Hype Cycle for Emerging Technologies, 2022

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Initiatives: Technology Innovation; CIO Leadership of Innovation, Disruptive Trends and Emerging Practices

Our 2022 Hype Cycle features emerging technologies that will greatly affect business and society over the next two to 10 years. These technologies help enterprise architecture and technology innovation leaders expand immersive experiences, accelerate AI automation and optimize technologist delivery.

Additional Perspectives

- Summary Translation: Hype Cycle for Emerging Technologies, 2022
  (26 August 2022)
- 先進テクノロジのハイプ・サイクル：2022年
  (18 November 2022)

Analysis

What You Need to Know

As a technology innovation leader, CTO or CIO, you must follow emerging technologies and applied frameworks to determine their impact on your industry and the opportunities they present for your organization. This year brings exciting opportunities to explore in your search for technology-enabled business transformation. If you're an early adopter, use this Hype Cycle as a starting point to:

- Analyze technologies with transformational potential for your business and technology capabilities.
- Explore the potential of these technologies for various use cases.
- Assess and exploit these technologies in line with your organization's ability to handle unproven technologies.

Your focus on scaling digital capabilities while improving sustainability in a multipolar world with expanding resource challenges means you must accelerate change and cut through the hype surrounding these technologies. The innovations highlighted in this research provide guidance on the business impact of emerging technologies and recommendations for how to use them to drive competitive differentiation and efficiency.

This year, the emerging technologies on our Hype Cycle fall into three themes:

- Evolving/expanding immersive experiences
- Accelerated AI automation
- Optimized technologist delivery

The Hype Cycle

The Hype Cycle for Emerging Technologies is unique among Gartner Hype Cycles because it distills insights from more than 2,000 technologies and applied frameworks that Gartner profiles each year into a succinct set of "must-know" emerging technologies. We used a variety of internal and external data sources to help select the technologies on this Hype Cycle for their potential transformational benefits and their broad impact across business and society.

All these technologies are at an early stage, but some are at an embryonic stage, and great uncertainty exists about how they will evolve. The embryonic technologies present greater risks for deployment, but potentially greater benefits for early adopters, which differentiates them from Gartner's top strategic technology trends.

This Hype Cycle tends to introduce technologies that haven't featured in previous iterations. Limited space means that we have had to retire most of the technologies highlighted in the 2021 version. The retired technologies remain important, and the majority are featured in other Hype Cycles (see the Off the Hype Cycle section).

Themes in Emerging Technologies

This year, our emerging technology coverage focuses on evolving/expanding immersive experience, accelerated AI automation and optimized technologist delivery.

Evolving/expanding immersive experiences: A collection of technologies that provide dynamic, virtual representations, environments and ecosystems of customers and people and new modes of user engagement. With these technologies, individuals can control their own identities and data, and experience virtual venues and ecosystems that can be integrated with digital currencies. The technologies also promote reaching customers in new ways to strengthen or open up new revenue streams.

To deliver evolving/expanding immersive experiences, examine the following technologies:

- Decentralized identity
- Digital humans
- Digital twin of the customer
- Internal talent marketplaces
- Metaverse
- Non-fungible token (NFT)
- Superapps
- Web3

Accelerated AI automation: Expanding adoption of AI as an integral part of products, services and solutions. This is accelerating the creation of specialized AI models and the application of AI to the development and training of AI models and their deployment to product, service and solution delivery. They also refocus the role of humans to consumers, assessors and overseers. Outcomes include more accurate predictions and decisions, and faster time to expected benefits.

To adopt accelerated AI automation, examine the following technologies:

- Autonomic systems
- Causal AI
- Foundation models
- Generative design AI
- Machine learning code generation

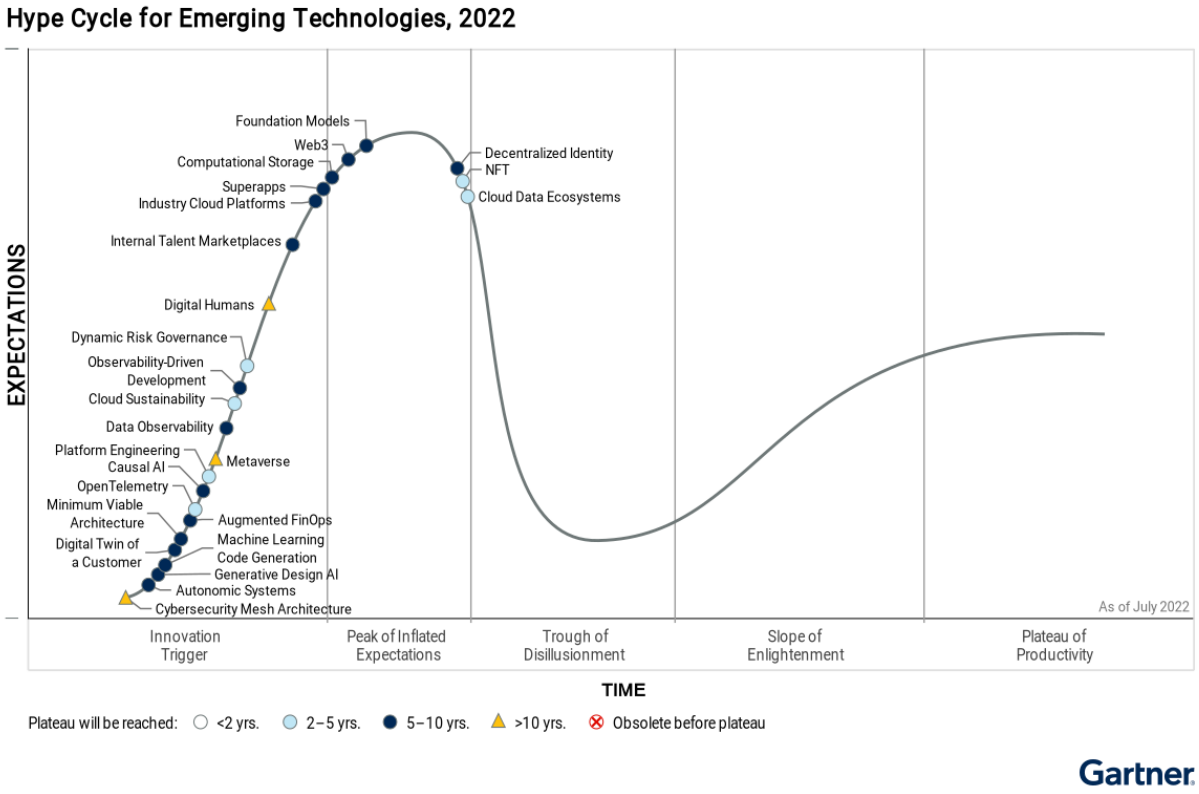
Optimized technologist delivery: Successful digital businesses are built, not bought, and this collection focuses on the product, service or solution builder communities (like fusion teams) and the platforms they use. These technologies provide feedback and insight that optimize and accelerate product, service and solution delivery and increase sustainability of business operations.

To optimize technologist delivery, explore the following critical technologies:

- Augmented FinOps
- Cloud data ecosystems
- Cloud sustainability
- Computational storage
- Cybersecurity mesh architecture
- Data observability
- Dynamic risk governance
- Industry cloud platforms

- Minimum viable architecture
- Observability-driven development
- OpenTelemetry
- Platform engineering

Figure 1. Hype Cycle for Emerging Technologies, 2022



Source: Gartner (July 2022)

The Priority Matrix

The Priority Matrix maps the benefit rating for each technology against the amount of time it requires to achieve mainstream adoption. The benefit rating provides an indicator of the potential of the technology, but the rating may not apply to all industries and organizations. You must identify which of the technologies offer significant potential benefits to your organization based on your use cases, then use this information to guide investment decisions.

Examine technologies that offer more significant, near-term benefits because they can offer both strategic and tactical benefits. Explore technologies with longer-term benefits if they offer strategic value. Track technologies that are important to your organization by creating a technology radar (see Toolkit: How to Build an Emerging Technology Radar). Alternatively, use our Hype Cycle Builder tool to create a customized Hype Cycle for your organization (see Create Your Own Hype Cycle With Gartner's Hype Cycle Builder).

Emerging technologies are disruptive by nature, but the competitive advantage they provide isn't yet well-known or proven. Most will take more than five years, and some more than 10 years, to reach the Plateau of Productivity. But some technologies on the Hype Cycle will mature in the near term, so you must understand the opportunities they present.

Most technologies have multiple use cases. To determine whether a technology will have a significant impact on your industry and organization, explore each use case. Prioritize those with the greatest potential benefit and prepare to launch a proof-of-concept project to demonstrate the feasibility of a technology for a specific use case. When a technology can perform in a particular use case with reasonable quality, examine the other obstacles to deployment to determine when to deploy. Obstacles may be related to technical feasibility, organizational readiness and external factors (see Assessing Emerging Technology Adoption Readiness).

Table 1: Priority Matrix for Emerging Technologies, 2022

(Enlarged table in Appendix)

Benefit	Years to Mainstream Adoption			
↓	Less Than 2 Years ↓	2 - 5 Years ↓	5 - 10 Years ↓	More Than 10 Years ↓
Transformational		Cloud Sustainability Dynamic Risk Governance NFT Platform Engineering	Augmented FinOps Autonomic Systems Decentralized Identity Digital Twin of a Customer Foundation Models Generative Design AI Industry Cloud Platforms Internal Talent Marketplaces Machine Learning Code Generation Minimum Viable Architecture Web3	Cybersecurity Mesh Architecture Metaverse
High		Cloud Data Ecosystems OpenTelemetry	Causal AI Computational Storage Data Observability Observability-Driven Development Superapps	Digital Humans
Moderate				
Low				

Source: Gartner (July 2022)

Off the Hype Cycle

The Hype Cycle for Emerging Technologies is not a typical Gartner Hype Cycle. It draws from an extremely broad spectrum of topics, and we intend it to be dynamic. It features many technologies for only a year or two, after which it doesn't track them to make room for other emerging technologies. Most technologies that we remove from this Hype Cycle continue to be tracked on other Hype Cycles. Refer to Gartner's broader collection of Hype Cycles for items of ongoing interest.

We've removed most of the technologies that appeared in the 2021 version of this Hype Cycle, including the following. Most are still tracked by Hype Cycles, but a few have been retired. The current profiles appear in the Hype Cycles referenced below:

- Active Metadata Management — Hype Cycle for Data & Analytics Programs and Practices, 2022; Hype Cycle for Data Management, 2022; Hype Cycle for Finance Data and Analytics Governance, 2022
- AI-Augmented Software Engineering — Hype Cycle for Open-Source Software, 2022
- Composable Applications — Hype Cycle for Cloud Computing, 2022; Hype Cycle for CRM Sales Technology, 2022; Hype Cycle for Enterprise Architecture, 2022; Hype Cycle for Manufacturing Digital Optimization and Modernization, 2022; Hype Cycle for Public Safety and Law Enforcement, 2022
- Composable Networks — Hype Cycle for Cloud Platform Services, 2022; Hype Cycle for CSP Networks Infrastructure, 2022
- Data Fabric — Hype Cycle for Data & Analytics Programs and Practices, 2022; Hype Cycle for Data Management, 2022; Hype Cycle for Public Safety and Law Enforcement, 2022
- Decentralized Finance — Hype Cycle for Digital Banking Transformation, 2022
- Digital Platform Conductor Tools — Hype Cycle for Agile and DevOps, 2022; Hype Cycle for I&O Automation, 2022; Hype Cycle for ITSM, 2022; Hype Cycle for Monitoring, Observability and Cloud Operations, 2022
- Generative AI — Hype Cycle for Artificial Intelligence, 2022; Hype Cycle for Digital Advertising, 2022; Hype Cycle for Digital Government Services, 2022
- Homomorphic Encryption — Hype Cycle for Data Security, 2022; Hype Cycle for Digital Banking Transformation, 2022; Hype Cycle for Privacy, 2022
- Influence Engineering — Hype Cycle for Customer Experience Analytics, 2022; Hype Cycle for Digital Advertising, 2022; Hype Cycle for Digital Government Services; Hype Cycle for Digital Marketing, 2022; Hype Cycle for Privacy, 2022
- Machine-Readable Legislation — No longer tracked.
- Multiexperience — Hype Cycle for Customer Service and Support Technologies, 2022; Hype Cycle for Digital Government Services, 2022; Hype Cycle for ITSM, 2022; Hype Cycle for User Experience, 2022

- Named Data Networking — No longer tracked.
- Physics-Informed AI — Hype Cycle for Artificial Intelligence, 2022; Hype Cycle for Oil and Gas, 2022
- Quantum ML — Hype Cycle for Data Science and Machine Learning, 2022
- Real-Time Incident Center as a Service — Hype Cycle for Digital Government Services; Hype Cycle for Public Safety and Law Enforcement, 2022
- Self-Integrating Applications — Hype Cycle for Application Architecture and Integration, 2022; Hype Cycle for CRM Sales Technology, 2022; Hype Cycle for Higher Education, 2022; Hype Cycle for K-12 Education, 2022
- Sovereign Cloud — Hype Cycle for Cloud Computing, 2022; Hype Cycle for Cloud Platform Services, 2022; Hype Cycle for Privacy, 2022

The “AI-Augmented Design” profile from the 2021 Hype Cycle has been renamed “Generative Design AI.”

On the Rise

Cybersecurity Mesh Architecture

Analysis By: Pete Shoard, Patrick Hevesi

Benefit Rating: Transformational

Market Penetration: Less than 1% of target audience

Maturity: Embryonic

Definition:

Cybersecurity mesh architecture (CSMA) is an emerging approach for architecting composable, distributed security controls that improve overall security effectiveness. It offers an approach to enabling secure, centralized security operations and oversight that emphasizes composable, independent security monitoring, analytics and enforcement, centralized intelligence and governance, and a common identity fabric.

Why This Is Important

CSMA addresses the growing complexity of managing security tools, intelligence and identity solutions. Selecting and deploying security tools in the traditional manner is no longer sufficient. Use cases, attacks and security tools are emerging, evolving and retiring far more quickly. Organizations must begin evolving toward a radically more flexible security architecture.

