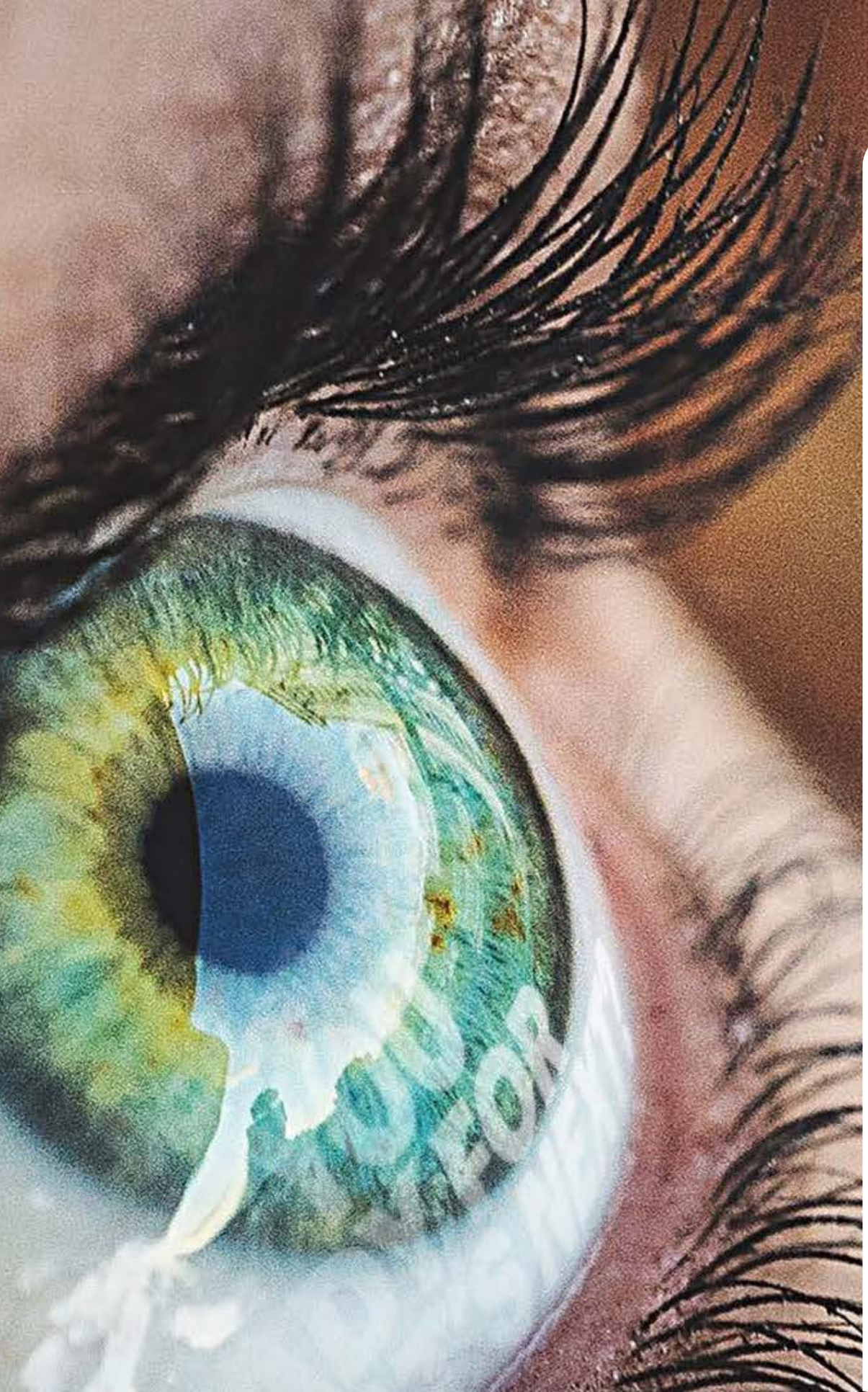
Rabobank

Technology Trend Report

2020

Tech Lab

Innovation & Strategy Hub



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Preface

We proudly present the next edition of the Rabobank Technology Trend report. We are happy to share our knowledge and findings with you regarding the latest technologies that are emerging from labs and being deployed in society. Some of these developments will change our lives forever; others might be greatly overestimated and remain niche concepts.

We don't know our future and we will never be able to predict it. That said, we can analyse trends, extrapolate findings and sketch a multitude of scenarios. Some possibilities are less likely, but others have a fair chance of coming to fruition and can give guidance on how to position Rabobank and/or her clients to reap the benefits of these developments.

This report is brought to you by the Tech Lab team of the Rabobank Innovation & Strategy hub. The role of the lab is to research emerging technologies, conduct experiments and accelerate useful adoption within Rabobank. In fact, our aim is to make technologies boring. By conducting thorough research, we want to separate sense from nonsense and unravel the mystique around innovations, piece by piece.

This leaves us with a brighter and better grounded view of what will come. Instead of adrenaline-based gazing into a far future, we can actually start building realities today.

By handing this research to you, we hope to inspire you with a glance of the future and to kick-start interactions. We'd like to challenge you to read this report with an open mind: if such innovations do take off, how could this technology be used to benefit you in your daily work and also your life? It's not always easy to think openly and optimistically about such developments; often, our tendency can be to fear new technologies. With this report we hope to build your confidence in new technologies and support the belief that they can help you, your clients and organisation as a whole.

This report is initially targeting Rabobank employees and our clients, and consequently lays its focus mostly on our customers and our banking environment. As we think these insights are applicable to other industries, companies and individuals as well, we are eager to share our lessons learned. We want to encourage you to extend these technical developments to your own situation. Please get in touch with us if you have questions, feedback or interesting opportunities

We hope you enjoy reading this report as much as we enjoyed facilitating its development.

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Introduction

A few decades ago the world welcomed a new era: the digital age. Extremely rapid digitisation meant we said goodbye to the world as we knew it. Most companies and organisations have already undergone a major digital transformation. We now find ourselves in a whole new chapter of the digital era, but that by no means implies that the most significant changes are behind us – not in the slightest. Rather, the world, again, finds itself at a tipping point.

This report explores the abundance of opportunities that digital technologies present the world, the banking and Food & Agri-industry and, in particular, Rabobank. Developments in various technologies have paved the way for new channels, collaborations and business models. To help the bank navigate all these technology-driven changes smoothly, and even more importantly, to ensure that the bank and its clients capitalise on all these new opportunities, the Tech Lab was launched.

In this Tech Lab, Rabobank researches all these technologies to accelerate the adoption of enhanced business models and to empower our employees.

The Tech Lab team has identified eight technological trends that it believes will have the most significant impact on the world, the banking industry and Rabobank, in particular, in the years to come. These trends are the Internet of Things; Next Generation Communication Networks; Extended Reality; Blockchain; Secure Multi-Party Computation; Voice Technology; Quantum Computing and Artificial Intelligence. This report digs a little deeper to unpack the definition, developmental context, future growth and practical application of each of these technologies.

In the coming years, we will continue to focus on how to leverage these technologies to do what we do even more effectively – serve our clients and their interests, while simultaneously working to make the world a better, smarter and more sustainable place. Because for us at Rabobank, this is one of our key priorities. We can only achieve true sustainability if people and businesses collaborate to contribute to a better, cleaner world. And a better world is precisely what Rabobank hopes to create by providing financial services that improve clients' access to information, knowledge and networks.

Leveraging technological trends to build new business models and drive economic development has its merits, but should never take priority over our responsibility to care for our people and our planet.

Artificial Intelligence

Chapter 01

Unpacking Artificial Intelligence

Artificial Intelligence (AI) refers to a collection of technologies that, when brought together, enables machines to act with human-like levels of intelligence. AI can be described as applications that leverage machine learning, natural language processing (NLP) and computer vision to learn new information, draw conclusions and comprehend content. By doing so, machines are able to automate certain tasks and replace the role of humans in carrying out predominantly routine, repetitive activities. Like in the case of Quantum Computing (QC) and Secure Multi-Party Computation (SMPC), the technology and maths behind AI has been around for ages; it's only flourished of late with the enormous increase in computational power, the explosion of available data and the increasing number of data professionals in the workforce. There's no doubt that AI, which combines and powers a wide range of developments, will change the way we work and live more so than any other technology alone.

Self-automated learning is a key aspect of AI. Machines are able to learn through:

- **Supervised learning** – the algorithm learns on a labelled dataset and has access to the correct answer that it can use to evaluate its accuracy on training data;
- **Unsupervised learning** – the algorithm tries to make sense of unlabelled data by extracting features and patterns on its own;
- **Reinforcement learning** – the algorithm learns by interacting with its environment, through a system of reward and punishment (trial and error).

Evolution of Artificial Intelligence

Today, approximately 80 percent of large companies have adopted examples of machine learning and other forms of AI to enhance their core business operations. Five years ago, this figure was less than 10 percent. Nevertheless, most companies still only use AI tools as point solutions – for fraud prevention, for instance – discrete applications that are isolated from the enterprise's wider IT architecture.

Every day, AI is getting closer and closer to human-like intelligence, and at some point we may no longer be able to tell the difference between machines' capabilities and those of people. That said, since AI currently still isn't able to grasp the full meaning of concepts, its scope of application is slightly limited. That might change, though. After all, when AI was first pioneered, it could only perform tasks that were easy and repetitive. It has since evolved and can now tackle far more multifaceted and complex activities – accurately predicting travel times in navigation apps, for instance. So, who knows what it will be capable of in the future?

Narrow AI versus Broad AI

At present, most AI applications fall under the Narrow AI category – meaning, they're built for a specific task. In the future, we expect the rise of Broad AI solutions – systems that can work on a broad range of problems.

Even though it's relatively early days as far as AI goes, businesses worldwide are already using AI and deep learning in several unique ways as invaluable tools. Thanks to developments in computer hardware, performance improvements, the advent of cloud computing and advancements in AI technology itself, AI has become accessible to enterprises of all sizes. That said, bigger technology companies are still the biggest investors in this field. The movements in this arena bode well for the future: today, AI is already capable of making highly accurate predictions, and going forward, it will take over more and more activities that humans are currently responsible for.

The other side of the Artificial Intelligence coin

As is the case with various other technologies, data quality and privacy are both still challenging issues when it comes to AI. Perhaps more than any other innovation, though, AI instills much fear in people. There are the more widely expressed concerns – 'Will we lose our jobs to robots?' – and then there's also anxiety about losing control over AI, its outcomes and impacts. As AI models become increasingly advanced, intelligent and complex, we as humans tend to understand them less – we need to be wary of possible biases that we don't immediately recognise and can't explain or even interpret. It's even been found that AI-driven models can make choices that us humans aren't capable of understanding – the "Computer says no" scenario is an example. Naturally, for many people, that's a scary thought.

What tomorrow holds for Artificial Intelligence

While human intelligence is still indispensable, we'll almost certainly see a drop in our dependence on the living brain in the coming years. One day, for instance, AI will be able to fully run the autopilot function in an aircraft. The reality is, though, we're not at this point yet. AI algorithms are still far from perfect – in fact, the idea of 100 percent accurate algorithms that can operate entirely on their own without the need for human intervention or decision-making is still a far-off ideal. Furthermore, many organisations today battle with the amount of data, and the level of data quality, needed for solid AI applications.

AI will completely change the way we work and live

While it will still be many decades before we see Quantum Computing (QC) take off on a large scale, it's predicted that when this happens, it will have a significant impact on the field of AI – leading to enhanced judgement, improved interaction, greater degrees of trust and products that are far more intelligent. In general, AI is going to change almost every aspect of daily life and the nature of work as we know it. To manage AI and harness its power within organisations, new jobs, roles and skills will be required. As AI tackles less complex, more mundane duties, employees can start taking on higher-value, more rewarding tasks.

Implications and applications for Rabobank and its clients

AI is bringing about a massive transformation in the banking industry. It yields many new data-driven insights, while increasing productivity and presenting new cost-saving opportunities. AI allows banks to enhance the customer experience, accelerate business growth, mitigate risks and increase operational efficiency.

This trend offered endless opportunities for Rabobank, too. AI can be applied to all of the bank's internal and available external sources of data. It has already been leveraged for multiple different purposes – for fraud prevention, personalised financial advice, real-time transaction monitoring, risk assessment, cybersecurity, enhanced human-machine interaction and even for marketing. Rabobank created an AI model to identify operational deposits, enabling the bank to conduct better risk assessments. The model was built in only six weeks, and saves the bank millions of euros per year - of course by using customer data only in accepted ways.

A proactive player in the market

Rabobank strives to promote a data-driven society and aims to improve confidence in AI. One way the bank contributes is by being an active player in the market. Rabobank is one of the investors behind ProducePay, a Los Angeles-based company that aims to overcome the lack of proper short-term access to financing and transparency within the farming industry supply chain by providing fresh produce farmers with financial resources, tech tools and data insights.

Another AI-driven initiative Rabobank is proud to support is JoinData, an authorisation data platform for the Dutch agricultural sector that enables companies, knowledge institutions and agricultural entrepreneurs to work together to stimulate sustainable entrepreneurship and innovation in the industry.

Artificial Intelligence in practice

Agricultural companies around the world are looking to technology to help them access data-driven insights, run operations more efficiently and reduce waste in food production. AI technology, in particular, is transforming the agricultural sector, as farmers can now rely on data from satellites like drones to assess their farms' state – they no longer have to walk the full length of their property. Machine learning models are being developed to track and predict the impact of environmental conditions, like weather changes, on crop yield. Finally, companies are also developing and programming autonomous robots to handle essential agricultural tasks, like crop harvesting, and to do so at a significantly higher volume and faster pace than human labourers could.

John Deere, American manufacturer of farming and industrial machinery, is a shining example of a company that's used AI to radically transform the farming industry. The company's pesticide and herbicide distribution systems use smart cameras, powered by computer vision, to distinguish between healthy and unhealthy plants as the equipment passes through the field – these smart machines then use this information to decide, then and there, which individual crops to dose with chemicals.

PEAT is a Berlin-based agricultural tech startup that has developed a deep-learning application called Plantix. Plantix can identify potential defects and nutrient deficiencies in soil using a software algorithm that correlates certain foliage patterns with soil problems, plant pests and diseases.

Financial institutions everywhere have also eagerly jumped on the AI bandwagon. JPMorgan Chase, for instance, has implemented a proprietary algorithm to detect fraud patterns. Every time a credit card transaction is processed, complete details of the event are sent to central computers in J.P. Morgan Chase's data centres, and these then decide if the transaction is fraudulent. Another example is US Bank, which has been using deep learning for anti-money laundering purposes for the past three years. By doing so, the bank has managed to double the output it could achieve using the previous system's capabilities. Lastly, it's also worth noting the example of Ceba, from the Commonwealth Bank of Australia. Ceba is a chatbot that's been trained to provide customers with in-the-moment digital support. The application is capable of answering a broad range of customers' day-to-day banking-related questions.

Blockchain

Chapter 02

Unpacking Blockchain

What exactly is blockchain? It's an IT solution that enable multiple parties to work on a shared set of data – this data could be, for example, all the information that flows through the mortgage chain, and is used by banks, notaries and financial advisors. It allows digital information to be distributed, while participating parties keep full ownership of their own individual pieces of data.

