WORLD ECONOMIC FORUM

Forging New Pathways

The next evolution of innovation in financial services

Part of the Future of Financial Services series
Prepared in collaboration with Deloitte

Foreword

Contact

For feedback or questions, please contact:

Drew Propson, Lead Author
drew.propson@weforum.org
+1 (917) 224-6239

The World Economic Forum applies a multistakeholder approach to address issues of global importance. Consistent with this mission, the creation of this report involved extensive outreach and dialogue with numerous organizations and individuals. These included the Forum's financial services, innovation and technology communities, as well as leaders from academia and the public sector.

The outreach comprised more than 200 interviews and nine international workshop sessions, conducted over the past 12 months, with the aim of capturing insight and opportunities relating to the impact of artificial intelligence and emerging technologies on the financial services industry.

The holistic and global content of this report would not be as rich without the support of, and contributions from, the subject matter experts who assisted in shaping our thoughts on the influence of AI and emerging technologies on the financial services industry. In particular, we thank this project's Steering Committee and Working Group. Their expertise and patient mentorship have been invaluable. Also critical has been the ongoing institutional support for this initiative from the World Economic Forum and the leadership of our Chairman, whose vision of the Fourth Industrial Revolution has been inspirational to this work. Finally, we are grateful to Deloitte for their commitment to and support of this project.

Editor's note

In recent years, discussions at the World Economic Forum Annual Meetings have highlighted both the opportunities and risks unlocked as AI is deployed at scale in the financial services industry. Alongside these discussions are a series of conversations about the potential impact of other technologies – including cloud, distributed ledger technologies, and quantum computing – that are coming to maturity, albeit at a different pace.

Many studies have examined the role of individual technologies. However, few have explored the transformations occurring as these technologies are clustered together. In one of the most comprehensive studies of its kind, we bring together a global community of stakeholders across a vast array of industries and disciplines to surface the critical effects of technology clusters on the financial services industry and provide valuable strategic insight to the public and private sectors alike.

This study, the third in the Forum's three-part Future of AI in Financial Services project, extends previous work focused exclusively on AI by exploring the intersection of AI and other emerging technologies that will be fundamental to the industry.

Our research underscores that, for financial services executives, having a detailed perspective on emerging technology clusters is essential, as the business of financial services is becoming increasingly reliant on the deep understanding, intelligent assembly and tailored execution of technology-driven capabilities.

We hope this document will help you make the strategic decisions needed to forge your institution's pathway into the future financial services landscape.

With regards,

Drew Propson

Head, Technology and Innovation in Financial Services
World Economic Forum

Rob Galaski

Vice-Chair and Managing Partner, Financial Services
Deloitte Canada

Past reports from the *Future of Financial Services* series

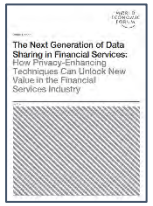
2015

2016

2016

2017

2018



2019

2019

Members of the Steering Committee

Josh Bottomley
Global Head of Digital, Data and Development, HSBC

Vanessa Colella
Chief Innovation Officer of Citi, Head of Citi Ventures & Citi Productivity, Citi

Juan Colombas
Executive Director and Chief Operating Officer, Lloyds Banking Group

Robert Contri
Global Financial Services Leader, Deloitte Global, USA

David Craig
Chief Executive Officer and Board Member, Refinitiv

Tony Cyriac
Enterprise Chief Data and Analytics Officer (2018-May 2020), BMO Financial Group

Michael Dargan
Head of Group Technology, UBS

Shivaji Dasgupta
Global Head of Data Products and Artificial Intelligence, Deutsche Bank

Rob Goldstein
Chief Operating Officer and Global Head of Blackrock Solutions, BlackRock

Lena Mass-Cresnik
Chief Data Officer, Moelis & Company

Max Neukirchen
Chief Executive Officer, Merchant Services, JP Morgan Chase

Kush Saxena
Executive Vice-President, Merchants and Acceptance, Mastercard

Nicolas de Skowronski
Head Wealth Management Solutions, Member of the Executive Board, Julius Baer

Abhishek Tomar
Chief Data Officer, Market Intelligence, S&P Global

James B. Walker
Member of the Group Executive Board, Chief Operating Officer, Credit Suisse

Michael Zerbs
Group Head Technology and Operations, Scotiabank

Members of the Working Group

Sami Ahmed
Chief Digital, Data and Analytics Officer (2019-August 2020), BMO Financial Group

Vinod Baya
Head of Emerging Technology, Citi Ventures, Citi

Ayse Duran
Global Head of Analytics Strategy and Special Projects, ING Group

Gero Gunkel
Group Head of Artificial Intelligence, Zurich Insurance

Jennifer Peve
Managing Director, Head of Business Innovation, DTCC

Laura Sartenaer
Strategy and Partnerships Manager, Refinitiv Labs, Refinitiv

Chadwick Westlake
Executive Vice-President, Enterprise Productivity and Canadian Banking Finance, Scotiabank

Seçil Arslan
Director of Applied AI and R&D (2013-April 2020), Yapi Kredi

Julien Blanchez
Head of Data, SWIFT SCRL

Thompson Eberline
Managing Director, Data Operations, S&P Global

James Harborne
Head of Group Digital Public Policy, HSBC

Gary Sanders
Director of Data Products, Lloyds Banking Group

Annika Schröder
Executive Director, Artificial Intelligence Center of Excellence, UBS

Sophie-Luise Baratta
Strategic Data Lead, Deutsche Bank

Richard d'Erizans
Senior Vice-President, Regional Solutions and AI Services, Mastercard

Roland Fejfar
Head Tech. Bus. Dev. and Innovation EMEA/APAC, Morgan Stanley

Jonathan Hayes
Head IWMS Business Innovation, Julius Baer

Nicole Sandler
Head of Digital Policy, Barclays

Dean Soteropoulos
Managing Director, Innovation Lead (CFO Office), Credit Suisse

Members of the Project Team

Project leadership

The Future of AI in Financial Services project leadership team includes the following individuals:

World Economic Forum

Drew Propson, Lead Author, Head of Technology and Innovation in Financial Services

Matthew Blake, Head of Financial and Monetary System Initiatives

Professional Services Leadership from Deloitte Canada

Rob Galaski, Co-Author, Project Adviser

Courtney Kidd-Chubb, Project Adviser

Project authors

The World Economic Forum expresses its gratitude to the following individuals on the project team:

Deloitte Canada

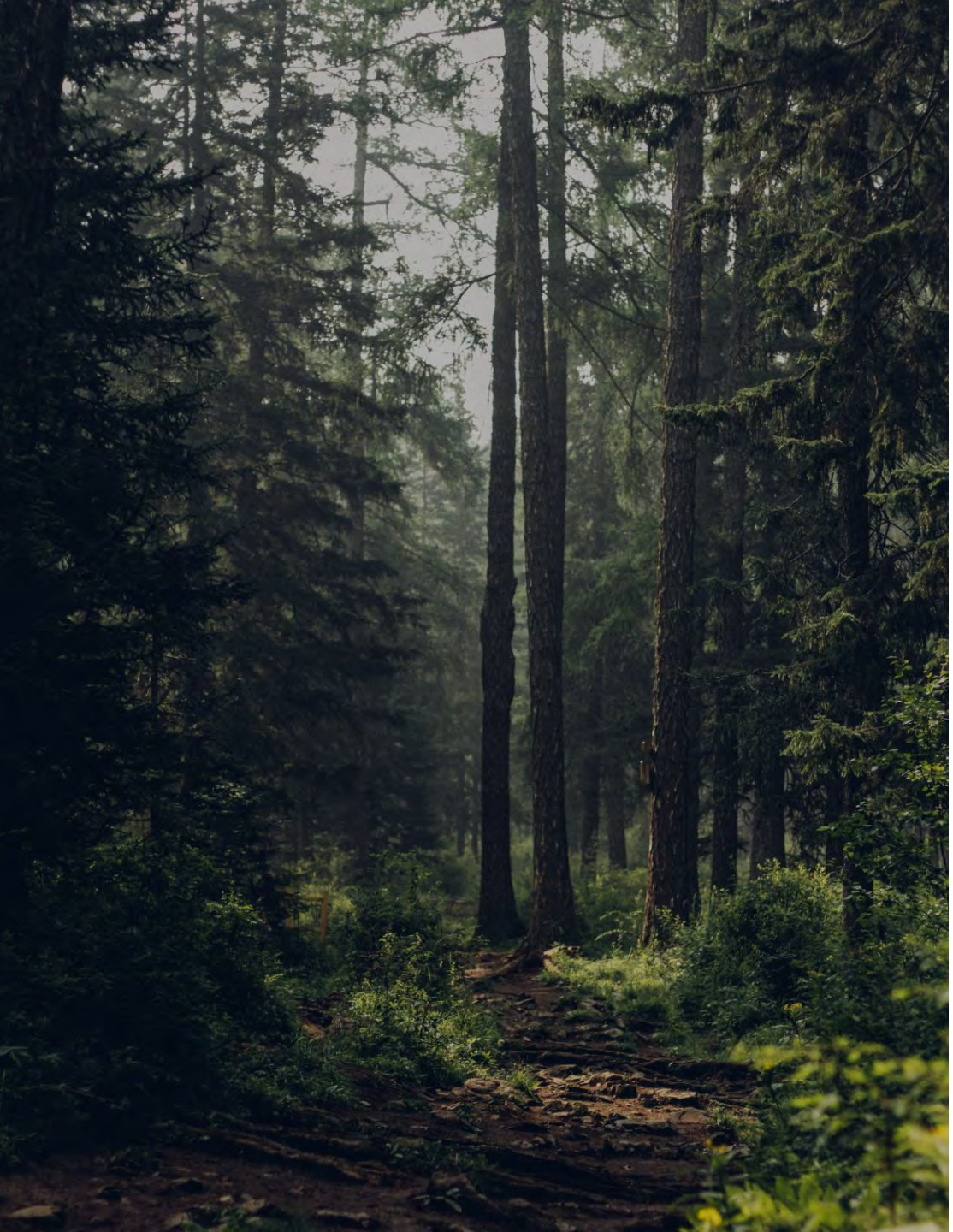
Luca De Blasis, Senior Consultant

Taryn Mason, Senior Consultant

Additional thanks

The project team expresses gratitude to the following individuals for their contributions and support:

Derek Baraldi
Mary Emma Barton
Andre Belelieu
Mark Belostotsky
Clara Chung
Kiera Han
Kiriko Honda
Kai Keller
Ishani Majumdar
Shigehiro Muraki
Saya Nagasawa
Jenny Pan
Yoshika Sawairi
Mizuho Toyama
Ben Weisman
Dancy Zhang



Contents

Context and approach

Over the past two years, the Forum's exploration of the future of artificial intelligence (AI) in financial services has highlighted a critical need to examine the intersection of AI and other emerging technologies

The New Physics of Financial Services explored how AI would impact three key areas of financial services, predicting:

New operating models
The front- and back-office operations of financial institutions will look radically different

New market structures
There will be major shifts in the structure and regulation of financial markets

New societal challenges
Critical societal challenges will be introduced by the adoption of AI, requiring collective solutions

Key insight influencing this report

AI **does not (and will not) exist in a vacuum** within financial services firms; it will be inextricably connected to many other emerging technologies, which together will alter the future financial services landscape

Navigating Uncharted Waters explored how financial institutions can ensure the responsible use of AI in the industry, specific to:

Responsible deployment
Responsibly deploying AI systems in the financial ecosystem by managing their "foreignness"

Responsible scaling
Responsibly scaling up the AI-ubiquitous financial ecosystem of tomorrow by re-examining policy

Harnessed potential
Harnessing the potential of a financial ecosystem built on responsible AI by raising the ethical bar of "trusted AI"

Key insight influencing this report

Other emerging technologies could help **reinforce the responsible use of AI** in financial services, or lead to **new or exacerbated challenges (e.g. ethical, environmental, societal)**

This report endeavors to **look beyond AI as an individual technology**, to **explore the multiplicative impacts** of emerging technologies when clustered strategically and applied to business problems in financial services

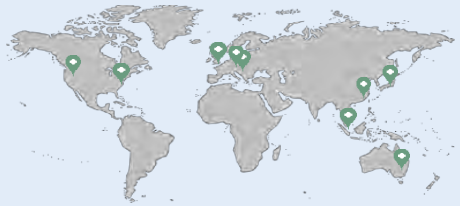
Over the past year of research, industry leaders and subject matter experts were engaged in a series of global workshops and expert interviews

Expert interviews

200+ interviews with leading subject matter experts and **senior executives** from **over 100 of the world's leading financial services firms**, playing across the spectrum of financial services (banking, insurance, capital markets, payments etc.)

Global workshops

Nine multistakeholder workshops at global financial hubs with participants including industry leaders, additional subject matter experts, and regulators



Workshop locations

- Beijing, China
- Davos, Switzerland
- London, UK
- New York, USA
- San Francisco, USA
- Singapore
- Sydney, Australia
- Tokyo, Japan
- Zurich, Switzerland

The inclusion of company case studies within this report does not reflect an explicit endorsement of the company or its products and services by the World Economic Forum.

This report will provide executives, regulators and policy-makers with a perspective on how emerging technologies are unlocking new value propositions and reshaping strategic choices in the industry

This report WILL…

- **Explore cross-sectoral opportunity areas** that emerging technologies create, and implications on competitive dynamics
- **Detail the capabilities unlocked by emerging technologies** on both an individual and a clustered basis
- **Highlight new, tangible customer-centric use cases** that financial institutions could offer, enabled by emerging technologies

This report WILL NOT…

- **Provide a detailed technical description** of any specific emerging technology
- **Make specific recommendations** on which use cases or opportunity areas that individual institutions should pursue
- **Outline specific approaches** that institutions may pursue to implement emerging technologies or new value propositions

This report seeks to help…

- **Strategic decision-makers at financial institutions** critically assess the true capabilities unlocked by emerging technology clusters, understand the opportunity areas that are developing in the financial services industry as they mature, and evaluate how these opportunity areas affect long-term strategic planning
- **Regulators and policy-makers** understand the potential impact of emerging technologies on the financial services industry, and craft responses that foster an innovative ecosystem while ensuring adequate safeguards are built for consumers, markets, institutions and society

This report **defines "financial institution" as any organization engaged (in whole or in part) in financial services activities**, inclusive of incumbent institutions, fintechs and other innovators, and primarily non-financial firms that are engaged in some form of financial activity.

Executive summary

Financial service executives have long been challenged to move forward on aggressive technology initiatives, although new forces are increasing the appetite and capacity for change

In today's rapidly changing and evolving financial services environment…

Many financial institutions are playing innovation "catch up"…

Financial institutions are undergoing large-scale modernization projects but are often still hampered by ageing technology infrastructure. For instance, as of mid-2019, as many as 70% of banks were still reviewing their legacy core banking platform implementations,[1] and 43% of US banks were still using COBOL, a coding language dating to 1959.[2]

…but even as new permissions strengthen the mandate to innovate…

Recent industry forces (e.g. heightened competitive pressures, COVID-19) have given financial institutions new permission (e.g. from customers, regulators, shareholders) to make radical changes to their operating models. For example, in the middle of the pandemic, 63% of customers stated they were more willing to try digital applications.[3]

…executives remain uncertain of where to place "bold bets" for the future

To compete in a changing operating environment, most financial services executives have targeted AI and cloud as clear investment priorities in the near term. However, many executives are still grappling to understand the impact that the coordinated deployments of emerging technologies could have, and develop a powerful innovation strategy accordingly.

For many executives, the link between developments in emerging technology and tangible business outcomes is still unclear

Alongside permission to embrace technology-enabled change, multiple technologies are coming to maturity within a similar timeframe

Artificial intelligence (AI): over the past few years, AI has evolved from an enabler of point solutions in financial services into, in some cases, a truly cross-business intelligence layer

Cloud computing: As some firms experiment with multi-cloud strategies, others are developing innovative co-creative partnerships with a provider of choice; collectively, cloud equates to nearly half of the industry's 2020 IT spend[4]

Quantum computing: While quantum is several years away from scaled commercial accessibility, hybrid quantum solutions are beginning to allow firms to reimagine the speed and accuracy of fundamental industry calculations

Task-specific hardware: As more enterprise AI workloads are being pushed to the cloud, market leaders are now able to access highly specialized processing units (e.g. those for neural network processing) at scale

Augmented/Virtual reality (AR/VR): High potential impacts of augmented and virtual reality in financial services revolve around transforming how consumers seek information about, and ultimately pay for, goods and services

5G networking: Institutions are looking beyond the immediate speed benefits of 5G to explore how it can be used to improve device security in a more remote-work world and coordinate entire networks of autonomous "things"

Internet of things (IoT): Physical data from IoT is making possible the continuous adjudication of risk, while providing institutions with operational and contextual data they have never had access to before

Distributed ledger technology (DLT): Several successful commercial launches of DLT networks – such as *Spunta Banca* reconciliation network for Italian banks[5] or HQLA[x] for collateral lending – are finally proving DLT's enterprise-level viability[6]

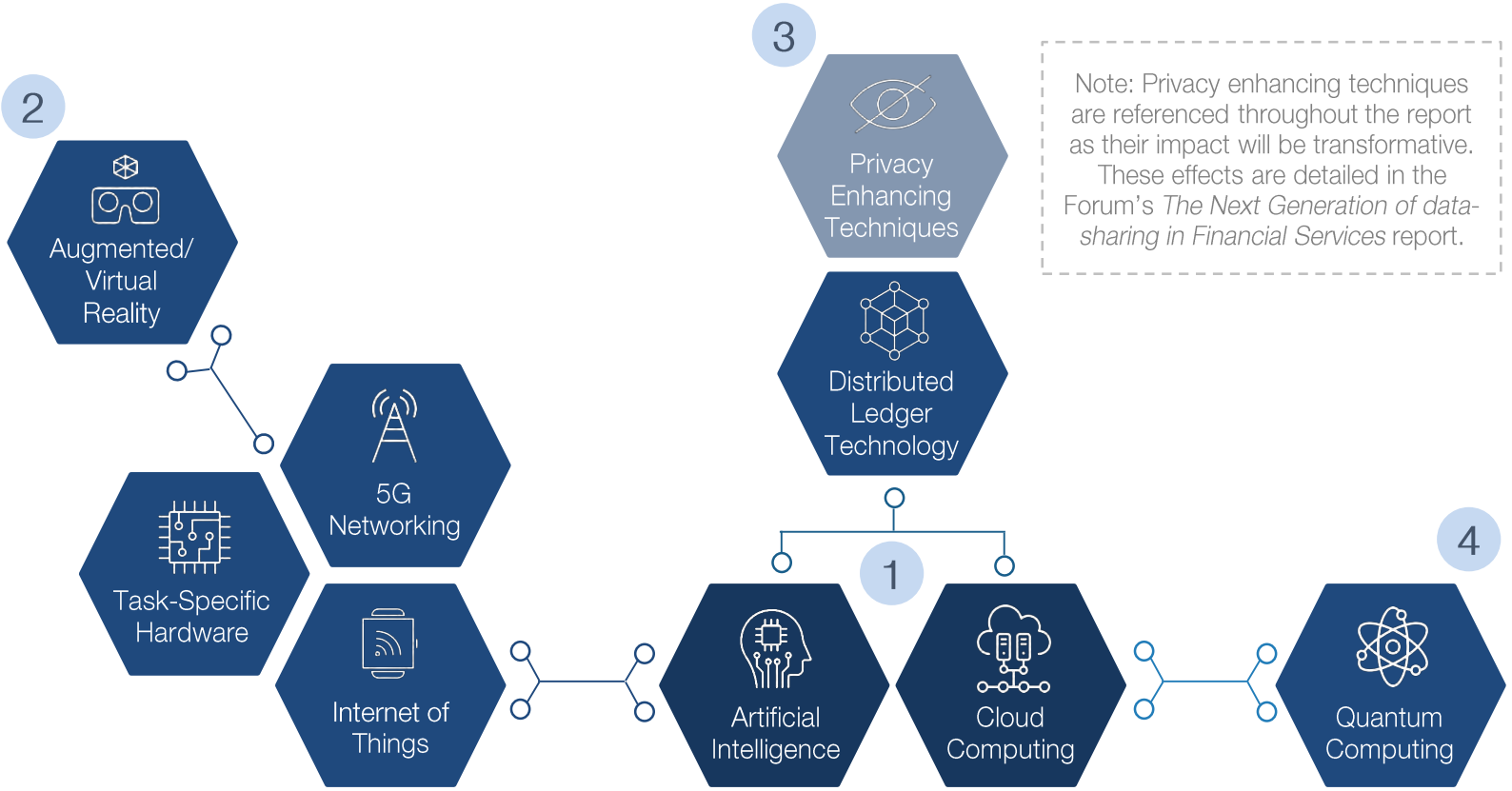
Strong organizational fluency across each of the technologies will be a key differentiator of winning organizations; institutions should look to proactively explore their impact alongside policy-makers, regulators, industry bodies and other key stakeholders

Note: A detailed exploration of each technology can be found in the **Explorations of Emerging Technologies** section of the report

While powerful individually, it is the multiplicative impacts of these emerging technologies that will be transformative to the financial services industry

Exploring the technologies further, common ways of clustering them in financial services become apparent:

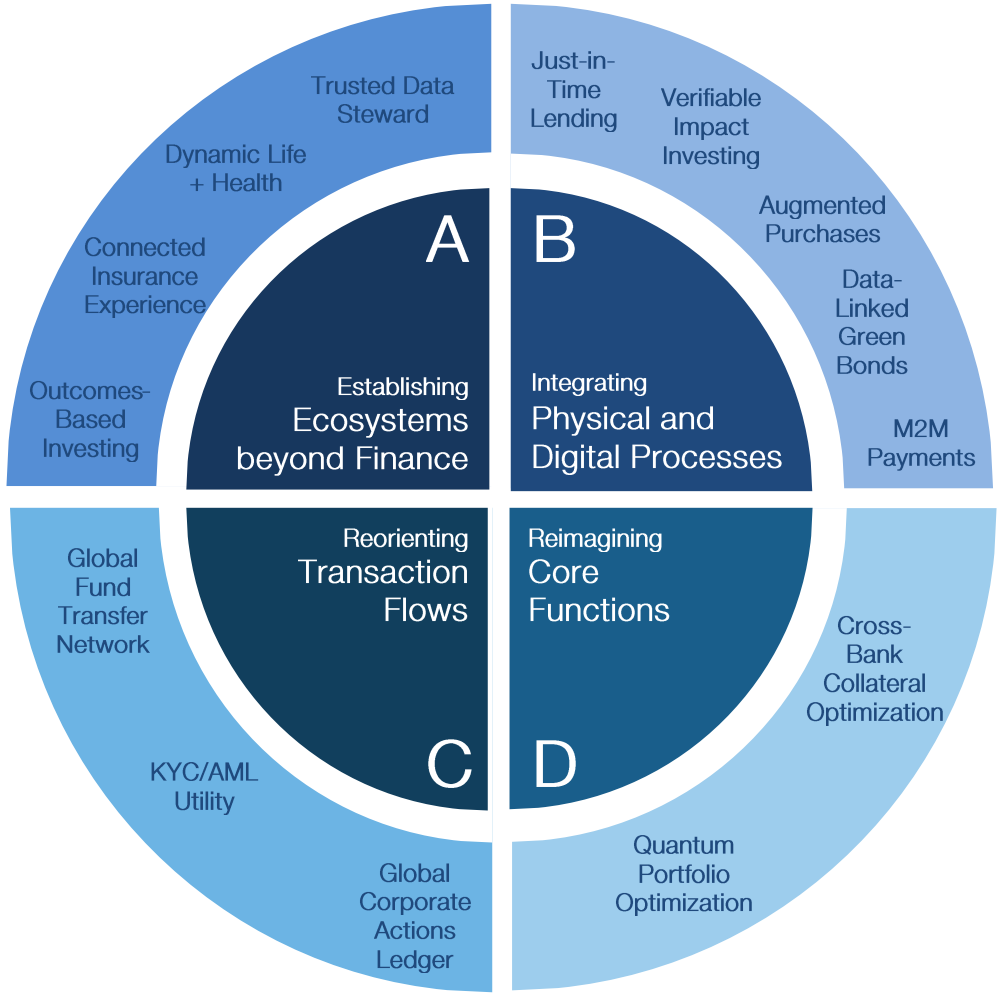
1. AI and cloud sit at the core of each cluster:
   - AI helps to analyse, interpret and make decisions upon the data that many of the other technologies generate, store or process.
   - Cloud creates connectivity to access other technologies as-a-service (e.g. infrastructure as a service).
2. The branch to the left features technologies that help bridge the gap between the physical and digital financial worlds, creating new ways of generating and accessing data.
3. The middle branch enables new, more secure methods of orienting and structuring transactions of both value (e.g. currency, securities) and data.
4. The branch to the right augments the analytical capabilities of AI.



Note: Privacy enhancing techniques are referenced throughout the report as their impact will be transformative. These effects are detailed in the Forum's *The Next Generation of data-sharing in Financial Services* report.

By anchoring investments in AI and cloud computing, and viewing other technologies as specifically enabled by them, financial institutions will be able to more easily access and implement the clusters of emerging technology most important to solving their key business problems

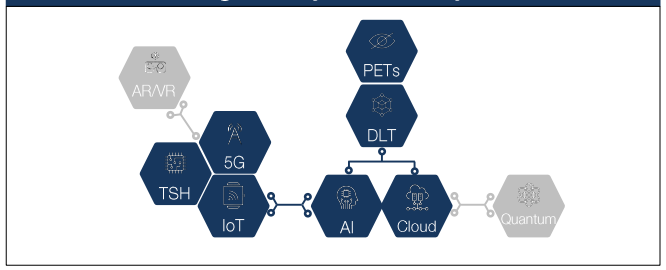
These technology clusters are unlocking unique pathways for innovation in financial services and, in doing so, begin to establish the architecture for the financial institution of the future



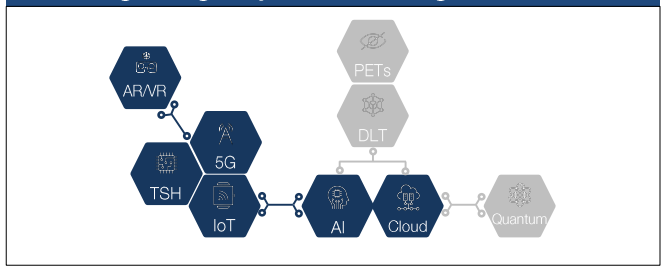
Innovation pathways in financial services

The diagram to the left highlights four key innovation pathways in the financial services industry enabled through technology clusters (below). Aligned to each of these pathways, in the outer ring, is an illustrative (but certainly not exhaustive) set of sector-specific use cases that show how financial institutions could bring these technologies together to create new value propositions.

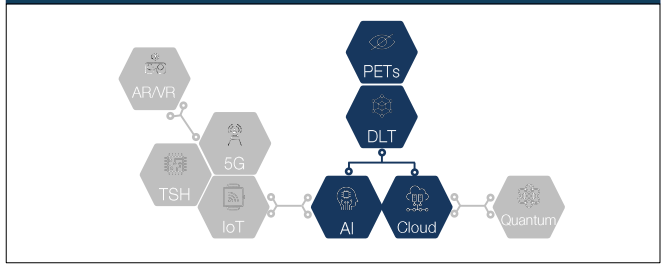
A. Establishing Ecosystems beyond Finance



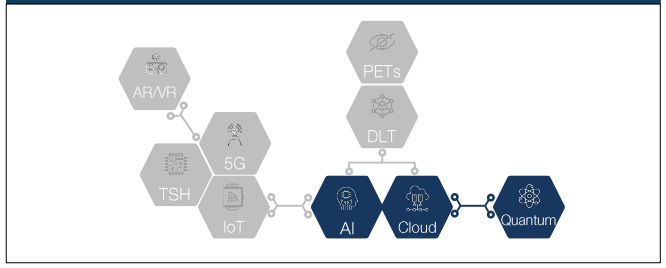
B. Integrating Physical and Digital Processes



C. Reorienting Transaction Flows



D. Reimagining Core Functions



Note: Pathways are not listed in an explicit order.

The conditions for action have never been stronger, giving institutions the licence to pursue these innovation pathways at a pace and sophistication seldom seen before

Three indicators point to the financial services industry being ripe for a substantial wave of technology-enabled transformation

Increased confidence to implement a progressive innovation agenda

Institutions that made strategic investments in emerging technologies over the past few years have, in recent times, demonstrated resilience against new competitive entrants, margin compression and unprecedented uncertainty.

New permission for future-oriented investments

Having transitioned to remote work due to COVID-19, institutions rapidly stood up digital capabilities and accelerated transformation plans. Many found they had the capacity and agility to execute in a fraction of the time initially set aside and will find it difficult to revert to old ways of working and analog tools.

Signs of cautious regulatory flexibility

In some geographies, institutions are seeing signs of regulatory flexibility on new technology implementation, helping them provide more critical services digitally. In areas where this flexibility is rewarded via better processes and minimal new risk, it will spark digital investment where firms may have once been hesitant due to lack of regulatory clarity.

Alongside the rapid “coming to maturity” of emerging technologies, the above indicators make it clear that now is the time for executives to fast-track the implementation of new use cases that emerge from key technology clusters

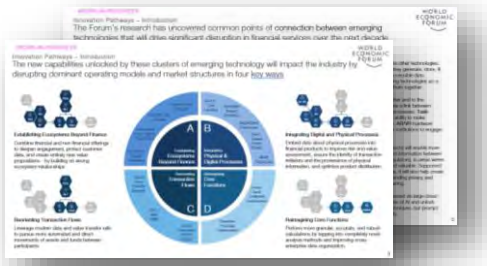
This report is comprised of four core sections that explore the impact of emerging technologies on the financial services industry

01 Key findings

02 Innovation pathways

03 Sector use cases

04 Exploration of emerging technologies



Description

The major takeaways for financial institutions, including a perspective on future sources of value, areas of risk and changes to dominant market structures

An exploration of new opportunity spaces in financial services, including a description of the enabling technologies and the identification of areas where disruption is most likely to occur in the industry

Customer-centred narratives describing use cases that exist at the intersection of different technologies in each sector of financial services (e.g. lending and deposits, insurance, capital markets, payments etc.)

Detailed capability descriptions, development timelines and critical business applications of the most relevant emerging technologies in financial services

References

1. "Next-generation core banking platforms: A golden ticket?", McKinsey, 12 August 2019, https://www.mckinsey.com/industries/financial-services/our-insights/banking-matters/next-generation-core-banking-platforms-a-golden-ticket
2. "Why banks can't delay upgrading core legacy banking platforms", Ernst & Young, 18 June 2019, https://www.ey.com/en_gl/banking-capital-markets/why-banks-can-t-delay-upgrading-core-legacy-banking-platforms
3. "Digitalization is changing banking – These 3 trends will help shape its future", 22 June 2020, World Economic Forum, https://www.weforum.org/agenda/2020/06/digitalization-is-changing-banking-these-three-trends-will-help-shape-its-future/
4. "The Cloud: A silver lining for financial institutions?", Refinitiv, 2019, https://www.refinitiv.com/en/resources/special-report/public-cloud-investment-barometer-report
5. "Italian banks go live on Spunta Banca DLT platform", Finextra, 28 April 2020, https://www.finextra.com/newsarticle/35715/italian-banks-go-live-on-spunta-banca-dlt-platform
6. Hqla-x, https://www.hqla-x.com/

Key findings

The multiplicative impact of emerging technologies will be transformative for the financial industry in important ways

Alter competitive dynamics and dominant operating models

1. With transformative technologies becoming widely accessible, the competitive standard will increase for all participants. Financial institutions will only find differentiation through **assembly, execution and relationships**
2. Deriving maximum benefit from these technologies will require **traditional industry lines to blur**, creating both interdependency and opportunity

Equip institutions with the tools needed to tackle old barriers and unlock new opportunity

3. Near-term value will be found in use cases that **combat data fragmentation** and those that **accelerate feedback loops** to anticipate customer moments of need
4. **Age-old industry barriers will deteriorate** as capabilities emerge to accelerate productivity, transition from data portability to insight portability and allow compliance to move at the speed of data
5. As technologies unlock the potential for real-time interactions and true disintermediation, the financial system must beware the unintended consequences of removing **frictions that are necessary to maintain stability, liquidity and good governance**

Create the impetus to tackle systemic industry challenges

6. **Operational security and resiliency** will be essential to the safe deployment of emerging technologies, as malicious actors will have access to the same capabilities and exploit them to find new attack vectors
7. Applications of emerging technologies will both create and reinforce **ethical, social and environmental challenges**; grappling with these challenges may stunt their deployment across the financial services industry

The competitive standard will increase for all participants as the advantages derived from transformative technologies become more widely available and accessible

Current differentiators that will become standard across the financial services industry:

Operational efficiency

The emergence of a "best-of-breed" operational stack, accessible on-cloud, will eliminate cost advantages from more efficient operations

Product development

New methods to standardize financial services (e.g. Fintech Open Source Foundation creating open source financial products) make it easier to quickly assemble new financial service products

Connectivity

Lower connectivity costs and standardization (e.g. REST APIs) will allow institutions of all sizes to flexibly connect with new ecosystem partners without significant effort

Data access

Open data initiatives, alongside inexpensive hardware and standardized connectivity, will make it easy to access financial and non-financial data with customer consent

Customer convenience

Democratized access to AI and automation will make straight-through processing and one-click product purchases the norm; smart contracts will enable T+0 transactions

The adoption and application of emerging technologies will be critical to success in the short term; however, in the long term, financial institutions will only find sustainable differentiation in core capabilities such as assembly, execution and relationship management

Leading institutions are already beginning to revert to differentiators such as assembly, execution and trusted relationship management in order to compete in saturated markets

Case studies

Innovators are assembling unique ecosystem solutions and often displacing incumbent relationships

LLOYD'S LLOYD'S OF LONDON · Parsyl

Parsyl has **assembled** a unique solution in the data-driven insurance space. It manufactures its own IoT sensor devices to monitor storage conditions (e.g. temperature, humidity). It uses the proprietary data it captures, alongside an in-house, AI-driven risk engine, to manufacture a parametric cargo insurance product on behalf of Lloyd's of London, a large European insurer. Parsyl is **building trusted relationships** directly with large commercial clients (that may previously have dealt directly with a large carrier) and is trusted with sensitive operational data.[1]

Leaders are developing teams and incentive structures across ecosystem partnerships to optimize execution

Google · Deutsche Bank

In July 2020, Google and Deutsche Bank launched a 10-year cloud partnership aimed at helping the bank **effectively execute** on a plan to digitalize its operations and push forward its overall digital transformation agenda. As part of the announcement, the companies also declared that they would be actively pursuing a co-investment strategy in new technologies in the banking sector that would ultimately drive joint product development (matched by a revenue-sharing agreement).[2]

Strategies for financial institutions

Assemble new capabilities and incentive models

Different use cases (or applications of emerging technologies) will be better aligned to the corporate objectives of certain institutions than others. Financial institutions should organize the right combinations of emerging technologies, talent and data that will help build the capabilities required to unlock prioritized use cases. Innovators (e.g. neo-banks) unencumbered with legacy technology and data architectures will have an advantage.

Execute effectively with in-house and third parties

Institutions should determine the appropriate combination of in-house capability development and integration of best-of-breed third-party capabilities. When working with vendors, creating new incentive models with partners (e.g. incentivize internal and partner staff to jointly develop products) can help institutions execute faster and at larger scale; a number of these vendor relationships may also become strategic partnerships where desired.

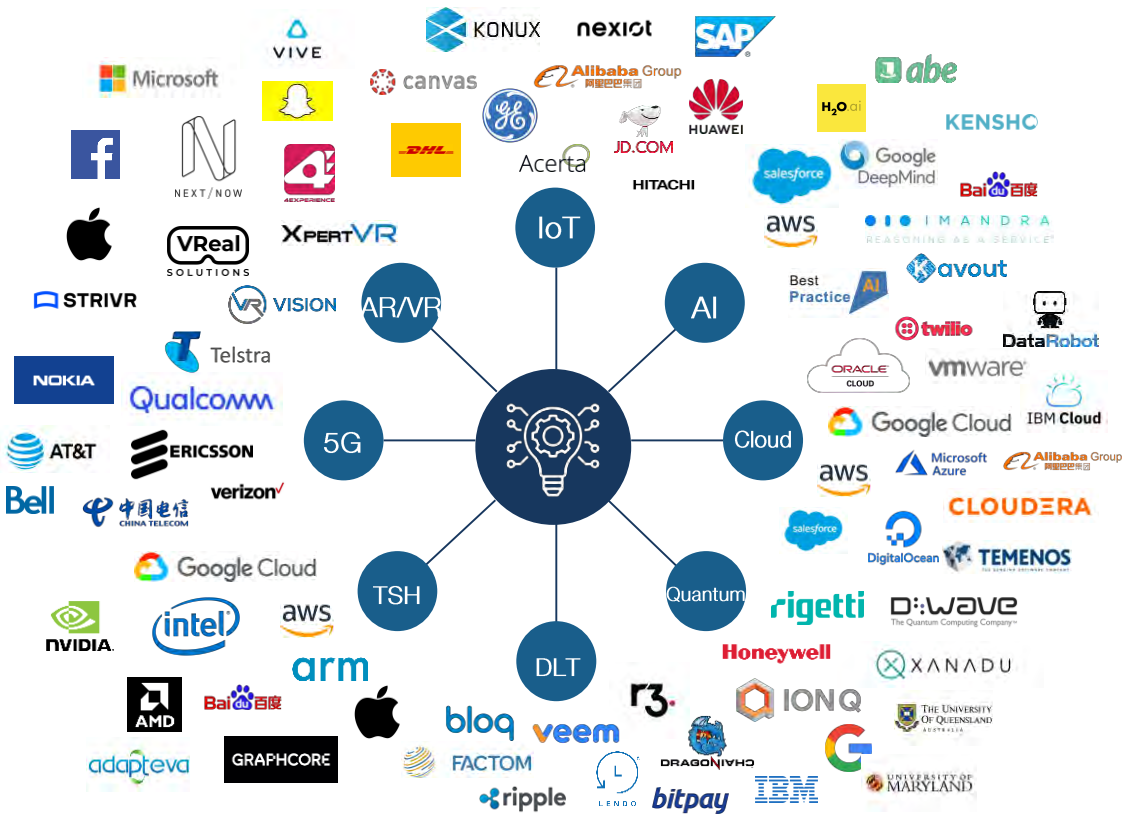
Focus on establishing trust with customers

Deeply understanding the customer to offer proactive solutions, while relentlessly protecting their personal data and limiting potential "creep factor" through consistent feedback loops, will help financial institutions build a trusted brand. For example, offering just-in-time loans could lower a customer's need to shop around, enhancing stickiness so long as their data is used safely and transparently.

Access to emerging technologies will largely be controlled by a range of non-financial service providers, establishing new interdependencies and opportunities for financial institutions

The balance of power across third-party relationships will shift:

- Large cloud providers will continue to dominate developments in artificial-intelligence-as-a-service (either directly or by providing access to a network of fourth parties via the cloud, e.g. SaaS vendors) and, in the long term, quantum-as-a-service
- Most recently, these developments have been taking place in areas such as operations (KYC tools), analytics (credit modeling) and cybersecurity (real-time fraud detection) as AI continuously learns from data provided by multiple financial clients and becomes more powerful than what a single institution could develop
- Ownership of hardware, such as IoT devices that stream operational data that can be linked to risk pricing, or AR/VR devices that can enable new payment experiences, will rest with customers, who will be the ultimate arbiters of consent over data streams
- With the exception of some internal protocols, most cross-institution DLT networks will be jointly managed by a group of financial institutions, regulators and others (e.g. customers), creating joint governance challenges and requiring institutions to build and manage new sources of connectivity



To manage an increasingly fragmented partnership landscape, financial institutions will need to proactively identify and manage end-to-end responsibilities and controls (e.g. of liability, data-sharing) across many vendor relationships

As traditional industry lines blur, a sophisticated ecosystem strategy will be essential to developing and managing partnerships with many different types of organizations

Case studies

The growth of "superapps" is increasing the prevalence of embedded finance

gojek

Gojek, a leading rideshare player in Indonesia, has expanded its platform to include more than 20 different offerings, one of which is a payments service that processes $6.3 billion in gross transactions annually. Gojek is in the process of expanding into many other countries, tailoring its menu of services (e.g. entertainment, food, transport) to meet local preferences.[3]

Industry lines are blurring as adjacent industry players look to expand their offerings

字节跳动 ByteDance

ByteDance, the owner of video-sharing platform TikTok, has been hinting at a foray into the financial services space. It recently applied for a wholesale banking licence in Singapore to build and embed fund transfer solutions for its content creators and has also obtained an insurance brokerage licence. Furthermore, in May 2020, it led a funding round into the fintech Lingxi, an AI-driven SaaS player focused on optimizing financial product sales.[4]

Strategies for financial institutions

Understand the stop-start of different partners' capabilities

Financial institutions require deep cross-enterprise technology expertise to understand the capabilities of the vendors they consider working with, including validating the vendor's claims and parsing out how it contributes to the institution's broader ecosystem of capabilities.

Enter into more flexible and short-term vendor agreements

The rapid advance of technology and changes to the competitive landscape require financial institutions to move more quickly than ever before. Vendor lock-in may prevent financial institutions from being able to make quick strategic decisions or stand up new offerings.

Consider where best-of-breed solutions are truly required

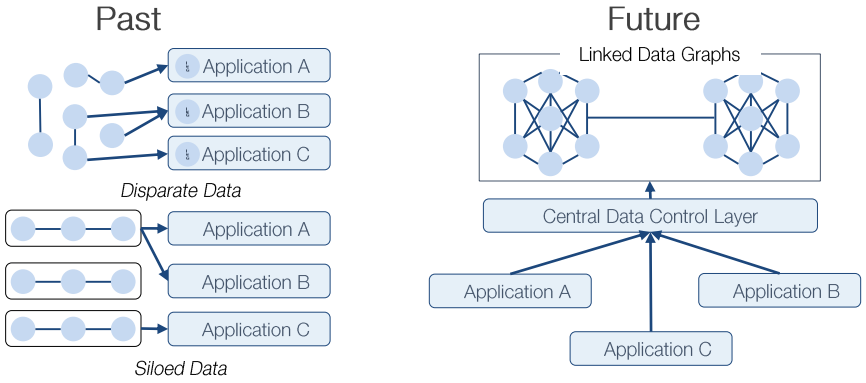
Financial institutions will need to weigh the cost/benefits of different technology providers closely and develop a holistic vendor selection model that considers when best-of-breed services will be critical to the organization's strategy.

Establish robust internal interconnectivity

Organizational siloes will have to dissolve, as complex ecosystem relationships will distribute the flow and storage of data across multiple channel partners; being able to bring disparate sources of data together for analysis and action will be critical.

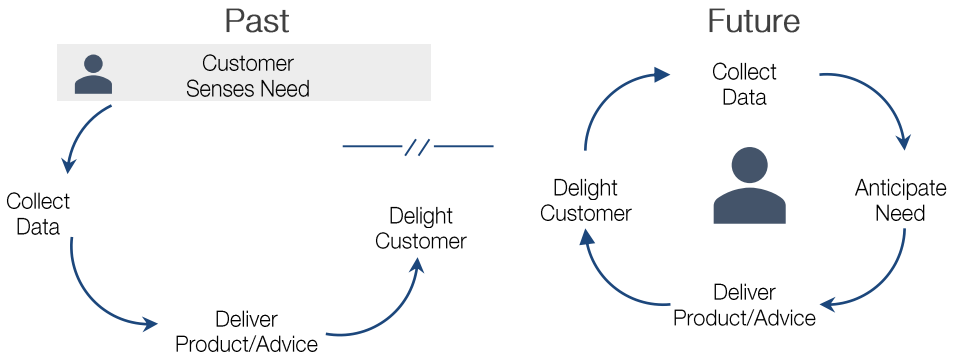
Use cases that strive to combat data fragmentation and accelerate feedback loops to anticipate customer moments of need will allow organizations to capture value quickly

1 Combat data fragmentation



- Given the more distributed nature of an ecosystem-led industry, institutions will have to spend significantly more time and effort centralizing data and building ontologies that connect disparate sources while ensuring high data quality
- Doing so will help create a more complete understanding of customers across products and channels, increase the effectiveness of algorithms and minimize the risk of data compliance breaches
- Knowledge graph methods, which are beginning to gain popularity, allow the semantic structuring and linking of organizational data to tease out complex interrelationships; this will allow for better credit assessments, reduced fraud and the organization of disparate sets of information to achieve a 360-degree view of the customer

2 Accelerate feedback loops to sense moments of need



- Individually, emerging technologies help tailor financial products, connect to new channels and assess real-time moments of need
- Bringing these technologies together allows for dynamic optimization: delivering a tailored product to a consumer in the exact moment of need through a channel likely to maximize attention
- This drives sustainable advantage because moment combinations are inherently scarce, and emerging technologies allow “customer-obsessed” institutions to enter a virtuous cycle whereby they can learn more about the customer to then “win” additional customer moments

There will likely exist a degree of dependency that should be considered when looking to invest in these types of use cases; improving the structures that support data capture and organization will augment the ability to develop feedback loops attuned to customer moments of need

Implementing these use cases will require new approaches to data and talent, while reinforcing the importance of relationship exclusivity

Case studies

Knowledge graphs are helping combat data fragmentation in financial services

TigerGraph, pagantis

TigerGraph, a provider of knowledge graph analysis that creates firm-wide data ontologies for financial institutions, worked with Pagantis, a European e-commerce instalment lender, to build an anti-fraud model on AWS that links a specific customer with all of the data associated with them stored in the company's cloud, and update associations in real time. Pagantis was able to significantly improve their real-time fraud detection capabilities.[5]

Institutions are partnering with third parties to create proactive feedback loops

ESSENTIA ANALYTICS

By analysing large datasets of their trading behaviour, Essentia Analytics is providing in-the-moment, contextual nudges to fund managers through both an automated platform and a network of coaches, in order to optimize investment and asset allocation decisions. Essentia works with several leading institutional investors, including Morgan Stanley Investment Management and Cambridge Global Asset Management.[6]

Strategies for financial institutions

Deepen partnerships with as-a-service tools

Many consumers will come to expect that financial products and advice will be pushed to them on an as-needed basis and may look to financial management tools (e.g. PFM, accounting software) to coordinate advice and product offers, making them less likely to browse around for new providers.