Business Impact

CSMA introduces a potential solution to problems currently suffered by defense-in-depth security architectures that most organizations employ. These are often made up of multiple point solutions that are poorly interconnected. The alignment and integration challenges that CSMA addresses include; centralized policy management and threat databases, a coordinated approach to detection methodology, threat correlation and response, and an increase in the efficiency of cross-tool collaboration.

Drivers

- IT security organizations can be overwhelmed when trying to stay ahead of new and more complex attacks, and when deploying the latest security tools to ever-expanding infrastructure. Teams are not able to implement the required amount of autonomy or be predictive and dynamic regarding their security enforcement and response decisions. Furthermore, these decisions, when they are made effectively, are rarely fast enough to meet business needs.
- Effective security and identity management requires a layered and collaborative approach, but today's solutions are instead siloes that operate with insufficient knowledge of other tools and leave gaps. These silos are time-consuming to operate and monitor. Organizations understand and acknowledge the skills gaps and challenges in volumes of work, but do not have clear solutions to deal with these issues.
- Organizations are frustrated by the lack of integration and consistent visibility on their current security situation. Security and risk management leaders require an architecture that not only reacts to the current security issues (those that are visible in the organization), but provides a coordinated and holistic approach to complex security problems. Creating a collaborative ecosystem of security tools will address inconsistency and help understand and minimize the exposure that is consistent with business expectations. Addressing inconsistency is a key driver, but understanding impact and likelihood alongside vulnerability creates an understanding of exposure that is crucial in making probusiness security decisions.

Obstacles

- As vendors start to add CSMA approaches to their products, vendor lock-in will likely be a concern. If a proprietary CSMA approach is employed, and it serves to block rather than facilitate cross-tool integration, then gaps in coverage will likely appear and this inflexibility will drive up cost.
- Those organizations with the budget and drive to create their own CSMA construct will likely need significant engineering effort to integrate disparate products. Custom solutions may suffer if the security industry moves toward a set of standards for interoperability after significant custom integration work has been completed.
- CSMA is a forward-looking approach that enables security tools to more effectively operate as an intelligent system of systems: it does not yet formally exist as a defined architecture, and there is only strategic best practice guidance available.
- Currently there are no vendors that offer a complete CSMA solution.

User Recommendations

- Position your organization for a future of rapid change by making a strategic shift in the way you buy and deploy security tools to align with CSMA principles. Even if a tool functions well today, if it doesn't follow CSMA principles, it will not be flexible enough to meet future needs.
- Mature your security infrastructure by selecting point product vendors that have fully developed and advanced APIs, complete adherence to modern security standards, and integrations into security partner networks.
- Evolve your identity infrastructure to an identity fabric by removing silos to achieve dynamic real-time identity capabilities that incorporate a more complete set of context and risk signals (such as device proximity, posture, biometrics and location).
- Improve your responsiveness by centralizing your policy, posture and playbook management along with building an integrated "single pane of glass" view into your CSMA.

Gartner Recommended Reading

The Future of Security Architecture: Cybersecurity Mesh Architecture (CSMA)

Top Strategic Technology Trends for 2022

Top Trends in Cybersecurity 2022

Autonomic Systems

Analysis By: Erick Brethenoux, Nick Jones, David Cearley

Benefit Rating: Transformational

Market Penetration: Less than 1% of target audience

Maturity: Embryonic

Definition:

Autonomic systems are self-managing physical or software systems, performing domain-bounded tasks, that exhibit three fundamental characteristics: autonomy (execute their own decisions and tasks autonomously without external assistance); learning (modify their behavior and internal operations based on experience, changing conditions or goals); agency (have a sense of their own internal state and purpose which guides how and what they learn and enables them to act independently).

Why This Is Important

Autonomic systems are emerging as an important trend as they enable levels of business adaptability, flexibility and agility that can't be achieved with traditional AI techniques alone. Their flexibility is valuable in situations where the operating environment is unknown or unpredictable and real-time monitoring and control aren't practical. Their learning ability is valuable in situations where a task can be learned even though there is no well-understood algorithm to implement it.

Business Impact

Autonomic systems excel where:

- Conventional automation applying composite AI techniques is inadequate, or using fixed training data is impractical or not agile.
- It is impractical to provide real-time human guidance, or training conditions can't be anticipated.
- We cannot program the exact algorithm, but the task is learnable.
- Continuously or rapidly changing tasks or environments make frequent retraining and testing of ML systems too slow or costly.

Drivers

Autonomic systems are the culmination of a three-part trend:

- Automated systems are a very mature concept. They perform well-defined tasks and have fixed deterministic behavior (e.g., an assembly robot welding cars).

- Autonomous systems go beyond simple automation to add independent behavior. They may exhibit some degree of adaptive behavior, but are predominantly under algorithmic control (e.g., self-driving cars or a Boston Dynamics' Spot Robot 1 that has its overall route and goals set by a remote human operator but has substantial local autonomy over how it achieves them).
- Autonomic systems exhibit adaptive behavior through learning and self-modifying algorithms (e.g., Ericsson has demonstrated the use of reinforcement learning and digital twins to create an autonomic system that dynamically optimizes 5G network performance. It learns from network behavior and local conditions and adjusts software and physical network control parameters to optimize performance).

Autonomic behavior is a spectrum. Today, many systems exhibit learning. For example, chatbots learn from internet discussions, streaming services learn which content you like, and delivery robots share information about paths and obstructions to optimize the fleet's routing.

However, in the longer term, the advantages of systems that can learn and adapt their behavior will be compelling, and many examples will involve physical devices. Substantial academic research is underway on autonomics, which will result in more widespread use.

Obstacles

- Nondeterminism: Systems that continuously learn and adapt their behavior aren't predictable. This will pose challenges for employees and customers who may not understand how and why a system performed as it did.
- Immaturity: Skills in the area will be lacking until autonomics becomes more mainstream. New types of professional services may be required.
- Social concerns: Misbehavior, nondeterminism or lack of understanding could generate public resistance when systems interact with people.
- Digital ethics and safety: Autonomic systems will require architectures and guardrails to prevent them from learning undesirable, dangerous, unethical or even illegal behavior when no human is validating the system.
- Legal liability: It may be difficult for the supplier of an autonomic system to take total responsibility for its behavior because that will depend on the goals it has set, its operating conditions and what it learned.

User Recommendations

IT leaders responsible for technology innovation must:

- Pilot autonomic technologies in cases where early adoption will deliver agility and performance benefits in software or physical systems.
- Create a multidisciplinary task force to prepare for the business, legal, social and ethical consequences of deploying partially nondeterministic systems.
- Optimize the benefits of autonomic technologies by piloting them in situations, such as complex and rapidly changing environments where early adoption will deliver agility and performance benefits in either software or physical systems.
- Manage risk in autonomic system deployments by analyzing the business, legal and ethical consequences of deploying autonomic systems — which are partially nondeterministic. Do so by creating a multidisciplinary task force.
- Start by building experience with autonomous systems first to understand the constraints and requirements (legal, technical and cultural) that the organization is subjected to.

Sample Vendors

GrammaTech; IBM

Gartner Recommended Reading

Top Strategic Technology Trends for 2022: Autonomic Systems

Generative Design AI

Analysis By: Brent Stewart, Frank O'Connor

Benefit Rating: Transformational

Market Penetration: Less than 1% of target audience

Maturity: Embryonic

Definition:

Generative design AI, or AI-augmented design, is the use of artificial intelligence (AI), machine learning (ML) and natural language processing (NLP) technologies to automatically generate and develop user flows, screen designs, content and presentation-layer code for digital products.

Why This Is Important

Generative design AI is in its infancy. Soon, we expect to see generative design AI at work in several product markets, including user experience (UX) design tools, low-code/no-code and citizen design tools. This will lead to major leaps in efficiency, quality and time to market. Generative design AI will appear first as feature-level support (e.g., intelligent design recommendations) and will rapidly transition to a full digital product design and development capabilities.

Business Impact

In a future powered by generative design AI, sites, apps and software will be generated in minutes or days, rather than weeks or months. The resulting designs will be based on proven design principles that ensure maximum usability and accessibility. In this future, UX teams will become more strategic and directional, with the remaining practitioners focused on research, strategy and design curation, rather than detailed design production.

Drivers

To understand the drivers for generative design AI, consider this hypothetical scenario for creating an online store:

- Tell the AI that you want an online store; the AI automatically generates the standard structural elements of an online store from the homepage to product detail templates to the shopping cart.
- Provide the app your brand identity or style guide, giving the AI inputs on color, typography, iconography, photographic style, writing style, etc.
- Provide some inspiration to the AI by indicating a set of stores you'd like to emulate.
- Hit submit and, within minutes, the AI produces three high-fidelity design directions which you can evaluate and iterate.

Furthermore, every design element will have an associated code component that is updated as you tweak or curate the final design.

The promise of operational efficiency and “democratization” of UX design contribute to the business case driving generative design AI. Key drivers in this category include:

- **Product delivery** — Generative design AI promises to accelerate digital product delivery more than any technology in recent history.
- **Accessibility** — Generative design AI design and code deliverables will account for assistive technologies and deliver the most accessible screen designs and code possible. This will drastically improve the digital lives of people with disabilities.
- **Democratization** — More and more nonprofessional (citizen) designers and researchers are engaging in UX tasks and must be able to produce high-quality experiences without deep design training or education.
- **User interface (UI) design standardization** — The overwhelming majority of digital products are based on established product types and UI design patterns. In general, the standardization of common digital experiences continues to expand.

Generative design AI will quickly apply three key technologies to common UX tasks, as they expand:

- Visual AI (computer vision)
- ML
- NLP

Obstacles

The growth and velocity of generative design AI may be inhibited by four key factors:

- **Cost** — Generative design AI is a heavy lift that requires deep talent, long timeframes and deep pockets.
- **Jobs** — Generative design AI will drastically reduce low-level UX production tasks, reducing the need for production designers, presentation layer developers and UX writers. These team members will need to retool and “move left” to become UX design strategists/researchers who can guide and tweak the output of design bots.
- **Originality** — Since generative design AI pulls from established product types and design patterns, it will not be notable for its originality. Many UX practitioners are concerned that user experiences will become too uniform and lack originality.

- **Ethics** — AI algorithms and associated training datasets may contain inherent gender and cultural bias.

User Recommendations

- Assess developments in generative design AI, specifically at Adobe, followed by Figma and leaders from the low-code/no-code market.
- Prepare digital product teams for the emergence of generative design AI, first through design-to-code technology, followed by bots that produce high-fidelity screen designs and written content.
- Transition the role of humans in the design process from production-level creators to strategic curators.

Sample Vendors

Adobe; Autodesk; Builder.ai; Designs.ai; Figma; nTopology; TeleportHQ

Gartner Recommended Reading

Top Strategic Technology Trends for 2022: Generative AI

Predicts 2022: Generative AI Is Poised to Revolutionize Digital Product Development

Emerging Technologies: Critical Insights Into AI-Augmented Software Development

Top Strategic Technology Trends for 2022: AI Engineering

Predicts 2022: Artificial Intelligence Core Technologies

Machine Learning Code Generation

Analysis By: Van Baker

Benefit Rating: Transformational

Market Penetration: Less than 1% of target audience

Maturity: Embryonic

Definition:

Machine learning code generation tools include cloud hosted machine learning models that plug into professional developer IDEs. The IDE extensions provide suggested code based on either natural language descriptions or partial code fragments. They are typically incorporated in cloud based developer environments and are built from large language models using customized curated datasets optimized for code generation.

Why This Is Important

Application code created by machine learning models can improve the productivity of developers by providing suggested code. These plug into existing IDEs allowing developers to use these models without having to change their existing development environments. Developers can type a portion of code or, in some cases, a natural language description of the functionality and suggested lines of code are generated automatically for the developer to review and adapt if required.

Business Impact

All businesses have applications that are built or customized to run the business or engage customers. ML code generation will make development teams more productive allowing them to code and deliver components of applications much more rapidly. As the technology improves, and developers get comfortable with the tools, this should improve the overall quality of the code in applications. ML-generated code will not replace talented developers, but will allow them to create more applications.

Drivers

- The reality that “every business is a software business” continues to prove true as companies must become digital if they are to survive.
- In business, almost everything is software-defined with code automating everything from your web app logic to your deployments, policy-based governance, cloud infrastructure automation, cybersecurity and more.
- The number of applications and digital products that businesses need to function continues to increase, putting more pressure on software engineering organizations to create or revamp business applications.
- Backlogs for needed software continue to grow, while talented developers are becoming harder to hire and retain.
- ML- generated code is, in some current cases, already producing 30% to 40% of needed code and this is expected to grow to 50% or more by 2026.
- The accuracy and code quality of ML-generated code is expected to continue to improve rapidly.
- New entrants to the ML code generation tool market are expected to emerge quickly.

Obstacles

- Developers are reluctant to trust (and therefore use) machine-generated code.
- As with human-generated code, ML-generated code can have mistakes and security flaws.
- Current solutions are cloud based due to the use of large models, and this will likely remain true for the foreseeable future.
- Current solutions are limited to pro code tools and will not likely be extended to low-code platforms in the near term.
- Current offerings have limited availability at this time but this will change quickly.
- There are many misconceptions about the level of autonomy and the scale of code generation circulating at this time, causing confusion in the market.
- Natural-language-to-code conversions are somewhat limited in their execution.

User Recommendations

Software engineering leaders should:

- Make sure development teams experiment with these tools to understand how they support them and fit into their workflows as soon as they are readily available.
- Correct misconceptions within the organization regarding how these tools impact development teams and how to plan for their deployment within development teams.
- Ensure that development team expectations are appropriate and that these tools are not dismissed or overstated.
- Assume that all the multiple cloud providers and multiple AI/ML companies will offer tooling similar to this within a short period of time.
- Expect rapid improvement in the performance and quality of ML code generation.
- Enterprises will find that adopting cloud-hosted development platforms will enhance use of these tools, though they can be used with on-site environments as well in some cases.