Imagine a shared spreadsheet that exists in the IT systems of all participants. Each individual cell is owned by one party, and if changes are made, they are executed across all copies of the shared spreadsheet. As a result, this "spreadsheet" (or blockchain solution) serves as mutual place to store data and a single version of the truth for involved parties.

Blockchain technology enables Bitcoin and other cryptocurrencies, but can actually be used to facilitate the transaction of any type of digital asset. It does so by creating and maintaining a distributed ledger that functions as a registry of transaction records. Blockchain helps to improve the way businesses, governments and individuals work together by ensuring that all digital agreements are secure and trustworthy, so that the involved parties can be worry-free.

Key areas for application include financial services infrastructure, supply chain and identity verification. Blockchain empowers businesses to reimagine how financial transactions, like payments and post-trade processing, are executed. Enhanced security, transparency and speed makes way for cheaper, faster and safer settlements in the context of cross-border and mobile payments. When it comes to trade finance, the purchase order, bill of lading and letter of credit for a transaction is verified via

blockchain, which leads to fewer errors and disputes. Today, moving money requires complex messaging; in the future, blockchain could minimise exceptions and simplify reconciliation.

Private versus public blockchains

Blockchain can be implemented as permissioned (private) or permissionless (public) network. In the case of permissionless blockchain networks, anyone can participate without a specific identity – there are no barriers to entry. Such public blockchains typically involve a native cryptocurrency and consensus is based on proof of work. A permissioned blockchain secures interactions among a group of known, identified participants that have a common goal,such as businesses that exchange funds, goods or information. Permission is required for any party to access or transact on the network. With governance covering the identities of the peers, a permissioned blockchain can rely on a more efficient means of consensus.

Minimising security risks

Blockchain technology enables smart contracts: immutable computer code running in the blockchain that defines and automatically enforces the rules and obligations of an agreement. In turn, smart contracts facilitate conditional payments, also known as "if-then" triggered transactions. Meaning, only when amount X is paid will action or payment Y be triggered. The consensus mechanism behind blockchain minimises, but doesn't entirely eliminate, the type of security risks that are normally present when multiple parties share data. The integrity of transactions is maintained by ongoing audits that are built into the protocol.

The role of cryptography

Transactions represent a transfer of information (e.g. book entries, financial transactions or identity data) between two or more addresses within the network. Every member of the network holds a copy of the ledger – there is no need for a "master copy" or a trusted third party. Blockchain uses cryptography to ensure that copies are identical and no transaction is duplicated, and to control access to the stored data. Moreover, cryptography allows for the secure authentication of parties – if one of the involved parties is compromised, the rest of the network will remain secure.

The key advantages of blockchain

In short, blockchain enables entities (companies, individuals, things) to store information securely while enjoying a degree of anonymity through the use of pseudonyms. The chief advantages of blockchain technology include:

- A blockchain-enabled platform is 100 percent transparent and is constantly updated
- Blockchain networks decrease dependency on trusted third parties (the so-called middle man);
- Blockchain exchanges are fully verifiable – transactions can be traced back to their inception;
- Transactions within the network are executed securely via smart contracts and rely on the use of pseudonyms; computer protocols are used to facilitate, verify and enforce the near real-time negotiation of a contract, and hence no human intervention is needed. Such decentralised self-executing contracts are expected to take flight in the foreseeable future.

Evolution of Blockchain

The sense of "togetherness" and openness that underpin blockchain are elements that resonate with Rabobank's DNA. It's why the bank started experimenting with blockchain technology and solutions even in its earliest days. In 2014, Rabobank started with cross-border payments and the bank has remained involved in such innovations ever since.

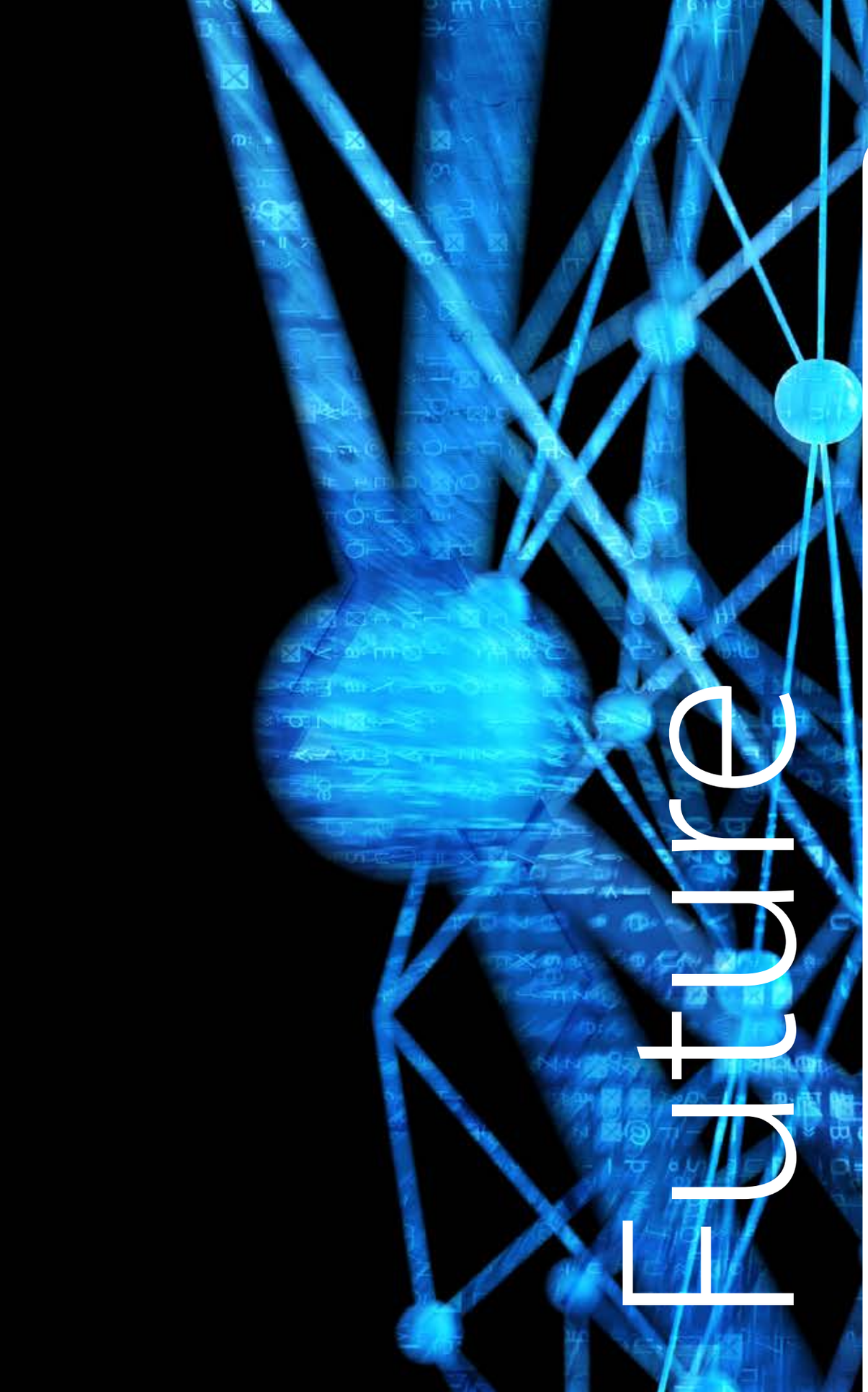
Rabobank as a blockchain frontrunner: we.trade and komgo

Alongside its participation in a large number of blockchain platforms, Rabobank is also a founding partner of we.trade, an innovative digital trade platform that was launched in 2018 to assist SMEs looking to engage in European cross-border trade. Guided by the motto, 'You're into business; we're into banking', we.trade offers companies on the hunt for new trading possibilities a blockchain solution that helps businesses and banks across Europe to collaborate to create a transparent, secure environment where opportunities and growth come together. By doing so, the startup 'simply makes trade smarter', as it's put on the we.trade website. The focus is on delivering business value, not on the technical solution.

Another groundbreaking venture that Rabobank is involved in is komgo, a solution that transforms commodity trade finance via a secure blockchain platform. Launched in 2018, komgo facilitates P2P transactions in a secure environment, offering both parties full visibility. By allowing banks, traders and other participants to transact using the same secure software, komgo aims to simplify operations and communication across the industry on a scale never seen before.

A promising solution: the identity wallet

Some time ago, Rabobank drew up a list of 200 potential blockchain use cases and selected 20+ to explore further, which it has been doing over the past few years. The most promising of these applications is the concept of the Identity (ID) Wallet – an empowering blockchain-enabled solution that lets users securely store and manage identity information and documents. Together with parties like Randstad, Rabobank is currently proactively exploring ways to market a Blockchain Career Wallet, an application of the ID Wallet that facilitates sharing of employee credentials (such as course results or required diplomas and certificates) via blockchain. Rabobank wholeheartedly supports the notion of true 'self-sovereign identity' and genuinely hopes to contribute to the realisation of this ideal.



What tomorrow holds for Blockchain

For good reason, blockchain is believed to have great disruptive potential, whether applied alone or in combination with other capabilities. Interest in DLT has exploded, with blockchain- and cryptocurrency-focused startups collecting almost $3.9 billion in investments in the first three quarters of 2018 – that's nearly three times the total for all of 2017.

$3.9
billion investment in 2018

3x
the investment compared to 2017

According to Accenture's 2019 Technology Vision report, 51 percent of technology professionals are already piloting projects, or evaluating pilots, related to DLT/blockchain. The World Economic Forum also predicts that blockchain technology will account for 10 percent of the global GDP by 2027.

In addition, a 2018 Constellation Research study found that 67 percent of US companies are either evaluating or implementing blockchain technology initiatives, with a quarter already having projects underway or completed. For the vast majority of com-

panies, their adoption of this trend is driven by a desire for competitiveness. Results of the survey showed that 57 percent of respondents agreed, or strongly agreed, that their organisation should adopt blockchain technology to remain competitive.
With all the attention on blockchain technology, we've also seen great progress in this field – this is mainly driven by smaller open-source parties, rather than bigger technology companies. It's worth noting, though, that such rapid development, while mainly positive, comes with drawbacks, too.

The key challenges: scalability, competition paradox and privacy

Despite rapid developments, three major challenges continue to hinder the widespread adoption of blockchain solutions: limited scalability, the competition paradox and privacy challenges.

Challenge #1: Scalability

As mentioned, blockchain ecosystems are designed to store all transactions from day one, thereby guaranteeing transparency and traceability. The challenge is, this endless record of transactions greatly limits scalability. As the amount of data stored continues to increase, blockchain systems tend to become slower and, naturally, have much greater storage demands.

Challenge #2: Competition paradox

Another challenge when it comes to blockchain technology is the so-called competition paradox. The technology enables – or, in fact, forces – competing parties from all over the world to cooperate equally to redefine markets and improve global industries. Naturally, it can be difficult to get competitors to work together.

Challenge #3: Privacy

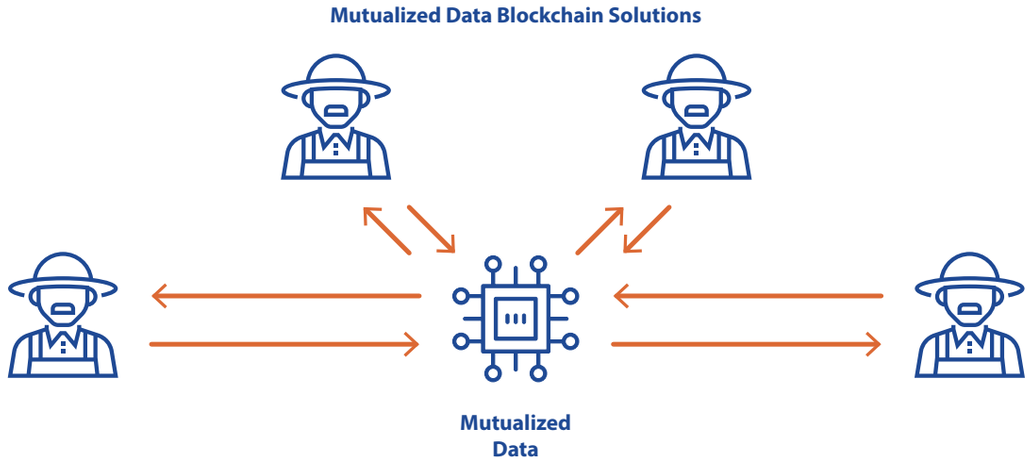
The fact that blockchain networks have eternal memory poses yet another challenge: the issue of privacy. This is particularly problematic in light of the General Data Protection Regulation (GDPR) – how can we justify information and transactions being memorised forever? While the GDPR enforces people's right "to be forgotten", blockchain technology makes forgetting impossible. It seems to contradict the way the world is going. The question is, how can blockchain and privacy co-exist? We know that there are answers to this conundrum, and many people are working hard to find them, but we haven't yet discovered an ultimate solution. Aside from these three key challenges, there's also the struggle to ensure that all data stored in a blockchain is actually reliable. Involved parties simply have to trust that the information is accurate, and for obvious reasons, that's not always easy to do.

Not a blanket solution

Despite various success stories and all the potential that blockchain technology offers, we do need to acknowledge that it is, by no means, a blanket solution. Before turning to a blockchain-based platform, it's important to ask, "how exactly will this technology support our case?", and "what information should stakeholders ideally be storing in a blockchain network?".

The million-dollar question

Over the past years, there's been a lot of hype around blockchain. Today, it would seem things have risen to a crescendo, and now it's time to separate the wheat from the chaff – it's time to distinguish between the blockchain applications that add value to our economy and society, and those that don't.



Implications and applications for Rabobank and its clients

Rabobank is convinced that blockchain will have a huge impact on companies and consumers over the coming decades. For this reason, the bank proactively investigates the technology's possible applications. Research takes place in the Blockchain Acceleration Lab (BAL), where programmers and specialists collaborate with businesses and startups in various industries to experiment with blockchain and develop projects, like the aforementioned we.trade platform.

As mentioned previously, Rabobank has been at the forefront of blockchain developments for some time now and has participated in relevant projects across a range of industries, including trade finance, real estate, and food and agriculture. Rabobank sees great potential in various initiatives and is optimistic about the role the bank could play in these arenas.

