Hype Cycle for Emerging Technologies, 2021

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Initiatives: Technology Innovation

Our 2021 Hype Cycle highlights emerging technologies that will significantly affect business and society over the next two to 10 years. It includes technologies that accelerate growth, engineer trust and bring order to the chaos of a changing world by sculpting change.

Additional Perspectives

- Summary Translation + Localization: Hype Cycle for Emerging Technologies, 2021 (27 August 2021)

Analysis

What You Need to Know

As a technology innovation leader, CTO or CIO, you must stay up to date with emerging technologies 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.
- Plan to exploit these technologies in line with your organization's ability to handle unproven technologies.

Technology innovation has become a key enabler of competitive differentiation and is the catalyst for transforming many industries. Breakthrough technologies are continually appearing, challenging even the most innovative organizations to keep up. Your focus on digital business transformation means you must accelerate change and cut through the hype surrounding these technologies. The innovation profiles highlighted in this research provide guidance on the business impact of emerging technologies and recommendations for how to use them to drive competitive differentiation.

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

- Engineering trust
- Accelerating growth
- Sculpting change

The Hype Cycle

The Hype Cycle for Emerging Technologies is unique among Gartner Hype Cycles because it distills insights from more than 1,500 technologies that Gartner profiles each year into a succinct set of "must-know" emerging technologies. We have selected 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 2020 version. The retired technologies remain important and featured in other Hype Cycles (see the Off the Hype Cycle section).

Themes in Emerging Technologies

This iteration of the Hype Cycle highlights three themes that align with Gartner's overall themes for Hype Cycles as identified in the special report, 2021 Hype Cycles: Innovating Delivery Through Trust, Growth and Change. This year, emerging technologies focus on engineering trust, accelerating growth and sculpting change. These guiding principles are helping to drive the technologies and innovations needed to manage the change we all face.

Engineering trust. At a minimum, trust demands security and reliability. However, here the trust also extends to building innovations as a resilient core and foundation for IT to deliver business value. This foundation must consist of engineered, repeatable, trusted, proven, and scalable working practices and innovations. Risk for business must be minimized or managed so that IT can deliver. Resilience is key from both a business and technology perspective. Scalable repeatability helps build a resilient business core.

To engineer trust, examine the following technologies:

- Sovereign cloud
- Machine-readable legislation
- Decentralized identity
- Decentralized finance
- Nonfungible tokens (NFT)
- Homomorphic encryption
- Active metadata management

- Data fabric
- Real-time incident center
- Employee communications applications

Accelerating growth. Once the trusted core business is established, recovery and growth can happen. Growth targets should be achievable. Here risk is manageable in incremental steps when managed against business needs. Technology risk is balanced with the appetite for business risk (using Hype Cycles), and near-term objectives are attainable. Once the innovation-led core is scaling, accelerated growth extends delivery and value. At this point, risk and agility enhance IT delivery toward more distant horizons.

To accelerate growth, explore the following critical technologies:

- Multiexperience
- Industry cloud
- AI-driven innovation
- Quantum ML
- Generative AI
- Digital humans

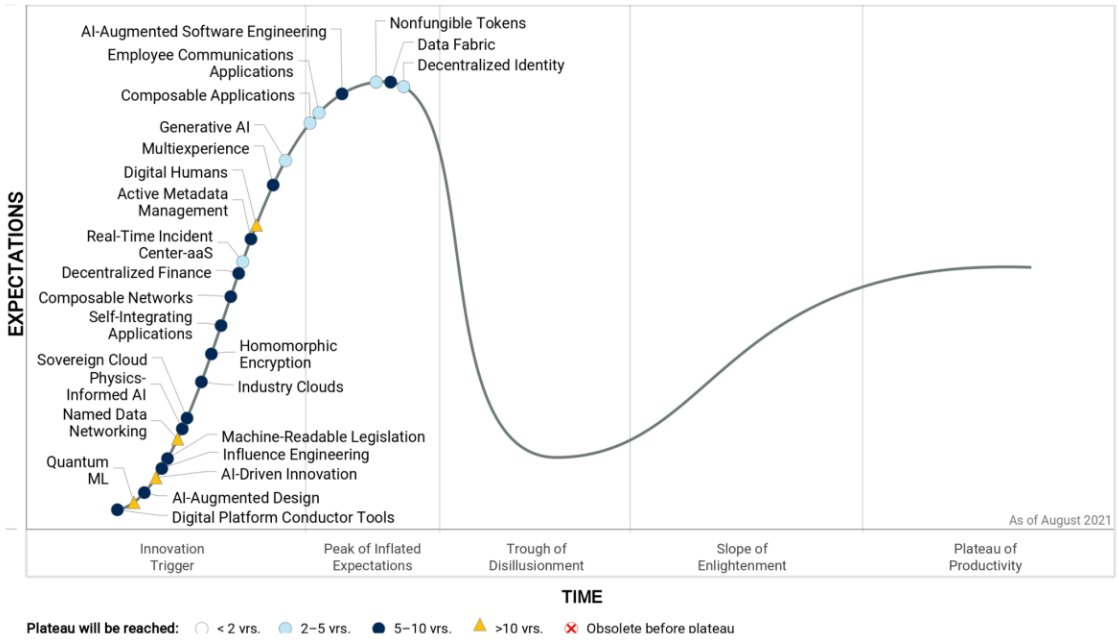
Sculpting change. Change is traditionally disruptive and often tied to chaos, but organizations can use innovations to sculpt change and bring order to chaos. The art is to anticipate and auto-tune to the needs of change. Experience helps scale business drivers. Risk may help innovations adapt to sculpture change, but this risk must be manageable. So change can be sculpted, while delivery is being assessed.

