Hype Cycle for Emerging Technologies in Banking, 2023

Emerging technologies continue to transform banks, with new products and services addressing customers of all types — consumers, enterprises and, increasingly, machines. In this Hype Cycle, we cite technologies that should be on your technology radars to prepare IT CIOs for the future of banking.

More on This Topic

This is part of an in-depth collection of research. See the collection:

- 2023 Hype Cycles: Deglobalization, AI at the Cusp and Operational Sustainability

Analysis

What You Need to Know

Technology innovations continue to drive substantive engagement and business model transformation — both within banks and across wider customer and financial services ecosystems. However, with so many emerging technologies impacting the future of banking, no one individual or role within a banking organization can realistically track all of them and be expected to be a deep domain expert. With this in mind, we offer additional perspectives and analysis on the technologies that banks should track and understand in order to deliver business value to their customers.

With this new 2023 Hype Cycle for Emerging Technology in Banking, we add to the core transformative technologies that are described in the Hype Cycle for Digital Banking Transformation. This Hype Cycle is different from its digital transformation focused sibling because here, we address technologies that:

- Will take a longer time to reach a stage of maturity than other more mainstream technologies

- Are identified as having either transformational or high business impact

- May initially appear tangential to the banking industry, but which Gartner considers will deliver true business impact for both banks and their customers

- Will significantly influence and impact how customers will consume banking products and services in the future

The Hype Cycle

This Hype Cycle directly addresses those clients who asked us to produce an additional, more "forward looking" hype Cycle for banking, covering a range of emerging technologies, that should be considered for strategic planning.

The technologies have been selected on the basis of how they will transform the banking industry and the related industry product and service needs. Some of the technologies will be selected by banks to improve their operations. Many, however, will be introduced to banks by customers using them to interact in new environments, changing the way they access and consume bank services and products. For example, the growth in digital twins of customers, machine customers and intelligent digital assets will offer banks fundamentally new ways of digital engagement with customers of all types. Additionally, emerging technologies will also change the rules of engagement of banking. For example, Quantum computing will change the rules for understanding customer behaviors, but also enable bad agents to attack banks in new ways, demanding a new approach for protecting customer identities and data. Early adoption of technologies, such as postquantum cryptography, may be one response to the challenge.

The Hype Cycle explores four core themes to better understand their impact on banks and banking:

Data Ecosystems and Data as Digital Assets

As banks shift to more-data-centric models, we highlight technologies that will generate, enrich and transform many new forms of data and data products, therefore shaping the data ecosystems and creating the foundation for future bank business models.

Artificial Intelligence and Increases in Computational Power

The deeper integration of AI-led technologies and advanced computational capabilities into bank, customer and "bad agent" (i.e., fraudsters, cyberattackers, etc.) ecosystems, will change the way banks and their staff operate, as well as the underlying principles on which customers engage with their banks.

The Impact of Decentralised Finance, Programmability and the Metaverse

The growth in autonomous business and decentralized finance capabilities will change the foundational principles on which modern day banking is based. Understanding the role for programmable money, machine customers and the wider metaverse will be key to securing the future role of banks in these new environments.

The Shift in Digital Identity and Encryption Technologies

Banking requires fundamental certainty over a number of factors, such as the identity of customers and other ecosystem participants, and the integrity and security of data. Technology changes are driving significant shifts in these domains, such as developments in decentralized identity management, which banks need to track and understand.

Figure 1: Hype Cycle for Emerging Technologies in Banking, 2023

Hype Cycle for Emerging Technologies in Banking, 2023
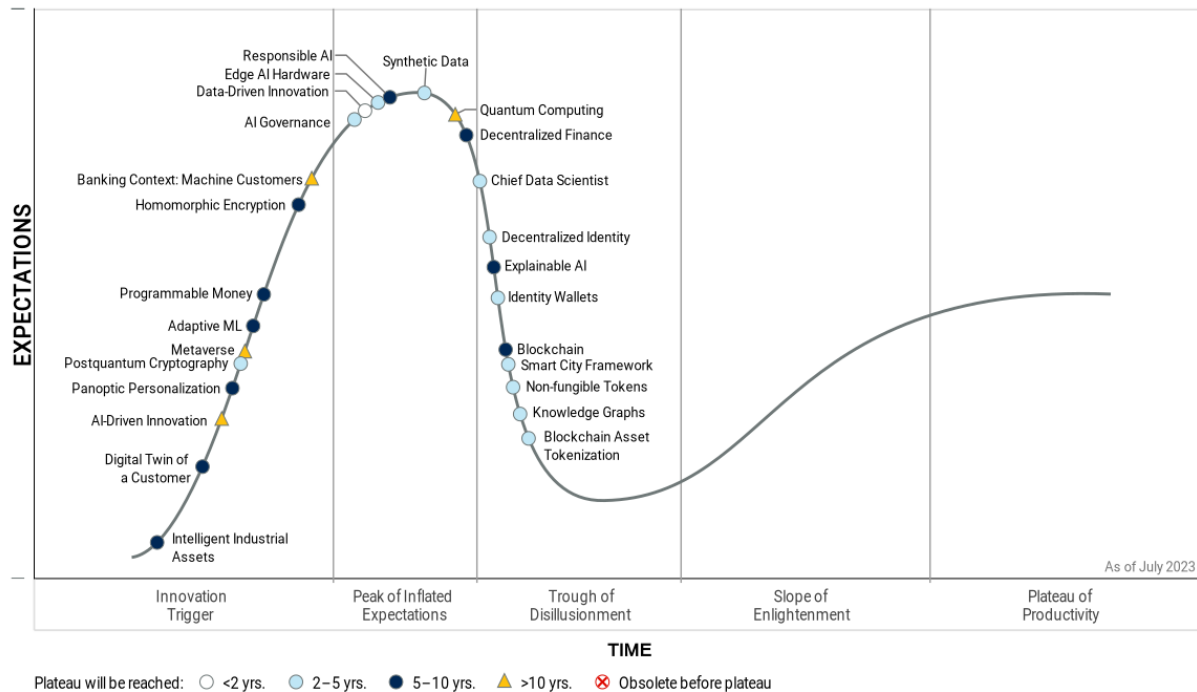
The Priority Matrix

This Hype Cycle focuses specifically on technologies with either transformational or high business impact for banking. For example, the integration of artificial intelligence into many customer-owned devices technologies will empower customers in their financial decision making. AI-driven technologies will play an increasingly important role in defining customer and bank relationships. AI will also drive responses from other banking ecosystem participants, be they competitors, regulators or criminals. In response, banks will need to innovate using AI — for example, at a product and service level using new forms of data-driven innovation models.

Intelligent machine assets and smart city frameworks will generate more contextual customer data. Digital twin technology will capture this data in a more digitally accessible facsimile of a bank customer. Ultimately, machine customers will act on behalf of their human owners to engage with banks.

Additionally, banks need to prepare for other disruptions, such as the potential for blockchain to enable and manage new and more programmable digital asset classes that create opportunities for custody operations, capital markets, asset management, transaction banking and their payment operations. The experiment of traditional finance with decentralized finance models is just starting and will be facilitated by technologies such as blockchain asset tokenization, combined with decentralized identity solutions.

Table 1: Priority Matrix for Emerging Technologies in Banking, 2023
(Enlarged table in Appendix)

Benefit	Years to Mainstream Adoption			
↓	Less Than 2 Years ↓	2 - 5 Years ↓	5 - 10 Years ↓	More Than 10 Years ↓
Transformational		Blockchain Asset Tokenization Decentralized Identity Non-fungible Tokens Smart City Framework	Decentralized Finance Digital Twin of a Customer Homomorphic Encryption Intelligent Industrial Assets Programmable Money Responsible AI	AI-Driven Innovation Metaverse Quantum Computing
High	Data-Driven Innovation	AI Governance Chief Data Scientist Edge AI Hardware Identity Wallets Knowledge Graphs Postquantum Cryptography Synthetic Data	Adaptive ML Blockchain Explainable AI Panoptic Personalization	Banking Context: Machine Customers
Moderate				
Low				

Source: Gartner (July 2023)

On the Rise

Intelligent Industrial Assets

Analysis By: Rich McAvey, Lloyd Jones

Benefit Rating: Transformational

Market Penetration: Less than 1% of target audience

Maturity: Emerging

Definition:

Gartner defines intelligent industrial assets (IAAs) as those with fully accessible and compatible datasets that support lean, automated and end-to-end processes that simultaneously optimize operations, engineering, maintenance, planning and economic performance for current market conditions.

Why This Is Important

Long-lived physical business assets, such as offshore rigs, refineries, pipelines, powerlines and generators, are the foundation for value in asset-intensive energy systems. Never-ending market turbulence and the demands of the energy transition mean new assets need fit-for-the-future designs that can be changed remotely through reconfiguration and orchestration. Intelligent assets can respond to changes in the external environment by intelligently coordinating to modify operations.

Business Impact

IIAs are strategic focal points that shape future digital investments. Future profitability relies on asset intelligence to drive four capabilities:

- Solving multiple objectives simultaneously

- Responding rapidly and without loss of efficiency

- Ultra-low-cost operations

- Full asset life cycle optimization

While the business impact will be transformational, it will take sustained effort over the coming years.

Drivers

- Commodity markets remain volatile, but companies are managing cash flows tightly and are generating profits. The near-term outlook is for a period of healthy cash flow that will support continued investment in oil and gas assets as well as alternative energy assets, such as renewable power and hydrogen. As energy markets continue to change faster than business asset designs, energy companies must employ IIA designs.

- Game-changing digital investment opportunities have come into focus. Virtually all energy companies have formal digital strategies and technology roadmaps. The situation is evolving very rapidly and most CIOs are supporting multiple digital investments at multiple levels.

- Technology markets have matured, enabling cheaper and faster change. Improvements made to connectivity, enterprise data management and edge computing have strengthened the digital foundations upon which new energy assets operate. These advances in digitalization have built organizational confidence in the potential of advanced technology and at the same time, narrowed the time frame to achieve the design and construction of intelligent assets.

- Business confidence in digital innovation is strong. The technology products and services available from vendors have also been rapidly evolving over the last few years. Today's digital environment is shifting toward modular and composable components of hardware, software, cloud/edge, SaaS and PaaS that can be easily integrated and reconfigured. This shift has greatly reduced the commitment needed to design and construct the basic building blocks of IIAs.

- Environmental priorities are reshaping digital ones. Companies can no longer afford to take a wait-and-see approach to the energy transition. Transitioning to net zero requires energy assets capable of balancing their emission implications simultaneously with other business objectives, such as reliability, safety and financial performance.

Obstacles

- Near-term priorities are confusing. Rapid demand volatility, supply chain disruption, inflation, geopolitical crises, and decarbonization mandates are affecting energy markets. Governments and companies are focusing on energy availability and security, driving policy and investment decisions.

- Longer-term priorities are also confusing. Energy companies are entering an era where business models and operating models will be reconstructed. Achieving ubiquitous, affordable, available and acceptable energy provision in these conditions will require advances and innovation across a wide range of energy technologies.

- Digital foundations are weak. The digital environment at most energy companies is dominated by commercial off-the-shelf (COTS) software that is narrowly scoped, hard to integrate and expensive to sustain. Although new digital solutions have shifted toward modular and composable components, these architectures represent too small a fraction of energy company digital foundations.

User Recommendations

- Start now to lead the transition to IIA designs and make progress while market conditions remain favorable. Conceptualize, sponsor and fund a minimum viable product program for developing intelligent asset designs and roadmaps.

- Consider hosting competitions to build engagement and creativity. Empower self-actualized teams to develop innovative and practical advances toward intelligent assets and motivate engagement with social recognition.

- Assign department leaders to work with like-minded colleagues to develop goals, strategies and early solutions for intelligent assets and operations, and to ensure orchestrated action across the company. Identify the key challenges blocking progress, then develop workaround solutions.

Gartner Recommended Reading

Quick Answer: What Are Intelligent Assets and Why Are They Important?

6 Top Practices for Winning the Race Toward Intelligent Assets

2023 Oil & Gas Trend: Preparing for Intelligent Operations

Digital Twin of a Customer

Analysis By: Melissa Hilbert, Michelle DeClue

Benefit Rating: Transformational

Market Penetration: 1% to 5% of target audience

Maturity: Embryonic

Definition:

A digital twin of a customer (DToC) is a dynamic virtual mirror representation of a customer that can be used to simulate and to emulate and anticipate behavior. Customers can be individuals, enterprise customer, personas, groups of people or machines.

Why This Is Important

DToCs help organizations of all sizes better understand their customers and anticipate their behavior. They increase efficiency and provide a personalized, empathetic service to customers, many of whose buying habits have changed during periods of disruption and change.

A DToC can be used to modify and enhance the customer experience (CX) and support new digitalization efforts, products, services and opportunities. It can be an engine of transformation and disruption.

Business Impact

Today, digital twins enable organizations to anticipate how a physical product will perform or need to be maintained in different conditions. Organizations can now use DToCs to simulate how a customer will react, given a specific set of ecosystem parameters, conditions, and control or input signals. DToCs help organizations selling products or services provide customers with better experiences, which results in increased revenue and lasting customer relationships.

Drivers

DToCs will help organizations drive revenue by:

- Gaining critical insights into customers

- Increasing revenue by enabling new ways to serve or capture customers, as well as by facilitating new data-driven business models

- Predicting and simulating behaviors with a view to making products, services, promotions and business campaigns more successful and reducing unnecessary costs of failure

- Improving customer engagement, customer retention, customer lifetime value and company growth

- Reducing churn, product failure and engagement abandonment

DToCs will help customers:

- Reduce friction in interactions with the supplier organization across their journey

- Increase positive outcomes, creating better value

- Engage in curated experiences and concierge-like experiences specifically tailored to drive value for them

- Protect privacy with the ability to change what personal data is collected and how organizations use it

Obstacles

- Privacy and cyber risk concerns may lengthen the time it takes DToCs to mature, and increase legal and regulatory risk.

- Organizations need competency in machine learning algorithms and some staff with data science skills to build or manage DToCs.

- Internal bias and concern exists about a DToC's ability to drive revenue or reduce costs. A strategy based on use cases of how to create value will be needed.

- The technology behind digital twins has focused on organizations and products. A customer focus is emerging, and lack of clear KPIs and other success measures limits the potential use of DToCs.

- Organizations need to establish trust with customers for customers to agree to share information. Customers will need transparency about what data is collected, how it will be used and the privacy and data controls that will be applied. For B2B, they need to know the benefits such as providing a more personalized experience, more relevant products or services, convenience and exclusive offers.

User Recommendations

■ Align your activities with customers' privacy and cybersecurity concerns based on the availability of customer assets and establish a trust center to house these documents and expectations.

■ Identify use cases for which DToCs could help deliver a better CX and for which suitable data is available by examining customer journeys and failure points.

■ Define clearly KPIs and specific objectives that can be measured to validate improved business outcomes such as CX, demand forecastability or agility of responsiveness.

■ Run a pilot, whether you build or buy a DToC, and compare results against a persona or C360 over a statistically significant period using significant data. Ensure your business and operating models are ready to support the endeavor.