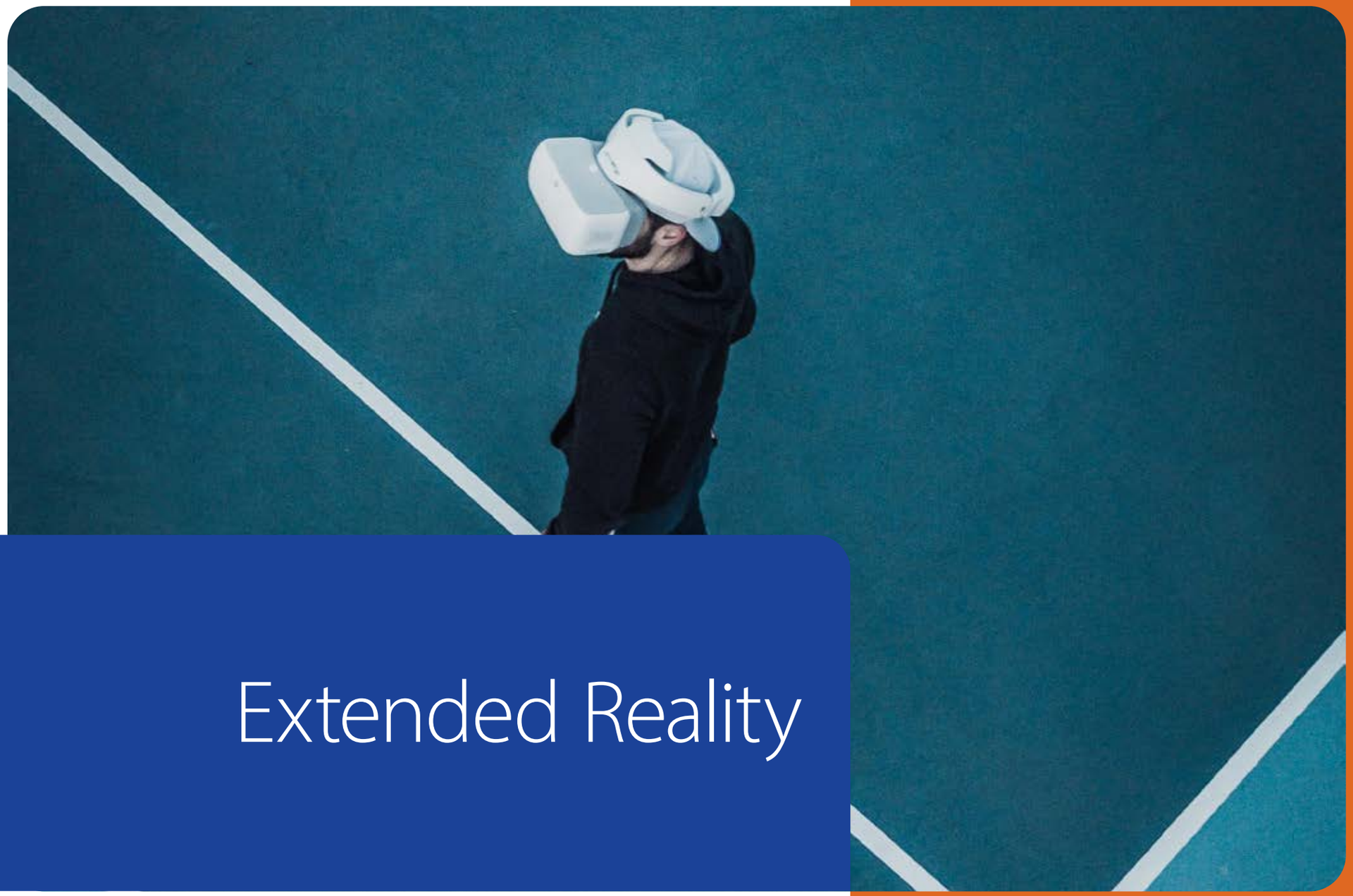
Rabobank aims to fulfil the role of a distributed ledger. Through projects like we.trade and komgo, Rabobank hopes to contribute to the elimination of fraud and a world where transactions take place without central authorities. Another blockchain initiative that Rabobank is proud to started experimenting with is Sustainable Pay per Use (PPU), an innovative project that aims to develop a blockchain-based payment system that would allow users to pay for their actual usage of a product or service, discarding the need to buy and own it. PPU facilitates the move from a possession-based society to a service-based society.

Blockchain in practice

As is clear, there's an abundance of examples of blockchain-based solutions being used in the financial industry, in many cases by some of the world's largest banks and financial institutions. J.P. Morgan, for instance, launched what's called the Interbank Information Network, the industry's largest bank-led blockchain project to date, with over 310 banks participating and 58 already live. This solution lets banks swiftly send additional payment details to other banks in order to enable faster processing of international transactions.

Blockchain-based networks have also been used to give consumers information about the origin of their food. One business that jumped on this bandwagon is Moyee Coffee, a small coffee roaster that calls blockchain its "magic ingredient" and has used the technology to create a digitised value chain with 100 percent transparency. Data about every transaction that occurs between the time the beans leave their farm of origin to the point they arrive in consumers' cups is recorded. The company's mission? To become the first "FairChain" coffee business in the world and radically transform the way this commodity is grown, produced, distributed and sold.

The Microbiome Center is another example of a Rabobank-affiliated company that uses blockchain technology. The Netherlands-based medical centre has pioneered a platform that allows general practitioners, pharmacies and researchers to exchange data on patients requiring treatment with probiotics. The technology ensures that all information is stored securely – eliminating the need for paperwork – but is still under the patient's control. It's circumstances like these for which blockchain offers the ultimate solution.



Extended Reality

Chapter 03

Definition

Unpacking Extended Reality

Extended Reality (XR) refers to the application of technology to broaden our experience of reality or produce entirely new environments and visualisations, complete with audio and/or visual feedback, and sometimes olfactory and haptic cues too. Essentially, XR blurs the line between the real and virtual worlds, and often sees physical and digital objects co-exist and interact in real time.

Two types of Extended Reality

XR is the first technology that is capable of "relocating" people in time and space, thereby changing the way people perceive their surroundings. XR is an umbrella term covering several sub-categories, including:

Virtual Reality (VR) takes the user out of their real-world environment and immerses them in a virtual setting. By putting on a headset (typically), the user is "transported" to a closed, simulated version of reality that completely replaces the physical world. With VR, people can, for example, take a tour through a building hasn't been built yet;

Augmented Reality (AR) overlays digital objects – information, graphics or sounds, for instance – on the real world, allowing the user to experience the interaction between virtual and real environments. Pokémon Go is the perfect example of AR in action, as are apps like IKEA Place, which lets users position virtual furniture in their own living spaces using their smartphone or tablet camera.

Evolution of Extended Reality

XR applications would not exist without advancements in Artificial Intelligence (AI), which is elaborated on later in this report. Many XR devices rely heavily on AI-related technologies, including computer vision and speech recognition.

While XR is capable of completely changing the way people live and work, in reality, the technology is still predominantly employed only in the entertainment industry, often to enhance (video) games. The main reason for this is that XR headsets tend to be expensive and relatively difficult to acquire. XR-related projects are, therefore, still quite costly to run and complex to deliver.

Another challenge is that, currently, Virtual Reality only really allows for single-person use. While we're definitely on the verge of a breakthrough – with XR being employed in other industries, too – we're still waiting to see what kind of revolutionary application will take XR to new heights. The million-dollar question remains: With all the potential XR offers, how can it be applied in a business context in a more sustainable, economical way?

Promising development: immersive experience rooms

One of the answers to the question above lies in the development of what's called "immersive experience rooms". These rooms are 360^0 projection spaces that can be used to walk users through any type of immersive content – they can be used for employee training, brainstorming sessions, sales pitches and much more. The concept tackles one of XR's current limitations by letting a whole group of people – not just one person – enjoy a shared virtual experience.

Some examples of the kind of content that can be displayed in these immersive rooms include:

- **Storytelling** – transporting people to environments that are conventionally un-reachable;
- **Prototyping** – exploring and testing new samples and models in life-size scale before they're built and deployed;
- **Capability showcases** – presenting deliverables in an immersive way;
- **Training** – providing instruction through VR interaction;
- **VR experiences** – interacting with content in a simulated world.

Unpacking Extended Reality

Virtual and augmented reality solutions continue to minimize the distance that lies between users and information, experiences and even other people. **While XR applications will develop to offer experiences that are more and more realistic and "credible", the necessary hardware will, over time, also become cheaper and more accessible.** For obvious reasons, this will remove barriers that stand in the way of the expansion of XR, and not only in the gaming industry.

XR-based solutions and innovations are gaining traction throughout the business world and are starting to feature in a growing number of customer-facing products and services. In fact, research suggests that by 2022, 70 percent of enterprises will be experimenting with immersive technologies for consumer and commercial use, and 25 percent will have deployed them to production.

Implications and applications for Rabobank and its clients

Over the past few years, Rabobank has started experimenting with XR. In a number of branches, maps of the Netherlands displayed on walls "come alive" through app-based AR technology to provide viewers with information and tell stories about the bank's history and the role it's played in different Food and Agriculture projects.

In addition, the bank has created a VR environment that lets Rabobank farmers connect – through Oculus Rift headsets – with other farmers from all over the world as part of the global farmers community.

There are many ways that the banking industry could further capitalise on XR developments. For instance, banks could provide real-time, 3D virtual training sessions that use immersive animations, simulations, role-plays and online instruction to teach wealth and asset managers how to better advise their clients for investment-related decisions. Client pitches can be made significantly more compelling through XR, as the technology allows for a far more visual, "lively" presentation of information and data. The result is that clients, analysts and other stakeholders are better able to grasp concepts, and can make decisions quicker.

Moreover, XR makes it possible to connect with people who aren't physically present. This is useful if, for instance, organisations want a certain specialist to give an "in-person" speech at an important gathering. By the same logic, virtual recruiting can be used by Rabobank and others to access, woo and engage some of the best talent globally, regardless of where candidates live. More generally speaking, XR can facilitate richer collaboration between colleagues in different parts of the world, which has the potential to improve work satisfaction and efficiency.

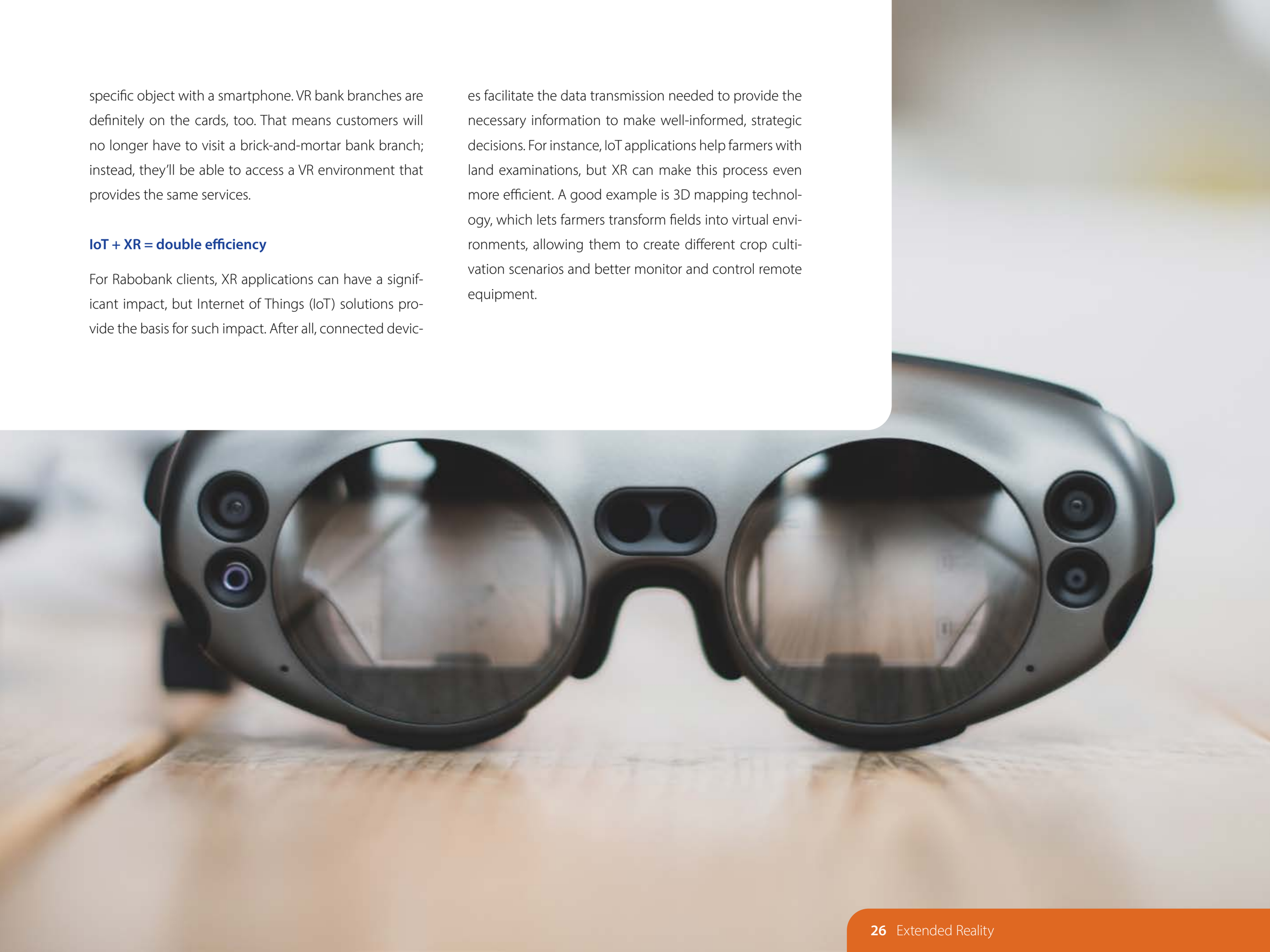
The rise of VR bank branches

Banks are also starting to use XR to improve customer experience and impart knowledge about complex financial products and processes. To enhance security, biometric data could be introduced into an intelligent system that's subsequently connected to a VR environment. Users could then access bank services, navigate ATM transactions and even make payments simply by scanning a

specific object with a smartphone. VR bank branches are definitely on the cards, too. That means customers will no longer have to visit a brick-and-mortar bank branch; instead, they'll be able to access a VR environment that provides the same services.

IoT + XR = double efficiency

For Rabobank clients, XR applications can have a significant impact, but Internet of Things (IoT) solutions provide the basis for such impact. After all, connected devices facilitate the data transmission needed to provide the necessary information to make well-informed, strategic decisions. For instance, IoT applications help farmers with land examinations, but XR can make this process even more efficient. A good example is 3D mapping technology, which lets farmers transform fields into virtual environments, allowing them to create different crop cultivation scenarios and better monitor and control remote equipment.



Extended Reality in practice

Financial services

Currently, most XR applications in business are used for training. Examples include New Zealand-based company **ImmerseMe**, which uses VR to "place" students in realistic environments that assist with language learning. **Salesforce** has been using Oculus Rift hardware to create immersive 3D environments for analysing data. This practice has also been adopted by Fidelity Labs (part of Fidelity Investments) – the company turns stock portfolios into a virtual 3D city (known as a "StockCity") so that investors can completely immerse themselves in all the available data. Rabobank is very proud of its own AR application PinPin. The app teaches young children how to responsibly deal with finances and how to save money. A specially designed section within the app gives parents the option to monitor how much their children are spending and saving.

BNP Paribas also recently jumped on the XR bandwagon and rolled out a VR-based app for its French retail banking customers. The app lets users virtually access their account activity and transaction records, and guides customers through the various steps involved in making a real estate purchase in VR mode. The Republic of Korea's Hana Financial Group takes things one step further by delivering instant mortgages to customers through AR-enabled apps on their smartphones. Using big data analytics, the app analyses information on an apartment, a house, a block of flats or even an entire neighbourhood, and couples that with data relating to the customer. When a user points their phone's camera at a certain property, they don't just receive pricing information, but also a real-time mortgage proposal.

Food & Agriculture (F&A)

In the agricultural sector, apps like FarmAR and Vaderstad are interesting examples of the positive impact that XR can have. FarmAR is a cloud-based platform that collects satellite data on farmers' land and uses AI and deep learning to pinpoint land locations that may need urgent attention. This information then appears as a 3D overlay on users' phones' camera display, so farmers can make key decisions quickly. The Vaderstad app, on the other hand, uses AR to give farmers a glimpse of the inner workings of their equipment through their smartphone or tablet camera.