Sample Vendors

Amazon Web Services; Microsoft; Open AI

Gartner Recommended Reading

Predicts 2022: Generative AI Is Poised to Revolutionize Digital Product Development

Digital Twin of a Customer

Analysis By: Melissa Hilbert, Michelle DeClue-Duerst

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 representation of a customer that simulates and learns to emulate and anticipate behavior. Customers can be individuals, 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 a period of upheaval.

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

Just as digital twins of a product enable organizations to anticipate how a physical product will perform or will need to be maintained in different conditions, organizations can 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:

- Gain critical insights into customers.
- Increase revenue by enabling new ways to serve or capture customers, as well as by facilitating new data-driven business models.
- Predict and simulate behaviors with a view to making products, services, promotions and business campaigns more successful and reducing unnecessary costs of failure.
- Improve customer engagement, customer retention, customer lifetime value and company growth.
- Reduce churn, product failure and engagement abandonment.

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 likely some staff with data science skills to build or manage DToCs.
- The technology behind digital twins has focused on organizations and products. A customer focus is only just emerging, and the lack of clear KPIs and other measures of success limits the potential use of DToCs.
- As customers may be wary, and tired, of having data about them collected, organizations need to establish trust. If customers are to agree to share information with organizations via DToC programs, they will want transparency about what data will be collected, how it will be used, and what privacy and data controls will apply. Importantly, they will also want to know how participation will benefit them by providing, for example, a more personalized experience, more relevant products and services, convenience and exclusive offers.

User Recommendations

- Align your activities with customers' privacy and cybersecurity concerns, based on the availability of customer assets. Avoid appearing creepy.
- 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.
- Whether you choose to build or buy a DToC, start by running a pilot and comparing results with and without a DToC over a statistically significant period using statistically significant data.
- Define the benefits to customers and establish trust by explaining why they would want a digital twin, and how they can use one to improve their experience of your products and services. Also explain how and to what extent they can control attribution and data usage, or cancel their digital twin altogether. This will provide clear visibility to customers, not just internal guidance.
- Establish a trust center to house privacy and security documentation, as well as documented expectations.

Sample Vendors

Absolutdata; Arrayworks; Fetch.ai; Salesforce; TCS

Gartner Recommended Reading

Gartner Business Quarterly — 2Q22

Survey Analysis: Digital Twin Expansion Plans Signal New Software Skills Investments Are Required

Use 4 Building Blocks for Successful Digital Twin Design

Toolkit: 5 Digital Twin/IoT Project Success Drivers

21 Lessons From Successful Digital Twin Implementations for Manufacturing

Minimum Viable Architecture

Analysis By: Akshay Jhawar, Andrew Gianni

Benefit Rating: Transformational

Market Penetration: 1% to 5% of target audience

Maturity: Embryonic

Definition:

Minimum viable architecture (MVA) is a standardized framework used by product teams to ensure the timely and compliant development, and iteration, of products. It refers to the set of minimal architecture deliverables needed to support business outcomes that serves as a compliance baseline against which agile delivery teams develop products. It is not fixed, and evolves with the changing needs of stakeholders and their learning through iterative product development.

Why This Is Important

In recent Gartner surveys, 84% of senior business leaders and IT leaders accepted having fusion teams (see Fusion Teams: A New Model for Digital Delivery), and 41% of employees in the enterprise were found to be business technologists (see Top 2022 Tech Provider Trend: Composable Business). Democratization is increasing with decision making distributed across fusion teams. To avoid silos, there is a need for shared architecture that allows different parts of the enterprise to collaborate.

Business Impact

MVA business impacts include:

- MVA helps organizations balance autonomy and alignment with shared architecture that is composable, consistent and reusable.
- Minimum viable is an adoption threshold aligned to customer priorities to make it worth their while. Therefore, MVA helps improve customer-centricity and, in turn, accelerates the delivery of targeted business outcomes.
- Co-creating the MVA brings a variety of stakeholders close together in fusion teams, helping build a more collaborative organizational culture.

Drivers

- The hype around MVA is increasing steadily, fueled by the complexity of decision making and coordination in democratized organizations. Gartner client interactions related to “minimum viable” increased by 5.1% in the number of client interactions between April 2021 and 2022 versus the prior 12 months.
- MVA succeeds where traditional, heavy-handed EA processes and guidance fail to support the swift decisions needed to deliver speed to value through iterative methods such as design thinking and agile.
- EA, often perceived as a bureaucratic and an unnecessary impediment, increasingly faces resistance from product teams. Developing an MVA requires close collaboration with product delivery teams and product lines through stronger relationships with product management.
- The pandemic has only accelerated the shift from traditional to digital organizations, focusing on innovation and adaptability. MVA, which is not fixed and can be augmented with evolving stakeholder needs, is well-suited to help organizations transform quickly and support experimental innovation methods.
- The pressing need for enterprise alignment, business agility and responsiveness are fueling the adoption of MVA.

Obstacles

- Misperceptions that EA is not required with agile methodologies are only strengthened with EA practitioners often enforcing design choice, outweighing local and emergent choice.
- Traditional architect roles either have an enterprisewide scope and strategic focus or a local scope and implementation focus. To create an MVA with such a balance, a hybridized product architect role must be embedded in product lines.
- Aligning silos of products requires communications and networking skills, rarely found in architects, to build trust and maintain relationships with stakeholders such as product owners, debt lead and innovation leads.
- MVA needs to be developed collaboratively via forums such as a community of practice (CoP). Yet, such forums often do not mandate participation. Motivating members to participate voluntarily often requires culture hacking.
- Misunderstanding MVA as equivalent to all facets of EA is an obstacle to EA success. All facets of EA contextually guide the development of MVA.

User Recommendations

- Develop and update the enterprise's minimum viable architecture collaboratively by working with product owners and through a CoP and by giving representative members of product teams voting rights and opportunities to share their challenges and feedback.
- Ensure the MVA eliminates technical debt, is scalable, conforms to enterprise standards, patterns and designs, and is reusable. Deliverables include but are not limited to reference architecture components, standards, principles and product line design patterns.
- Help the enterprise find the right mix between enterprise risk and agility. Step up and communicate key EA positions to business and IT leaders to get buy-in, and mandate for the MVA.

Gartner Recommended Reading

Quick Answer: What Is Meant by Minimum Viable?

Adaptive EA Governance: 4 Styles That Enable Digital Delivery

Predicts 2022: Enterprise Architecture Enables the Evolution of Democratized Digital Organizations

Quick Answer: How Must EA Governance and Assurance Change to Support Product Management?

Quick Answer: How Can We Position the Architecture Review Board for Success?

Augmented FinOps

Analysis By: Adam Ronthal, Dennis Smith

Benefit Rating: Transformational

Market Penetration: Less than 1% of target audience

Maturity: Embryonic

Definition:

FinOps applies the traditional DevOps concepts of agility, continuous integration and deployment, and end-user feedback to financial governance, budgeting and cost optimization efforts. Augmented FinOps automates this process through the application of artificial intelligence (AI) and machine learning (ML) practices — predominantly in the cloud — enabling environments that automatically optimize cost based on defined business objectives.

Why This Is Important

As more workloads move to the cloud, the cost of individual workloads is exposed with greater transparency than ever before. In the cloud, it is now possible to assess the cost of a specific workload or collection of workloads assigned to a project. However, the complexity and diversity of choice in underlying cloud infrastructure and service offerings makes it difficult to achieve optimal price performance outcomes. Augmented FinOps can automate this process by applying AI/ML techniques.

Business Impact

The automation of cloud budget planning and financial operations will allow businesses to express their objectives — ideally in natural language — and allow their cloud ecosystem to automatically optimize the underlying cloud resources to meet those objectives. This will result in more efficient use of resources, and therefore, optimal spend by reducing/eliminating misaligned or poor use of cloud infrastructure and service offerings.

Drivers

- Increased realization on the part of practitioners that cloud is fundamentally a complex cost optimization exercise.
- Need to reduce the unpredictability of cloud spending when using cloud infrastructure and services for analytics, operational database management systems (DBMSs), data lakes and other applications.
- While commit-based usage mitigates some unpredictability, consumption-based usage remains common in earlier stages of cloud adoption, driving the need for augmented FinOps.
- Cloud adoption often results in decentralization of the IT function to the consuming lines of business, wherein cost overruns are often downplayed/dismissed by highlighting improved productivity and agility.
- Automation of financial governance controls in cloud environments provides increased predictability and cost optimization, with less operational effort.
- Solid financial governance frameworks are positioning organizations to take advantage of FinOps.
- Owing to their complexity, cloud environments are ideally suited for the application of ML and AI methods to automate processes and track price and performance.

Obstacles

- Cloud service provider pricing models remain needlessly complex and diverse.
- Cloud ecosystems are (and will remain) open to third-party participants, which implies multiple commercial arrangements with multiple providers.

User Recommendations

IT leaders looking to optimize their cloud spend should:

- Seek out service offerings to automate (via AI/ML) performance, consumption and pricing options. Increasingly, incorporate these capabilities into cloud data ecosystems that will learn from consumption patterns as they seek to optimize the underlying resources, and by extension, cloud spending.

- Explore the use of augmented FinOps services for targeted and scoped use cases to establish the capability and actionability of the provider's product. An initial use case of machine instance type or DBMS service offerings will allow for a controlled evaluation and validation of the approach and capabilities available.

Sample Vendors

Anodot; Cloudwiry; Enteros; Oracle; OtterTune; Sync Computing; Unravel Data

Gartner Recommended Reading

CDOs and CFOs Must Join Forces in the Cloud to Connect Business Value With Cost

Predicts 2022: Data and Analytics Leaders Must Expand Value While Managing Cost and Risk

Cool Vendors in Augmented Data Management

How to Identify Solutions for Managing Costs in Public Cloud IaaS

Solution Criteria for Public Cloud Third-Party Cost Optimization Tools

OpenTelemetry

Analysis By: Gregg Siegfried, Dustin Hassemer, Pankaj Prasad

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Early mainstream

Definition:

OpenTelemetry is a collection of specifications, tools, APIs and SDKs that describe and support the implementation of an open-source instrumentation and observability framework for software. The initiative, curated by the Cloud Native Computing Foundation (CNCF), defines three flavors of telemetry — distributed traces, metrics and logs. The specification for the distributed tracing component reached v.1 in February 2021. The specifications for metrics and logs are in process as of this writing.

Why This Is Important

OpenTelemetry introduces a portable way to instrument, generate, collect and export telemetry data about application health and performance. It has changed the way application performance monitoring (APM) solutions are assessed, deployed and used. Even in its nascent state, OpenTelemetry has garnered widespread support and adoption. Many APM vendors, public cloud providers and observability tools have released or announced support for OpenTelemetry.

Business Impact

OpenTelemetry promises to:

- Enable deeper visibility into application health and performance, even across application and service provider boundaries.
- Facilitate the use of multiple vendors or the migration between vendors.
- Benefit product owners, SREs and platform operators by allowing them to “instrument once, analyze anywhere.”
- Standardize encoding, transport, and delivery of telemetry between sources and targets, thus improving reliability and scalability as more vendors become OTLP compliant.

Drivers

- **Uniformity of instrumentation:** Traces provide a rich, sequenced perspective to request handling in distributed software, but are not always enough to fully identify and resolve anomalies. By including support for correlating metrics and logs with traces, OpenTelemetry incorporates a more complete dataset for application observability use cases.
- **Software architecture:** Microservices, containers and functions are powerful constructs that serve as the basis for modern applications. Loose coupling facilitates the build, test and release of independent components.
- **Cost of APM solutions:** Many organizations cannot afford to monitor all of their applications with commercial APM offerings and either reduce the monitoring footprint or leverage a low-cost, secondary APM tool. OpenTelemetry facilitates the latter by allowing the same telemetry to be flexibly routed to different solutions.
- **Site reliability engineering:** In many organizations, SREs are responsible for health and performance management and are the most likely to demand insights from OpenTelemetry. Interest in building an SRE role is on the rise.

Obstacles

- **Maturity:** OpenTelemetry is evolving rapidly, but is only now beginning to be used widely in the field. There may be a cost in time and effort associated with adopting it now that will diminish over time.
- **Lack of autoinstrumentation:** Gaining maximum value from OpenTelemetry requires developers to instrument applications themselves, and most autoinstrumentation mechanisms currently require code changes to enable them.
- **Roadmap:** While the tracing specification is completely stable, OpenTelemetry logging and metrics as of this writing are under active development. These specifications often stabilize earlier, but full implementation of all flavors will be spotty through development.

User Recommendations

- Prefer vendors that are committed to OpenTelemetry when selecting monitoring solutions.
- Embrace OpenTelemetry for distributed tracing today when building trace instrumentation into your custom application software.
- Instrument your cloud-native applications using OpenTelemetry SDKs as they are available for your languages and frameworks.
- Augment existing APM solutions with OpenTelemetry for hybrid workloads.

Sample Vendors

Amazon Web Services; Cisco (AppDynamics); Datadog; Dynatrace; Honeycomb; Lightstep; New Relic; Splunk

Gartner Recommended Reading

Assessing OpenTelemetry's Impact on Application Performance Monitoring

Monitoring and Observability for Modern Infrastructure and Applications

Solution Path for Modern Infrastructure and Application Monitoring

Magic Quadrant for Application Performance Monitoring

Critical Capabilities for Application Performance Monitoring

Causal AI

Analysis By: Pieter den Hamer, Leinar Ramos, Ben Yan

Benefit Rating: High

Market Penetration: Less than 1% of target audience

Maturity: Emerging

Definition:

Causal artificial intelligence (AI) identifies and utilizes cause-and-effect relationships to go beyond correlation-based predictive models and toward AI systems that can prescribe actions more effectively and act more autonomously. It includes different techniques, like causal graphs and simulation, that help uncover causal relationships to improve decision making.

Why This Is Important

AI's ultimate value comes from helping us take better actions. Machine learning (ML) makes predictions based on statistical relationships (correlations), regardless of whether these are causal. This approach is fine for prediction, but predicting an outcome is not the same as understanding what causes it and how to improve it. Causal AI is crucial when we need to be more prescriptive to determine the best actions to influence specific outcomes. Causal AI techniques help make AI more autonomous, explainable, robust and efficient.