■ Encourage customers to share their data with you. Define benefits they can expect from a DToC, agree to the level of control they will have over their data including canceling the digital twin. Provide clear visibility into how their data will be used.

Sample Vendors

Absolutdata; Arrayworks; Fetch.ai; Infogain; Nstream; Salesforce; Tata Consultancy Services (TCS)

Gartner Recommended Reading

A Digital Twin of a Customer Predicts the Best Customer Experience

Quick Answer: Privacy Basics for a Digital Twin of a Customer

Innovation Insight: Demystifying Digital Twin of a Customer for B2B Sales

Quick Answer: Is a Digital Twin of a Customer the Future of a 360-Degree View of the Customer?

Supply Chain Executive Report: Drive Growth and Elevate Experiences With Digital Twin of the Customer

AI-Driven Innovation

Analysis By: Arun Chandrasekaran, Brian Burke, Ankita Khilare

Benefit Rating: Transformational

Market Penetration: Less than 1% of target audience

Maturity: Embryonic

Definition:

AI-driven innovation is a process that harnesses the power of AI technologies to accelerate innovation. It helps organizations unlock groundbreaking inventions in specialized domains, such as new drugs and material science. Moreover, AI-driven innovation could boost agility and efficiency across various industries, thus optimizing end-to-end innovations.

Why This Is Important

Advancements in AI and growing access to AI technologies are fueling innovations across various industries. AI is streamlined, data-driven and responsive to market disruptions. When AI technologies drive innovation, they can optimize products and services, enhance organizations' productivity and agility, and boost efficiency. With the advent of generative AI, breakthroughs are expected in R&D, such as helping researchers process vast amounts of data inside and outside their organizations.

Business Impact

In the short term, AI-driven innovation will impact many business areas, such as trend identification, pattern matching and technology scouting. Also, it will help generate, test and prototype ideas using agile, lean methodologies. AI can iterate generative designs for new ideas against user preferences and target customers, considering their demographics, gender and race. In the long term, it will help in the area of generative products and services development.

Drivers

- **Faster and improved ideation and prototyping:** Innovation is about generating ideas. AI can catalyze a wide range of innovations, removing the constraints of data and information processing during the ideation process. Recent advances in generative AI, foundation models and synthetic data have made it possible to apply AI to the ideation process, thus increasing its overall robustness and augmenting human decisions. By adding massive quantities of data and using pattern recognition and other techniques, AI systems can generate more ideas and a vast pool of hypotheses that can be tested before moving to the prototyping phase.

- **Competitive differentiation when creating innovative products:** Recent advancements in reinforcement learning have given rise to exciting new use cases. For example, robotics (contextual awareness), chemistry (optimizing molecular reactions) and autonomous vehicles.

- **Augmented ideation processes with generative AI:** Generative AI provides game-changing opportunities across various industries, such as drug discovery and material science. Also, recent use cases include optimizing prototype engineering and improving light and space efficiency in building design.

Obstacles

- Creating a decision framework on where to use AI during the innovation process, what techniques to employ and ensuring adequate availability of data and other resources.

- Trend identification and pattern matching tools are based on natural language processing (NLP). Gartner classifies NLP as an emerging technology. Although some commercial NLP products are available, many are not yet fully proven.

- While some high-value opportunities, like drug and material design, are at the early stages of development, solutions supporting generated content and synthetic data are becoming commercialized.

- In certain domains, such as image generation, AI-generated artifacts do not count on any copyright protection. This may decrease their value to enterprises.

- AI tools designed to test feasibility are domain-specific and at varying maturity levels.

- Using generative AI for prototyping is viable, and the technology is relatively stable. However, critics argue that, among other design issues, too many options may overwhelm decision makers and result in slower decision-making processes.

User Recommendations

- Shortlist specific areas where AI will augment your innovation process and allow you to bring products to the market in faster and less expensive ways. Start with more proven areas, such as trend identification, technology scouting and idea generation. These areas have higher business relevance and easier operationalization.

- Focus on AI management and employee training through AI and data literacy programs. Increase access to quality data and model explainability to demystify the AI decision process.

- Focus on AI as a tool for human augmentation in the innovation process. In the short term, generative AI is expected to be used only by the most aggressive technology adopters.

- Encourage experimentation among teams to gather hands-on experience on the various use cases provided by AI-driven innovation.

- Work with startups and vendors that can offer commercial solutions to address specific innovation process challenges rather than building your own AI tool from scratch.

Gartner Recommended Reading

Innovation Insight for Generative AI

Building a Digital Future: Emergent AI Trends

Panoptic Personalization

Analysis By: Laurie Shotton

Benefit Rating: High

Market Penetration: Less than 1% of target audience

Maturity: Emerging

Definition:

An enterprisewide strategy to combine data sources and technologies, incorporating artificial intelligence, to deliver actionable insights and emotional connectivity that enable the tailoring and adaptation of insurance products, pricing, services and interactions at all touchpoints. The key to panoptic personalization is an intimate feel from the user's point of view.

Why This Is Important

Insurance business leaders are focused on improving customer experience (CX) to drive revenue. Applying panoptic personalization allows them to do this across the value chain, including pricing, product and claims, improving CX. The aim is to improve the relatedness of insurance to the individual or enterprise by using data and technology to make every inflection point feel individualized even if in reality it is clustered.

Business Impact

A panoptic personalization approach can:

- Improve customer sentiment and resultant profitability through churn prevention, enhanced CX, product innovation and improved risk-based pricing based on individual risk data.

- Enable faster processing time and drive cost optimization with points of friction removed, support tailored products, and processes that drive greater straight through processing with more aligned products.

Drivers

- Customer communication and personalization is seen as a top priority for leaders with Gartner's CIO survey revealing that 67% of respondents stating their digital initiatives were focused on panoptic personalization.

- In some lines of business where markets are crowded, insurers need to differentiate, especially in commodity consumer markets.

- Consumer needs and expectations are evolving, and traditional static and commoditized pricing models do not match evolving customer needs. This requires more dynamic products and tailored offerings that go beyond pricing.

- The expansion of data sources and willingness to share data (e.g., consumer and Internet of Things [IoT]) alongside improvement in insurers analytics technologies creates the environment to leverage data to create personalized experiences. Data and improved technologies are helping enterprises to collect risk data, and support predictive and advanced modeling using AI/machine learning.

- Insurers investments in system architecture, core systems and automation are enabling more openness of data and streamlined processes that support more real-time decision making. These foundations can be used to improve customer outcomes, reduce process friction and speed up service levels which have dual impacts on customer satisfaction and transaction processing costs.

- Insurers also see an opportunity to increase customer satisfaction and improve Net Promoter Score (NPS) by making the customer feel listened to and fully engaged. Using technologies like voice of the customer tools to sense customer feelings and emotions, and tailor responses in call centers can drive increased connection with customers.

- Increased customer engagement can help drive new revenue streams. Insurers have an opportunity to increase frequency of customer engagement that will enable more aligned products and services, improving the opportunity to upsell and cross-sell an increased number of products per customer.

Obstacles

- A misuse of panoptic personalization can lead to customer manipulation and potential fines by regulatory authorities.

- A reduction in customer satisfaction or unethical use can result from overstepping with panoptic personalization. Using data that the customer doesn't expect or know that you have about them has the opposite effect to increased engagement.

- Panoptic personalization requires solid foundations in core systems and CRM plus greater understanding of customers through extended data sources to support customer centricity and many insurance organizations are still trapped by legacy.

- Approaches may require data sharing with partners to complete the engagement, and this requires trust and governance to ensure that partners behave and use data correctly.

- Insurance has been built on a collective-risk approach and a barrier to adoption is the risk of panoptic personalization, creating an unbalanced risk pool.

- There is a fundamental need to appreciate the privacy requirements of individuals and how that impacts your engagement with them.

User Recommendations

- Examine evolving panoptic personalization use cases within and outside the industry (e.g., retail and healthcare) to inspire the art of the possible by tasking a member of the team with reporting on developments at regular intervals.

- Develop a panoptic personalization strategy by documenting the entire value chain touchpoints with end customers and examining how data and technology can enable personalization across every inflection point.

- Invest in the foundational capabilities of back-office system flexibility and data and analytics needed for panoptic personalization by reprioritizing your IT roadmap to focus on core competencies (core systems, APIs and integration capabilities, CRM, and data analytics support).

- Use Gartner's digital business technology platform (DBTP) framework to prioritize technology decisions that support the foundational capabilities and help with the visualization of the interconnection of technologies to support a panoptic personalization approach.

Gartner Recommended Reading

Panoptic Personalization: An Insurance Trend for 2022

Quick Answer: Emerging Use Cases of Personalized Insurance That Go Beyond Pricing

Build a Digital Business Technology Platform to Support Emerging Insurance Business Models

Metaverse

Analysis By: Christophe Uzureau, Alistair Newton, David Furlonger

Benefit Rating: Transformational

Market Penetration: Less than 1% of target audience

Maturity: Embryonic

Definition:

Gartner defines a metaverse as a collective virtual 3D shared space, created by the convergence of virtually enhanced physical and digital reality. A metaverse is persistent, providing enhanced immersive experiences. Gartner expects that a complete metaverse will be device-independent and will not be owned by a single vendor: It will have a virtual economy of itself, enabled by digital currencies and non-fungible tokens (NFTs).

Why This Is Important

The current version of the metaverse lacks sufficient economic liquidity that would otherwise support growth. So for financial services providers (FSPs), this provides opportunities to support value exchanges across such environments and the issuance, protection and custody of new digital asset classes as well as digital ID services. New business models, such as build-to-earn (B2E) that Web3 enables, also create new customer segments for financial services institutions to serve.

Business Impact

Banks (such as Woori Bank, Bank of America, Julius Baer and JPMorgan Chase) are experimenting with the metaverse to build brand recognition and connect with younger audiences as potential clients. For banks, the opportunities do not depend on the metaverse becoming a reality. Banks can participate and benefit from research and development of the metaverse, which depends on digital asset custody, settlement and trading services, and payment and digital ID services that they can start providing now.

Drivers

Overall there are three main drivers for banks' activity in the metaverse:

- New engagement models, especially with younger, prospective clients, that the metaverse enables, such as embedded finance and digital ID services. For example, a bank could provide its customers with a dashboard accessible via its digital banking platform to monitor which security credentials they use across different digital environments.

- New digital asset classes created and/or exchanged in the metaverse that go beyond financial assets to include intellectual property (IP) for creating new designs, digital twin assets, data assets and gaming assets — and the opportunities they generate for banks. An example is JPMorgan Chase promoting its digital asset platform Onyx in Decentraland for digital asset custody, issuance and trading, currency exchange, and settlement capabilities.

- New business models that Web3 enables and how they create new customer segments for banks. ZEPETO is reporting 2.3 million studio creators that create digital wearables to sell to other participants. And NIKE's SWOOSH is an initiative to increase the participation of its customers in the design of wearables for games and the emerging metaverse. Those users are transitioning from being customers to prosumers or professionals and will expect payment acceptance, reporting and reconciliation services, as well as support in meeting their tax obligations, protecting their IP and obtaining financing.

Other drivers include the following:

- Enterprise clients looking for solutions to protect their digital assets. Examples include property developers creating a digital twin of new commercial real estate and using the metaverse to attract investors and companies and to support the due diligence process. They need some ability to monetize the access to this digital twin without third-party actors reusing the IP without permission.

- Overall demand for embedded finance capability and banking as a service (BaaS) — in emerging metaverse environments — to support the new monetization capabilities.

Obstacles

- The adoption of metaverse technologies is still nascent and fragmented. Emerging metaverses are siloed, noninteroperable experiences that do not satisfy the interoperable vision of the metaverse. This current walled-garden approach also strongly limits users' control of experiences.

- Another challenge is the attempt by digital giants, such as Meta, to design "a metaverse" that fits their existing business model. This risks limiting adoption and participation from consumers and companies, hence limiting the pace of development and innovation. Without Web3 technologies, there is a risk of a lack of participation and engagement from customers.

- While technology plays a significant role in achieving a mature metaverse, another big challenge will be around establishing user-centric guidelines for ethics and governance covering different aspects of the metaverse. This must include topics such as privacy, data sovereignty, acceptable terms of use, accountability, and identity and legal protections.

User Recommendations

- Enable the integration of your banking and payment services into the emerging metaverse through embedded capabilities, rather than re-creating your bank branches in the metaverse.

- Develop custody solutions for the new digital asset classes by paying attention to their specific purpose; for example, by ensuring custody solutions for data assets are supported by consent management capabilities.

- Deliver business banking and payment services to the new customer segments associated with the new business models, such as B2E, play-to-earn (P2E) and learn-to-earn (L2E), by reconfiguring your digital banking platforms to serve the unique characteristics of emerging prosumers.

- Capture transactional data associated with the metaverse, including from gaming activity, to augment your credit and risk assessments for existing customers, and build alternative credit scoring solutions for new customers.

Sample Vendors

Animoca Brands (The Sandbox); Baidu; Decentraland; Meta; NVIDIA; Roblox; ZEPETO

Gartner Recommended Reading

3 Focal Points for Bank CIOs to Create Business Value From the Metaverse

CEO Survey: Metaverse Apathy Highlights Digital Transformation Knowledge Gaps

Define and Map Cryptocurrencies, Digital Currencies and NFTs to Future-Proof Your Digital Transformation

Postquantum Cryptography

Analysis By: Mark Horvath, Matthew Brisse

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Embryonic

Definition:

Postquantum cryptography (PQC), also called quantum-safe cryptography, are algorithms designed to secure against both classical and quantum-computing attacks. PQC will replace existing asymmetric encryption, which will weaken over the next decade, deprecating existing classical encryption methodologies and processes.

Why This Is Important

PQC offers organizations a higher level of cryptographic protection, which will remain strong as quantum computers enter the mainstream.

Existing asymmetric algorithms like Diffie-Hellman, RSA and ECC are vulnerable and will be unsafe to use by the end of the current decade, requiring replacement for common cryptographic functions, such as digital signatures, public key encryption and key exchanges.

Business Impact

PQC has the following impacts:

- With the advent of stronger quantum computers, existing asymmetric algorithms must be replaced with quantum-safe ones. This includes all network, file and data encryption, IAM, as well as any other uses of asymmetric cryptography.

- There are no drop-in alternatives for existing cryptographic algorithms, leading to discovery, categorization and reimplementation efforts.

- As new algorithms have different performance characteristics, current applications must be retested and, in some cases, rewritten.

Drivers

- Existing asymmetric encryption algorithms will become vulnerable to quantum decryption attacks by the end of the decade, potentially requiring reencryption of all data where the risk of exposure of the symmetric keys or tokens is considered important.

- Governments around the world are preparing and issuing mandates and legal frameworks requiring government agencies and enterprises to start devising PQC strategies. For example, in the U.S., Quantum Computing Cybersecurity bill requires owners and operators of national security systems and organizations supplying to the U.S. government to start using postquantum algorithms.

- "Harvest now and decrypt later" attacks are an ongoing concern, leading to the urgency to implement PQC security measures sooner rather than later.