Internet of Things (IoT)

Chapter 04

Unpacking the Internet of Things

So much more than a single trend, the Internet of Things (IoT) is really the synthesis of a number of different technological advancements. Essentially, IoT refers to a network of uniquely identifiable "things" that can communicate with each other without a need for human interaction or intervention. The concept encompasses the millions of physical devices around the world that are connected to the internet and that can, therefore, observe, communicate, act and be utilised from a distance or fully automated. Portable devices like smartphones and wearables collect user data, while other objects – think appliances, buildings, machines and cars – measure their surroundings using built-in sensors.

From monitoring a coffee machine to monitoring the world

It all started in 1991 when a few computer scientists at the University of Cambridge invented the world's first webcam to monitor the status of a coffee machine's contents from their desks. Now, smart devices that are capable of communicating with one another are present everywhere we look. This development has predominantly been made possible by the rapid growth of communications technology and the fact that chips have become smaller, more efficient and cheaper.

Essentials for an IoT solution

The IoT relies on an ecosystem that is built around a particular environment, be it in a home, in a factory, on a farm or in a city's streets. There are five essential components in any IoT ecosystem. These are:

- Hardware, such as built-in chipsets and sensors;
- Networks that connect IoT solutions, thereby enabling data transmission;
- Remotes/interfaces through which the IoT solution can be managed (e.g. a smartphone, tablet, computer, smartwatch or smart speaker);
- An IoT platform – a central IT system that transmits messages between devices and stores data;
- Security protocols that ensure the IoT solution remains protected.

Evolution of the Internet of Things

From its beginnings as "merely" a device connector, IoT has evolved to now make way for the collection and analysis of data, too. Thanks to sensors, a huge amount of real-time data on parameters like location, temperature, motion and customer interaction has become available – offering tons of possibilities for new IoT solutions. Today, anything that can be embedded with a sensor or chip is a potential source of data – almost any "thing" can now be made smart.

The maturation of sensor and voice control technology

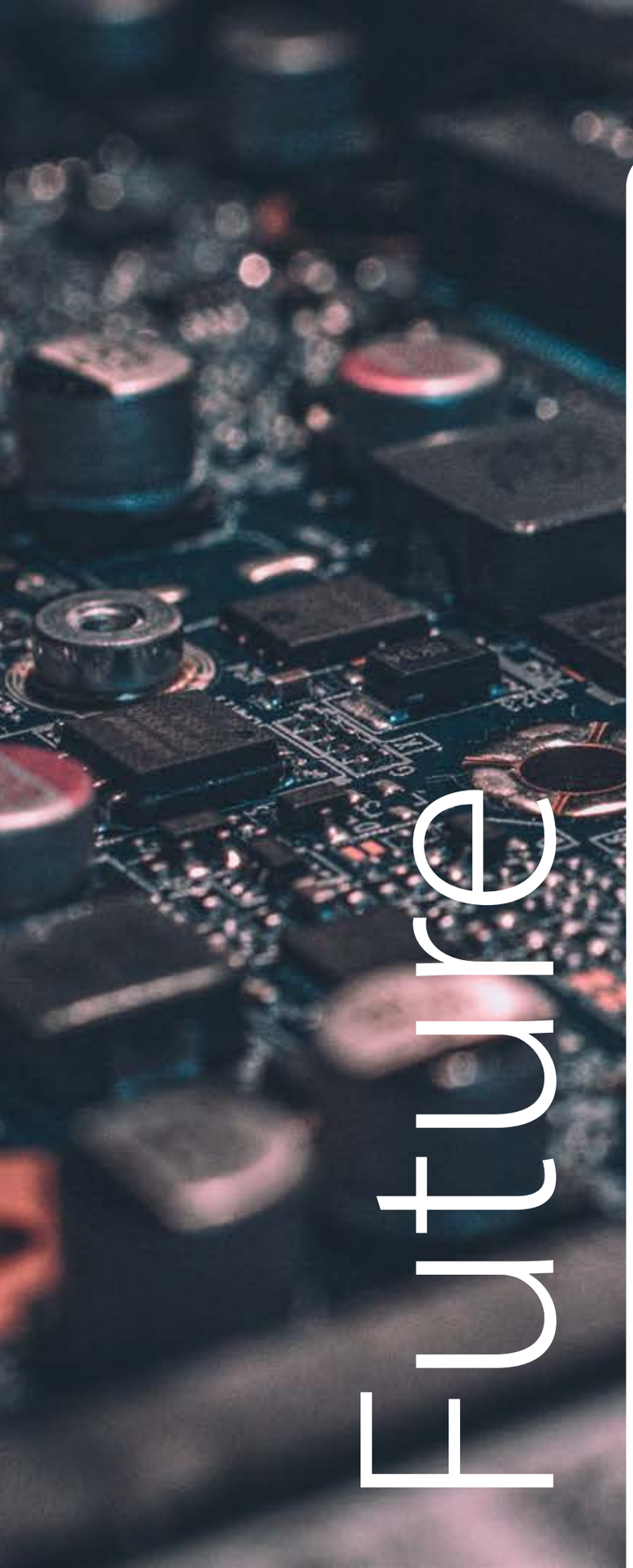
Sensor technology is becoming increasingly sophisticated and this has implications for IoT. Every object can be fitted with multiple sensors that are able to collect useful information on how the item is performing and on its internal and external conditions. This data can then be used to determine if maintenance is urgently required, for example. New human-machine interaction opportunities through voice user interfaces (VUIs) – used in the case of digital assistants like Siri, Alexa and Google Assistant – also expand the possibilities in the IoT realm. The integration of voice control into IoT devices completely changes the way people interact with their environment and carry out their work and life duties.

Abundance of applications

Think about it: aside from being able to play Spotify via Alexa, we're also not that far off from curtains opening automatically when the alarm on your phone goes off. Or from your washing machine warning you that you've left your phone or wallet in the pocket of your jeans. Some may be excited about such developments; others may be apprehensive. But the fact remains, they're coming.

The growing availability of big data also presents many new opportunities for the agricultural sector. Farmers can rely on IoT networks to retrieve data about their entire property or a particular grain silo. In fact, they can now even monitor the health and well-being of each individual cow and chicken. These developments completely change the game for the agricultural world and have the potential to increase profits, enhance crop quality and boost productivity. **AquaSpy** is a good example. This IoT solution lets farmers in South Carolina collect real-time data about crop health and the soil water status on irrigated land so they can better manage their corn fields. By providing such crucial input, it has helped to increase yields by 22 percent.

"Anything that can be embedded with a sensor or chip is a potential source of data – almost any "thing" can now be made smart."



What tomorrow holds for IoT

A new era of connectivity is on the horizon. Over the past years, the number of connected devices out there has grown exponentially, and it is anticipated that figures will only continue to rise. By 2020, it's predicted that there will be 31 billion connected devices in existence – a statistic that is expected to more than double to 75 billion by 2025.

31
billion connected devices by 2020

75
billion connected devices by 2025

Acceleration through other technologies

The catalyst that will boost IoT to its long-awaited full potential is the next generation of communication networks, as well as blockchain. The potential impact of IoT will be greatly heightened by other technological trends, all of which ultimately serve to make connected devices smarter than ever.

One catalyst that will thrust IoT to its long-awaited full potential is the launch of 5G networks – 5G and technology like LoRa will enable cheap, fast connectivity from almost anywhere. Artificial intelligence (AI) is also a game-changer. With the aid of AI algorithms and machine learning, patterns can be recognised and acted upon by IoT applications. AI can be used for data interpretation; and blockchain technology for data integrity, transparency and sharing. Voice control technology will also take flight, as it's already doing in English-speaking countries. Ultimately, everything will become "smart" – cities, streets and even the grid – and the more smart regions "talk" to one another, the smarter the world as a whole will become.

The challenges ahead

All this said, the rapid development of IoT presents a number of challenges. These include:

1. **Security threats** – enterprises have been building vast interconnected ecosystems for some time now, but only 29 percent of business and IT executives report that they're confident that their ecosystems are secure;

2. **Privacy issues** – devices in your house gather a lot of information. What happens if this data is improperly shared or misused?;

3. **Identity management** – how can a platform be sure that a machine truly is who it says it is?

4. **The standardisation of API platforms / IoT protocols** – some of them are closed; some slightly more open.

Futuristic scenes

While developments are ongoing, there is no doubt that IoT will greatly impact our future and transform the way we live. For instance, not long from now, while you're watching a movie at home, the lighting in the room will automatically adapt to match the mood of the scenes unfolding in front of you. What's more, you'll soon be able to shop for groceries and pay by simply walking out of the store – you won't need to scan a card or pass by a cash desk. Lastly, one day, our road taxes will be paid automatically as we drive our cars, as will our insurance fees, and we'll likely even get a discount if we drive responsibly. For the record: all of these concepts have already been piloted.

Implications and applications for Rabobank and its clients

The impact of the extraordinarily rapid rise of IoT on Rabobank is twofold:

- **Safer lending structures.** As IoT lets the owner follow assets – a house or machinery, for example – it leads to improved asset-based control with fewer risks and more security.

- **Shifts in smart agriculture.** A farmer managing his land from behind a desk is only the be ginning. Through IoT-enabled precision farming on the micro level, agricultural companies can raise their profits significantly.

Digital twins

A particular IoT application that companies in the Food and Agriculture sector can benefit from greatly is "digital twins" technology. Boeing recently started making use of this solution, which lets businesses create a detailed digital copy of a complex real-life machine or device, which is connected to the physical object via data transmission and built-in sensors. This way, manufacturers can simulate tests and run experiments on the shadow machine, while closely monitoring the state of the original machinery to determine whether it needs maintenance of any kind soon.

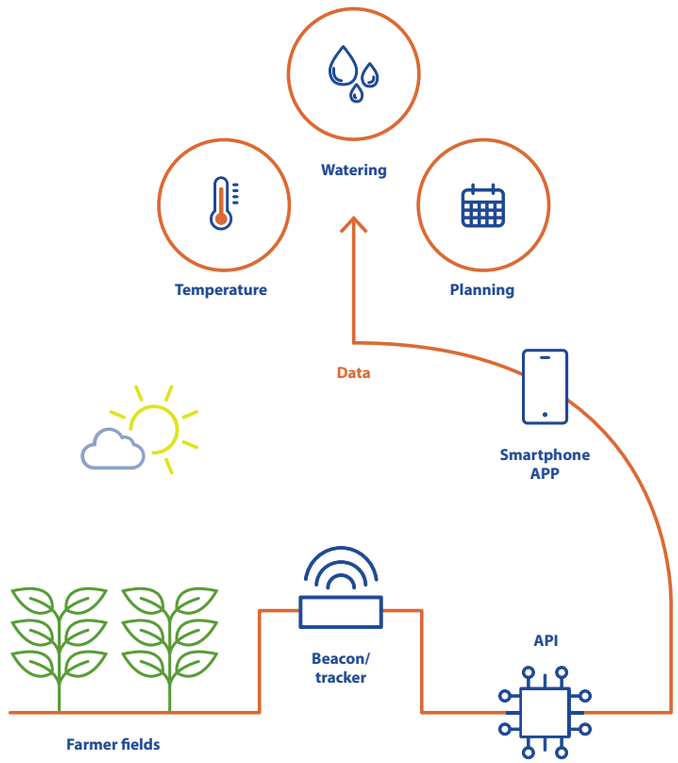
IoT in practice

Financial services

By combining IoT and blockchain a whole new world of applications becomes possible for all industries. Examples in the financial services field include **ApplePay** and **FitPay**, which add contactless payment capabilities to wearables. Then there's also Ally Bank's **Splurge Alert** – an app that protects users from what the brand calls "splurge stores" by using geo-fencing technology. When temptation is near, the app will send users an alert to encourage them not to give in and endanger their savings.

Food & Agriculture (F&A)

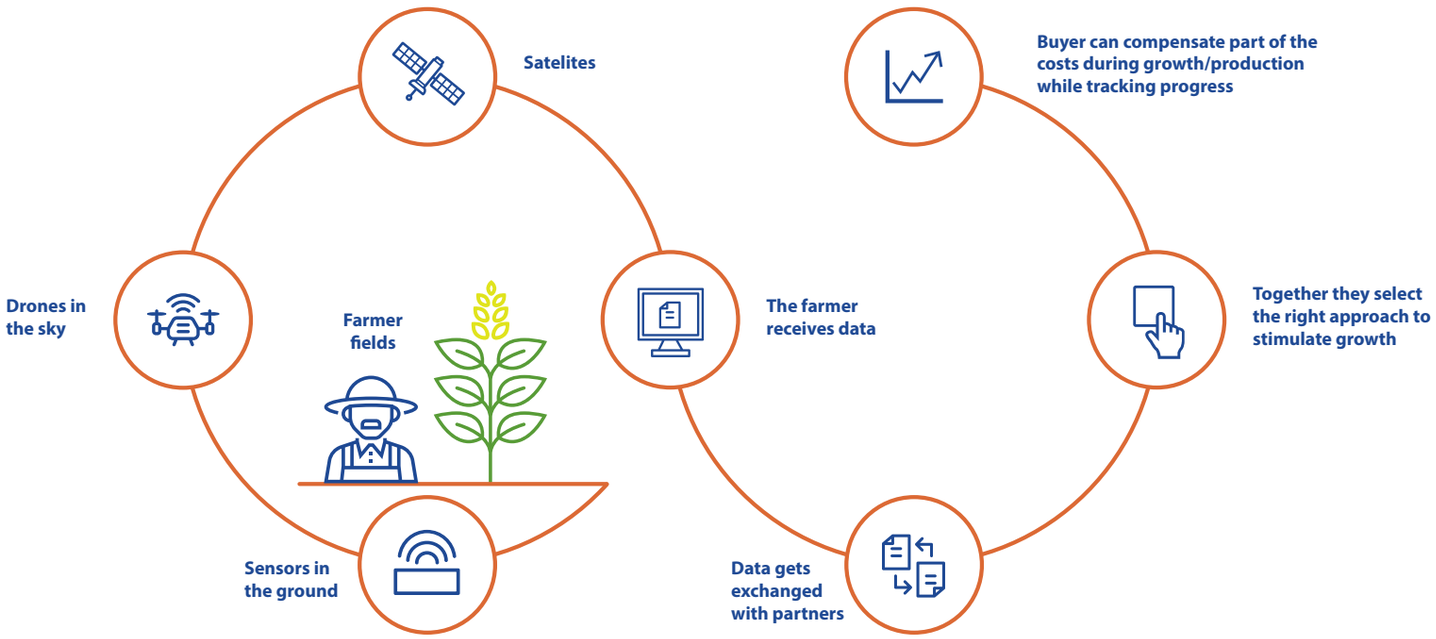
As already mentioned, IoT has already completely transformed the F&A sector. Due to the high costs attached to gathering precise field data, the use of digital agricultural technologies is still somewhat limited. Still, initiatives like **Smart Greenhouses** are on the rise. Smart Greenhouses remote monitoring systems use intelligent sensors to capture data related to irrigation, plant growth, pesticide usage and lighting. Predictive models use this information to give farmers real-time insights so that they can effect changes. Livestock Monitoring is another IoT application that captures data on the location and health of livestock. It works similarly to **mOOvement**, an intelligent track & trace system for cows. **Actuators** are another useful IoT solution that improves precision farming as a whole. Not only can these devices gather information, but they can also act on it accordingly. If, for example, the soil needs more water, actuators will pick up on this, and ensure that the land is irrigated. Lastly, **Rabobank Trade Commodity Finance** is involved in an IoT / blockchain



pilot, **ProducePay**, enabling the bank to monitor farmers' produce. Farmers are partially paid for their harvest while crops are still growing, but through production monitoring the bank can keep a close eye on developments.