Adopt a systems-based approach to data early on

Use cases that combat data fragmentation and accelerate feedback loops will only increase the volume and variety of data within the institution. Centralizing this data for efficient "productionalization", by developing a target state for how data flows are consumed and acted on, becomes an important undertaking.

Expand talent pool of data professionals

Combating data fragmentation requires the recruitment of data professionals across all lines of business. Talent with blended skills in data engineering, IT infrastructure and data science will ensure that the way in which data is centralized (e.g. via a knowledge graph or other format) can be integrated easily into the institution's analytics deployments.

Age-old industry barriers will deteriorate, as capabilities emerge to accelerate productivity, transition from data portability to insight portability and allow compliance to move at the speed of data

1 Talent scarcity

Recruiting and training top talent

- **"Gigification" of scarce talent:** Platforms that aim to democratize access to critical tech talent (e.g. data scientists) are growing; this allows financial institutions to invest in the top performing talent or algorithms on the platform for specific purposes
- **Autonomous code writing:** New applications of AI are enabling autonomous code writing that could significantly reduce the talent required for technical initiatives, such as migration to the cloud; additional offerings that teach employees to apply AI using "no-code" techniques are coming to the fore, making it easier to bring employees up to speed quickly

2 Liability attribution

Apportioning liability over the security of data

- **DLT for transparency:** Storing information about how data is transferred among multiple parties using a distributed ledger creates a transparent, immutable record of what, and to whom, data was shared; this could make it easier to trace where a potential breach occurred and can also improve auditability of data used for AI training
- **PETs for transferability:** PETs eliminate the need for data to be physically transferred for it to be analysed by a third party; this reduces the risk that data is breached while in transit, delineates clear liability and reduces de-anonymization risks

3 Regulatory barriers

Innovating rapidly while staying compliant

- **Adoption of AI-based algorithmic decomposition:** Techniques to analyse AI and explore all the ways it could behave could help analyse complex regulations, turn them into mathematical guardrails and then embed them into algorithms to automate compliance, increase transparency, uncover potential sources of bias and improve explainability
- **Growth of tokenization and central bank digital currencies (CBDCs):** Enhanced monitoring of tokenized assets and CBDCs by the regulator would facilitate instant transparency over potential prudential regulatory breaches; in-built code within the asset could prevent actions that contravene regulations

New tools and techniques will help institutions navigate changing labour market dynamics, as well as prepare for potential pdicy changes around trustworthy and fair AI, auditable and transparent data processes, and ecosystem or value-chain based liability models

Tackling these industry barriers will require support from organizations beyond financial services that specialize in different transformative technologies

Case studies

SketchAdapt, a tool developed by MIT, is combining deep learning and symbolic reasoning to "teach" AI to write code; AI-driven code development could be deployed, for instance, to optimize migration to the cloud or help with AI model selection.[7]

Google recently launched a set of completely open-source multi-party computation tools to allow companies to work together with sensitive datasets while keeping all data encrypted.[8]

Imandra is making it possible to use AI to analyse and audit all manner of complex systems (e.g. trading systems); this type of tool could one day be used to map out the complex data flows between legacy financial infrastructure, and evaluate all of the different ways that an AI algorithm could behave.[9]

Strategies for financial institutions

Plan dynamically for a new talent mix

When laying out transformation roadmaps, firms should plan for their talent mix to change over time. As low- or no-code tools allow non-technical employees to deploy AI like data scientists, and non-FTE resource pools (e.g. gig talent) proliferate, firms should think about how team structures and employee experiences need to evolve and be integrated into transformations.

Collaborate on next-generation data standards

The growing adoption of PETs could potentially address important concerns about secure data-sharing. However, their rollout will be slow and disjointed unless there is a concerted, industry-wide effort to standardize their use. Given the critical geopolitical implications, institutions should work to solicit help from policy-makers in sharing costs and effort.

Bring regulators into the institution's ecosystem

Institutions, regulators and customers alike could benefit if regulators had more real-time, cloud-based access to institutional data. Doing so would substantially decrease monitoring and reporting costs for individual firms and enhance overall trust and transparency. Regulators should work with institutions to better leverage tools like secure APIs to reduce compliance costs for constituents.

As technologies unlock the potential for real-time interactions and disintermediation, the industry must be aware of the unintended consequences of removing beneficial guardrails and intermediaries

Potential issues in moving to real-time interactions

Liquidity requirements in securities markets

Atomic (zero friction) delivery vs payment (DvP) rails have the potential to reduce security settlement times to zero, eliminating the need to post costly collateral. However, instant settlement is highly liquidity-expensive, which could largely counteract any collateral costs saved. Furthermore, it implies a requirement to pre-fund all (instant) transactions, making it impossible to obtain the secured credit that is critical to market activity.

Fraud increases in payments

The move to real-time payments (driven by advances in AI and automation, cloud APIs etc.) in many jurisdictions around the world has made it easier for everyone to move money between accounts quickly, including bad actors. The increased movement speed gives institutions almost no time to verify transactions to prevent financial crimes. As a result, many banks are now having to develop stronger identity and authentication processes to combat the increase in fraud.

Potential issues in disintermediating operating structures

Decentralization causing inclusion concerns

Participating in more decentralized, cloud-native financial infrastructures (e.g. maintaining a node on a global fund transfer network) represents a significant upfront capital and ongoing operational expenditure. Many small and mid-sized institutions may not have the resources or capabilities to actively participate and thus choose to rely on larger intermediaries for access. This would effectively re-intermediate the process, potentially limiting system-wide cost savings.

Interoperability challenges of alternative payments

The emergence of multiple alternative, token-based methods (e.g. stablecoins) to settle transactions creates large interoperability challenges. This is because redeploying capital across different networks, operating with unique tokens, would create inherent exchange rate risk. As well, final, legal settlement will likely always need to occur in legal tender. This implies that a central authority (e.g. a central bank) will always be required for off-network settlement, limiting the theoretical efficiency gains of new settlement approaches.

Without careful design and consideration, some of the new market structures unlocked by emerging technology could result in potential exclusion of network participants, new fraud concerns and outsized liquidity and interoperability costs

New proofs of concept are testing transformative technologies on more mission-critical processes, but several issues must be resolved prior to more widespread industry implementation

Case studies

The move to faster payment rails is significantly increasing fraud

Recent research from FICO revealed that 78% of banks in the Asia Pacific region state that the introduction of real-time payments resulted in increased fraud losses, including push payment fraud, money laundering, account application and takeover fraud. Many of these financial institutions expect the threat to continue to grow as these platforms extend to other parts of the ecosystem (e.g. governments, businesses) where the payouts can be even larger.[10]

DLT still leaves significant room for improvement before moving to more large-scale applications

SWIFT recently conducted a proof of concept (PoC) with 34 leading transaction banks globally to examine the potential of DLT to provide real-time visibility of Nostro accounts (a major pain point for banks today). While, overall, the PoC demonstrated that DLT has made huge progress, ultimately it was deemed unready for large-scale, mission-critical applications due to ongoing challenges related to scalability, governance, security and data controls.[11]

Strategies for financial institutions

Model systemic implications

While moving to more streamlined systems may at first seem optimal, institutions should thoroughly consider the systemic effects and highlight where new vulnerabilities could emerge. Consider the value that time-based frictions or centralized, intermediated processes bring to the system, and the long-term impacts of transformation, before investing in real-time and automated infrastructure.

Start small and champion diversity

When exploring new infrastructure models, taking a use-case-based approach helps quickly test assumptions across a range of participants, geographies and customer segments. Bringing together diverse perspectives can help surface a broader range of potential issues early on, but institutions should avoid seeking full group consensus to promote a culture of “fail fast, fail forward”.

Promote regulatory accord

Engaging relevant regulators early and often in the process of designing new infrastructure models – even small, private networks designed for use among a limited number of firms – can help uncover systemic challenges quickly and help firmly establish an agreed-upon roadmap for broader ecosystem-level implementation.

Malicious actors often have access to many of the same emerging technology capabilities available to financial institutions, and exploit them to find new ways to attack

Advanced decryption techniques

Quantum computers may one day be stable enough to reliably decrypt many of the most widely used public and private encryption algorithms, including the AES standard used to encrypt transactions in the financial services industry

Imagine if…a bad actor is collecting troves of sensitive banking data in order to decrypt it in the future

A group of researchers led by Microsoft have proven that decrypting AES-256 (a common standard) would require quantum hardware of moderate complexity[12]

Real-time feedback loops

As IoT devices serve as critical inputs to real-time feedback loops (e.g. weather data driving algorithmic derivative trading) or oracles to resolve smart contracts (e.g. parametric insurance), manipulating IoT devices could be exploited profitably

Imagine if…a commodity derivative is bid up due to spoofed weather data, benefiting a bad actor with large holdings

In July 2020, researchers at JSOF discovered vulnerabilities in more than 100 million commercial IoT devices that would allow bad actors to fully control the device[13]

Peer-to-peer (P2P) transactions

The growing use of P2P networks for instant and irrevocable asset transfer (e.g. lending, payments) is increasing the opportunity for fraudsters to trick users through social engineering and leave them with little post-transaction recourse

Imagine if…a bad actor takes over one's P2P payments account and requests emergency funds from family members

Javelin Strategy & Research observed a 722% increase in P2P fraud between 2016 and 2019, indicating that bad actors are quickly exploiting these platforms[14]

Hyper-realistic spoofing

Augmented reality (voice, video) and voice-based IoT devices (e.g. Alexa) are capable of always-on recording; as voice- and video-based authentication methods proliferate, the data captured by these devices could create convincing deepfakes using AI

Imagine if…a compromised IoT device could generate a deepfake of one's voice and use it to trick one's personal banker

In 2019, fraudsters used an AI-based deepfake to mimic a CEO's voice and demand that an employee transfer nearly $250,000 to a fraudulent offshore account[15]

Emerging technologies are making it easier for criminals to engage in fraud and other financial crime as malicious actors develop more sophisticated bot-attack tools, social engineering tactics and access "fraud-as-a-service" via the cloud

Defending against new vulnerabilities will require solutions that are at ecosystem-scale, secure data in new ways across participants and invest in the critical human component of ecosystems

Strategies for financial institutions

Build ecosystem-scale solutions

- **Utility formation:** Industry-wide utilities to monitor and detect fraud (e.g. in real-time payments) and verify user identity (e.g. for KYC) take advantage of collective insight to build more-accurate, faster learning models.
- **Early standard-setting:** Working together early on to set security standards for upcoming issues (e.g. quantum-secure encryption algorithms) builds resiliency.
- **Ecosystem accountability:** Increasing interconnectivity means that many attack opportunities (e.g. spoofing IoT data) lie outside of the institution's direct control; leveraging partner capabilities must be accompanied with fairly distributing accountability (e.g. holding cloud providers accountable for KYC to limit the number of fraudsters using public cloud tools and computing power).

Redesign data-sharing among partners

- **Use of PETs:** Leveraging PETs would substantially increase the security of transmitting insight about sensitive data (e.g. identity data, income records) and prevent man-in-the-middle attacks, as data need not be portable for it to be analysable. While this would improve privacy of sensitive information, wide-scale adoption requires collective action on common implementation approaches.
- **Enabling intelligent data:** Intelligent encryption techniques are equipping data with the ability to self-regulate and understand its location, how and by whom it is being used, and other insight; financial institutions are using this today to secure information being sent over unsecure networks to traders working from home, and to align data storage with GDPR and other regulations.

Make investments in first and last lines of defence

- **Enhanced training:** Financial institutions will see a rise in exploits from ransomware (38% increase between February and March 2020[16]) and other social engineering attacks designed to exploit digital channels. Material investments in training customers and staff to be aware of these risks will be a critical first line of defence for institutions to invest in, as it is unlikely customers and processes will return to manual methods post-pandemic.
- **Cybersecurity insurance:** Standard commercial insurance often provides limited coverage against cyberattacks (e.g. data breach, system downtime, risks emanating from fourth parties). In an increasingly ecosystem-led industry, such coverage serves as an important last line of defence and protects key assets that may be underinsured without it.[17]

Applications of emerging technologies will both create and reinforce ethical, social and environmental challenges, which may stunt their deployment across the industry

Reinforce explainability challenges

Quantum machine learning (AI) algorithms will leverage new data sources to dramatically lower the costs of decision-making, risk optimization and credit pricing

But the outputs of quantum computing algorithms are inherently unexplainable (based on the properties of quantum mechanics) and, when used to make financial decisions (e.g. pricing an insurance product), they could entrench embedded sources of bias

Augment market concentration

Cloud computing is a core enabler of a more ecosystem-led financial services industry, facilitating connectivity and interoperability

But the cloud market is highly consolidated and, as cloud providers increasingly become gateways for institutions to access emerging technologies, the industry risks a large concentration of market power and lock-in conditions with these providers

Negatively impact the environment

DLT, hosted on the cloud, has the potential to improve collaboration and sensibly remove transaction friction in the industry

But the outsized energy consumption of popular consensus protocols, including the proof-of-work protocol that underpins popular blockchains like Ethereum, could significantly increase the carbon footprint of the financial services industry

Discriminate based on customer wealth

As IoT devices feed real-time operational data into AI, instant decision loops will de-risk credit provision and underwriting through access to a new level of data granularity, potentially improving credit access

But this could sometimes favour wealthier customers who can afford hardware to provide data real-time access (e.g. dense IoT networks); also, as access to alternative data sources grows and as AI interrogability remains poor, the distinction between risk pricing based on cost and “propensity to pay” could blur

Balancing the risk-benefit trade-off of emerging technologies will be a decision faced by all financial institutions in the future. Those who are able to build effective governance models to manage these trade-offs will be able to accelerate innovation and stave off disruptive forces

Nonetheless, innovative firms are quickly finding unique ways of facing and resolving these challenges through new business models, technical architectures and collaborations

Case studies

The Gaia-X project is working to democratize access to cloud resources while boosting competition among providers	GAIA-X	In Europe, the cross-industry Gaia-X initiative is working to develop an interoperability layer for cloud computing, facilitating seamless cross-cloud data exchange and interoperable access to a marketplace of smart "as-a-service" tools. While the initiative is still in the early stages of development, it aims to substantially reduce lock-in conditions while creating a level playing field that allows small, specialized cloud providers to compete.[18, 19]
Current insurance practices are being investigated for discrimination	NAIC National Association of Insurance Commissioners	The National Association of Insurance Commissioners in the United States recently launched an investigation into existing sales, pricing and underwriting of insurance to identify practices that may disadvantage minorities. The proposed legislation and guidelines coming out of this group have the potential to affect the operations of many large insurers in the United States.
IoT costs are being subsidized through cheaper financial services	stellapps Smart Systems. Stellar Applications.	Stellapps is an India-based start-up developing cross-value-chain monitoring and analysis solutions for the dairy industry. It helps subsidize IoT device costs for its rural farmer clients by providing access to discounted loan and animal insurance products through an end-to-end digital lending and insurance platform, mooPay.[21]
DLT infrastructure players are experimenting with energy-efficient architectures	ethereum	In 2020, the Ethereum network is set to launch the first phase of its Eth2.0 framework, a long-awaited update to the network's core infrastructure. The most significant shift is the move from an energy-intensive proof-of-work consensus algorithm to a "proof-of-stake" algorithm, which the organization claims will reduce energy consumption by 99%. If successful, Ethereum's open source architecture may pave the way for other distributed ledger networks.[22,23]

Our research did not uncover a practical solution to improving the explainability of quantum algorithm (e.g. quantum machine learning, quantum simulation) outputs. Some institutions may choose to limit the use of quantum algorithms where the need for explainability is high, such as when making decisions about an individual consumer's credit risk. Hypothetically, other institutions may even be required by regulators to limit their use in these instances.

References

1. "Parsyl announces new initiative with Lloyd's to offer enhanced coverages for marine cargo classes", CNA Hardy, 7 December 2018, accessed 9 August 2020, https://www.cnahardy.com/news-and-insight/news/parsyl-announces-new-initiative-with-lloydz
2. "Google, Deutsche Bank Agree to 10-Year Cloud Partnership", Bloomberg, 7 July 2020, accessed 9 August 2020, https://www.bloomberg.com/news/articles/2020-07-07/google-deutsche-bank-agree-to-10-year-alliance-including-cloud
3. "From Uber to Asia, the pandemic is remaking the world's 'super app' race", CNBC, 7 July 2020, https://www.cnbc.com/2020/07/07/from-uber-to-asia-pandemic-is-remaking-worlds-super-app-race.html
4. "Bytedance, Ant Financial vie for digital banking licences in Singapore", Technode, 3 January 2020, https://technode.com/2020/01/03/bytedance-ant-financial-vie-for-digital-banking-licences-in-singapore/
5. "Pagantis Chooses TigerGraph To Deliver Faster Consumer Finance Services", TigerGraph, 21 October 2019, https://info.tigergraph.com/pagantis-tigergraph
6. "About Essentia", Essentia Analytics, accessed 9 August 2020, https://www.essentia-analytics.com/about-essentia/
7. "Toward artificial intelligence that learns to write code", MIT News, 14 June 2019, http://news.mit.edu/2019/toward-artificial-intelligence-that-learns-to-write-code-0614
8. "Google Releases Open Source Tool For Computational Privacy", ThreatPost, 19 June 2019, https://threatpost.com/google-computational-privacy/145835/#:~:text=Google's%20new%20multi%2Dparty%20computation,privacy%20around%20sensitive%20data%20sets.
9. "Machine Reasonable Design with Imandra", Medium, 22 August 2018, https://medium.com/imandra/machine-reasonable-design-with-imandra-9a7febcab6f5
10. "Unwrapping APAC's Faster Payments Fraud Threat", Pymnts.com, 30 January 2020, https://www.pymnts.com/news/b2b-payments/2020/unwrapping-apacs-faster-payments-fraud-threat/
11. "SWIFT completes Proof of Concept", Ledger Insights, accessed 9 August 2020, https://www.ledgerinsights.com/swift-completes-proof-of-concept/
12. "Applying Grover's algorithm to AES: quantum resource estimates", Grassl et al., 15 December 2015, https://www.microsoft.com/en-us/research/wp-content/uploads/2016/04/1512.04965-1.pdf
13. "Ripple20 vulnerabilities expose hundreds of millions of IoT devices to hacking", Silicon Angle, 16 June 2020, https://siliconangle.com/2020/06/16/ripple-20-vulnerabilities-expose-hundreds-millions-iot-devices-hacking/
14. "The Fallout From ID Fraud And Account Takeovers Includes a Lot More P2P Payment Fraud", Digital Transactions, 7 April 2020, https://www.digitaltransactions.net/the-fallout-from-id-fraud-and-account-takeovers-includes-a-lot-more-p2p-payment-fraud/#:~:text=The%20722%25%20increase%20found%20between,Cash%20grow%20ever%20more%20popular.
15. "Fraudsters Used AI to Mimic CEO's Voice in Unusual Cybercrime Case", Wall Street Journal, 30 August 2019, https://www.wsj.com/articles/fraudsters-use-ai-to-mimic-ceos-voice-in-unusual-cybercrime-case-11567157402
16. "Amid COVID-19, Global Orgs See a 148% Spike in Ransomware Attacks; Finance Industry Heavily Targeted", CarbonBlack, 15 April 2020, https://www.carbonblack.com/blog/amid-covid-19-global-orgs-see-a-148-spike-in-ransomware-attacks-finance-industry-heavily-targeted/
17. "How COVID-19 may change the cyber insurance landscape", Canadian Underwriter, 3 May 2020, https://www.canadianunderwriter.ca/insurance/how-covid-19-may-change-the-cyber-insurance-landscape-1004178028/
18. Tung Liam, "Meet GAIA-X: This is Europe's bid to get cloud independence from US and China giants", ZDNet, 8 June 2020, https://www.zdnet.com/article/meet-gaia-x-this-is-europes-bid-to-get-cloud-independence-from-us-and-china-giants/

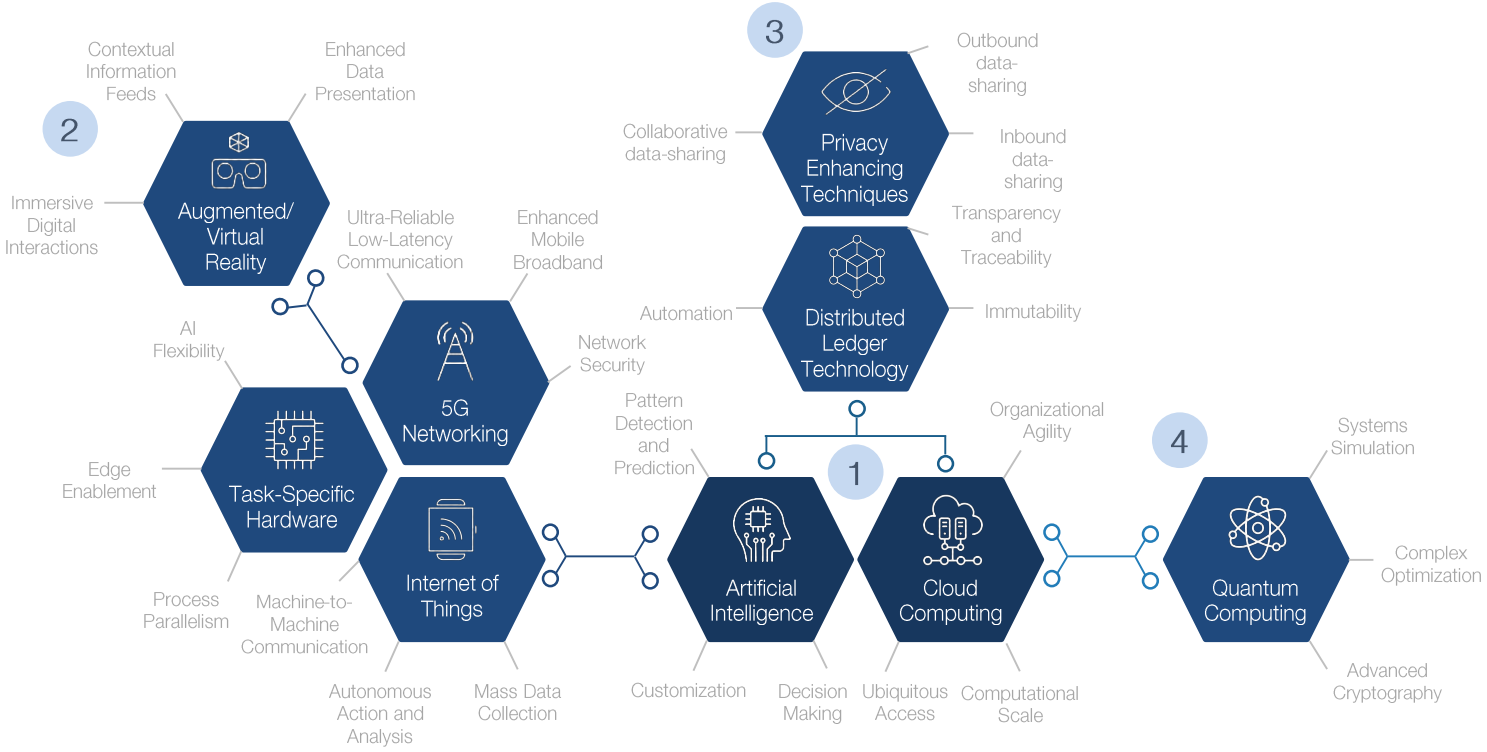
References

19. "Gaia-X: The European project kicks off the next phase", German Federal Ministry for Economic Affairs and Energy (BMWi), June 2020, https://www.data-infrastructure.eu/GAIAX/Redaktion/EN/Publications/gaia-x-the-european-project-kicks-of-the-next-phase.pdf?__blob=publicationFile&v=7
20. Schreiber Daniel, "AI Can Vanquish Bias", Lemonade, 9 December 2019, https://www.lemonade.com/blog/ai-can-vanquish-bias/
21. "MooPay", Stellaps, accessed 11 August 2020, http://ixdtm.com/projects/stellapps-wordpress/moopay/
22. Kim Christine, "Ethereum 2.0: How it works and why it matters", Coindesk, July 2020, https://www.coindesk.com/wp-content/uploads/2020/07/ETH-2.0-072120.pdf
23. Fairley Peter, "Ethereum Plans to Cut Its Absurd Energy Consumption by 99 Percent", IEEE Spectrum, 2 January 2020, https://spectrum.ieee.org/computing/networks/ethereum-plans-to-cut-its-absurd-energy-consumption-by-99-percent

Innovation pathways in financial services

The assembly of emerging technologies into common clusters provides insight to where innovation could be achieved in financial services over the next decade

Common clusters of emerging technologies



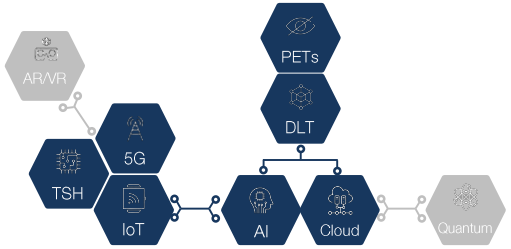
1. **AI and cloud** are key to unlocking the other technologies. AI analyses the data other technologies generate, store and transmit, while cloud is a ubiquitously accessible data repository and gateway to accessing technologies-as-a-service.

2. **IoT devices**, connected via **5G networks**, could more directly link physical data to financial processes. **Task-specific hardware** gives these devices the ability to make preventative decisions at the edge or improve the efficiency of cloud analysis. **AR/VR** creates data-rich channels for firms to engage with stakeholders.

3. **DLT** will enable more direct, atomic transfers of value and information between parties, in areas where disintermediation is beneficial. Supported by **PETs**, it will create collective solutions to long-standing questions about data-sharing.

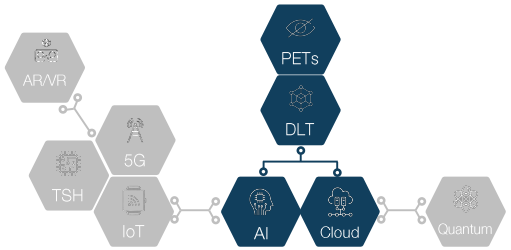
4. **Quantum computing** power, accessed via large cloud providers, will extend the capabilities of AI and unlock specific, powerful new analysis techniques, but prompt new questions about data security.

The new capabilities unlocked by these clusters of emerging technologies will disrupt dominant operating models and market structures in four critical ways



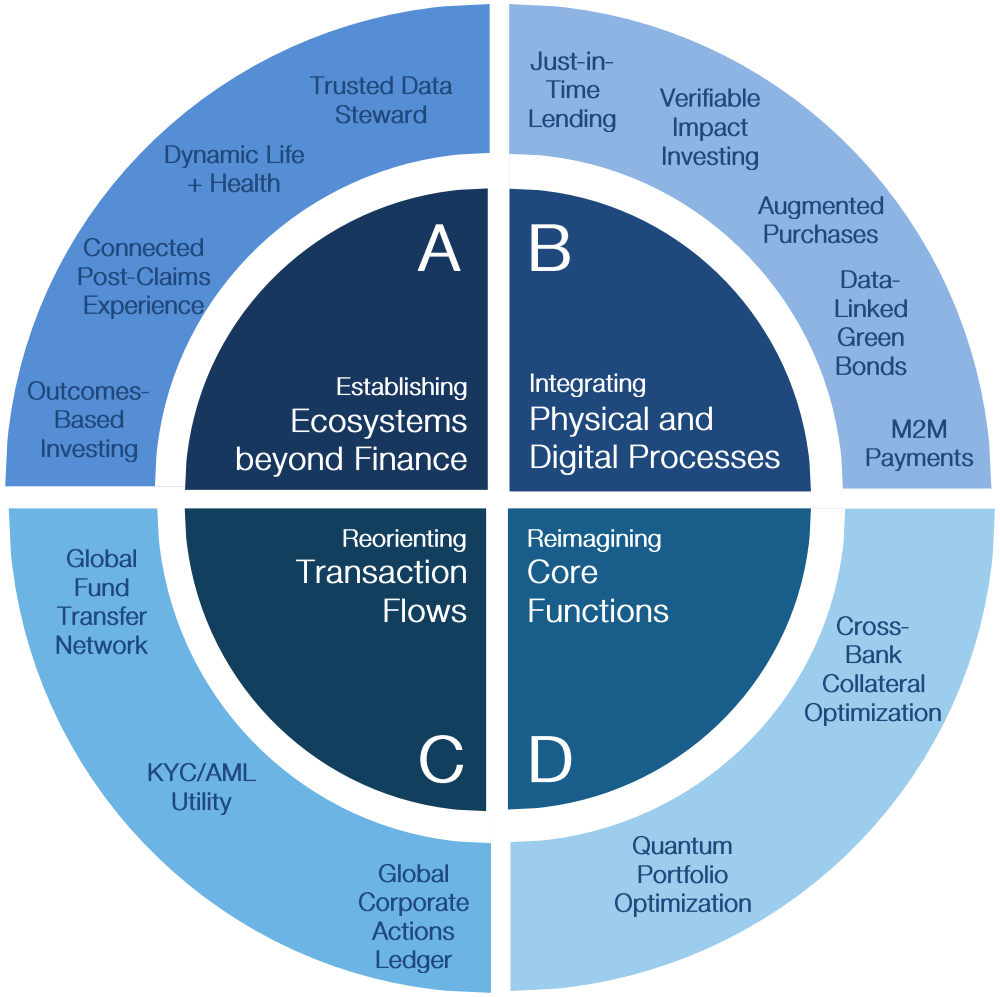
Establishing ecosystems beyond finance

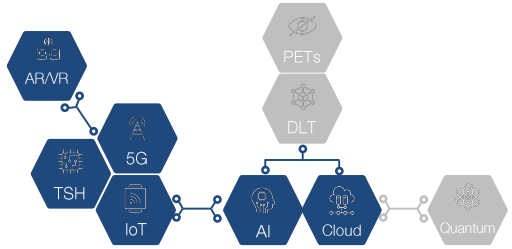
Combine financial and non-financial offerings by building on strong ecosystem relationships to deepen customer engagement and create entirely new value propositions.



Reorienting transaction flows

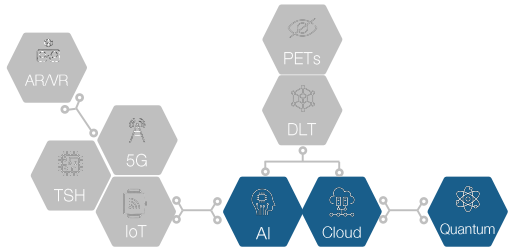
Leverage modern data and value-transfer rails to pursue more automated and direct movements of assets and funds between participants.





Integrating physical and digital processes

Embed data about physical processes into financial products to improve risk and value assessment, assure the identity of transaction initiators, validate provenance of physical information and optimize product distribution.



Reimagining core functions

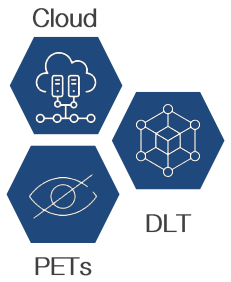
Perform more granular, accurate and robust calculations by tapping into leading-edge analysis methods and improve cross-enterprise data organization.

Note: Use cases related to each innovation pathway are listed in the outer ring of the diagram. See the sector use cases for more information.

Innovation pathway A: Establishing ecosystems beyond finance

Capabilities that allow the institution to share information across ecosystem partners in a secure and standardized way will help package financial and non-financial offerings

Assembling the technologies

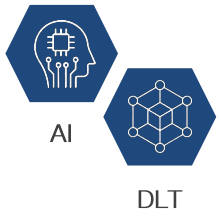


Reduce data-sharing risk

The intersection of data storage and sharing technologies (e.g. cloud, DLT), and PETs allow us to create combined sources of information that can be queried and analysed without sharing the underlying data.

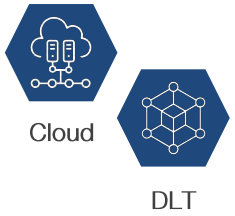
Secure data provenance

DLT creates immutable sources of information that allow us to trace the provenance of information (e.g. data from IoT devices sent over 5G networks), more easily reconcile data with collaborators and minimize the risk of information being doctored by malicious actors.



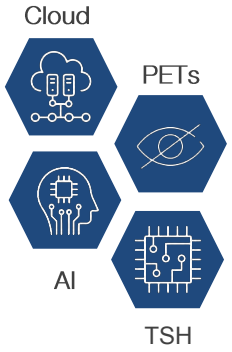
Facilitate transaction autonomy

Smart contracts on a distributed ledger reduce the effort spent manually reconciling agreements and processing transactions (as they happen automatically) and allow for real-time and autonomous payments to flow to different types of partners upon completion of specific contractual terms.



Drive ecosystem interoperability

Ongoing initiatives aimed at standardizing various connectivity methods (e.g. OpenAPI Initiative, NACHA's API standardization for financial services) are reducing the cost and complexity of outsourcing to as-a-service providers (e.g. those accessible via the cloud), sending financial instructions or embedding products into non-financial contexts.[1, 2]



Securely augment AI

Building increasingly robust artificial intelligence models often requires ingesting large amounts of data from partners. Privacy-enhancing techniques allow AI models to be trained (using task-specific hardware) on sensitive information without exposing that information, which could be beneficial, for instance, in creating collective transaction monitoring models without exposing sensitive transaction data to competitors.

Related use cases: Dynamic Life + Health, Connected Insurance Experience, Trusted Data Steward, Outcomes-Based Investing

Disruption is most likely to occur where financial institutions are able to go to market with non-financial partners, and where opportunities exist to integrate disparate pools of customer data

Areas where disruption is likely to occur

Where financial products can be "embedded" in non-financial contexts

- Advances in connectivity technology and standardization allow financial products to be natively integrated into non-financial contexts.[3] For instance, a financial product delivered simultaneously to a non-financial one (e.g. parametric insurance built into home purchase) or offered natively on the platform of a partner (e.g. gig-work app making short-term loans)

Embedding will be disruptive because:

1. Non-financial players can be incentivized to create exclusive arrangements to embed only a particular institution's product, giving them direct access to captive customer pools and exclusive data
2. When financial products are embedded into a third-party's platform, the institution may risk losing direct customer touchpoints, limiting their ability to build deeper relationships (e.g. advisory)

Where customers struggle to make financially linked decisions

- Institutions can work with ecosystem partners to deliver personalized tools, recommendations, and access to ancillary services to help clients make non-financial decisions that are linked to their financial well-being (e.g. career planning)[4]

Providing non-financial decision support will be disruptive because:

1. White-labelled players across industries are driving the standardization of, and margin compression in, core product lines; in this environment, advice and ancillary services can become key differentiating factors, helping customers conveniently make important decisions
2. Ecosystem connectivity will help institutions access non-standard data about customers to further tailor and improve offerings

Where disjointed data pools meet high trust bars

- A trusted intermediary (e.g. financial institution) with high security standards may have a distinct advantage by helping consumers manage access to disjointed (i.e. held with multiple different parties) but highly sensitive data[5]

Empowering customer data control will be disruptive because:

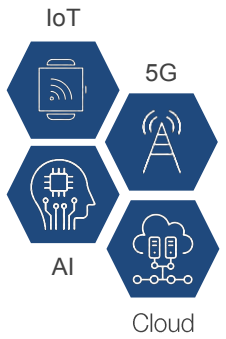
1. Shifts in consumer attitudes towards data privacy are causing a reassessment of the major institutions and a growing number of data regulations are requiring institutions to give back control over information to consumers
2. This creates an explicit trust gap that will drive a fundamental reshaping of how consumers manage their data and creates an open question about who may help them simplify and orchestrate this management; generally, financial institutions are well-poised to play this role

Creating ecosystems beyond financial services will matter most in consumer-facing sectors of the industry, where customers rely on financial institutions to reach some other end (e.g. buy a plane ticket, rent a home), beyond the current reach of financial services

Innovation pathway B: Integrating physical and digital processes

Integrating physical data into the digital world of financial services will drive new capabilities around real-time and edge-based analysis and unlock new methods of data visualization

Assembling the technologies

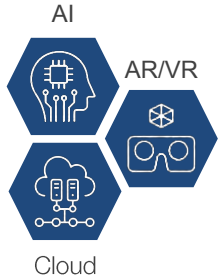


Analyse real-time physical data

IoT sensors that monitor data about assets (e.g. output of machinery), spaces (e.g. foot traffic in a particular shopping mall) and inventories (e.g. temperature inside a shipping container), and report them over 5G networks to the cloud, provide near real-time data upon which AI analyses risk or predict future cashflows.

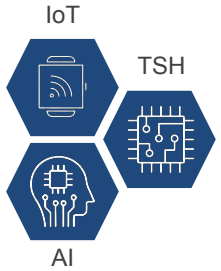
Data anomaly detection

AI can contribute to anomaly detection to help ensure that data streaming from IoT devices is accurate (e.g. data has not been fraudulently manipulated). This is critical because, as data feeds into AI-based adjudication engines in real time, the potential impact of incorrect or malicious data increases.



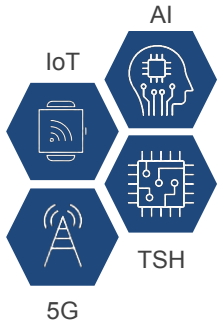
View hypercontextual information

AR is a powerful tool to augment the world around us with valuable data. When paired with AI, AR can help detect and classify objects (e.g. search a product online to find the cheapest purchase option) or people (e.g. use computer visioning to identify a client walking into a branch and pull up relevant information about them).



Reduce data velocity

Data emanates from IoT-enabled devices at high velocity; even for modern cloud architectures, the storage and analysis of real time data flows can be prohibitively resource-intensive.[6] Edge AI can perform analysis on the device and allow collated insight (vs raw data) to be sent to the cloud to reduce workloads (e.g. analyse trends in operational data and use this input, vs raw data, to inform risk models).



Make decisions at the edge

Massive machine-type communications (MMTC) capabilities of 5G allow IoT devices to rapidly communicate with one another. IoT equipped with edge AI can then use this information to make financial decisions (e.g. a sensor in a house managed by an insurer could detect humidity and communicate with a smart circuit breaker to prevent loss).

Related use cases: Just-in-Time Lending, Verifiable Impact Investing, Augmented Purchases, Data-Linked Green Bonds, M2M Payments

Conducting continuous adjudication will offer new levels of insight and provide physical assets with the ability to make financial decisions

Areas where disruption is likely to occur

Where shifts from moment-in-time to continuous adjudication occur

- A real-time flow of information about physical assets or processes allows agile competitors to run ongoing adjudications about credit and risk-worthiness; this can trigger automated decisions that reduce lag-time between data capture and decision-making
- Continuous decision engines are widely applicable across financial services; for instance, in banking, to better understand operational impacts to cash-flows in order to predict and fill funding needs; in insurance, to track and trace physical assets to build more complete risk models and take preventative action; in the capital markets, to augment quantitative trading models by incorporating relevant, real-time information

Continuous adjudication will be disruptive because:

1. It will allow institutions to offer richly predictive and preventative insight to customers, creating new sources of loyalty
2. Data about the physical world – e.g. changes in foot traffic for a retail business that ultimately affects cashflow, sustained changes in physical fitness that lead to personal longevity – serves as a strong leading indicator to financial outcomes but has been historically hard to access[7]

Where physical assets can make financial decisions

- Allowing physical assets to make and receive payments (e.g. via a digital wallet), access other financial products (e.g. loans) or influence pricing of a financial asset (e.g. a green bond) gives institutions the opportunity to help their clients capture new revenue streams and simplify decision-making
- Industries outside of financial services are equipping physical assets with the ability to make decisions autonomously (e.g. self-driving vehicles); it will be critical to also ensure that relevant financial transactions will be able to flow between them just as efficiently

Assets making financial decisions will be disruptive because:

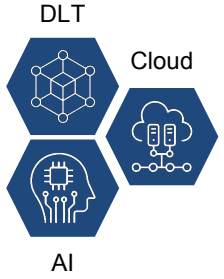
1. Owning physical assets drives financial transactions (e.g. car ownership implies funds collected from car-sharing or loans taken out for maintenance) that ultimately involve a financial decision (e.g. in which account to receive funds, from whom to take a loan); first movers could capture transaction flow from competitors, as they create convenience benefits (i.e. default transaction methods) that disincentivize clients from seeking out-of-band products via other channels[8]
2. Economic rents will be further fragmented along the value chain as asset manufacturers (e.g. automakers) will likely want to share in fee revenues

The integration of physical and digital processes will increase the granularity and speed of data, evolving the way decisions are made across every sector of the financial services industry

Innovation pathway C: Reorienting transaction flows

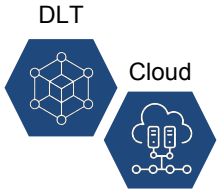
Modern value-transfer rails will allow institutions to transact atomically and autonomously where feasible, better organize their data and reduce the risk of sharing that data with partners

Assembling the technologies



Facilitate transaction autonomy

Smart contracts on the DLT reduce effort spent manually reconciling agreements and processing transactions and allow payments to flow autonomously based on a trigger tied to smart automation (e.g. payment to a peer for successfully verifying KYC data, revenue-sharing payment to a channel partner for selling an embedded financial product).

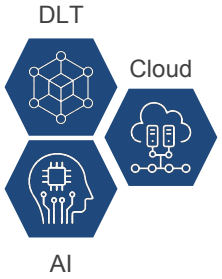


Conduct atomic transactions

DLT (e.g. blockchains or smart contract ledgers) allow for transaction and settlement atomicity between counterparties. In some markets, this could minimize the need to have multiple intermediaries present to settle transactions, maintain records and balances, and transfer value or information between two parties.

Create “centrally distributed” sources of data

Leveraging privacy-enhancing techniques together with distributed data structures (e.g. inter-institutional distributed ledgers) can allow insight to flow within or among institutions without sharing underlying information or creating a central honeypot, making it easier to break down regulatory barriers to partnering and tap into collective sources of valuable data among peers.



Allow for real-time-transaction visibility and monitoring

Deploying AI on top of information and value-transfer networks – including both decentralized (such as a DLT-based security swap platform) and centralized (such as a national debit network built on cloud-based API connections) networks – could enable transactions to be monitored, classified and flagged in real time (e.g. to monitor financial fraud).