- Secondary uses of new encryption (e.g., homomorphic encryption, stateful signatures, etc.) will offer new business opportunities beyond data protection.

- Once PQC is adopted by an organization, data should be secure for the foreseeable future.

Obstacles

- Most organizations don't know how cryptography functions within their organization, where keys and algorithms are used, or how secrets are stored and managed. Swapping them out for new algorithms will be challenging.

- Encrypted file sizes and digital signatures for new algorithms are typically much bigger than existing equivalents, necessitating hardware and network infrastructure improvements.

- New PQC algorithms will require new standards. The current set of PQC candidates' standards are expected to be released in late 2023 or early 2024, while fresh algorithm development will continue for the rest of the decade, affecting hardware, firmware, software and credentials used along with supported algorithms.

- Most vendors are typically unprepared when it's time to upgrade the cryptography and often require some pushing from their clients to recognize the demand.

- Some very important protocols lack built-in crypto-agility. For instance, no one is developing plans on how to incorporate new algorithms into WS-Security, which is used to safeguard SOAP APIs (a crucial type of API for all financial transactions).

User Recommendations

- Build a cryptographic metadata database of all in-use cryptographic algorithms.

- Develop crypto policies for easing the transition to new algorithms.

- Perform an exercise for data identifying the expected end-of-life targets in the short, medium and long-term time scales, and create a key life cycle policy to reflect risks to asymmetric and symmetric crypto keys.

- Create a transition phase plan identifying which algorithms are suitable for particular use cases.

- Implement transitional crypto policies for when algorithms should be replaced and which new algorithms should be used in each use case.

- Implement crypto-agile application development and stage to production after extensive testing.

- Vet and test new PQC algorithms to understand their characteristics and uses.

- Implement crypto-agility initiatives with an object-based approach to address future changes in PQC algorithm updates and replacement.

- Prioritize business impact potential when selecting potential PQC use cases.

Sample Vendors

Amazon; Google; IBM; ISARA; Microsoft; Qrypt; Quantum Xchange; SandboxAQ

Gartner Recommended Reading

Preparing for the Quantum World With Crypto-Agility

Emerging Tech: How to Make Money From Quantum Computing

Emerging Tech: Critical Insights on Quantum Computing

Infographic: How Use Cases Are Developed and Executed on a Quantum Computer

Adaptive ML

Analysis By: Pieter den Hamer, Erick Brethenoux

Benefit Rating: High

Market Penetration: Less than 1% of target audience

Maturity: Emerging

Definition:

Adaptive machine learning (ML) is the capability of frequently retraining ML models online in their runtime environment, rather than only training ML models when offline in their development environment. This capability allows ML applications to adapt more quickly to changing or new real-world circumstances that were not foreseen or available during development.

Why This Is Important

Adaptive ML gets AI much closer to self-learning — or at least to more frequent learning or better contextualization — compared with most current AI applications, which only use static ML models that depend on infrequent redeployment of new model updates to improve themselves. Adaptive ML can respond more quickly and effectively to change, enabling more resilient and, ultimately, autonomous systems that are responsive to the dynamics of gradual change and massive disruptions.

Business Impact

Adaptive ML is most relevant in areas where the context, conditions, actor behavior or actor preferences (or the behavior or preferences) change persistently. It is also used to fine-tune, contextualize or personalize models once in production. Example application areas include customer churning in highly competitive markets, gaming, organized crime fighting and anti-terrorism, fraud detection, cybersecurity, quality monitoring in manufacturing, virtual personal assistants and chatbots, semiautonomous cars, and smart robotics.

Drivers

- The ever-increasing complexity, pace and dynamics in society and business require ML models that frequently adapt to changing circumstances and impactful events. More automation requires systems that process data in real time with very frequently updated models for continuous decision intelligence.

- With adaptive ML, models remain accurate longer and suffer less from model drift. Data science teams can improve their productivity by leveraging adaptive ML to reduce the need for conventional, time-consuming model monitoring, periodic retraining and redeployment — also known as MLOps.

- Adaptive ML can be used to compensate for limited availability of training data or "small data," hindering offline (for example, supervised or reinforcement) learning. Adaptive ML may start out with a minimal viable model pretrained offline and then incrementally improved or fine-tuned during the actual online usage. For this reason, adaptive ML is also known as continual or continuous learning. For example, reinforcement learning may be done in a simulated environment during development and continued in a real environment during production.

- Adaptive ML allows for the personalization or contextualization of ML models, using a more general ML model as a starting point and then adjusting this to their user's preferences or the specifics of their context. This, for example, happens through the user prompting of ChatGPT, where style, format and contents of the response are adjusted to the context set through one or multiple session prompts.

- More conventional, offline ML is becoming more adaptive too, although to a lesser extent. With automation in MLOps, models can be retrained with the latest data and redeployed more frequently. Also, some adaptability can be achieved through automated champion-challenger model rotation.

- Combined with federated or swarm ML, adaptive ML can benefit from model improvements in multiple locations and usage contexts. Together, these approaches can ultimately enable autonomous systems, such as self-driving vehicles or smart robots, which should be able to demonstrate resilience in their ever-changing contexts.

- Adaptive ML will evolve to adaptive AI. Self-configuring/self-learning composite AI or multiagent systems — not limited to ML techniques — will offer a more generic approach to adaptive AI.

Obstacles

- Adaptive ML depends on the availability of (real-time) feedback from users, from operating environment or from closed loop data about the quality of the ML output (for example, prediction errors) while online.

- There may be no time for repeated full retraining of the model but only for incremental retraining while online. This requires online or incremental learning algorithms that must be tuned in terms of weighting new data versus older data, mitigating the risk of so-called "catastrophic forgetting."

- Responsible AI and fairness must be addressed not only during offline development but also during online operations. Bias may creep in with continuous model changes, which can be mitigated with periodic offline checks for bias (and also drift and overfitting) and online fairness feedback.

- Implementation is technically challenging with tool and open-source framework support — varying per learning algorithm — only just emerging.

- Nontechnical challenges include ethical, reliability, liability, safety and security concerns that come with self-learning and autonomous systems.

User Recommendations

- Use adaptive ML not to replace but to complement current ML. Most adaptive ML applications will start out with a model that was first trained offline. Adaptive ML can further improve, maintain, contextualize, personalize or fine-tune the quality of ML models once online.

- Accompany adaptive ML with model monitoring for accuracy, bias and relevancy as well as with proper risk analysis and risk mitigation activities, if only to frequently monitor the quality and reliability of adaptive ML applications. Even with adaptive ML, a periodic offline full retraining of the model may be required, as incremental learning has its limitations.

- Manage the required talent, infrastructure and enabling technology, actively. For example, adaptive ML is likely to be more demanding in terms of compute power in runtime environments and will require the development of knowledge about new (incremental learning) algorithms and tools.

Sample Vendors

Accern; Guavus; IBM; Microsoft; Pandio; SAS; TAZI.AI; Toloka

Gartner Recommended Reading

Top Strategic Technology Trends for 2023: Adaptive AI

Use Gartner's MLOps Framework to Operationalize Machine Learning Projects

Programmable Money

Analysis By: Christophe Uzureau, David Furlonger, Alistair Newton, Peter Ryan

Benefit Rating: Transformational

Market Penetration: Less than 1% of target audience

Maturity: Embryonic

Definition:

Programmable money is any form of digital money or money exchange that can be programmed by software that determines its operation based on algorithmic criteria. Programmable money can rely on blockchain-enabled tokenization and smart contracts in order to enable a higher level of programmability as well as increase the participation of economic actors to program the value exchanges.

Why This Is Important

Programmable money defines the terms and rules of usage for the exchange of value in the programmable economy, including where machine customers become autonomous participants in the monetary system. With machine customers, money will need to be programmed because value exchanges will be facilitated with no direct human intervention or control, and demand atomic exchanges. Enterprises will be required to engage machine customers as new types of customers, as well as business peers and employees.

Business Impact

For financial services providers, the programmability of money is transformational since it enables the issuing and adoption of digital assets and new monies. It supports new value creation, valuation, financing, custody, and asset exchange models, including the ability of machine customers to trade with other machine customers via data assets — transforming supply and financial value chains.

Drivers

- The financial services industry's capabilities for conversion, trading, transfer and settlement services have to accommodate a growing number of digital asset classes. For example, driving the demand for programmability, such as in the real estate sector with the fractionalization of property ownership via digital tokens.

- Increase the use of automated systems (Internet of Things [IOT], apps, embedded finance, etc.), which require more real-time and atomic value exchanges, such as locating, booking and paying for a parking space in a smart city.

- Web3 collaborative business models (build-to-earn [B2E], rent-to-earn [R2E], etc.) rely on programmable money to support a higher level of modularity and automation to deal with the issuance and exchange of the underlying digital assets.

- Programmable money enables the contextualization of financial services for specific commercial value chains like agribusiness, for example, enabling the validation of contracts, automation of transactions, and improved data certification and collection to support sustainability and green finance.

- Programmable money drives the programmability of data, enhancing risk management capabilities and accelerating data monetization, and turning data assets into a medium of exchange for machine customers.

- Programmable money enables new incentive structures for machine customers (incentivized by tokens of value or data tokens) and existing economic actors (for example, to create intellectual property), which will become essential as large language models (LLMs) influence economic exchanges.

- The development of wholesale central bank digital currencies (CBDCs) shows the business value of programmable money to support new settlement models such as via smart contracts (delivery vs. payment [DvP] and automated foreign exchange PvP settlement) and reducing settlement times and counterparty risk.

- Existing deployments of retail CBDCs show a current lack of adoption by retail as well as business customers (notably merchants) and making payment value chains more programmable is becoming urgent to build adoption.

Obstacles

- Misperception by market participants of what is programmable money — that tends to be perceived in terms of purpose-bound money (PBM) such as distributing vouchers. As a result, enterprises lack the understanding, skills and use-case designs to adequately assess the value proposition.

- While improving, there is still a lack of maturity (and understanding) of the underlying infrastructure of programmable money — blockchain interoperability, tokenization, security, privacy, accessibility and smart contracts.

- Defensive behavior from incumbents — notably in the payment sector — that could see their four-party interchange models (for example, card networks) challenged by higher levels of programmability — leading those stakeholders to challenge the security, interoperability and performance of programmable money.

- Lack of market segmentation models and data analytics to analyze machine customers, human customers and businesses that will increasingly rely on programmable money.

User Recommendations

- Plan for the issuance, custody and exchange of new digital asset classes that will serve as the medium of exchange, store of a value and unit of accounts of the programmable economy.

- Revamp your digital ID capability to handle the demand of machine customers and portability of IDs across ecosystems (including the metaverse) that will be essential in value exchanges.

- Develop in-house smart contract talent while encouraging collaboration with open-source developer communities and identify where smart contracts will impact your existing business flows.

- Improve your understanding of business use cases and programmable designs; for example, investigate the potential of green financing initiatives to use programmable monies to support your business customers with additional pricing, risk and performance capabilities.

- Investigate and analyze cross-chain bridges including from the perspective of off-chain business activities (such as data certification) in order to reduce technology risks.

Sample Vendors

ConsenSys; Fetch.ai; JPMorgan Chase & Co.; Ocean Protocol Foundation; R3; Societe Generale – FORGE

Gartner Recommended Reading

Banking CIOs Must Prepare Now for the Programmability of Money and Data

3 Focal Points for Bank CIOs to Create Business Value From the Metaverse

Define and Map Cryptocurrencies, Digital Currencies and NFTs to Future-Proof Your Digital Transformation

The Programmable Economy Is Driving a New Growth Reality and Business Opportunities

How to Model the Programmable Economy to Assess Digital Business Growth Opportunities

Homomorphic Encryption

Analysis By: Mark Horvath, Bart Willemsen

Benefit Rating: Transformational

Market Penetration: Less than 1% of target audience

Maturity: Emerging

Definition:

Homomorphic encryption (HE) uses algorithms to enable computations with encrypted data. Partial HE (PHE) supports only limited use cases, such as subtraction and addition, but with little performance impact. Fully homomorphic encryption (FHE) supports a wider range of repeatable and arbitrary mathematical operations; however, it worsens performance.

Why This Is Important

HE offers an unparalleled advance in privacy and confidential data processing, although this is largely at the database level. Benefits include the ability to:

- Perform analytics on data while in an encrypted state, so that the processor never sees the data in the clear, yet delivers accurate results.

- Share and pool data among competitors.

- Share all or part of users' data, while protecting their privacy.

- Systems based on lattice encryption, which are quantum-safe.

Business Impact

Even in restricted form (PHE), HE enables businesses to use data, send it to others for processing and return accurate results, without fear it will be lost, compromised or stolen. Any data intercepted by a malicious actor is encrypted and unreadable, even by the coming generation of quantum computers.

Applications include:

- Encrypted search

- Data analytics

- Machine learning (ML) model training

- Multiparty computing

- Securing, long-term record storage, without concerns about unauthorized decryption

Drivers

- The enhanced enforcement of data residency restrictions worldwide is forcing organizations to protect data in use, rather than only when it is in transit or at rest.

- Globally maturing privacy and data protection legislative frameworks demand that more-precise attention be paid to sensitive data. As a result, data pooling, sharing and cross-entity analysis use cases increasingly benefit from forward-looking and sustainable technologies, such as HE.

- Aside from primarily financial use cases (e.g., cross-entity fraud analytics), other industries can benefit as well. One example is the healthcare industry, where analysis of sensitive data across various entities happens often with data protected while in use.

- Solving issues of trust and cooperation with secure multiparty computation (sMPC) will benefit internal and external protection of data.

- The oncoming availability of quantum computing (QC), as highlighted by NIST and the Canadian Forum for Digital Infrastructure Resilience, threatens to compromise the confidentiality of almost all data. This includes digital communication previously considered protected by conventional cryptography. For example, there are signals that malicious actors may retain exfiltrated encrypted data in expectation of the ability to decrypt it years later and re-engage with victims for extortion and ransom demands. Timely adoption of HE in data protection will sustainably protect data, even when previously compromised in (conventionally) encrypted form.

Obstacles

- The application of various forms of HE to daily use cases leads to a degree of complexity, slows operations and requires highly specialized staff.

- The market's unfamiliarity with this technology stands in the way of speedy adoption.

- Although PHE can be a Turing-complete implementation, which means an arbitrary set of instructions could be executed, no vendor has a robust implementation that exploits this capability.

- Some scenarios will never be a good match for HE — for example, those that require security in components beyond analytics and processing, such as production databases and proprietary algorithms.

User Recommendations

- Brainstorm opportunities with your technical and executive teams. For example, come up with a list of five to 10 use cases for HE to improve the adoption of core solutions.

- Treat potential HE projects as experiments, keeping in mind the early stage of the technology's development and the significantly not-real-time nature of HE products. Consider these experiments proofs of concept (PoCs) to build experience, until the technology matures.

- Continue with existing security controls. HE does not necessarily negate the need for other security controls, observance of data residency requirements or access control.

- Assess the core benefits of using HE in combination with other quantum-safe or privacy-enhancing computation techniques.

- Integrate in-use protection via forms of HE into messaging and third-party analytics services.