Startups

Through the integration of different APIs, startups present the world with interesting new IoT solutions on a daily basis. **Metromile** is one such example. By using IoT-connected trackers, this app offers cost-effective pay-per-mile insurance plans based on mileage and driving behaviour. Then there's also **Kontakt.io**, an IoT startup that produces low-energy Bluetooth beacons that can be used for mobile payments. They take the place of traditional (more costly) point-of-sale technology and help to streamline the shopping process and improve the data-generation capabilities of businesses. Yet another example is **30Mhz**, an agricultural IoT startup, that aims to become the go-to data platform for horti- and agriculture, providing farmers with all necessary information to make the best decisions for their crops.



Next Generation Communication Networks

Chapter 05

Unpacking Next-Generation Communication Networks

Broadly speaking, Next-Generation Communication Networks (NGCNs) cover a wide range of developments in the field of telecommunications dominated by the evolution of fixed and mobile network infrastructures from distinct networks with their own standards, to converged networks (ones that can carry a combination of data, voice and video traffic) based on IP. As NGCNs promise much faster speeds (shorter time in transit for data), higher bandwidth (transmitting more data at the same time) and more reliable connections (certainty of not losing data), they will be, the number one enabler of other technological developments and applications. While not particularly interesting in and of themselves, when combined with other movements, NGCNs can change the world as we know it.

5G and LoRa

The two most important new next-generation communication technologies are 5G and LoRa.

- **5G** is the next-generation cellular standard and long-awaited successor of 4G. It's a true game-changer: Speeds are up to 100 times faster than those offered by 4G. 5G will offer unprecedented global coverage with high bandwidth at a reasonable cost. Whereas the upgrade from 3G to 4G merely entailed more bandwidth and a shift to a different frequency, the move from 4G to 5G encompasses a number of different fundamental changes that will have a significant impact on the world and create far more possibilities.

- **LoRa** stands for Long Range and refers to the long-range, low-power wireless platform that has become the de facto technology for global IoT networks. LoRa technology offers compelling features for IoT applications, including long-range connectivity (< 15km), low-power consumption and secure data transmission. It's then only a small step from LoRa to Low Earth Orbit (LEO) satellite communication, sending the ground station into space – the anticipated future of communication networks. Elon Musk is a pioneer in this area: His company SpaceX has already sent dozens of satellites into orbit for its Starlink internet network project and is preparing for thousands more satellite launches this year.

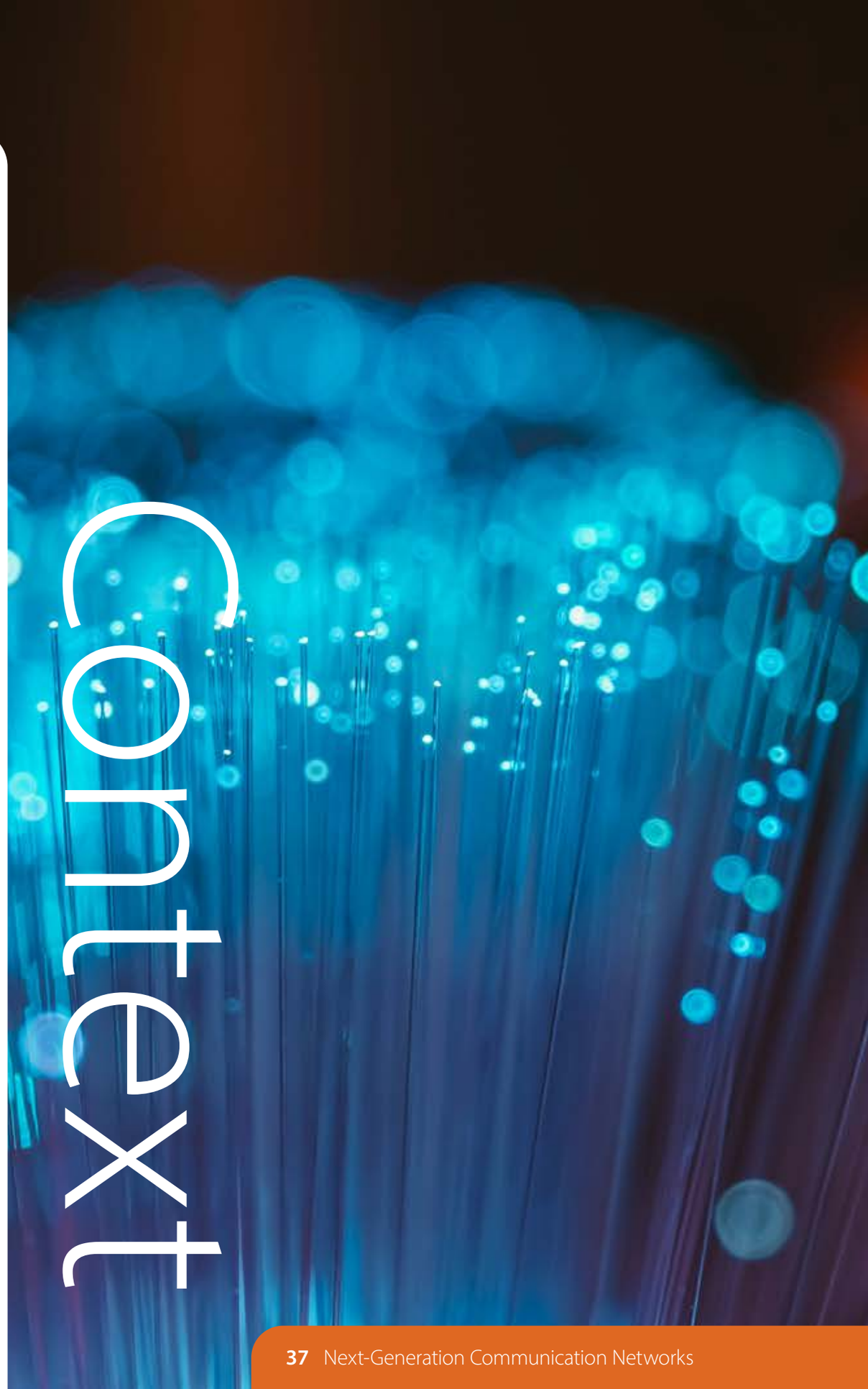
Evolution of Next-Generation Communication Networks

The 5G network will provide significant improvements over 4G in three main areas: **broadband connectivity, low-latency critical communications** and **high-density connections**. Moving to 5G is much more than just a generational step; the fifth generation of wireless networking technology will fundamentally transform the role that mobile technology plays in society. 5G is about the entire connected experience – not just faster speeds.

5G is designed to support three major types of traffic:

- Enhanced Mobile Broadband (eMBB)
- Ultra-Reliable Low-Latency Communications (URLLC)
- Massive Machine-Type Communications (mMTC)

Each of the above types has its own applications. For instance, eMBB will allow connected cars to receive traffic information and media streams, while URLLC will enable remote surgery and factory automation. Lastly, mMTC works to, among other things, connect smart electricity meters with energy providers so usage information can be communicated instantly.



What tomorrow holds for Next-Generation Communication Networks

Mobile data traffic is expected to increase by nearly eight times by 2024. That means that in just five years time 5G networks will carry more data than 2G, 3G and 4G networks transfer together today. 5G technology will power billions of new connected devices and supercharge the adoption of transformative technologies. It will provide the basis for a truly intelligent network of cars, robots, drones, and more — all of which will be able to communicate in real time in response to people's needs. In many ways, it will reinvent the business world. In the face of such rapid developments, companies must anticipate and seize opportunities.

NGCNs will, for example, have a huge impact on the field of autonomous driving. While advanced vehicles of today can anticipate traffic and detect movement using sensors and cameras, in the future, with 5G, they'll be able to "talk" to one another from kilometres away. China recently launched a test track comprising 2.2 km of smart road, equipped with advanced technology and sensors, that can communicate with cars through 5G.

Each sector will have different IoT connectivity needs. The wide variety of networking options – each with their own pros and cons – combined with constantly evolving technology requirements, put businesses in a slightly tricky position. If companies bet on one connectivity option and another becomes dominant, their IoT devices, applications and solutions could quickly be rendered obsolete. On the other hand, if they wait to see how the network landscape evolves, they could fall behind.

The challenges ahead for 5G

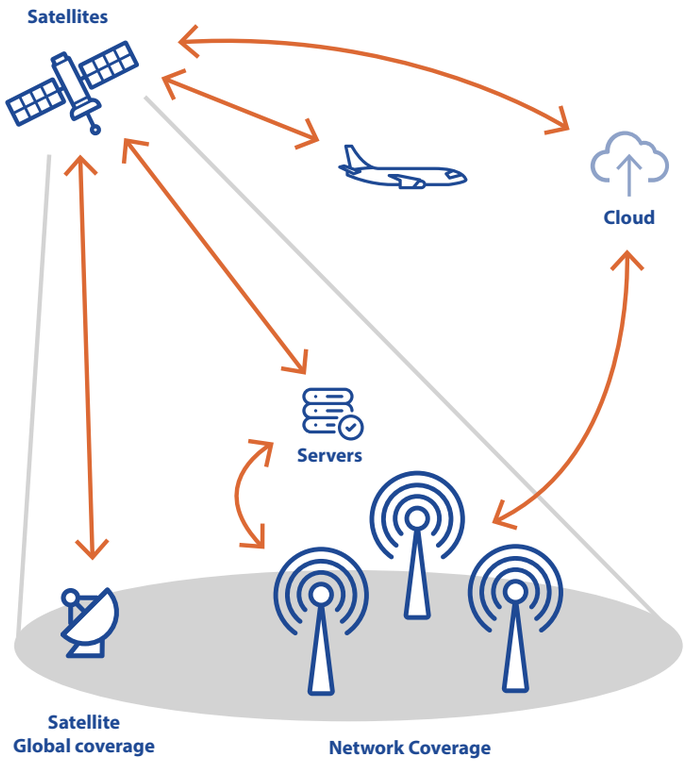
- In crowded areas 5G implementation is not easy, and we would need to install a significantly higher number of amplifiers and antennas;

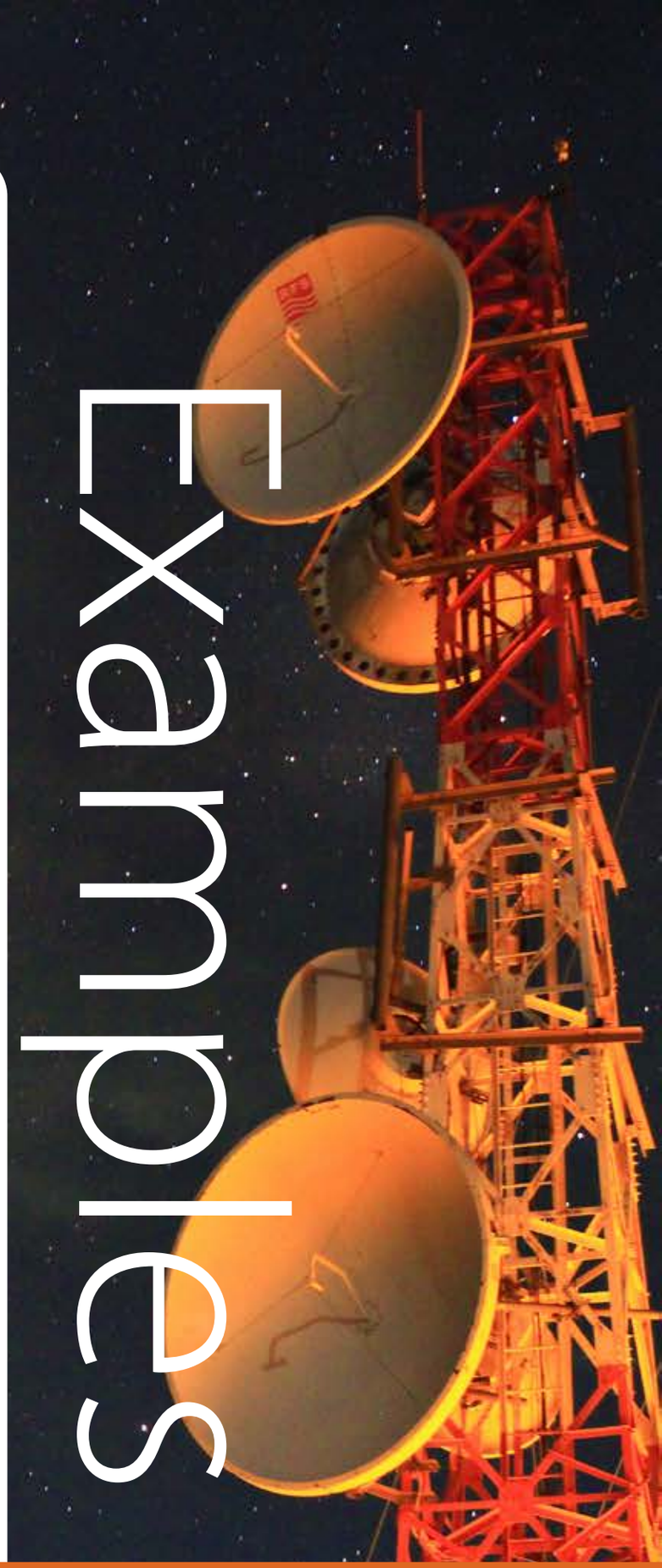
- The 5G chip market suffers from the trade war between the US and China, so chips are currently hard to come by;