Related use cases: Global Fund Transfer Network, Global Corporate Actions Ledger, KYC/AML Utility

Groups of disruptors will build collective transaction rails that capture entire process lifecycles and eliminate highly intermediated, but decentralized, processes

Areas where disruption is likely to occur

Where high intermediation meets lack of centralization

- Opportunities exist to improve efficiency in markets where there is no central counterparty, but are nonetheless highly intermediated, by facilitating direct transactions between parties (e.g. in cross-border payments)[9]
- For many of these decentralized structures (e.g. correspondent banking networks), centralization may be an undesirable or impossible outcome;[10] however, not having a common means to coordinate and reconcile information creates conditions for manual processing, increases systemic costs due to intermediary rent-seeking and causes delays

Eliminating this intermediation will be disruptive because:

1. Bringing together counterparties to transact directly on a single network will eliminate a source of revenue for intermediaries, who often take a fee for providing facilitation services (e.g. being a link in a correspondent banking chain)
2. It may alter the pathway of how information and value flows through the ecosystem, either by shortening transaction chains (e.g. direct fund transfer vs correspondent banking) or allowing new forms of data-sharing among parties (e.g. individual KYC vs a DLT-based KYC utility)

Where an entire lifecycle can be captured on a single platform

- Research shows that technologies that reorient transaction flows to be more direct and atomic display strong scale benefits: the greater the number of assets traded, participants engaged, or processes captured on a common platform, the more valuable the solution[11]
- High interconnectedness in the financial services ecosystem makes it challenging to replace a single process without causing costly process bifurcation for participants (who would still have to maintain connectivity to legacy platforms), dampening any potential cost benefit
- Experts suggest that it is beneficial to build small-scale use cases to prove functionality and ROI, but if the intention is to not capture entire lifecycles, or include all assets/participants, attaining long-term value may be difficult

Capturing an entire lifecycle will be disruptive because:

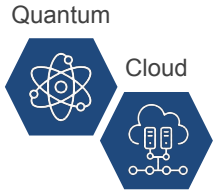
1. The need to capture entire markets or lifecycles on the same platform implies wholesale re-engineering of current operations, and the development of fundamentally new rails that will reshape how the industry transacts (e.g. developing a single, global fund transfer network for all currencies is a step-function change to how remittance is done today)

The journey to reorient transaction flows starts with a handful of use cases, but the intention should be to extend to entire networks, lifecycles and asset classes to capture the full value of emerging technologies

Innovation pathway D: Reimagining core functions

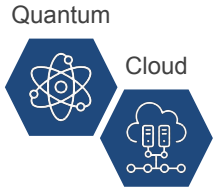
Capabilities that enable faster, more accurate methods of performing some of financial services' most important calculations will drive substantial cost savings for institutions

Assembling the technologies



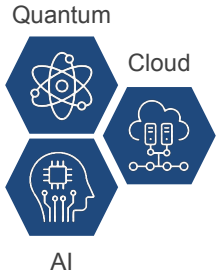
Increased optimization speed

Quantum computers, accessible through cloud networks and leveraging data from the cloud, are able to rapidly solve complex optimization problems (e.g. FX arbitrage, portfolio management, liquidity allocation) that were previously nearly impossible for traditional computers to solve in a timely way.



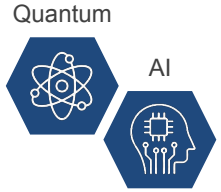
Augmented accuracy

A number of critical financial calculations – including Economic Capital Requirement and Value at Risk (VaR) are made with many estimations and approximations. When these calculations are run through a quantum device, practitioners can consider a larger number of inputs and fewer constraints, leading to a more accurate output.[12]



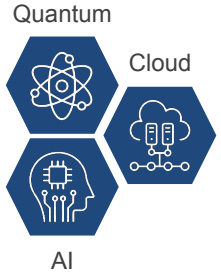
Reduced data fragmentation

Cloud architecture can help institutions to create and deploy shared datasets, platforms and tools to standardize data intake, treatment and governance. This will improve data integrity, hygiene and cross-enterprise scalability. Tools like knowledge graphs can then be deployed to semantically link data across the enterprise.



More robust AI methods

Quantum computers allow specialized data scientists to build more robust machine learning (AI) algorithms that improve the training speed and inferential accuracy of classification, allowing institutions to monitor and classify transactions (e.g. as fraudulent) in real time or dynamically optimize portfolios.[13]



Improved data readiness

AI and cloud are critical to achieving the benefit of quantum as they will help organizations process data to be readily available for quantum analysis. Specifically, AI can help to create synthetic datasets for experimenting with quantum or help automatically organize data in a way that is digestible to a quantum computer.

Note: While fully developed, commercially scaled quantum computers are likely a decade (or more) away, new hybrid forms of quantum computers are allowing financial institutions to harness the power of quantum technology in the short to medium term. The innovation pathways and use cases highlighted in this report feature business applications of quantum computers that are possible using these hybrid quantum computers.

Related use cases: Cross-Bank Collateral Optimization, Quantum Portfolio Optimization

Disruptors will significantly improve their ability to manage data, allocate capital, and more precisely calculate risk, driving cross-enterprise efficiency gains and unlocking deeper insights

Areas where disruption is likely to occur

Where a central data organization layer can be developed

- A partnership-driven organization will necessarily consume a significantly larger amount of data about customers, partners, and the market, from a multitude of new sources
- A central, cloud-based data management layer that captures, refines, and creates an ontology to connect data together for simplified retrieval from across the institution, can help gain a more cross-enterprise picture of customer activity, break down informational siloes, and enable better real-time monitoring of transactions and activity[14]

A central data layer will be disruptive because

1. It can help institutions unlock more sophisticated insights and drive greater collaboration.
2. An enterprise-wide approach to standardized, hygienic, scalable data is a significant pre-requisite to deriving benefits from AI and quantum

Where resource allocation decisions create a speed-precision trade-off

- Where firms must make frequent resource allocation (optimization) decisions, such as how to allocate collateral across functions (e.g. multiple trading desks) while minimizing margin requirements and maximizing liquidity, they often sacrifice calculation accuracy for speed
- Quantum computation can help break this trade-off between speed and accuracy, as it can achieve significant processing speedups on optimization problems with very few constraints

Breaking this trade-off will be disruptive because

1. Firms often overcollateralize and make large approximations in portfolio calculations to avoid risk, driving up opportunity and liquidity costs. For portfolio optimization, cost savings are estimated to be up to 3% of AUM[15]

Where regulatory compliance or revenue pools depend on risk simulations

- Key prudential regulations across financial services involve simulating financial risk using standardized methods (e.g. the Value-at-Risk method for Basel III compliance), and managing holdings against pre-defined risk limits[16]
- Quantum dramatically improves the speed and accuracy of simulation techniques (e.g. Monte Carlo methods)

Quantum simulation will be disruptive because

1. It would allow institutions to develop more accurate models of their risk position on an ongoing basis, reducing compliance risks
2. It would permeate key financial decisions made by the institution, allowing them to more actively manage the enterprise balance sheet
3. More accurate simulations would lead to better derivative pricing, improving trading margins

Quantum and AI have the potential to transform balance sheet operations, but questions around the commercial timeline and scalability of quantum computing indicate that Pathway D will likely be most disruptive in the long term

Critical uncertainties and enabling conditions

A set of market uncertainties will define how and when institutions are able to pursue the innovation pathways

Market uncertainties

Competitive impact of collective industry solutions

Will collective networks meant to promote systemic efficiency/security (e.g. a KYC/AML utility, global fund transfer network) strategically disadvantage smaller firms without the resources to participate?

Other outstanding questions

- How might these institutions still benefit (e.g. by sharing connectivity costs with competitors)?
- What role (if any) should policy-makers and regulators play in levelling the playing field (e.g. funding support)?

Potential evolution of centralized market structures

Will the ability to conduct atomic, peer-to-peer transactions significantly reshape the way highly centralized processes are conducted (e.g. centrally cleared securities trading)?

Other outstanding questions

- If so, which centralized market structures/processes are most primed for disruption (e.g. where does centralization bring the least benefit)?
- Are DLTs always required to achieve this goal or are there other architectures that are fit for purpose?

Role of large technology players

Given their importance in the provision of financial intelligence as a service, what will be the strategic response of large technology players (e.g. cloud providers) if financial regulators decide to bring them under their oversight?

Other outstanding questions

- Will those with existing stakes in financial services across their portfolios decide to make a more formal foray into the industry (e.g. obtaining a regulatory licence through an affiliate)?
- Will the cloud computing services provided by many big tech players be forced to evolve into more regulated, utility-like services?

Quantum commercial availability

How quickly will quantum computing capabilities (e.g. hardware, useful algorithms) become scalable and economically accessible to institutions across the financial services industry?

Other outstanding questions

- Will the industry coalesce around a standard for quantum-secure encryption before scalable commercial availability is achieved?
- How must talent models evolve to attract the limited number of highly specialized practitioners with expertise in quantum computing to financial institutions?

There are also uncertainties that sit outside of the institution's direct locus of control, specific to potential regulatory action and the evolution of customer views and values

Regulatory uncertainties

Data regulation regionalization

Will data regulations continue to become more regionalized, driven by heightened geopolitical tensions and diverging positions around data privacy and control?

Other outstanding questions

- Will the use of privacy-enhancing techniques become a required standard for cross-border data-sharing?
- How might data regionalization affect how institutions design cloud architectures?

Digital currency adoption

Will China's intended 2020 launch of a central bank digital currency (CBDC) hasten the development of CBDCs in other major economies?

Other outstanding questions

- How will policy-makers and regulators balance the desire for digital asset traceability with preserving the privacy of citizens?
- Will the widespread adoption of CBDCs obviate the need for privately issued settlement coins (e.g. Fnality's Universal Settlement Coin) or will these currencies still have a role to play?

Customer and societal uncertainties

Changing views on institutional trust

Will customers trust their financial institutions to provide non-financial recommendations, and trust non-financial institutions (e.g. large platform providers) to supply them with financial advice and products?

Other outstanding questions

- To what extent will customers outside of specific markets (e.g. Asia) be comfortable accessing financial services through integrated platforms provided by non-financial players (e.g. "big tech" firms)? Will we see some players from Asia make significant inroads in other markets?
- Who will orchestrate the most important "ecosystems beyond financial services" (e.g. incumbent financial institutions, big techs)?

Value attributed to data privacy

Will growing customer concern over data control and privacy result in the emergence of market-led models for data that give customers control over their data and compensate them directly for consenting to data-sharing?

Other outstanding questions

- What "price" would financial institutions be willing to pay to access and leverage different types of customer data?
- How might these markets be governed, and what role could financial institutions play in their governance? What role would financial regulators play?

While the outcomes of these uncertainties will ultimately shape the viability and feasibility of each pathway, there exists a set of enabling conditions that will support foreseen industry transformations

Enabling conditions for innovation pathways

1 Regulatory inclusivity

What does this condition imply?

- Non-financial ecosystem players (e.g. cloud providers) are brought under the purview of financial regulators
- Frameworks to distribute liability and accountability across financial and non-financial ecosystem partners (e.g. ability to rely on another institution's data to make KYC/AML decisions)

Why is the condition an important enabler?

- A more equitable distribution of responsibility liability associated with adopting emerging technologies could promote innovation while preserving the safety of customers and markets[17]
- Policy questions related to liability distribution have often slowed implementation of collective data-sharing solutions in financial services, despite the technical capability to securely share insight among peers (e.g. PETs)

What actions could industry stakeholders take?

- Support a balance between broad regulations that are technology-neutral and activity-based, and dynamic (i.e. regularly updated) sector guidance on the use of specific technologies, as use cases can differ across sectors (e.g. need for explainable AI in consumer-facing vs non consumer-facing applications)
- Invest in collective insurance pools to handle redress and to make customers whole as a priority, and then work to establish institutional liability

2 Distinguished talent strategies

What does this condition imply?

- Less emphasis on FTE*-centric models and greater focus on improving the experience of other working arrangements and sourcing talent from non-traditional pools (e.g. part-time/contract/joint-development roles with partners)
- Tailoring talent experience more finely to employee preferences, capabilities and long-term goal orientation
- More focus on creating diverse and cross-functional teams as a standard

Why is the condition an important enabler?

- Doing so can help drive productivity and lower talent acquisition costs via enhanced satisfaction and retention[18]
- It gives the firm flexibility in managing spikes in supply and demand of valuable capabilities during transformation[19]
- It unlocks the ability to stand up and stand down crowds against priorities, as required, reducing FTE lock-in

What actions could industry stakeholders take?

- Develop policies that prioritize talent acquisition speed (e.g. look beyond traditional talent pools) and enable internal mobility (e.g. more project-based, gig-like roles; more opportunities to join cross-functional teams)
- Provide programmes to support training, career progress and mental health, and drive flexibility in location (e.g. remote), hours and skill development plans
- Develop common systems/metrics/experiences across many work arrangements

* FTE = Full-time equivalent

Firms may be at different stages of maturity across the enabling conditions; action is required to assess current state maturity against strategic ambition

Enabling conditions for innovation pathways

3 Data process and infrastructure modernization

What does this condition imply?

- Data workflows capable of ingesting, cleaning, structuring and linking disparate sources of high-quality data across the institution, and breaking down data siloes
- Seamlessly connecting data workflows to core analysis tools (e.g. customer data from multiple sources flowing into a risk model)
- Flexible, cloud-based infrastructure (e.g. core systems, partner connectivity networks) coordinating the integration of multiple data-centric technologies

Why is the condition an important enabler?

- Ecosystem-led firms will consume larger volumes of data, at higher velocity, about customers and markets, and legacy systems are not well-poised to cope
- This data creates a virtuous cycle of learning (e.g. about customers), product tailoring and future partnership developments to deepen trusted relationships
- Navigating the regulatory environment increases in complexity at the confluence of open data, new proprietary data streams and modern privacy laws; greater customer scrutiny over privacy will set a high bar for transparency and control

What actions could industry stakeholders take?

- Approach data productionization as a strategic issue; dedicate resources to replace legacy, integrate data talent cross-functionally and improve data quality
- Take a systems-based approach to deploying data-centric technologies, mapping out how to integrate them across every facet of the organization
- Work to develop a digital identity framework that standardizes and coordinates the flow of data across individuals, businesses and physical assets

4 New models of execution excellence

What does this condition imply?

- Centralized accountability over key strategic priorities coupled with distributed decision-making authority, and more multifunctional project teams
- Established feedback loops for every stakeholder (e.g. employees, clients, partners) to rapidly sense, capture and analyse critical feedback
- Reassessment of traditional industry orthodoxies around “standard” project timelines, perfection vs completion mentality, and entrenched ways of working

Why is the condition an important enabler?

- It can help promote greater levels of organizational agility and delivery speed, alongside enhanced internal collaboration and communication[20]
- Deep and trusted stakeholder relationships will likely become an increasingly important differentiator as access to technologies democratizes
- Modernizing outdated processes and updating faulty assumptions can give firms the confidence to unlock new efficiencies

What actions could industry stakeholders take?

- Stand up cross-functional teams based on capabilities needed to achieve results (vs basing on roles and titles) and empower them with decision rights
- Create technology-enabled, two-way communication channels with key stakeholders, and dedicate resources to analysing and implementing feedback
- Create a culture of experimentation within the organization, and seek partners with a similar mindset; develop centralized contract and procurement policies

References

1. OpenAPI Specification, *OpenAPI Initiative,* n.d., accessed 7 August 2020, https://www.openapis.org/
2. "Nacha's API Standardization: A Necessary Undertaking", *PaymentsJournal, 23* July 2019, https://www.paymentsjournal.com/nachas-api-standardization-a-necessary-undertaking/
3. "Embedded Finance: The Future of the Economy", *Anthemis*, November 2019, https://www.anthemis.com/embedded-finance/
4. "Fifth Third Bank Partners to Offer Free Career and Financial Coaching", *Fifth Third Bank,* 20 May 2020, https://www.53.com/content/fifth-third/en/media-center/press-releases/2020/press-release-2020-05-20.html
5. "The Appropriate Use of Customer Data in Financial Services", *World Economic Forum*, September 2018, http://www3.weforum.org/docs/WP_Roadmap_Appropriate_Use_Customer_Data.pdf
6. Talia Domenico, "A view of programming scalable data analysis: from clouds to exascale", *Journal of Cloud Computing 8, 4 (2019),* 11 February 2019, https://doi.org/10.1186/s13677-019-0127-x
7. Oyeniyi Temi, Yang Zack, & Tortoriello Richard, "Risky Business: Foot Traffic, Vacancy Rates, and Credit Risks", *S&P Global Market Intelligence: Quantamental Research Brief*, May 2020, https://www.spglobal.com/marketintelligence/en/documents/qr-brief-risky-business-foot-traffic-vacancy-rates-and-credit-risks.pdf
8. Srinivas Val, Fromhart Stephen, and Wadhwani Richa, "'Default' payment methods: The digital marketplace reset you did not see coming!", *Deloitte University Press, 2016,* https://www2.deloitte.com/content/dam/insights/us/articles/3374_Default-payments-digital-reset/DUP_Default-payment-methods-digital-reset.pdf
9. BIS Committee on Payments and Market Infrastructures, "Correspondent banking", *Bank for International Settlements,* July 2016, https://www.bis.org/cpmi/publ/d147.pdf
10. Bank of Canada, Monetary Authority of Singapore, Accenture, and JP Morgan Chase & Co., "Enabling Cross-Border High Value Transfer Using Distributed Ledger Technologies", 2019, https://www.mas.gov.sg/-/media/Jasper-Ubin-Design-Paper.pdf?la=en&hash=EF5857437C4857373A9287CD86F56D0E7C46E7FF
11. TMX, R3, Payments Canada, Bank of Canada, Accenture, "Securities Settlement Using Distributed Ledger Technology," October 2018, https://www.payments.ca/sites/default/files/jasper_phase_iii_whitepaper_final_0.pdf
12. Mevissen Martin et al., "Quantum computing for Finance: state of the art and future prospects", *IBM Quantum*, 26 June 2020, https://arxiv.org/pdf/2006.14510.pdf
13. Ibid.
14. Webber Jim, "Why Knowledge Graphs Are Foundational to Artificial Intelligence", *Datanami*, 20 March 2018, https://www.datanami.com/2018/03/20/why-knowledge-graphs-are-foundational-to-artificial-intelligence/
15. Langione Matt et al., "Where Will Quantum Computers Create Value—and When?", BCG, 13 May 2019, https://www.bcg.com/publications/2019/quantum-computers-create-value-when
16. Mevissen Martin et al., "Quantum computing for Finance: state of the art and future prospects", *IBM Quantum*, 26 June 2020, https://arxiv.org/pdf/2006.14510.pdf
17. Bhat Vik, Kapur Sunil, & Hodgkinson Sean, "FFIEC statement on risk management for cloud computing services", Deloitte Center for Regulatory Strategy Americas, 21 May 2020, https://www2.deloitte.com/us/en/pages/regulatory/articles/financial-services-cloud-computing-regulation.html
18. Willemse Andrea et al., "Lessons Learned During COVID-19: A Banking Study", Deloitte, 2020, *Forthcoming*
19. Roberts Todd et al., "People in Payments: The need for talent transformation in financial services", Deloitte, 2020, https://www2.deloitte.com/ca/en/pages/financial-services/articles/people-payments.html
20. Willemse Andrea et al., "Lessons Learned During COVID-19: A Banking Study", Deloitte, 2020, *Forthcoming*

Sector use cases

Use cases are customer-centred narratives that describe meaningful industry solutions at the intersection of emerging technologies, prioritized against a common set of gating criteria

Gating criteria to prioritize use cases

1 Emerging technology confluence

The use case is only plausible at the intersection of three or more emerging technologies.

2 Use case desirability

The use case helps address a core industry need (e.g. consumer need, institutional need) identified throughout the research.

3 Use case viability

The use case is supported by a logical business case where revenue and cost-savings drivers are likely to outweigh cost drivers.

4 Use case feasibility

The use case is theoretically feasible in the next three to five years given technology maturity and pace of change in the industry (e.g. regulatory, customer preferences).

Prioritized use cases

Lending and deposits	Investment management	Payments	Insurance	Capital markets	Market infrastructure
Just-In-Time Lending	Outcomes-Based Investment Products	M2M Payment Protocol	Dynamic Life + Health Insurance	Cross-Bank Collateral Optimization	Global Fund Transfer Network
Trusted Data Steward	Verifiable Impact Investing	Augmented Purchases	Connected Post-Claims Experience	Quantum Portfolio Optimization	Global Corporate Actions Ledger
				Data-Linked Green Bonds	Distributed KYC/AML utility

Use cases will manifest across different time horizons and are not intended to provide a comprehensive view of every future opportunity available in each sector; while some technologies are naturally reaching scalable commercial adoption faster than others, pursuing any of the use cases will require near-term investment in maturity assessment, strategic planning, partnership development and capability-building

Lending and deposits

The lending and deposits sector focuses on the core value chain activities of retail and commercial banks, including distribution, financial advisory and lending/deposit products

Trends

"Big tech" players are **continuing to enter financial services** in a **consumer-facing** capacity, often through **partnerships with large incumbents.**[1]
Amazon is now embedding access to Marcus (Goldman Sachs) business lines of credit directly into its merchant platform.[2]

Growing up in a **digital world** has reshaped Gen Z's expectations; as it relates to their finances, they often want to "**get the job done**" in a single place as opposed to seeking out and curating multiple products from different providers.[3]
Many robo-investing platforms popular among Gen Z (e.g. Wealthsimple) have launched chequing and debit products to provide users a one-stop-shop.[4]

Banks have **greatly increased their investments** in **modernizing technology stacks;** industry-wide technology spend **increased ~10% in 2019.**[5]
For instance, global institution JP Morgan's technology budget has increased to $11.4 billion in 2020, up $600 million from its 2019 spend. [6]

COVID-19 has pushed firms to **shorten implementation timelines** for digital offerings; projects scoped across multiple months were often **completed in weeks.**[7]
In weeks, a Singaporean bank introduced many comprehensive solutions for SMEs, like loan deferments and bridge loans in response to the pandemic. [7]

Use cases

The following use cases were prioritized because they aim to solve the core customer need of frictionless access to funding and secure movement of data, while also creating a compelling business case for banks of the future:

1 Just-in-time lending

Tailored small to mid-sized business lending products and advice provided just when the customer's funding needs arise; offered by institutions that factor multiple data sources into a continuous risk analysis and pricing engine.

2 Trusted data steward

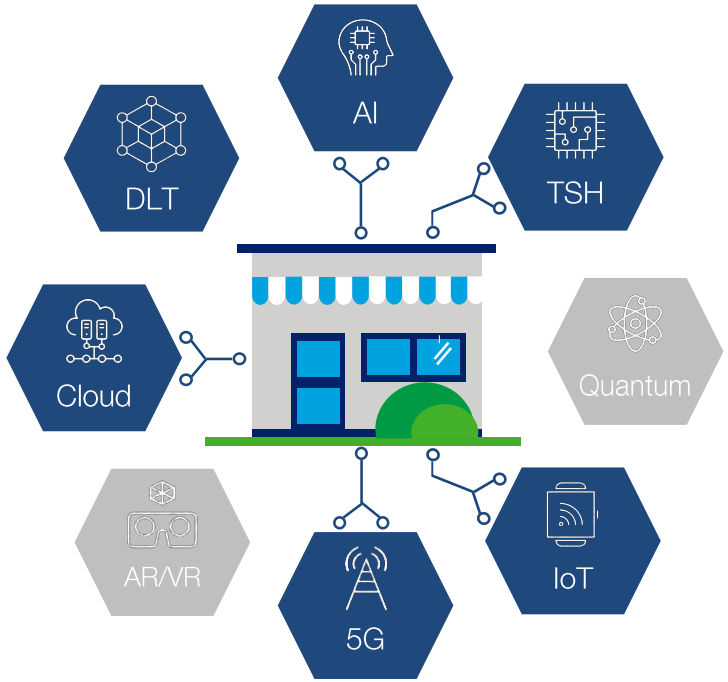
A financial institution (or syndicate of institutions) serves as a central consent management platform that links sources of customer identity attributes (i.e. data) to users of that data (e.g. service providers) and uses AI to scan and "police" the third parties misusing client data.

Just-in-time lending

Just-in-time lending refers to tailored small to mid-sized (SME) business lending products and personalized advice that are provided both proactively and in the moment that unexpected needs arise

Key takeaway	SME clients could benefit from tailored business advice and lending products that grow with their business. The financial institution could also reposition itself as a strategic adviser and source of trusted operational advice.

Emerging technologies



The new user experience

Paula runs a small manufacturing business in Australia. Lately, her business has been growing so rapidly that she often struggles to obtain funding when she needs it.

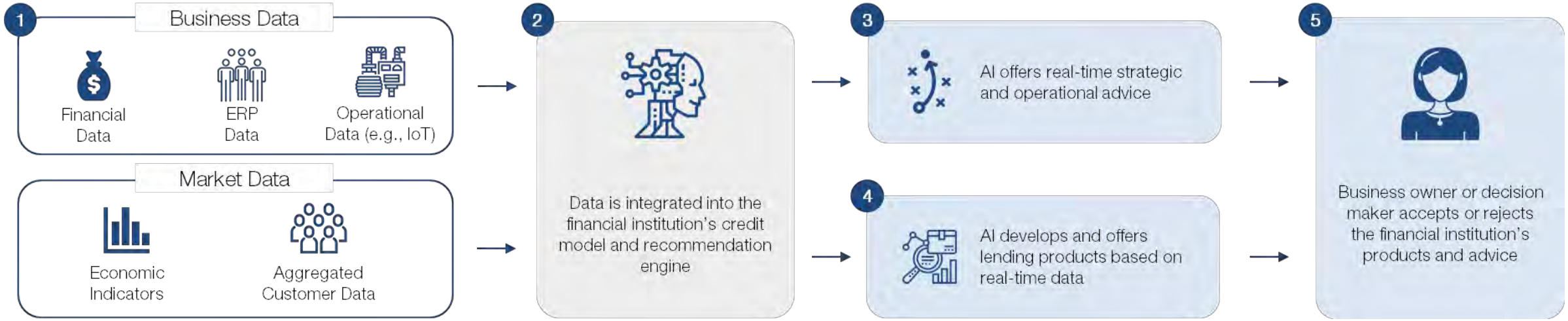
Paula and her bank work together to connect their credit engine to her operational data (e.g. supply chain information) and financial data (e.g. working capital, accounting system) and to install IoT sensors on critical machines for maintenance and use monitoring. From the real-time information collected, and by leveraging AI decisioning tools, the bank can proactively lend to Paula when a new order comes in or when key equipment breaks down, subject to specific parameters.

For example, if the model identifies a discrepancy between Paula's cash on hand and the raw materials needed for a new order, the model will automatically underwrite a loan and continually adjust the rate based on incoming data. This saves Paula from completing multiple applications and gives her more time to focus on her business.

The bank also uses this data, combined with relevant marketplace data, to equip Paula with personalized tips on how she could improve operations (e.g. cost reductions, machine downtime, staff optimization). This removes friction and positions the bank as an important strategic adviser to Paula.

An AI-based continuous adjudication engine relies on multiple data streams (including operational data from IoT devices) to provide tailored lending and advice

Process flow



Assembling the technologies

Infrastructure	Cloud computing
Core	AI IoT
Complementary	DLT 5G networking Task-specific hardware

- IoT sensors monitor assets (e.g. machinery), inventories etc. and collect data about operations; when embedded with task-specific hardware, they can perform AI edge analysis (e.g. basic predictive analysis using deep learning techniques)
- For added security, the collected data could be linked to a distributed ledger that minimizes fraud risk by automating the collection and writing of data to an immutable repository
- Wireless networking connects the IoT data, along with data from accounting, invoicing, human resources and other systems to a cloud server, where storage and more rigorous AI-driven computation (e.g. computer visioning for IoT cameras) occurs. 5G is useful (but not strictly necessary) given the potential for large data transmission volumes and enterprise security benefits
- An AI-based recommendation engine helps the bank accurately determine how operational factors impact lending risk, price this risk accurately, and communicate with the client (e.g. using a natural language processing-based chatbot)

Growing SME technological maturity can help institutions more confidently close the funding gap by making more accurate risk predictions, and improve servicing for an often-underserved sector

Reinforcing trends

Customers are becoming more willing to adopt sensor technology

- The industrial IoT market is expected to grow to nearly $120 billion by 2025,[1] with the number of sensors potentially reaching 50 billion. At the same time, the cost of these sensors has dropped substantially. Between 2015 and 2020, the cost-per-sensor (now at $0.38) is estimated to have declined by 25% - making large-scale monitoring and analysis systems more feasible.[2]

Financial institutions are beginning to realize the benefits of automating SME servicing

- To offset the cost of serving SMEs (often high relative to loan value), many lenders have already deployed automation and AI to parse invoice documentation and underwrite based on historical data.[3] The basic infrastructure is often in place to incorporate more sophisticated data streams and more proactively issue tailored funding.
- Lenders are using alternative data to effectively assess the creditworthiness of SMEs.[4] Wiserfunding uses financial, governance and management-capacity data to develop a model they claim predicts commercial default probability with 90% accuracy.

SMEs continue to have unmet financial and strategic needs

- The lending gap for SMEs continues to widen ($5 trillion in the US and $1 trillion in Europe in 2019), suggesting that large institutions with strong balance sheets have an outsized role to play in satiating this credit need.[5]
- A recent YouGov (UK) study found that SME owners spend an average of 4+ hours/week on administrative and finance-related tasks (e.g. loan applications), taking away from time that could be used on making long-term strategic decisions – and losing approximately £9 billion every year as a result.[6]

Financial institution impacts

Cost drivers

- Increased costs related to sector-specific data collection and analysis
- Potentially lower default rate from more accurate risk predictions by integrating operational indicators
- Increased costs related to developing continuous adjudication models

Revenue drivers

- Monetize aggregated operational data and provide a better customer experience by offering predictive insight/advice
- Leverage detailed client data to cross-sell value-added advisory and planning services

Operational impacts

- Requires hiring/training for sector-specific expertise in analysing and contextualizing non-financial data to price financial products
- Transforms the role of the loan officer into more of a business adviser and assessor of strategic opportunities

This arrangement helps better position lenders as strategic partners for their clients; early evidence of just-in-time lending is emerging across more capital-intensive industries

Early experimenters

Global Mobility Service (GMS), a Japanese mobility provider, developed an IoT-based service giving autorickshaw drivers in Asia the ability to purchase and operate their own vehicles. Drivers pay a regular usage fee (i.e. a loan repayment), and failure to repay results in the vehicle being locked for further usage. Over time, the operational data, like estimated daily sales, passenger volume and driving behaviour, allows GMS's lending partners to offer additional credit to drivers (e.g. to fund a fleet of vehicles) to spur business growth.[7]

Commerzbank has developed a proof of concept for "pay-per-use" capital asset loans, which uses data from sensors embedded in the asset to tailor repayment terms based on how the asset is being used. The repayment rate fluctuates in step with the actual output or uptime of the asset (e.g. construction crane) to more tightly match asset usage with repayment cycles.[8] Overall, the service allows Commerzbank clients to preserve liquidity and operate at a lower break-even point, since loan repayment matches production.[9]

Necessary conditions

Customer investment

If IoT is not already embedded in the client's operations, they will likely need to invest in the hardware and new data capabilities to benefit from the offering, which not all sizes of SMEs may be able to implement.

Trusted customer relationship

Customers will need to value their relationships with financial institutions for more than just specific financial advice and see them also as broader strategic partners.

Strategic segmentation

This solution is more compelling for certain industries (e.g. manufacturing) than others; institutions need to identify the customer segments where proactive capital access and lower administration costs matter.

Data sensitivity

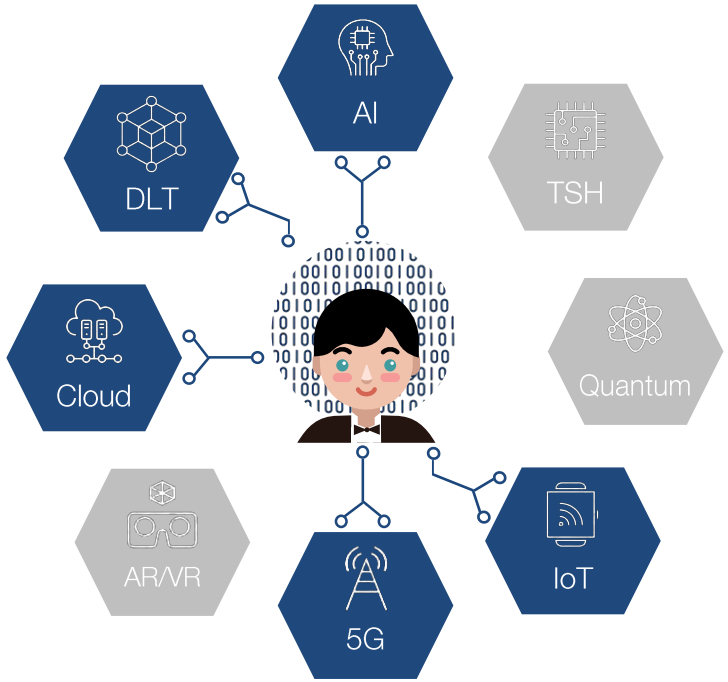
Banks will need to aggregate and handle sensitive data with caution. Customers must be reassured that sensitive data will not be shared in ways that could threaten competitive advantages.

Trusted data steward

Institutions operate a central consent management platform that links sources of customer data to service providers who use that data, and proactively scan usage patterns to flag potential misuse

Key takeaway	Financial institutions have historically served as the trusted keepers of consumers' financial assets and have the opportunity to reposition themselves as the trusted stewards of data assets in addition to financial assets.

Emerging technologies



The new user experience

Rafiq, a citizen of a European country, has been offered a job at a large multinational. His employer requires verification of specific identity attributes, including his citizenship status and proof of educational attainment. The request is routed to Rafiq's bank, VillageBank, to whom he has given a data stewardship mandate.

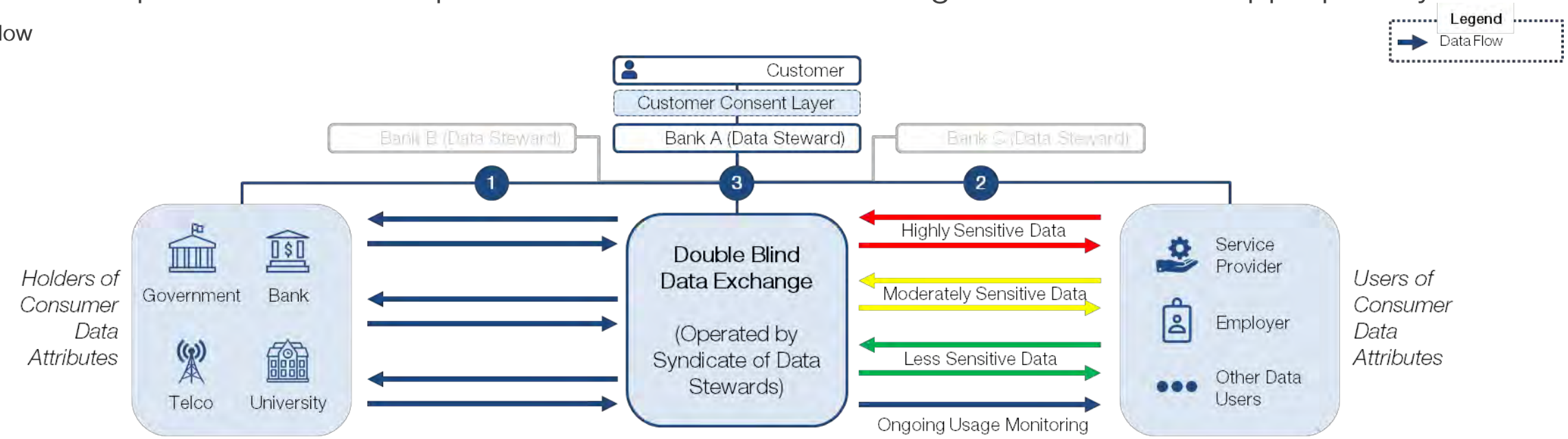
VillageBank is a member of BankSyn, the national data stewardship and digital identity network. Through its member institutions (including VillageBank), BankSyn operates an exchange that mediates consent and access to identity attributes (both inherent and attributed) in Rafiq's country.

Through a simple mobile application, Rafiq is able to consent to information being shared automatically with his employer. For specific requests (e.g. proof of his educational attainment), the underlying data (e.g. his transcript), is not transferred; rather, VillageBank (via BankSyn) only communicates a trusted proof that Rafiq has graduated by connecting with his university.

A year after Rafiq leaves the organization, VillageBank notices that some of Rafiq's personal data has been transferred to a server outside the EU, in contravention to GDPR. On Rafiq's consent, VillageBank automatically lodges a formal complaint on his behalf.

A double-blind exchange ensures secure transfer of only necessary information, while "smart encryption" helps monitor service providers to ensure data is being used and stored appropriately

Process flow



Assembling the technologies

Infrastructure	Cloud computing
Core	AI DLT PETs
Complementary	5G networking IoT

- The exchange and consent management platform is built on a flexible, cloud-based architecture, accessible by both holders and users of consumer data through secure APIs
- Highly sensitive data is wrapped in an encryption layer and governed by a smart contract that encodes covenants for how the data is to be used, stored and disposed of (e.g. ensure that customers are protected against breach or improper residency of their data); the exchange utilizes AI to monitor compliance with the contract and detect anomalies
- For less sensitive data, the exchange leverages zero-knowledge proofs (a privacy-enhancing technique) to share only necessary data (e.g. a yes/no response to prove majority age vs date of birth)
- 5G and IoT (e.g. mobile devices) are used to transmit data about the customer that feeds into a probabilistic authentication model operated by the customer's financial institution; an extended set of data such as location, biometric information, typing style etc. is used to continuously authenticate customers in the background to increase security

Consumers and regulators alike face challenges in protecting data and facilitating individual control, providing an opportunity for trusted institutions to leverage their expertise in managing sensitive data

Reinforcing trends

While adoption of data privacy and portability legislation is picking up steam globally, enforcement is seen as lacking, even in mature markets

- Many new privacy legislations have gone live or are under development; for instance, the California Consumer Privacy Act (often seen as a blueprint for broader national legislation in the US) went live on 1 January 2020.[1]
- While legislation is important, evidence from the EU's GDPR experience suggests that consumers are often still not being protected adequately; claims of underfunded legislators and slow enforcement suggest that, alongside regulation, market-led consumer protection has a substantial role to play.[2]

Consumers are slowly but surely increasing demand for data privacy and portability tools

- A study by IBM's Institute for Business Value conducted in 2019 found that over 80% of consumers have increased their level of concern over the use of their data.[3]
- However, consumers largely believe that protecting their data is not achievable solely through tougher legislation, and often do not make changes to their behaviour. 55% of Americans prefer better data management tools to harsher legislation, and <50% update privacy settings regularly.[4]

Managing consent and enforcing privacy legislation are non-trivial challenges

- Under GDPR, enforcing privacy rights implies taking legal action upon suspicion of misuse; however, transparent visibility into how consumer data is used is still highly limited, making it difficult to spot misuse in the first place.[5]
- Consent management platforms operated by service providers themselves, and not an independent third-party, present a misalignment of incentives; service providers (e.g. a website looking to collect data) are generally incentivized to employ tactics (e.g. consent walls) to maximize data collection.[6]

Financial institution impacts

Cost drivers

- Fixed infrastructure costs to develop the data exchange, which may be syndicated across multiple firms and the public sector
- Development and maintenance of integrations with data holders and ongoing security monitoring

Revenue drivers

- Receivers (users) of customer identity data may pay a subscription or per-transaction fee to receive data securely from the exchange
- Governments may provide subsidies to institutions for them to operate this important infrastructure

Operational impacts

- May require the creation of a separate legal entity to operate the information exchange in order to isolate liability risk for institutions
- Requires significant collaboration with cross-sectoral regulators, and a cross-sectoral liability-sharing model

Components of the solution, including smart encryption and identity exchanges, are in the development stage, but collective action on legislation, standardization and architecture is needed

Early experimenters

Keyavi, a data security start-up, developed a platform allowing sensitive data to be "wrapped" with a smart encryption protocol layer that defines conditions for how the data can be accessed (and restricts access if the conditions are not met),[7] similar to a digital rights management platform for sensitive data. For instance, the system could render the data inaccessible if it is being accessed on an unsecure network or on a server that is outside geographic boundaries. The protocol also allows the holder of the data to issue a "data recall" request to control access.

A consortium of organizations, spearheaded by the Linux Foundation and including **Mastercard**, **Finicity** and DLT infrastructure leader **R3**, have launched a common standard for the exchange of digital identity data and credentials. Called the **Trust over IP (ToIP) Foundation**, it aims to collaboratively develop an architecture and set of protocols for password-less authentication, data provenance and identity verification to allow any two peers to quickly and accurately verify, and transact with, one another.[8]

Necessary conditions

Modernized privacy legislation

Modernized data privacy legislation, with requirements for informed consent and the right to be forgotten create a market incentive for entities to centralize data-sharing through a trusted authority.

Natural monopoly positioning

Capturing the scale economies and providing a seamless customer experience, no matter where their data is used, likely implies a single, national regional exchange operated by a group of participating firms.

Synergies with other offerings

Large tech firms and governments will also look to play this role; for banks to succeed, they should look to bundle it with existing products (e.g. savings account) and link it to other security initiatives (e.g. KYC/AML Utility).

Interoperable data standards

Requires the development of interoperable standards for the transmission of identity attribute (inherited or attributed) data across the economy. This requires cross-industry collaboration over the design of the exchange.