- Assess the merits of piloting HE by using a vendor's solution, which could offer functionality without the time investment associated with a custom solution.

Sample Vendors

CryptoLab; Duality; Enveil; IBM; Inpher; IXUP; LiveRamp; Lorica; Ziroh Labs

Gartner Recommended Reading

Emerging Technologies: Homomorphic Encryption for Data Sharing With Privacy

Emerging Technologies and Trends Impact Radar: Security

Three Critical Use Cases for Privacy-Enhancing Computation Techniques

What Executives Need to Do to Support the Responsible Use of AI

Achieving Data Security Through Privacy-Enhanced Computation Techniques

Banking Context: Machine Customers

Analysis By: Alistair Newton, Mark Raskino

Benefit Rating: High

Market Penetration: Less than 1% of target audience

Maturity: Emerging

Definition:

Machine customers are nonhuman economic actors that obtain goods or services in exchange for payment. Examples of machine customers include virtual personal assistants, smart appliances, connected cars and Internet of Things (IoT)-enabled factory equipment. Machine customers act on behalf of a human customer or an organization.

Why This Is Important

Currently, there are more internet-connected machines with the potential to act as customers than humans, and the number of machine customers, such as virtual assistants with AI capabilities, will rise steadily over time. Machines will play an increasingly important role in banking and payment decisions, generating better financial outcomes for their human owners (see Banking CIOs Must Prepare Now for the Programmability of Money and Data). Further, their role will evolve from simple informers to advisors and, ultimately, decision makers.

Business Impact

Over time, trillions of dollars will be in the control of nonhuman customers, offering new opportunities for revenue, efficiencies and engaging customers. For banks, this is both a threat and an opportunity but requires significant reimagining of operating and business models. Core lending and payment systems will require reengineering to adapt to new real-time microtransactions. Banks that miss this market change will be marginalized, similar to the retailers who missed the digital commerce wave.

Drivers

- In the next few years, machine customers are expected to become significant stakeholders in the banking industry, as both customers and advisors.

- In the forthcoming years, billions of connected products may have the potential to behave as customers — that is, to shop for all types of products and services for themselves and their owners. For banks, this will remove much of the current opacity on pricing and services that they and their competitors offer.

- Machines will make financial decisions based on the best outcome for their owners and their ability to analyze near-perfect market data. In this scenario, the impacts on the bottom-line profitability of banks across the globe will be significant.

- Currently, in the nonbanking world, most machines merely inform or make simple recommendations. However, some machines are emerging as more complex customers. For example, some Tesla cars already order their own spare parts and Amazon offers its Dash Replenishment Service for a variety of household appliances. Advances in generative AI and applications, like OpenAI's ChatGPT, will accelerate the development and deployment of machine customers. These tools can diagnose and break down complex tasks to make the right recommendations, service requests and other functions.

- In the future, an autonomous vehicle could determine what parking garage to take its human passengers to. This decision would be based on criteria such as distance from destination, price, online review score, parking space dimensions and valet options.

- Machines already operate in the banking world. In high-speed financial trading environments, machines already make multiple high-impact decisions on behalf of internal and external banking clients. In the retail investing and wealth management space, digital financial advisors have been advising — and in some instances automatically trading — for customers, for a number of years.

Obstacles

Machine customers in banking are still in the Innovation Trigger phase and may not reach the Plateau of Productivity for the next 10 years because of:

- **Regulatory Restrictions**: The concept of a machine customer will challenge many regulators, who may be slow to adapt to this new phenomenon. Regulators will need a new definition of "customer" and adapt regulations as appropriate.

- **Lack of trust:** Humans may not trust the machine customer technology they use to predict, execute and maintain privacy accurately, or make financially sensitive decisions on their behalf. Conversely, machine customers may not trust the supplier organization to do the same.

- **Fear of machines or machine-driven outcomes:** Some humans may initially be uneasy about delegating purchasing functions to machines. Organizations must consider what ethical standards, legal compliance, and fraud and risk mitigation are needed to operate in a world of machine customers.

User Recommendations

- Identify how machine customers will change the consumption of banking products and services in the future. Collaborate with your chief digital officer, chief data officer, chief strategy officer (CSO), sales leaders and chief customer officer (CCO) to explore the business impacts of machine customers.

- Audit your risk and pricing models and your competitive intelligence models. Machine customers will undermine the core principles on which you currently price your products and services, so prepare the ground for this transformation.

- Build your capabilities around digital commerce and AI, especially generative AI. Use APIs and enterprise bots to enable machine customers for low-complexity internal transactions. Then, extend your organization's capabilities to other facets, such as processing information to make informed decisions and perform purchase transactions. Assess your ownership of some IoT platforms or join other platforms with these capabilities if you don't have the resources to build them yourself.

Sample Vendors

Amazon; Google; HP Inc.; Significant Gravitas; Tesla

Gartner Recommended Reading

Why Machine Customers May Be Better Than Human Customers

CIOs Can Maximize Product Lifetime Value by Embracing Machine Customers

Infographic: A Day in Your Life in a World of Machine Customers

Podcast: When Machines Become Customers

At the Peak

AI Governance

Analysis By: Svetlana Sicular

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

AI governance is the process of creating policies, assigning decision rights, and ensuring organizational accountability for risks and investment decisions for the application and use of artificial intelligence techniques. AI governance is part of adaptive data and analytics governance, addressing the predictive and generative nature of AI.

Why This Is Important

With AI now delivering value in the enterprise, data and analytics leaders observe that scaling AI without governance is ineffective and dangerous. Generative AI and applications, like OpenAI's ChatGPT, make AI governance a necessity, as using pretrained AI models billions of times sharpens risk concerns. The leaders want to balance AI's business value and the need for appropriate oversight. AI draws the attention of legislators worldwide, who mandate actions by clarifying AI governance priorities.

Business Impact

AI governance, as part of the organizational governance structure, enacts responsible AI, and provides common implementation and adherence mechanisms across the business ecosystem when it comes to:

- Ethics, fairness, and safety to protect the business and its reputation,

- Trust and transparency to support AI adoption via explainability, bias mitigation, model governance, operationalization, and collaboration norms and capabilities.

- Diversity to ensure the right technology and roles for each AI project.

Drivers

- AI governance is in the peak area of the Hype Cycle. Enterprise practitioners are taking steps toward establishing AI governance. Leading organizations in various industries establish AI governance by addressing standards for AI development and operations, providing best practices, guidelines for model management and monitoring, data labeling and interpretation, explainability, fairness, bias mitigation, security, and legal.

- Regulations around the globe target AI directly and affect AI practices indirectly, making AI governance goals more concrete. The U.S. Blueprint for an AI Bill of Rights provides governance pathways, from principles to practice. The objective of the EU AI Act is to "enhance governance and effective enforcement of existing law on fundamental rights and safety requirements applicable to AI systems." The Algorithmic Impact Assessment is a mandatory risk assessment tool intended to support the Treasury Board of Canada. Singapore's Model AI Governance Framework guides organizations in developing appropriate governance structures and mechanisms.

- Trust and transparency of AI solutions are crucial for AI adoption. The probabilistic and opaque nature of AI is new to audiences familiar with deterministic outcomes. AI governance can minimize misinterpretations of AI results by scrutinizing trust in data sources and the explainability of AI decisions. It provides specific testing and validation guidelines, differentiating "life-critical AI."

- AI governance is necessary to establish AI accountability. It is difficult to achieve because use cases differ in terms of their data, solution and outcome requirements. It outlines reactive responsibilities, actions and procedures in the case of unanticipated and unintended consequences. It ensures that ethics are considered for each use case.

Obstacles

- Often, AI governance is stand-alone from mainstream governance initiatives, which stalls its progress. The best method is to extend existing governance mechanisms to take advantage of recognizable policies and methods, such as in data governance. AI governance benefits from a conversation with the security, legal and customer experience functions.

- Many governance initiatives assume command and control. Instead, adaptive governance supports freedom and creativity in AI teams but also protects the organization from reputational and regulatory risks. Little or no governance in AI teams to facilitate freedom and creativity is an acceptable approach if this is a conscious governance decision.

- AI value assurance and model risk management are new in AI. While methods exist — for example, in the financial industry — they are largely unknown to others, and every governance organization is inventing its own.

- Technologies to support AI governance are fragmented and are often designed for a single industry.

User Recommendations

- Extend to AI your existing governance mechanisms, such as risk management or data and analytics governance.

- Establish and refine processes for handling AI-related business decisions. Blend processes, people and technology to succeed.

- Aim to align your AI governance framework with the laws and regulations in your jurisdiction(s) to directionally assure your efforts amid evolving AI-specific considerations. Gain agreement on AI risk guidelines that are driven by the business risk appetite and regulations.

- Decide on the organizational structure and accountability for propagating responsible AI — for example, what to centralize and what to do locally.

- Implement tools for AI review and validation. For each AI use case, require an independent AI model validator, a data scientist whose job is to assure model explainability and robustness. Have all parties in the process defend their decisions in front of their peers and validators.

- Ensure that humans are in the loop to mitigate AI deficiencies.

Sample Vendors

Arthur; Chatterbox Labs; Credo AI; DarwinAI; FICO; Google; IBM; Prodago; SAS; Weights & Biases

Gartner Recommended Reading

Applying AI — Governance and Risk Management

Data-Driven Innovation

Analysis By: Tsuneo Fujiwara, David Pidsley

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Mature mainstream

Definition:

Data-driven innovation (DDI) is the use of data and analytics (D&A) to develop or foster new products, processes, organizational methods and markets. A human-centric innovation process starts with idea generation followed by idea evaluation. DDI uses D&A to augment the human being as a primary consideration in these steps. D&A can drive both the discovery and the execution of innovation, helping organizations create new business models, products and services with a confirmed business value.

Why This Is Important

Given the volume and ubiquity of data organizations have, DDI may be a more pragmatic way to innovate in some situations compared to conventional idea-based innovation, which starts with design thinking or human-centered design. Data itself can also bring value to organizations that sell or license it. Generative AI, which could be considered a contributor or driver of DDI, has gained popularity this year, bringing DDI into sharper focus.

Business Impact

DDI can have a high impact on all industries, as well as on the digital innovation process itself. DDI improves the speed and success rate of digital innovations through the study of data and data correlations and insights gained from analyzing data. This means organizations can gain more efficiency, effectiveness and impact from innovating new digital products and services.

Drivers

- Digital business acceleration is increasing the migration of socioeconomic activities to the internet; lowering the costs of data collection, storage and processing; and resulting in the generation and use of vast amounts of data. Rich, immediate and reliable data provides a mechanism for innovation ideas generation and evaluation, thus driving DDI.

- Recent acceleration in digital innovations is enabled by the adoption of data such as facial recognition at airports, improved weather forecasting for farmers and the monetization of sensor data in various industries. This acceleration is driving organizations to leverage DDI processes so they don't leave innovation ideation and evaluation to chance.

Obstacles

- Some organizations embrace DDI without ensuring the goals of DDI align with their business goals. This alignment is essential for the DDI to create business value, and business goals should drive DDI.

- Without first establishing a culture of innovation, organizations will be unable to plan and execute DDI.

- The D&A team and the innovation team usually work in silos with limited or no collaboration. But collaboration must be established before any DDI can be done (see Quick Answer: How Do I Get Started With Data Monetization?).

- DDI requires the innovation team to possess analytical modeling capabilities. Without these capabilities, it will be unable to model a complex situation, which is usually quicker in data than constructing mock-ups would be.

- In order to productize the innovation to create business value, the innovation should be transferred to the appropriate business units, which are ideally involved from early on. Unfortunately, most innovation dies before being transferred to the business units.

User Recommendations

- Leverage DDI processes when creating a new product or a new service for digital innovation, including business model innovation. Given the volume and ubiquity of data, DDI may be a more pragmatic way to innovate compared to the conventional idea-based innovation starting with design thinking or human-centered design.

- Separately, data itself could become a digital product when it has value in itself.

- Use the predictive analysis capability enabled by AI techniques to conduct a series of experiments against an analytical model and evaluate an innovation idea for different scenarios or event types. Assessing an innovation using data and analytics reduces the risk of failure. For instance, generative AI capabilities that use unsupervised learning algorithms to create new digital images, video, audio, text or code can also produce novel scenarios.

Sample Vendors

Accenture; Capgemini; Deloitte; KPMG; Tata Consultancy Services; Wipro

Gartner Recommended Reading

Use Data-Driven Innovation to Achieve Digital Business Growth

Accelerate Digital Business Through Data-Enhanced Innovation Process

Quick Answer: How Do I Get Started With Data Monetization?

Case Study: Data Product Development to Prioritize Data Monetization (ZF Group)

Magic Quadrant for Data and Analytics Service Providers

Edge AI Hardware

Analysis By: Alan Priestley

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Emerging

Definition:

Edge artificial intelligence (AI) hardware comprises a wide range of systems, add-in boards and chips designed and optimized to execute deep neural network (DNN)-based data analytics applications within edge hardware infrastructure deployments.

Why This Is Important

Many edge computing and endpoint deployments utilize applications that leverage DNN-based algorithms to analyze complex datasets close to their point of capture (such as video, images, audio or sensor data). The processing required by these applications is often beyond that which can be easily supported by traditional microprocessors and microcontrollers. Consequently, a wide range of new edge AI hardware designs optimized specifically for these tasks are being developed.

Business Impact

Edge AI hardware brings significant business benefit in designs that:

- Require sophisticated AI or machine learning (ML)-based applications to be executed in low-power edge computing and endpoint devices.

- Need a local analysis of captured data.

- Demand low-latency decision making.

- Have limited, intermittent or costly connectivity to central data centers.

- Face governance or regulatory restrictions on the type of data that can be captured and stored.

Drivers

Edge AI hardware enables data analysis to be undertaken at, or close to, its point of capture.

- A key element of many system designs is being able to interpret this data and make decisions on the data content in a timely and efficient manner. However, data volume and complexity captured by edge computing and endpoint devices are increasing.

- For many deployments, it may not be practical to transfer this data to the cloud or a remote data center and utilize hosted analytics services. This is especially the case where low latency, interactivity, autonomy, privacy and security are required, or communication services may be intermittent or expensive.

- Edge AI hardware can be utilized in many deployments that would previously have required transferring the data to the cloud or remote data center in order to analyze. Example use cases include video surveillance, facial/gesture recognition, factory automation, voice response/control and monitoring a wide range of sensor data.

- Developments by semiconductor vendors are delivering chips optimized to efficiently execute DNN-based analytics. Managing this within constrained power and form factor has made it viable to deploy AI-based analytics into a wide range of edge computing and endpoint applications.

- Edge AI hardware complements the processing capabilities deployed in edge computing and endpoint devices freeing resources for local decision making and process control.

Obstacles

- To fit within the power and price constraints, edge computing and endpoint device deployments require optimized AI hardware and have the potential to impact overall analytics performance.

- The range of deployments where this equipment can be utilized may be limited, necessitating the use of cloud or data-center-based service to implement the desired analytics functions.

- Many DNN-based applications are developed within data centers using high-performance graphics processing unit (GPU)-based systems. This may limit the ability of these applications to be deployed on edge AI hardware.