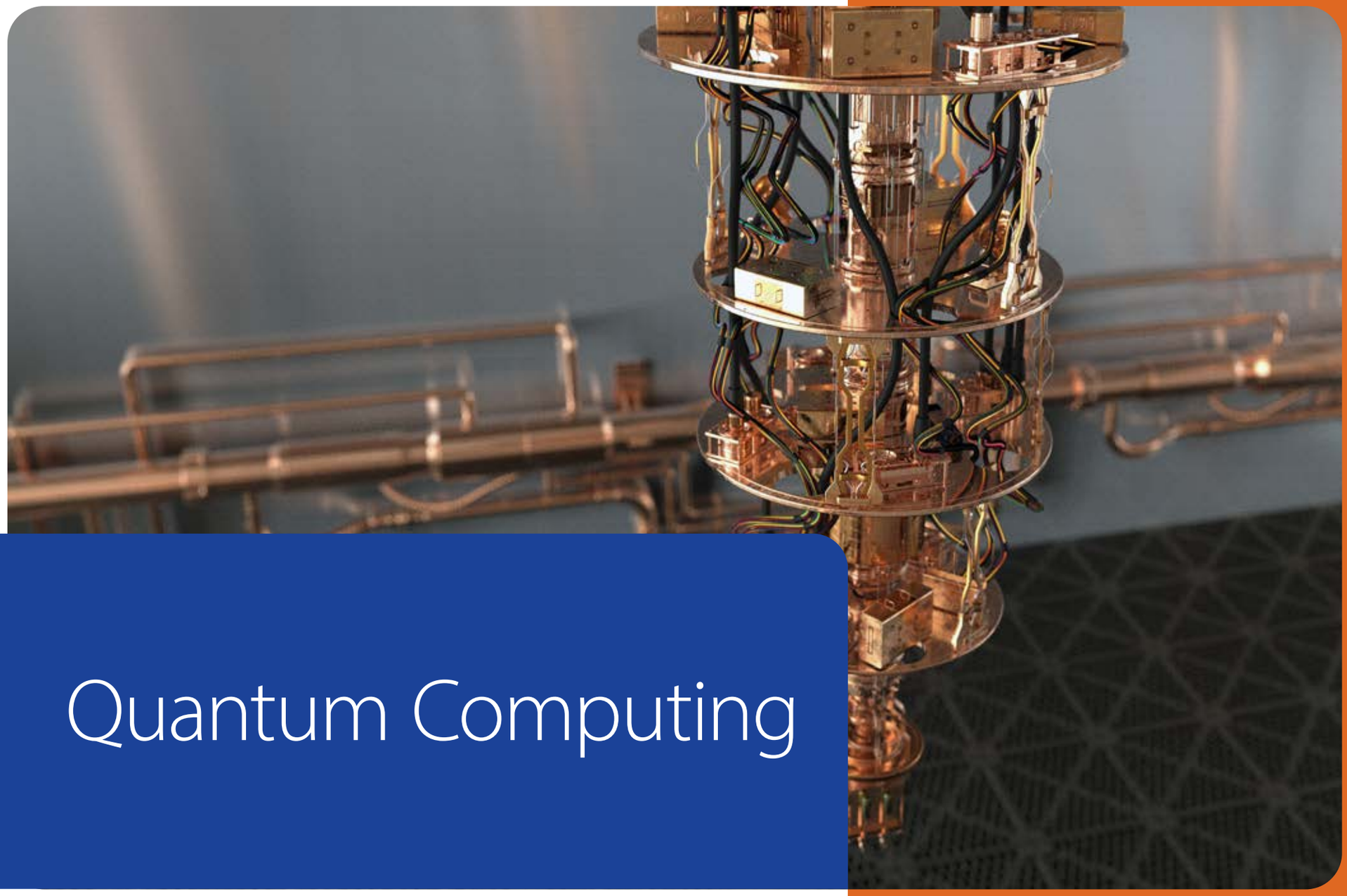
- Although not officially proven, 5G is considered by many people to be a health risk due to the increase of radio waves in the ether. Protests against 5G may delay, or even impede, implementation.

Next-Generation Communication Networks in practice

Due to high capital investment demands, it's predominantly only large(r) companies that are currently able to enter the world of NGCNs. Examples include **Banco Santander** and **Telefónica**, who have reached an agreement to launch a joint innovation 5G technology project focused on the banking sector. **Vodafone** has also been experimenting, rather successfully, with 5G at Manchester Airport to offer passengers download speeds that are four times faster than those provided by 4G. In the area of startups, **IoTium** is an interesting example. The California-based company, which launched in 2017, has made huge steps towards creating secure, scalable industrial IoT connections.







Quantum Computing

Chapter 06

Unpacking Quantum Computing

Quantum Computing (QC) entails a fundamentally different approach to computing than that adopted by classical computers of today. Quantum computers don't use transistors or classical bits; rather, they're based on qubits (quantum bits). Quantum computers have the capability to perform complex computations in a fraction of time it would take classical computers to run the same calculations. It's predicted – even expected – that such computers will, one day, be able to run the operations necessary to simulate models of complex, logistic problems in the blink of an eye. Not only does QC pave the way for us to improve the interaction between medication and cells in our bodies on a molecular level, but it could also help us to enhance weather models and, thus, make more accurate weather forecasts over longer periods of time. Ultimately, QC potentially – hopefully – will enable us to solve some of the world's most pressing problems, including the climate change issue.

Qubits versus classical bits

Qubits are the basic unit used by quantum computers to encode information. While classical binary bits can take two possible values – either "0" or "1", qubits can have properties of both values at the same time. Qubits can affect one another even when they're not connected and can perform many computations simultaneously. This enables quantum computers to solve complex problems that classical computers would battle to handle, and at radically faster speeds. It also helps us to solve complicated problems that involve probabilities – when there are many possible outcomes and scenarios.

QC is suited to tackling a certain type of problem, mainly in the fields of optimisation and pattern recognition. By using QC to simulate highly complex models, we can take a massive step forward in our ability to "replicate" the natural world. In fact, QC is the only way we could potentially simulate a model of the climate in future.

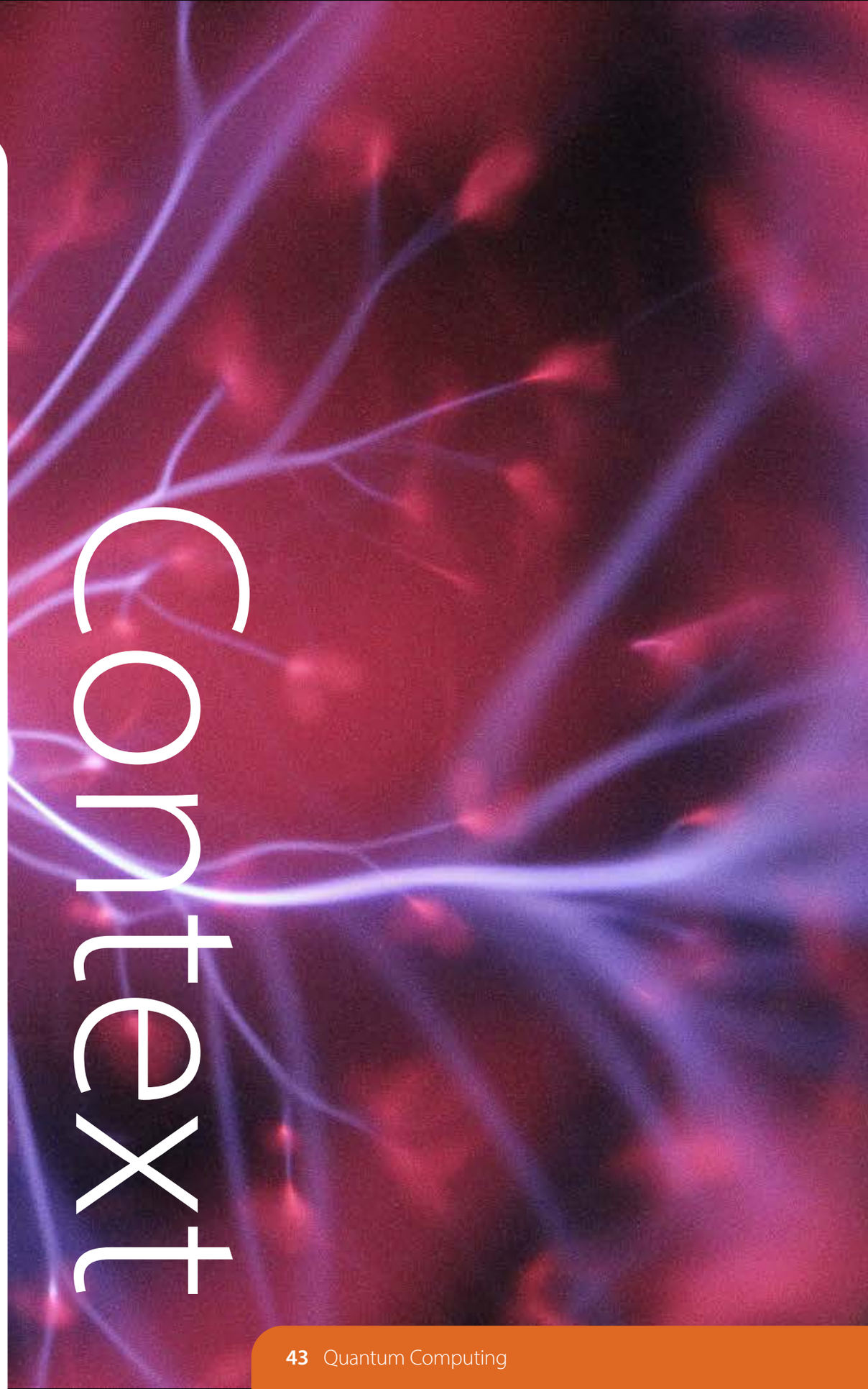
One at a time versus all at once

The difference between the capacity of a classical computer and that of a quantum computer can best be illustrated by a simple example: Imagine a library that stocks every book ever written. A conventional computer would process each book sequentially to search for a particular phrase, whereas a quantum computer would be able to "read" all the books simultaneously.

Evolution of Quantum Computing

Physicists and mathematicians were already theorising how a quantum computer could work in practice three decades ago. In fact, the possibility of QC was proposed in the early '80s, by physicist Richard Feynman. However, scientists and engineers have had much difficulty actually building such a computer. For this reason, quantum computers remained a theoretical concept for many years.

The situation has changed over the last five years, though, and we've seen the relevant hardware and software necessary for QC move out of university labs and into business contexts – that is, the technology has evolved from a theoretical concept to a practical phenomenon. That said, QC still has a lot of maturing to do before it's a viable computing option for enterprises that can deliver meaningful, cost-effective business results.



The key challenges facing Quantum Computing

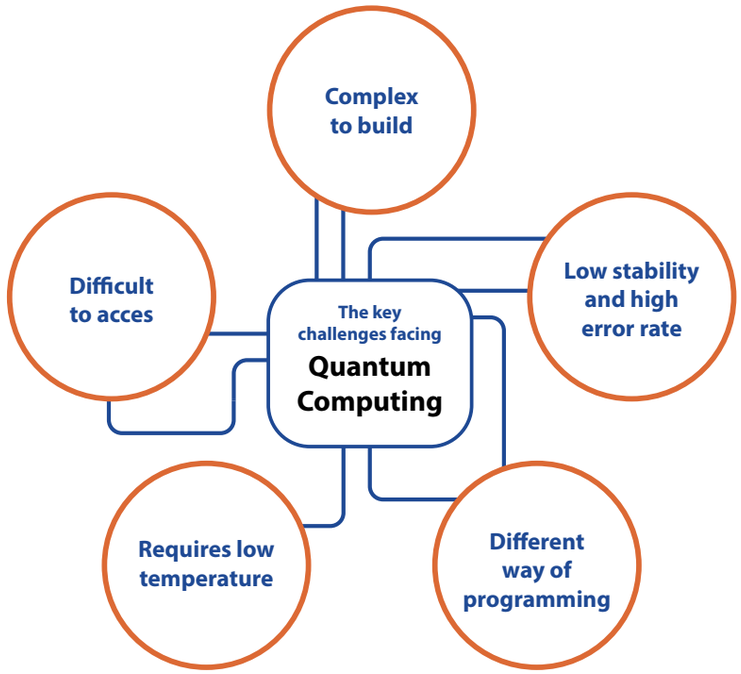
There are reasons why QC hasn't quite taken flight yet, even though there's been on-going research in this field for the past 30 years. Some of these include:

- It's incredibly difficult to get access to a quantum computer. There are currently only a few in existence and they're based at the offices of some of the world's biggest companies (e.g. NASA, Google, ExxonMobil, IBM and CERN). Quantum computers are extremely expensive and very complex to build from a technical standpoint;

- QC requires extremely low temperatures to function optimally. The cores of D-Wave quantum computers operate at -273 degrees Celsius. For this reason, QC consumes an inordinate amount of energy;

- The number of stable qubits is still low – max 50 - 100 unstable qubits or 10 stable qubits – and the error rate is still too high. As a result, our ability to apply QC in the real world is still very limited;

- QC is radically different from traditional computation and requests a very different way of programming – of which we only have seen the beginnings



The biggest threat of them all

While the focus tends to be on the positive impact QC might have, the technology poses a fundamental threat, too: It has the power to break cryptographic keys in an extremely efficient way. This could expose businesses and governments to major cybersecurity threats, and potentially cause complete mayhem. Think about it: All the data that we believe is so safe could be out there on the streets if the supposedly "secure" systems operated by banks and governments are hacked. Hence, the first thing the world needs to focus on, is making encryption methods entirely quantum-proof.

Closer to home, efforts towards building the first secure Dutch quantum network are currently underway. Recently, KPN Nederland and QuTech (a collaboration between Delft University of Technology and TNO) signed a cooperative agreement to work together to make quantum internet a reality. Quantum internet is a network of smaller, connected quantum computers that promises "unhackable", and therefore secure, communication, with privacy being guaranteed. For KPN and QuTech, improving online safety is a top priority, especially since, as they say, the arrival of quantum computers will ultimately render much of today's encryption unreliable.

What tomorrow holds for Quantum Computing

Threats, risks and challenges aside, QC gives us plenty of reason to feel positive about the future. This is because QC has the potential to help businesses across industries to overcome major stumbling blocks and run computationally challenging, or even previously impossible, operations. Companies are increasingly aware of this: Research shows that 40 percent of businesses are taking proactive steps towards QC, with 36 percent planning to take steps to invest in QC within the next two to five years.

Although a world that has resolved all climate change dilemmas is still a lifetime away, we're already getting glimpses of the solutions QC can offer in this regard. QC is certainly no longer just hype or a phenomenon you only see in sci-fi movies. These days, more and more parties are seriously looking at viable and valuable ways to use the technology.

When used in combination with Artificial Intelligence (AI) – specifically, machine learning – QC's potential could be elevated to whole new heights. Over time, qubits will become more powerful, quantum computers will become more accurate and error rates will drop. As soon as these challenges are tackled, QC can really take off – watch this space. We just need to make sure all encryptions are quantum-proof before it's too late. It is important to note, however, that even when QC reaches maturity and fulfils all the promises the world envisions it will, the technology will still not fully replace classical computing – not anytime soon, anyway.

Implications and applications for Rabobank and its clients

Rabobank's motto isn't "Growing a better world together" for no reason. In times when we're dealing with major overpopulation and an environment that's under strain, the bank is looking for sustainable ways to operate. We all know that the way we're currently going about life and work is no longer feasible, but what's the answer? Quantum Computing enables us to conduct analyses that provide valuable insights into ways we can address some of the world's most dire dilemmas.

It's an opportunity that greatly appeals to Rabobank, which is why the bank is actively exploring ways to use QC, even if its investigations are still in the very early stages. That said, the bank doesn't expect users to actually acquire a quantum computer. Most users will leverage QC through the cloud.

Quantum Computing in practice

There are numerous situations that would benefit greatly from QC, especially in the financial industry, which relies on complex, multifaceted models – simulation could open up a whole new world of opportunities here. More specifically, QC could make a difference in the areas of fraud detection, dynamic portfolio analysis and optimisation, clustering and arbitrage.

Similarly, in the Food and Agriculture (F&A) sector, QC can be used to simulate processes like photosynthesis or to model energy systems and interactions. In addition, QC could help with the development of new or improved fertilisers, thereby helping to improve the world's food sources.

While we've got a long way to go in this arena, it's both exciting and encouraging to see that an increasing number of companies are investing in QC and following in the footsteps of pioneer D-Wave, the sole manufacturer of commercial adiabatic quantum computers, having released three models since 2010.