References

Lending and deposits

1. Aspan Maria, "Why Every Company Wants to Look Like a Bank – Without Becoming One", *Fortune,* 18 November 2019, https://fortune.com/2019/11/18/big-tech-banking-regulation-apple-goldman-sachs-google-citigroup/
2. Alix Laura, "Amazon, Goldman will offer small-business lines of credit", *American Banker*, 10 June 2020, https://www.americanbanker.com/news/amazon-goldman-will-offer-small-business-lines-of-credit
3. Alaan Mark, "Millennials and Gen Z Demand Digital Investing Tools", *The Financial Brand,* 2 July 2020, https://thefinancialbrand.com/97912/financial-institutions-wealth-management-transfer-millennial-gen-z-fintech-robo-advisor/
4. Wealthsimple Cash, https://www.wealthsimple.com/en-ca/product/cash
5. Martinuzzi Elisa, "The Banking Industry Is Spending Wildly of the Latest Tech", *Bloomberg Opinion,* 23 January 2020, https://www.bloomberg.com/opinion/articles/2020-01-23/the-banking-industry-is-spending-wildly-on-the-latest-tech
6. "JP Morgan Annual Report 2019", JPMorgan, April 2020, https://www.jpmorganchase.com/corporate/investor-relations/annual-report-proxy.htm
7. Bensley & Chheda & Schiff & Stephens & Zhou, "Remaking banking customer experience in response to coronavirus", McKinsey & Company, 7 April 2020, https://www.mckinsey.com/industries/financial-services/our-insights/remaking-banking-customer-experience-in-response-to-coronavirus

Just-in-time lending

1. PR Newswire (2020). *Industrial IoT (IIoT) Market Size to Reach USD 118,413.63 Million by 2025.* https://www.prnewswire.com/news-releases/industrial-iot-iiot-market-size-to-reach-usd-118-413-63-million-by-2025--valuates-reports-301028748.html
2. Supply Chain Dive (2019). *Declining price of IoT sensors means greater use in manufacturing.* https://www.supplychaindive.com/news/declining-price-iot-sensors-manufacturing/564980/
3. Globe and Mail (2018). *Fintech start-up that bases loans on artificial intelligence assessment helping many small businesses.* https://www.theglobeandmail.com/business/small-business/article-fintech-start-up-that-bases-loans-on-artificial-intelligence-assessment/
4. Bloomberg (2019). *Z-Score Creator Altman Builds Model for Small Business Defaults.* https://www.bloomberg.com/news/articles/2019-04-27/z-score-creator-altman-builds-model-for-small-business-defaults
5. Business Insider (2019). *Large funding gap forms in SME lending sector as UK banks fund just 8% of small business loans.* https://markets.businessinsider.com/news/stocks/large-funding-gap-forms-in-sme-lending-sector-as-uk-banks-fund-just-8-of-small-business-loans-1028754154
6. SmallBusiness (2017) *UK SMEs lost 8.72 Billion Pounds every year managing company expenses.* https://smallbusiness.co.uk/sme-lose-billion-company-expenses-2536838/
7. Global Mobility Service: https://www.global-mobility-service.com/en/
8. Finextra (2018). *Commerzbank taps IoT data to adjust loan repayments for capital equipment.* https://www.finextra.com/newsarticle/32201/commerzbank-taps-iot-data-to-adjust-loan-repayments-for-capital-equipment

References

9. Commerzbank (2018) *Commerzbank the first German bank to offer new data-based loans for corporate clients.* https://www.commerzbank.de/en/hauptnavigation/presse/pressemitteilungen/archiv1/2018/quartal_18_02/presse_archiv_detail_18_02_75466.html

Trusted data steward

1. The Future of Commerce (2020) *3 consumer privacy & data protection trends for 2020.* https://www.the-future-of-commerce.com/2020/01/09/data-protection-trends-2020/
2. Harvard Business Review (2020) *Why companies make it so hard for users to control their data.* https://hbr.org/2020/01/why-companies-make-it-so-hard-for-users-to-control-their-data;
3. Axios (2020) *Consumers kinda, sorta care about their data.* https://www.axios.com/consumers-kinda-sorta-care-about-their-data-3292eae9-2176-4a12-b8b5-8f2de4311907.html
4. Pew Research (2019) Americans are somewhat more likely to favor better consumer tools than stronger laws to help safeguard personal data. https://www.pewresearch.org/internet/2019/11/15/americans-attitudes-and-experiences-with-privacy-policies-and-laws/pi_2019-11-14_privacy_4-09/
5. European Commission (2020) What should I do if I think that my personal data protection rights haven't been respected? https://ec.europa.eu/info/law/law-topic/data-protection/reform/rights-citizens/redress/what-should-i-do-if-i-think-my-personal-data-protection-rights-havent-been-respected_en
6. CookieBot (2020) Consent Management Platform. https://www.cookiebot.com/en/consent-management-platform-cmp/
7. Keyavi data. https://www.keyavidata.com/
8. Trust Over IP Foundationhttps://trustoverip.org/

Investment management

The investment management sector includes those firms engaged in asset management, brokerage and investment advisory services

Trends

The rise of no-fee trading platforms and passive ETFs has caused **significant downward pressure** on industry cost structures, **forcing consolidation.**[1]
*In a spate of recent merger activity, Charles Schwab announced it would purchase TD Ameritrade, while Morgan Stanley announced it would acquire E*Trade.* [2, 3]

Buy-side investors continue **to invest heavily in alternative data sources**; spending is believed to have **increased around 535% over the past four years.**[4]
A study found that 72% of investment firms saw benefit in alternative data, while one-fifth stated they generate 20% of their alpha through these means. [4]

Leading institutional investors have made strong commitments to look beyond financial returns and **weigh societal factors (e.g. climate)** in investment decisions.[5]
In a 2020 letter to investors, BlackRock committed to place sustainability at the centre of its investments and core to its future strategy. [6]

Rich personalized experiences in media have shifted retail investors' expectations as they now demand personalized offers, moving away **from one-size-fits-all** products.[7]
Wealthsimple, a robo-investment platform, allows investors to invest in a personalized portfolio tailored to their risk tolerance and long-term goals.[8]

Use cases

The following use cases were prioritized because they will help investment managers provide more tailored financial planning and outcomes to customers (both consumers and businesses), while also generating new sources of alpha:

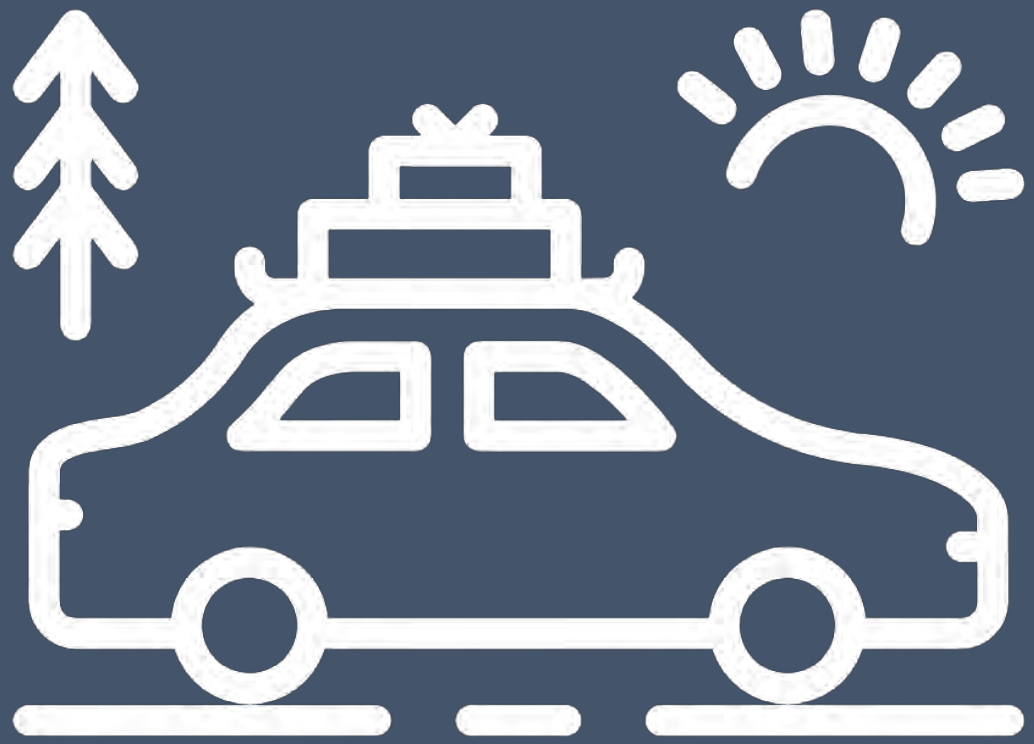
1 Outcomes-based investment products

Customers are offered the opportunity to purchase investment products that guarantee specific life experiences or outcomes; these products are structured as tokenized contracts that could subsequently be traded on a secondary market.

2 Verifiable impact investing

A service that provides SMEs the ability to issue investment tokens, directly linked to verified financial and operational data, in order to establish credibility and raise funding from investors who gain access to new and trusted sources of alpha.

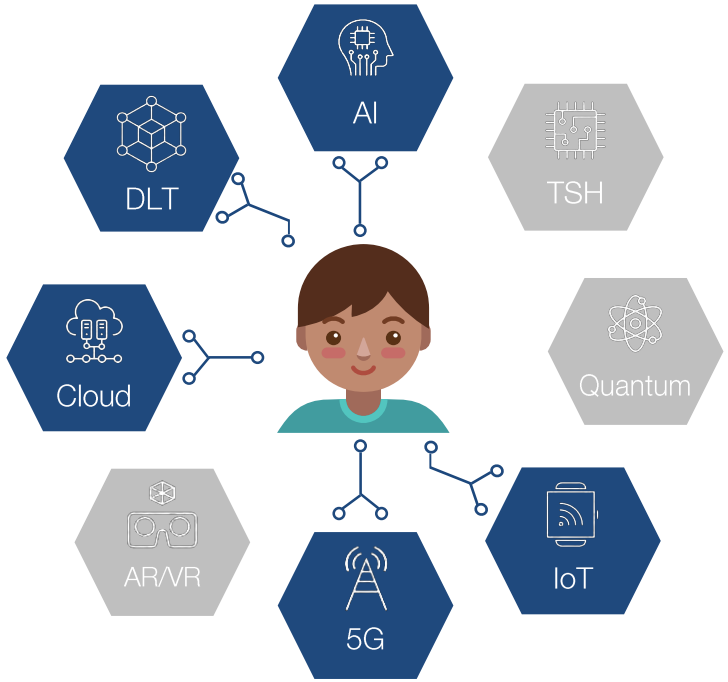
Outcomes-based investment products



Customers are offered the opportunity to purchase investment products that guarantee specific life experiences (outcomes) structured as tokens that can also be traded on a secondary market

Key takeaway	The customer could pay the financial institution in exchange for a specific future experience. In the period between the principal payment and final payment to the merchant for the outcome, the institution invests the cash and keeps all returns above the cost of the outcome.

Emerging Technologies



The new user experience

Michael is looking to invest some of his savings to afford a vacation with his girlfriend in one year. While browsing a vacation package on a popular travel website, he notices an “Invest For This Trip” button provided by his bank, MilBank. Clicking on it, he’s presented with a payment plan to transfer some of his savings to a dedicated investment account managed by MilBank for a fee in order to pay for the trip at a discounted price.

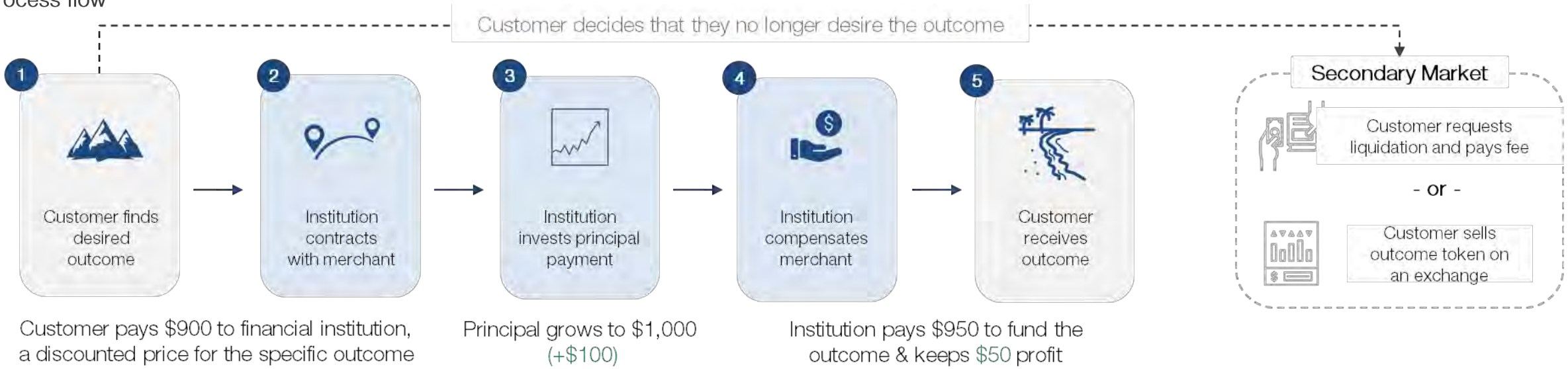
In the interim, MilBank books the trip on his behalf with its travel website partner and invests his savings into a diversified basket of securities and other financing vehicles. At the end of the year, if the value of the account is less than the trip price, the bank is liable to fund the difference on Michael’s behalf.

However, if the value of his investment account is slightly above the trip amount, MilBank takes this spread as profit. MilBank also provides this service for other investment types, including automobiles and big-ticket items (e.g. trips, event tickets, school tuition).

MilBank, in partnership with other investment-holding institutions, also gives Michael the ability to sell his investment to others if he has immediate cash needs.

AI is used to construct a portfolio and price the investment, which is then embedded on a retailer's platform as a payment option; in a secondary market, investment tokens can be liquidated or traded

Process flow



Assembling the technologies

Infrastructure	Cloud computing
Core	AI
Complementary	DLT

- The institution interfaces with various retailer/marketplace partners through cloud-based API connections, embedding the outcome-based investment option directly on to the partner's platform
- AI is used to predict funding need, construct a portfolio with high certainty of return, and price the investment appropriately; the price is presented to the customer, who makes a "purchase" using the outcome-based investment option; this data is then transferred to the institution, which structures an investment portfolio it believes will cover the cost of the outcome over the relevant time horizon, and adds it to the customer's account
- AI-driven personal financial management tools (PFMs) can help users search investments proactively, and recommend new experiences that match user-defined criteria or longer-term goals
- Investments are structured as tradeable tokens on a DLT-based digital exchange, so that consumers who no longer want a specific outcome can sell their position to others or liquidate it (for a fee); agreements between the institution and the retailer/marketplace can also be structured as smart contracts

Changes to customer preferences and the competitiveness of the trading environment are driving the need to innovate to drive AUM, but guaranteeing outcomes implies dedicated risk management

Reinforcing trends

The next generation of investors are unsatisfied with current investment options

- In a recent Wall Street Journal survey, >50% of millennials admitted to not knowing where to begin when it came to investing;[1] simultaneously, a Canadian study found that nearly 60% of this group is worried about losing money in the markets with traditional investment options.[2] The recent surge in younger investors taking an interest in digital trading platforms during COVID-19 is unlikely to impact these findings.

Younger consumers are more experience-oriented

- In some markets, experts observe that younger consumers increasingly view money with a different lens, focusing more on the outcomes or experiences that it offers than the net amount itself;[3] as a result, many are seeking offerings that not just manage their money, but also manage their outcomes. According to research from the UK Financial Conduct Authority, the youngest consumers (i.e. generation Z) are also the least likely group to incur consumer debt, signalling a change in the way that they fund their lifestyles.[4]

Consumers are becoming more comfortable engaging through alternative channels

- Providers of alternative payment methods such as Affirm, which allows customers to fund purchases through installment loans, are quickly becoming embedded at the point-of-sale of major retailers and e-commerce platforms, signalling a desire from merchants to offer customers more payment option flexibility.[5]

The zero-fee trading environment is encouraging brokerages to find new sources of differentiation

- The growth of robo-advisers ($2.2 trillion AUM by 2020) highlights consumer willingness to abstract from the details of their portfolios and align to a broad, outcome-based strategy (e.g. growth, risk avoidance).[6] To compete, brokerages are adopting zero-fee trading, creating competitive pressure to differentiate and a need to seek alternative revenue streams.[7]

Financial institution impacts

Cost drivers

- The "guaranteed" payout represents a new source of risk that would have to be managed via derivatives/insurance
- Per-transaction revenue-sharing with the vendor or marketplace
- Fund transfer fee from customer account (if not primary institution)

Revenue drivers

- Serves as a source of additional, term-locked AUM; wise portfolio construction would ensure that a majority of contracts are overfunded
- Institutions capture a fee to offset portfolio construction costs, and for managing the secondary market

Operational impacts

- Necessitates close collaboration with regulators in design, structuring and marketing to ensure compliance with securities regulation
- Requires the development of new merchant partnerships

Players are beginning to tie financial products directly to outcomes and experiences to cater to younger consumers, but developing more complex offerings requires a concerted effort

Early experimenters

Vacation Fund gives employers a tool to help their employees save for vacations. The company combines automated vacation savings with automatic employer-matched funding to incentivize employees to take vacation time. Companies that have implemented Vacation Fund have improved retention rates, especially among millennial and generation Z employees, signaling that outcome and experience-based investment products appeal to this demographic.[8]

Stash's investment platform provides a simple, outcome-centric approach to help its consumers manage their investment portfolios; for instance, while it provides access to a number of common market ETFs, Stash re-names them with easy-to-understand, outcome-focused descriptions like "Match the Market," "Inflation Defense" and "Combat Carbon" to appeal to younger investors. To ensure investor protection, Stash has also developed a platform called Stash Learn, which provides users with timely articles to learn more about investing and offers personalized guidance and risk assessment tools.[9]

Necessary conditions

Ecosystem execution

Partnerships and data-sharing agreements between marketplaces and institutions will help ensure a seamless "payment" experience for the customer and ensure an attractive outcomes ecosystem.

Secondary market function

Design and maintenance of a well-functioning secondary market is crucial to instil consumer confidence; liability must be determined for issues like extension of investment time horizons or non-delivery of outcomes.

Hedging and insurance capacity

A liquid market for institutions to offload or hedge their positions will ensure that these products are widely adopted by institutions and can be priced such that they provide value.

Data about customer behaviour

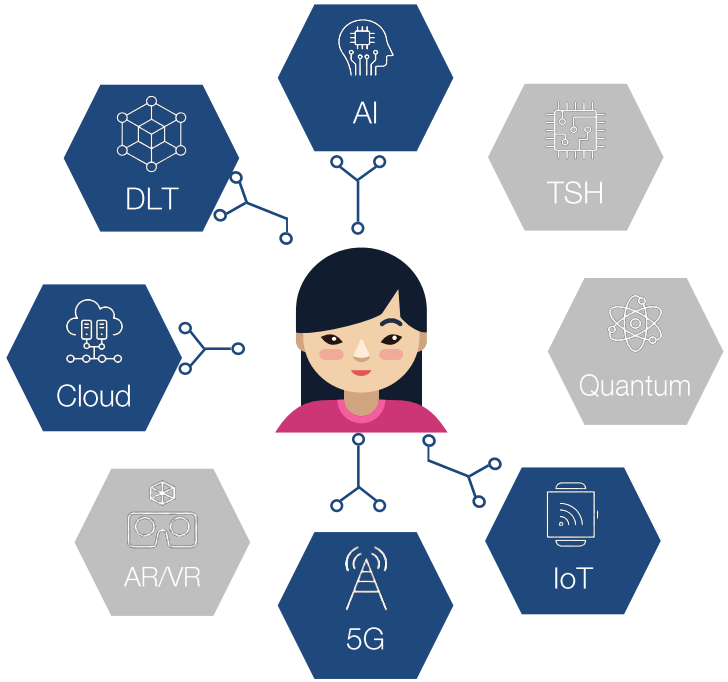
More granular information about consumer preferences should be integrated with other parts of the business to further drive cross-sell, segmentation and related benefits.

Verifiable impact investing

Verifiable impact investing is a service that allows SMEs to issue investment tokens, directly linked to verified data, to raise funding from investors who gain access to new and trusted sources of alpha

Key takeaway	The data traceability benefits of DLT, in addition to the data collection and access benefits of IoT and cloud computing, could help SMEs access funding and unlock new sources of alpha for impact investors.

Emerging technologies



The new user experience

Shiwan works for a major asset manager on a desk focused on impact investing. She is constantly searching for new sources of alpha but has struggled to find robust and trusted impact opportunities in which to invest.

Often, the opportunities that she finds typically lead to a series of logistical issues that create friction in the investment process (e.g. fund transfer friction, lack of verified documentation).

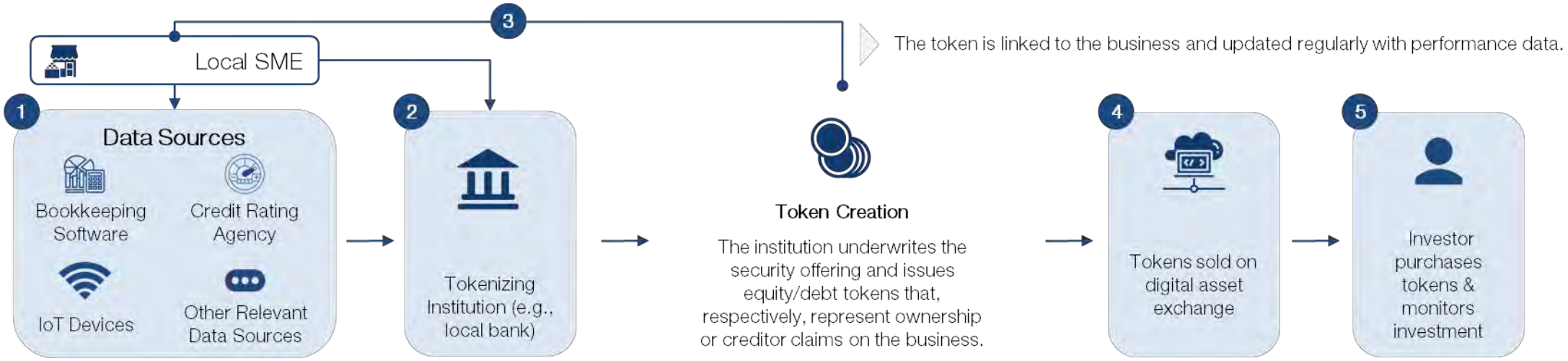
Shiwan decides to explore an impact investing platform that offers opportunities to invest in private SMEs and comes across the opportunity to invest in an SME focused on healthcare.

She decides to purchase the SME's impact tokens after doing her due diligence, using verified sources of company data that are directly linked to the tokens.

The DLT technology behind the impact tokens allows Shiwan to transfer value to the SME in a frictionless way, while also creating an immutable record of the transaction. As the tokens are updated with new data, Shiwan is able to easily monitor and report on the investment.

Tokens – traded on a digital asset exchange – are linked to verified operational, financial and other data that can be accessed securely by prospective and existing investors

Process flow



Assembling the technologies

Infrastructure	Cloud computing DLT
Core	AI 5G networking IoT
Complementary	PETs

- The digital asset exchange is built on a distributed ledger that is hosted on a cloud platform, and equity or debt stakes in the SME are structured as security tokens that live natively and can be transacted on this ledger
- These equity/debt tokens are linked to real-time sources of data (e.g. IoT data delivered over 5G networks; accounting data), giving investors the ability to monitor the performance of their investments, and potential investors the ability to make informed decisions
- Using PETs like homomorphic encryption (which allows parties to analyse encrypted data) allows the SME's underlying data to remain private while still maintaining transparency for investors and potential investors
- AI can be deployed by investors to analyse the data associated with the token in order to make investment decisions, and by the tokenizing institution to monitor first-party data sources (e.g. IoT sensors) to prevent potential fraudulent manipulation of information

For institutional investors, sourcing high-quality investments to meet unique portfolio goals (e.g. small-cap emerging markets or sustainability-focused funds) presents a significant challenge

Reinforcing trends

There is growing demand for environmental, social, and corporate governance (ESG)-focused assets from a large group of institutional investors

- Demand for ESG investing is anticipated to grow as a result of the intergenerational wealth transfer to millennials. Deloitte estimates that the value of this transfer will reach up to $24 billion by the end of 2020.[1] According to Morgan Stanley, 86% of millennials are interested in sustainable investing.[2]
- As a result of consumer demand, and growing evidence that these assets may outperform financially,[3] many large asset managers are considering ESGs when making investment decisions.
- For example, BlackRock announced multiple initiatives at the start of 2020 that put sustainability (e.g. ESG) at the centre of its investment approach.[4]

There are barriers in the financial system that make it difficult to connect supply and demand

- According to the Global Impact Investing Network, 95% of impact investors identify collecting data on investment products and opportunities as a challenge,[3] and the International Institute for Sustainable Development reports a lack of robust, bankable impact projects at the scale that institutional investors would require.[5]
- Additionally, impact investments introduce liquidity risk because it is difficult to acquire fair valuations when investors want to exit their positions. Many impact investment opportunities are private securities with longer holding periods and limited secondary market activity.[5]

Financial institution impacts

Cost drivers

- The tokenizing institution will command a premium due to complexity of tokenizing assets, and fees must be paid to digital asset custody providers
- For investors, there are costs to operate a node on the exchange (e.g. firewalls, configuration, protocols)

Revenue drivers

- Opens up new investment vehicles that would have previously incurred significant search and information validation costs
- Can repackage/securitize multiple tokens into new investment products (e.g. verifiable impact token ETFs)

Operational impacts

- Improved transparency and traceability of investments as a result of immutable ledger of transactions and SME data
- Helps mitigate significant investment risks around liquidity and investment data verifiability

While the solution represents an explicit data trade-off for SMEs and requires further market and governance development, early examples of these investment platforms are emerging

Early experimenters

Moeda is a cooperative investment platform aiming to connect investors directly with small businesses that foster the UN Sustainable Development Goals. Using DLT, Moeda guarantees the transparency of the projects for investors by utilizing the flexibility of digital tokens and their impacts. This helps community-owned enterprises that face challenges finding funding through the traditional banking system.[6]

Veridium Labs is a global marketplace for digitized environmental assets. Utilizing IBM blockchain technology, the organization has tokenized carbon-offset credits, allowing for greater transparency and liquidity between buyers and sellers. Veridium is also capable of calculating how many tokens an organization may need to fully offset their carbon emissions, simplifying a historically difficult task. Overall, the token provides assurance to various stakeholders that funding is used for environmentally beneficial projects.[7]

Necessary conditions

Institutional champions

One or more major institutional investors (e.g. a sovereign wealth fund) will need to champion the development and initial investment in both the platform and tokens to build critical mass.

Business trade-off

SMEs must be willing to trade off the privacy of sensitive operational data with the desire to attract new sources of funding, as the platform requires them to provide investors with transparency.

Clear regulatory framework

A regulatory framework on the legality of tokenized securities, their ability to be held by foreign nationals and the ability to transfer organizational data must be established to reinforce trust in the tokenizing institution.

Consistent connectivity

Lack of resources and infrastructure stability may make it challenging for certain businesses (e.g. depending on region, sophistication) to collect and store data on their business that would be required by investors.

References

Investment management

1. Bernard Tara, "Low Cost Investing Can't Get Any Lower Than Free", *The New York Times,* 1 October 2019 https://www.nytimes.com/2019/10/01/your-money/charles-schwab-free-trades.html
2. "Morgan Stanley to Acquire E Trade Creating a Leader in all Major Wealth Management Channels", *Morgan Stanley*, 20 Feb 2020, https://www.morganstanley.com/press-releases/morgan-stanley-to-acquire-e-trade
3. Klebnikov Sergei, "Charles Schwab Wins DOJ Approval For $26 Billion TD Ameritrade Deal", *Forbes*, 4 Jun 2020, https://www.forbes.com/sites/sergeiklebnikov/2020/06/04/charles-schwab-wins-doj-approval-for-26-billion-td-ameritrade-deal/#8e2378468127
4. Watts William, "The explosion of 'alternative' data give regular investors access to tools previously employed only by hedge funds", *Market Watch,* 19 September 2019, https://www.marketwatch.com/story/the-explosion-of-alternative-data-gives-regular-investors-access-to-tools-previously-employed-only-by-hedge-funds-2019-09-05
5. Eccles Robert & Klimenko Svetlana, "The Investor Revolution", *Harvard Business Review,* May 2019, https://hbr.org/2019/05/the-investor-revolution
6. Fink Larry, "Letter to CEO", BlackRock, 2020, https://www.blackrock.com/corporate/investor-relations/larry-fink-ceo-letter
7. "Personalization is the Key to Winning Emerging Investor Loyalty", *Archer,* 7 May 2019, https://www.archerims.com/2019/05/07/personalization-is-the-key-to-winning-emerging-investor-loyalty/
8. *Wealthsimple*, 2020, https://www.wealthsimple.com/en-ca/

Outcomes-based investment products

1. Wall Street Journal (2020) A Guarded Generation: How Millennials View Money and Investing. https://www.wsj.com/articles/the-recession-left-millennials-loaded-with-debtand-cynical-11583956727
2. Ontario Securities Commission (2017). Missing Out Millennials and the Markets. https://www.osc.gov.on.ca/documents/en/Investors/inv_research_20171127_missing-out-report.PDF
3. Deloitte (2019) The Consumer is changing, but perhaps not how you think. https://www2.deloitte.com/us/en/insights/industry/retail-distribution/the-consumer-is-changing.html
4. Financial Conduct Authority (2017) Financial Lives Survey. https://www.fca.org.uk/publication/research/financial-lives-survey-2017.pdf
5. Affirm. https://www.affirm.com/
6. Kearney (2015) The coming waves of Robo Adoption. https://www.kearney.com/documents/20152/4956162/Hype+vs+Reality_The+Coming+Waves+of+Robo+Adoption.pdf/7933ae48-8f0c-124a-c84d-007e96190276?t=1545110266951
7. Financial Post (2019) Zero Commission stock trading revolution sweeps the U.S but Canadian investors may have to wait. https://financialpost.com/investing/zero-commission-stock-trading-revolution-sweeps-the-u-s-but-canadian-investors-may-have-to-wait
8. Vacation Fund. Accessed 2020. https://www.vacationfund.io/
9. Stash Invest. Accessed 2020. https://www.stashinvest.com/investments/etfs

References

Verifiable impact investing

1. Deloitte (2020) Advancing environmental, social and governance investing. https://www2.deloitte.com/us/en/insights/industry/financial-services/esg-investing-performance.html
2. Morgan Stanley (2017) How younger investors could reshape the world. https://www.morganstanley.com/access/why-millennial-investors-are-different#:~:text=In%202017%2C%20Morgan%20Stanley's%20Institute,social%20and%2For%20environmental%20impact.
3. The Global Impact Investing Network (2020) Impact Investing: Need to Know. thegiin.org/impact-investing/need-to-know
4. Blackrock (2020) Larry Fink CEO Letter. https://www.blackrock.com/corporate/investor-relations/larry-fink-ceo-letter
5. International Institute for Sustainable Development (2019) Impact tokens. www.iisd.org/sites/default/files/publications/impact-tokens.pdf
6. Moeda. https://moedaseeds.com/en-us/about/
7. Veridium. https://www.veridium.io/

Payments

The payments sector includes all institutions that facilitate the exchange of funds between parties across all channels

Trends

Continued consolidation is occurring as incumbents look to integrate the value chain, offer **omnichannel payment experiences,** and/or **drive scale economies.**[1]
Notable mergers highlighting the consolidation occurring in the industry include FIS/WorldPay (2019) and Visa/Plaid (2020).[2,3]

Large non-traditional players are continuing to **enter the payments space** with products that are **issued and underwritten by incumbent banks.**[4]
For instance, consider the launch of the Uber Card, backed by Barclays, or the Apple Card backed by Goldman Sachs.[5]

Early **real-time payment (RTP)** adopters – including Australia, Malaysia and the UK – have **seen implementation success** in terms of **greater financial control** and **liquidity management** but have had to manage an uptick in fraudulent transactions.[6]
UK saw 23% growth in RTP in 2018-2019 and expect 2.3 billion transactions by 2026; however, push-payment fraud increased nearly 43% YoY in 2019.[7,8,9]

Rewards are becoming **increasingly expensive** for card providers as per-card reward expenses **increased by 30%** between 2015 and 2018.[10]
These cards often do not drive long-term loyalty as intended; studies suggest 25% of consumers are willing to switch cards in order to obtain better rewards.[11]

Use cases

As payments globally move to more real-time, frictionless rails, the next evolution of payments will see increased automation (which benefits the institutions involved) and an enhanced, data-rich purchasing experience (desired by customers)

1 Machine-to-machine (M2M) payment protocol

A payment network, or consortium of payment networks, banks, wallet providers and other financial institutions, develops a protocol through which asynchronous M2M payments are decisioned, authenticated and transmitted/received on behalf of consumers.

2 Augmented purchases

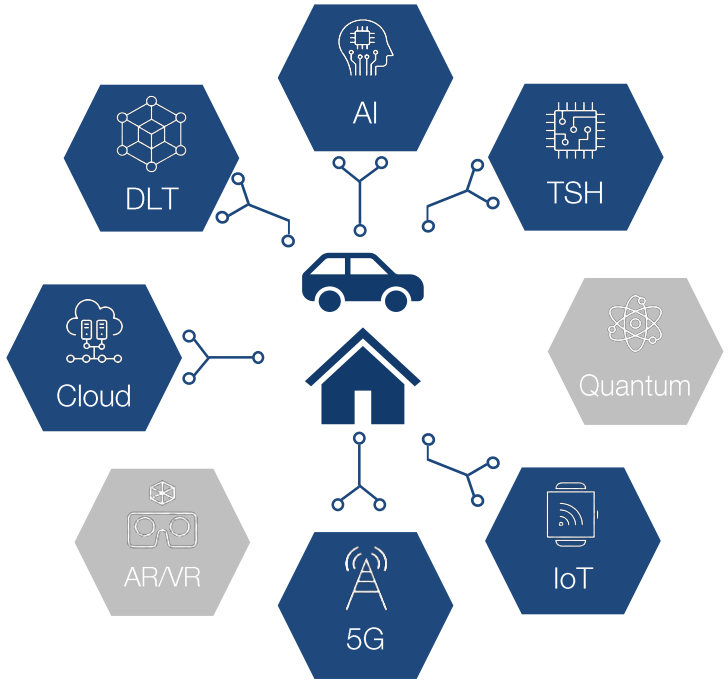
A frictionless shopping experience (delivered through AR) providing contextual access to product data and seamless transaction execution, whether the customer is browsing the product virtually or physically.

Machine-to-machine (M2M) payment protocol

A payment network, or consortium of institutions, develops a protocol through which asynchronous M2M payments are decisioned, authenticated and transmitted/received on behalf of consumers

Key takeaway	A robust M2M ecosystem could improve efficiency in the payments system and drive overall transaction volume growth.

Emerging technologies



The new user experience

Sample experience: Vehicles

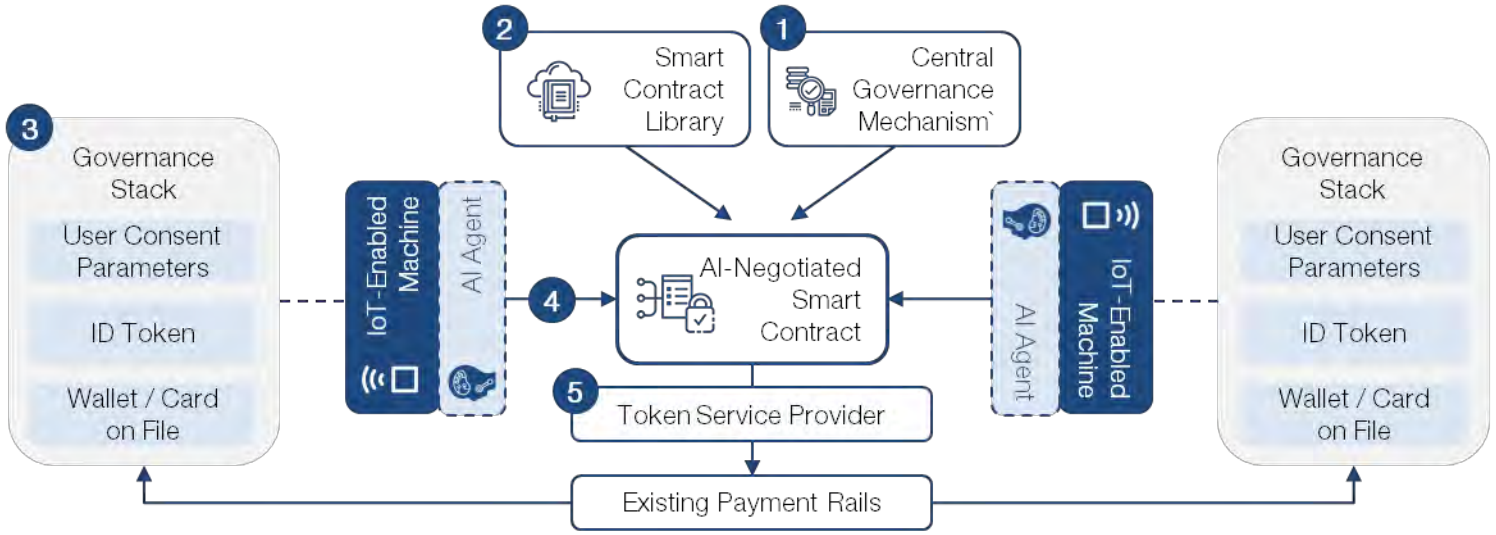
Lucy's electric vehicle has an embedded digital wallet linked to her personal bank account. On a typical day, Lucy's trip to work triggers a number of different payments that her vehicle controls. For instance, when her vehicle enters the freeway, a toll fare is automatically deducted from the wallet. Arriving at work, she is dropped off as the vehicle searches for a recharging spot, which it pays for. Lucy has enabled the ride-sharing option on the car, so it becomes part of an autonomous transit system while she is at work, ferrying people around and collecting payment.

Sample experience: Properties

AirProp, a short-term property rental company, maintains multiple properties, each with a wallet linked to its commercial banking relationship. The wallet takes in payments from guests, pays out maintenance fees and taxes, and hires essential services (e.g. cleaners) autonomously. Before, many of these administrative tasks were coordinated by AirProp directly. The wallet is directly linked to the property's mortgage with PropBank and can pay monthly charges based on guest revenue. Each property is also fitted with solar panels, and micropayments are sent to the properties' wallets for energy sold.

An AI agent negotiates optimal terms between two assets (based on prior user-defined parameters and consent) and encodes them on to a smart contract without human involvement

Process flow



Governance Stack:

- **Consent Parameters:** User-defined, conditional payment instructions (e.g., limits), definition of step-up events that require additional levels of consent, transaction limitations, etc.
- **Identification Token:** Token links user's identity & payment method to asset and helps user authorize step-up events
- **Account/Wallet/Card on File:** Payment/receipt method

Assembling the technologies

Infrastructure	Cloud computing 5G networking
Core	AI IoT DLT
Complementary	Task-specific hardware PETs

- AI embedded on IoT devices negotiates the M2M communications on behalf of users on either side of the transaction, pulling from a library of standard smart contracts (dependent on transaction type) with certain customizable parameters (e.g. price, length); the agents negotiate contract parameters based on network rules and user consent to predefined parameters
- An extendible smart contract framework allows for dynamic contracting between AI-enabled IoT devices; these contracts can be queried, read, defined and accepted by AI (subject to user and system constraints)
- IoT devices perform edge inference to find the Pareto optimal outcome for both parties; periodically, models are updated via federated learning through a central cloud platform, based on multiple transactions across the network
- Ultra-low-latency and high-bandwidth 5G networks carry messages directly between devices, facilitate interaction with cloud services (e.g. contract library) and create secure end-to-end trusted connection for machines to transact

Growth of machine-based payment demand and favourable policy developments are creating the potential for institutions willing to invest in protocol design to capture large payment volumes

Reinforcing trends

Demand for M2M payments is growing, exemplified by strong market growth

- The IoT payments market, which includes sensors that facilitate per-mile insurance payments, voice assistants with a payment card on file, and other similar devices, is set to reach $410 billion by 2023.[1]

Global advances in governing payment service providers is creating the required conditions (third-party, autonomous initiation) for M2M payments acceptance

- As part of global open data and payments modernization initiatives, third-party payment providers in many jurisdictions have been granted latitude to initiate payments based on consumer consent; in the UK and EU, Open Banking and PSD2 (respectively) have rolled out this feature, while the New Payments Platform in Australia (a payments modernization initiative) allows for third-party initiation directly on the payment rail.[2]
- The German regulator BaFin gave explicit regulatory approval for a 2019 joint pilot project by Commerzbank and Daimler (an automotive manufacturer) to develop a blockchain-based currency wallet and payment platform that handles automated, M2M payments.[3]

Interest from large fleet-management organizations is spurring early investments

- Organizations that manage large logistics operations (e.g. commercial vehicle fleets) will likely be among the earliest adopters of this protocol. An early use case for this market segment includes rooting out fraud and simplifying billing and expense management. These operators are working with start-ups like CarIQ on developing proofs-of-concept for M2M payments.[4]

Financial institution impacts

Cost drivers

- Development of applications (e.g. wallets, digital tokens) that facilitate value exchange on the protocol
- Insurance scheme to make customers whole in case of AI agent making improper choice or malicious exploitation of smart contract

Revenue drivers

- Drives broad increases in overall transaction volume for multiple parties; revenue may flow to payment providers (credit/debit) from transaction processing fees, while infrastructure developers may charge a small, volume-based usage fee

Operational impacts

- Implementation of rigorous contract auditing and fraud monitoring processes, and an auditable dispute resolution process
- Automated customer service to minimize human involvement in M2M transactions

Many early examples are being observed in the transport and mobility space, as providers test out new payment rails, consent and identity mechanisms, and data standards

Early experimenters

CarIQ, which recently closed a $5 million Series A funding round from Citi Ventures, among others, has developed what they call a "vehicle payment gateway" – while the product is still in the proof-of-concept stage, it will ultimately allow commercial vehicles to connect to standard payment networks, authenticate themselves based on IoT data, and pay for services. In the fleet management space today, this could help eliminate the cost of reimbursing employees for vehicle-related expenses (e.g. truck-drivers refueling their rigs); in the future, it will likely be a key enabler of autonomous fleets.[4]

Visa and **Mastercard** are both pursuing IoT payments initiatives as part of their long-term strategies; for instance, the Visa Ready tokenization service allows Visa credit cards to be integrated with digital wallets to tokenize payments made through IoT devices; Mastercard, on the other hand, has partnered with Sonic (a fast-food chain) to develop an "AI-enabled voice ordering and recommendation system", which could one day enable a fully autonomous food-delivery service.[5, 6]

Necessary conditions

Modern payment rails and low costs

Requires modern and flexible payment rails that are able to process small-dollar transactions at near-zero costs and allow for application development by third-parties wishing to provide services on top of the protocol.

Asynchronous payment consent

Regulation must allow for third-party providers to make payments on behalf of users, for payments to be made asynchronously from instruction, and for consent to be given to broad parameters vs for every transaction.

Machine identity

A robust identity platform that grants each machine on the network a tokenized "machine identity" that is ultimately linked to the identity of its beneficial owner, will ensure that payments are authorized appropriately.

Contract and messaging standards

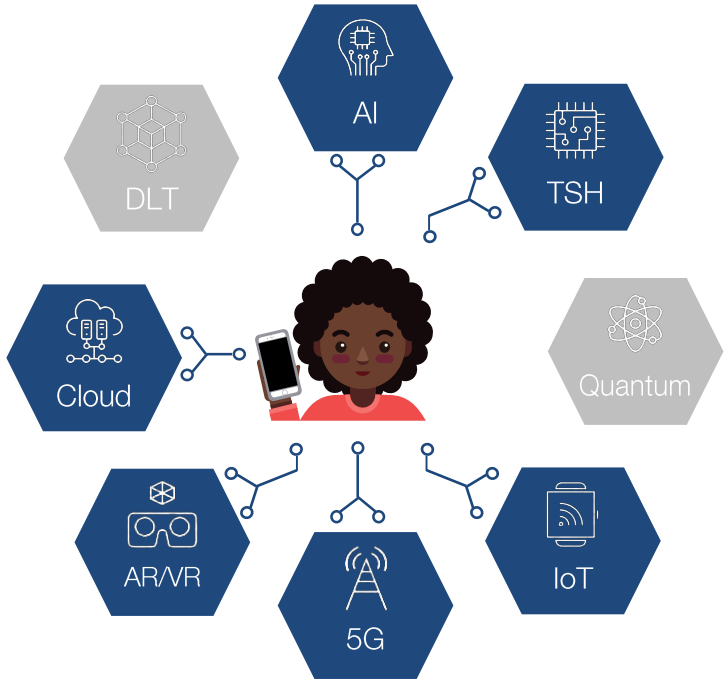
Standardization of payment messaging and contract terms is vital, as M2M systems across industry, manufacturer and jurisdictional boundaries must be able to communicate seamlessly.

Augmented purchases

Augmented purchases refers to a frictionless shopping experience delivered through AR that provides contextual access to product data and intuitive transaction execution

Key takeaway	Emerging technologies could equip shoppers with access to real-time, contextual product information and a seamless checkout experience.

Emerging technologies



The new user experience

Early Saturday morning, Kim is watching a movie starring her favorite actress. In the opening scene, she notices the outfit the actress is wearing and wishes she could buy it for herself. Kim unlocks her smartphone and opens up an AR application that allows her to scan the outfit appearing on the screen.

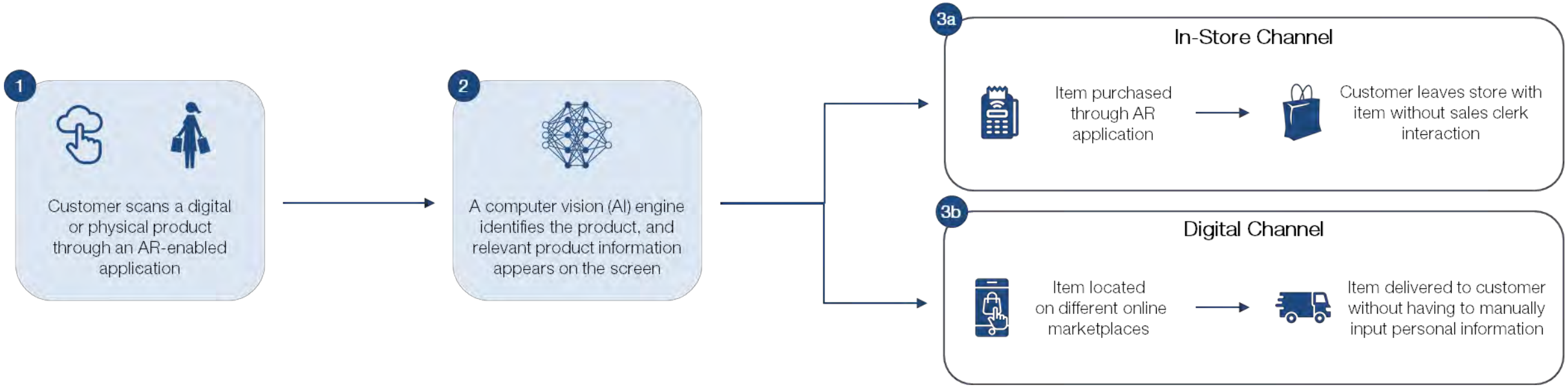
An algorithm scans the image and recommends either the exact outfit or similar pieces. The application also identifies the price, customer ratings, similar/complementary products, and other useful product data. With a biometric scan of her face (to prove it is truly Kim attempting to make a purchase), Kim charges the outfit to her stored credit card and the outfit is shipped to her home.

Later that afternoon, Kim decides to go to the mall. She is looking to buy a pair of shoes that have been sustainably sourced. Kim walks into a department store and opens up an app that lets her scan the shoes in front of her to access information about them.

After finding a pair she liked with an adequate sustainability rating, Kim scans her face again; her mobile phone sends an automatic notification to the store's POS, which processes the transaction. Without interacting with a sales clerk, Kim walks out with the product.