- Even if the edge AI hardware is GPU-based, applications may still require optimization before they can be deployed in lower-performance non-data-center locations to ensure latency/responsiveness targets are met.

User Recommendations

- Determine the need to leverage edge AI hardware by assessing the types and complexity of data to be analyzed.

- Simplify development workflow by leveraging cloud-based services and toolsets.

- Assess the use of edge AI hardware for local analytics by taking into account the sophistication of remote decision making that can be implemented using edge AI hardware versus data-center-based analytics services.

- Assess the cost, availability and reliability of data communication to remote locations.

- Examine the regulatory and governance impacts of where data is stored and analyzed.

Sample Vendors

Advantech; Dell Technologies; Hailo; Hewlett Packard Enterprise (HPE); Intel; NVIDIA

Gartner Recommended Reading

Emerging Technologies: Tech Innovators in Neuromorphic Computing

Forecast: AI Semiconductors, Worldwide, 2021-2027

Emerging Tech Impact Radar: Edge AI

Emerging Tech Impact Radar: Edge Computing

Responsible AI

Analysis By: Svetlana Sicular

Benefit Rating: Transformational

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Definition:

Responsible artificial intelligence (AI) is an umbrella term for aspects of making appropriate business and ethical choices when adopting AI. These include business and societal value, risk, trust, transparency, fairness, bias mitigation, explainability, sustainability, accountability, safety, privacy, and regulatory compliance. Responsible AI encompasses organizational responsibilities and practices that ensure positive, accountable, and ethical AI development and operation.

Why This Is Important

Responsible AI has emerged as the key AI topic for Gartner clients. When AI replaces human decisions and generates brand-new artifacts, it amplifies both good and bad outcomes. Responsible AI enables the right outcomes by ensuring business value while mitigating risks. This requires a set of tools and approaches, including industry-specific methods, adopted by vendors and enterprises. More jurisdictions introduce new regulations that challenge organizations to respond in meaningful ways.

Business Impact

Responsible AI assumes accountability for AI development and use at the individual, organizational and societal levels. If AI governance is practiced by designated groups, responsible AI applies to everyone involved in the AI process. Responsible AI helps achieve fairness, even though biases are baked into the data; gain trust, although transparency and explainability methods are evolving; and ensure regulatory compliance, despite the AI's probabilistic nature.

Drivers

- Responsible AI means a deliberate approach in many directions at once. Data science's responsibility to deliver unbiased, trusted and ethical AI is just the tip of the iceberg. Responsible AI helps AI participants develop, implement, utilize and address the various drivers they face.

- Organizational driver assumes that AI's business value versus risk in regulatory, business and ethical constraints should be balanced, including employee reskilling and intellectual property protection.

- Societal driver includes resolving AI safety for societal well-being versus limiting human freedoms. Existing and pending legal guidelines and regulations, such as the EU's Artificial Intelligence Act, make responsible AI a necessity.

- Customer/citizen driver is based on fairness and ethics and requires resolving privacy versus convenience. Customers should exhibit readiness to give their data in exchange for benefits. Consumer and citizen protection regulations provide the necessary steps, but do not relieve organizations of deliberation specific to their constituents.

- With further AI adoption, the responsible AI framework is becoming more important and is better understood by vendors, buyers, society and legislators.

- AI affects all ways of life and touches all societal strata; hence, the responsible AI challenges are multifaceted and cannot be easily generalized. New problems constantly arise with rapidly evolving technologies and their uses, such as using OpenAI's ChatGPT or detecting deepfakes. Most organizations combine some of the drivers under the umbrella of responsible AI, namely, accountability, diversity, ethics, explainability, fairness, human centricity, operational responsibility, privacy, regulatory compliance, risk management, safety, transparency and trustworthiness.

Obstacles

- Poorly defined accountability for responsible AI makes it look good on paper but is ineffective in reality.

- Unawareness of AI's unintended consequences persists. Forty percent of organizations had an AI privacy breach or security incident. Many organizations turn to responsible AI only after they experience AI's negative effects, whereas prevention is easier and less stressful.

- Legislative challenges lead to efforts for regulatory compliance, while most AI regulations are still in draft. AI products' adoption of regulations for privacy and intellectual property makes it challenging for organizations to ensure compliance and avoid all possible liability risks.

- Rapidly evolving AI technologies, including tools for explainability, bias detection, privacy protection and some regulatory compliance, lull organizations into a false sense of responsibility, while mere technology is not enough. A disciplined AI ethics and governance approach is necessary, in addition to technology.

User Recommendations

- Publicize consistent approaches across all focus areas. The most typical areas of responsible AI in the enterprise are fairness, bias mitigation, ethics, risk management, privacy, sustainability and regulatory compliance.

- Designate a champion accountable for the responsible development and use of AI for each use case.

- Define model design and exploitation principles. Address responsible AI in all phases of model development and implementation cycles. Go for hard trade-off questions. Provide responsible AI training to personnel.

- Establish operationalize responsible AI principles. Ensure diversity of participants and the ease to voice AI concerns.

- Participate in industry or societal AI groups. Learn best practices and contribute your own, because everybody will benefit from this. Ensure policies account for the needs of any internal or external stakeholders.

Sample Vendors

Amazon; Arthur; Fiddler; Google; H2O.ai; IBM; Microsoft; Responsible AI Institute; TAZI.AI; TruEra

Gartner Recommended Reading

A Comprehensive Guide to Responsible AI

Expert Insight Video: What Is Responsible AI and Why Should You Care About It?

Best Practices for the Responsible Use of Natural Language Technologies

Activate Responsible AI Principles Using Human-Centered Design Techniques

How to Ensure Your Vendors Are Accountable for Governance of Responsible AI

Synthetic Data

Analysis By: Arun Chandrasekaran, Anthony Mullen, Alys Woodward

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

Synthetic data is a class of data that is artificially generated rather than obtained from direct observations of the real world. Synthetic data is used as a proxy for real data in a wide variety of use cases including data anonymization, AI and machine learning development, data sharing and data monetization.

Why This Is Important

A major problem with AI development today is the burden involved in obtaining real-world data and labeling it. This time-consuming and expensive task can be remedied with synthetic data. Additionally, for specific use-cases like training models for autonomous vehicles, collecting real data for 100% coverage of edge cases is practically impossible. Furthermore, synthetic data can be generated without personally identifiable information (PII) or protected health information (PHI), making it a valuable technology for privacy preservation.

Business Impact

Adoption is increasing across various industries. Gartner predicts a massive increase in adoption as synthetic data:

- Avoids using PII when training machine learning (ML) models via synthetic variations of original data or synthetic replacement of parts of data.

- Reduces cost and saves time in ML development.

- Improves ML performance as more training data leads to better outcomes.

- Enables organizations to pursue new use cases for which very little real data is available.

- Is capable of addressing fairness issues more efficiently.

Drivers

- In healthcare and finance, buyer interest is growing as synthetic tabular data can be used to preserve privacy in AI training data.

- To meet increasing demand for synthetic data for natural language automation training, especially for chatbots and speech applications, new and existing vendors are bringing offerings to market. This is expanding the vendor landscape and driving synthetic data adoption.

- Synthetic data applications have expanded beyond automotive and computer vision use cases to include data monetization, external analytics support, platform evaluation and the development of test data.

- Increasing adoption of AI simulation techniques is accelerating synthetic data.

- There is an expansion to other data types. While tabular, image, video, text and speech applications are common, R&D labs are expanding the concept of synthetic data to graphs. Synthetically generated graphs will resemble, but not overlap the original. As organizations begin to use graph technology more, we expect this method to mature and drive adoption.

- The explosion of innovation in AI foundation models is boosting synthetic data creation. These models are becoming more accessible and more accurate.

Obstacles

- Synthetic data can have bias problems, miss natural anomalies, be complicated to develop, or not contribute any new information to existing, real-world data.

- Data quality is tied to the model that develops the data.

- Synthetic data generation methodologies lack standardization.

- Completeness and realism are highly subjective with synthetic data.

- Buyers are still confused over when and how to use the technology due to lack of skills.

- Synthetic data can still reveal a lot of sensitive details about an organization, so security is a concern. An ML model could be reverse-engineered via active learning. With active learning, a learning algorithm can interactively query a user (or other information sources) to label new data points with the desired outputs, meaning learning algorithms can actively query the user or teacher for labels.

- If fringe or edge cases are not part of the seed dataset, they will not be synthetized. This means the handling of such borderline cases must be carefully accommodated.

- There may be a level of user skepticism as data may be perceived to be "inferior" or "fake."

User Recommendations

- Identify areas in your organization where data is missing, incomplete or expensive to obtain, and is thus currently blocking AI initiatives. In regulated industries, such as healthcare or finance, exercise caution and adhere to rules.

- Use synthetic variations of the original data, or synthetic replacement of parts of data, when personal data is required but data privacy is a requirement.

- Educate internal stakeholders through training programs on the benefits and limitations of synthetic data and institute guardrails to mitigate challenges such as user skepticism and inadequate data validation.

- Measure and communicate the business value, success and failure stories of synthetic data initiatives.

Sample Vendors

Anonos (Statice); Datagen; Diveplane; Gretel; Hazy; MOSTLY AI; Neuromation; Rendered.ai; Tonic.ai; YData

Gartner Recommended Reading

Innovation Insight for Synthetic Data

Innovation Insight for Generative AI

Data Science and Machine Learning Trends You Can't Ignore

Cool Vendors in Data-Centric AI

Case Study: Enable Business-Led Innovation with Synthetic Data (Fidelity International)

Quantum Computing

Analysis By: Chirag Dekate, Matthew Brisse

Benefit Rating: Transformational

Market Penetration: Less than 1% of target audience

Maturity: Embryonic

Definition:

Quantum computing is a type of nonclassical computing that operates on the quantum state of subatomic particles. These particles represent information as elements denoted as quantum bits (qubits). Qubits can be linked with other qubits, a property known as entanglement. Quantum algorithms manipulate linked qubits in their entangled state, a process that addresses problems with vast combinatorial complexity.

Why This Is Important

Quantum computing will not displace conventional computers. However, it will disrupt areas such as some classes of BQP (bounded-error, quantum, polynomial time) problem, quantum realistic simulations (used in material science, chemical simulations and drug discovery) and cryptography (security), where it will deliver results beyond what is feasible using classical techniques. Quantum computing could also advance the speed and/or quality of machine learning and optimization solutions.

Business Impact

With minimal investment required to investigate a broad range of quantum use cases, the potential rewards hugely outweigh the risks. Multiple use cases, such as optimization, run optimally on quantum computing system architectures. Also, the growing maturity of quantum ecosystems enables organizations to choose from a variety of quantum computing as a service (QCaaS) offerings. Enterprises need to plan for four key areas of impact: optimization, simulation, BQP and security.

Drivers

■ Significant investments by governments, major corporations and startups amount, in aggregate, to more than $2 billion yearly.

■ Enterprise and academic research teams have produced promising results for diverse use cases, including optimization and materials simulation, using current-generation noisy intermediate-scale quantum (NISQ) systems.

■ Demonstrations of foundational quantum technology using electrons, ions, cold/neutral/helium atoms and photons are resulting in potential pathways to scalable quantum computing.

■ The scale of superconducting gate-based quantum systems continues to increase, with some quantum computing vendors developing systems that scale to hundreds of qubits.

■ Error correction algorithms and new methods such as error mitigation and error suppression are in development. These promise to make NISQ systems more usable.

■ Managed service providers, including boutique quantum services companies, are partnering with enterprises to identify use cases and develop quantum algorithms.

Obstacles

- With few use cases guaranteeing an ROI, enterprises might deprioritize investments in quantum computing.

- Current, limited-scale qubit technology is too noisy and delivers returns of limited value.

- Standardization is lacking across programming, middleware and ecosystems.

- The market is highly fragmented, with over 600 startups operating in high-risk macroconditions. This exposes enterprises to innovation risk.

- Although small numbers of qubits can represent large amounts of data, quantum computers cannot convert large amounts of data to a quantum state, due to quantum RAM's immaturity.

- Unlike computing-on-silicon technology, there is no single physical computing stratum for quantum computing, and it is not possible to mix platforms at the quantum level. This results in a highly diverse range of potential platforms and in enterprises choosing platforms that might prove incompatible with future quantum computers.

- Enterprise leaders recognize that quantum computing will take more than 10 years to mature. This results in limited short-term investment.

User Recommendations

- Be frugal when it comes to investment in quantum computing. Focus on the problem you want to solve and ways to mature the quantum computing ecosystem. Quantum innovation is a long-term endeavor, so it is imperative to temper expectations.

- Create a pipeline for quantum computing talent by funding academic research projects that closely align with your use cases. When quantum computing becomes relevant to your organization, even a few quantum-capable employees will make a material difference.

- Plan for quantum-inspired classical optimization projects for skills development in areas such as warehouse routing, traffic routing, portfolio balancing and workforce planning.

- Plan for innovations in chemistry and materials science. Quantum computing has the potential to enable quantum-realistic simulations that could prove important in diverse fields, such as manufacturing, aerospace and defense.

Sample Vendors

Classiq; Google; IBM; Infleqtion; IonQ; IQM; PASQAL; Quandela; SandboxAQ; Zapata Computing

Gartner Recommended Reading

Cool Vendors in Quantum Computing

Infographic: How Use Cases Are Developed and Executed on a Quantum Computer

Preparing for the Quantum World With Crypto-Agility

Decentralized Finance

Analysis By: Christophe Uzureau, Ali Merji, David Furlonger

Benefit Rating: Transformational

Market Penetration: Less than 1% of target audience

Maturity: Emerging

Definition:

Decentralized finance (DeFi) is a market infrastructure that lacks the presence of a central intermediary. DeFi uses blockchain complete technology solutions to enable peer-to-peer (P2P) exchanges for trading, fractionalizing, issuing, lending, settling or collateralizing a digital asset. This creates alternative sources of funding or capital for an individual or an organization, leading to new governance and business models.

Why This Is Important

- DeFi provides and combines alternative capital, financing, governance and value exchange mechanisms that enable the programmable economy.

- DeFi disrupts traditional financial service provider intermediation while providing transparency, more control over, and access to, opportunities by both investors and borrowers.

- Traditional financial providers are now attempting to integrate some DeFi elements into their offering, such as Societe Generale with its FORGE subsidiary.

Business Impact

- Increases investor control over their assets by enabling P2P transactions and new financing capabilities (e.g., asset fractionalization via NFTs)

- Lowers cost and increases speed of financing for SMBs (e.g., via STOs)

- Increases market transparency and fairness (e.g., via blockchain forensics)

- Enables open frameworks, technologies and nonproprietary capabilities that reduce financial and technology provider lock-ins

- Automates transaction execution via smart contracts and settlement of larger asset pools

Drivers

There are multiple types of DeFi products relying on various DeFi protocols that enable smart contracts and decentralized applications (dApps). All are key market drivers:

- Deposit/lending protocols that enable the deposit of digital assets in "liquidity pools" for investors to earn fees or receive governance tokens (i.e., being rewarded with an allocation of digital assets). Getting rewarded for locking up digital assets (usually cryptocurrencies) in such pools is referred to as yield farming. Submitting assets to a liquidity pool via a DeFi protocol is called liquidity mining.

