gigabits per second per wavelength and could process 16 wavelengths per fiber in 2000. The core network we built in 2015 connecting our main four data centers (the so-called ZARA[6] locations) can process 200 Gigabits per second and process 88 wavelengths per fiber.

However, the amount of data transferred via wired networks is doubling every 18 months. As such, the current generation fibers are no longer expected to meet demand by 2025. In anticipation of this, research is already being done into next generation fiber cables.

Research is also being done into using photonic integrated circuits to further boost capacity of optic data transport networks. PIC technology is available in research labs and, like many other photonic innovations, it is expected to become commercially available as demand for high-capacity and faster data transport grows. Quantum computing, which is also based on photonics, is expected to push the implementation of photonics in the long term.

3   Why is photonics relevant to KPN?

As one of the leading telecom operators in the Netherlands, KPN owns the country's largest fiber optic network. To maintain our leading role in connectivity, we must encourage the implementation of new technologies that will help make our network even more flexible, scalable, and cost and energy efficient. Photonics can provide all of this. Our core network, which connects our biggest data centers in the Netherlands, already uses the best of today's optic fiber technology.

[6]   Zwolle Amsterdam Rotterdam Arnhem

## 4   What are the key technologies, timings and hurdles?

A combination of in-depth knowledge of optics, electronics and telecom networks is relevant to integrated optics technology. Fundamental research, alongside other research programs at universities and institutes across the world, has already made new technologies available that could further improve photonics. Implementation is only a matter of time and depends on balancing the demand for higher-capacity and faster data transport with the vast investments required.

KPN is currently considering when and where to use PICs and other optical components to faster process even more data. We are collaborating with Eindhoven University of Technology (TU/e) in the SmartOne project. Although this project is only at the research stage, PICs may be used in KPN's core network within the next five years and a new generation of fibers could be in use by 2025.

5   Who are the frontrunners in this area?

The Institute of Photonic Integration at TU/e is among the world's leading institutes in photonics research, along with the Nokia Bell Labs and NEC Labs in the United States. The University of Southampton in the UK is a frontrunner in research into optical amplifiers and so are NTT Labs and KDDI in Japan. In China, Huawei is a leader in optics.

Connected and automated driving
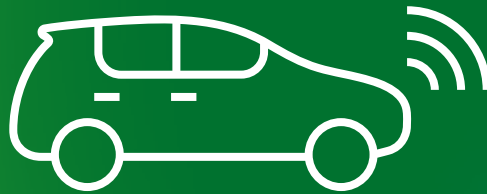
12

1   What is connected and automated driving and why does it matter?
Several technologies and trends discussed in this technology book, such
as 5G, IoT en identity management, come together in connected and
automated driving. This is a way of driving and managing traffic where
vehicles are connected with each other, with roadside infrastructure and
with other road users via wireless networks, to reduce traffic jams and
accidents, and enhance driver convenience.

Connected and automated driving is often confused with autonomous
driving. Although this fully automated way of driving may eventually
become a reality, the more imminent steps to increase connectivity between
cars and road infrastructure may have a wider societal and economic impact
than just on individual drivers.

A connected car comes with sensors, internet access and usually also a
wireless local area network. This facilitates vehicle-to-vehicle (v2v) and
vehicle-to-infrastructure (v2i) communication, as well as communication
with other road users, such as cyclists and pedestrians (v2p). It can help
improve road safety and driver convenience in many different ways.

**2   What is the current status and what are the anticipated
        developments?**
So far, connectivity in cars is mainly for infotainment purposes, downloading
software updates and sharing maintenance diagnostics. Besides that, there
are several applications already available for connected driving. For instance,
since 2018 new cars have been equipped with a modem that automatically
calls emergency services if there is a collision. Real-time traffic information
provider Flitsmeister not only warns its users of police speed checks, but
also notifies them if an ambulance is approaching or roadworks are ahead.

Today, many car manufacturers provide autopilot features, such as parking assistance and adaptive cruise control. Most of these services are currently based on sensor data acquired by the car itself. These services cannot therefore be classified as connected and automated driving, but rather as 'cooperative driving'.

Governments are expected to be the engine of connected and automated driving. In densely populated countries like the Netherlands, where space is restricted and building more highways often encounters resistance, connected and automated driving is seen as a viable option to reduce traffic congestion and enhance road safety.

Experts believe that in coming years, the industry will make the transition from cooperative driving to connected and automated driving. We will not arrive at the even more advanced stage of autonomous driving before 2030 at the earliest, they estimate.

3 Why is connected and automated driving relevant to KPN?

KPN's current 4G network is already very suitable for facilitating basic connected and automated driving use cases. This was demonstrated during the summer of 2017 in a project where trucks transporting flowers were given priority when approaching traffic lights near Schiphol. When nearing the lights, the truck indicated its location, speed and driving direction to the traffic lights. The lights in turn responded with speed advice, for which the truck was guaranteed a green light. All communication between truck and traffic light was sent nearly real-time using the KPN 4G network.