Whether the customer is browsing a physical product or a virtual one, they are easily able to bring up relevant product data and purchasing options

Process flow



Assembling the technologies

Infrastructure	Cloud computing 5G networking
Core	AI IoT AR/VR
Complementary	Task-specific hardware

- Through the camera on the user's IoT-enabled AR/VR device (e.g. mobile phone, glasses), an AI computer visioning algorithm (supported by advanced task-specific hardware that supports on-device inference) scans the product being displayed to identify patterns and categorize the item by drawing on cloud-based product databases
- Powered by the ultra-reliable low latency of 5G, AR technologies are able to quickly retrieve and overlay transparent displays of important data (e.g. price, sustainability information, comparable products etc.) about the product to the customer via the device
- If the customer decides to purchase the product after reviewing the information displayed on the AR overlay, biometric authentication (e.g. retinal scanning, voice authentication) supported by AI identifies the customer is who they say they are, and then automatically processes the payment by connecting to stored payment information

As improvements to the technology and software supporting AR/VR slowly increase its market ubiquity, innovative payments providers can capture new revenue streams

Reinforcing trends

The hardware and software behind AR/VR is improving significantly and will propel its ability to support advanced use cases

- While many contemporary smartphones support early AR/VR applications, advanced spatial sensors that can pinpoint a device's location down to the centimeter and quickly develop accurate 3D-models of their surrounding are expected to become a key part of smartphone hardware in the near future[1]
- The development of the ARCloud is one of the major driving forces behind the proliferation of AR technologies. The ARCloud overlays an augmented world over physical surroundings (e.g. data about a product in a store)[2].

The increased proliferation of 5G networking will provide necessary data throughput to support AR/VR

- At the time of writing, over 12,000 cities globally have had commercial roll-out of a 5G network[3]
- 5G's ultra-reliable low-latency communications will equip AR devices with the ability to process and transmit large amounts of data to the cloud with limited delay[4]

The development of consumer applications across industries is beginning to accelerate as developers make significant hardware improvements

- Historically, AR/VR user interfaces have been clunky and difficult to use. Recent advances in hardware have dramatically improved the user experience, and the technology has since seen success across multiple different industries, including financial services, manufacturing, and healthcare[3]
- For instance, Citibank recently leveraged the Microsoft HoloLens virtual reality device to provide traders with 3D visualizations of trading information, allowing them to manipulate complex data to derive better insights[5]

Financial institution impacts

Cost drivers

- A payment provider (e.g. card issuer) may look to develop the product scanning application as a means of building a new customer touchpoint, or build a payment token service and API payment initiation integration into third-party applications

Revenue drivers

- If the product scanning application is developed by a payment provider (e.g. card issuer), they may also earn additional per-sale revenue by allowing specific merchants/marketplaces to appear higher in product search results

Operational Impacts

- If a payments provider builds the augmented app, they must take on partnership development with retailers to accurately retrieve product data, and build out a dedicated app development and front-end UX function

Embedding payments into augmented reality is a natural evolution, but will require deep ecosystem participation from financial and non-financial players

Early experimenters

Over 75% of the user-base of the popular social media application **Snapchat** engage with the application's in-built AR tools every day. This number increased during the COVID-19 pandemic, and Snapchat saw a 37% increase in "snaps" sent with AR filters in March compared to February 2020. Snapchat also noted that the use of sponsored lenses increased by 18% as the crisis developed. The company continues to expand its AR options for advertising (e.g. logo identification) and e-commerce usage.[1]

Apple first implemented the Quick Look AR tool, which allows users to view virtual objects, in 2018 with limited uptake. Recently, however, they have updated the technology to allow consumers to view and purchase products directly through the AR preview in Quick Look. Broadly, the company is reported to be making significant investments in the AR space and clearly believes in its long-term viability. This belief will further enable the technology to grow as it is introduced to millions of consumers simultaneously via iOS products.[7]

Necessary conditions

AR/VR ubiquity

A critical mass of consumers must have the means to access a cost-effective AR device (likely a smartphone in the short term) and AR must be well-integrated into consumers' daily lives.

Retailer/marketplace cooperation

Retailers and online marketplaces will be responsible for building an integration layer between their product databases and product scanning applications, which may be a significant undertaking.

Successful 5G rollout

An immersive and responsive AR overlay is dependent on the successful and scaled rollout of 5G; this will ensure that significant amounts of information can be transferred to and from the AR device.

Ability to render product attributes

The use case depends on the ability to accurately convey key product attributes to customers (e.g. reviews, promotions), which will likely require integrating product data from multiple sources.

References

Payments

1. Kumar Ram, "How M/A is driving consolidation in the fragmented payments industry", *Medium,* 16 July 2019, https://medium.com/@ramkumar1984.rajachidambaram/how-m-a-is-driving-consolidation-in-the-fragmented-payments-industry-d7d28b213719
2. Black Dondi, "What the FIS and Worldpay Merger Means", *FISGlobal,* 22 October 2019, https://www.fisglobal.com/insights/what-we-know/2019/october/what-the-fis-and-worldpay-merger-means
3. Visa, "Visa to Acquire Plaid", 13 Jan 2020, https://usa.visa.com/about-visa/newsroom/press-releases.releaseId.16856.html
4. Verhage Julie and Surance Jennifer, "Big Tech Is Coming for Banking: Experts Predict Fintech's 2020", *Bloomberg,* 23 December 2019, https://www.bloomberg.com/news/articles/2019-12-23/big-tech-is-coming-for-banking-experts-predict-fintech-s-2020
5. Barclays, 2020, https://cards.barclaycardus.com/?p=uber
6. Rolfe Alex, "Realtime payment offer immense potential for banks and FinTechs globally", *Payments Cards & Mobile,* 19 November 2019, https://www.paymentscardsandmobile.com/realtime-payments-offer-immense-potential-for-banks-and-fintechs/
7. Hunt Rachel, "Local Perspectives: Real-Time Realities Across Asia-Pacific in 2019", *ACI Worldwide,* 18 March 2019, https://www.aciworldwide.com/insights/expert-view/2019/march/real-time-payments-across-asia-pacific-money2020-asia
8. Cox David, "How the U.K.'s rollout of Confirmation of Payee combats fraud despite delays", *PaymentsSource,* 2 July 2020, https://www.paymentssource.com/news/how-the-u-k-s-rollout-of-confirmation-of-payee-combats-fraud-despite-delays
9. Rolfe Alex, "Authorised Push Payment Fraud (APP Fraud): The perfect storm", *Payments Cards & Mobile,* 6 January 2020, https://www.paymentscardsandmobile.com/authorised-push-payment-fraud-app-fraud/#:~:text=In%20the%20UK%2C%20one%20of,and%20reached%2084%2C624%20in%202018
10. Aron Zachary & Scala Megan & Guigui Ulrike, "Getting ahead of the curve", Deloitte, 26 February 2020, https://www2.deloitte.com/us/en/insights/industry/financial-services/consumer-payment-survey.html
11. Ibid.

Machine to machine payments

1. Payments Next (2018), IoT Payments a novelty now but will reach $410 billion by 2023. http://paymentsnext.com/iot-payments-410-billion-by-2023/
2. Deloitte (2019), Open Banking: Payment initiation – completing the vision. www2.deloitte.com/content/dam/Deloitte/au/Documents/financial-services/au-fsi-deloitte-open-data-banking-payment-060120.pdf
3. FinTech Futures (2019) Commerzebank tests blockchain payment solution with Daimler trucks. www.fintechfutures.com/2019/08/commerzbank-tests-blockchain-payment-solution-with-daimler-trucks
4. CarIQ (2019) Car IQ secures $5 million in series A funding to accelerate growth of autonomous payment gateway for vehicles. http://www.gocariq.com/news/
5. Pymnts (2020) Card Ecosystem Elevates Its Value Prop For Corporates. https://www.pymnts.com/news/b2b-payments/2020/card-ecosystem-elevates-value-prop-for-corporates
6. Visa, "Visa Ready and IoT Payments", Accessed 28 Jul 2020, https://usa.visa.com/visa-everywhere/innovation/visa-ready-and-iot-payments.html

References

Augmented purchases

1. Caddy Becca, "What Apple's U1 chip tells us about its future AR and smartwatch plans", *Wareable,* 4 October 2019, https://www.wareable.com/apple/apple-u1-chip-guide-ar-apple-watch-wearables-7667
2. Forbes (2020) The five biggest virtual and augmented reality trends in 2020 everyone should know about. www.forbes.com/sites/bernardmarr/2020/01/24/the-5-biggest-virtual-and-augmented-reality-trends-in-2020-everyone-should-know-about
3. Verdict (2020) Augmented reality technology trends. https://www.verdict.co.uk/augmented-reality/
4. SpeedTest (2020) Ookla 5G map. https://www.speedtest.net/ookla-5g-map
5. Finextra (2016) Citi taps Microsoft HoloLens for VR trading. https://www.finextra.com/newsarticle/28712/citi-taps-microsoft-hololens-for-virtual-reality-trading
6. Social Media Today (2020) Snapchat provides tips for creating effective AR experiences as lens usage increases. https://www.socialmediatoday.com/news/snapchat-provides-tips-for-creating-effective-ar-experiences-as-lens-usage/576211/
7. The Verge (2020) Apple now lets you shop directly in AR. https://www.theverge.com/2020/2/14/21138536/apple-ios-ipad-os-quick-look-ar-augmented-reality-shopping-apple-pay

Insurance

The insurance sector includes institutions that provide protection against uncertain future events by externalizing and pooling different types of risk (e.g. property, life, health)

Trends

Low interest rates and stagnant market growth has incumbents investing more in newer technology, like AI, to **decrease costs** and meet customer demands.[1]
A 2019 study reveals that around 50% of insurers are planning on new system investments.[2]

The **increase in natural catastrophes** has **widened the protection gap,** driving incumbents to **consider new product expansion.**[3]
For instance, 50% of economic losses from natural disasters were uninsured in 2018.[4]

The increased number of direct-to-consumer offerings has **diminished consumer loyalty**, prompting incumbents to **go beyond core product offerings.**[7]
Belfius, a Belgian insurer, recently launched Jaimy, a platform that connects individuals with home improvement professionals.[8]

To combat the **historically slow-moving industry pace of change**, incumbents have continued to partner with insurtechs, **driving substantial cultural and technological change.**[5]
2019 was a record year for the insurtech space, with $6.37 billion projects funded.[6]

Use cases

Customers are demanding more transparent, digital, and personalized insurance experiences; the following two use cases were prioritized because they address these customer needs and are feasible given technology development:

1 Dynamic life + health insurance

An integrated life and health product that proactively serves the customer by collecting real-time data as they engage in everyday activities; this improves the insurance company's risk analysis, allowing for dynamically priced products and personalized customer rewards.

2 Connected post-claims experience

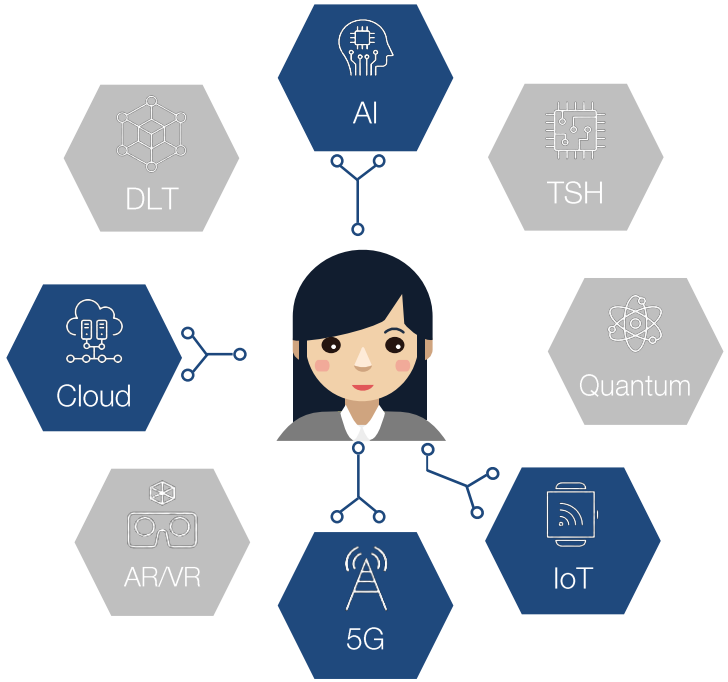
A post-claims experience created through a connected ecosystem of product/service providers that creates a differentiated claim-handling process to drive customer loyalty and increase back-office efficiency.

Dynamic life + health insurance

Dynamic Life + Health insurance refers to a blended product that proactively collects real-time data as the customer engages in everyday activities to improve risk analysis and personalize rewards

Key takeaway	A dynamic life and health offering could help align incentives between the insurer (from better risk management), the consumer (from a healthier lifestyle) and other third-parties in the ecosystem (from increased sales).

Emerging technologies



The new user experience

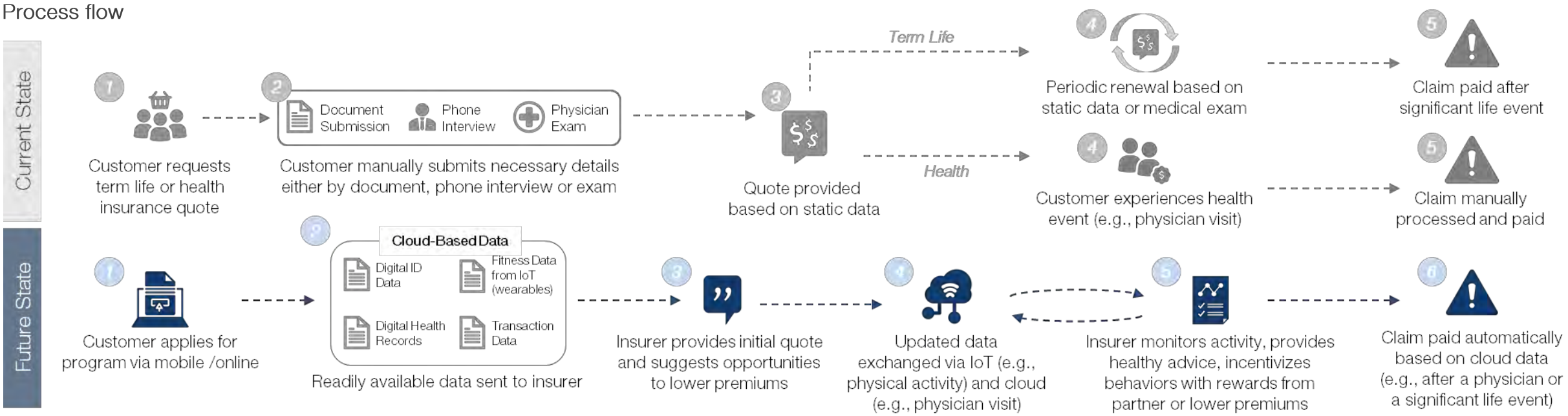
Emily is shopping for groceries when she receives a push notification on her mobile phone from her grocery app. The push notification suggests that, by purchasing a healthier grocery basket, Emily can earn rewards from her insurance provider. Emily decides to purchase the healthier groceries and share data from her purchases with her insurer.

Later that day, Emily's fitness tracker notifies her that she earned additional rewards from her insurer for meeting her weekly fitness targets and sharing this data with her insurer. Emily can redeem these rewards for personalized benefits from a network of companies that the insurer is partnered with (e.g. at-home equipment from a popular fitness brand, or healthy treats from a popular grocery chain) or bank the rewards for future use.

A few days later, Emily goes to her routine dentist appointment and her insurer is automatically notified and pays for the cost of the appointment. At the end of the month, Emily receives a progress update from her insurer that states the total rewards she earned and a (potentially lower) life insurance premium. Emily also receives personalized tips for how she can live a healthier life (and earn additional rewards) next month.

Two previously separate products (term life and health insurance) become a holistic offering for consumers by breaking down data siloes to improve pricing and reward healthy behaviours

Process flow



Assembling the technologies

Infrastructure	Cloud computing 5G networking
Core	AI IoT
Complementary	N/A

- The customer applies for the programme once and creates a detailed profile that is stored in the cloud, eliminating the degree of manual entry for the customer every time they need to file a claim
- The customer's profile is automatically updated via information flows from 5G-powered IoT devices (e.g. smart watches, smart health devices) as the customer engages in different activities (e.g. grocery shopping, fitness classes, medical visits)
- AI algorithms derive meaningful insight about the customer that allows the insurer to improve risk analysis and product pricing while providing personalized recommendations to help them live a better life and receive tailored rewards
- API-based connections with rewards partners means that the customer can be offered highly relevant rewards (e.g. discounted groceries) dynamically, based on past behaviour or to incentivize future behaviour

Competitive pressures and increased sensor ubiquity are creating opportunities to engage in more fine-grained risk analysis, and leverage partner ecosystems to reward healthy behaviours

Reinforcing trends

Customers are willing to share detailed information with insurers on an ongoing basis

- Customers are willing (and expect) to share data with insurers through digital channels to access better pricing. For instance, a recent survey found that more than two-thirds of customers said they would attach a sensor to their car in exchange for lower premiums.[1]

Insurers are facing competitive pressures to innovate on multiple fronts

- Insurers are beginning to realize the benefits of embedding AI into front/middle/back office operations. This is dramatically reducing operational costs, allowing funds to be redirected to other organizational efforts. Some predict that, by 2025, 95% of all customer interactions in insurance will be powered by chatbots.[1]
- The entrance of non-traditional players (e.g. insurtechs, digital intermediaries) who do not carry technology debt are increasing the need for incumbents to invest in digital to maintain customer satisfaction.[1]
- Many customers believe that modern insurance products are rigid, complex and difficult to understand. It was recently revealed that one-in-four people in the US avoided medical treatment as a result of uncertainty over their health coverage.[2]

Insurers are struggling with new risk pooling challenges

- As customers become more informed about their individual risk levels and healthy individuals opt-out of life insurance, some insurers may struggle to price appropriately as a result of adverse selection. As a result, accurately predicting cash flows becomes more difficult.[3]

Financial institution impacts

Cost drivers

- Increased costs related to developing or contracting (e.g. via an MGA) connectivity, data storage and data analysis capabilities
- Cost of building a customer advisory capability, powered by both human and bot advisers

Revenue drivers

- Increased upsell and cross-sell opportunities as a result of improved data management and analysis capabilities
- Increased customer loyalty as a result of a more digital and personalized offerings (e.g. rewards, advice)

Operational impacts

- Cross-ecosystem data streams will need to be integrated to understand all customer activities that impact the customer's risk level
- Shift from a low-touch, reactive organization to a high-touch, predictive organization

Insurers are building ecosystems of devices and reward partners to develop offerings that go beyond simple coverage, but much rests on the outcome of ongoing debates about consent

Early experimenters

Manulife recently partnered with Discovery Health to launch Vitality, which tracks customer health based on personalized physical and mental assessments. By participating, users win prizes (e.g. gift cards) for reaching wellness goals. In alignment with the launch of their life insurance app, Manulife (along with several other large insurers) signed a pledge to make 100 million people more active by 2025.[4]

Dialdirect launched its Driving App in 2017 to monitor customers' driving behaviours and offer insurance premiums back in cash for low-risk drivers. The company's phone-based IoT sensors watch for harsh braking, speeding, phone usage and night-time driving. According to the company, 71% of the top 5,000 regular users have improved driving scores by ~30% since launch. The growing use of sensors to monitor driving behaviour serves as a great example of both customer and institutional comfort with using IoT sensors to improve pricing.[5]

Necessary conditions

Customer trust to personal data

Some consumers may perceive the deep personalization to be overly invasive; others may not want their information used to iteratively price their insurance products

Ecosystem participation

Insurers will need to collaborate with a wide range of other industries (e.g. retailers, wellness, travel) to capture a range of data to form a holistic view of their customer

Regulatory receptivity

Insurers must be allowed to collect and use personal customer data with customer consent, and provide mechanisms to rescind; regulators will also have to ensure fair pricing and equal access opportunities

Access to new data types

NEW

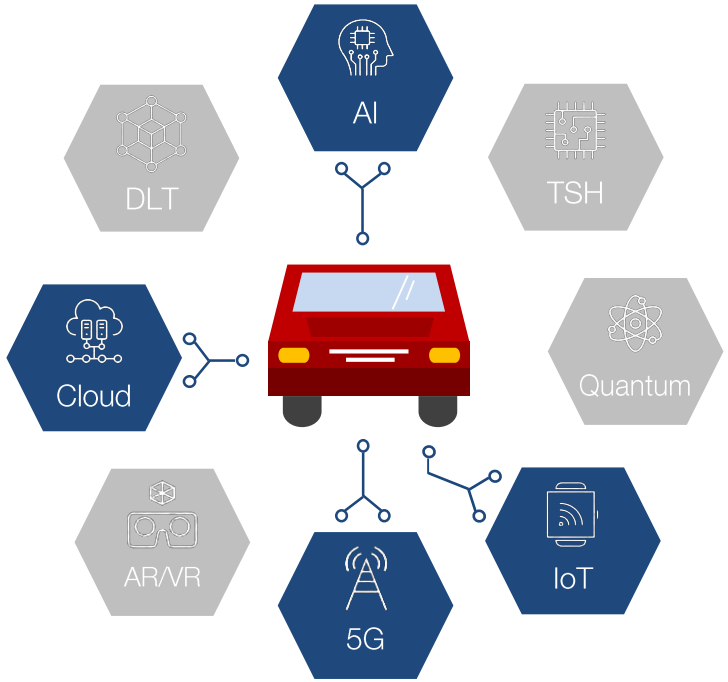
In order to price insurance policies with increased accuracy and personalization, insurance companies may look to access data they previously could not use (e.g. genetics)

Connected post-claims experience

Insurers are connected to an ecosystem of product and service providers in order to automatically assess, process and fulfil claims, minimizing policyholder effort

Key takeaway	Customers could benefit from proactive signals from their insurer to help mitigate loss where possible or, in the event of loss, seamlessly receive claim benefits while avoiding complicated claim-filing processes.

Emerging technologies



The new user experience

On John's way home from work, he gets rear-ended by another vehicle as he is stopped at a red light. His insurance company, ConnectCo, is notified of the accident based on sensors that John has embedded in his car (e.g. speed, g-force value, airbag deployment, fluid levels).

Based on their analysis of data collected through the IoT sensors, ConnectCo is able to gauge the extent of damage and determines that it is not a serious accident.

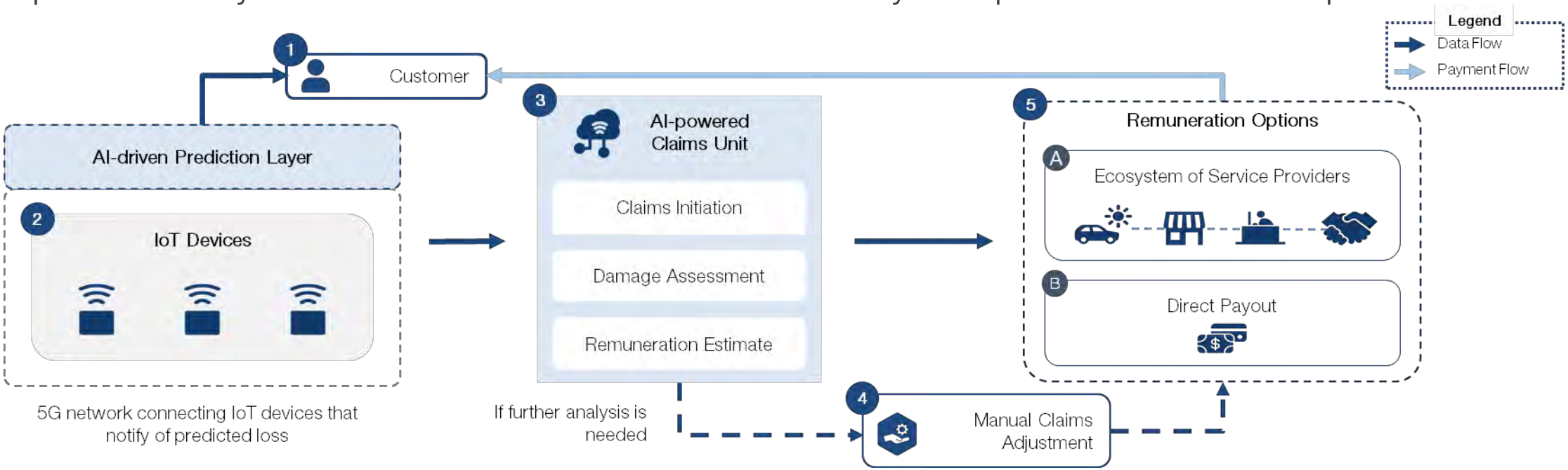
ConnectCo maintains a number of cross-industry partnerships through an approved supplier network and leverages them to provide immediate services related to the accident.

For instance, John is notified by ConnectCo that there is a tow-truck on the way, and a body shop appointment booked for the next day.

A partnership with a popular ride-hailing platform allows John to book a ride home while a partnership with a car rental company automatically reserves a car for John for the next day.

IoT helps deliver preventative advice and assess losses, while API connectivity between insurers and a broader partner ecosystem allows claims to be initiated directly with product and service providers

Process flow



Assembling the technologies

Infrastructure	Cloud computing
Core	AI IoT
Complementary	5G networking

- Sensors embedded in, around and within assets (including homes, vehicles, electronics, big-ticket items) transmit data to the insurer's cloud through modern networking rails (e.g. Wi-Fi, 5G) for storage and analysis, where an AI-driven prediction layer is used to warn customers of impending loss so they can take remediating action if possible
- If a loss occurs, AI can help assess the severity of loss/damage (based on data transmitted to the cloud) and accurately price a claim without significant human intervention (and/or provide a claim adjuster with a relevant estimate if further analysis is required)
- 5G plays a role in connecting devices even if local networks (e.g. Wi-Fi) have been taken down due to damage
- Cloud and robotic process automation help facilitate API-based communication with partners to send autonomous requests (e.g. sending request to an auto body shop to make a same-day assessment and repair booking)

Digitized claims are improving efficiency and remediating dissatisfaction; liaising directly with recipients of claims funds (i.e. product/service providers) can drive further cost savings and better experiences

Reinforcing trends

Digital and connected claims processes are driving efficiency to lower operating costs

- A study of insurers concluded that digitally transforming the claims experience can drive marked gains in efficiency (expense reduction of 25%-30%) from lower-touch claims handling and reduced back-office spend.[1] This is especially important, as claims handling can account for up to 15% of net earned premium.[2]
- According to benchmarking analysis by SAP, maintaining an approved supplier network could help insurers achieve a 33% lower cost of procuring claims (while providing superior customer experiences) and reduce spend on outside suppliers by 70%.[3]

Customer churn rates are rising as switching becomes easier and clients are drawn to user-friendly, digital experiences

- As incumbents and insurtechs alike develop and upgrade digital platforms, customers are finding it easier to switch among providers. Over the past few years, customer churn has increased across P&C lines (including an 11% churn rate in auto insurance in 2019).[4]
- With the upcoming launch of Haven (a joint Amazon-JP Morgan-Berkshire Hathaway initiative), it is clear that "big tech" firms – experts in connected ecosystems – are interested in the insurance space.[5]
- Multiple studies have shown that a significant percentage of millennials would purchase insurance from a non-incumbent, with preference for big tech firms like Amazon or Google.[6,7]

Current claims management experiences are driving customer dissatisfaction

- Globally, the claims management experience is one of the biggest drivers of customer dissatisfaction. A ResponseTek analysis found that the Net Promoter Score of insurers dropped from +4 to -49 between the researching/purchasing and claims management stages of the customer journey.[8]

Financial institution impacts

Cost drivers

- Increased costs to develop and maintain partnerships and create an ecosystem of trusted providers (e.g. potential revenue-sharing with partners)
- Lower claims costs as partnerships help insurers access preferred pricing/volume discounts

Revenue drivers

- Increased loyalty in an environment where switching is easier, especially with consumers who are used to seamless digital experiences
- licence to increase premiums as customers see the value of having a turnkey solution in a loss event

Operational impacts

- Requires deep collaboration and data-sharing across the organization, (e.g. claims, corp. dev., underwriting)
- As AI assesses most basic loss events, adjuster role will require more specialized experience and may become more relationship-focused

Insurers are beginning to leverage emerging technologies and ecosystem connectivity to experiment with verified partner networks and instant claims verification

Early experimenters

Control€xpert, a German claims verification business working with insurers, leasing companies and automotive dealers, uses AI to analyse images of auto accident damage to assess damage severity and repair costs; its Adaswatch product also connects insurers to verified body shops to simplify and verify certain aspects of the repair and invoicing process for windshield repairs.[9]

Lemonade, a US insurtech, operates a chatbot-based claims management system that allows policy-holders to file claims directly from their mobile device for homeowner, rental and pet insurance – 30% of its users receive instant approval and payout of their claim based on AI-analysis of user-submitted data (e.g. a video explaining the loss event, receipts to prove purchase). Instant claims verification is a necessary pre-condition of this use case, as it allows the customer to be connected with value-added products and services without significant post-loss delay; such verification can be further improved through verified IoT data that can help prove loss.[10]

Necessary conditions

Ecosystem development

Requires curation of a value-added ecosystem of partners that are involved in an outsized proportion of claims cases (e.g. roadside assistance, rental agencies, technology retailers)

Modern technology stack

Real-time, on-demand digital connectivity between the insurer, policy-holder and service provider demands a flexible technology stack and careful platform integration

Ubiquitous sensor deployment

Digital-first notification of loss and claims verification is only as good as the technology available in detection and monitoring; sensors must be ubiquitous in order to accurately detect and compensate for losses

Contextual preferences

If customers grant insurers access to their banking data, AI analysis of customer transactions can help the insurer further personalize the experience for their customers (e.g. driver's preferred autobody shop)

References

Insurance

1. Friedman & Gokhale & Canaan & Ashani, "2020 Insurance Outlook", Deloitte, *3* December 2019, www2.deloitte.com/us/en/insights/industry/financial-services/financial-services-industry-outlooks/insurance-industry-outlook.html#regulating-the-insurer
2. "IT Spending for 2020", *Insurance Canada,* 3 October 2019, https://www.insurance-canada.ca/2019/10/03/novarica-insurer-cio-study-it-spending/
3. Santenac & Majkowski & Peters & Manchester, "2020 Insurance Outlook", EY, 2019, https://www.ey.com/Publication/vwLUAssets/Insurance_outlook/$FILE/ey-global-insurance-outlook.pdf
4. "The natural disaster of 2018 in figures", *MunichRE,* 1 August 2019, https://www.munichre.com/topics-online/en/climate-change-and-natural-disasters/natural-disasters/the-natural-disasters-of-2018-in-figures.html
5. Grzadkowska Alicja, "Hunting for the right insurtech partnerships is no easy feat", *Insurance Business Magazine,* 16 October 2019, https://www.insurancebusinessmag.com/us/news/technology/hunting-for-the-right-insurtech-partnerships-is-no-easy-feat-180685.aspx
6. "2019 InsurTech investment reaches all-time high with 1/3 of historical total", *Intrado GlobeNewWire,* 30 January 2019, https://www.globenewswire.com/news-release/2020/01/30/1977329/0/en/2019-InsurTech-investment-reaches-all-time-high-with-one-third-of-historic-total-almost-2-billion-invested-in-Q4-alone.html
7. Rush & Buesnel & Sparshott & Montalbo & Walsh, "A demanding future", Deloitte, 2019, https://www2.deloitte.com/content/dam/Deloitte/uk/Documents/financial-services/deloitte-uk-insurance-trends-2019.pdf
8. Ben-Hutta Avi, "Belfius & Beyond", *Coverager,* 11 October 2018, https://www.coverager.com/belfius-beyond/

Dynamic life and health

1. Policy Advice (2020). *Insurance Industry Trends 2020: Growth, Stats, and Forecast.* https://policyadvice.net/blog/insurance-industry-trends/
2. Policy Genius (2019). Health Insurance Literacy Survey 2019. https://www.policygenius.com/blog/health-insurance-literacy-survey-2019/
3. Deloitte analysis
4. Financial Post (2019). *Manulife's insurance app rewards healthy lifestyles but also raises 'health surveillance' concerns.* https://business.financialpost.com/technology/tech-news/manulifes-insurance-app-rewards-healthy-lifestyles-but-also-raises-health-surveillance-concerns
5. Dial Direct, accessed 2020. https://www.dialdirect.co.uk/carinsurance/

Connected post-claims experience

1. McKinsey & Company (2018). Claims in the digital age: how insurers can get started. https://www.mckinsey.com/industries/financial-services/our-insights/claims-in-the-digital-age
2. Kumar Shishir, "Global Best Practices in Insurance Claim Cycle Time & Leakage", *Insurance and Risk Management,* 2010, http://www.revueassurances.ca/wp-content/uploads/2016/01/2010_78_no1_2_Kumar.pdf

References

3. Digitalist Magazine (2019). *Digital, fully automated claims is not a 2030 dream – it's possible today.* https://www.digitalistmag.com/customer-experience/2019/04/10/digitally-fully-automated-claims-is-not-2030-dream-its-possible-today-06197774
4. Bain (2019). *Insurers: how to lead in the new era of connectivity.* https://www.bain.com/insights/insurers_how_to_lead_in_the_new_era_of_connectivity/
5. GeekWire (2019). *Amazon and JPMorgan to roll out new health insurance plans as part of Haven joint venture.* https://www.geekwire.com/2019/amazon-jpmorgan-roll-new-health-insurance-plans-part-haven-joint-venture/
6. Kabaivanova Angelika, "How Millennials will change the insurance industry forever", *Fadata,* 9 November 2018, https://www.fadata.eu/blog/why-modern-consumer-behaviour-is-forcing-the-insurance-industry-to-change
7. Bain (2019). *Insurers: how to lead in the new era of connectivity.* https://www.bain.com/insights/insurers_how_to_lead_in_the_new_era_of_connectivity/
8. ResponseTek. *Whitepaper: customer feedback in the global insurance industry.* https://www.responsetek.com/whitepaper-customer-feedback-global-insurance-industry/
9. Control Expert (2020). https://www.controlexpert.com/de-de/
10. Lemonade, accessed 2020. https://www.lemonade.com/claims

Capital markets

The capital markets sector includes companies involved in the buying and selling of financial securities (debt, equities, derivatives etc.)

Trends

KYC requirements have become increasingly complex due to new regulation and the growing sophistication of criminals, leading banks to invest in **automating client onboarding** processes through robotic process automation (RPA).[1]
For instance, Danske Bank has reduced onboarding time from 30 minutes to a few seconds through RPA.[1]

Globally, policy-makers have renewed interest in studying the implications of CBDCs as **China prepares to launch its own digital currency in late 2020.**[2]
The US Federal Reserve, for instance, recently remarked on the possibility of a FedCoin.[3]

Institutions have **continued to heavily invest in cybersecurity infrastructure** as the **financial** and **non-financial consequences** of a breach have **dramatically increased in recent years.**
The average cost of a cyberattack for a bank is $18.4 million, an increase of 11% from 2017.[4]

Globally, investment banks have begun to engage in **operating model rationalization and cost-cutting efforts**, facing headwinds from sluggish global growth, low-interest-rate environment, and new sources of competition from asset managers (who are working with companies directly) and direct listings.[5]
Revenues from the 12 largest global investment banks fell nearly 6% over the last three years, leading to a 60 BPS fall in average return on equity across the sector. During the same period, overall full-time equivalent headcounts also fell 8%.[6]

Use cases

The following use cases were prioritized to support capital markets players in their efforts to adopt more data-driven approaches to investing and client service, as well as to improve optimization across different fundamental calculations:

1. **Cross-bank collateral optimization**
   The ability to rapidly allocate collateral in the most efficient way across the entire institution to minimize cost of delivery and transformation costs, using quantum computing and AI.

2. **Quantum trade optimization**
   Applying quantum computing to supercharge the optimization of trading strategies and asset allocation, minimizing the cost and market impact of trading.

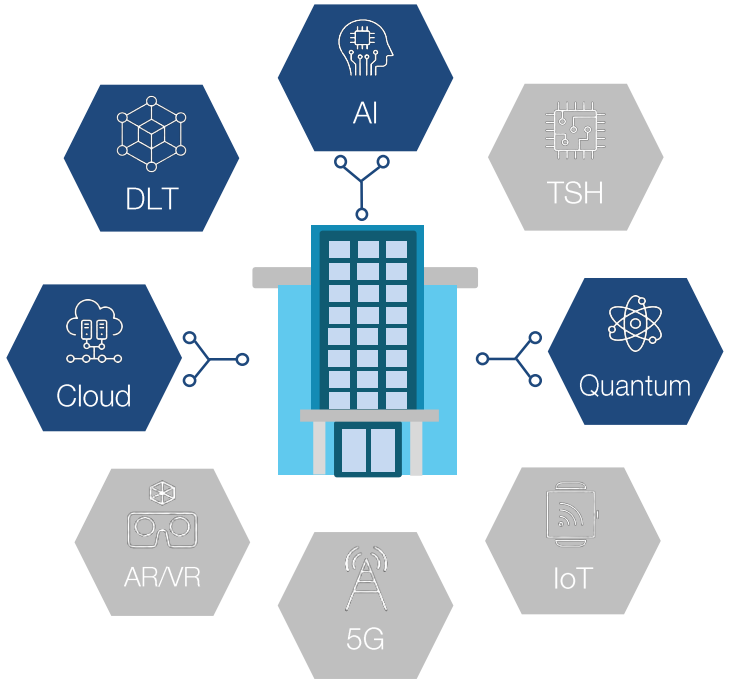
3. **Data-linked green bonds**
   Green bonds that fund sustainable projects linked to trusted sources of data that help monitor sustainability outcomes and can trigger covenant events.

Cross-bank collateral optimization

Cross-bank collateral optimization will equip financial institutions to allocate collateral in the most efficient way across the entire institution, minimizing the cost of delivery

Key takeaway	Quantum's optimization capabilities, accessed through the cloud, could lead to significant savings for financial institutions by remedying suboptimal collateral allocation.

Emerging technologies



The new user experience

XBank had been facing significant cost and regulatory pressures and decided to seek out more efficient ways of managing collateral across the bank to relieve some of this pressure.

Historically, Xbank used a hard-coded system that segregated assets using multiple separate groupings of dealers and maintained excess collateral in different locations across the institution. This resulted in suboptimal collateral allocation.

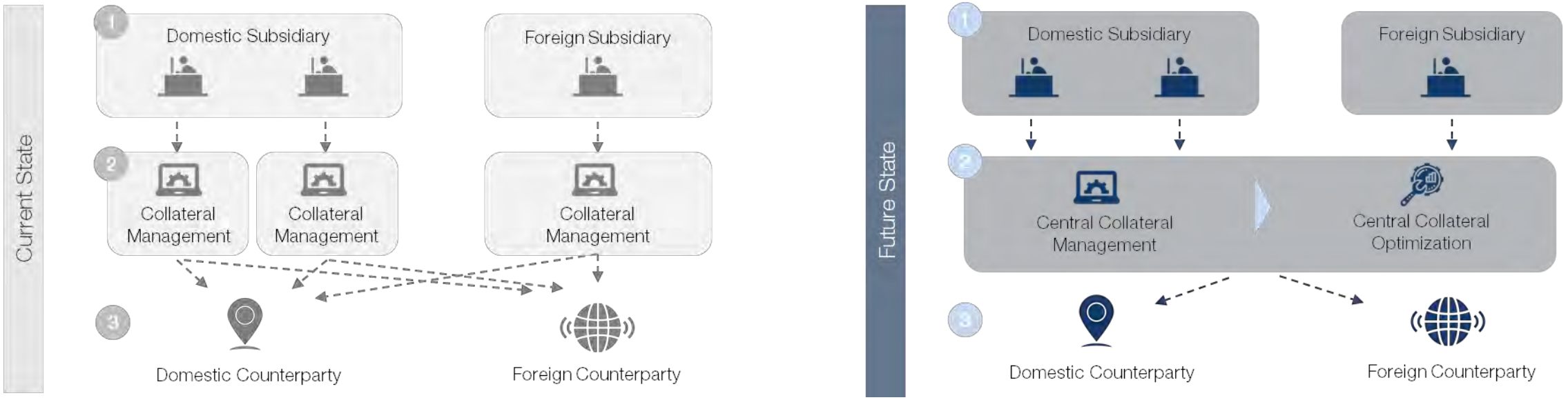
XBank now partners with a "quantum-as-a-service" provider to solve the computationally intensive optimization problem in minutes.

By connecting to a third-party quantum provider via cloud computing, XBank is able to rapidly and cost-efficiently determine how to allocate collateral across the entire institution, while considering many constraints and variables (e.g. cost of capital, liquidity conditions and frameworks).

By using their collateral more optimally, Xbank is able to benefit from cost saving of up to 15 basis points per portfolio.

Quantum computers will be able to optimize against a larger set of inputs, meaning previously siloed collateral management processes could be centralized to obtain a common view of allocation decisions

Process flow



Assembling the technologies

Infrastructure	Cloud computing
Core	AI Quantum computing
Complementary	DLT

- Most institutions will access quantum computational power through third-party providers using cloud-based APIs
- Quantum optimization algorithms (and, in the near-term, hybrid quantum/classical algorithms) solve complex optimization problems with many constraints that are nearly impossible for classical devices. As development progresses, quantum machine learning (AI) algorithms could clean and remove outliers from troves of transaction data before the quantum device completes the optimization operation (e.g. to find cheapest to deliver for collateral transformation)
- More advanced quantum computers could also able to conduct quick “what if” analyses by running rapid simulations (e.g. simulate how certain markets for eligible collateral types will play out)
- If DLT networks that allow for collateral to be tokenized and moved in real-time proliferate, an AI-based collateral management tool could use the probabilistic output of quantum optimization to facilitate real-time collateral movements. Such networks could also help quickly simplify collateral ownership identification along complex rehypothecation chains

Stricter capital and liquidity requirements, as well as increased pressure to deploy capital in revenue generating activities, make a clear case for a more efficient collateral allocation system

Reinforcing trends

Regulatory pressures on collateral maintenance and reporting are heightening

- Revisions to the Basel framework are defining stricter capital and liquidity requirements (e.g. the liquidity coverage ratio)[1], setting higher minimums for high-quality capital reserves. Collateral optimization can help mobilize more liquidity to reduce internal competition for available capital and increase financing for business activities.[2]
- New collateral transparency rules (e.g. EU's Securities Finance Transaction Regulation) will come into force in the next few years. As a result, firms will have to provide detailed reports on collateral received and held. Centralizing collateral management and having cleaned, standardized collateral data will improve compliance.[3]

The business case for optimizing collateral across the institution is becoming more pronounced

- An optimized collateral management system may minimize the costs associated with securing incremental collateral by pinpointing resources available for deployment across global operations. This allows banks to participate in more revenue-generating activities across the institution.[4]
- Several firms are looking deeper into their collateral and understanding that two different lines of stock can have a different value depending on the asset, and that moving an asset from a trade or counterparty to another might be cost-effective.[5]

Quantum computing is becoming more accessible

- Many new players are emerging in the quantum space, making it easier for organizations to design proofs-of-concept, access hardware and analyse outputs.[6] For example, CogniFrame aims to help financial institutions run quantum simulations, connecting them to quantum hardware providers and helping interpret the output to improve financial operations.[7]

Financial institution impacts

Cost drivers

- Increased cost to organize and structure data that will feed into the optimization engine
- Cost to access quantum computational capabilities via cloud
- Specialized talent to develop and maintain quantum algorithms

Revenue drivers

- Increased ability to redeploy capital into additional revenue-generating activities (e.g. more secured lending), leading to a higher return on capital
- Increased organizational efficiency by eliminating multiple collateral management ops

Operational impacts

- Real-time insight will give early warnings that could reduce organizational risk
- Drives decreased siloing of decisions made about collateral, as this will come from a central function and be globally optimized

Industry leaders are beginning to experiment with quantum technology to improve collateral allocation and other highly complex use cases, though further development of quantum technology is required

Early experimenters

D-wave partnered with machine learning company CogniFrame to offer collateral optimization services to financial services clients. In this partnership, CogniFrame acts as the financial services operating layer that translates the financial institution's optimization problem to be "quantum ready", sends this information to D-wave's quantum computer, and deciphers the quantum output into useful decision-making information for the financial institution. This improved ability to optimize collateral across the bank has helped clients minimize the cost per trade associated with pre-trade, trade and post-trade processes.[9]

Barclays recently teamed up with IBM to run a proof of concept that leveraged IBM's cloud-based quantum computer to solve the complex problem of transaction settlement. The goal of settlement is to settle as many transactions as possible during the batch window, which today is a computationally intense (i.e. time-consuming) problem to solve. By "plugging in" to IBM's quantum computer, Barclays was able to use their seven-qubit system to optimize settlement much more quickly and efficiently. While this proof of concept is a step in the right direction, there are still many barriers to widespread commercialization (e.g. talent shortage, explainability etc.).[8]

Necessary conditions

Quantum accessibility

Increased accessibility to quantum computation through an active third-party ecosystem is critical; many financial institutions will be neither willing nor able to develop in-house quantum hardware and software (e.g. algorithms)

Increasing cost of capital

If cost of capital continues to broadly increase, institutions will feel heightened profit margin pressure, which will reinforce the need for a better understanding of collateral and efficiency in the allocation process

Regulatory complexity

This solution becomes more compelling as new clearing rules require additional collateral for certain exposures (e.g. liquidity coverage ratio) and new standards for reporting are established

Data aggregation

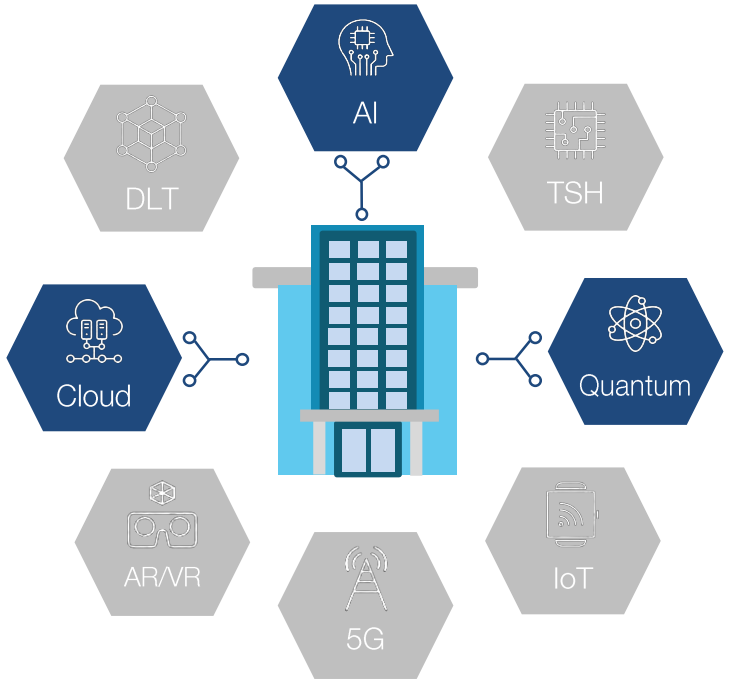
Without a consolidated and accurate view of the relevant collateral data, the AI and optimization algorithms would not be able to provide accurate outputs around collateral allocation

Quantum portfolio optimization

By applying quantum optimization and simulation, institutions supercharge the optimization of trading strategies and asset allocation, minimizing the cost and market impact of trading

Key takeaway	By applying quantum optimization, simulation, AI and cloud computing, institutions will be able to consider a larger set of assets and potential trading strategies to optimize their portfolios in near real-time.