- Derivatives and synthetic asset protocols to create and trade in speculative and hedging instruments in various cryptocurrencies.

- Decentralized exchanges that permit users to trade certain cryptocurrencies for other cryptocurrencies, without the need to transfer any tokens to a centralized exchange or other intermediary.

- Insurance protocols that offer various safeguards against threats to cryptocurrency assets. Examples include insurance against cryptowallet theft, collateral protection for crypto-backed loans, and coverage for losses stemming from the hacking or manipulation of smart contracts, all without the involvement of a conventional insurance company.

- Prediction markets that permit participants to bet on the outcome of future events, such as elections and sporting events, without the need for intermediaries to manage and collect on bets.

- Developments of new Web3-enabled business models, such as gaming ecosystems like Roblox.

- The traditional financial services industry trying to understand how to connect to DeFi (and whether it is possible in the first place). For example, the Monetary Authority of Singapore has launched Project Guardian with the objective to explore how it could use DeFi to improve the financial infrastructure of Singapore.

Obstacles

- The market correction in the price of cryptocurrencies and the collapse of FTX (and SVB) have damaged the perception of DeFi initiatives — even if FTX was a centralized exchange.

- DeFi is also not currently subject to the same levels of regulatory oversight or having fail-safe devices.

- DeFi also requires a level of investor sophistication, diligence and tools not available or not understood by most retail investors.

- The existing tokens and smart contracts are not programmable or fungible enough.

- The governance of DeFI dApps by decentralized autonomous organizations (DAOs) is puzzling for some investors and is continuously evolving as DeFi matures.

- There is limited interoperability across blockchain platforms.

- Participants have to trust smart contract codes as reminded by the experience of The DAO in 2016.

- Hacking events highlight security risks as well as damage trust in DeFi.

- Cryptowallets are often unique/separate from mainstream consumer wallets.

- Asset custody is a challenging issue from a fiduciary and legal perspective.

User Recommendations

- Challenge executives to accept that some customers would like to deal with new digital assets such as cryptocurrencies — while demonstrating that the digital asset opportunity is not just about bitcoin. Provide insight into deposit attrition.

- Explore how existing currency and assets will benefit from the new tokenization mechanisms and DeFi protocols.

- Ensure finance and blockchain projects and innovation teams have a solid grasp of asset types and token standards beyond ERC-20 (including the relatively new BRC-20 Bitcoin network) to enable adequate accounting for, and fungibility of, new digital asset classes.

- Allocate sufficient business and IT resources to follow this emerging market as part of your digital transformation initiatives.

- Track the evolution of global and local regulation, including accounting and tax treatment of digital asset holdings. Regulators are increasingly focused on flexing oversight to accommodate innovation, while trying to maintain control.

Sample Vendors

ConsenSys; Liqwith; MakerDAO; PiLab; Polymath; Sygnum; Taurus

Gartner Recommended Reading

In the Spotlight: How Financial Services Leaders Are Responding to the Collapse of FTX

3 Focal Points for Bank CIOs to Create Business Value From the Metaverse

Define and Map Cryptocurrencies, Digital Currencies and NFTs to Future-Proof Your Digital Transformation

How Can Blockchain Non-Fungible Tokens (NFTs) Accelerate Digital Transformation?

The Programmable Economy Is Driving a New Growth Reality and Business Opportunities

Sliding into the Trough

Chief Data Scientist

Analysis By: Peter Krensky, Erick Brethenoux, Carlie Idoine, Aura Popa

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Definition:

Chief data scientist is an evolving leadership role responsible for translating analytics and AI strategy into efficient and effective implementations of advanced D&A products and services. The role is typically the most senior data science position within an organization and has a specific focus on applied data science approaches.

Why This Is Important

The complexity, pervasiveness and criticality of advanced analytics and AI requires dedicated attention. The chief data scientist ensures alignment with critical business priorities. Chief data scientists are also responsible for enterprise data science teams and for execution of the data science vision. They must think tactically, assess the current situation and deliver value today while planning strategically, in parallel, to coordinate and maximize the future use of advanced analytics and AI.

Business Impact

The business value derived from advanced analytics and AI done right is more than what can be accomplished by other means. Chief data scientists propel the use of advanced analytics and AI forward by:

- Transforming the business vision to advanced analytics and AI initiatives.

- Coordinating all advanced analytics and AI initiatives across the organization, reliably delivering advanced analytics and AI solutions and accelerating time to value.

- Delivering measurable results and value to the organization.

Drivers

- Communicating the value of advanced analytics and AI, not just delivering projects, is a key business priority. Efforts are required to manage and coordinate both centralized and decentralized teams to deliver measurable business outcomes.

- Growing data science teams are fueled by generative AI hype, excitement and strategic funding. These teams especially need help with communication, coordination and stakeholder management.

- Organizations are digitizing and automating more of their processes with AI and analytics at the core. As AI becomes a critical function in processes underlying digital businesses, it requires leadership skills and oversight.

- Siloed, unstructured approaches to advanced analytics and AI not only consume significant time and resources but also increase risk and minimize return on investment and overall trust in these techniques. The role of chief data scientist aids breaking down and eliminating silos.

- Value from advanced analytics and AI requires a consistent, managed approach. Chief data scientists are responsible for establishing processes resulting in consistent delivery of high-value advanced analytics solutions.

- The democratization of data science has generated an increasing number of ML models that are often not operationalized. The need for better coordination with the lines of business and IT and the harmonization of DSML practices requires a chief data scientist role.

- A shortage of staff with data science skills requires a concerted effort to recruit, retain, organize and develop data science talent across the organization.

Obstacles

- Recruiting and retaining an experienced chief data scientist, with the right blend of management, technical, business and communication skills, is challenging.

- D&A leaders and their IT and business partners often lack influence, organization, process and practice to deliver, operationalize and scale advanced analytics and AI solutions and approaches.

- The chief data scientist role may not have enough organizational clout and defined authority to drive the enterprisewide changes required to reap the benefits of AI.

- The lack of business recognition often leaves the organization open to data science poaching, weakening the role of the chief data scientist.

- Keeping roles and responsibilities clearly defined is challenging when organizations also have (sometimes multiple) CDOs and CAOs.

- Organizations may think they need a CDS role when it is still too early in their maturity to warrant the position.

User Recommendations

- Define the chief data scientist role as a complement to other CxO roles, recognizing that alignment between these roles is critical.

- Work both within (the internal IT team and the broader organization) as well as outside the organization to orient the chief data scientist within the broader community and identify opportunities for learning and partnership.

- Empower chief data scientists to build a diverse team, develop processes and procure tools to deliver models in a way that builds trust while tracking the impact on key business priorities and value generated.

- Leverage the chief data scientist role to drive and coordinate application, exploration and delivery of advanced analytics and AI methods and techniques to align those methods with real, prioritized business problems.

Gartner Recommended Reading

Lessons From Data Scientists on Their Education and Career Development

How CDAOs Can Lead Upskilling Initiatives in Data Science and Machine Learning

Decentralized Identity

Analysis By: Michael Kelley, Akif Khan, Arthur Mickoleit

Benefit Rating: Transformational

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

Decentralized identity (DCI) allows an entity to control their own digital identity by using decentralized identifiers (DIDs) to connect and authenticate themselves to other entities. Private keys and verifiable credentials (VCs) are contained in digital wallets, supported by an identity trust fabric for making DIDs discoverable. By establishing trust, privacy and security, DCI is an attractive alternative to traditional models of storing, sharing and verifying identity data.

Why This Is Important

Identity fragmentation is a problem due to service providers (banks, retailers and governments) forcing consumers to create individual identities for every service. DCI offers an attractive approach with increased security, privacy and usability compared to traditional digital identity approaches like federated identity. While legislative efforts to secure privacy and ensure interoperability are multiplying around the world, standards continue to be refined, and DCI use cases continue to emerge.

Business Impact

Users gain greater control of their identities and data, and service providers gain higher trust, speed and confidence. Currently, providers collect huge amounts of identity information about users to increase assurance to an acceptable level. DCI can provide trust, security, privacy and convenience, and can provide portability of identity data for end users without needing centralized data, reducing risks of data breaches, account takeovers and privacy compliance violations.

Drivers

- Vendor investments in DCI: Due to the volume and influence of vendors investing in this space, there is high potential to drive the DCI market forward, and significant investments have been made by IBM, Microsoft and Ping Identity. In addition, Gartner has been tracking more than 80 startups and vendors of DCI technologies and DCI components (e.g., digital wallets and trust fabrics).

- Government activity: Public sectors are increasingly shaping digital identity trends around DCI. The EU, national governments like Finland or Canada, as well as states and provinces like Utah and Ontario are actively pursuing and investing in DCI use cases that span public and private sector interests.

- Privacy regulations: Countries continue to formalize the requirement for user privacy, specifically for collecting and securing large amounts of user data through regulations. DCI provides a more user-centric way of complying with privacy regulations through decentralized user data.

- Client and overall market interest in DCI: Interest is increasing due to attractive elements such as the ability to enable new digital business opportunities while maintaining client privacy. For example, using DCI to share verified claims, such as age/income, employment status, professional credentials, educational credentials without exposing sensitive personal data.

- Standards: Standards are maturing, led by entities such as the World Wide Web Consortium (W3C), the Decentralized Identity Foundation (DIF), the OpenWallet Foundation and OpenID for verifiable credentials to create a consistent approach to DCI. Expanding and maturing standards will help move the market forward.

- User experience: Asking users to repeatedly go through identity proofing and affirmation processes for every online interaction with a service provider is a broken model. Significant friction can be removed from UX if users could assert their identity using a digital wallet with full control over their identity data.

Obstacles

- Authority of issuers: Ensuring that an organization is authoritative to issue a VC (e.g., only an accredited facility issuing educational credentials).

- Adoption: Service providers may resist accepting identity claims via DCI unless they see user adoption, and users may be reluctant to adopt DCI wallets unless they see meaningful use cases for them.

- Interoperability: Adoption is slow due to most development taking place in pockets and a continued lack of standards.

- Technical challenges: Concerns about performance, interoperability, scalability and maturity, as well as wallet standards.

- Regulations: More work is required for how verifiable claims can be used in regulated use cases such as KYC, as required in financial services, online gambling and other industries. Governments are exploring regulatory needs for citizen interactions.

- User interface challenges, ID proofing and account recovery processes are vulnerable for security and privacy, and will require standard approaches.

User Recommendations

- Explore use cases for verifiable claims by identifying tasks and processes that are expensive, complex and time-consuming in the real world, which will benefit from a verifiable claims approach.

- Build a business case for trialing acceptance of DCI by targeting reduced identity proofing and affirmation costs and an improved UX.

- Identify attainable use cases through following successful POCs, such as a DCI solution focused on remote employee onboarding, educational credentials, health credentials and passwordless authentication.

- Partner with existing vendors to understand the possibilities and potential of DCI. Track government activities around use cases for citizen IDs.

- Be cautious of overly optimistic vendor claims. Evaluate the technical security aspects of centralized and partially decentralized identity trust fabrics or using blockchain platforms under consideration. In particular, examine vendor plans for support of standards, such as W3C, DIF and the OpenWallet Foundation.

Sample Vendors

1Kosmos; Evernym; IBM; IdRamp; Microsoft; Nuggets; Ping Identity; Scytale; SecureKey; Wise Security Global

Gartner Recommended Reading

Guidance for Decentralized Identity and Verifiable Claims

Innovation Insight for Decentralized Identity and Verifiable Claims

Predicts 2023: Users Take Back Control of Their Identities With Web3 Blockchain

Top Trends in Government for 2022: Digital Identity Ecosystems

Explainable AI

Analysis By: Peter Krensky, Sumit Agarwal

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

Explainable AI (XAI) is a set of capabilities that describes a model, highlights its strengths and weaknesses, predicts its likely behavior, and identifies any potential biases. It can clarify a model's functioning to a specific audience to enable accuracy, fairness, accountability, stability and transparency in algorithmic decision making.

Why This Is Important

XAI gives visibility into how a model arrived at a particular decision. This helps in building trust, confidence and understanding in AI systems. In highly regulated sectors such as insurance or banking, regulations directly or indirectly mandate the need for model explainability to properly manage model risk.

Business Impact

XAI is the responsibility of both vendors (data scientists and solution developers) and also of end-user organizations that consume them. Not supporting this capability puts businesses and decision making at risk. However, different levels of explainability are required for customers, the organization's IT and management, society, and regulators to direct AI governance.

Drivers

■ The lack of model transparency or interpretability among model users, managers and consumers impacted by models' decisions severely limits an organization's ability to manage AI risk. Fairly or unfairly, consumers hold the originating organization responsible for the performance and behavior of AI.

■ Not ensuring explainability invites model risk that can lead to financial loss, poor business and strategic decision making, or damage to organizational reputation.

■ A lot of organizations are shifting to augmented decision-making capabilities with the use of AI models. As a result, they should be able to explain how an AI model arrived at a particular prediction or decision.

■ XAI capabilities are prebuilt into both platforms and innovations in the open-source community to explain and interpret models are on the rise.

■ Ethical and moral considerations need to be accounted for while relying on augmented decision making, often supported by thorough governance and auditing capabilities for these models.

■ New regulations and legal interventions are taking place that mandate the use of explainable AI methodologies.

■ Explainable models also help with attrition, so data scientists who quit the job do not leave black boxes behind them. Models that are interpretable help business audiences gain trust in AI.

Obstacles

- Explainability is often confused with ML interpretability. Although the latter serves data scientists, the former applies to different personas interacting with the AI life cycle.

- XAIs are often looked at as a task or a step required while creating AI projects toward the end of the AI life cycle, but they have to be continuous and tested throughout training, development and production phases.

- An inherent lack of trust exists in AI systems that keeps organizations from adoption, since they're simply not aware of XAI techniques or frameworks.

- Explainability tools are fragmented, and XAI is often consumed in an oversimplification such as showing feature importance to end users. Although that approach works in the beginning, XAI is much wider than that, and requires a deep understanding of the subject.

- Organizations that focus on the accuracy of the models rather than on the interpretability stall their decisions on creating a more explainable AI.

User Recommendations

- Define a range of actions that can be taken independently that identify unacceptable results and that flag those results for human intervention. Minimizing the number of incorrect results derived from AI is critical, because users will lose trust in a poorly performing system.

- Educate, train and foster ongoing conversations with key stakeholders, including line-of-business managers, legal and compliance, to understand the AI model's explainability requirements, challenges and opportunities.

- Strive for XAI for each model along the dimensions of business, data, algorithms, models and production.

- Accept deficiencies in explainability as a natural consequence of systems becoming increasingly complex. Document notable deficiencies or potential biases so that they can be used to make corrections in the future.

- Establish the role of AI model validator, a data scientist whose job is to ensure that models are explainable and robust, and meet all possible constraints.