1QBit, a Vancouver-based company, partners with Fortune 500 clients and leading hardware providers to solve industry problems in the areas of optimisation, simulation and machine learning. It has created a hardware-agnostic software platform, using APIs to provide web-based access to quantum computations. Entropica Labs is a Singapore-based quantum software company that uses QC for computational genomics applications in market segments like healthcare, pharmaceuticals and agritech. Since joining the IBM Q Network, Barclays and JPMorgan Chase have been experimenting with IBM's QC technology, too. Closer to home, there is also QuTech, an advanced research centre for QC and Quantum Internet, a collaboration founded in 2014 by the Delft University of Technology and the Netherlands Organisation for Applied Scientific Research (TNO).

Secure Multi-Party Computation

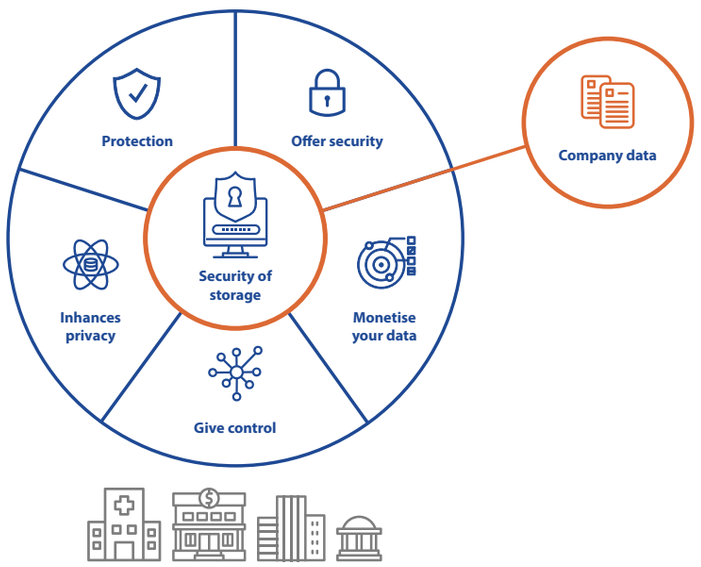
Chapter 07

Unpacking Secure Multi-Party Computation

Despite referring to Secure Multi-Party Computation (SMPC) as an upcoming trend, the technology itself is anything but new. SMPC is a subfield of cryptography; it refers to a collection of cryptographic algorithms that enables multiple organisations to combine their data for analysis and intelligence, while ensuring that each participating company doesn't have access to competitive or private data from any other business.

Unlike traditional cryptographic functions, which assure security and integrity of communication or storage, SMPC protects participants' input, computations and private information, while still allowing them to share outputs. Organisations can, for example, share financial, personal or patient data for the purpose of comparison and analysis, but never receive or have access to other parties' data.

The key advantages of a Secure Multi Party Computation (SMPC)



The key advantages of SMPC

Naturally, SMPC is well-positioned to solve security and privacy issues. More specifically, some of the key concrete advantages of this trend include:

- It enables proprietary solution protection, allowing different parties to jointly execute a calculation while keeping their inputs secret from one another;
- It offers security;
- It enhances privacy;
- It makes it impossible for other parties to monetise your data;
- It empowers parties by giving them control, allowing them to determine who receives the output of the calculations (and who doesn't).

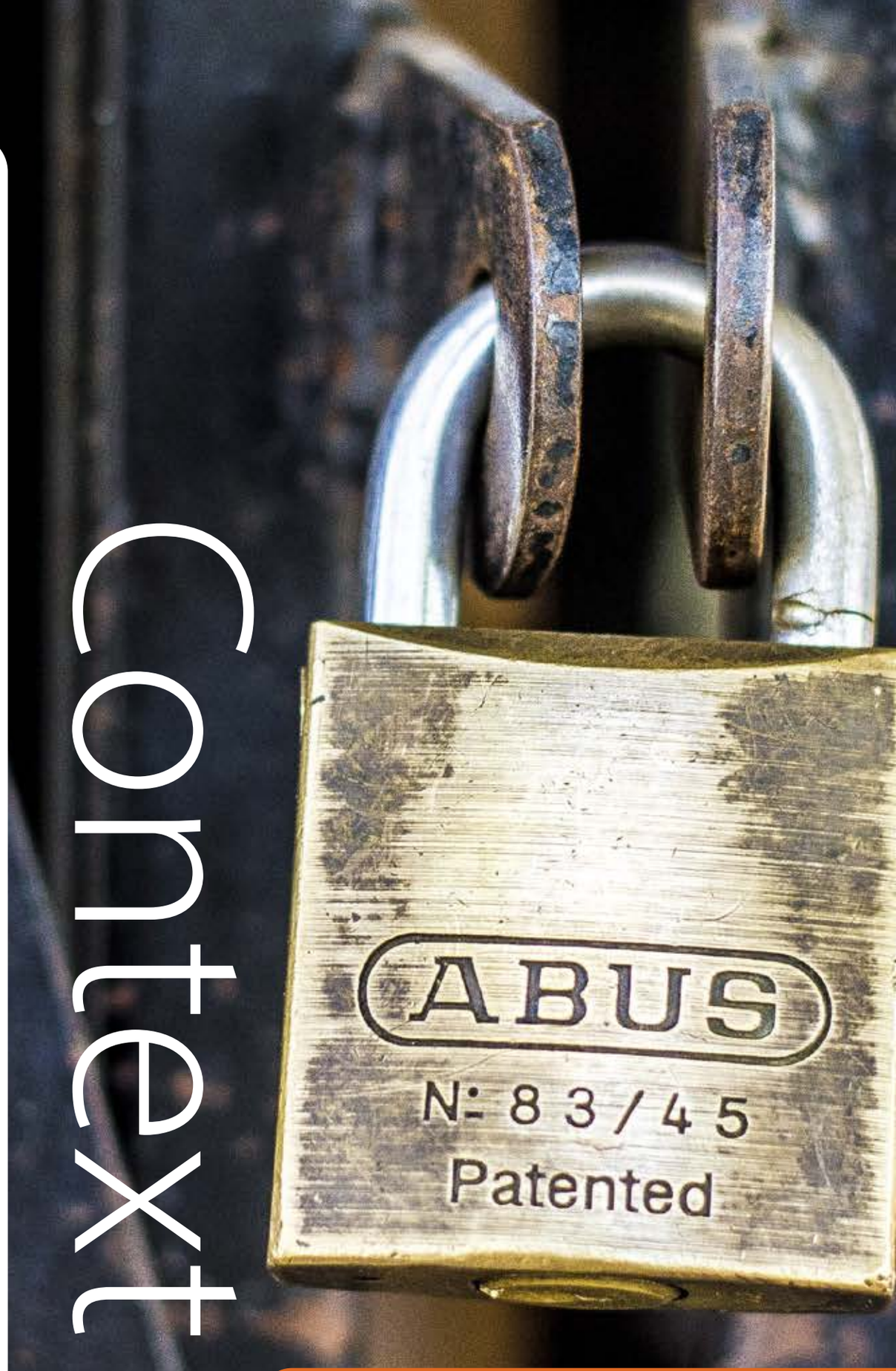
Evolution of Secure Multi-Party Computation

As already mentioned, the highly complex mathematics and technology behind SMPC are far from new. That said, there have been significant developments in this field over the past few years. As SMPC provides a way to securely share results, it's seen massive growth with the rise of AI and blockchain. The rise of the Internet, enhanced computational power, improved inter-party cooperation and the increased focus on privacy have also all played a role. As evidenced by the growth of blockchain, people of today have lower levels of trust in third parties and middle men. These days, companies no longer want to share data or even receive other parties' data, out of fear of juridical implications and the risk of losing data.

Challenge: Tension between data sharing and data protection

When it comes to using data for the sake of the public good – to find a new way to treat cancer or to remedy the issue of traffic congestion, for instance – there is often a societal tension between data sharing and data protection. In many cases, data sharing is constrained or obstructed by legal, ethical or privacy restrictions. Through SMPC, this data can still be used to analyse highly complex problems, shed light on new solutions and even resolve otherwise unanswerable questions.

However, confidence remains a challenge. As is the case with blockchain, organisations engaging in SMPC need to rely on the other involved parties to deliver 100 percent accurate and reliable data – without being able to verify them.



What tomorrow holds for Secure Multi-Party Computation

As SMPC provides a secure, (more) private platform for the safe interchange of large amounts of data, it can be deployed in various ways to solve complex issues and enable better decision-making. The future certainly looks promising for SMPC, but it must be noted that we're still in the exploratory stage when it comes to this technology, mainly due to its technical complexity (speed) and issues around scalability.

Empowering consumers

SMPC is especially good news for consumers. After all, there's a growing concern among us about who receives our private data and what it's used for. SMPC heightens customer-business trust as consumers can rest assured that their personal information remains private and protected, even when data is shared.

Implications and applications for Rabobank and its clients

Due to the aforementioned challenges and limitations that come with the technology, the adoption of SMPC has been fairly slow. Still, experiments in this field are definitely on the rise.

Rabobank is one of a few innovative parties exploring SMPC applications. For instance, the bank has been involved in an SMPC experiment to analyse diversity in Dutch companies. Using the input of a large number of organisations, the experiment aims to establish a diversity benchmark, without publicly sharing the sensitive information of the participating companies. Empowering clients is high on Rabobank's list of priorities. That's why the bank has also been investigating the possibility of using SMPC when customers apply for a mortgage. In these cases, clients typically have to provide a lot of personal information to establish a customer's creditworthiness. With the help of SMPC, this data can be kept private but can still be used by the bank for the sake of decision-making. In this way, SMPC can help maintain data integrity and improve data quality.

A very inspiring example of the use of SMPC is an experiment conducted by a Dutch healthcare insurance company. Doctors treating a particular type of cancer exchanged the results of their interventions, while the data remained secure and anonymous – it wasn't even possible to trace which particular hospital each of the patients attended. The experiment revealed that there is a vast number of differences in the way various hospitals treat the illness, and in the results that are achieved.

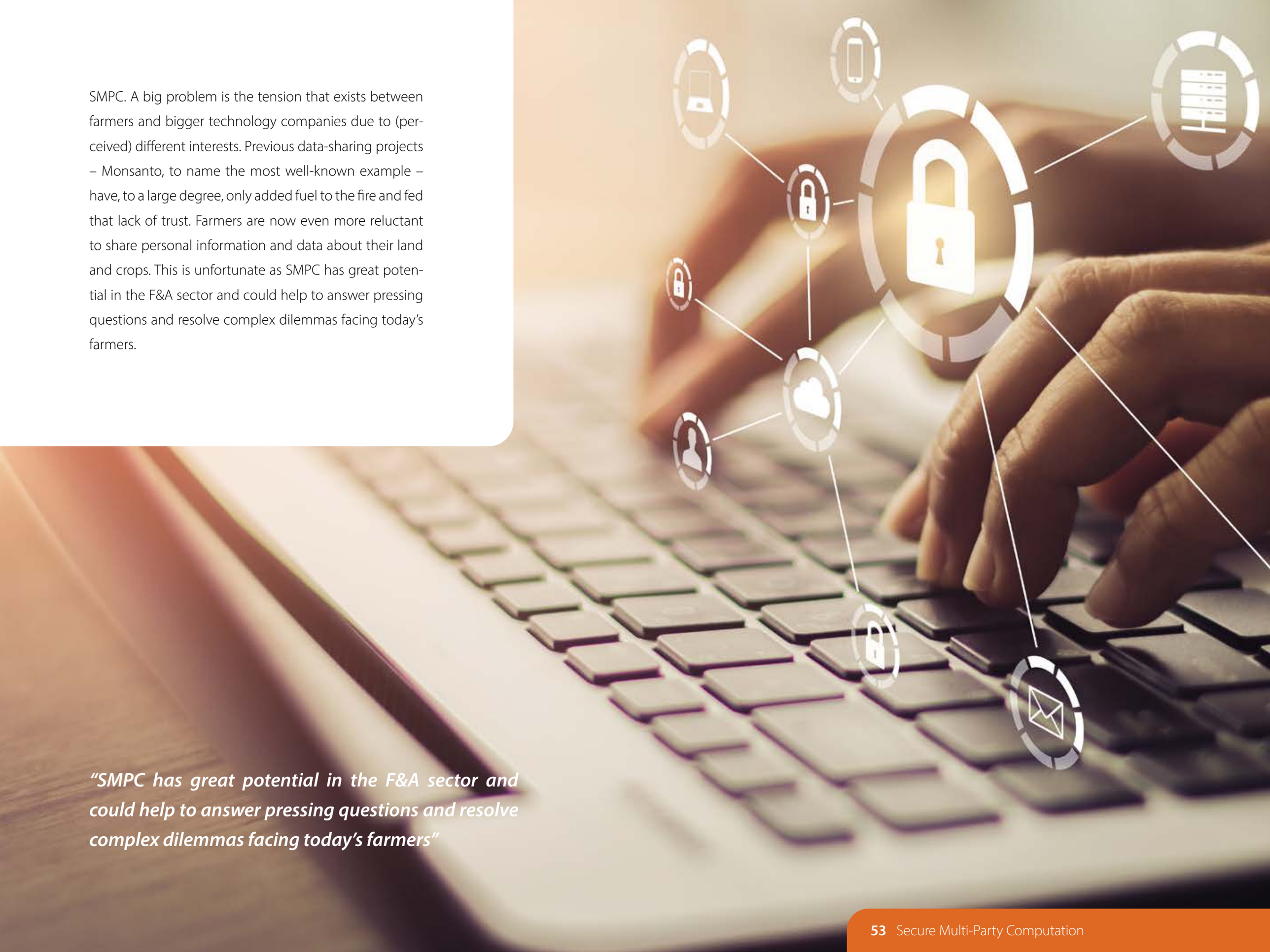
More implications for the financial market

SMPC could play a vital role in asset management and trade finance (through supply chain optimisation), and on the capital markets. Moreover, if banks aren't as reluctant to share data thanks to SMPC, it can also help with efforts to detect fraud sooner and can boost anti-money laundering initiatives.

Food & Agriculture (F&A)

In the F&A industry in particular, confidence – or rather a lack thereof – is a key obstacle hindering the evolution of

SMPC. A big problem is the tension that exists between farmers and bigger technology companies due to (perceived) different interests. Previous data-sharing projects – Monsanto, to name the most well-known example – have, to a large degree, only added fuel to the fire and fed that lack of trust. Farmers are now even more reluctant to share personal information and data about their land and crops. This is unfortunate as SMPC has great potential in the F&A sector and could help to answer pressing questions and resolve complex dilemmas facing today's farmers.