Emerging technologies



The new user experience

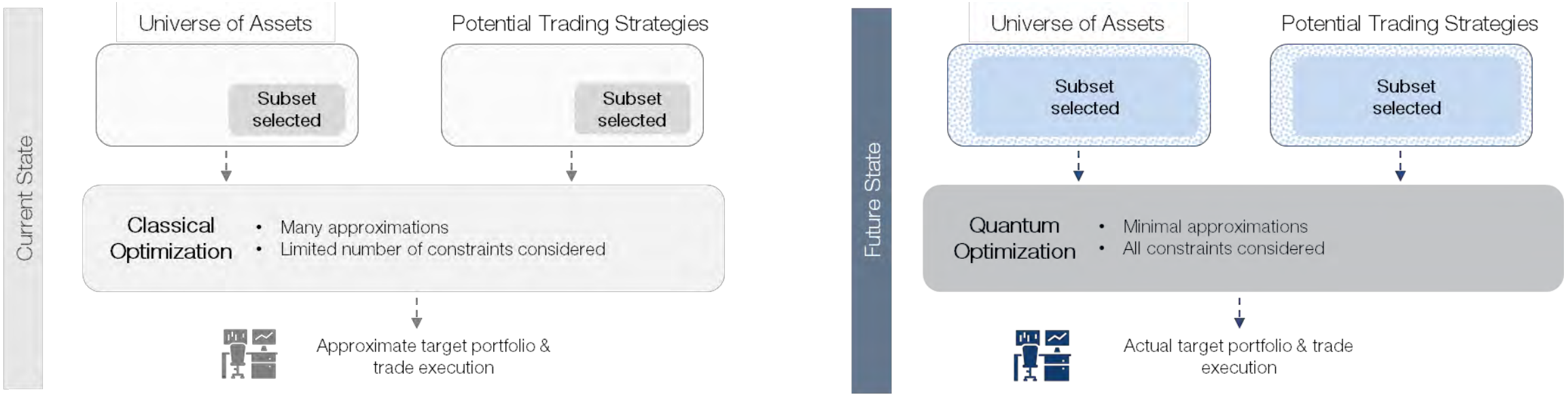
Portfolio managers at GloFund, leveraging quantum computation provided by CloudTech, are able to rebalance their portfolios in optimal ways with significantly more speed. Quantum computing allows GloFund to take into account more constraints (e.g. regulatory requirements, volume limits, percentage limits etc.) and examine a larger set of inputs (e.g. different security classes) when rebalancing their portfolios.

Historically, this has been a very computationally intensive calculation for GloFund that, in past, took several hours, if not days to complete. As a result, they have often had to sacrifice accuracy of the calculation (e.g. simulated annealing, threshold accepting etc.) in order to make faster, more efficient portfolio decisions.

However, by deploying quantum algorithms alongside CloudTech's quantum hardware, GloFund is able to solve the combinatorial optimization of the portfolio and conduct advanced market simulations. Portfolio managers at GloFund are thus able to process significantly more portfolio combinations simultaneously to find rapid and more accurate results.

Financial institutions will be able to consider a larger subset of assets and potential trading strategies by encoding large amounts of data on to qubits

Process flow



Assembling the technologies

Infrastructure	Cloud computing
Core	AI Quantum computing
Complementary	N/A

- Institutions will likely access quantum hardware and software through a third-party by plugging into a cloud network using APIs, enabling them to access advanced computational power in a highly cost-effective manner
- Different types of quantum hardware could be applied; using the quantum annealing approach, for example, the optimization problem is encoded into an equivalent physical problem; this allows the quantum machine to analyse the situation more efficiently than traditional computers; it ultimately allows banks to consider a larger selection of potential assets for the portfolio; as a result, more trading strategies and additional constraints can be considered
- Quantum machine learning algorithms could help clean and remove outliers from large amounts of portfolio data and market data before the quantum computer completes the optimization operation
- Over the longer term, quantum simulation algorithms could help create granular simulations of broad market conditions to inform trading and portfolio construction decisions

More accurate and timely portfolio rebalancing through quantum computing has the potential to decrease trading costs and improve overall portfolio returns

Reinforcing trends

Increased investment in quantum computing is making the technology more accessible to financial institutions

- Between 2017 and 2018, innovators received approximately $450 million in private funding for quantum computing efforts.[1] Additionally, the Quantum Initiative Act has helped fund academics focused on quantum research at the University of Chicago, MIT and the University of Cambridge.[2]
- Multiple quantum hardware players are partnering with major cloud computing providers to make quantum computing more accessible to institutions.[3] For instance, in December 2019, Rigetti Computing announced that its quantum computers would be available to users through Amazon Braket (an AWS-based solution).[4]

Asset managers are playing "technological catch-up"

- According to a recent Accenture study, 42% of asset managers believe that their operations and technology are not configured to support the firm's overall strategy.[5] Many firms are focused on more effectively leveraging technologies such as AI to increase organizational flexibility and adaptability.
- 66% of asset managers state that data management is the area of their business most in need of total disruption.[5]

The regulatory scope is widening for asset managers

- Asset managers are likely to face increased regulatory oversight, particularly as it relates to managing systemic risk and protecting investors.[6] As these constraints increase, it will become increasingly challenging for asset managers to accurately and efficiently optimize portfolios in consideration of upcoming regulations.

Financial institution impacts

Cost drivers

- Increased cost to structure data appropriately for use with specialized quantum hardware
- Cost to access quantum computer capacity via cloud providers
- Specialized talent to develop and maintain quantum algorithms

Revenue drivers

- Improved returns as a result of ability to rebalance portfolio with more accurate optimization; decreased trading costs by minimizing rebalancing transactions
- More efficient long-term capital deployment as risk models are significantly more robust

Operational impacts

- Increased operational agility from real-time visibility and portfolio decision-making
- Ultimately, requires most quantitative analysts to be familiar with quantum computing, affecting both hiring and training strategies

While early quantum hardware is starting to become more accessible to financial institutions via the cloud, continued development of quantum technology is needed

Early experimenters

Fujitsu and Commerzbank teamed up for a "quantum-inspired" proof of concept that optimized the selection process for a securitized loan portfolio. Using the Fujitsu Digital Annealer, Commerzbank was able to take into account multiple loan selection factors simultaneously (e.g. regulatory requirements, absolute volume limits, percentage limits for specific asset characteristics etc.) in order to achieve greater risk diversification in the portfolio.[7]

Rigetti Computing and Commonwealth Bank of Australia conducted a joint experiment applying the quantum approximate optimization algorithm (QAOA) and the quantum alternating operator ansatz to portfolio rebalancing. The experiment was a success, identifying portfolios within 5% of the optimal adjusted returns and with optimal risk for a small portfolio, and demonstrating the potential tractability of this application on more advanced quantum hardware.[8]

Necessary conditions

Cost-effectiveness at scale

The costs of accessing quantum hardware would have to be less than the potential gains realized from portfolio optimization, which may benefit larger-scale players in the near term as resources and talent are expensive

Multi-player collaboration

Successful implementation will require participation from financial institutions, big tech companies, quantum hardware specialists and regulators to allow sensitive trading strategy data to be analysed on-cloud

Regulatory complexity

The more complex it becomes for asset managers to remain compliant (e.g. the more regulatory constraints that are added), the more likely it is that institutions would adopt quantum solutions for portfolio management

Structured data

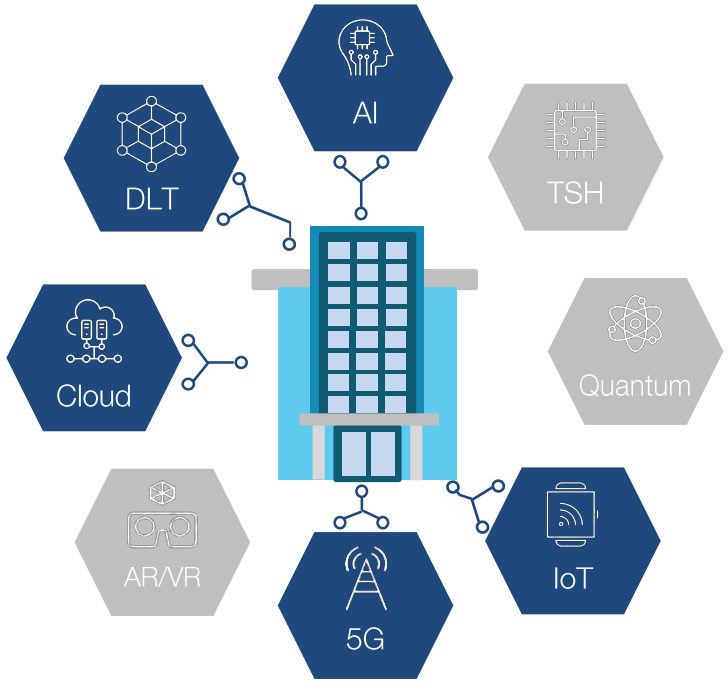
Quantum computing is dependent on a strong data foundation, particularly clean and structured data, to easily reformat the specific optimization problem to be quantum-ready

Data-linked green bonds

Data-linked green bonds could be issued to fund sustainable projects and linked to trusted sources of data that help measure and monitor sustainable outcomes

Key takeaway	Sustainability data could be monitored and sourced from a number of different IoT sensors, and linked to a blockchain, such that an immutable ledger of the data is created to increase investor visibility and issuer accountability.

Emerging technologies



The new user experience

GreenCorp wishes to raise funds to construct a new, carbon-neutral manufacturing plant. It works with its sell-side investment bank, GreenBank, as well as a third-party sustainable certification authority, to structure the bond and create an environmental index against which the sustainability of the construction and operation of the plant will be measured.

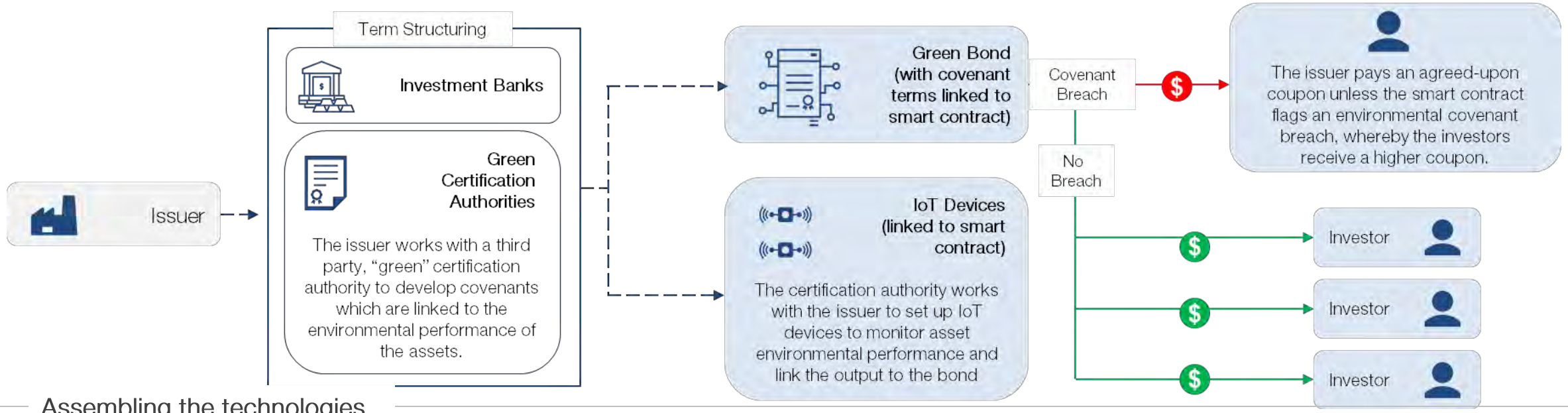
This index includes measures of emission levels from the plant's exhaust vent, the plant's net energy usage from non-renewable sources, and water quality in the plant's tailing ponds, among other sources of data.

GreenBank sources a group of institutional investors who would be willing to accept a small discount to the bond's coupon if GreenCorp meets its sustainability targets, such that the investors can construct and sell green investment products to their clients. GreenCorp issues the bonds and uses the funds to construct the facility and link data sources to the bond covenants.

One year into operation of the plant, emission levels from the plant's exhaust vent exceed the limits set forth in the covenant. GreenCorp's bonds automatically begin paying a higher coupon rate (as defined in the bond covenants) until the issue is rectified appropriately.

Linking smart contract technology to the bond's covenant terms could trigger covenant events that incentivize issuers to comply with the terms of the green bond

Process flow



Assembling the technologies

Infrastructure	Cloud computing
Core	AI DLT IoT
Complementary	5G networking PETs

- The environmental data being monitored is sourced from a number of different IoT-linked sensors; these sensors are linked to a DLT network, such that an immutable ledger of the data is created, documenting it in a tamper-proof and traceable way, which would help verify the data's authenticity and reinforce trust in its provenance; PETs could also be applied to reinforce the security of the information and flag covenant breaches without revealing the underlying data
- Environmental covenants (e.g. those related to metrics like CO_2 emissions, net energy use etc.) can be structured as a DLT-based smart contract, so that covenant events (coupon step-up, call events) can be triggered automatically based on readings from IoT sensors
- This ledger is stored in the cloud, such that the data is easily auditable by issuer, certification agencies, and bondholders; AI algorithms running on cloud infrastructure could then help in two primary ways: anomaly detection to help verify and authenticate the data; and predictive analysis to forecast potential covenant breaches and warn issuers in advance if covenants are close to being breached

There is growing demand for green investment opportunities among investors of all sizes, however many existing opportunities lack proper tracking and reporting processes

Reinforcing trends

Demand for sustainable investing is growing among all investor classes, including large institutional investors

- A recent *Harvard Business Review* survey of 40+ institutional investors found that ESG issues were among the most important in investment decisions.[1] Executives, most notably BlackRock Chief Executive Officer Larry Fink, have openly committed to exiting investments with high sustainability risk and voting against management teams that are not making progress in this space.[2]
- In 2019, more than $250 billion of green bonds were underwritten (1,800 securities from 500 issuers), representing a 51% year-over-year growth, signalling increased investor demand for this asset class.[3]
- The EU, a leading player in the space, accounted for nearly half of this total, including the largest single issuance, the Dutch State Treasury Agency's Climate Bonds Certified ($6.7 billion).

Regulatory requirements and government incentives are evolving for "green investments"

- In Europe, regulators are taking more stringent measures, through the EU's Taxonomy Regulation, to rigorously define "green investments" in order to prevent greenwashing.[4] In the US, under the Clean Renewable Energy Bond Program, 70% of the coupon is paid for by tax credit or subsidy.[5] In addition, many municipal green bonds in the US are tax exempt to offset lower coupons. In China, ESG disclosures have become mandatory for public companies since 2020.[6]

Reporting measures on environmental impact of investments are lagging

- According to a Baker McKenzie report, <50% of all issuers report both the ongoing environmental impact of the projects associated with their green bonds and provide disclosure on the use of proceeds.[7] In fact, very few bonds are structured such that covenants are directly tied to sustainable outcomes.

Financial institution impacts

Cost drivers

- The investment bank would likely have to share part of the underwriting fee with the third-party authority
- In the near term, banks may suffer from inefficient pricing costs, as there is no playbook on how to price a step-up event based on environmental factors

Revenue drivers

- Automating data collection could result in an estimated 90% reduction in proof-of-impact reporting costs[8]
- The aggregate data captured as part of covenant monitoring, with appropriate privacy protections, can be built into advisory services

Operational impacts

- A dedicated team of sustainable finance experts could help structure deals and environmental covenants appropriately
- Finding suitable issuers requires changes to the due diligence process in order to screen for greenwashing

Before data-linked green bonds can become a scalable reality, regulators, institutions and certification authorities would need to come together to establish common standards

Early experimenters

In 2019, **Dürr**, a German mechanical engineering firm, raised nearly $1 billion from a data-linked green loan offering that was coordinated on a proprietary blockchain platform; the loan was syndicated across a number of global lenders, including European giants BNP Paribas, Deutsche Bank and UniCredit. The interest rate of the loan is linked to a proprietary sustainability rating, which is monitored by a third-party agency, and pays out higher coupons if the sustainability rating decreases.[9]

BBVA issued the world's first green bond on the blockchain in 2019 on behalf of MAPFRE, for €35 million. The funds obtained are to finance green projects within **BBVA**'s framework of Sustainable Development Goals and has been categorized as a green bond by DNV GL, a global leader in certification. By using its internal blockchain technology, BBVA was able to simplify processes, allow for customization of the bond, and streamline the negotiation time frames.[10]

Necessary conditions

Policy support

Until many investors are willing to trade yield for sustainable outcomes, governments wishing to increase funding of green projects via green bonds may have to offer subsidies to compensate for lower yields

Issuer IoT strategy

Issuers must build an IoT strategy into their "use of funds" to ensure that there is a clear and agreed-upon approach to measuring and obtaining relevant, high-quality data across the fund usage lifecycle

Coupon pricing standards

An accepted market view of how different environmental outcomes influence coupon prices will help standardize green bond terms; this makes it easier for investors to compare offerings

Data sensitivity

Some of the data that could be used to help set covenants could be very sensitive or considered trade secrets; various PETs could be used to ensure robust, and yet highly secure, monitoring of the data

References

Capital markets

1. "Here is why financial services companies are adopting RPA", *Wissen,* N.d, https://www.wissen.com/blog/here-is-why-financial-services-companies-are-adopting-rpa/
2. Alonso Trabanco Jose, "China Prepares to Launch Its Own Digital Currency", *Geopolitical Monitor,* 9 September 2019, https://www.geopoliticalmonitor.com/china-prepares-to-launch-its-own-digital-currency/
3. Saphir Ann, "Fedcoin? The US central bank is looking into it", *Reuters,* 5 February 2020, https://www.reuters.com/article/us-usa-fed-brainard/fedcoin-the-us-central-bank-is-looking-into-it-idUSKBN1ZZ2XF
4. Sobers Rob, "110 Must-Know Cybersecurity Statistics for 2020", *Varonis,* 21 July 2020, https://www.varonis.com/blog/cybersecurity-statistics/
5. Val Srinivas, Jan-Thomas Schoeps, Tiffany Ramsay, et al., "2020 banking and capital markets outlook", Deloitte, 3 December 2019, https://www2.deloitte.com/us/en/insights/industry/financial-services/financial-services-industry-outlooks/banking-industry-outlook.html
6. Damyanova Vanya, "Global investment banks' 2019 revenues slip to 2008 levels amid equities slump", *S&P Global Market Intelligence,* 20 February 2020, https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/global-investment-banks-2019-revenues-slip-to-2008-levels-amid-equities-slump-57196937

Cross-bank collateral optimization

1. Bank for International Settlements (2020) Basel III: International regulatory framework for banks. https://www.bis.org/bcbs/basel3.htm
2. Fisglobal (2016). *Techniques for Post-Trade Collateral Optimization.* https://www.fisglobal.com/solutions/institutional-and-wholesale/asset-management/-/media/fisglobal/files/report/techniques-for-post-trade-collateral-optimization.pdf
3. DTCC (2019) Increasing transparency is key in the brave new collateral management world. https://www.dtcc.com/dtcc-connection/articles/2019/december/04/increasing-transparency-is-key-in-the-brave-new-collateral-management-world
4. Activeviam (n.d.). *Collateral Optimization White Paper.* https://activeviam.com/images/pdf/white-papers/ActiveViam_White_Paper_-_Collateral_Optimization.pdf
5. Finextra (2015). *Centralized limits and collateral management.* https://www.finextra.com/blogposting/11162/centralized-limits-and-collateral-management
6. BCG (2018) The next decade in quantum computing – and how to play. https://www.bcg.com/en-ca/publications/2018/next-decade-quantum-computing-how-play
7. CogniFrame (2020). https://www.cogniframe.com/
8. Computer Weekly (2019) Barclays demonstrates proof of concept quantum clearing algorithm. https://www.computerweekly.com/news/252472462/Barclays-demonstrates-proof-of-concept-quantum-clearing-algorithm
9. D Wave (2020) What in a Name? https://www.dwavesys.com/press-releases/what%E2%80%99s-name-d-wave-unveils-next-generation-system-name-announces-first-next

References

Quantum portfolio optimization

1. Nature (2019) Quantum gold rush: the private funding pouring into quantum start-ups. https://www.nature.com/articles/d41586-019-02935-4
2. Quantum Computing Report (2020) U.S. senators introduce industries of the future bill with a potential $10B in spending. https://quantumcomputingreport.com/news/
3. The Next Platform (2020) Quantum computing providers pick their dance partners. https://www.nextplatform.com/2020/01/08/quantum-computing-providers-pick-their-dance-partners/
4. AWS (2020) Hardware providers. https://aws.amazon.com/braket/hardware-providers/
5. Accenture (2019) Reinventing operations in asset management. https://www.accenture.com/_acnmedia/PDF-107/Accenture-Reinvent-Operations-Asset-Management.pdf
6. KPMG (2019) A seas of voices: evolving asset management regulation report. https://assets.kpmg/content/dam/kpmg/xx/pdf/2019/06/a-sea-of-voices-eamr2019.pdf
7. Fijitsu (2019) Fijitsu quantum-inspired digital annealer delivers securitization optimization for main incubator. https://www.fujitsu.com/emeia/about/resources/news/press-releases/2019/emeai-20190829-fujitsu-quantum-inspired-digital-annealer.html
8. QuantaNeo (2020) Advancing quantum computing applications for finance with commonwealth bank of Australia and Rigetti. https://www.quantaneo.com/Advancing-Quantum-Computing-Applications-for-Finance-with-Commonwealth-Bank-of-Australia-and-Rigetti_a361.html

Data-linked green bonds

1. Harvard Business Review (2019). *The Investor Revolution.* https://hbr.org/2019/05/the-investor-revolution;
2. The New York Times (2020). *Blackrock CEO Larry Fink: Climate Crisis Will Reshape Finance.* https://www.nytimes.com/2020/01/14/business/dealbook/larry-fink-blackrock-climate-change.html
3. "2019 Green Bond Market Summary, *Climate Bonds Initiative,* 2019, https://www.climatebonds.net/resources/reports/2019-green-bond-market-summary
4. Energypost.eu (2020). *Defining green investments, ending greenwash: the EU's new Taxonomy Regulation.* https://energypost.eu/defining-green-investments-ending-greenwash-the-eus-new-taxonomy-regulation/
5. ClimateBonds (2020) Tax incentives for issuers and investors. https://www.climatebonds.net/policy/policy-areas/tax-incentives
6. BNP Paribas (2020). *Green finance: what about Asia?.* https://cib.bnpparibas.com/sustain/green-finance-what-about-asia-_a-3-3370.html
7. Baker Mackenzie (2019). *Critical challenges facing the green bond market.* https://www.bakermckenzie.com/en/insight/publications/2019/09/-/media/files/insight/publications/2019/09/iflr–green-bonds-(002).pdf
8. HSBC, Sustainable Digital Finance Alliance, "Blockchain: Gateway for sustainability-linked investments", accessed 20 July 2020, https://docs.wixstatic.com/ugd/3d4f2c_a8d74cac6f974984a67f7b8c05146fbe.pdf
9. Durr Group (2019) Durr AG agrees innovation syndicated loan with sustainability component. https://www.durr-group.com/en/media/news/news-detail/view/duerr-ag-agrees-innovative-syndicated-loan-with-sustainability-component-77038
10. BBVA (2019) BBVA issue the first blockchain supported structured green bond for MAPFRE. https://www.bbva.com/en/bbva-issues-the-first-blockchain-supported-structured-green-bond-for-mapfre/

Market infrastructure

The market infrastructure sector includes organizations involved in providing venues, information, networking, IT, clearing and settlement services to industry participants

Trends

Steep price and product competition has forced exchanges to **seek horizontal expansion** to **drive economies of scale and scope.**[1]
For example, Euronext's acquisitions of Oslo Børs and 66% of Nord Pool.[2]

Exchanges have pursued **vertical integration** with a focus on data aggregation and analytics and are looking towards **mass distribution of** market data.[3]
For instance, LSE recently committed $27 billion to purchase Refinitiv, a global provider of financial market data.[4]

Stock exchanges around the world are being called to **help improve environmental data shared by financial services firms.**
Mark Carney (UN Special Envoy for Climate Finance) and David Schwimmer (Chief Executive Officer of LSE) have written to several exchanges asking them to support the United Nations Sustainable Stock Exchange (UN SSE), set to launch in September 2020.[5]

Stiff post-crisis regulation has made central clearing **less economical**; central clearinghouses have since been rapidly **expanding their portfolios to incorporate adjacent product offerings.**[1]
In 2020, DTCC launched its API for its Risk Management as a Service feature, which gives clients a view of their risk and liquidity positions.[6]

Use cases

The following use cases were prioritized as significant infrastructural changes expected over the next decade; the use cases would help solve common points of inefficiency for a large number of industry participants:

1 Global fund transfer network

A DLT fund-transfer network that optimizes and improves the speed and transparency of the flow of high-value fund transfers across jurisdictions.

2 Global corporate actions ledger

A single, permissioned ledger where data on mandatory and voluntary corporate actions are published in machine-readable formats to drive consistency and reduce intermediation.

3 Distributed KYC/AML utility

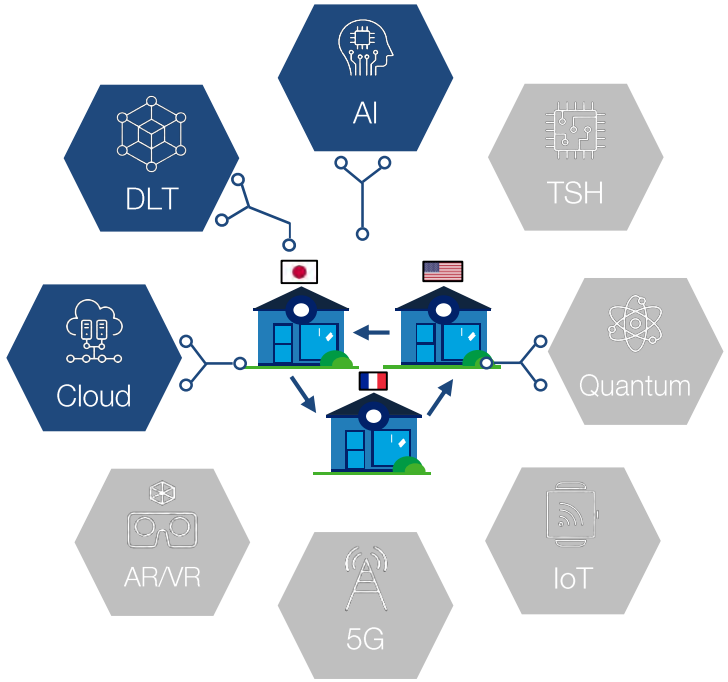
A platform that simplifies customer onboarding and continuously monitors transactions, using the combined data and analytical capabilities of all institutions to reduce duplication of effort.

Global fund transfer network

A reimagined fund-transfer network leveraging DLTs could optimize and improve the speed and transparency of the flow of high-value transfers across different jurisdictions

Key takeaway	The correspondent banking system today is slow and inefficient and creates traceability issues; the global fund transfer system of tomorrow could be faster and more transparent by applying emerging technologies such as DLT and AI.

Emerging technologies



The new user experience

A truck manufacturer in the US wants to make a cross-border payment to a parts manufacturer from Japan. Typically, this process would involve funds being sent through a complex chain of correspondent banks and a combination of straight-through processing and manual data entry.

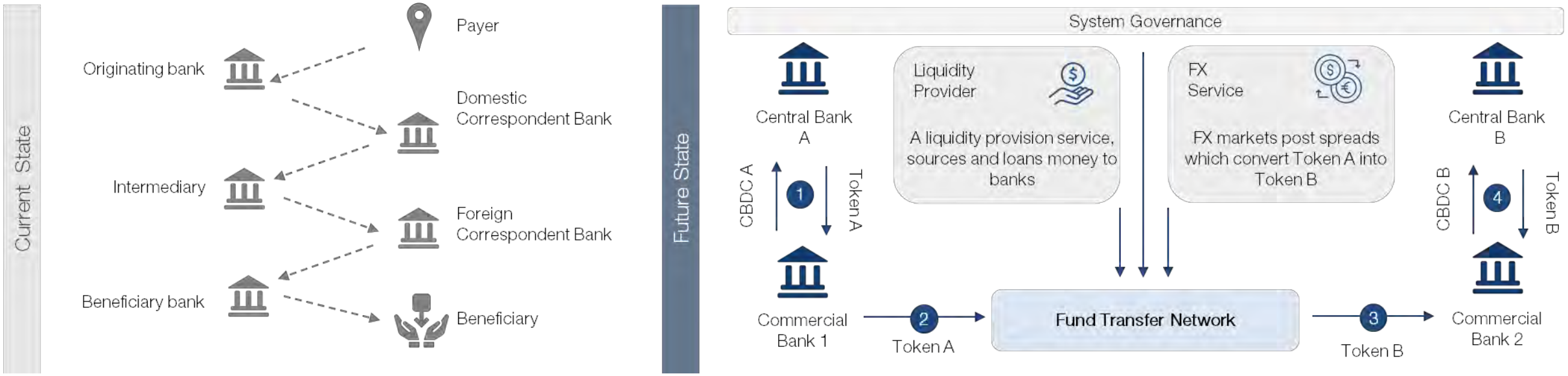
Several days would likely have to pass in order to successfully complete the payment. This correspondent banking process often results in errors and poor data traceability as a result of the multiple points of contact.

By leveraging DLT, many intermediaries can be omitted from the process, and the financial institutions representing the two companies can interact directly with one another to facilitate the funds transfer much more quickly; this increases transparency and efficiency in the system.

In addition, it creates a more seamless customer experience for the truck manufacturer, which is able to make an instant, atomic payment to its vendor (including FX conversion) and receive real-time updates on the status of the funds.

The current global fund transfer system is dependent on the legacy correspondent banking system, which causes system inefficiencies and lack of real-time transparency

Process flow



Assembling the technologies

Infrastructure	Cloud computing
Core	AI DLT
Complementary	N/A

- The global fund transfer network is structured as a blockchain with five types of a nodes: A system governance and operational node facilitates transaction settlement, gridlock resolution and dispute resolution services; central banking nodes facilitate the exchange between fiat currency (i.e. CBDC) and network tokens that represent units of fiat currency; commercial banking nodes transfer tokens between each another; an FX node populated by market makers who post bid/ask spreads denominated in tokens and stand ready to buy and sell tokens; and a liquidity provider node to provide just-in-time liquidity
- Nodes are hosted on the cloud, and API connectivity is used to transmit payment instructions through the network
- The governance operator can use AI for real-time transaction monitoring to determine whether transactions meet regulatory requirements; this governance node is likely run by a collection of participating central banks and potentially regulators

The imperative for a more efficient global fund transfer network is growing as the number of cross-border transactions increases every year

Reinforcing trends

The correspondent banking business model is becoming less attractive due to cost and compliance concerns, leading to declines in the number of participants

- The correspondent banking model for cross-border transactions creates high transaction costs, settlement risk (for high-value transfers) and a lack of transparency. In recent years, rising compliance costs due to increased AML/CFT scrutiny and shifts in bank strategy away from providing correspondent services has decreased the model's attractiveness.[1]
- Owing to this, the model has seen significant declines in profitability, and thus correspondent banking relationships, further increasing payment costs as chains get longer. From 2012 to 2019, the number of correspondent relationships declined by 20%.[2] Most of the costs (~7% of a transaction) are associated with suboptimal liquidity of nostro accounts.[3]

Cross-border transactions are increasing rapidly, and are coming up against new inefficiencies

- Cross-border transactions accounted for $23.7 trillion globally in 2018.[4] However, Alan Koeningsberg, Global Head of New Payment Flows at Visa Business Solutions, remarked that "whenever we talk to financial institutions, we find a significant amount of their stress and friction comes from the cross-border space."[5]

Modernization of domestic payments infrastructure is opening the door to more coordinated global payments infrastructure

- Consumer behaviour is driving business expectation as emerging payments companies (e.g. Venmo) facilitate real-time consumer payments. Simultaneously, jurisdictions are beginning to experiment more seriously with the roll-out of CBDCs for domestic retail and wholesale payments, including China (slated to launch in 2020) and Sweden. If built to be widely interoperable, domestic infrastructure could be leveraged for global use.[6]

Financial institution impacts

Cost drivers

- Banks would pay a fee to a local governance node (e.g. central bank) to cover build and operating costs
- Maintaining a ledger node involves ongoing connectivity, security and initial infrastructure build, which may be significant for some small banks

Revenue drivers

- Greater efficiency in settlement (which is completed on a gross, real-time basis), FX procurement and liquidity (reduces need to fund multiple nostro accounts across correspondents)
- Reduction in cross-border payment risks (e.g. Herstatt non-settlement risk)

Operational impacts

- Collect richer data, making AML/CFT compliance and payment reconciliation easier for banks
- More operational flexibility from not having to rely on the hours of operation of the existing wholesale payments system

Governments around the world are beginning to collaborate on proofs-of-concept to replace the existing system, often revealing new barriers such as the need for broad network participation

Early experimenters

The **Bank of Canada** and the **Monetary Authority of Singapore** have developed a joint conceptual architecture and technical proof of concept for global fund transfer called Jasper/Ubin. In a 2019 design paper, they laid out a framework for an architecture where domestic institutions (e.g. a central bank, a nationally designated intermediary) could participate in the Real-Time Gross Settlement system of foreign jurisdictions and serve as the go-between for domestic banks to transfer funds to foreign banks. This would effectively reduce the number of intermediaries in the foreign exchange corridor to one.[7]

The **Bank of Thailand** and the **Hong Kong Monetary Authority** recently completed a proof of concept for global fund transfer called Inthanon-Lionrock. In the Inthanon-Lionrock model, DLT network tokens that represent holdings of fiat currency (and denominated in that currency) are traded among institutions, which are de-facto allowed to hold network tokens denominated in a foreign currency in their domestic accounts. However, the proof of concept develops a "segregated corridor" for cross-border transactions that effectively ringfences the use of the network token for the purposes of cross-border transactions only.[8]

Necessary conditions

Domestic digital currency networks

In markets without a domestic CBDC, the central bank conversion between fiat currency and network token may involve significant friction that adds cost and complexity

Broad ecosystem participation

The presence of strong network effects means that it is critical for there to be broad network participation across jurisdictions, or else institutions may find it easier to simply rely on existing corridors

Encoding regulatory principles

Relevant regulations should be encoded directly into the smart contracts underpinning transactions, or else manual reconciliation may outweigh efficiency gains

Regulatory oversight and reporting

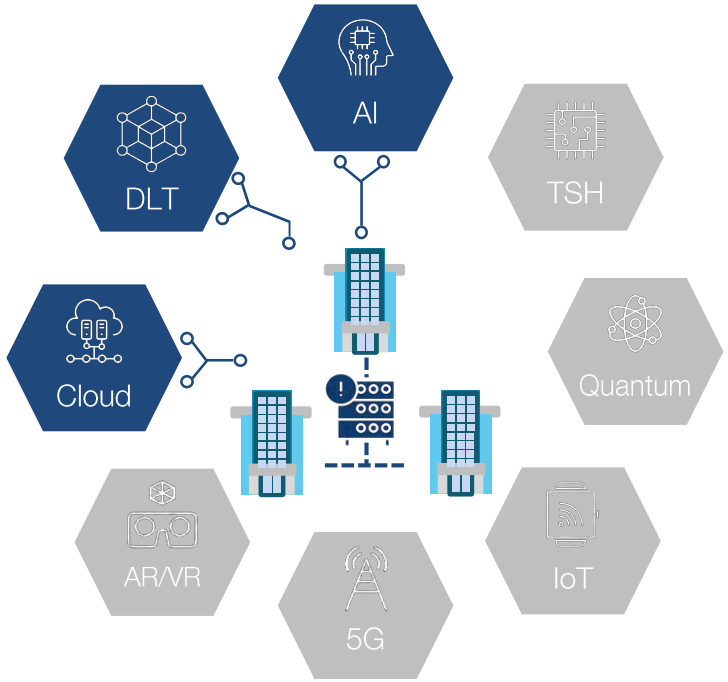
Data flowing through the network can simplify regulatory requirements for post-trade reporting as the data associated with each transaction could be stored on an immutable ledger

Global corporate actions ledger

A single, permissioned ledger where data on corporate actions is published in machine-readable format could achieve straight-through processing when updating security analyses

Key takeaway	An automated global corporate actions ledger, supported by the immutability and traceability capabilities of distributed DLT, could significantly reduce redundancy and error in capital markets businesses around the world.

Emerging technologies



The new user experience

FundCo is a large fund manager that invests in a global portfolio of public equities on behalf of over 20,000 individual investors and has an AUM of over $50 billion.

As a part of WorldLedger, a collaborative global corporate actions ledger, it can access real-time corporate actions data emanating from all of its global holdings, from Canada to Hong Kong.

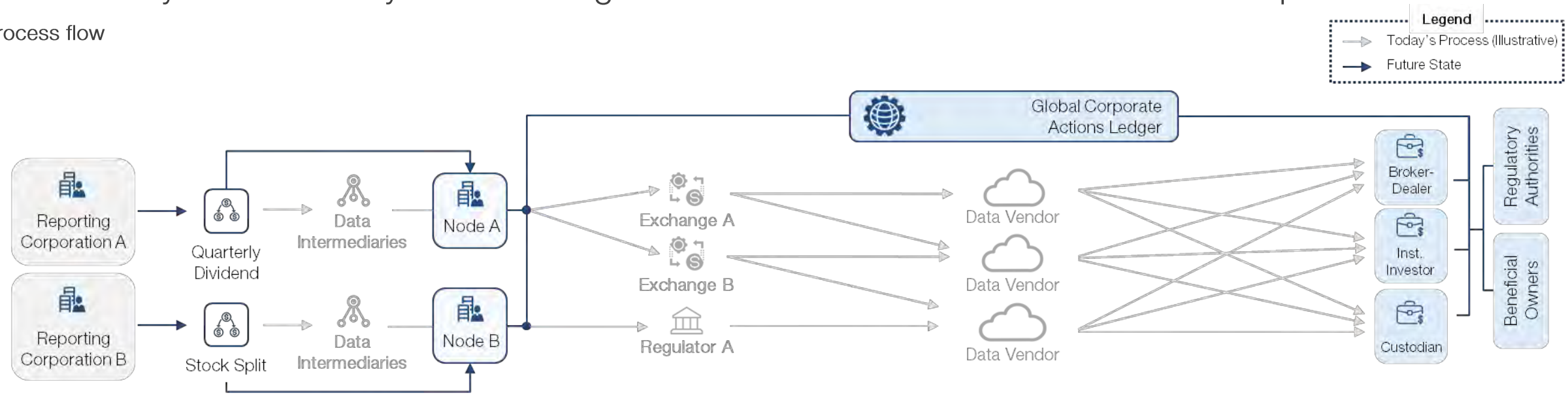
The data is provided to FundCo in a standardized, machine-readable format. This allows FundCo to achieve straight-through processing and high levels of automation for many of the processes that result from relevant corporate actions, for instance updating its fund accounting or informing beneficial owners (i.e. its individual investors) of changes to the securities they own. WorldLedger also provides a web-based tool for voluntary action voting (e.g. warrant exercising).

Depending on the agreement with its investors, FundCo can either complete the voting on behalf of its investors or share a link with them so they can quickly make the choices on their own.

The ledger could also be consulted by relevant national tax authorities in order to source first-hand information and issue rulings on tax treatments for disbursements.