Sample Vendors

Dataiku; EazyML; Fiddler AI; Google; H2O.ai; IBM; Microsoft; Modzy; Superwise; TruEra

Gartner Recommended Reading

Innovation Insight for Bias Detection/Mitigation, Explainable AI and Interpretable AI

Top 5 Priorities for Managing AI Risk Within Gartner's MOST Framework

Market Guide for AI Trust, Risk and Security Management

Incorporate Explainability and Fairness Within the AI Platform

Identity Wallets

Analysis By: Michael Kelley, Akif Khan, Arthur Mickoleit

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Early mainstream

Definition:

Identity wallets, both in the form of mobile and web apps, enable users to store, manage and selectively disclose digital identity data from different sources and for various purposes. Users can also use identity wallets to hold their credentials to validate claims. Overall, identity wallets represent an interface for issuing and verifying credentials.

Why This Is Important

A digital identity wallet provides individuals greater control over their identity data and has the potential to enable higher trust for validation of identity claims. For service providers, identity wallets can enable new service models that require consented sharing of identity data. Use cases can involve commercial and government entities for verifiers and issuers of credentials and attributes. Governments are exploring the need for standards and regulations around identity wallets.

Business Impact

Identity wallets help individuals manage personal data from any public or private source. For example, ID cards, driving license data, employer data, COVID-19 vaccination, digital passports and tickets. Use cases span from in-person identity verification and online transactions to contactless check-ins. The data managed by identity wallets include verifiable claims for decentralized identity (DCI), digital representation of electronic data, like airline or concert tickets, and even cryptocurrency and non-fungible tokens (NFTs).

Drivers

- **Privacy and security:** Digital wallets prioritize benefits like security, privacy and anonymity through zero-knowledge protocols and data minimization.

- **Health information:** Digital wallets can safely and securely communicate health information from patients to medical providers.

- **Citizen credentials:** Mobile driver's licenses and other documents providing proof of citizenship. These specific use cases contribute to the growing public interest and debate about digital wallet services on the smartphone.

- **Growing traction of decentralized identity:** Interest in identity wallets is growing with increased interest in DCI. Global standards, like World Wide Web Consortium (W3C) verifiable credentials (VCs) and decentralized identifiers (DIDs), are driving additional use cases for verifiable claims in digital wallets. These enable the creation of open, interoperable identity wallet services.

- **Payments and fintech:** Identity wallets are serving payment-related use cases. For example, to manage financial assets and transactions. The confluence of identity and payment use cases in mobile apps, like Apple Wallet, are already visible today.

- **User experience (UX):** Identity wallets will reduce the need for users to repeatedly prove their identity across multiple service providers. Mobile devices will become the primary means for proving identity claims. Asserting an identity claim from already verified identity attributes will reduce onboarding friction and likely become a competitive advantage.

- **Future monetization of identity data:** Today's identity wallets are focused on nonremunerated consent for sharing personal identity data. Future iterations and use cases for identity wallets may include an individual granting consent of their personal data for commercial use in return for remuneration or other rewards.

Obstacles

■ **Market understanding**: There is confusion about the term "identity wallets." The term can refer to proprietary mobile ID apps — where identity data is confined to a centrally defined ecosystem — and to open standards-based wallets that enable decentralized, portable and interoperable identity.

■ **Wallet standards**: The market and governments are actively working on standards and strategies for interoperability. The OpenWallet Foundation is currently working on defining an open standard for interoperability.

■ **User acceptance**: The adoption of identity technologies will be driven by relevant use cases. Focus on use cases that effectively communicate the tangible benefits of identity wallets.

■ **User experience (UX)**: The interface for the identity wallet must be easy to use and intuitive. Alternatives to mobile devices must be explored.

■ **Trust and recoverability**: When users begin to store and manage personal or payment data with their wallet, data security, encrypted keys and recoverability after loss or theft will be a top priority.

User Recommendations

■ As soon as standards evolve, be prepared to support multiple wallets for varied use cases. For example, a wallet for concert tickets, a government-issued wallet for citizen-identity information, a personal wallet holding banking, employment and educational credentials, or a wallet for storing cryptocurrency or processing payments.

■ Explore emerging use cases, like verifiable claims for decentralized identity, cryptocurrency and NFTs, while supporting traditional use cases — for example, digital representations of physical things, such as airline and events tickets, driver's licenses, digital passports and other government-related documents.

■ Observe or participate in shaping regulations, standards and reference frameworks that are relevant to your geography. For example, the EU's ongoing large-scale pilots and electronic identification, authentication and trust services (eIDAS) regulation revision.

■ Investigate the value of digital wallets for representing identity in online digital communities, like Web 3.0 and metaverse applications.

Sample Vendors

1Kosmos; Apple; Evernym; ID.me; Google; Microsoft; Nuggets; Ping Identity; Scytáles; SecureKey

Gartner Recommended Reading

Guidance for Decentralized Identity and Verifiable Claims

Innovation Insight for Decentralized Identity and Verifiable Claims

Predicts 2023: Users Take Back Control of Their Identities With Web3 Blockchain

Predicts 2022: Identity-First Security Demands Decentralized Enforcement and Centralized Control

Top Trends in Government for 2022: Digital Identity Ecosystems

Blockchain

Analysis By: Ali Merji, David Furlonger

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Emerging

Definition:

Blockchain is an expanding list of cryptographically signed, irrevocable blocks of records shared by all participants in a peer-to-peer (P2P) network. Each block is time-stamped and references link to previous data blocks. Anyone with access rights can trace a state change in data or an event, belonging to any participant. Blockchain-enabled insurance refers to a portfolio of activities, potentially transformed by enterprise applications of blockchain technologies.

Why This Is Important

Blockchain technology enables the development of new insurance products, thanks to programmability and more specifically the use of tokenized records combined with smart contracts — cost savings, transparency, faster payouts (oracles and smart contracts supporting parametric insurance) and fraud mitigation. This allows data to be shared in real time between various parties in a trusted and traceable manner.

Business Impact

The transformative impact of blockchain will be seen when:

- Decentralization and tokenization are used to innovate business models (e.g., P2P insurance), and to adjust behaviors, such as reward tokens to incentivize insurance premium reductions.

- But also to support insurance products for consumers and companies evolving into web3-enabled environments, dealing with new digital asset classes (e.g., intellectual property registered as a non-fungible token (NFT) — and rented to brands).

Drivers

- Leaders are predominantly exploring the use of private/permissioned blockchains in support of complex transactions and relationships (such as between insurers and reinsurers, or agents, and brokers and insurers). The goal is to improve collaboration and operational efficiency by reducing reconciliation.

- Our 2022 Financial Services Tech survey, suggests 27% insurance firms have already invested in a blockchain initiative, 29% will be planning/investing within the next 12 months (actively experimenting) and another 14% within the next 12 to 18 months. Current investment is limited to experiments and early production limited production use cases. There is still optimism due to developments around web3, and its promise of creating new business models for Insurance, creating new customer segments with new needs, this can also mean existing insurance products adjust to these new needs.

- Some insurers are using smart contracts in support of simple parametric insurance products, such as flight insurance and disaster insurance, for example, payout example for skiing. Smart contracts used in other industry contexts will also impact how insurance products are priced, sold and supported, as they change the time frames of decision making, payout structures and potentially the legal foundation for the commercial arrangement.

- Blockchain promises to transform the insurance industry in terms of new kinds of monetization of data, customer convenience via enhanced self-service using smart contracts and integration of blockchain with other technologies like AI and Internet of Things (IoT) for faster claims management.

- The development of the metaverse demands new digital asset portability or transfer services — which will demand some guarantees against theft but also technology risks (especially taking into account the current lack of interoperability of blockchain solutions).

Obstacles

■ Use cases require cooperation between disparate enterprises with different abilities to share and digitize data.

■ The challenges of extending pilots and proofs of concept (POC) into full-fledged production solutions persist.

■ The lack of cohesive legal frameworks and the threat of disintermediation enabled by decentralized insurance processes and business models require careful analysis by strategic planners and business leaders.

■ The lack of maturity as well as talent to create and maintain the smart contracts essential to parametric insurance

■ Lack of clear regulatory treatment for digital assets, notably when dealing with cross-border transactions.

■ No clear method of valuing some digital asset classes significantly increases insurance risk.

User Recommendations

■ Establish a C-level team to determine the implications of blockchain, cryptocurrencies, central bank digital currency (CBDC), NFTs and metaverse, and plan for assessments of technology, information security, regulations, use-case applicability and insurance technology (insurtech) startup provider viability.

■ Educate your business peers on the opportunities and implications of smart contracts, tokenization and web3 in insurance, set appropriate expectations and identify future opportunities.

■ Develop a framework for engaging with clients and understand how innovative P2P insurance business models enabled with blockchain will be relevant in their context.

■ Focus your pilots and POCs on how to use programmability via smart contracts to support product development and on how to value new digital asset classes.

Sample Vendors

Accenture; Cognizant; Deloitte; Etherisc; Everledger; IBM; Infosys; The Institutes RiskStream Collaborative; Toucan

Gartner Recommended Reading

Top 10 Technology Trends for Investment Management CIOs in 2023

Crypto and Digital Asset Opportunities for Insurance

How to Grow Digital Business to Capture a $163 Trillion Revenue Opportunity

Define and Map Cryptocurrencies, Digital Currencies and NFTs to Future-Proof Your Digital Transformation

Smart City Framework

Analysis By: Bettina Tratz-Ryan

Benefit Rating: Transformational

Market Penetration: 5% to 20% of target audience

Maturity: Emerging

Definition:

A smart city framework guides urban development toward a data exchange of an intelligent urban ecosystem. This will improve citizens' lives, stimulate the economy and protect the environment. The ecosystem of actors is facilitated with data marketplaces, algorithmic business, legal frameworks and policies. They define and measure the impact of technology through data and analytics to create a user-focused and contextualized experience.

Why This Is Important

Many intelligent urban ecosystems and cities accelerate the development of a smart city framework based on social development, sustainability, economic recovery and safety issues, rather than solely on technology they could invest in. Local governments are now including data exchanges to generate data sharing-enabled ecosystems that build digital business services and experiences for customers and citizens.

Business Impact

The business impact of smart city frameworks is driven by the ability to automate and deliver better service experiences through data exchange and data trust. Open data portals and data marketplaces will provide transformational access to an urban context that will be used to drive more use cases and user-specific ambient services, including demographic changes, digital skills, knowledge exchange and sustainability-related ambience.

Drivers

- The digitalization of daily life and urban operations, especially with the increasing flow of data, is driving the architecting of a city framework that will keep the level of embedded application on an equitable level with citizen trust and benefit. It will allow decision makers to develop a vision with guardrails that neither stifle innovation nor expose the community to perceived intrusive technology choices.

- Governance and engagement structures will be established by local governments that will manage and support the interactions and create a winning formula between city, economy and society.

- Contextualized data will come from preferences and movement data of residential and business users that map to real-time data from infrastructure and services.

- The smart city framework will be empowered through technology approaches such as cloud and big data management. As cities work together as regions, a holistic platform approach with a system of systems is being developed that allows interoperability and data governance of new services, including city algorithms as a service.

- Sustainability- and climate-change-related issues are becoming an increasingly litmus test for cities, as they need to follow net zero carbon emission timelines for infrastructure, traffic and operations. Biodiversity in spatial planning, near zoning green spaces and recreation, as well as the health aspects that it creates for people, will be factors for environmental implementations that are socially balanced and do not burden society.

Obstacles

- Blending data will add to privacy and safety discussions in specific use cases across the ecosystem, including local government.

- With increasing data analytics and AI utilization, the challenge of the perception of security and bias in storage and management of data is increasing, and the framework needs governance. Therefore, digital equity, data laws and AI ethics need to be included, leading toward a data vault and trust factors. Digital needs to be aligned with social equity, including service equity, which is often aligned with decision makers outside of smart city or digitalization initiatives.

- Building a framework requires all stakeholders to agree on a common set of goals. This includes not only the definition of urban development, but also the holistic social, demographic and economic objectives as embedded in a sustainable smart city environment. Articulating the outcome and benefits often hinges on political, financial or short-term priorities, rather than long-term vision.

User Recommendations

- Operate and manage the city perception of residential and business constituents as depicted in the framework by developing a data-driven decision roadmap.

- Develop guidelines and a governance mechanism for data trust, ethical AI and data privacy issues.

- Share insights and data orchestration with other smaller cities or regional partners by developing a synchronized network of best practices for cities, avoiding the duplication of infrastructure, Internet of Things (IoT) platforms or data analytics. This could become a system-of-systems approach or smart city as a service.

- Apply a technology inventory that will support the set of objectives, as well as the information and data exchange governance requirements for the city and the public-private initiatives.

Sample Vendors

Accenture; Arup; Fluentgrid; Fujitsu; IBM; Microsoft; NEC; NTT DATA; Quantela; ZainTech

Gartner Recommended Reading

Predicts 2023: Sustainable Smart City Decision Making Using Urban Data

Case Study: An Intelligent Urban Ecosystem Approach to a Sustainable Smart City

Non-fungible Tokens

Analysis By: Christophe Uzureau, David Furlonger

Benefit Rating: Transformational

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

A non-fungible token (NFT) is a blockchain-based monetized record of unique noninterchangeable information that represents a piece of digital media. NFTs can link to any form of digital asset, such as digital art, text, videos, photos, songs (or samples), lines of code and so on. NFTs can also represent, in a tokenized form, any digitally represented artifact (i.e., a physical asset that has been digitized).

Why This Is Important

NFTs are exclusive artifacts due to programmable software used in their creation that can encode specific rights and uses over the assets they represent. NFTs represent the provenance and auditability of the underlying asset. They operate on the principle of decentralized finance (DeFi), whereby assets and participants to a market operate on a peer-to-peer (P2P) and decentralized basis. For financial services providers, this provides opportunities across custody, payment, trading and collateralization.

Business Impact

NFTs are transformational, thanks to the following opportunities:

- **Custodial services** — NFTs create new custody services opportunities for gamers, artists and creators such as designers of content in the metaverse.

- **Access to new collateral** — NFTs can be used as collateral notably to target younger customers (such as via gaming assets, collectibles used to customize avatars).

- **Capital market opportunities** — The programmability of NFTs enable the fractionalization of real-world assets such as real estate.

Drivers

- From a banking perspective, NFTs provide an alternative way to finance projects, as well as opportunities for trading and investing into a new digital asset class. There are payment opportunities in supporting the transfer of ownership of NFTs, as well as in supporting payments to NFT issuers in the first place.

- NFTs afford opportunities for banks and insurers to differentiate offerings due to an NFT's ability to prove the integrity of and ownership over an underlying asset and to set terms and rules for its usage.

- The capabilities for decentralization also provide for value to be captured directly by the creators of the asset — initially at sale and potentially as a form of annuity through models such as leasing, rental, royalty and so on. Those creators are transitioning from being customers to prosumers and will expect payment acceptance, reporting and reconciliation services, as well as support in meeting their tax obligations, protecting their intellectual property and obtaining financing.

- The Ethereum blockchain, the dominant blockchain supporting NFT minting (e.g., for ERC-721 and ERC-1155 tokens), has transitioned to proof of stake (POS), significantly reducing its impact on the environment, and driving participation by brands into the NFT market. For example, Nike's SWOOSH is an initiative to increase the participation of its customers in the design of wearables for games and the emerging metaverse.