Business Impact

Causal AI leads to:

- Greater decision augmentation and autonomy in AI systems by estimating the intervention effects
- Greater efficiency by adding domain-knowledge to bootstrap causal AI models with smaller datasets
- Better explainability by capturing easy-to-interpret cause-and-effect relationships
- More robustness and adaptabilty by leveraging causal relationships that remain valid in changing environments
- Ability to extract causal knowledge with less costly and time-consuming experiments
- Reduced bias in AI systems by making causal links more explicit

Drivers

- **Ongoing shift from predictive analytics (What is likely to happen?) toward more prescriptive analytics (What should be done?)**. Making accurate predictions will remain key, but a causal understanding of how to affect predicted outcomes will be increasingly important.
- **AI systems increasingly need to act autonomously to generate business value,** particularly for time-sensitive and complex use cases where human intervention is not feasible. This will only be possible by AI understanding the effect of actions and how to make effective interventions.
- **Limited availability of data for certain use cases is pushing organizations toward more data-efficient techniques like causal AI**, which leverages human domain knowledge of cause-and-effect relationships to bootstrap AI models in small data situations.
- **The growing complexity of use cases and environments where AI is applied requires more robust AI techniques.** Causal structure changes much more slowly than statistical correlations, which makes causal AI more robust and adaptable in fast-changing environments. The volatility in the last few years has exposed the brittleness of correlation-based AI models across industries which struggled to adapt since they had been trained under a very different context.
- **The need for greater trust and explainability of AI models is increasing the interest of models that are more intuitive to humans**. Causal AI techniques, like causal graphs, allow us to be explicit about causes and explain models in terms that humans understand.

Obstacles

- **Causality is not trivial.** Not every phenomenon is easy to model in terms of its causes and effects. Causality might be unknown, regardless of AI use.
- **The quality of the causal AI models depends on its causal assumptions and on the data that is used to build them**, which are susceptible to bias and imbalance. Just because a model is causal doesn't mean that it will outperform correlation-based ones.
- **Causal AI requires technical and domain expertise** to set up for properly estimating causal effects. This is often a more difficult exercise than building correlation-based predictive models, and requires active collaboration between domain experts and AI experts.
- **AI experts might be unaware of causality methods** and be overly reliant on data-driven models like ML, which could result in pushback when looking to implement causal AI
- **A nascent vendor landscape and current low enterprise adoption could represent a challenge** when running initial causal AI pilots and identifying specific use cases where causal AI is most relevant.

User Recommendations

- Acknowledge the limitations that come from the prevalent approach to correlation-based AI and ML, which focuses on leveraging correlations and mostly ignores causality.
- Use causal AI when you need more augmentation and automation in decision intelligence, when AI is needed not only to generate predictions but to understand how to affect the predicted outcomes. Examples include customer retention programs, marketing campaign allocation and financial portfolio optimization.
- Select different causal AI techniques depending on the complexity of the specific use case. These include causal rules, causal graphs and Bayesian networks, simulation and the use of machine learning for causal learning.
- Conduct studies on where causal AI can provide distinct advantage over classical correlational AI by prioritizing the highest impact ones.
- Educate your data science teams on causal AI, how it differs from correlation-based AI, and the range of techniques available to incorporate causality.

Sample Vendors

Agena; AgileThought; Bayesia; causaLens; Causality Link; Causaly; IBM; Lucid.AI; Scalnyx; Xplore.ai

Gartner Recommended Reading

Innovation Insight for Causal AI

Innovation Insight for Composite AI

Innovation Insight for Decision Intelligence

Top Strategic Technology Trends for 2022: Autonomic Systems

Top Trends in Data and Analytics for 2021: From Big to Small and Wide Data

Platform Engineering

Analysis By: Bill Blosen, Paul Delory

Benefit Rating: Transformational

Market Penetration: 20% to 50% of target audience

Maturity: Emerging

Definition:

Platform engineering is the discipline of building and operating self-service internal developer platforms (IDPs) for software delivery and life cycle management. Each platform is a layer, created and maintained by a dedicated product team, designed to support the needs of software developers by interfacing with tools and processes. The goal of platform engineering is to optimize the developer experience and accelerate product teams' delivery of customer value.

Why This Is Important

Given the need for digital enterprises to respond quickly to customer needs with complex distributed systems, software product teams are struggling to focus on feature building, as platform-related tasks consume a substantial amount of attention and time. Platform engineering empowers these teams by providing a self-service, curated set of tools, capabilities and processes aligned with enterprise architecture to provide an improved developer experience and accelerate value delivery.

Business Impact

Platform engineering empowers application teams to deliver software value faster. It removes the burden of underlying infrastructure construction and maintenance, and increases teams' capacity to dedicate time to customer value and learning. Using IDPs makes compliance and controls more consistent and simplifies the chaotic explosion of tools used to deliver software. Platform engineering also improves the developer experience, thus reducing employee frustration and attrition.

Drivers

- **Emerging platform construction tools:** Many organizations have built their own IDPs, but to date these platforms have been homegrown, individual efforts tailored to the unique circumstances of the organizations that build them. Platforms generally have not been transferable to other companies, or sometimes even to other teams within the same company. However, a new generation of platform-building tools is intended to change that.
- **Complexity:** Adoption of modern, distributed architectural patterns and software delivery practices means that the process of getting software into production involves more tools, subsystems and moving parts than ever before. This places a burden on product teams to build a delivery system in addition to the actual software they are trying to produce.
- **Need for increased speed and agility:** The speed and agility of software delivery is a critical metric that CIOs care about. As a result, IT organizations are pursuing tighter coupling of infrastructure and operations (I&O) and development teams to drive shorter development cycles, faster delivery and increased deployment frequency. This will enable organizations to respond immediately to market changes, handle workload failures better, and tap into new market opportunities. Platform engineering can drive this type of cross-team collaboration.
- **Scale:** As more teams embrace modern software development practices and patterns, economies of scale are created whereby there is enough value to justify creating a platform capability shared by multiple teams.
- **Infrastructure modernization:** Forward-looking I&O teams sometimes embrace a new platform engineering role as a way to deliver more business value, thereby keeping themselves relevant.

Obstacles

- **Lack of skills:** Platform engineering requires solid skills in software engineering, product management and modern infrastructure, all of which are in short supply. Many organizations also undervalue the benefits of platform engineering.
- **Outdated management/governance models:** Many organizations still use request-based provisioning models. Those need to give way to a self-service, declarative model that depends on integration and automation, with the primary focus being the effectiveness of the end users developing and operating solutions using the platform.
- **Internal politics:** There are many intraorganizational fights that could derail a platform engineering initiative. For example, product teams may resist giving up control of their customized toolchains to adopt platform engineering solutions. There might also be no appetite to improve the developer experience. Enterprises may also refuse to fund IDPs without a clear ROI.

User Recommendations

- **Start with cloud-native workloads:** Aim your early platform-building efforts at cloud-native applications. Containers and Kubernetes provide a substrate for distributed systems that can also be your platform's foundation.
- **Embed security into platforms:** IDPs should embed security into workflows. Security teams need to "shift left," so that their organization can build holistic continuous integration/continuous delivery (CI/CD) pipelines that impact software delivery and infrastructure configuration, with security embedded in every layer of the workflow.
- **Don't expect to buy a platform:** Though some vendors may claim otherwise, any commercially available tool is unlikely to provide the entirety of the platform you need. A substantial amount of time and effort will be required to customize a platform to your needs.
- **Know that the acronym "IDP" has multiple meanings:** A related meaning is "internal developer portal," which represents a subset of an internal developer platform's capabilities.

Gartner Recommended Reading

Using Platform Ops to Scale and Accelerate DevOps Adoption

Guidance Framework for Implementing Cloud Platform Operations

Solution Path for Applying Microservices Architecture Principles

Innovation Insight for Internal Developer Portals

Metaverse

Analysis By: Marty Resnick, Matt Cain, Tuong Nguyen

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

A metaverse is the next level of interaction in the virtual and physical worlds. It will allow people to replicate or enhance their physical activities. This could happen either by transporting or extending physical activities to a virtual world, or by transforming the physical one. Although the goal of a metaverse is to combine many of these activities, there are currently many emerging metaverses with limited functionality.

Business Impact

Enterprises can expand and enhance their current businesses in unprecedented ways, opening up innovative opportunities. The following are examples of opportunities that metaverse offers to enterprises:

- Spatial computing (e.g., real-time shopping recommendations)
- Gaming (e.g., collaborative “serious games” for training)
- Digital humans (e.g., customer service reps)
- Virtual spaces (e.g., live virtual events)

- Shared experiences (e.g., immersive meetings)
- Tokenized assets (e.g., NFTs)

Drivers

There are three drivers for the metaverse:

- **Transport:** The ability to "go and immerse oneself" in a virtual world. That world may be a 3D simulation and/or in virtual reality.
- **Transform:** Bringing digital to the physical world. This allows the user to have access to real-time information, collaboration and experiences in the physical world.
- **Transact:** The economic foundation of the metaverse through the use of cryptocurrency, NFTs and blockchain.

Some of the main activities for the metaverse that will require one or more of these drivers are:

- **Collaboration:** Encouraging collaboration and participation from a diverse group of stakeholders, wherever they may be located.
- **Engagement:** Employees and customers are often disengaged. The metaverse facilitates a feeling of presence ("being there") as if the participants were in-person, turning their focus to the task at hand with less distraction.
- **Connectedness:** Metaverse enables us to connect in a more immersive way with shops, work environments, schools and communities of interest — regardless of where or if they exist in the physical world.

Ultimately, people desire to enhance and/or augment their lives in digital and physical realities.

Obstacles

- The adoption of metaverse technologies is nascent and fragmented. Be careful when investing in a specific metaverse, as it is too early to determine which investments have long-term viability. Furthermore, this is a time of learning, exploring and preparing for a metaverse with limited implementation. Financial and reputational risks of early investments are not fully known, and caution is advised.
- Current manifestations of metaverses are siloed, app-based, noninteroperable experiences that do not satisfy the decentralized and interoperable vision of the metaverse. This current, walled-garden approach also strongly limits users' control of experiences.
- While technology plays a key role in achieving a mature metaverse, another challenge involves establishing user-centric guidelines for ethics and governance covering different aspects of the metaverse. This must include topics like privacy, data sovereignty, acceptable terms of use, accountability, identity and legal protections.

User Recommendations

Recommendations for strategic approaches toward the metaverse will vary. In general:

- Task an innovation team to look for opportunities where metaverse technologies could optimize digital business, or create new products and services.
- Work with qualified agencies to evaluate the viability of metaverse technologies in terms of user and customer reach, and engagement rates with new, early adopter audiences.
- Build metaverse products and solutions by building a pipeline of innovation based on combinatorial emergent technologies, such as spatial computing, rather than a "killer app."
- Identify metaverse-inspired opportunities by evaluating current high-value use cases vis-a-vis your product or service.
- Develop technology strategies that leverage the built-in infrastructure and participants of the metaverse, and provide digital product or service opportunities.
- Be careful when investing in a specific metaverse, as it is still too early to determine which investments will be viable in the long term.

Sample Vendors

Animoca Brands (Sandbox); Decentraland; Linden Labs; Meta; Microsoft; Nvidia; Roblox

Gartner Recommended Reading

Predicts 2022: 4 Technology Bets for Building the Digital Future

Emerging Technologies: The Future of the Metaverse

Emerging Technologies: Critical Insights on Metaverse

Quick Answer: What Is a Metaverse?

Quick Answer: How Will the Metaverse Shape the Digital Employee Experience?

Data Observability

Analysis By: Melody Chien, Ankush Jain, Robert Thanaraj

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

Data observability is the ability to understand the health of an organization's data landscape, data pipelines, and data infrastructure by continuously monitoring, tracking, alerting, analyzing and troubleshooting incidents to reduce and prevent data errors or downtime. It tells us not only what went wrong but also why, and assesses the impacts. Data observability improves reliability of data pipelines by increasing our ability to observe changes, discover unknowns and take appropriate actions.

Why This Is Important

Data observability provides mechanisms in observing changes in data, data pipelines, data infrastructure, and user's behavior. It uses machine learning and data lineage to identify data issues, locate root causes and assess impacts. It helps:

- Provide visibility to how components of a data pipeline are operating and whether data meets expectations.

- Improve data quality, and optimize data pipelines to meet business requirements and strategies.
- Prevent downtime or critical data issues before affecting business.

Business Impact

Impacts include:

- For IT or data teams: Gain a holistic view of the health of data and pipelines; identify and recover from unplanned outages caused by data quality issues; spend less time firefighting or debugging data problems; facilitate data fabric design concepts with insight and recommendations.
- For business users: Gain visibility of data behavior and data usage from governance considerations, such as whether the data quality meets the predefined standard, and whether data is used and managed appropriately for security, privacy, or retention/disposal concerns.

Drivers

While “observability,” as a concept, emerged about five years ago, “data observability” has only recently risen to prominence due to the following drivers:

- Organizations face a growing complexity of the data stack, diversity of datasets, unexpected data drifts such as change in schema or business context, high demand for data quality and near zero tolerance of downtime. All these add to the challenges in data management. Data and analytics leaders must have a holistic view of the state of data pipelines within interconnected systems.
- Data pipelines move data from point to point and deliver data to consumers. This journey can be disrupted by unexpected events such as data quality issues, or lack of infrastructure resources. The data that flows through these pipelines needs to be monitored for loss of quality, performance, or efficiency. Organizations need to be able to identify points of failure before they have a chance to propagate.
- Observability goes beyond the traditional monitoring, tracing and alerting. It collects and analyzes logs, trace files, alerts, and provides actionable knowledge of the whole environment, therefore, creating insights of what to do next.

- Data observability provides a multidimensional view of data including performance, quality, usage and its impact to the downstream applications. Leveraging active metadata, lineage of data and ML, data observability generates real-time insight by monitoring the business context and analyzing data pattern, comparing history, and developing a semantic understanding of the data. This capability is essential to the data fabric design concept and becomes an important building block to further automation in data management practices.