Corporations would register corporate actions with ledger node organizers, then the data would be automatically verified and synced to a single source of truth accessible to all interested parties

Process flow



Assembling the technologies

Infrastructure	Cloud computing
Core	AI DLT
Complementary	N/A

- Eligible reporting corporations share data with an organization that maintains a node on a global ledger (e.g. a CSD, a national utility etc.) hosted on the cloud; based on the actions taken by corporations, the utility adds to the ledger, updating the network on the actions taken by all corporations within its jurisdiction, and also maintains a shareholder registry
- Underpinning the ledger is a standardized messaging language that is able to codify the rules and outcomes of all corporate actions (accounting for jurisdictional differences); the utility plays the role of consolidating, verifying and uploading data, which can be accessed directly by the investor, without having to go through multiple custodians and data vendors
- The utility automates consolidation and transmission of data through a combination of RPA for processing machine-readable (standardized) actions and to document exceptions, and NLP-based AI tools to process unstructured action data; users also benefit from the machine readability of the data to automatically update beneficial owners, internal models etc.
- Voluntary actions (e.g. scrip dividend issues) can be structured as smart contracts that collect and provide voting records

Today, the lack of a common source of truth is creating process duplication and inefficiency across the financial services industry

Reinforcing trends

The lack of a consistent source of corporate actions information drives fragmentation and contributes to slow processing

- The sources of truth of corporate actions announcements (1,500+ sources) are fragmented;[1] in the US, for instance, notifications for publicly traded companies are handled by the exchanges on which the company is listed[2] (of which there are 12+), while OTC security actions are announced by a regulator, FINRA.[3]
- According to research by Compeer, over 80% of wealth managers continue to process corporate actions manually, largely due to legacy vendor solutions not optimized for machine processing.[4]

Growth in the volume and complexity of corporate actions is driving real economic costs

- While public record-keeping of corporate actions volumes is scarce, market observers have pointed out consistent growth in both the number and complexity of actions undertaken globally. Figures from earlier in the decade have pointed to double digit annual growth (in the 10%-15% range) and there has been little indication of this growth tapering.[5]
- A recent white paper pegged the annual cost to investors for suboptimal decisions about scrip dividends alone (one of hundreds of corporate action types) at $1.3 billion.[6]

A more stringent regulatory environment will demand more seamless data flows for corporate actions, but current processes are not yet capable of handling this

- Regulations such as MIFID II and SRD II (which comes into force September 2020) in the EU have put fiduciaries (e.g. institutional investors) under increased scrutiny and time constraints with respect to their handling of voluntary actions and proxy voting;[7] SRD II, for instance, implements strict timelines (e.g. T+1) on notifying shareholders about data related to action-linked voting, a difficult proposition in today's manual actions processing environment.[8]

Financial institution impacts

Cost drivers

- Fees paid to a national utility to access the ledger, against the costs associated with development, upkeep and maintenance
- Development of RPA and AI-based techniques to parse and action machine-readable data

Revenue drivers

- Eliminates the costs associated with contracting multiple, overlapping intermediaries to ensure coverage
- A single source of truth can reduce suboptimal trades made on incorrect data and allows for more straight-through action processing

Operational impacts

- Drives democratization of data and increased fairness in participation in the capital markets, especially for smaller institutional investors
- Reduces risks associated with outsourcing activities that rely on actions data (e.g. fund administration)

Industry participants would need to align on common messaging standards and proper system governance to ensure that the true collaborative benefit can be captured

Early experimenters

Broadridge, a leading global provider of financial information, recently launched its Global Asset Servicing Solution, a popular corporate actions processing platform, as a service available through the Amazon Web Services cloud. It has already onboarded two Tier-1 financial institutions to the platform that are able to access corporate actions information in real-time through a dedicated API.[9]

Citigroup, a global investment bank, recently spun off their proxy voting platform **Proxymity**, which is now being developed and maintained by a global consortium of financial institutions (including JP Morgan, BNY Mellon, Deutsche Bank, and HSBC) that are collectively supporting the venture. The consortium of banks aims to revamp the proxy voting process by providing shareholders with real-time data (e.g. post-meeting vote confirmations) and automation of standard practice (e.g. shareholder ID requests). Proxymity leadership has claimed that the consortium-led product will help improve transparency and increase straight-through processing and have suggested that a recent $20.5 million capital raise will help the product scale up globally.[10]

Necessary conditions

Messaging standardization

Driving consistency across 700+ corporate action types on a global ledger, and enabling greater straight-through processing, will necessitate the adoption of a standard language for messaging and actions

Policy and regulatory cooperation

Cooperation between regulators and industry to both develop policies centralizing action reporting, and stand up national utilities to maintain ledger nodes, will help control access and ensure global consistency

End-user processing capabilities

The benefits of the ledger will flow to end users who build AI and RPA-based processing tools on top of the ledger to achieve higher rates of straight-through processing, requiring end-user sophistication

Node-driven data augmentation

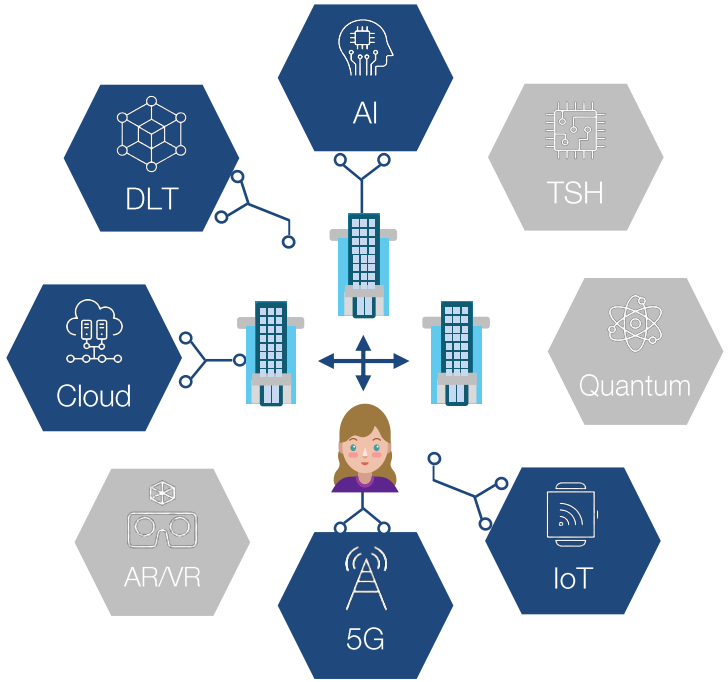
Corporate actions result from issuers of all sizes and capabilities, and some may not be able to publish actions in machine-readable format; ledger nodes will need to play a role in cleansing the data

Distributed KYC/AML utility

A central utility that simplifies customer onboarding and continuously monitors customer transactions to reduce duplication of effort and increase security

Key takeaway	A shared KYC/AML utility, supported by AI, DLT and cloud computing (among other technologies), could substantially reduce duplicated effort and costs across the industry.

Emerging technologies



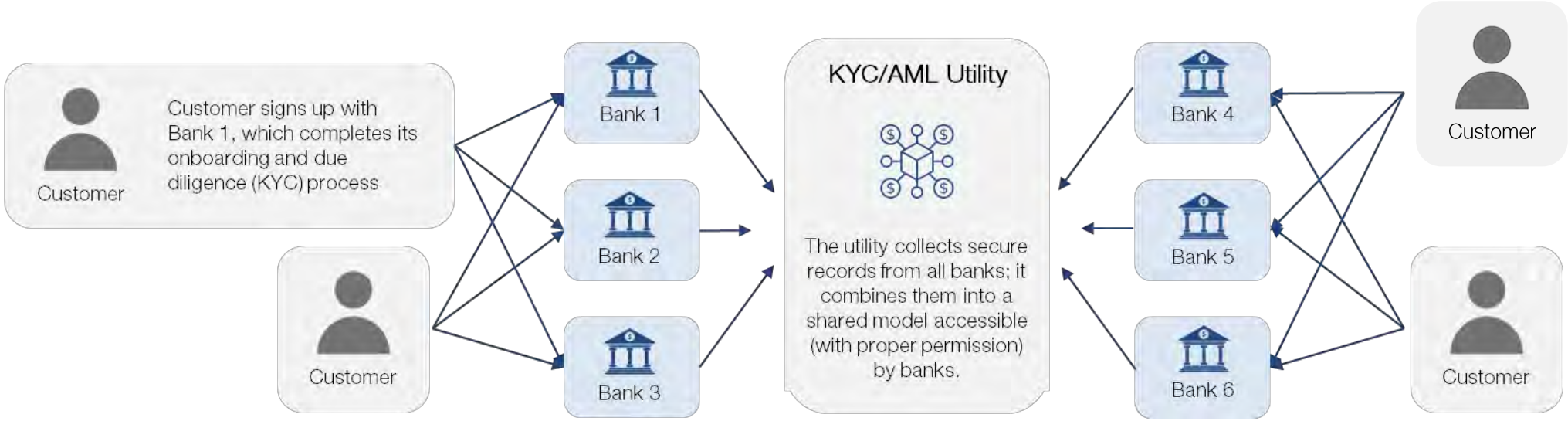
The new user experience

Maria has recently immigrated to London and sets up an account with BritBank. Because she is new to the country, she undergoes a full KYC process, sharing with BritBank key documents and biometric information. After one year, she decides to buy a house, and finds a competitive rate with RoyalsBank. To sign up for her account, RoyalsBank asks simply for a face scan and a photo of her passport because she is an existing customer of a British bank; it is able to use the full KYC information from BritBank to complete her onboarding.

A few months later, Maria leaves her tablet unattended at a library. A stranger takes her tablet, which is logged into her banking application with BritBank. The stranger later attempts to make a rent payment through BritBank to an account held at KingdomBank. BritBank queries the transaction against the central KYL and AML utility, which uses a probabilistic model to flag it as suspicious for a few reasons: Maria has never made a rental payment to the account before and has just made a mortgage payment on her house with RoyalsBank; the stranger's typing style does not match Maria's, and the attempt is made from a location far away from her home. As a result, additional identity verification is required to process the transaction, stopping the malicious actor from stealing Maria's funds.

The KYC/AML utility would rely on the joint data and analytical capabilities of all institutions on the DLT network, which would be hosted in the cloud

Process flow



Assembling the technologies

Infrastructure	Cloud computing
Core	AI DLT PETs
Complementary	5G networking IoT

- The utility is built on a distributed ledger that is hosted in the cloud, with each institution serving as a node in the utility, and privacy-enhancing techniques governing the sharing of information
- When an institution requests information about a customer from another, this transaction is structured as a smart contract that swaps a verified information request (e.g. a request with proof of customer consent) from one institution for the data of another institution
- In the case of sharing customer due diligence (KYC) information across institutions, this could take the form of zero-knowledge proofs; when the smart contract is executed, it would share only necessary data (or metadata)
- The KYC/AML utility would employ AI to analyse transactions against a federated learning model to flag aberrant behaviour, without any institution seeing the underlying transactions of others; informing this model is data from IoT devices delivered over 5G networks that help build a probabilistic authentication model for transactions

KYC/AML processes are ripe for disruption given the increasing cost of compliance and the current amount of redundancy in these processes in the industry

Reinforcing trends

Regulatory stringency is driving significant increases in compliance costs, stemming from both preventative measures and penalties

- Regulators are developing stricter policies on KYC/AML violations. In Europe, the 5th Anti-Money Laundering Directive (5AMLD) extended CFT/AML regulation to institutions dealing in cryptocurrency and increased transparency on beneficial ownership and politically exposed persons.[1]
- In 2019, institutions were fined $10 billion for KYC, AML and other financial crime sanctions violations, including 12 of the 50 largest banks, a 160% increase since 2018. More than 50% of the fine value was levied on firms abetting tax evasion and other AML violations.[2]

Regulators are increasing their comfort with digital forms of onboarding and due diligence information sharing

- Globally, regulators are becoming more comfortable with digital forms of onboarding.[3] In the EU, the 5AMLD includes guidance on the increased use of facial biometric authentication.[4] In the Netherlands, a small-scale proof of concept for a shared KYC utility service between three large banks was developed to share key due diligence information (e.g. beneficial ownership changes) with the explicit backing of Dutch regulators and the central bank.[5]

Despite significant resources spent on KYC/AML, the process remains fragmented and rife with error

- Despite advances in emerging technology, strict regulation of the conduct KYC/AML and other anti-financial crime processes remains largely the same;[6] a recent study found that more than 80% of procedures across institutions are identical, and thus duplicative.[7]
- An IBM report found that many organizations have a false positive rate of ~98% on KYC alerts, driving a vicious cycle of costly manual reviews.[8]

Financial institution impacts

Cost drivers

- Institutions will likely share the capital costs to stand up the utility, and ongoing operational costs
- Institutors will have to adopt a standard data format for KYC/AML data, involving process re-engineering and system reconfiguration

Revenue drivers

- Significant cost savings from the reduction of duplicative processes across the sector
- An economic model could see institutions remunerate each other for validating data, or by providing KYC services to non-financial players

Operational impacts

- Improvement to risk/reputation management as better data lowers risk of fines for non-compliance
- Greater efficiency of KYC/AML processes from less manual intervention, which may affect back-office workforce

Several European banks and regulators are exploring the potential of a shared KYC/AML utility, but a new liability model for data-sharing is required to scale up the solution

Early experimenters

INVIDEM

A group of six financial institutions in the Nordics (**Danske Bank, DNB Bank, Nordea Bank, SEB, Svenska Handelsbanken** and **Swedbank**) has partnered to develop a joint KYC management utility called **Invidem**, set to launch in 2020. The platform will initially focus on simplifying the KYC onboarding processes for large corporate customers and providing them with a standardized format to report necessary KYC data to the utility. It also includes consent management tools that allow customers to control who has access to their sensitive data.

FCA

At the UK FCA's most recent TechSprint Hackathon, teams representing leading fintechs, incumbent institutions and regulators developed a number of proofs of concept for collaborative data-sharing to fight financial crime using privacy-enhancing techniques. One team, Neighbourhood Watch, developed a solution that allows institutions to query each other's KYC databases using secure homomorphic encryption to gather more data about risky customers. Another, Citadel, uses homomorphic encryption and AI to develop a golden-source register for ultimate beneficial owners (UBOs) – a key KYC data point.[10]

Necessary conditions

Explicit regulatory support

Broad regulatory support required to ensure legal basis for data-sharing (e.g. amending privacy legislation to allow institutions to rely on KYC data from others), as well as central oversight and liability management

New liability models

Allowing institutions to rely on data verified by others necessitates a new liability model (e.g. developing an insurance fund to make customers whole); value is lost if institutions have to double-check KYC data

Use-case-based approach

Obtaining broad buy-in to the new system is easiest if institutions focus on slowly enabling different use cases to minimize all-at-once impact and learn from small-scale mistakes

Privacy-enhancing techniques

The multiplicative security and connectivity benefits of DLT, cloud and PETs are the best opportunity for industry collaboration on KYC/AML, as they reduce the need to share sensitive data

References

Market infrastructure

1. "The Future of Clearing", *Oliver Wyman,* 2019, https://www.oliverwyman.com/content/dam/oliver-wyman/v2/publications/2019/apr/The-Future-Of-Clearing.pdf
2. "Euronext to acquire control of Nord Pool, a leading physical power market in Europe, reinforcing Oslo as Euronext's hub in the Nordics", *Intrago GlobeNewswire,* 5 December 2019, https://www.globenewswire.com/news-release/2019/12/05/1956574/0/en/Euronext-to-acquire-control-of-Nord-Pool-a-leading-physical-power-market-in-Europe-reinforcing-Oslo-as-Euronext-s-hub-in-the-Nordics.html
3. Kotthoff Jost & Byrne Darragh, "Stock Exchanges/Clearing Houses/Trading Venues", *White & Case,* 17 February 2020, https://www.whitecase.com/publications/insight/financial-ma-h1-2020/stock-exchanges
4. Jones Huw & Barbaglia Pamela, "London Stock Exchange shareholders bless $27 billion Refinitiv deal", *Reuters,* 26 November 2019, https://www.reuters.com/article/us-lse-m-a-refinitiv/london-stock-exchange-shareholders-bless-27-billion-refinitiv-deal-idUSKBN1Y01DD
5. "Carney calls for more climate action from world's stock exchanges", *The Guardian,* 10 July 2020, https://www.theguardian.pe.ca/business/reuters/carney-calls-for-more-climate-action-from-worlds-stock-exchanges-471849/
6. "DTCC launches app store, first API is 'Risk Management as a Service'", *Securities Finance Monitor,* 5 February 2020, https://finadium.com/dtcc-launches-app-store-first-api-is-risk-management-as-a-service/

Global fund transfer network

1. Bank for International Settlements (2019) On the global retreat of correspondent banks. https://www.bis.org/publ/qtrpdf/r_qt2003g.htm
2. Bank for International Settlements (2019) New Correspondent Banking Data. https://www.bis.org/cpmi/paysysinfo/corr_bank_data/corr_bank_data_commentary_1905.htm
3. Liquidity Management: real-time nostro time? https://www.fintechfutures.com/2017/10/liquidity-management-real-time-nostro-time/
4. Payments Canada (2019) How cross-border payments are evolving. https://www.payments.ca/industry-info/our-research/payments-perspectives/how-cross-border-payments-are-evolving
5. Smart Payments (2020) Challenging the B2B Payment Status Quo. https://smartpayments.com/corporate-payments/challenging-the-b2b-payment-status-quo/
6. The Economist (2020) China aims to launch the worlds first official digital currency. www.economist.com/finance-and-economics/2020/04/23/china-aims-to-launch-the-worlds-first-official-digital-currency
7. Bank of Canada (2019) Digital currencies and fintech projects. https://www.bankofcanada.ca/research/digital-currencies-and-fintech/projects/
8. Hong Kong Monetary Authority (2020) "The outcomes and finding of project inthanon-lionrock and the next steps. https://www.hkma.gov.hk/eng/news-and-media/press-releases/2020/01/20200122-4/

Global corporate actions ledger

1. "Global Corporate Actions", *SIX,* 2018, https://www.six-group.com/dam/download/financial-information/reference-pricing-data/corporate-actions/six-factsheet-global-corporate-actions-en.pdf

References

2. Corporate Actions (2020 Vendors. https://www.corporate-actions.net/vendors/
3. NASDAQ (2017) Corporate Actions by Publiv Companies – What you should know. https://www.nasdaq.com/articles/corporate-actions-public-companies-what-you-should-know-2017-12-28
4. Contemi (2019) Resolving the corporate actions paradox – the case for automation. https://contemi.com/articles/resolving-the-corporate-actions-paradox-the-case-for-automation
5. Advent (2019) Corporate Actions Processing. https://cdn.advent.com/cms/pdfs/papers/WP_Corporate_Actions_Processing.pdf
6. Finextra (2020) The billion-dollar oversign investment managers maker every year. https://www.finextra.com/blogposting/18602/the-billion-dollar-oversight-investment-managers-make-every-year
7. Deloitte (2020) SRD II Implementing Regulation. https://www2.deloitte.com/lu/en/pages/investment-management/articles/srd-ii-implementing-regulation-september-2020.html
8. BNY Mellon (2019) SRD II. https://www.bnymellon.com/emea/en/_locale-assets/pdf/our-thinking/shareholder-rights-directive-ii-regulatory-summary.pdf
9. Broadridge (2020). https://www.broadridge.com/ca/
10. American Banker (2020) Citigroup spins off proxy-voting start-up Proxymity. https://www.americanbanker.com/news/citigroup-spins-off-proxy-voting-start-up-proxymity

Distributed KYC & AML Utility

1. Comply Advantage (2020) 5AMLD. https://complyadvantage.com/blog/5mld-fifth-anti-money-laundering-directive/
2. Value Walk (2020) Fines for global banks top $36 billion for sanction violations. https://www.valuewalk.com/2020/01/bank-fines-sanctions-violations/
3. Medium (2019) Digital onboarding – is it the key to increased trust, convenience and customer centricity? https://medium.com/@ITMAGINATION/digital-onboarding-is-it-the-key-to-increased-trust-convenience-and-customer-centricity-4cbc5c539b56
4. Finextra (2020) Why retrospective ID investigation is critical for 5AMLD compliance. https://www.finextra.com/blogposting/18436/why-retrospective-id-investigation-is-critical-for-5amld-compliance
5. ACAMS (2019) Largest Dutch banks plan shared KYC database. https://www.moneylaundering.com/news/largest-dutch-banks-plan-shared-kyc-database/
6. McKinsey (2019) Transforming approaches to AML and financial crime. https://www.mckinsey.com/~/media/McKinsey/Business%20Functions/Risk/Our%20Insights/Transforming%20approaches%20to%20AML%20and%20financial%20crime/Transforming-approaches-to-AML-and-financial%20crime-vF.pdf
7. Woolley Rachel, "KYC Utilities: The Promised Silver Bullet for Nordic Banks", *Finextra,* 6 September 2019, https://www.finextra.com/blogposting/17839/kyc-utilities-the-promised-silver-bullet-for-nordic-banks
8. IBM (2018) IBM and Promontory: looking for a needle in a haystack with Watson. www.ibm.com/blogs/regtech/ibm-and-promontory-looking-for-a-needle-in-a-haystack-with-watson
9. Invidem (2020). https://invidem.com/
10. FCA (2019) 2019 Global AML and Financial Crime TechSprint. https://www.fca.org.uk/events/techsprints/2019-global-aml-and-financial-crime-techsprint

Exploration of emerging technologies

Artificial intelligence (AI)

AI will continue to extend human analysis/reasoning capabilities and interface more naturally with humans, allowing financial institutions to transform a wide range of organizational processes

Definition

Since the phrase was coined in 1955 by John McCarthy, AI has been subject to a wide range of interpretation. In the Forum's *The New Physics of Financial Services* report, AI was defined as a suite of technologies, enabled by adaptive predictive power and exhibiting some degree of autonomous learning, which have made dramatic advances in our ability to use machines for analysis and action.[1] Others have taken a more human-centred approach, defining AI in terms of systems that extend human capability by sensing, comprehending, acting and learning.[2]

State of functionality

Current state

- More advanced applications of AI are taking place across the entire organization (i.e. front-, middle- and back-office) as organizational data is being made more usable for AI applications[3]
- Low to moderate task displacement is occurring, mediated by individual organizations' AI adoption rate (i.e. some basic customer service queries by chatbots); most applications are largely in support of existing human teams vs replacement[3]
- Some institutions still lack trust in AI outputs, leading investments in AI to be applied in pockets and largely focused on process automation

Short-term prediction (3-5 years)

- AI evolves from an enabler of narrow point solutions to an organizational layer that manages cross-enterprise processes, due to a wider adoption of more flexible cloud architectures and task-specific hardware to run AI at scale[3]
- More significant worker displacement occurs in certain roles, and new roles that govern the responsible use of AI (i.e. algorithm evaluators) are adopted at scale by organizations[3]
- Institutions and consumers are more comfortable letting AI-driven tools make simple financial decisions (e.g. purchasing insurance coverage)

Long-term prediction (5+ years)

- AI replaces significant verticals or functions (e.g. most call centre inquiries, significant portions of data entry and reconciliation) supported by much smaller teams of humans as needed
- New jobs emerge to make AI interfaces appear more human-like in its behaviour; experts in non-traditional disciplines are recruited to develop more natural human-machine interfaces (e.g. human psychology, linguistics, ethics)[4]
- Cross-functional, AI personal assistants become a key part of many consumers' lives, organizing their finances, purchasing necessities, interacting with other AIs to make appointments etc.

AI is enabling the scalability of a core set of capabilities that enhance the ability of machines to classify, analyse, predict and act upon data

Capabilities and applications

Decision-making
Generate rules from general data, apply specific profiles against those rules and then take action or flag for review

Foresight
Determine the probability of future events given large sets of data, and use the probabilities to inform prediction-making

Customization
Generate rules from specific profiles and apply general data to tailor and optimize individual outcomes (e.g. customer tailoring)

Interaction
Interpret voice and text, and communicate with humans through digital or analogue media by applying natural language processing

Pattern detection
Recognize (ir)regularities in large amounts of data in order to analyse patterns that humans cannot easily detect

Generate alpha
Identify previously unexplored correlations between securities and economic indicators to generate superior returns

Risk prediction
Predict consumer loss event risk with greater accuracy to improve pricing and rapidly deploy new insurance products

Tailoring advice
Offer customized investment advice at a large scale to improve the individual customer's financial position

Customer service
Assess customer sentiment while interacting with a customer service agent (bot or human) to approach requests more efficiently

Fraud detection
Conduct analysis of a payment network to identify or link individuals who may be conducting fraudulent activity

Today, many of the most prominent debates in AI revolve around how humans will work alongside and, ultimately, trust AI-enabled machines

Sample use cases

C3.ai

C3.ai recently developed a platform application that is able to predict a permanent balance reduction 90 days in advance, allowing relationship managers at a large bank to determine interest rate sensitivity and adjust product pricing proactively.[5]

OpenAI

Open AI released their GPT-3 for private beta testing in July 2020. GPT-3 is the most powerful AI-based natural language processer in the world. It has the ability to write convincing streams of text in different styles and on different topics with a single prompting sentence.[6]

Topical debates

Trustworthy AI

- The explainability, fairness and accountability of AI algorithms has become a particularly contentious issue, as developers and users are sometimes unable to parse how and why complex algorithms make certain decisions[7]
- Poor explainability erodes trust as, when AI inevitably makes a counterintuitive (or incorrect) decision that it cannot explain, we are often unable to interrogate it, preventing (for instance) humans from learning from the machines to improve their own decisions or heuristics
- There is skepticism about how workforces will evolve to trust and work alongside AI[8]

Use of AI for facial recognition

- Facial recognition systems, powered by computer vision algorithms, have recently become the subject of intense scrutiny by regulators and civil rights groups
- These groups contend that their use should be severely curtailed, as some systems have been shown to be biased against certain minority groups and could be used for unwanted purposes (e.g. mass surveillance)[9]
- At the same time, proponents point to the benefit of continuing research to improve contactless payment systems and to continue making biometric authentication more robust to fight identity fraud[10]

References

Artificial intelligence (AI)

1. "The New Physics of Financial Services", World Economic Forum, Aug 2018, http://www3.weforum.org/docs/WEF_New_Physics_of_Financial_Services.pdf
2. Marr Bernard, "The Key Definitions of AI That Explain Its Importance", *Forbes,* 14 February 2018, https://www.forbes.com/sites/bernardmarr/2018/02/14/the-key-definitions-of-artificial-intelligence-ai-that-explain-its-importance/#79b0b0684f5d
3. Agrawal & Gans & Goldfarb, "Prediction Machines: The Simple Economics of Artificial Intelligence", 2018
4. Daugherty & Wilson, "Human + Machine: Reimagining Work in the Age of AI", 2018
5. Siebel Tom (2019) "Tom Siebel: The key to digital transformation lies simplicity", *C3.ai,* 9 September 2019, https://c3.ai/tom-siebel-the-key-to-digital-transformation-lies-in-simplicity/
6. Heaven Will Douglas (2020) "OpenAi's new language generator Gpt-3 is shocking good – and completely mindless", *MIT Technology Review,* 20 July 2020, https://www.technologyreview.com/2020/07/20/1005454/openai-machine-learning-language-generator-gpt-3-nlp/
7. Schmelzer Rob, "Understanding Explainable AI", 23 July 2019, https://www.forbes.com/sites/cognitiveworld/2019/07/23/understanding-explainable-ai/#6b8bddd67c9e
8. Dickson Ben, "Self Supervised learning: The Plan to make deep learning data efficient", *Tech Talks,* Ben Dickson, 23 March 2020, https://bdtechtalks.com/2020/03/23/yann-lecun-self-supervised-learning/
9. Taulli Tom, "Facial Recognition Ban: What do they mean for AI?", *Forbes,* 13 June 2020, https://www.forbes.com/sites/tomtaulli/2020/06/13/facial-recognition-bans-what-do-they-mean-for-ai-artificial-intelligence/#39fe137846ee
10. Lourenco Rafael "What Facial Recognition Technology Can Do for Safety Right Now and What It Can't Do yet", *CPO Magazine,* 30 June 2020, https://www.cpomagazine.com/cyber-security/what-facial-recognition-technology-can-do-for-safety-right-now-and-what-it-cant-do-yet/

Cloud computing

Cloud has quickly become a dominant computing paradigm for the modern enterprise and is providing the basis upon which future ecosystems in financial services and beyond are constructed

Definition

Cloud computing is the delivery of on-demand, remote computing services (e.g. data storage, computing power) over the internet. This allows organizations to "rent" computational capacity from third-party providers as opposed to building and owning their own computing resources. However, cloud providers today are offering more than just technology infrastructure. They are also developing and maintaining ecosystems of "as-a-service" tools, processes and capabilities to enhance all manner of business operations.[1]

State of functionality

Current state

- Many organizations are still in the process of defining their cloud strategy and transitioning current workflows from legacy technology stacks to cloud systems; some firms that adopted a single cloud strategy originally are beginning to explore multi-cloud strategies[2]
- Services, software and platforms rely on proprietary technology and are incompatible with competitor products in many cases
- Some organizations are still building their own data centres and investing in on-premise hardware as part of their overall technology infrastructures[3]

Short-term prediction (3-5 years)

- More firms adopt blended fog architectures, blending traditional cloud hardware for large-scale, non-immediate data storage and analysis, and on-the-edge computation applications where instant decisions are necessary
- Services, software and platforms are increasingly open source, allowing for industry collaboration and agile updates without being locked into a single provider
- Organizations rely more heavily on service providers to test IT services, and conduct financial reporting and other enterprise processes

Long-term prediction (5+ years)

- A splintering of global data regulations leads to the formation of multiple different cloud ecosystems with distinct rules and practices (likely defined by geographical and ideological differences) causing challenges for global enterprises
- Cloud providers offer even more advanced data analytics and quantum-as-a-service applications to companies of all sizes
- "Serverless" architecture is commonplace, where cloud providers manage IT functions, significantly simplifying the burden on enterprise IT teams

Shifting to the cloud has allowed institutions to improve both internal processes and customer service delivery by providing a more flexible architecture for data and application access

Capabilities and applications

Ubiquitous access
Access and control large-scale computing assets remotely from any internet-connected environment

Organizational agility
Develop modular architectures that allow for easy addition, removal and upgrade of digital capabilities

Computational scale
Obtain flexible and unlimited access to computing power, data analysis tools and storage space

Data storage and traceability
Increase the ability to store and verify the history/ location/application of data across the enterprise

Flexible workforce
Replace traditional firewall standards with zero-trust enterprise security models, and allow users to work remotely from any location with an approved device

Platform configuration
Allow users (e.g. employees) to access readily available organizational assets (e.g. platform applications) that can be tailored to their needs on demand

Increased speed to market
Launch and scale up new products to market more quickly than previously possible by tapping into flexible computation and storage resources

AML risk management
analyse whole-of-enterprise data to cross-reference customer actions from multiple data sources, transactions and networks to identify fraudulent activity

While cloud is a significant source of investment across the industry, concerns exist about the disproportionate control wielded by the largest service providers and the security of public clouds

Sample use cases

BBVA stands out in the industry for being an early adopter of the banking-as-a-service model. BBVA's cloud-based Open Platform product provides verification, money movement, account origination and card issuance for all products.[4]

National Australia Bank (NAB) is working with AWS (Amazon) to accelerate the bank's three-year transformation by migrating 400 workloads to the cloud, including its entire foreign-exchange platform, data lake and its NAB Discovery Cloud analytics environment.[5]

Topical debates

Fair access vs disproportionate control

- The cloud market displays highly oligopolistic tendencies, where a small number of large providers have substantial control; some argue that such a structure is appropriate, as high capital costs reward scale, which in turn keeps usage costs low for customers[6]
- However, others have contended that cloud providers have a disproportionate amount of control over access to value-added services, including emerging technologies (e.g. quantum computing power) and "intelligence-as-a-service" capabilities, on which modern institutions are increasingly dependent; they believe that this control could ultimately lead to unfair pricing

Public vs private cloud security

- An ongoing debate exists over whether private cloud infrastructure or public cloud infrastructure is more secure
- Proponents of private clouds argue that greater control over hardware begets higher visibility and security, and allows for isolation of cloud resources to maximize protection[7]
- Proponents of public clouds argue that the cybersecurity tools of large cloud providers are often significantly more advanced than those of individual enterprises, and that their automated defence systems benefit from being trained on much larger datasets[8]

References

Cloud computing

1. "What is cloud computing?", *Microsoft,* 2020, https://azure.microsoft.com/en-ca/overview/what-is-cloud-computing/
2. Pettey Christy, "6 Steps for Planning a Cloud Strategy", *Gartner,* 30 Jul 2019, https://www.gartner.com/smarterwithgartner/6-steps-for-planning-a-cloud-strategy/
3. "The Future of Data Centers", *CB Insights,* 24 January 2019, https://www.cbinsights.com/research/future-of-data-centers/
4. Miller Zach, "BBVA's Banking as a Service Offering", *Tearsheet,* 27 February 2020, https://tearsheet.co/podcasts/on-open-platform-bbvas-banking-as-a-service-offering-with-susan-french/
5. "National Australia Bank Begin Enterprise Transformation Using AWS", *AWS,* 2018, https://aws.amazon.com/solutions/case-studies/national-australia-bank/
6. Groucutt Peter, "Managing the Risks of the Cloud Oligopoly", *Computer Business Review,* 21 November 2018, https://www.cbronline.com/opinion/managing-the-risks-of-the-cloud-oligopoly
7. "Private Cloud", *IBM,* 10 April 2020, https://www.ibm.com/cloud/learn/introduction-to-private-cloud
8. Kroonenburg Ryan, "The Basic Advantages of Public Cloud", *Cloud Guru,* 15 October 2018 https://info.acloud.guru/resources/the-basic-advantages-of-public-cloud

Task-specific hardware

The development of specialized hardware to augment AI will continue to grow in importance as the use of AI becomes ubiquitous

Definition

Task-specific hardware (also known as hardware acceleration) refers to a set of related hardware devices that accelerate and/or optimize the training and inference of AI models because they are physically fabricated to process AI models (usually a specific model, like deep learning or reinforcement learning). They are commonly found in data centres, where they are accessed via the cloud by enterprises looking to train models and use those models to infer decisions. They can also be found embedded into edge devices (for instance, IoT devices or mobile phones), where they are primarily used to perform near real-time inference (or, increasingly with better power management, edge training of AI algorithms). Task-specific hardware can help improve the speed, efficiency, cost-effectiveness and environmental footprint of using AI.[1]

State of functionality

Current state

- A rapid proliferation of cloud-based task-specific hardware in the 2010s has driven major improvements in algorithmic efficiency; most large cloud providers have specialized AI offerings based on third-party (e.g. AWS NVIDIA GPU[2]) or native (e.g. Google TPU[3]) hardware
- Edge-specific hardware is just beginning to grow in popularity; this includes Apple's neural engine, built into recent versions of their iPhone chip to handle machine learning training and inference,[4] and a chipset being built by Tesla to run the real-time inference needed for its autopilot feature[5]

Short-term prediction (3-5 years)

- Specialized hardware will dominate the cloud server racks as AI use increases; cloud providers will invest heavily in programmable chips to process general workloads better than current GPUs, and charge clients a premium for access to highly specialized hardware for specific uses
- As sophisticated edge inference becomes increasingly necessary to run real-time algorithms, a small number of large technology providers will progressively develop integrated task-specific hardware and software solutions that will permeate many of our everyday devices; these chips will be tailored to the device's use[6]

Long-term prediction (5+ years)

- An evolution of the von Neumann architecture (e.g. compute-in-memory, photonic computing) will lead to exponential improvements in model training and inference[7]
- AI will largely replace humans in the task-specific hardware development process; specialized AI that studies algorithm-hardware interaction will quickly analyse inefficiencies and develop new and better architectures for a given algorithm;[8] flexible manufacturing (e.g. based on 3D printers) will quickly turn concept into reality, allowing for significant flexibility in chip design[9]

Task-specific hardware supports AI by making training and inference more efficient (i.e. in time or resource intensiveness) and more suitable to different environments (e.g. edge computing)

Capabilities and applications

Resource efficiency
Train and infer specific types of AI models using fewer resources by using hardware that has been physically constructed to optimize for solving that model

Parallelism
Train or infer from complex models more quickly by taking advantage of hardware that is able to run many more processes in parallel

Flexibility
Use Field Programmable Gate Arrays (FPGAs), a hardware that can be reprogrammed on the fly, to adapt hardware to process different model types

Edge enablement
Leverage edge (IoT) devices that can perform sophisticated training and inference based on hardware optimized for power usage

Algorithmic trading
Train large and sophisticated deep learning models for algorithmic trading, which take into account multiple data types and sources, more efficiently (improving training speed and saving cloud computing costs)

Model testing
Quickly test different types of AI models to find the optimal approach to solving a specific problem by simply altering hardware parameters before running the model

Dynamic insurance pricing
Process real-time driving data to automatically update car insurance pricing for drivers, taking advantage of data from multiple sensors in a connected vehicle

While key debates continue about the degree to which hardware will drive AI improvement and the potential for new architectural models, hardware acceleration has become critical to the AI stack

Sample use cases

Xilinx, in partnership with **NTT Disruption**, has developed a specialized FPGA for processing complex value-at-risk models, which they claim provides a 15x baseline improvement vs traditional solutions.[10]

Citi is leveraging GPUs made by **NVIDIA** to efficiently process hundreds of millions of daily data points and deploy multiple algorithmic trading strategies in the dollar treasury and futures market to find hidden liquidity.[11]

Topical debates

Hardware's future role in AI improvement

- Over the last decade, advances in AI have arisen through both more-efficient and effective algorithm development (software), and greater specialization and efficiency of hardware; there is some debate over how this may continue in the future
- For instance, the research firm OpenAI has, in recent years, observed a 44x improvement in the efficiency of training AI through algorithmic progress vs an 11x cost improvement via better hardware, implying that better algorithms currently play a more important role in improving AI[12]
- However, others believe that significant advances in hardware architectures (e.g. energy-efficient chips that drive model training and inference on IoT devices) will drive major benefits in terms of greater security and lower analysis latency for real-time use cases

Future of brain-inspired architecture

- One line of research in AI hardware and software development has emerged around replicating the brain's architecture (i.e. "neuromorphic" or "brain-inspired" architecture)
- Proponents reason that such architectures alone will allow AI to more closely build aspects of general intelligence (i.e. an AI that is able to replicate human cognition and can learn to perform tasks in a similar manner to humans)
- However, skeptics believe that it is still largely unclear whether neuromorphic replication will lead to more robust, cognitive and transferrable intelligence, and that pursuing this path may not bring any measurable improvement in computing power or efficiency, and may have limited practical application[13]

References

Task Specific Hardware

1. "Semiconductors – the Next Wave", *Deloitte,* April 2019, file:///C:/Users/mbelostotsky/Downloads/tw-semiconductor-report-EN.pdf
2. "Recommended GPU Instances", *AWS,* 2020, docs.aws.amazon.com/dlami/latest/devguide/gpu.html
3. "Tensor Processing Unit" *Google Cloud*, 2020, https://cloud.google.com/tpu/docs/tpus
4. Simonite Tom, "How Apple Makes the AI Chip Powering the iPhone's Fancy Tricks", *Wired,* 10 September 2018, https://www.wired.com/story/how-apple-makes-ai-chip-powering-iphones-fancy-tricks/
5. Lee Timothy, "Elon Musk confirms Tesla is building its own chips for Autopilot", *Arstechnica,* 8 December 2017, https://arstechnica.com/cars/2017/12/elon-musk-says-teslas-ai-chips-will-be-the-best-in-the-world/
6. Webb Amy, "How the Tech Titians and Their Thinking Machines Could Warp Humanity", 2019
7. Bailey Brian, "AI Architectures Must Change", *Semiconductor Engineering*, 13 August 2018 https://semiengineering.com/ai-architectures-must-change/
8. Moore Samuel, "Google Invents AI That Learns a Key Part of Chip Design", *IEEE Spectrum,* 23 March 2020, https://spectrum.ieee.org/tech-talk/semiconductors/design/google-invents-ai-that-learns-a-key-part-of-chip-design
9. Towes Rob, "AI is driving a silicon revolution", *Forbes,* 10 May 2020, https://www.forbes.com/sites/robtoews/2020/05/10/artificial-intelligence-is-driving-a-silicon-renaissance/#5f4e3745553c
10. "NTT Disruption & Xilinx Speed Zero Latency World for Good", *NTT Disruption,* 1 May 2020
11. Dave Ahana, "See How Financial Leaders Are Solving Data Challenges with AI, at GTC", *Nvidia,* 28 February 2019, https://blogs.nvidia.com/blog/2019/02/28/gtc-finance-industry-ai/
12. "AI and Efficiency", *Open AI,* 5 May 2020 https://openai.com/blog/ai-and-efficiency/
13. Ray Tiernan, "Intel's neuro guru slams deep learning: 'it's not actually learning'", 23 February 2020, https://www.zdnet.com/article/intels-neuro-guru-slams-deep-learning-its-not-actually-learning/

Quantum computing

While still in the early stages of commercial readiness, quantum computing holds the potential to solve a narrow, but critical, range of problems significantly more efficiently than classical computers

Definition

Quantum computing relies on the physical phenomena of nature to manipulate information via quantum mechanics. Quantum bits, referred to as qubits, can exist in two states at once (i.e. a 0 and a 1). This is known as superposition. These qubits may also be entangled with each other so that calculations can be performed with significantly more information than a traditional string of bits. These effects afford quantum computers the potential for massive increases in computational power. However, quantum computers are not a general-purpose replacement for classical computers; since quantum computing works in ways fundamentally different from classical computing, they are able to solve specific types of problems more effectively.[1]

State of functionality

Current state

- Quantum supremacy – proof that a quantum computer can solve some problems better than a classical computer – was demonstrated by a team at Google[2]
- In 2020, the largest publicly available quantum computer currently has 53 qubits, but hardware firms are actively working to increase this number and enable additional uses of the technology[3]
- Initial proofs of concept are being conducted with success in financial services, largely using hybrid systems of quantum and classical computers that split different parts of an algorithm across the two architectures to optimize performance[4]

Short-term prediction (3-5 years)

- Noisy, intermediate-scale quantum (NISQ) hardware begins to demonstrate instances of genuine quantum advantage in certain areas of financial services (e.g. capital markets)
- The public and private sector begin formally rallying behind quantum cryptography, to align on standards and improve encryption techniques[6]
- The use of quantum computing (e.g. quantum ML) begins to become a unique differentiator for large institutions; most large cloud providers have a market-ready "quantum-as-a-service" tool

Long-term prediction (10+ years*)

- Quantum computing hardware advances to the point where decoherence (a process that causes quantum information to be lost, a significant barrier to today's quantum computers) can be controlled via quantum error correction and meaningful quantum advantage is solidified
- Modern encryption techniques (e.g. RSA, AES 256) become easily decrypted by quantum computers; however, most governments, businesses and other large organizations (e.g. those who govern the encryption of the internet) have moved on to "quantum-secure" forms of encryption (e.g. lattice-based methods)

Note: Timeline has been adjusted to reflect the longer-term time horizon expected for developments in quantum computing

Quantum computers are highly adept at solving optimization problems, performing rapid simulation, computing prime factorizations and training machine learning models

Capabilities and applications

Optimization
Find both faster and higher-quality global solutions to a range of complex combinatorial optimization problems

Quantum machine learning
Enable more powerful and accurate machine learning algorithms by reducing the time and cost of training and inference

Simulation
Model the behaviour and evolution of complex systems rapidly and continuously to surface patterns

Prime factorization
Break down large integers into their prime factors more quickly and efficiently than classical computers

Portfolio optimization
Improve accuracy of portfolio construction by applying various quantum algorithms that solve continuous optimization problems

Credit scoring
Efficiently perform projection operations to consider significantly more attributes and improve client credit classifications

Risk analysis
Examine a wide range of different inputs and run complex quantum Monte Carlo simulations to calculate value at risk (VaR)

Public key decryption
Decrypt many of the most popular modern encryption techniques (which today protect nearly all of the world's data) based on the difficulty of factoring large integers

While fundamental questions remain about current-state practicality, leading financial institutions are actively engaging quantum experts in the development and testing of high-potential use cases

Sample use cases

Barclays recently collaborated with **IBM** to run a proof of concept on optimization for transaction settlement. They demonstrated that settlement optimization can be modeled on quantum algorithms to improve settlement efficiency.[7]

Scotiabank and **BMO** partnered with **Xanadu** on a proof of concept to discover computational speedups and accuracy improvements in trading. By applying quantum simulations they benefitted from predictions that were faster than traditional methods.[8]

Topical debates

Commercial accessibility timeline

- Quantum computing is making significant strides in its practical viability. Today, however, most quantum hardware is highly error prone, because the hardware is simply not stable enough to function for more than short periods of time; most quantum computers must be stored in precise, difficult-to-maintain environments[9]
- Complete error-correction, which would be fundamental to a multipurpose, commercially accessible quantum computer, remains a significant engineering challenge, and is a point of contention between academia and industry[9]
- Many believe that large-scale implementation is extremely challenging without full error-correction; however, those at the vanguard of industry implementation believe that by applying hybrid models of quantum technology, useful implementations are possible within 2-5 years[10]

Quantum algorithm development

- A common refrain espoused by a number of industry participants is that the advancement of quantum computing is solely limited by hardware
- In reality, it is also limited by the progress of quantum algorithms to solve real-world applications. This is because classical algorithms cannot simply be run on quantum computers and benefit from exponential speed-up
- Special quantum algorithms must be written and physically encoded on the computer itself and, to-date, few quantum algorithms that actually improve upon classical computers have been discovered[11]
- This misconception is reinforced by the “race for quantum supremacy” or “qubit wars” between several large technology companies, which are racing to develop machines with an ever-larger number of qubits (i.e. processing hardware) without necessarily demonstrating practical uses

References

Quantum computing

1. "What is Quantum Computing", IBM, 2020, https://www.ibm.com/quantum-computing/learn/what-is-quantum-computing/
2. Porter Jon, "Google Confirms 'quantum supremacy' breakthrough", *The Verge,* 23 October 2019, https://www.theverge.com/2019/10/23/20928294/google-quantum-supremacy-sycamore-computer-qubit-milestone
3. "IBM's new 53-qubit quantum computer is the most powerful machine you can use", *MIT Technology Review,* 18 September 2019, https://www.technologyreview.com/2019/09/18/132956/ibms-new-53-qubit-quantum-computer-is-the-most-powerful-machine-you-can-use/
4. Gossett Stephen, "8 Quantum Computing Applications & Examples", *Built-In,* 25 March 2020 https://builtin.com/hardware/quantum-computing-applications
5. "A game plan for Quantum computing", *McKinsey Digital,* 6 February 2020, https://www.mckinsey.com/business-functions/mckinsey-digital/our-insights/a-game-plan-for-quantum-computing
6. Korolov, Maria & Drinkwater, Doug, "What is quantum cryptography? It's no silver bullet, but could improve security", *CSO,* 12 March 2019, https://www.csoonline.com/article/3235970/what-is-quantum-cryptography-it-s-no-silver-bullet-but-could-improve-security.html
7. Saran Cliff, "Barclays demonstrates proof-of-concept quantum clearing algorithm", *ComputerWeekly,* 17 October 2019, https://www.computerweekly.com/news/252472462/Barclays-demonstrates-proof-of-concept-quantum-clearing-algorithm
8. "BMO Financial Group and Scotiabank Partner with Xanadu on Quantum Computing Speedups for Trading Products", *Cision,* 20 August 2019, https://www.newswire.ca/news-releases/bmo-financial-group-and-scotiabank-partner-with-xanadu-on-quantum-computing-speedups-for-trading-products-866739711.html
9. "Quantum Error Correction", *TU Delft,* 2020, https://www.tudelft.nl/eemcs/the-faculty/departments/quantum-computer-engineering/quantum-computer-architecture-lab/research/quantum-error-correction/#:~:text=Quantum%20Error%20Correction-,Quantum%20Error%20Correction,prone%20resulting%20in%20unreliable%20computations.
10. "Five Innovations that will change our lives within five years", IBM, 2020, https://www.research.ibm.com/5-in-5/quantum-computing/
11. Pakin, Scott & Coles, Patrick, "The Problem with Quantum Computers", *Scientific American,* 10 June 2019, https://blogs.scientificamerican.com/observations/the-problem-with-quantum-computers/