With 5G approaching, even more advanced use cases of connected and automated driving will become possible. 5G networks will provide higher reliability and lower latency than 4G, two key ingredients for connected and automated driving.

Besides connectivity, the success of connected and automated driving will be based on collecting, storing and processing huge amounts of data – a natural match with KPN's core competences. As part of the Dutch government program Beter Benutten, various partnerships have been set up, including Talking Traffic. KPN plays an important role in the Talking

Traffic initiative, facilitating data sharing through its Data Services Hub set up for this purpose. Public and private parties that worked separately for years are now able to join forces, with KPN acting as a neutral, trusted and reliable agent, safeguarding privacy and intellectual property.

4   What are the key technologies, timings and hurdles?

Another requirement is sophisticated positioning technology, advanced GPS or maybe even 5G, that can pinpoint a vehicle's location down to centimeters. One potential hurdle could be that the real benefits of connected and automated driving will not be achieved unless all cars are connected, which may take a long time.

There are also concerns about the introduction of connected and automated driving related to potential privacy infringements, safety issues and the risk of hacking.

5   Who are the frontrunners in this area?

There are frontrunners in different domains that need to work together to realize connected and automated driving. These include car manufacturers, network providers and governments. The US government recently introduced regulation requiring all new cars to have an on-board unit for v2x communication installed. In Europe many initiatives are now being started, often funded by the European Union or local governments. KPN tries to contribute as much as possible.

Technology
and ethics

13

According to some developers and businesses working with new data-driven technologies, the implementation of these technologies in society may be hampered by a lack of clear regulation and public trust. At times, the general public seems to waver about what should and shouldn't be allowed when dealing with data, especially personal data. Consumers seem to take conscious decisions about what to allow and what not, but their decisions can vary widely: many are keen to share data to enable services such as Google Maps, but reluctant to let data on their own movements be collected, stored and used for other purposes.

Disparity between rapid technological developments and ethical standards and regulation is a hurdle, developers say, potentially causing businesses to postpone investments in new applications.

1   What are the latest developments regarding ethics and regulation affecting technology?

The divergence between ethics and technology should be put into perspective, as the two have historically always developed at different paces. At the same time, steps are currently being taken to better clarify the situation. Important new regulations have been implemented or will be implemented soon.

Europe has taken the lead in strengthening privacy protection with the implementation in 2018 of the General Data Protection Regulation. This regulation aims primarily to give control back to citizens and residents over their personal data. It also aims to simplify the regulatory environment for international business by unifying the regulation within the EU.

Debates in member states on this regulation have raised the awareness of privacy rules among consumers and businesses alike. People are asking more questions about what will be done with their data, while businesses are having to decide how to use data for every application. To do this,

businesses will most likely need to include a 'nuclear option', meaning consumers will get the option to prohibit their data from being used for commercial purposes.

2   Is there sufficient clarity regarding the application of privacy regulations?

What's still lacking are clear and uniform mechanisms to enforce privacy regulation. Relatively few privacy cases have been brought to EU courts and as such the resulting jurisprudence provides little guidance. Jurisprudence will need to develop further before legal precedence can help create more certainty about the limitations and possibilities of using personal data, according to ethics experts. That being said, national data protection agencies already provide some guidance at a national level. At EU-level, data protection agencies cooperate in the European Data Protection Board to coordinate the enforcement of data protection regulation.

What's more, the right to privacy is a constitutional right in the EU. As such, privacy matters represent a challenge to innovators. However, those developing new applications based on data technology in the telecom and technology sectors could try to avoid this hurdle with privacy by taking a different approach. Instead of taking available data as a starting point for developing applications, they could try to think of a specific service they'd like to provide and see how this can be done without using personal data. For instance, guiding drivers to empty parking spaces close to their destinations in smart cities can easily be done without needing to access personalized data. Anonymous data can be used for a range of applications.

3   How do companies and technology innovators respond to privacy and other ethics regulations?

Innovators could include ethical considerations earlier in their product development process, something that is actually gradually happening. Also, more and more large corporations are appointing ethics officers. It would be good if the developers behind new applications would consult their ethics officer, whenever relevant. KPN, meanwhile, has developed a tool for innovators to assess a range of legal and compliance matters when designing new products or services. The first tests of this privacy impact assessment tool are planned for 2018.

Some developers have directly addressed the situation by creating privacy-friendly solutions, such as Mycroft voice assistant. The Mycroft smart speaker in early 2018 became a hit on crowdfunding platform Kickstarter under the motto 'Mycroft brings you the power of voice while maintaining privacy and data independence'. Mycroft aims to offer a privacy-friendly alternative for Google Home and Amazon Echo.

Boosting public trust in new technologies and applications could also help bring about a wider acceptance of new applications. Like many other organizations, KPN has seen that customer confidence in new technologies does not always grow at the same pace as innovation, which itself is getting faster and faster. As such, KPN joined the newly established Dutch think-tank Innovatie en Vertrouwen, which aims to develop ways to foster greater public trust in new technologies. In doing so, the think-tank hopes to ensure that technological innovation can continue to contribute to society in a responsible and sustainable fashion.