- New protocols are emerging to support new use cases. An example is the ERC-4907 enabling the creation of renting contracts for NFTs, and non-Ethereum blockchains (such as Solana, Polygon and Flow) continuing to offer alternative options for clients in terms of costs, transaction speed and target clients.

- It is also becoming more urgent as NFTs will contribute to the disintermediation of traditional financial services if the latter neglect NFTs' ability to support new customer demand, such as the use of NFTs as part of the collateralization processes.

Obstacles

The high level of market hype has led to a correction in the valuation and volume of NFTs. As a result, they are increasingly shifting to deal with more practical and nonspeculative use cases. However, there is a need to deal with weaknesses in the overall market infrastructure:

- NFT wash trading is an issue that damages investors' trust in NFT markets.

- The market has different layers of decentralization, so it is not economically frictionless.

- The underlying asset can be altered — even deleted or moved after an NFT sale. Depending on the rules created under the NFT construction, such actions may have significant legal and financial implications for market participants.

- There is a lack of market and legal clarity on how to use NFTs as part of the collateralization of digital and physical assets and the implications from an insurance and financing perspective.

- There is a lack of interoperability of the underlying blockchain platforms.

User Recommendations

- Support new funding and payment mechanisms, as well as custody services. This includes new financial products, including using NFTs as collateral. And plan to deliver such services as part of your embedded finance strategy.

- Use the programmability of NFTs — which could represent a real-world asset such as a property or a digital twin — to enable their fractionalization.

- Participate in data market creation and integration. NFTs can contain and connect to valuable information about specific assets, their use and the transaction participants. Such a data ecosystem has value in terms of analytical services such as supporting green financing thanks to NFT-based carbon credits.

- Analyze the links between NFT opportunities, blockchain, AI and the emerging metaverse, since NFTs improve the portability of data and other digital assets across digital environments and therefore support the economic outcomes of digital transformation.

Sample Vendors

Axie Infinity; Binance; Dapper Labs; Decentraland; Enjin; OpenSea; The Sandbox; YellowHeart

Gartner Recommended Reading

3 Focal Points for Bank CIOs to Create Business Value From the Metaverse

How Can Blockchain Non-Fungible Tokens (NFTs) Accelerate Digital Transformation?

Knowledge Graphs

Analysis By: Afraz Jaffri

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Definition:

Knowledge graphs are machine-readable representations of the physical and digital worlds. They include entities (people, companies, digital assets) and their relationships, which adhere to a graph data model — a network of nodes (vertices) and links (edges/arcs).

Why This Is Important

Knowledge graphs capture information about the world in an intuitive way yet are still able to represent complex relationships. Knowledge graphs act as the backbone of a number of products, including search, smart assistants and recommendation engines. Knowledge graphs support collaboration and sharing, exploration and discovery, and the extraction of insights through analysis. Generative AI models can be combined with knowledge graphs to add trusted and verified facts to their outputs.

Business Impact

Knowledge graphs can drive business impact in a variety of different settings, including:

- Digital workplace (e.g., collaboration, sharing and search)

- Automation (e.g., ingestion of data from content to robotic process automation)

- Machine learning (e.g., augmenting training data)

- Investigative analysis (e.g., law enforcement, cybersecurity or financial transactions)

- Digital commerce (e.g., product information management and recommendations)

- Data management (e.g., metadata management, data cataloging and data fabric)

Drivers

- The need to complement AI/ML methods that detect only patterns in data (such as the current generation of foundation models) with the explicit knowledge, rules and semantics provided by knowledge graphs.

- Increasing awareness of the use of knowledge graphs in consumer products and services, such as smart devices and voice assistants, chatbots, search engines, recommendation engines, and route planning.

- The emerging landscape of Web3 applications and the need for data access across trust networks, leading to the creation of decentralized knowledge graphs to build immutable and queryable data structures.

- Improvements in graph DBMS technology that can handle the storage and manipulation of graph data structures at scale. These include PaaS offerings that take away the complexity of provisioning and optimizing hardware and infrastructure.

- The desire to make better use of unstructured data held in documents, correspondence, images and videos, using standardized metadata that can be related and managed.

- The need to manage the increasing number of data silos where data is often duplicated, and where meaning, usage and consumption patterns are not well-defined.

- The use of graph algorithms and machine learning to identify influencers, customer segments, fraudulent activity and critical bottlenecks in complex networks.

Obstacles

- Awareness of knowledge graph use cases is increasing, but business value and relevance are difficult to capture in the early implementation stages.

- Moving knowledge graph models from prototype to production requires engineering and system integration expertise. Methods to maintain knowledge graphs as they scale — to ensure reliable performance, handle duplication and preserve data quality — remain immature.

- The graph DBMS market is fragmented along three properties: type of data model (RDF or property), implementation architecture (native or multimodal) and optimal workload (operational or analytical). This fragmentation continues to cause confusion and hesitation among adopters.

- Organizations want to enable the ingestion, validation and sharing of ontologies and data relating to entities (such as geography, people, events). However, making internal data interoperable with external knowledge graphs is a challenge.

- In-house expertise, especially among SMEs, is lacking, and identifying third-party providers is difficult. Often, expertise resides with vendors of graph technologies.

User Recommendations

- **Create a working group of knowledge graph practitioners and sponsors** by assessing the skills of D&A leaders and practitioners and business domain experts. Highlight the obstacles to dependable and efficient data delivery for analytics and AI, and articulate how knowledge graphs can remove them.

- **Run a pilot to identify use cases that need custom-made knowledge graphs.** The pilot should deliver not only tangible value for the business, but also learning and development for D&A staff.

- **Create a minimum viable subset that can capture the information of a business domain to decrease time to value.** Assess the data, both structured and unstructured, needed to feed a knowledge graph, and follow Agile development principles.

- **Utilize vendor and service provider expertise** to validate use cases, educate stakeholders and provide an initial knowledge graph implementation.

- **Include knowledge graphs within the scope of D&A governance and management.** To avoid perpetuating data silos, investigate and establish ways for multiple knowledge graphs to interoperate and extend toward a data fabric.

Sample Vendors

Cambridge Semantics; Diffbot; eccenca; Neo4j; Ontotext; Stardog; TigerGraph; TopQuadrant; Trace Labs

Gartner Recommended Reading

How to Build Knowledge Graphs That Enable AI-Driven Enterprise Applications

3 Ways to Enhance AI With Graph Analytics and Machine Learning

Working With Graph Data Stores

How Large Language Models and Knowledge Graphs Can Transform Enterprise Search

Blockchain Asset Tokenization

Analysis By: Christophe Uzureau, Ali Merji, David Furlonger

Benefit Rating: Transformational

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Definition:

Blockchain asset tokenization is the process of creating or representing value, such as an asset (monetary value or data, or an ID), and/or conveying the right to use such an asset. The rules that define the creation, representation and exchange of the assets are executed via a smart contract. The exchanges can occur via almost any medium, including person-to-person, machine-to-machine, person-to-machine and machine-to-person.

Why This Is Important

The continued growth in gaming, the evolution of the metaverse and the digitalization of industry and the economy requires new forms of money, money creation mechanisms and funding options. As part of the programmable economy, blockchain-enabled tokenized assets are better suited to handle atomic and P2P transactions and afford liquidity and monetization capabilities — including via decentralized finance (DeFi) — that fiat cannot support.

Business Impact

A lot of attention on digital assets and tokenization has focused on new payment and settlement mechanisms (stablecoins as well as some CBDCs) and cryptocurrencies. However, the transformational potential of blockchain asset tokenization also resides in the creation of: new digital products and assets (such as NFTs), the decentralization of finance (such as via security tokens), the creation of data tokens and the implementation of decentralized self-sovereign IDs (SSIs).

Drivers

- Data tokens allow data producers (individuals and companies, citizens, institutions and governments) to opt into sharing certain pieces of information and access new processing capabilities. For example, this is an important contribution to certify green assets and deal with greenwashing.

- Data tokens and incentive tokens enable the creation and discovery of new markets for contextual information. Data is an important complementary solution to generative AI — as illustrated by Fetch.ai and its autonomous economic agents (a type of machine customer) — to certify an outcome and incentivize machine customers to carry out a specific task.

- Security tokens (as well as NFTs) provide an opportunity to broaden the pool of investors by facilitating and fractionalizing the ownership of the assets and improving their distribution. This applies to digital but also to physical assets that are usually difficult to invest in, such as high-value objects, real estate, etc., and illiquid capital assets on enterprise balance sheets. In this way, new opportunities exist for financing, investing, supply chain management, and ecosystem development and participation.

- The Ethereum blockchain, the dominant blockchain supporting NFT minting (e.g., for ERC-721 and ERC-1155 tokens), has transitioned to proof-of-stake (POS), significantly reducing its impact on the environment and driving participation by brands into the NFT market. New token standards such as the ERC-4907 enables the creation of renting contracts.

- New protocols are emerging to support new use cases such as the ERC-4907, enabling the creation of renting contracts for access to other digital assets, intellectual property and data. Non-fungible tokens and non-Ethereum blockchains (such as Solana, Polygon, Flow) continue to offer alternative options for clients in terms of costs, transaction speed and target clients.

Obstacles

- There is still fragmentation of protocols, a lack of interoperability across blockchain platforms, as well as a lack of mature digital assets marketplaces and certification mechanisms of the token issuers and of the participants.

- The accounting and valuation for digital assets remains difficult. With uncertain liquidity, accounting professionals have difficulty in ascertaining their fair value.

- The fragmentation of regulatory regimes and cross-border portability of rights of ownerships of digital assets lead to a lack of legal protection for digital assets today. This could create reputation risk as well as expose participants to further regulatory risks. Additionally, there are regulatory gaps in how to deal with customers' assets such as with taxation, especially from a cross-border perspective.

- Custody markets are embryonic and new providers lack general market experience, capabilities and regulatory oversight which means risk factors are high for stranded assets.

User Recommendations

- Analyze the impact of tokenization on your market by assessing the underlying factors driving the issuance, usage and exchange of the digital business assets (DBAs) using tokenization.

- Map your token universe by inventorying the tokens that are in use by your enterprise, as well as in your ecosystem, to discover new financing and value exchange opportunities.

- Review the progress of security tokens, NFTs and CBDC initiatives and educate your peers about the different types of tokens.

- Prepare for autonomous digital business by testing tokens as mediums of exchange for microtransacting between smart things, as well as for monetizing and exchanging items of data.

- Define and refine the impact of tokenization for key financial functions such as issuance, custody and trading, and therefore reprioritize your R&D investments.

- Analyze the viability of existing systems by undertaking a technology capability assessment to evaluate if those systems can tokenize the digital assets of your ecosystem.

Sample Vendors

DBS; Polymath; Societe Generale — FORGE; Tokeny Solutions

Gartner Recommended Reading

In the Spotlight: How Financial Services Leaders Are Responding to the Collapse of FTX

Banking CIOs Must Prepare Now for the Programmability of Money and Data

3 Focal Points for Bank CIOs to Create Business Value From the Metaverse

Define and Map Cryptocurrencies, Digital Currencies and NFTs to Future-Proof Your Digital Transformation

Creating Business Value From Central Bank Digital Currencies

Appendixes

Hype Cycle Phases, Benefit Ratings and Maturity Levels

Table 2: Hype Cycle Phases

(Enlarged table in Appendix)

Phase ↓	Definition ↓
Innovation Trigger	A breakthrough, public demonstration, product launch or other event generates significant media and industry interest.
Peak of Inflated Expectations	During this phase of overenthusiasm and unrealistic projections, a flurry of well-publicized activity by technology leaders results in some successes, but more failures, as the innovation is pushed to its limits. The only enterprises making money are conference organizers and content publishers.
Trough of Disillusionment	Because the innovation does not live up to its overinflated expectations, it rapidly becomes unfashionable. Media interest wanes, except for a few cautionary tales.
Slope of Enlightenment	Focused experimentation and solid hard work by an increasingly diverse range of organizations lead to a true understanding of the innovation's applicability, risks and benefits. Commercial off-the-shelf methodologies and tools ease the development process.
Plateau of Productivity	The real-world benefits of the innovation are demonstrated and accepted. Tools and methodologies are increasingly stable as they enter their second and third generations. Growing numbers of organizations feel comfortable with the reduced level of risk; the rapid growth phase of adoption begins. Approximately 20% of the technology's target audience has adopted or is adopting the technology as it enters this phase.
Years to Mainstream Adoption	The time required for the innovation to reach the Plateau of Productivity.

Source: Gartner (July 2023)

Table 3: Benefit Ratings

Benefit Rating ↓	Definition ↓
Transformational	Enables new ways of doing business across industries that will result in major shifts in industry dynamics
High	Enables new ways of performing horizontal or vertical processes that will result in significantly increased revenue or cost savings for an enterprise
Moderate	Provides incremental improvements to established processes that will result in increased revenue or cost savings for an enterprise
Low	Slightly improves processes (for example, improved user experience) that will be difficult to translate into increased revenue or cost savings

Source: Gartner (July 2023)

Table 4: Maturity Levels

(Enlarged table in Appendix)

Maturity Levels ↓	Status ↓	Products/Vendors ↓
Embryonic	In labs	None
Emerging	Commercialization by vendors Pilots and deployments by industry leaders	First generation High price Much customization
Adolescent	Maturing technology capabilities and process understanding Uptake beyond early adopters	Second generation Less customization
Early mainstream	Proven technology Vendors, technology and adoption rapidly evolving	Third generation More out-of-box methodologies
Mature mainstream	Robust technology Not much evolution in vendors or technology	Several dominant vendors
Legacy	Not appropriate for new developments Cost of migration constrains replacement	Maintenance revenue focus
Obsolete	Rarely used	Used/resale market only

Source: Gartner (July 2023)

Recommended by the Authors

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Understanding Gartner's Hype Cycles

Tool: Create Your Own Hype Cycle With Gartner's Hype Cycle Builder

3 Focal Points for Bank CIOs to Create Business Value From the Metaverse

How Financial Services CIOs Can Prepare for Autoadapting Smart Products

Banking CIOs Must Prepare Now for the Programmability of Money and Data

Gartner

Table 1: Priority Matrix for Emerging Technologies in Banking, 2023

Benefit	Years to Mainstream Adoption			
↓	Less Than 2 Years ↓	2 - 5 Years ↓	5 - 10 Years ↓	More Than 10 Years ↓
Transformational		Blockchain Asset Tokenization Decentralized Identity Non-fungible Tokens Smart City Framework	Decentralized Finance Digital Twin of a Customer Homomorphic Encryption Intelligent Industrial Assets Programmable Money Responsible AI	AI-Driven Innovation Metaverse Quantum Computing
High	Data-Driven Innovation	AI Governance Chief Data Scientist Edge AI Hardware Identity Wallets Knowledge Graphs Postquantum Cryptography Synthetic Data	Adaptive ML Blockchain Explainable AI Panoptic Personalization	Banking Context: Machine Customers
Moderate				
Low				

Source: Gartner (July 2023)

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Gartner

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