Internet of things (IoT)

IoT refers to a combination of hardware and software that can record, analyse and transmit data to bridge the physical and digital worlds

Definition

IoT refers to a combination of hardware and software that allows devices and other physical objects to generate data and transmit that data or otherwise communicate with other devices over the internet. These devices range from simple sensors that transmit information back to a central server, to smarter devices capable of inference and communicating with each other (called machine-to-machine communications) to take specific actions based on analysed data.[1]

State of functionality

Current state

- There are over 30 billion connected devices in the world today, with many consumers sharing data in exchange for personalized services despite privacy concerns[2]
- Proof of concept exists for IoT applications with niche use cases in financial services (e.g. insurance, lending) but, to date, there has been moderate adoption overall in the industry[3]
- IoT devices are mostly sensory and must communicate with processors in the cloud to unlock value (e.g. wearables, industrial sensors)[4]

Short-term prediction (3-5 years)

- The number of connected devices and amount of data scales, and there is a strong push to adopt standardized security measures to protect users[5]
- Proof of value for IoT applications and strong business cases are established to ignite mass commercial adoption across industries, including financial services (e.g. to expand into just-in-time lending or more fine-grained insurance offerings)
- Emerging technologies and capabilities such as 5G and edge computing through task-specific hardware enable shorter data transfer latency and allow for more advanced IoT usage (e.g. smart cities)[6]

Long-term prediction (5+ years)

- Individuals will own ~15-20 connected devices, and AI-based software will help them control how data from these connected devices is shared with third parties, how they could be remunerated for sharing this data, and manage seamless integrations between them and other devices (e.g. autonomous vehicles picking up and paying for groceries)[7]
- Significantly more advanced AI is embedded in IoT devices so a high degree of computing and analysis can be done at the source, resulting in highly sophisticated use cases (e.g. nanosensors for in-body patient monitoring)[8]

IoT enables the collection and transmission of large amounts of granular data at significant velocity, as well as in-situ analysis; it also enables devices to communicate and take action autonomously

Capabilities and applications

Real-time data monitoring
Enable real-time data from the device, or its surroundings, to be streamed back to another location (e.g. cloud) for storage and analysis

Autonomous analysis and action
Use efficient hardware to allow small devices to perform inference (and even training) and take action (e.g. change parameters) at the edge

Device control
Control various devices autonomously or via human input from a remote location (e.g. a remote monitoring centre)

Machine-to-machine communication
Allow two or more devices to communicate with one another without human input or manipulation

Weather data: Commodities price
Collect weather data to make predictions about the future prices of weather-linked commodities (e.g. crops), enhancing the trading business

Asset-based preventative action
Use devices embedded on assets to help insurance companies avoid claims (e.g. auto-shutoff of wind turbines if overheat is predicted); this kind of analysis could be done remotely (from a supervisory control and data acquisition (SCADA) centre or cloud server or entirely on the object (i.e. using edge inference)

Machine-to-machine payments
Enable autonomous vehicles with the ability to make automatic toll payments when passing through a sensor-enabled toll booth on the highway

The growing ubiquity of IoT raises significant questions about the security of these devices and the potential invasion of privacy they may facilitate, especially in sensitive environments

Sample use cases

Nodle has developed a DLT-based micropayments protocol for IoT devices to send payments among each other. Currently, they are testing a use case that reimburses mobile phone users for providing internet connectivity to IoT devices.[8]

Rabobank has partnered with **ProducePay**, which creates a marketplace to facilitate cash advances between distributors and farmer. Rabobank entered in an IoT-based pilot to use crop development data as in input into its loan financing terms.[9]

Topical debates

Securing the IoT

- As the number of internet-connected devices grows, so too does the opportunity for, and the economic impact of, device compromise; this is exacerbated by IoT security lagging that of other connected devices[10]
- The majority of commercial IoT devices (e.g. sensors) are designed to consume limited amounts of power and run on highly optimized hardware; conventional wisdom suggests that this leaves little room for implementing robust security and, indeed, many experts believe that focusing on overall network architecture security (vs device security) is the best approach[10]
- However, experts in the field of "lightweight encryption" – which miniaturizes the footprint of encryption algorithms such that they can be run on small devices – believe that device-level security through encryption is both feasible and highly advantageous[11]

IoT's use in the workplace

- A common narrative about IoT devices is that they may disrupt the modern office by improving employee efficiency and overall well-being. Proponents believe that sensors can be used to streamline basic workplace tasks (e.g. automate meeting room selection based on employee location) or provide efficiency-enhancing recommendations (e.g. recommending that a distracted employee take a short break)[12]
- However, there is a significant amount of dissent from those who believe that such devices infringe upon employee privacy, and could lead to flawed or incomplete assessments of preference or productivity
- The COVID-19 pandemic is exacerbating this debate, as employers discuss the use of sensors to enforce physical distancing or conduct temperature screenings, which some believe creates a slippery slope towards more wide-scale employee surveillance[13]

References

Internet of things

1. Ranger Steve, "What is the IoT? Everything you need to know about the Internet of Things right now", *ZD Net,* 3 February 2020, https://www.zdnet.com/article/what-is-the-internet-of-things-everything-you-need-to-know-about-the-iot-right-now/
2. Hodgson Martin, "The top five frustrations faced by IT admins and how to deal with them", *IT Pro Portal,* 23 July 2020, https://www.itproportal.com/features/the-top-five-frustrations-faced-by-it-admins-and-how-to-deal-with-them/
3. "IoT Use Cases", Ericsson, 2020, https://www.ericsson.com/en/internet-of-things/cases
4. "The IoT Evolution – Top 9 IoT Use Cases", *Western Digital Blog,* N.d, https://blog.westerndigital.com/top-9-iot-use-cases/
5. Molla Rani, "People say they care about privacy but they continue to buy devices that can spy on them", *Vox,* 13 May 2019, https://www.vox.com/recode/2019/5/13/18547235/trust-smart-devices-privacy-security
6. Shaw Keith, "What is edge computing and why it matters", *Network World,* 13 November 2019, https://www.networkworld.com/article/3224893/what-is-edge-computing-and-how-it-s-changing-the-network.html
7. Heslop Brent, "by 2030, Each Person will own 15 connected devices- here's what that means for your business and content", *Martech Advisor,* 4 March 2019, https://www.martechadvisor.com/articles/iot/by-2030-each-person-will-own-15-connected-devices-heres-what-that-means-for-your-business-and-content/#:~:text=When%20estimates%20state%20that%20the,and%
8. "Rabo Frontier Ventures invests in Agtech Company Produce Pay", Rabobank, 2018, https://www.rabobank.com/en/press/search/2018/rabo-frontier-ventures-invests-in-agtech-company-producepay.html
9. "The first steps in effective IoT Device Security", *Trend Micro,* 31 October 2019, https://www.trendmicro.com/vinfo/hk-en/security/news/internet-of-things/the-first-steps-in-effective-iot-device-security
10. Newman Hay Lily "The Debate Over How to Encrypt the Internet of Things", *Wired,* 23 November 2018, www.wired.com/story/lightweight-encryption-internet-of-things
11. Saner Emma, "Employers are monitoring computers, toilet breaks – even emotions. Is your boss watching you?", *The Guardian,* 14 May 2018, https://www.theguardian.com/world/2018/may/14/is-your-boss-secretly-or-not-so-secretly-watching-you
12. "Lenovo Launches Internet of Things Solutions TO Make the Workplace Safer During COVID 19", 24 June 2020, https://iotbusinessnews.com/2020/06/24/83500-lenovo-launches-internet-of-things-solutions-to-make-the-workplace-safer-during-covid-19/

5G networking

The fifth generation of cellular networking represents a step-function improvement over previous generations, with the potential to enable use cases reliant on high-velocity data transmission

Definition

5G networking refers to the fifth-generation standard for cellular networking technology, which will (gradually, after a period of coexistence) replace the previous 4G/LTE standard as the chief system through which mobile devices (e.g. phones, IoT devices etc.) communicate with one another and connect to the internet. 5G is not a singular piece of software or hardware; rather, it is an integrated architecture of hardware (e.g. radio antennas), software (e.g. device management) and new radio frequencies that promises improved speeds, lower latency and greater network security, among other benefits.[1]

State of functionality

Current state

- There is an ongoing competition between major telecommunications firms globally for ownership of 5G infrastructure; recently, this evolved into a significant geopolitical issue due to concerns about cross-border surveillance and control
- Commercial 5G adoption is limited by expensive infrastructure and availability of 5G-enabled hardware
- Financial services use cases for 5G are limited to branch enhancements (e.g. VR experiences, low-latency video transmission, portable ATMs and real-time payments)

Short-term prediction (3-5 years)

- 5G networks are commonplace in urban areas leading to a multitude of new applications that leverage low-latency communication (e.g. AR glasses, VR videoconferencing)[2]
- Due to ultra-reliable low-latency communications capabilities, private networking and mission-critical communications are enabled (i.e. remote surgery, VR videoconferencing)[3]
- Financial services experiment with customer engagement use cases (e.g. personalized relationships, easier access to advisers, contextualized shopping experiences)[3]

Long-term prediction (5+ years)

- 5G coverage is available all over the world, including rural areas, and its low costs lead to enhancements across industries (e.g. autonomous trucks with rural routes, drone deliveries, connected-home robots)[3]
- Due to massive machine-type communications capabilities, mesh communication and incredibly dense data transmission by IoT devices are possible[4]
- Financial services firms see significant benefit from 5G connectivity (e.g. fully wireless campuses; virtual asset evaluations; enhanced risk evaluations)[5]

Beyond improved download speeds and lower latency communications, 5G brings with it the ability to create massive mesh networks of low-powered IoT devices with enhanced security

Capabilities and applications

Enhanced mobile broadband (EMBB)
Deliver faster and more reliable (3-10x) upload/download speeds than 4G networks

Ultra-reliable low-latency communications (ULLC)
Enable the ability to process and transmit large amounts of data over the network with little delay

Massive machine-type communications (MMTC)
Allow an extremely high density of IoT-enabled devices to communicate with one another

Lower power usage
Allow IoT devices to dedicate more power to analysis through lower energy usage than existing network technologies

Greater network security
Enable increased automation of device management, better encryption of sensitive data stored on mobile, and improved device tracking reduce data breach threats

Payments fraud prevention
Deploy real-time transmission and analysis of more data (e.g. biometrics, location, video) at the point of sale to reduce instances of payments fraud

AR/VR advisory
Deploy rich virtual reality experiences, like offering customers the chance to speak with a 3D avatar of a remote financial adviser

Automated payments
Create massive mesh networks of devices that instantly transfer payments to one another for services rendered (e.g. car to parking spot, car to toll road)

Edge analytics for insurance
Update pricing for auto and other asset insurance in real-time, using IoT devices at the edge that have greater power capacity to perform complex calculations

Office connectivity
Implement completely wireless office/campus network infrastructure, while improving security through better device management

As debate continues about where 5G will have the most impact, institutions are working with telecom providers to build secure networks for their campuses and exploring virtual branch options

Sample use cases

Both BBVA and Commonwealth Bank of Australia are trialing 5G at campuses and branches to provide quicker access to critical market information (e.g. stock market data) that previously required fixed landline infrastructure.[5,6]

Unnamed Large Financial Institution

US carrier AT&T is working alongside an unnamed large financial institution to pilot a mobile branch offering that is driven by ultra low-latency 5G and involves a "video-centric customer experience".[7]

Topical debates

Difficulty of achieving ubiquitous coverage

- Continuous 5G availability and widespread coverage are key to realizing use cases that rely on real-time data transfer; however, 5G requires a significantly higher hardware density (i.e. towers per km^2) than previous network technologies (30%-50% of rural 5G implementation costs stem from last-mile connectivity)[8,9]
- Some believe that this will limit 5G's potential to create widespread benefit, as it makes the technology hard to implement outside of urban areas, where fixed capital costs can be spread across more consumers[8]
- Others have argued that the problem is solvable; for instance, AT&T's AirGig technology allows power line infrastructure to be repurposed into 5G transmitters, significantly reducing coverage costs[9]

Most transformational 5G capabilities

- Many industry players are assessing investments in 5G primarily based on its ability to deliver enhanced mobile broadband to drive down the per-gigabyte cost of data, and significantly increase speed and reduce latency in data transfer
- However, experts believe that it is the less-discussed 5G use cases, including ULLC and MMTC, that will create the most transformational benefits for enterprises
- ULLC, for instance, will allow organizations to deploy 5G in office settings, exponentially reducing the capital costs associated with network infrastructure while providing highly advanced and automated device management and security capabilities, while MMTC will allow upwards of 1 million IoT devices per km^2 to communicate seamlessly[10]

References

5G networking

1. "What is 5G? Understanding The Next-Gen Wireless System Set to Enable Our Connected Future", *CB Insights,* 19 March 2020, https://www.cbinsights.com/research/5g-next-gen-wireless-system/#industries
2. "The four industry myths surrounding 5G", Ericsson, 2020, https://www.ericsson.com/en/reports-and-papers/consumerlab/reports/5g-consumer-potential
3. "What is 5G? Understanding The Next-Gen Wireless System Set to Enable Our Connected Future", *CB Insights,* 19 March 2020, https://www.cbinsights.com/research/5g-next-gen-wireless-system/#industries
4. "What is 5G? Understanding The Next-Gen Wireless System Set to Enable Our Connected Future", *CB Insights,* 19 March 2020, https://www.cbinsights.com/research/5g-next-gen-wireless-system/#industries
5. Legters Bob, "Five Ways 5G Might Change How You Bank", *Forbes,* 15 May 2019, : https://www.forbes.com/sites/boblegters/2019/05/15/five-ways-5g-might-change-how-you-bank/#563dd6105fc8
5. "Quantum Computing, 5G and blockchain technologies that will market the next decade in banking", *BBVA,* 23 January 2020 https://www.bbva.com/en/quantum-computing-5g-and-blockchain-technologies-that-will-mark-the-next-decade-in-banking/
6. "Telstra and CBA partner on 5G banking trials", *Australian FinTech,* n.d, https://australianfintech.com.au/telstra-and-cba-partner-on-5g-banking-trials/
7. "What is 5G? Understanding The Next-Gen Wireless System Set to Enable Our Connected Future", *CB Insights,* 19 March 2020, https://www.cbinsights.com/research/5g-next-gen-wireless-system/#industries
8. Thompson Larry & Stadt Vande Warren, " 5G is Not the Answer For Rural Broadband", *Broadband Communities,* March 2017, https://www.pcmag.com/news/what-will-5g-do-for-rural-areas
9. Segan Sascha, "What Will 5G Do for Rural Areas", *PC Mag,* 19 December 2018, https://www.pcmag.com/news/what-will-5g-do-for-rural-areas
10. "Evaluation of LTE-M towards 5G IoT requirements", *LTE-M,* 2020, https://www.telenor.no/binaries/LTE-M%20Performance%20Towards%205G%20White%20Paper%20V1.1%20Final_tcm95-356995.pdf

Augmented/virtual reality (AR/VR)

Many believe that AR/VR, two interrelated technologies that integrate physical and virtual information, will enable an important shift in human-computer interaction

Definition

AR/VR refers to two distinct but highly interrelated classes of technologies that integrate the virtual world with the real world. Augmented reality (AR) involves the use of computer-generated overlays that superimpose virtual objects (e.g. people, infographics, furniture) on to our view of the world around us, either through a mobile camera or other lens (e.g. glasses). By contrast, virtual reality is a completely self-contained, and computer-simulated virtual world that involves the complete immersion of one or more senses (most commonly sight and hearing, but increasingly incorporating touch and smell).[1]

State of functionality

Current state

- AR use cases in retail are emerging that begin to bridge the gap between digital and physical worlds (e.g. “in-home” simulation of furniture, AR dressing rooms)[2]
- VR use cases in education and training are gaining traction for enterprises, including in financial services; in sports and entertainment, it has unlocked new consumer experiences[3]
- AR/VR developer kits are being created to promote development of useful applications (e.g. Apple’s ARKit 3, Oculus Mobile SDK)[4]

Short-term prediction (3-5 years)

- The first commercially successful smart-glasses are launched that are sleek and operate independent of mobile devices, enhancing many daily tasks (e.g. object identification)
- VR headsets become more affordable, graphics become more realistic and there is a wider range of content that appeals to mass consumers
- AR/VR technology matures given the move to more remote work and customer service and, as a result, personal data is collected more frequently (e.g. motor actions, eye movement patterns); some view this as being too intrusive, but uptake is generally high

Long-term prediction (5+ years)

- AR experiences are deeply embedded into some aspects of our daily lives and become a reliable secondary option for interacting with one other and the world around us
- VR is able to create unique, user-specific experiences in real-time by leveraging AI, edge computing and IoT to accelerate rendering times
- Issues of identity privacy and security become more prominent; companies can analyse kinematic data (displacement and orientation of body segments) to recreate hyper-realistic holograms of people in any situation, raising deepfake concerns

AR/VR devices are designed to deliver contextual information about the world around us (AR) or create completely immersive virtual worlds (VR)

Capabilities and applications

Enhanced data presentation
Allow for the visualization and organization of complex financial information (e.g. livestreaming market data) to improve decision-making

Augmented training
Serve as an immersive and interactive training tool that can mimic real-life/situational environments to maximize knowledge retention

Immersive digital interactivity
Enable humans to interact with each other (or an advanced AI algorithm) in an immersive environment that mimics real-life settings

Contextual information feeds
In the case of AR, serve richly contextual information about the world around us to guide behaviours and decision-making

Interactive data analysis
Deploy a 360-degree view of popular financial terminal (e.g. Bloomberg) screens using VR that can be manipulated by research analysts to enhance productivity

Infrastructure repair
Overlay tutorial steps and use computer visioning AI algorithms to detect faults in order to guide technical staff through hardware repairs

Immersive teleconferencing
Develop teleconferencing solutions that use advanced cameras, microphones and AR/VR to mimic in-person meetings

AR/VR payments
Use computer visioning AI algorithms, connected to an AR device, to recognize products (e.g. walking through a mall), determine their availability online and allow users to make purchases

While AR/VR hardware has improved substantially, it is still largely considered niche; nonetheless, firms are evaluating their potential to improve data analysis, employee training and payment experiences

Sample use cases

Citibank is utilizing Microsoft HoloLens AR headset to help analysts visualize 3D models of their data. Traders are able to utilize voice and hand gestures to manipulate the real-time, visualized data.[5]

Apple is working with a number of retailer partners, including Home Depot and Wayfair, to add Apple Pay integration to its "Quick Look" feature, allowing users to see how an object (e.g. a table) looks in the space around them, and then purchase it.[6]

Topical debates

AR's potential for ubiquity

- Many consider AR to be a potentially dominant paradigm in human-computer interaction, one that evolves our engagement with technology from near-constant interaction (mobile phones, computers) to constant interaction (e.g. AR glasses)[7]
- However, early developers have faced challenges in designing interfaces that integrate seamlessly into everyday life and strike a balance between usefulness and intrusiveness
- This has led to dissent about whether AR will become an always-on experience or only be called upon for specific uses (e.g. displaying product information when shopping)[8]

Privacy and data security concerns

- A key area of debate in AR is how devices will preserve individual privacy and what methods exist to prevent malicious use
- A particular area of concern are devices that constantly scan and record the world around them (e.g. AR glasses)
- These could allow a malicious user to capture voice and facial data of those around them, which could later be used to create deepfakes or spoof certain authentication methods[9]
- Concern has also been raised about how data capture of a user's everyday experiences and behaviours could potentially be exploited by advertisers[10]

References

Augmented/virtual reality

1. "What's the Difference Between AR, VR, And MR?", *The Franklin Institute,* 2020, https://www.fi.edu/difference-between-ar-vr-and-mr#:~:text=Augmented%20reality%20(AR)%20adds%20digital,shuts%20out%20the%20physical%20world.
2. "Augmented Reality & Business: bridging Virtual & Physical Gaps", *Cognizant,* January 2018, https://www.cognizant.com/whitepapers/augmented-reality-and-business-bridging-virtual-and-physical-gaps-codex2922.pdf
3. "Virtual Reality App Development", *Invisible Toys,* 2020, https://invisible.toys/virtual-reality
4. Kim "Top 34 AR/VR Development Tools and SDKs You Should Know About", *Bluewhale,* 2020, https://bluewhaleapps.com/blog/top-ar-vr-development-tools-and-sdks-you-should-know-about-development/virtual-reality-in-education/
5. "Citi Taps Microsoft HoloLens for Virtual Reality Trading", *Finextra,* April 2016, https://www.finextra.com/newsarticle/28712/citi-taps-microsoft-hololens-for-virtual-reality-trading
6. Potuck Michael, "Apple launches purchase button for AT Quick Look Feature with Home Depot and Wayfair on Board", *9 to 5 Mac*, 13 February 2020, https://9to5mac.com/2020/02/13/apple-ar-quick-look-purchase-button-for-retailers/
7. Mark Zuckerberg, Facebook, 9 January 2020, https://www.facebook.com/zuck/posts/10111311886191191
8. Paris Francesca, "A Strange New World: Has Virtual Reality Gaming Lived Up To Its Promise", *WBUR,* 24 February 2020
9. Rauschnabel Philipp "Augmented Reality And Privacy Concerns", 1 February 2019, http://www.philipprauschnabel.com/2019/02/research-on-augmented-reality-privacy/#:~:text=When%20it%20comes%20to%20AR%2C%20two%20forms%20of%20privacy%20concerns,what%20he%2Fshe%20is%20doing.
10. Soare Bianca, "What are the Security and Privacy Risks of VR and AR", *Heimdal Security,* 25 June 2019, https://heimdalsecurity.com/blog/vr-ar-security-privacy-risks/

Distributed ledger technology (DLT)

DLT comprises a set of related technologies (e.g. public and private blockchains, smart contracts) that governs the flow of value and data across decentralized participants

Definition

DLT enables a digital ledger of transactions, contracts or tokenized (i.e. dematerialized) assets that is supported by a replicated, synchronized and decentralized network (i.e. across different users and locations). DLT is a catch-all term that, in this document, encompasses three main technologies: public distributed ledgers (e.g. public blockchains, including those used to mine and trade cryptocurrencies), permissioned distributed ledgers and smart contracts. Developed out of the desire to remove intermediaries by enhancing trust among institutions, DLT aims to achieve consensus among participants in order to create a common source of truth.[1]

State of functionality

Current state

- Financial institutions are testing a wide range of use cases, with a number already in early production, while researchers are developing more advanced solutions to constraints around speed, security and decentralization[2]
- Dominant platforms are beginning to proliferate, and emerging standards aimed at building foundational infrastructure across industries are developing (e.g. Enterprise Ethereum Alliance)[3]
- Multiple public and private initiatives are underway to address the need for "cash on a ledger" (e.g. China is close to unveiling the world's first official CBDC using DLT)[4]

Short-term prediction (3-5 years)

- More institutions are embedding DLT into core pieces of infrastructure and embracing smart contracts; capital markets processes, cross-border payments and supply chains become more secure and streamlined
- Increased collaboration and more widespread infrastructure upgrades lead to the emergence of stable and scalable cross-chain solutions that link different ledgers (e.g. blockchains) together
- More countries start to pilot CBDCs and develop the necessary infrastructure to enable this (e.g. payment rails and interfaces)

Long-term prediction (5+ years)

- Robust applications for DLT are created across industries beyond financial services and supply chain (e.g. ledger-protected voting, proof of purchase for insurance claims); contract mediation and data reconciliation processes must evolve appropriately
- The technology becomes mature enough that some governments use DLT to certify digital identity across several use cases
- Wholesale and retail CBDCs begin to gain significant traction and, in many jurisdictions, become a common method of payment

Distributed ledger architectures can help improve the transparency, auditability and security of information transfer and improve transaction automation and atomicity

Capabilities and applications

Data transparency and traceability
Provide all network members access to the same information (i.e. a full copy of the ledger), which can also be encrypted

Immutability
Create a verifiable audit trail of transactions that is nearly impossible to alter or manipulate

Smart contract automation
Smart contracts allow users to programme pre-agreed conditions that are automatically executed once certain conditions hold

Security
Remove single points of attack and create more resiliency as a result of distributed, cryptographically secure information storage

Cross-firm data reconciliation
Use consensus algorithms to ensure cross-border fund transfers occur in real-time and offer a single source of truth to all participants

Insurance fraud prevention
Trace physical goods back to their origin to improve the legitimacy of supply chains and mitigate instances of commercial insurance fraud

Parametric insurance
Embed insurance contracts with the ability to automatically pay out a certain amount of funds from a digital wallet if specific conditions are exceeded (e.g. crop insurance payment based on wind speed)

Decentralized identity
Enable decentralized identity and access management processes for customers that limit centralized honeypots of customer information and allow for self-sovereign authentication

Widescale implementation has remained minimal due to skepticism about decentralization and tokenization; however, live use cases are beginning to emerge, especially in the capital markets

Sample use cases

UBS and **Clearmatics** founded the Utility Settlement Coin Initiative in 2015 to tokenise fiat currencies and address the "cash on a ledger" problem; as of 2019, 15 major institutions have backed the initiative with the creation and investment in Fnality International.[5]

Credit Suisse and **ING** executed the first live securities lending transaction on a DLT, settled using R3's Corda platform. The basket of swapped securities held a value of €25 million and has been celebrated as a major milestone in DLT-based capital markets infrastructure.[6]

Topical debates

Viability of decentralized finance (DeFi)

- A number of industry participants have argued that decentralized alternatives to traditional financial institutions, products and assets enabled by DLT (e.g. P2P lending, stable coins, cryptocurrencies) will become a viable operating model for financial services in the future, because less intermediation significantly reduces costs, increases automation and atomicity, and benefits transparency[7]
- Others, however, stress that intermediation and centralization play irreplaceable roles in financial services, and that transaction atomicity is not always beneficial; for instance, central clearinghouses play a vital role in centrally settling transactions, which significantly reduces the capital requirements vs P2P settlement, while single, centrally issued currencies reduce the complexity that multiple, competing stablecoins/cryptocurrencies (with multiple FX rates) would create[8]

Liquidity benefit of mass tokenization

- Proponents of asset tokenization argue that doing so will create new liquidity pools in illiquid markets (e.g. rare assets), allow for low-cost fractionalization of ownership (increasing the accessibility of investment classes, such as government bonds for retail investors), reduce transaction costs through automation and minimize information asymmetries to improve the accuracy of price discovery[9]
- However, these views are not universally held. In the rare asset market, some argue that, in practice, the desire to hold these investments over the long term, and limited market-moving information, will create temporary primary market liquidity but little secondary market liquidity
- In the government bond market, some believe that transaction costs will not necessarily be low enough to attract retail investors and drive more primary- and secondary-market liquidity

References

Distributed ledger technology

1. "Blockchain & Distributed Ledger Technology", The World Bank, 12 April 2018, https://www.worldbank.org/en/topic/financialsector/brief/blockchain-dlt
2. "The growing list of applications and use cases of blockchain technology in business and life", *Business Insider,* 2 March 2020. https://www.businessinsider.com/blockchain-technology-applications-use-cases
3. Mourselas Costas, "DTCC warns derivatives industry on fragmented DLT", *Global Capital,* 24 April 2018, https://www.globalcapital.com/article/b17wy8nlj4k4zt/dtcc-warns-derivatives-industry-on-fragmented-dlt
4. "China is ready for central bank digital currency issuance. Here's the plan", *Ledger Insights,* 2019, https://www.ledgerinsights.com/china-ready-central-bank-digital-currency-cbdc/
5. Watkins, Jon, "Utility Settlement Coin: A project the banks can get behind", *The Trade,* 28 November 2019 https://www.thetradenews.com/utility-settlement-coin-project-banks-can-get-behind/
6. "Credit Suisse and ING execute first live transaction using HQLAx securities lending app on R3's Corda blockchain", Credit Suisse, 3 January 2018, www.credit-suisse.com/about-us-news/en/articles/media-releases/cs-and-ing-execute-first-live-transaction-201803.html
7. "Decentralized Finance: What Do you need to know?", *Medium,* 9 December 2019, https://medium.com/@philippsandner/decentralized-finance-defi-what-do-you-need-to-know-9cd5e8c2a48
8. Evans Jon, "DeFinance: billion-dollar finance, million dollar hacks and very little value", *Tech Crunch,* 18 February 2020 https://techcrunch.com/2020/02/18/defiance-billion-dollar-finance-million-dollar-hacks-and-very-little-value/
9. Zainuddin Aziz, "The benefits of Tokenizing Real World Assets", *eToroX,* 23 September 2019, https://etorox.com/news/opinions/the-benefits-of-tokenizing-real-world-assets/#:~:text=Tokenization%20enables%20fractional%20ownership%2C%20in,can%20now%20access%20these%20assets.

Concluding remarks

Exploring the opportunities at the intersection of emerging technologies reveals a future of financial services that is more connected, collaborative and competitive than ever before

As a result of emerging technology adoption, future financial institutions will be:

Ecosystem-oriented: Industry boundaries continue to blur, as financial and non-financial products are being embedded in new ways to fulfil broad customer journeys. In addition, many technical and competitive barriers to collaboration are being lessened, improving business cases of partnering with peers to create mutually beneficial offerings.

Customer-obsessed: The fight to capture scarce moments of customer attention and build exclusive partnerships that drive unique advice, personalization and complementary offerings will necessitate the development of rapid and closely monitored feedback loops.

Coordinated and agile: Data analysis, storage and transfer technologies are helping financial institutions easily link together disparate sources of information, enhancing coordination and decision-making agility while necessitating the breakdown of organizational siloes.

At the same time, they will have to contend with an operating environment that will soon become:

Highly democratized: In the long run, economical and democratized access to the suite of emerging technologies will eliminate most of the competitive advantage associated with speed and efficiency; ultimately, this will require institutions to return to some of the most core competitive principles of assembly, execution and relationships.

Fraught with new challenges: If their deployment is not considered carefully, technology clusters could bring new or reinforced governance challenges to the fore, and lead to investments in ultimately undesirable market structures.

Liberated of old assumptions: Innovators will rethink traditional talent operating models, develop new approaches to manage the challenges associated with risky data collaborations, and build closer and more transparent relationships with regulators to reimagine how compliance is conducted.

While the multiplicative forces that arise at the intersection of AI and other emerging technologies are a source of inspirational new value propositions, they also give rise to **new and highly complex systemic risks**. At the same time, they unlock **new approaches to mitigating these risks**. To this end, The World Economic Forum is initiating an exploration into how emerging technologies may come together to augment, create or mitigate sources of systemic risk.

Acknowledgments

Contributors

The project team would like to express its gratitude to the following subject matter experts who contributed their valuable perspectives through interviews and by participating in workshops and roundtable discussions (in alphabetical order):

Ed Abbo	C3.AI
David Ackley	University of New Mexico
Yoshiharu Akahane	NTT Data
Rasheed Al Maraj	Central Bank of Bahrain (CBB)
Victor Alexiev	Citi
Jeremy Allaire	Circle
Bruno Amaro	Barclays
Vartika Ambwani	Silicon Valley Bank
Rakesh Arora	Bank of Canada
Dean Athanasia	Bank of America
Evangelos Avramakis	Swiss Reinsurance Company Ltd
Pavle Avramovic	Financial Conduct Authority (UK)
Didier Baclin	Zopa
Sanjiv Bajaj	Bajaj Finserv Ltd
Tim Baker	Refinitiv Limited
Marc Barrachin	S&P Global
James Beeson	Skippr
Daniel Belfer	Bank J. Safra Sarasin Ltd
Micha Benoliel	Nodle
Laurent Bertrand	Bettertrade-off
Peng (Luther) Bian	China Construction Bank
Pedro Bizarro	Feedzai
Kjerstin Braathen	DNB ASA
Julien Brazeau	Deloitte Canada
James Breeze	AXA XL
Aneta Buchert	Bank of England
Craig Burel	Reciprocal Ventures
Neil Butters	Interac
Ann Cairns	Mastercard
Arthur Calipo	Deloitte Australia
Anne-Sophie Cartray	ConsenSys
Bill Cecil	State Farm
Anna Celner	Deloitte Switzerland
Javier Sebastián Cermeño	BBVA SA

Contributors (Continued)

The project team would like to express its gratitude to the following subject matter experts who contributed their valuable perspectives through interviews and by participating in workshops and roundtable discussions (in alphabetical order):

Philippe Chambadal	C3.AI
Natalie Chan	Hong Kong Monetary Authority
Brenton Charnley	Cover Genius
Dan Chesterman	Australian Securities Exchange
Frederick Cheung	Hong Kong Monetary Authority
Toshiya Cho	Hitachi
Michael Coles	Cedent
Melissa Collett	Chartered Insurance Institute
Stephen Cottell	Macquarie Group
Simon Crisp	Deloitte Australia
Mario D'Almo	Intesa Sanpaolo SpA
Ye Daqing	Rong 360
Shrikant Dash	Citi
Alexander De Croo	Kingdom of Belgium
Bastiaan De Goei	AXA SA
Tom de Swaan	ABN AMRO
Laura Deaner	S&P Global
Mike DeNoma	Kanbawza Bank (KBZ)
Beth Devin	Citi
Victor Dodig	Canadian Imperial Bank of Commerce (CIBC)
Richard Eldridge	LenddoEFL
John Fawcett	Quantopian
Ji Feifeng	China Development Bank
Michele Ferrario	Stashaway
Lars Fetzer	Deutsche Bank AG
Lisa Fiondella	Finastra
Andy Fitze	Swiss Cognititve
Clare Flynn Levy	Essentia Analytics
James Fok	Hong Kong Exchanges & Clearing Limited (HKEX)
Marc Folch	Interac
Chris Forrest	Deloitte Canada
Malcolm Frank	Cognizant Technology Solutions US Corp.
Rachel Freeman	TymeGlobal
Tatsuto Fujii	au Financial Holdings Corp
Debbie Gamble	Interac
David Garvin	Rigetti
Cars Gerhardt	Rabobank
Marco Giancotti	Gojo & Company Inc.

Contributors (Continued)

The project team would like to express its gratitude to the following subject matter experts who contributed their valuable perspectives through interviews and by participating in workshops and roundtable discussions (in alphabetical order):

Sebastian Göbel	Deutsche Bank AG
Shafi Goldwasser	University of California, Berkeley
Muneaki Goto	ABEJA
Tim Grant	SDX (SIX Digital Exchange)
Andrew Gray	Depository Trust & Clearing Corporation (DTCC)
Roland Greber	Bank Linth
Simon Greenman	Best Practice AI
Wang Guoxu	LianLian Pay
Mindy Guthrie	Invesco
Michel F.C. Haddad	Turing Institute
Wu Haishan	WeBank
Paul Hamalainen	Financial Conduct Authority (UK)
Kevin Hanley	Royal Bank of Scotland
Scott Hendry	Bank of Canada
Martin K. Hess	Swiss Bankers Association
Chee Wai Ho	Nium
Babak Hodjat	Cognizant
Charlotte Hogg	Visa Inc.
Stewart Holmes	National Australia Bank
Danijela Horak	AIG
Geoff Horrell	Refinitiv Limited
Jack Howell	Zurich Insurance Group
Yuxiang Huang	One Connect
Ben Hubbard	Parsyl
Evgueni Ivantsov	European Risk Council
Daichi Iwata	NEC
Rafal Janik	Xanadu Quantum Technologies
Antony Jenkins	10X Future Technologies
Feng Jian	China Reinsurance
Zhou Jianxun	LianLian Pay
Ge Jun	Shanghai Advanced Institute of Finance
Michael Kane	Hydrogen
Yusuke Kaneko	Sumitomo Mitsui Financial Group
Sunny Kang	Inpher
Serge Kaulitz	Luzerner Kantonalbank
Tatsuo Kawasaki	Unison Capital Inc.
Aiaz Kazi	Banco Santander SA
Sabine Keller-Busse	UBS AG

Contributors (Continued)

The project team would like to express its gratitude to the following subject matter experts who contributed their valuable perspectives through interviews and by participating in workshops and roundtable discussions (in alphabetical order):

Hwan Kim	Deloitte Canada
Christian Kitchell	Bank of America
Lisa Knight	AIG
Michael Kollo	Faethm AI
Theresa Kraus	Synchrony Financial
Fynn Kreuz	Numbrs
Shameek Kundu	Standard Chartered Bank
Mary Kyle	City of London
Paul Lam	Asian Infrastructure Investment Bank
Brian Lam	Hong Kong Monetary Authority
Philippe Landucci	Swiss National Bank
Wei-Lin Lee	Paypal
Gerard Levy Bensoussan	Insured by Us
Elliot Lewis	Keyavi Data
Adams Li	Hong Kong Exchanges & Clearing Limited (HKEX)
Xuchun Li	Monetary Authority of Singapore
Xinfan Liao	100Credit
Shuki Licht	Finastra
Adam Lieberman	Finastra
Kelly Littlepage	OneChronos
Yan Liu	Taikang Insurance Group
Andrew Lo	Invesco Asia Ltd
Dave Luken	Skidata - Kudelski Group
Xu Luwei	China Construction Bank
Dinaro Ly	Interac
James Macarthur	WorldQuant
Blair Mackasey	JP Morgan Chase & Co.
Fil Mackay	DigitalAsset
Ysbrant Marcelis	Commerce Ventures
Alvaro Martin Enriquez	BBVA SA
Masateru Mashita	JCB Co., Ltd.
Kevin McCarthy	Inpher
Severine Melis-Cooper	C3.AI
Eli Mernit	Hydrogen
Sears Merritt	MassMutual
Szymon Mitoraj	PZU SA
Ryo Mori	Deloitte Japan
Daragh Morrissey	Microsoft Corp.
Sophia Mouhoub	Fortia Financial Solutions
Markus Mutz	OpenSC

Contributors (Continued)

The project team would like to express its gratitude to the following subject matter experts who contributed their valuable perspectives through interviews and by participating in workshops and roundtable discussions (in alphabetical order):

Jeff Myers	State Farm
Benjamin Nadareski	SDX (SIX Digital Exchange)
Ash Nair	QBE Insurance
Akira Nakayamada	Moge Check
Daniel Nilsson	Deloitte Australia
Jackie Noakes	Bank of Ireland
Illah Nourbakhsh	Carnegie Mellon University
Koichiro Okamoto	Altoa
Masahiko Oshima	Sumitomo Mitsui Banking Corporation
Florian Ostmann	Turing Institute
Mert Ozcan	Deloitte Canada
Diana Paredes	Suade Labs
Grant Passmore	Imandra AI
Anju Patwardhan	CreditEase
Lukas Petrikas	Hong Kong Exchanges & Clearing Limited (HKEX)
Miroslav Petrov	Fortia Financial Solutions
Jürgen Petry	Raiffeisen Bank
Aviad Pinkovezky	Hippo Insurance
Winslow Porter	New Reality Company
Tomi Poutanen	TD Bank Group
Melvyn Pun	Yoma Strategic Holdings Ltd
Efi Pylarinou	Efi Pylarinou Advisory
Jun (QJ) Qian	Fanhai International School of Finance
Oleksiy Rachok	Aegon NV
Srinivasa Raghavan	Infosys Limited
Raman Rai	Deloitte Canada
Vish Ramakrishnan	CogniFrame
Aki Ranin	Bambu
Stephen Reilly	Hesta
Andre Renfer	Hypothekarbank Lenzburg HBL
Diane Reyes	HSBC Holdings Plc.
Philipp Rickenbacher	Bank Julius Baer & Co. Ltd
Oscar Roque	Interac
Joe Rothermich	Refinitiv Limited
Yutaka Sakurai	AI Finance Application Research Institute
Christophe Salmon	Trafigura Group Pte Ltd
Ohad Samet	True Accord
Veerathai Santiprabhob	Bank of Thailand

Contributors (Continued)

The project team would like to express its gratitude to the following subject matter experts who contributed their valuable perspectives through interviews and by participating in workshops and roundtable discussions (in alphabetical order):

Kai-Uwe Schanz	The Geneva Association
Andrew Schlossberg	Invesco Ltd
Tobias Schmidt	Allianz SE
David Scognamiglio	Credit Simple
Dan Seideman	S&P Global
Yuuta Seki	Nomura Holdings Inc.
Anindya Sengupta	Prudential Financial
Rami Sghaie	Fortia Financial Solutions
Ghiath Shabsigh	International Monetary Fund
Dinesh Shah	Bank of Canada
Shereen Shermak	Flybridge Capital
Yogesh Shetty	Avibra
Chunqi Shi	Hong Kong Exchanges & Clearing Limited (HKEX)
Akira Shibata	DataRobot
Makoto Shibata	Finolab
Manjula Shirwaiker	Australian Securities Exchange
David Sica	Nyca Partners
Mike Sigal	500 start-ups
Travis Skelly	Citi Ventures (Citi)
Sean Slotterback	Decipher Finance, LLC
Jiri Smejc	HomeCredit Group
Eva Smith	Western Union
Greg Smyth	Deloitte Canada
Timothy Sparks	National Australia Bank
John Stackhouse	RBC (Royal Bank of Canada)
Dalith Steiger	Swiss Cognititve
Marc Stein	Underwrite.ai
Daniel Steingruber	SIX Group AG
Nathan Stevenson	ForwardLane
Tobias Straessle	Commerce Block
Julia Strain	Commonwealth Bank of Australia
Gufei Sun	ZA Tech
Nobutake Suzuki	Bank of Tokyo-Mitsubishi UFJ Ltd.
Andrew Szabo	Scotiabank
Lukasz Szpruch	Turing Institute
Takao Takahashi	Gojo & Company Inc.
Geok Leng Tan	AIDA Technologies
John Tang	Cerberus Technology Solutions
Lin Tao	Uber Technologies Inc.
Oliver Thew	Bank of England

Contributors (Continued)

The project team would like to express its gratitude to the following subject matter experts who contributed their valuable perspectives through interviews and by participating in workshops and roundtable discussions (in alphabetical order):

Kendra Thompson	Deloitte Canada
Paul Tierno	Federal Reserve Bank of San Francisco
Li Ting	Yunfeng Financial Group
Yvonne Tsui	Hong Kong Monetary Authority
Cherry Tung	Hong Kong Monetary Authority
Jamie Twiss	Westpac Banking Corporation
Dialekti Valsamou	Fortia Financial Solutions
Payal Vasudeva	Deloitte UK
Amit Vasudeva	Infosys Limited
Ivan Vatchkov	Private Investor
Asha Vellaikal	Marsh (Marsh & McLennan Companies)
Dominique Velter	Compagnie Financière Tradition
Philipp von der Schulenburg	Munich Re
Nathan Walsh	Athena Home Loans
Michael Walsh	Green Visor Capital
Amy Walter	Synchrony Financial
Debra Walton	Refinitiv Limited
Shen Wang	China Reinsurance
Ling Wang	Hua Tai Securities
Ken Watanabe	NTT Data
Thibault Weintraub	Moneythor
Eugene Wen	Manulife Financial
Aric Whitewood	XAI Asset Management
Jacek Wieclawski	Rabobank
Phil Wilson	Deloitte US
Danielle Winandy	BNP Paribas SA
Chris Woodcock	Essentia Analytics
Joshua Xiang	CreditEase
Peng Xu	Ant Financial Services Group
Shen Xu	Hong Kong Exchanges & Clearing Limited (HKEX)
Hideo Yamamoto	NTT Data
Han Yan	China Construction Bank
Zack Yang	FomoPay
Edith Yeung	RaceCapital
Kong Sheng (Angus) Yi	Tokopedia
Yang Yichen	Taikang Insurance Group

Contributors (Continued)

The project team would like to express its gratitude to the following subject matter experts who contributed their valuable perspectives through interviews and by participating in workshops and roundtable discussions (in alphabetical order):

Emre Hidekazu Yuasa	Globis Capital Partners
Milica Zec	New Reality Company
Shaofeng Zhang	100Credit
Liu Zhiyong	CreditEase
Nina Zhou	Swiss Reinsurance Company Ltd
Jennifer Zhu Scott	Radian Partners
Martin Zielke	Commerzbank AG

WORLD
ECONOMIC
FORUM