Obstacles

- Data observability technologies overlap with monitoring, and data quality tools. The term “data observability” is often misused (or to some degree abused) in the market. Some vendors claim to provide data observability tools, which may offer just traditional monitoring features. These tools are very different in terms of underlying technologies, depth of observability and coverage area.
- Data observability doesn’t deliver data or ensure data is accurate. It **observes,** meaning it provides insights into whether or not data is being delivered as it should be or whether the data is accurate and reliable.
- Some data observability tools cover only data at rest, not data in motion. Therefore, the data has to be landed and stored in the database or file systems in order to be observed.
- Most data observability tools target the data engineer persona. Business users may find these tools less user friendly and insufficient in addressing their requirements.

User Recommendations

- Identify the data elements or certain data pipelines which have high standards or SLA in quality, uptime, latency, and performance. Pilot data observability principles by building a monitoring mechanism as a starting point to increase visibility over the health of data.
- Evaluate current data observability tools to enhance your observability based on priority of business requirements, primary users and how the tools fit to the overall enterprise ecosystems.
- Include both business and IT perspectives when evaluating data observability tools by engaging with both personas early on in the evaluation process.
- Partner with business stakeholders to evaluate and demonstrate business value of data observation practices by tracking improvement of data quality within data pipelines to show tangible benefits.

Sample Vendors

Acceldata; Bigeye; Datafold; Databand; Kensu; Monte Carlo; Sifflet; Soda; Unravel

Gartner Recommended Reading

The State of Data Quality Solutions: Augment, Automate and Simplify

Innovation Insight for Observability

Data and Analytics Essentials: DataOps

Cloud Sustainability

Analysis By: Ed Anderson

Benefit Rating: Transformational

Market Penetration: 5% to 20% of target audience

Maturity: Emerging

Definition:

Cloud sustainability is the use of cloud services to achieve sustainability benefits within economic, environmental and social systems. As such, cloud sustainability refers to both the sustainable operation and delivery of cloud services by a cloud service provider, as well as the sustainable consumption and use of cloud services.

Why This Is Important

Cloud sustainability is a key emerging trend as organizations consider the use of technology models to achieve their sustainability ambitions. Public cloud services offer great potential to produce sustainability benefits because of their ability to operate at scale using a shared services model, which results in greater efficiency in the use of computing resources. Cloud services can be physically located near renewable energy sources, further extending their sustainability potential.

Business Impact

The worldwide focus on climate change is pressuring organizations to improve their sustainability posture. Customers, investors, regulators, employees and the public at large are driving increased attention to sustainability. Organizations can use technology, including cloud, to help meet their sustainability objectives. Cloud computing has the potential to improve the sustainability posture of an organization by moving workloads from legacy data centers to more efficient cloud environments.

Drivers

- Sustainability is a rising imperative for organizations across all industries and in all countries and regions around the world, and encompasses environmental, social and economic factors.
- Although there may be differing opinions on the need for sustainability action, market data shows that customers, investors, regulators, citizens and employees value organizations with commitments to achieving sustainability outcomes.
- Sustainability investments correlate with operational efficiency, which means that most organizations operating in an increasingly sustainable fashion also recognize other benefits such as reduced spending on energy, reductions in waste and improvements in water use.
- Cloud providers, being among the world's largest data center operators, are making progress toward delivering sustainable cloud service offerings. Sustainability benefits complement the other benefits of moving applications and data to the cloud.
- Regulatory and legislative mandates for sustainability are increasing and are likely to be common in the next several years. Using cloud services provides a means to track sustainability metrics such as carbon emissions from technology use, which will help organizations comply with future regulatory reporting requirements.

Obstacles

- Accounting for sustainability outcomes adds complexity to the existing challenges of cloud operations, multicloud management, hybrid integrations, cost management and optimization.
- Cloud providers claim to have made great strides in offering sustainable cloud solutions, but these claims are often difficult to verify. Currently, there are no mandated sustainability reporting standards, making it difficult to interpret provider claims.
- Assessing the sustainability posture of a cloud provider is challenging, particularly when assessing across the multiple dimensions of sustainability including environmental, social and economic sustainability.
- Achieving cloud sustainability outcomes is a shared responsibility between the cloud provider and the customer. The cloud provider must demonstrate progress in sustainable cloud operations, and cloud consumers must employ sustainability practices in their use of cloud services. If one of these parties doesn't do its part, then sustainability outcomes are compromised. Partners can be useful in helping customers achieve their desired sustainability outcomes.
- The world is still developing new, sustainable energy sources. Currently, there aren't enough renewable energy sources to support all cloud service offerings. Further improvement, including development, will be needed before sustainable cloud services are pervasive in the industry.

User Recommendations

- Embrace the sustainability opportunities of using cloud by validating the sustainability capabilities of specific cloud service offerings. Use sustainability information to inform workload placement.
- Seek the benefits of using cloud to meet sustainability ambitions including the environmental, social and economic benefits produced by cloud service providers.
- Engage in the shared responsibility model for sustainability by holding cloud service providers accountable for their sustainability practices as well as your progress toward sustainable use of cloud services.
- Track sustainability performance KPIs as published by cloud service providers to ensure you are realizing the expected results from your use of cloud services. Bolster these metrics with an audited assessment of technology use within overall progress toward a sustainable organization.

Sample Vendors

Amazon Web Services (AWS); Google; IBM; Microsoft; Oracle; Salesforce; SAP; VMware

Gartner Recommended Reading

Executive Leadership: Sustainability Primer for 2022

Leading Sustainability Ambition, Goals and Technology in the 2020s

How to Set Strategic Ambition for Sustainable Business

Positioning I&O for Environmental Sustainability

Sustainability: A Customer Priority and Provider Imperative

Observability-Driven Development

Analysis By: Manjunath Bhat

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

Observability-driven development (ODD) is a software engineering practice that provides fine-grained visibility and context into system state and behavior by designing systems to be observable. It relies on instrumenting code to unravel a system's internal state, using externally observed data. As part of a shift-left approach to software development, ODD makes it easier to detect, diagnose and resolve unexpected system anomalies early in the development life cycle.

Why This Is Important

Building observable systems can expedite issue resolution because observability data serves as a useful debugging aid. Designing for observability also amplifies the benefits from other resilience engineering practices such as site reliability engineering (SRE) and chaos engineering. ODD enables software engineers and product owners to understand how the software is performing, as well as how it is being used. However, the tools and practices to institutionalize ODD are still emerging.

Business Impact

Built-in observability helps engineering teams ship code confidently, because they can more easily pinpoint likely root causes of failure. This makes it easier to comply with customer-specific and regulatory SLAs. Also, systems designed for observability help unravel code quality issues of performance, security, latency and other nonfunctional attributes early in the software development life cycle (SDLC). This creates software engineering teams that are focused on reliability and security.

Drivers

ODD is driven by the following factors:

- Reliability as a key differentiator — Organizations adopting SRE and chaos engineering practices need the data provided by designing for observability, because these practices are fundamentally data-driven.
- User experience is subjective and is difficult to measure, because it depends on a variety of factors that span the complete technology stack. Some factors, such as last-mile network connectivity, affect user experience (UX), but are difficult to optimize for — unless systems are designed to be observable to extract data related to such signals as response rates and latency.

- Mobile and edge environments present unforeseeable challenges because apps can run on potentially unknown devices and untrusted environments. These production environments can significantly differ from the local environments used to test the application. Therefore, ODD is valuable for capturing and investigating the "unknown unknowns" at runtime.
- Distributed system architectures increase the need for observability, because issues can arise due to previously untested and unexpected component interactions. Troubleshooting issues in distributed applications requires fundamentally different techniques, compared with monolithic or client/server applications. Building in observability narrows down the problem domain and helps engineers inspect the specific problematic component.
- The rise of vendor-agnostic, open-source standards — such as OpenTelemetry (resulting from a merger of OpenCensus and OpenTracing) — has made ODD more accessible. OpenTelemetry standards include protocols to ingest data from traces, metrics and logs. Open standards supported by open-source communities and commercial implementations are increasing developer adoption.

Obstacles

Organizations must overcome the following obstacles in adopting observability-driven development:

- Monitoring (and by association, observability) is commonly viewed as an operational responsibility. Software engineers often lack expertise with observability as a practice and with the tools and frameworks that are used to implement observability.
- The perception that observability can be achieved merely by implementing an "observability" tool. Observability is a property that must be designed and built into systems to ensure that it provides business benefits.
- A piecemeal approach to observability may thwart efforts to adopt ODD at scale. ODD as a standard practice has greater benefits when all components of a system are designed with an observability mindset. For example, distributed tracing requires that all components contributing to the trace be "instrumented" and propagate context for diagnosing response time issues.

User Recommendations

Software engineering leaders responsible for building reliable systems must:

- Adopt ODD as a standard software engineering practice to prepare their teams to handle unexpected and unforeseeable system behaviors and anomalies.
- Treat observability as a critical property that provides insight to resolve errors in production, and provides continual feedback to understand how the software is being used.
- Keep up with the pace of innovation in observability by using open standards and open-source-based technologies, such as OpenTelemetry. Gartner predicts that, by 2025, 70% of new cloud-native applications will adopt OpenTelemetry for observability, rather than vendor-specific agents and SDKs.
- Be wary of vendor hype regarding observability merely as a way to provide access to logs, metrics and traces. Use ODD as a fundamental software engineering practice that improves UX and resilience with granular insight into system state and behavior.

Sample Vendors

Cisco (Appdynamics); Datadog; Dynatrace; Honeycomb; IBM (Instana); Logz.io; New Relic; ObservIQ; ServiceNow (Lightstep); Splunk

Gartner Recommended Reading

Predicts 2022: Modernizing Software Development is Key to Digital Transformation

Innovation Insight for Observability

Monitoring and Observability for Modern Services and Infrastructure

Dynamic Risk Governance

Analysis By: Malcolm Murray

Benefit Rating: Transformational

Market Penetration: 5% to 20% of target audience

Maturity: Emerging

Definition:

Dynamic risk governance (DRG) is a new approach to risk governance — i.e., the critical task of defining the roles and responsibilities for risk management. As opposed to traditional risk governance models, like the three lines of defense (3LOD), DRG offers a revolutionary approach, making risk management more digital and more closely connected to strategy. By customizing risk governance appropriately to each risk, organizations can better manage risks and lower the cost of assurance.

Why This Is Important

In the volatile world in which organizations operate today, with surprising post-COVID-19 effects like inflation and the return of geopolitical risk with Russia's invasion of Ukraine, risk management is more important than ever. However, it is also more difficult than ever. Risks are more interconnected and can no longer be managed by one owner in one silo. DRG offers a method to improve all of the organization's risk management holistically, instead of tackling management of different risks in a piecemeal fashion.

Business Impact

DRG is quantitatively proven to lead to better risk management than traditional risk governance such as 3LOD. It benefits risk and assurance functions (such as information security and compliance) by improving their collaboration and benefits the business by reducing its "assurance fatigue." DRG also makes it easier to make risk aligned with strategy by applying risk appetite and tolerance to risk governance decisions.

Drivers

While the risk landscape has evolved dramatically in the last few years, risk governance models have not evolved. While risks have become dynamic and digital, risk management remains too inflexible and uniform.

The risk landscape has been changed by several important drivers, among them are:

- The increased interconnectivity of risks. As organizations have become more complex, risks have become more interconnected. Today's top organizational risks, such as supply chain, cybersecurity and third-party risk, all cut across large parts of the organization.
- The increased digitalization of organizations. This has meant the creation of new, fully digital risks, such as ransomware, as well as an increase in the speed and volatility of other risks such as third-party risk. Risks now change in their nature more often and quickly.

- Decision making has become more distributed. Organizations increased their risk appetite coming out of COVID-19 and are moving quickly, making business model and strategy changes. This leads to new-to-world decision types and risks and more frequent needs to make decisions outside an organization's guidance of risk tolerance.

These factors add up to a need for a new approach to risk governance, an approach that is more dynamic and digital to be appropriate for the risks organizations face today.

Obstacles

In a full DRG implementation, the management of each risk is customized, focused on essential activities carried out by the most suitable parties and fully leveraging digital tools. Obstacles include:

- The lack of shared technology platforms and tools where risk information and analytics are shared between all relevant functions. These platforms, such as GRC (Governance, Risk and Compliance) and IRM (Integrated Risk Management) systems, are evolving, but there is still a lack of adoption and a lack of full implementation.
- A lack of maturity in terms of the collaboration between risk and assurance functions. Due to organizational history, artificial lines of separation and regulatory pressure, the level of alignment of assurance efforts is still limited and has remained static over the last years. Adopting DRG aids collaboration, but our research shows that a higher initial level of risk management agility in the collaboration between functions is helpful.

User Recommendations

Organizations should adopt DRG instead of continuing to rely on the three lines of defense (now known as three lines) and similar risk governance models that are no longer fit for purpose. For this:

- Apply different governance models for different risks, tailored to your characteristics and update your governance more frequently.
- Assign accountable parties for risk management activities based on their actual suitability for the task and not their function. Use risk RACI charts to map this, limiting risk management activities to only the essential ones and separate out responsibility from accountability.

- Put digital risk management considerations first when designing and refining risk governance models to streamline risk governance with automation, and more centralized and coordinated data analytics usage.
- Make the board and senior management more involved in risk discussions by leveraging risk governance as the connection between strategy and risk management.

Gartner Recommended Reading

Use Dynamic Risk Governance to Align Risk Management to Strategy

Dynamic Risk Governance Is the New Risk Mandate

Ignition Guide to Piloting Dynamic Risk Governance

Achieving More Dynamic Risk Governance in Financial Services While Maintaining 3LOD Independence

Digital Humans

Analysis By: Marty Resnick, Adrian Lee, Anthony Mullen

Benefit Rating: High

Market Penetration: Less than 1% of target audience

Maturity: Embryonic

Definition:

Digital humans are interactive, AI-driven representations that have some of the characteristics, personality, knowledge and mindset of a human. They can interpret speech and gestures, along with images, and generate their own speech, tone and body language. These traits make them appear to be humans and behave in a “humanlike” manner. Digital humans are representations of people, typically rendered as digital twins, digital avatars, humanoid robots or conversational user interfaces.