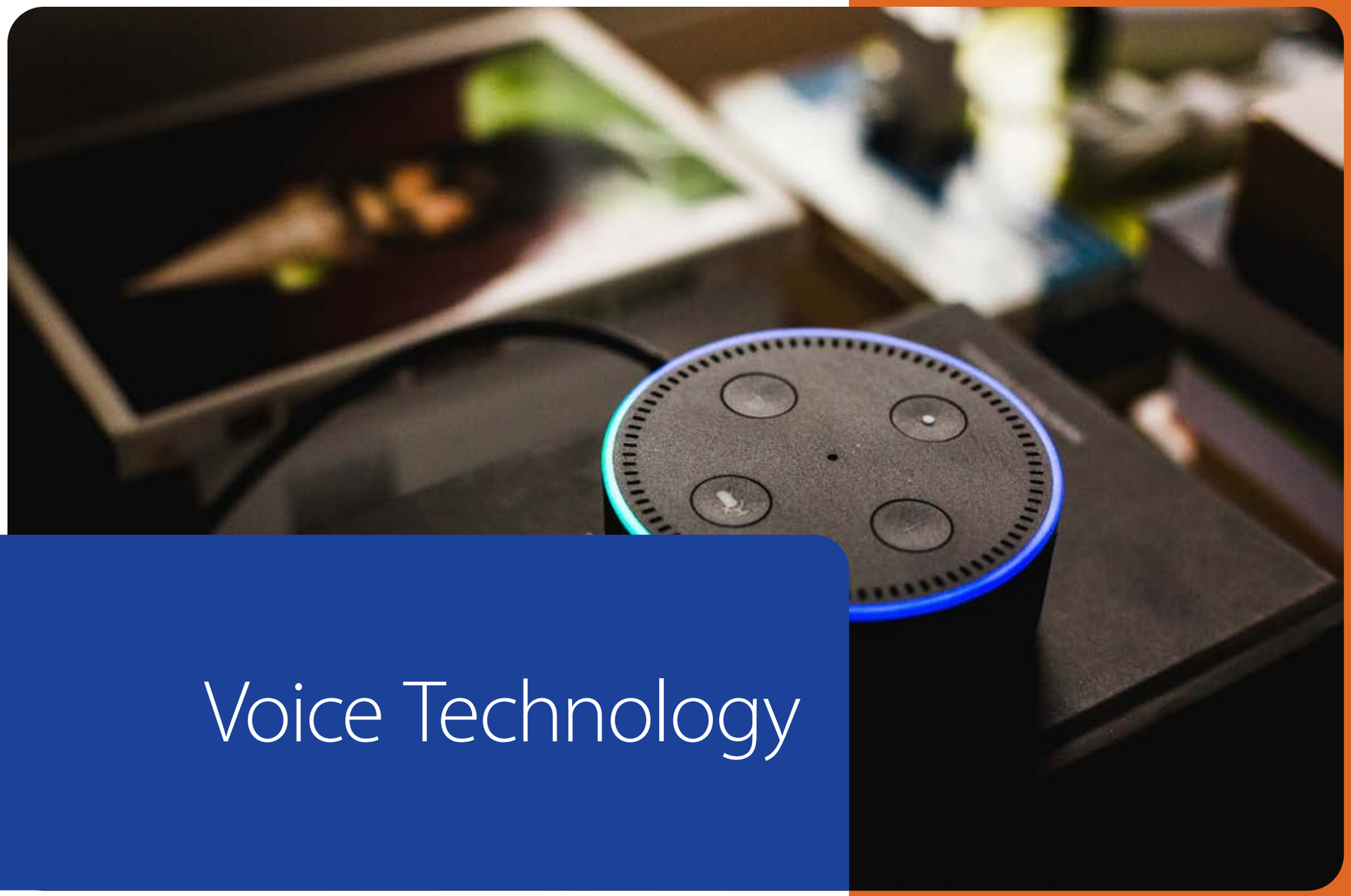
"SMPC has great potential in the F&A sector and could help to answer pressing questions and resolve complex dilemmas facing today's farmers"

Secure Multi-Party Computation in practice

Partisia is an interesting example of a company utilising SMPC to set a new standard for privacy-enhancing software. SMPC's functionality makes it possible to implement basic economic ideas, such as a commercial platform focusing on SMPC or commercial activities like market design and data analytics. Another player in the SMPC market is Inpher, a global data security and analytics company based in Switzerland and the United States. Inpher has pioneered an advanced cryptographic Secret Computing® platform that keeps data – used for anti-money laundering initiatives, for instance – protected while it's processed.

Like Rabobank, other global banks are actively looking at how to adopt SMPC for beneficial purposes. Several Danish banks have teamed up to investigate how the technology can help them to effectively and securely determine the creditworthiness of Danish agrarians. ING Belgium started using SMPC to build analytical models using data from multiple countries – like Switzerland and Luxembourg – that have stringent data security and privacy rules. Proprietary algorithms generated by ING data science teams are secretly computed by all regional data centres and/or cloud service providers without revealing any sensitive information: no personally identifiable information (PII) is exported from any jurisdiction.

Obviously, Google wouldn't dare fall behind. The company released an open-source cryptographic tool known as Private Join and Compute last June. The system facilitates the process of joining numeric columns from different datasets to calculate a sum, count or average on data that is encrypted and unreadable during its entire mathematical journey. Only the results of the computation can be decrypted and viewed by all parties – in other words, those involved only get access to the outputs of the calculations, not the raw data that belongs to other parties.



Voice Technology

Chapter 08

Definition

Unpacking Voice Technology

'Alexa, what's the weather like in New York?' 'Siri, please call my mother'. Voice technology has rapidly grown in popularity in modern times – most of us are now familiar with Amazon's Alexa, Apple's Siri, Google Assistant, Microsoft's Cortana and Samsung's Bixby. Deriving from the intersection of Artificial Intelligence (AI) the Internet of Things (IoT) and several other developments, voice technology powers devices to mimic human intelligence while engaging in natural conversation with users.

Digital Voice Assistants (DVAs) exist in many different shapes and forms, with the most popular of the lot being built into smart speakers, smartphones and even cars. DVAs are built with software that combines large data sets with AI, leveraging machine learning and natural language processing (NLP). The technology works by converting the waveforms of speech into smaller text-based words and parts. These combinations and their context are then analysed and matched to words that have already been learned. Aside from its everyday uses, voice technology can also be applied for the purpose of authentication (biometrics) or emotion detection.

Evolution of Voice Technology

"Ease of use and time savings are two of the primary reasons why people choose to use voice assistants. "

In the United States (US), voice-activated technology has become one of the most popular applications for AI today, and it's predicted that the use of DVAs and other conversational interfaces will only continue to rise. Ease of use and time savings are two of the primary reasons why people choose to use voice assistants.

Dutch delays

While the technology has evolved rapidly in the US and other parts of the world, developments have been much slower in the Netherlands. The reason for this lag is simple: DVAs aren't yet fluent in Dutch. While the Dutch language skills of Siri and Google Assistant are fairly up to scratch, Alexa and Bixby aren't very familiar with our native tongue. It would seem that the Dutch market is not as interesting from a business and investment point of view as the English, German and Spanish markets. That said, as soon as the issue of language is resolved, there's no doubt that a ton of opportunities will open up in the field of voice recognition here, too.

Challenges for voice technology: language, privacy and audience

Aside from the language challenge, privacy is also an issue. After all, personal assistants are always listening – often for the purpose of "quality assurance" – and can therefore record more information than users would like. Voice technology is merely a channel, driven by an underlying party like Google, Apple or Amazon. How can consumers be confident that these agents aren't eavesdropping or, even worse, storing our conversations? Yes, the software belongs to these big tech corporates, but they should only be the technical facilitators; they shouldn't be able to claim the right to our data, right? When such parties tell us they don't plan to store or use our information, we really have no other choice but to trust them.

Additionally, we still don't entirely understand who comprises the primary market for voice technology? While the elderly would likely find voice assistants very useful, it remains to be seen whether this target audience actually adopts and makes use of voice-enabled solutions.

Revolutionising the market

Importantly, research shows that DVAs have a big influence on which devices consumers buy and how they use them. In other words, voice-first solutions are impacting the whole consumer technology and service ecosystem in a way that no other innovation, including smartphones, has done before. More than half of the owners of standalone DVA devices report that since they purchased their unit, they've been using their smartphones for fewer services.

What tomorrow holds for Voice Technology

It appears that voice will continue its rise as the new user interface. Today, 11 percent of Americans own a standalone DVA, and 20 percent plan to purchase one in the next 12 months. Three out of four standalone DVA owners use the device daily or several times per week. With ongoing technological advances making voice assistants even more capable, it seems we're in for a future that will see voice technology becoming one of the more frequently used modes of interaction. In time, machine learning algorithms will be able to process more data, recognise patterns faster and provide increasingly personalised responses. It's likely that voice technology will evolve from its fairly basic current state – only being able to engage in short question-answer exchanges – to a point where it can take on far more complex workloads, engage in increasingly elaborate conversations, and even detect the emotions of users.

In the coming years, we'll no doubt see new players entering the voice market with new devices, enhanced by improvements in NLP and machine learning, and by developments in computing and telecommunications infrastructure (e.g. more powerful smartphones, better cellular networks and faster cloud computing). It's impossible to know how the swift upsurge of different players will impact the market. That's as much of an unknown as which generation will benefit most from the technology, and both require a wait-and-see approach.

As far as voice technology in households is concerned, there's no doubt that it'll take flight here and enter our homes even more so than it already has. We've evolved significantly from voice technology in cars – it's first application and something that's now considered commonplace – and now we're up for the next chapter: from voice-activated microwaves, fridges and lamps to fully conversational homes and hotel rooms.

That said, how widely voice-enabled solutions are ultimately adopted will largely depend on how well we tackle the aforementioned challenges – the issues of privacy, trust and language.

Implications and applications for Rabobank and its clients

Voice-based authentication

Rabobank has been following developments in the field of voice technology closely for some time now. The bank started testing voice-based authentication (using voice to verify identity) six years ago, which is important as banks are perceived as a "trusted" party. Clients are now able to use Google Assistant to request balance information or to send payment requests.

Ongoing experiments

Conversational banking will become increasingly embedded in the bank's daily routines. At present, the bank is experimenting with taking these conversations to the next level, enabling Google Assistant to engage in more complex discussions and answer questions like, 'How much can I borrow from the bank?'. Similarly, it aims to get to the point where voice technology will facilitate all sorts of financial transactions.

Voice Technology in practice

We're all familiar with voice technology being used to enhance customer service: when we phone an institution and our questions are handled by a voice assistant, rather than a human. Google Duplex is a project by Google that allows users to make a restaurant reservation by phone, but instead of speaking directly to a restaurant employee, callers will speak to a AI-based bot, powered by Google Assistant – the bot is even programmed to interject with the occasional "uhm" to sound more human.

Aside from this fairly commonplace example, voice technology can applied more generally to ensure overall operational excellence. Like Rabobank, several global banks, including Citi, HSBC and TD Bank, use this technology for voice-based authentication. Citibank, for example, enabled over one million customers in the Asia-Pacific region to use new voice biometrics to verify identity over the phone.

Food & Agriculture (F&A)

The agricultural sector still makes relatively little use of voice as a new user interface, aside from for simple applications, like to capture observations on a smartphone while ploughing land or to access phone services when hands are dirty. Startups like AgVoice aim to introduce mobile voice interaction into farming contexts by enabling agriculture professionals to capture crucial data and insights on the go. AgVoice's software registers the information and stores it so that farmers don't need to turn to a computer or pen and paper. Alibaba Cloud ET Agricultural Brain is another example of an AI-powered programme that uses facial, temperature and voice recognition to assess pigs' health.

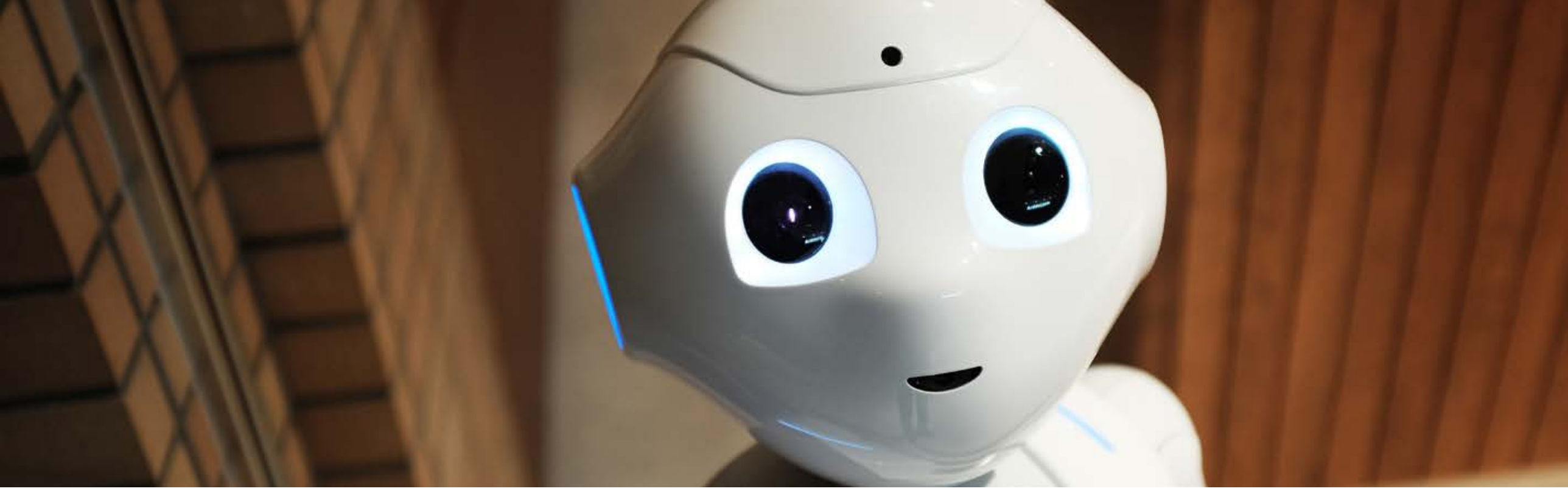
Examples in other industries are easy to come by. The American financial industry, in particular, is enthusiastic about the uses of voice technology. The Florida-based Best Innovation Group launched a platform that enables credit unions and retail banks from across the US to offer voice-first banking. Customers can pay their mortgage, transfer between accounts, access account histories and more using the software, which works with both Alexa and Google Assistant. Customers of the US Bank also have access to bank-by-voice services, allowing them to check balances, pay off credit and mortgages, and even ask Alexa or Google about the dates that bills are due. Lastly, another inspiring and highly practical deployment of voice technology comes in the form of the British Red Cross's 'First Aid'. If your nose starts to bleed and you want to know how to stop it, you can just cry out, 'Alexa, ask First Aid how to treat a nosebleed' and just like that, technology will come to your rescue!

Conclusion

It's fair to argue that the transformation that digital technologies have inspired has been more significant and more radical than anything we've seen before. And this is just the tip of the iceberg. This report offered a glimpse at eight technological trends, the changes they've brought about, and the possibilities they'll continue to offer the world and the people living in it. Digital has become the new normal, and will continue to alter the world as we know it – radically.

Rabobank is at the forefront of ongoing technological developments. Digital technologies offer the bank a myriad of opportunities to improve services, boost its impact and enhance its connection with clients and partners. In particular, the rapid evolution of fields like Artificial Intelligence – combined with blockchain, extended reality and quantum computing – will not only change the way the bank conducts business, but also completely alter its relationships with clients, employees and partners.

Ultimately, digital technologies will help Rabobank to gain an even better understanding of its clients, and to be able to respond to their needs accordingly. More specifically, the bank can apply developments to make banking more straightforward, more efficient and more customer-friendly. It's up to you to use all the knowledge and predictions contained in this report and convey these insights to people around you so that they, too, can grasp the impact these eight trends could have on their businesses and their world.



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