Why This Is Important

Digital humans can interact, learn and express themselves in humanlike ways. These capabilities are driven by natural language understanding and emotion AI. They are rendered by conversational UIs, CGI and 3D real-time autonomous animation. They open up opportunities for organizations that embrace the technology early. Digital humans enable new business channels, advance digital transformation and create a marketplace-based business model called the digital human economy.

Business Impact

Digital humans provide organizations the opportunity to develop new business models for competitive advantage. Currently, the most impactful use cases are in HR training, communications, customer service, medical care and marketing. Businesses are no longer limited by the physical, and can communicate, interact, buy, sell and teach anytime, anywhere and in multiple places at once. Digital humans ensure highly personalized, individualized experiences at every employee and customer touchpoint.

Drivers

- Companies seeking to create unique, personalized experiences are pursuing digital avatars to interact at a higher level with customers to aid financial transactions, travel decisions and so on.
- Digital humans combined with robotics offer a unique solution to advancing the education and social development of children with special needs.
- As companies decide on a fully remote or hybrid (remote/office) future, digital humans provide a pathway to overcoming the challenges of remote onboarding and training.
- Digital humans and avatars have already performed concerts and starred in feature films. This will accelerate as the technology becomes more advanced and seamless.
- Companies are already using digital avatars as brand influencers, and their success will fuel copycat behavior.
- Digital human technology can enable true multipresence — a person is always available for interaction, regardless of their physical presence.
- Democratize app-based digital human creation. Applications with citizen AI and compositional tools enable anyone to create real-time, photorealistic digital humans with human-like expressions on smartphones.

Obstacles

- The act of creating and utilizing digital humans could raise regulatory and ethical concerns.
- The foundations of computer vision, sentiment analysis and CGI technologies are present, but the capability to fully replicate the personality and characteristics of a human will still take years to hone.
- Some customers will reject the idea and demand a real human.
- Customers may treat digital human representatives differently and in ways that have undesirable results.
- Creating high-quality digital humans requires functional improvements in composite AI techniques to bring together speech, vision and conversation.
- To capitalize on the ecosystem opportunities, corporations need to share key capabilities and allow others to add value, rather than hoarding the best technology. Current implementations of digital humans are siloed and walled up within one or limited digital interaction points for end users.

User Recommendations

- Track and engage early with digital human technology.
- Assess your current capabilities to provide the prerequisite customer data (such as CDP, CRM and digital experience analytics) needed to supply context to immediate use cases for implementing digital humans.
- Scenario-plan how digital humans fit within your organization as brand ambassadors, service agents, salespeople, developers or leaders.
- With the aid of an environmental, social and governance (ESG) charter, decide on the rules and ethics that the organization will follow in pursuit of digital humans.
- Decide the role (platform, creator, consumer, provider, etc.) your organization is best positioned to play in the digital human ecosystem.
- Keep an eye out for undesirable and unexpected consequences in early deployments.
- Modify your mid- to long-term technology roadmap to include opportunities that digital human analytics can bring.

Sample Vendors

Furhat Robotics; Hanson Robotics; Openstream.ai; Soul Machines; UneeQ

Gartner Recommended Reading

Maverick* Research: Digital Humans Will Drive Digital Transformation

Internal Talent Marketplaces

Analysis By: John Kostoulas, Helen Poitevin

Benefit Rating: Transformational

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

The “gig economy” relies on marketplace platforms to match customer demand to workers who are offering products, services or solutions. An internal talent marketplace uses similar principles to match internal employees and, in some cases, a pool of contingent workers, to timeboxed projects and various work opportunities, with no recruiter involvement. It includes marketing features, matching algorithms and feedback functionality, while aligning with principles of adaptive organizational design.

Why This Is Important

The COVID-19 pandemic and the subsequent societal and market shifts have made adaptability and resilience critical. Upskilling and reskilling have long been promoted as necessary, due to the potential of technological unemployment with the rise of AI and automation. Agile learning is the necessary enterprise response, including learning through experiences. Internal talent marketplaces are key to enabling adaptability, resilience and agile experiential learning.

Business Impact

Early adopters of ITM have been using this capability to:

- Understand their workforces through a different lens — focused on the work, rather than the role.
- Gather data and support their talent through new and more agile methods.

- Encourage and track employee development and collaboration in new ways, with a focus on skills.
- Address rapidly changing business priorities, and redeploy existing employees in order to improve organizational sustainability, while increasing employer brand appeal.

Drivers

- **Business agility and composability:** Agile and composable organizations will require more flexible deployment of workers across projects, products and other initiatives. Composable businesses are architected for real-time adaptability and resilience in the face of uncertainty. They need people with learning agility to adapt to changing skills demands. They also need to be able to align a highly networked workforce to the work that needs to get done in a dynamic way.
- **Talent visibility:** HR and other organizational leaders benefit from the data and insights from internal talent marketplaces to support workforce planning and other talent processes. Team, project and product leaders within organizations benefit from more flexible staffing and improved visibility into talent. When deployed correctly, employees and contingent workers have better visibility into work opportunities, and can stretch and build up their skills and experiences in order to grow their portfolio of work and career.
- **Technology availability:** Hype around the internal talent marketplace has increased. Further point solutions have emerged in the market. HCM suite providers have acquired or developed capability to meet increasing demand and interest. Maturity in applying AI to detect, infer and map relationships between skills has increased, as has the use of AI techniques to automatically match talent to work opportunities.

Obstacles

Organizational challenges impeding adoption include:

- Talent hoarding.
- Lack of cultural readiness for more dynamic and adaptive organizational models.
- Lack of readiness to use AI-enabled skills graphs to infer and detect skills data which is more granular and detailed compared to existing competency frameworks.
- Lack of trust in AI-generated skills data.

Data related challenges include:

- Access to data regarding worker and worker experiences, knowledge and skills.
- Use of organization-specific and more granular skills to enable better matching.
- Difficulties in balancing privacy and the need for significant amount of talent data to enable better user experiences through more relevant matching.

User Recommendations

- Pilot internal talent marketplaces within business units or lines of business that use adaptive or agile organization models, or work with progressive talent management leaders who want to deliver agile skills development.
- Move forward with caution, given the emerging state of these technologies, and anticipate significant investments of resources into co-developing products with application providers.
- Use AI along with multiple data sources to generate initial skills and experience data. Ensure that there are workflows that allow employees to correct, add and refine this data over time.
- Invest in design thinking, work design and workplace ethnography. Deconstructing jobs into deliverables, skills and capabilities, and then allowing employees to bid for these jobs, represents a significant change to management practices.
- Market the internal talent marketplace, as it gets adopted within your organization, as an essential, growth-focused part of your differentiated employer brand.

Sample Vendors

365Talents; Degreed (Adepto); Eightfold AI; Fuel50; Gloat; Hitch; Oracle; ProFinda; SAP; Workday

Gartner Recommended Reading

Innovation Insight for Internal Talent Marketplaces

Future of Work Trends Will Drive New Technologies to Track, Develop and Deploy Talent

Market Guide for Talent Acquisition (Recruiting) Technologies

Industry Cloud Platforms

Analysis By: Gregor Petri

Benefit Rating: Transformational

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

Industry cloud platforms leverage underlying SaaS, platform as a service (PaaS) and infrastructure as a service (IaaS) cloud services to offer industry-relevant packaged business and technical capabilities to an identified vertical as a whole product offering. Industry cloud platforms turn to composability and modularity to reduce the risk of platform complexity and lock-in.

Why This Is Important

Cloud providers are launching industry cloud platforms by combining SaaS, PaaS and IaaS offerings with industry-specific functionality and composable capabilities to create more compelling propositions for mainstream customers. Emerging industry cloud platforms are leveraging innovative approaches such as composable packaged business capabilities (PBCs), PBC marketplaces, data grids and fusion teams to accommodate faster change and platform adaptability.

Business Impact

Broader cloud adoption within enterprises will require more vertical-targeted whole-product solutions that follow defined industry scenarios and process models, rather than technology-oriented solutions that enterprises have to largely configure and integrate themselves. Industry clouds will have a lasting impact on cloud customers, blurring the lines between established cloud services such as SaaS, PaaS and IaaS.

Drivers

- Industry cloud platforms can create value for enterprises by bringing traditionally separately purchased solutions together in a composable and modular way. This can simplify the sourcing, implementation and integration process.
- Leaders in this space are expected to leverage composable cloud and edge approaches to create more holistic and comprehensive industry offerings, which enterprises' staff and talent will be able to recompose to meet unique or special requirements.
- Currently, industry cloud platforms are largely being initiated and created by large technology providers, although we see some enterprises considering creating — either jointly or in collaboration with a technology provider — a dedicated industry cloud platform as the basis for a more autonomous industry ecosystem.
- Enterprises can gain business value from industry clouds through shared best practices; vertically specialized go-to-market and implementation teams; compliance of the infrastructure platform with industry-specific regulations, such as HIPAA or FedRAMP; analytical capabilities to integrally mine the data from existing and new applications; industry-specific add-on functionality in front and back office enterprise applications; and fully vertical specific solutions, combined with collections of composable building blocks available in industry cloud marketplaces.
- Providers are creating whole-product offerings that cater directly to the established needs of vertical industry enterprises.

Obstacles

- Industry clouds are at risk of following the same path as community clouds, such as dedicated government clouds, where providers added specific vertical functionality. This often led to breaking the compatibility and upgradability with the cloud it was derived from and left enterprises on a long-term unsupported or unsupportable copy of the cloud.
- Industry cloud platforms can be overwhelming in terms of the wide breadth of functionality they potentially cover. Customers and providers must therefore be disciplined and not burn precious resources on fixing/replacing things that are not broken. Implementing an industry cloud platform must be approached as adding an exoskeleton, bringing new and improved capabilities rather than a vital organ transplant, replacing or repairing functionality that was already present.
- To reach their full potential, industry clouds will need to evolve into something best described as ecosystem clouds. Enterprises can leverage these ecosystems by participating in shared (business) processes, such as procurement, distribution, payment procession, and maybe even R&D and innovation. This will be a step beyond the initial sharing of infrastructure and technology.

User Recommendations

- Assess the industry-specific features promoted by various cloud providers, and distinguish between real technology or functionality offerings versus marketing messages.
- Evaluate long-term industry cloud roadmaps to understand the strategic focus of different industry cloud offerings and how they evolve industry specificity, taking into account that vendors choose different paths to add industry value.
- Establish communications with current application and infrastructure providers about which industry cloud ecosystems they plan to support or envision to become part of in the future.

Sample Vendors

Amazon Web Services (AWS); Google; IBM; Infor; Microsoft; Oracle; Salesforce

Gartner Recommended Reading

Quick Answer: What Makes Industry Clouds Different From Today's Cloud Offerings?

Providers of Cloud Managed Services: Use Composable Industry Platforms to Productize Your Offerings

Predicts 2022: The Cloud Moves From Technology Disruption to Business Disruption

Leverage Gartner's Vertical Strategy Framework for Composable Industry Cloud Offerings

Create Differentiated Cloud Managed Services for the Banking and Investment Services Industry

Superapps

Analysis By: Jason Wong

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Emerging

Definition:

A superapp is more than just a composite mobile app. It is built as a platform to deliver modular microapps that users can activate for personalized app experiences. A superapp is the front end of a platform into which internal developers and third-party providers can publish microapps (or miniprograms).

Why This Is Important

Superapps emerged in China and have spread into Southeast Asia and other parts of the globe. WeChat by Tencent and Alipay by Ant Group are the archetypal superapps. Superapps have come to market in India (Tata Neu and Paytm), South America (Rappi), and Middle East/Africa (Careem and Yassir). Industries such as financial services, retail, healthcare and telecommunications are adopting superapps to gain competitive advantage.

Business Impact

Organizations can create superapps to consolidate multiple mobile apps or related services to reduce UX friction (such as context switching) and development effort. Superapps can help achieve economies of scale and leverage the network effect of a larger user base and multiple providers. Superapps can provide a more engaging experience for their customers, partners or employees. They improve UX by enabling users to activate their own toolboxes of microapps and services.

Drivers

- Superapps are growing beyond mobile apps for consumer use cases. The superapp concept is expanding to include enterprise mobile and desktop experiences, such as workflow, collaboration and messaging platforms (e.g., Slack and Microsoft Teams, which already have a large number of add-on apps to their main applications). Superapps will eventually expand to support a wider range of modalities, including chatbots, Internet of Things (IoT) technologies and immersive experiences like the Metaverse.
- A superapp advances the concept of a composite application which aggregates services, features and functions into a single app. Superapps go further in three key ways. Multiple internal development teams and external partners can provide discrete services to users by building and deploying modular microapps to the superapp. App users can configure their superapp experience by selecting the microapp they want to use when they need it in the superapp. Data sharing is key, including simple user authentication, such as single-sign-on (SSO) and tracking user preferences or app usage history.
- We expect superapps to continue to gain interest from early-adopter organizations that embrace composable business thinking.

Obstacles

- There are numerous technical ways to build a superapp, but creating the business ecosystem can become a bigger challenge than technology implementation. A superapp serves as a platform for internally developed microapps and for third-party, externally developed microapps. Business partners to create an extended ecosystem for monetization by deploying microapps to an established user base. This provider ecosystem also amplifies the superapp's value by providing convenient access to a broader range of services within the app.
- Another obstacle is getting the UX design of a superapp right for the audience, and also having consistency of the microapps published to the superapp. Different user personas prefer to interact differently with apps, for example some prefer single task-focused apps versus others preferring everything at their fingertips. Inconsistent UX patterns in a superapp could negatively impact adoption and retention.

User Recommendations

To enable the creation of a superapp, application and software engineering leaders must:

- Ensure there is a sound business model and organizational structure to support the distributed development ecosystem for microapps.
- Identify core features in your superapp (such as commerce, communications or collaboration) that will drive a critical mass of adopters to drive interest in developers to serve those users.
- Clearly define security and data protection requirements by establishing governance reinforced with common platform implementation to satisfy security and data protection constraints.
- Offer an easy developer experience and convenient developer tools (such as APIs, SDKs, frameworks) for partners to build and submit apps.
- Use a mesh app and services architecture (MASA) to underpin composable architecture and multiexperience development principles.

Sample Vendors

Alipay; Grab; Ionic; KOBIL; LINE; Microsoft; PayPay; Paytm; Slack; WeChat

Gartner Recommended Reading

Quick Answer: What Is a Superapp?

At the Peak

Computational Storage

Analysis By: Jeff Vogel, Julia Palmer

Benefit Rating: High

Market Penetration: Less than 1% of target audience

Maturity: Emerging

Definition:

Computational storage (CS) offloads host processing from the main memory of the CPU to the storage device. CS involves more sophisticated processing capabilities located on the storage device. Computational storage products employ greater processing power in the form of FPGA and ASICs with low-power CPU cores on the SSD.

Why This Is Important

CS is a new class of storage drive that provides consistent performance for latency-sensitive applications such as AI/ML, high-performance computing, immersive and mixed reality streaming, and high-frequency trading on-premises and at the edge. Edge computing remains an opportunity, along with applications that favor distributed processing and power efficiency. CS reduces memory management challenges associated with applications. This solves the data movement issue associated with storage.

Business Impact

CS's low-power footprint versus traditional SSD improves performance-per-watt ratio, decreasing power consumption costs for applications at the edge. Using a more powerful embedded compute engine with the SSD controller will increase storage efficiencies, lower overall application costs and may prove to be a better green initiative with edge applications. CS engines can substantially reduce processing time, improve compression, and other critical drive functions.

Drivers

- Reduces performance inefficiencies, energy consumption and latency-sensitive issues in the movement of data between storage and application compute resources.

- Processes data and analyzes where it is generated and stored, empowering users to extract actionable insights at the device level.
- Reduces latency with edge workloads as data volumes increase, and movement of data becomes a bottleneck.
- Eliminates application performance issues that require data movement when the dataset size exceeds memory.
- Removes bottlenecks in data-intensive applications such as AI/ML, database, high-performance computing, analytics, high-frequency trading, and immersive and mixed-reality streaming.

Obstacles

- CS system architecture is more complex and may likely require applications to be recompiled.
- It may require additional APIs, or for the host system to be aware of the services that are provided by the CS system.
- Will require operational tasks to be offloaded into the SSD drives so host applications must be able to adequately communicate with CS storage drives.
- Follows the standards body which is expected to be finalized later this year. Some cloud providers are experimenting with CS and may offer commercial solutions.
- Requires a software framework that enables a host server application to interact with a CS device and is based on an open and standard framework that is currently being actively worked on.
- Are relatively nascent, and the value for what's being offered is difficult to justify in some cases.

User Recommendations

- Explore potential benefits that can be gained from specific use cases such as encryption, video encoding, AI/ML facial recognition, but carefully weigh the cost vs. performance gains vs. opex savings and amount of work required to deploy. This is especially true where certain workloads that are very input-/output-bound and would benefit the most from processing in storage.

- Determine compression/decompression engines that enable the drive both to store more data per gigabyte of flash and to maintain high performance within a narrow band regardless of the read/write mix.
- Perform sufficient vendor due diligence as each has taken a slightly different approach to design and implementation. Also, the vendor landscape are generally small startups that may not be sufficiently funded or staffed to support large-scale application demands.

Sample Vendors

Arm; Eideticom; NETINT Technologies; NGD Systems; Samsung Electronics; ScaleFlux

Web3

Analysis By: Avivah Litan, Adrian Leow

Benefit Rating: Transformational

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

Web3 is a new stack of technologies for the development of decentralized web applications that enable users to control their own identity and data. These technologies include blockchain as a trust verification mechanism, privacy-preserving and interoperability protocols, decentralized infrastructure and application platforms, decentralized identity, and support for applications like decentralized finance. These will eventually realize the vision of a decentralized web.

Why This Is Important

Web3 enables new business and social models. Smart contracts run applications that eliminate intermediaries and administrative overhead of controlling centralized entities. Tokens (including cryptocurrencies) power the business models and economics of Web3, and are built into blockchain protocols. Web3 provides building blocks for new types of applications. It supports new business opportunities, for example, the monetization of non-fungible tokens (NFTs) in new metaverse applications.

Business Impact

Web3 offers new features to manage digital assets and ownership rights for content creators. Other benefits include:

- Trustless transaction verification
- Smart contract automation
- Tokenization of digital or physical assets
- Self-sovereign identity

Existing Web3 applications, such as decentralized finance (DeFi), NFTs, and decentralized autonomous organizations (DAOs), have already yielded previously unachievable gains for everyday users, investors, artists, content creators and communities.

Drivers

- The metaverse will require many of the features that Web3 enables.
- Web3 apps are useful for authentication and trading of data. For example, carbon credits authenticated and traded on blockchains are starting to help companies reduce their carbon footprints.
- Web3 empowers content creators to sell their work in the form of NFTs that ensure they — and not intermediaries — are paid for their work based on contract terms they set themselves whenever, for example, they sell an artwork.
- Web3 user-owned content enables gamers to earn revenue to supplement income, rather than yielding most of the games' profits to the studios that sponsor them.
- Tokenization of real-world assets can benefit from Web3 applications, such as DeFi loans or blockchain-based content distribution. Early adopters are realizing new business opportunities and benefits that were not possible before. For example, the Vatican made its archived documents available online as NFT-based documents so that they can control content ownership rights and distribution while making their archives readily available to researchers worldwide.
- DeFi protocols, such as Aave and MakerDAO, provide users with lending and borrowing services run by smart contracts that eliminate the need for intermediaries, thereby enabling higher yields and returns, albeit with much more risk.
- Brands are realizing new revenue streams with Web3 apps, especially with NFT issuance and sales.
- Community-based investing is enabling social groups to mobilize capital for their collective goals. For example, ConstitutionDAO bid on a copy of the U.S. Constitution at a Sotheby's auction in December 2021.

Obstacles

- Web3 poses many risks, such as lack of customer protections, security threats and swings toward centralized control. Although future internet technologies will be more decentralized, it will not eliminate centralized authorities from most enterprise B2B and B2C applications.
- Enterprises will be unwilling to give up governance, oversight and control of most business applications. We expect enterprises to continue using Web 2.0 for most applications through 2030, and only use Web3 only for applications that benefit from new blockchain-enabled business models, social and gaming networks.
- Some early Web3 activities have achieved success, but much work remains to improve performance, governance, risk management and user interfaces. Additionally, success in well-established industries is sparse.
- The current lack of widely applicable Web3 business applications for enterprises, for example, in business-to-business use cases, is hindering enterprise adoption of Web3.

User Recommendations

- Pay attention to innovative and successful Web3 initiatives in areas such as gaming, DeFi, art, entertainment and sports for ideas and partnerships.
- Keep abreast of developments in Web3 protocols and standards by monitoring the initiatives of Ethereum, Web3 Foundation and ISO/TC 307 for blockchain and distributed ledger technologies.
- Evaluate and pilot blockchain applications that implement a Web3 vision by giving end users control of their own identity data and compliant access to Web3 apps. These applications include decentralized identity, verifiable claims, cryptocurrency payments and investments, and new apps that are yet to appear.

Sample Vendors

Avalanche; Bitcoin.org; Ethereum; Polygon; Solana

Gartner Recommended Reading

DeFi, CeFi and How Blockchains Interoperate: Case Study in Carbon Trading

Quick Answer: What Is Web3?

Foundation Models

Analysis By: Arun Chandrasekaran, JC Martel

Benefit Rating: Transformational

Market Penetration: 1% to 5% of target audience

Maturity: Adolescent

Definition:

Foundation models (previously called transformers) are transformer architecture-based models, such as large language models, which embody a type of deep neural network architecture that computes a numerical representation of text in the context of surrounding words, emphasizing sequences of words. They are called Foundation models because of their critical importance and applicability for a wide variety of downstream use cases due to the pretraining of the models.

Why This Is Important

Foundation models represent an important step forward in the field of AI due to their massive pretrained datasets and wide use-case applicability. They are capable of delivering more state-of-the-art natural language processing capabilities with higher efficacy than their predecessors. Foundation models have become the go-to architecture in NLP and the model architecture has also been applied to computer vision, audio processing, software engineering, biochemistry, finance and legal use cases.

Business Impact

Foundation models:

- Have the potential to enhance applications across a wide variety of natural language use cases, such as creating well-formed blocks of text from keywords and generating human-like conversational responses.
- Will have a wide impact across vertical industries (i.e., financial services, healthcare, law, government, education, etc.). Their capabilities are extending to domains such as translating natural language to code with Codex from OpenAI and AlphaCode from Google DeepMind.

Drivers

Foundation models:

- **Require only limited model customization to deliver effective results:** Clients report to Gartner that they are able to use Google's open-source BERT implementation without training the entire network. Rather, they retrain only the top few layers to customize for their language domain.
- **Deliver superior text classifications:** The difference between these models and prior neural network solutions is stark. Transformer architecture model patterns are in relatively large blocks of text, as opposed to predicting the next word based on the preceding words. These improvements have materially advanced speech, language and text applications. A notable example is the improvement in Google Translate.
- **Can create well-formed text passages from minimal inputs:** GPT-3 is a foundational model developed by OpenAI and licensed by Microsoft. This transformer model, which incorporates 175 billion parameters, is designed to create paragraphs or pages of text from small excerpts. GPT-3 does this based on predicting the most likely next word in a sentence, based on its absorbed accumulated training.
- **Have accelerated the innovation in the space of AI** with massive model sizes. Examples include OpenAI's GPT-3, with 175 billion parameters; DeepMind's Gopher and Chinchilla, with 280 billion and 70 billion parameters; Meta (Facebook), with OPT model of 175B parameters; Google's PaLM, with 540 billion parameters; Microsoft — Nvidia's Megatron —Turing NLG, with 530 billion; and Alibaba's M6 with 10 trillion parameters. In addition, both Meta and Google have also open sourced their models.

Obstacles

Foundation models:

- **Do not deliver perfect results:** Although a significant advance, foundation models still require careful training, and can deliver unacceptable results due to their black box nature. They can propagate downstream any bias in the datasets.
- **Require appropriate skills and talent:** As with all AI solutions, the end result is dependent on the skills, knowledge and talent of the trainers.

- **Expand to impractical sizes:** Large models are up to billions, or even trillions, of parameters. These models are impractically large to train for most organizations because of the necessary compute resources, which can make them expensive and ecologically unfriendly.
- **Concentration power:** These models have been mostly built by the largest technology companies with huge R&D investments and significant AI talent. This has resulted in concentration of power with a few large, deep-pocketed entities, which may create a significant imbalance in the future.

User Recommendations

- **Create a strategy document** that outlines the benefits, risks, opportunities and execution plans for these models in a collaborative effort.
- **Plan to introduce foundation models into existing speech or text programs:** If you have any older language processing systems, moving to a transformer-based model could significantly improve performance. One example might be a voice interface, where transformers can interpret multiple ideas in a single utterance. This shift in approach can significantly advance language interfaces by reducing the number of interactions.
- **Start with established, open source-based models,** which have superior ecosystem support across DSML platforms and are more widely deployed.
- **Explore new use cases,** such as natural language inference or sentiment analysis, where the models can significantly improve both accuracy and time to market.

Sample Vendors

Alibaba; Amazon; Baidu; Google; IBM; Microsoft; Nvidia; OpenAI; Tencent

Decentralized Identity

Analysis By: Michael Kelley, Arthur Mickoleit, Akif Khan

Benefit Rating: Transformational

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

Decentralized identity (DCI) allows an entity (typically a human user) to control their own digital identity by leveraging technologies such as blockchain or other distributed ledger technologies (DLTs), along with digital wallets. By establishing trust, privacy, and security through identity attributes contained in decentralized verifiable claims, DCI provides a more secure alternative to storing identity information centrally.

Why This Is Important

Existing approaches for digital identities cannot scale to the accelerating needs of a digital society. Fragmentation is a problem due to service providers (banks, retailers and governments) forcing consumers to create individual identities for every service. DCI offers an approach with increased security, privacy and usability compared to traditional digital identity approaches. As standards continue to be refined, and legislative efforts around the world are multiplying, use cases for DCI are emerging in the market.

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, in order to increase assurance to an acceptable level. DCI can help identity and service providers increase trust, security, privacy, and access convenience for end users without the need for centralized data; thereby 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. Significant investments have been made by IBM and Microsoft, and Gartner has observed over $450MM in investment in more than 80 startups and vendors of DCI technologies and DCI components like digital wallets and trust fabrics over the past six years.
- **Government activity:** Public sectors are increasingly keen on shaping digital identity trends around DCI and SSI. The EU, governments in Germany, Canada and other countries are actively pursuing and investing in DCI use cases that span public and private sector interests.
- **Privacy regulations**: Countries around the world are formalizing 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, without the need to expose sensitive personal data. Many initiatives aiming to break out of identity silos and enabling cross-sector identity ecosystems.
- **Standards:** Standards are maturing, led by entities such as the World Wide Web Consortium (W3C) and Decentralized Identity Foundation (DIF), 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 new bank, online store, employer, healthcare provider, educational institution or government department 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

- **Adoption:** Service providers may resist accepting identity claims via DCI unless they know many users have adopted DCI-based digital identity wallets. And users may be reluctant to adopt DCI wallets unless they see significant value added, e.g., by many service providers accepting them.
- **Interoperability:** Adoption is slow due to most development taking place in pockets. There are currently many vendors, as well as governments active in this space. While use cases are emerging, the standards and frameworks for interoperability are still maturing.
- **Technical challenges:** A lack of DLT/blockchain performance, interoperability, scalability and maturity. A lack of clear security, and 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 interactions between decentralized and traditional identity schemes.

User Recommendations

- Build a business case for trialing acceptance of DCI that involves reduced identity proofing and affirmation costs and improved UX.
- Develop and deliver attainable use cases as POCs, such as a DCI solution focused on remote employee onboarding, educational credentials, health credentials, etc.
- Partner with DCI vendors to understand the possibilities and potential of DCI. Explore also government opportunities in more advanced geographies.
- Be cautious of overly optimistic vendor claims. Evaluate the technical security aspects of blockchain platforms under consideration. In particular, examine vendor plans for support of standards, such as W3C and DIF.
- Factor in user education and outreach into your DCI project plans, to drive adoption of DCI among your existing and prospective users to drive engagement and use of DCI for your services.

Sample Vendors

1Kosmos; Civic; Evernym; Finema; IBM; InfoCert; Microsoft; Nuggets; Ping Identity; SecureKey

Gartner Recommended Reading

Guidance for Decentralized Identity and Verifiable Claims

Innovation Insight for Decentralized Identity and Verifiable Claims

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

Top Trends in Government for 2022: Digital Identity Ecosystems

NFT

Analysis By: Avivah Litan

Benefit Rating: Transformational

Market Penetration: 1% to 5% of target audience

Maturity: Adolescent

Definition:

A non-fungible token (NFT) is a unique programmable blockchain-based digital item that publicly proves ownership of digital assets, such as digital art or music, or physical assets that are tokenized, such as houses, cars or documents. Most NFTs today are unique ERC 721 tokens that live on Ethereum, but other blockchain platforms support them as well. NFTs store data and logic and typically link to off-chain records for storage purposes.

Why This Is Important

NFTs support the "creator economy" as creators retain ownership rights over their work and the assets the token represents. NFTs support new economic models, e.g. where content creators perpetually retain most of the revenue from sales of their works. Enterprises are beginning to tokenize real-world assets for many advantageous purposes. NFTs have broad applicability in many markets and will open up new types of marketplaces, for example in metaverses, that are not possible without them.

Business Impact

NFTs present new ways for content creators to manage, promote and monetize their assets. Entities can depend on the validity, integrity and uniqueness of NFTs. Blockchain technology brings tamper resistance to NFTs, which is hard to do with other kinds of digital assets. Enterprises are beginning to tokenize real-world assets for new economic opportunities such as tracking an automobile's history, controlling content distribution rights, and for negotiating contracts represented as NFT records.

Drivers

NFTs offer new methods to ensure trust and integrity with digital and physical content. In addition, NFTs enable the technology and support the standards that allow content creators, sellers and buyers to transact with trusted digital (and sometimes physical) content. In the absence of legacy digital signatures, which require a trusted relationship with certificate authorities and tedious workflows, NFTs leverage public blockchains such as Ethereum.

Due to the nature of a public blockchain, any entity can create and transact with NFTs. Backed by emerging standards, such as ERC721, the potential for vibrant digital ecosystems for digital content is possible and is already transpiring.

Other driving factors include:

- New business models for content creators, for example blockchain/decentralized gaming.
- New products and services, such as escrow, insurance or persistent secure storage, that make NFTs more transparent and trustworthy.
- Enterprises are creating or buying NFTs to appeal to their customers, especially those engaged in Web3 virtual environments and games.
- Ability to authenticate/validate digital (and in some cases physical) goods. For example, authenticating artwork can be a tedious process today. By leveraging NFTs, ownership (in some cases) and authenticity can be validated in real time. They can also be linked to applications in the enterprise space, such as with examples from WISeKey.

- Evolution of standards required to ensure interoperability, longevity and utility. At this point in time, the primary standards are Ethereum-based, such as ERC (Ethereum request for comments). Specifically, ERC721 aims to standardize NFTs. This standard helped with NFTs such as Decentraland, CryptoBeasties, Etheremon and CryptoKitties.

Obstacles

- NFTs are unique within a single blockchain network. Blockchain interoperability needs to expand to ensure that NFTs retain their uniqueness and integrity across digital ecosystems.
- NFT business models and approaches haven't fully been realized for enterprise users. Actual utility and value is still unclear for most enterprise users.
- Enterprises are just beginning to experiment with tokenizing real-world assets for future economic benefits.
- Buyers are sometimes duped into buying an NFT that is not what it pretends to be. Scams are prevalent, and fraud prevention must become stronger and ubiquitous.
- Buyers are not aware of the numerous risks/constraints on their ownership rights. For example, copyright issues that prohibit transferring their object to other forms, or storage configurations that don't provide persistence and security for their objects.
- NFT play-to-earn game currencies have been manipulated by traders. Controls must be instituted to prevent this usurious activity.

User Recommendations

- Conduct POCs. IT leaders that are interested in the potential of NFTs should conduct early stage research, and consider investigating how they are made, distributed and monetized.
- Engage with relevant business leaders to inform and advise on the risks, benefits and limitations of emerging NFT technology.
- Conceptualize potential business and monetization models.
- Leverage good cybersecurity to ensure that risks are understood and mitigated. As NFTs increase in value, so will attacks.
- NFT storage should use a distributed file system, for example IPFS-based. Nodes should be replicated across many servers. While NFTs are cryptographically secured on a blockchain, it does not mean that the NFT is legitimate. NFTs can be misrepresented to buyers.

Sample Vendors

Animoca Brands; Arweave; Avalanche; Centrifuge; Ethereum; Flo; OpenSea; Polygon: Rarible; Solana

Gartner Recommended Reading

Quick Answer: What Is Web3?

Quick Answer: How to Protect the Use and Trading of NFTs

Garbage In, Garbage Forever: Top 5 Blockchain Security Threats

Cloud Data Ecosystems

Analysis By: Adam Ronthal, Donald Feinberg, Robert Thanaraj

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

Cloud data ecosystems provide a cohesive data management environment that ably supports the whole range of data workloads, from exploratory data science to production data warehousing. They have a common governance and metadata management framework and unified access management, and they integrate augmented data management capabilities with a set of services accessible by the business user. Operational data sources and third-party vendors also participate in data ecosystems.

Why This Is Important

Data and analytics leaders report that the cloud experience today requires a significant integration effort to ensure that components work well together. Cloud service providers (CSPs) and independent software vendors (ISVs) are responding with more refined cloud data ecosystems as the market moves from “some assembly required” to a “packaged platform experience.” Cloud data ecosystems provide streamlined delivery and comprehensive functionality that is straightforward to deploy, optimize and maintain.

Business Impact

These offerings promise to unify the exploratory world of data science with the production delivery of data warehouses, with streamlined delivery and easy integration of operational data sources. They promise to unify operational and analytics systems with a holistic management framework. They address key data management disciplines such as data integration, data sharing, governance and metadata — via augmentation for automation — and provide the basis for full-scale analytics capabilities.

Drivers

- Data and analytics architectures are under significant stress on two fronts: hybrid and multicloud deployment environments, and the diversity of data persistence models required to meet the increasing demands of data and analytics.
- Data and analytics leaders are seeking to rationalize data silos, which now span multiple deployment environments and frequently require different and potentially conflicting operating models.
- At the same time, enterprises are looking to unify the way they engage with different data models, platforms and use cases.
- Data ecosystems serve as a unifying approach to resolving these pressure points. Built on a common foundation of governance and metadata, they enable new practices like DataOps, and new architectures like the emerging data fabric. Infused with artificial intelligence (AI) and machine learning (ML) capabilities, they will become self-optimizing and self-tuning, and support financial governance efforts through cost optimization.

Obstacles

- While cloud data ecosystems have a vision of unifying data and analytics environments (exploratory analytics, production delivery, operational systems and analytics systems) with common governance, security and metadata, significant work is still needed to make this a reality. Gaps exist in data integration, data quality, metadata and governance. These will need to be addressed either through native CSP offerings or partnerships with ISVs to fully realize the vision of the cloud data ecosystem.
- When combining native CSP offerings with third-party ISV offerings, data and analytics leaders may find that additional effort is required to integrate these components. This undermines the core concept of a unified, holistic data ecosystem. While CSPs are working with third-party ISVs to provide open ecosystems, their initial focus remains on ensuring that their own components are working well together, and a more polished experience for both ISV and CSP offerings may be delayed.

User Recommendations

Data and analytics leaders will need to assess the maturity of these offerings, and the degree to which they deliver on the promise of a unified environment. End users report that cloud data ecosystems are still early in their maturity, with new features and capabilities emerging on a regular basis. Early adopters should be sure to:

- Assess points of integration between various components to determine how cohesive the resulting ecosystem is. A less cohesive ecosystem will require significantly more integration time and effort.
- Ensure that their cloud data ecosystem has a well-articulated path to production for the full data life cycle (from discovery to production-optimized delivery).
- Define what they expect CSPs to deliver as part of the solution, and what capabilities they expect to obtain from third-party ISVs; expect to spend more time on integration efforts when combining CSP and ISV offerings.

Sample Vendors

Amazon Web Services; Cloudera; Databricks; Google Cloud Platform; IBM; Microsoft; Oracle; SAP

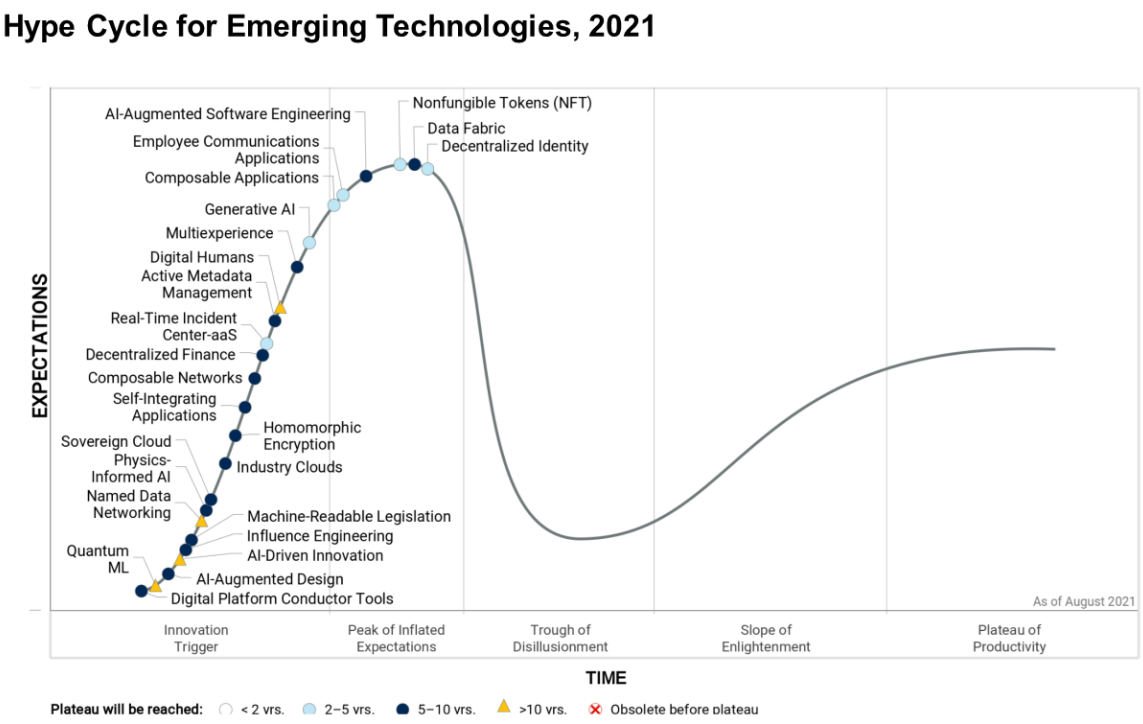
Gartner Recommended Reading

The Impacts of Emerging Cloud Data Ecosystems: An Architectural Perspective

Strategic Roadmap for Migrating Data Management to the Cloud

Appendixes

Figure 2. Hype Cycle for Emerging Technologies, 2021



Source: Gartner (August 2021)

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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 2022)

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 2022)

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 2022)

Evidence

Client inquiries, Gartner search analytics, Google trends, Gartner social media analysis of emerging technology topics in May 2022.

Document Revision History

Hype Cycle for Emerging Technologies, 2021 - 11 August 2021

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Hype Cycle for Emerging Technologies, 2018 - 6 August 2018

Hype Cycle for Emerging Technologies, 2017 - 21 July 2017

Hype Cycle for Emerging Technologies, 2016 - 19 July 2016

Hype Cycle for Emerging Technologies, 2015 - 27 July 2015

Hype Cycle for Emerging Technologies, 2014 - 28 July 2014

Hype Cycle for Emerging Technologies, 2013 - 9 August 2013

Hype Cycle for Emerging Technologies, 2012 - 31 July 2012

Hype Cycle for Emerging Technologies, 2011 - 28 July 2011

Hype Cycle for Emerging Technologies, 2010 - 2 August 2010

Hype Cycle for Emerging Technologies, 2009 - 21 July 2009

Hype Cycle for Emerging Technologies, 2008 - 9 July 2008

Hype Cycle for Emerging Technologies, 2007 - 13 July 2007

Recommended by the Authors

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Understanding Gartner's Hype Cycles

Create Your Own Hype Cycle With Gartner's Hype Cycle Builder 2021

Assessing Emerging Technology Adoption Readiness

Table 1: Priority Matrix for Emerging Technologies, 2022

Benefit ↓	*Years to Mainstream Adoption*			
	Less Than 2 Years ↓	***2 - 5 Years*** ↓	***5 - 10 Years*** ↓	***More Than 10 Years*** ↓
Transformational		Cloud Sustainability Dynamic Risk Governance NFT Platform Engineering	Augmented FinOps Autonomic Systems Decentralized Identity Digital Twin of a Customer Foundation Models Generative Design AI Industry Cloud Platforms Internal Talent Marketplaces Machine Learning Code Generation Minimum Viable Architecture Web3	Cybersecurity Mesh Architecture Metaverse
High		Cloud Data Ecosystems OpenTelemetry	Causal AI Computational Storage Data Observability Observability-Driven Development Superapps	Digital Humans
Moderate				

Benefit	Years to Mainstream Adoption			
↓	Less Than 2 Years ↓	2 - 5 Years ↓	5 - 10 Years ↓	More Than 10 Years ↓
Low				

Source: Gartner (July 2022)

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