To sculpt change, examine the following technologies:

- Composable applications
- Composable networks
- AI-augmented design
- AI-augmented software engineering

- Physics-informed AI
- Influence engineering
- Digital platform conductor tools
- Named data networking
- Self-integrating applications

Figure 1: Hype Cycle for Emerging Technologies, 2021



Source: Gartner

Downloadable graphic: Hype Cycle for Emerging Technologies, 2021

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. So 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 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, 2021

(Enlarged table in Appendix)

Benefit	Years to Mainstream Adoption			
	Less Than 2 Years	2 - 5 Years	5 - 10 Years	More Than 10 Years
Transformational		Composable Applications Decentralized Identity Employee Communications Applications Generative AI Nonfungible Tokens (NFT) Real-Time Incident Center as a Service	Active Metadata Management AI-Augmented Design AI-Augmented Software Engineering Composable Networks Data Fabric Decentralized Finance Digital Platform Conductor Tools Homomorphic Encryption Industry Clouds Influence Engineering Machine-Readable Legislation Multiexperience Physics-Informed AI Self-Integrating Applications Sovereign Cloud	AI-Driven Innovation Digital Humans Named Data Networking Quantum ML
High				
Moderate				
Low				

Priority Matrix for Emerging Technologies, 2021

Source: Gartner (August 2021)

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 important 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 2020 version of this Hype Cycle, including:

- Adaptive ML — Hype Cycle for Data Science and Machine Learning, 2021 still tracks this technology
- Authenticated provenance — Two Hype Cycles still track this technology, including Hype Cycle for Blockchain, 2021
- Bidirectional brain-machine interface — Two Hype Cycles still track this technology, including Hype Cycle for Higher Education, 2021
- Biodegradable sensors — Our Hype Cycles no longer track this technology
- Bring your own identity — Two Hype Cycles still track this technology, including Hype Cycle for Identity and Access Management Technologies, 2021
- Carbon-based transistors — Our Hype Cycles no longer track this technology
- Citizen twin — Four Hype Cycles still track this technology, including Hype Cycle for Smart City Technologies and Solutions, 2021
- Composable enterprise — This innovation profile has been split into five components: applications, infrastructure, networks, ERP and D&A, which are all tracked on different Hype Cycles
- Composite AI — Two Hype Cycles still track this technology, including Hype Cycle for Artificial Intelligence, 2021
- Differential privacy — Four Hype Cycles still track this technology, including Hype Cycle for Privacy, 2021
- Digital twin of the person — Two Hype Cycles still track this technology, including Hype Cycle for the Internet of Things, 2021
- DNA computing and storage — Our Hype Cycles no longer track this technology
- Embedded AI — Our Hype Cycles no longer track this technology, as it has become ubiquitous
- Explainable AI — Four Hype Cycles still track this technology, including Hype Cycle for Analytics and Business Intelligence, 2021
- Generative adversarial networks — Hype Cycle for Data Science and Machine Learning, 2021 still tracks this technology
- Health passport — Two Hype Cycles still track the renamed health pass, including Hype Cycle for Digital Government Technology, 2021

- Low-cost single-board computers at the edge — Hype Cycle for Edge Computing, 2021 tracks the renamed technology, single-board edge computers
- Ontologies and graphs — Hype Cycle for Natural Language Technologies, 2021 still tracks the renamed technology, ontologies and knowledge graphs
- Packaged business capabilities — Six Hype Cycles still track this technology, including Hype Cycle for Cloud Computing, 2021
- Private 5G — Three Hype Cycles still track this technology, including Hype Cycle for Enterprise Networking, 2021
- Responsible AI — Four Hype Cycles still track this technology, including Hype Cycle for Artificial Intelligence, 2021
- Secure access service edge (SASE) — Eight Hype Cycles track the renamed SASE, including Hype Cycle for Cloud Computing, 2021
- Self-supervised learning — Hype Cycle for Data Science and Machine Learning, 2021 still tracks this technology
- Small data — Three Hype Cycles still track the renamed small and wide data, including Hype Cycle for Enterprise Information Management, 2021
- Social distancing technologies — Two Hype Cycles still track this technology, including Hype Cycle for Business Continuity Management and IT Resilience, 2021

On the Rise

Digital Platform Conductor Tools

Analysis By: Roger Williams, David Cappuccio, Dennis Smith

Benefit Rating: Transformational

Market Penetration: Less than 1% of target audience

Maturity: Embryonic

Definition

Digital platform conductor (DPC) tools coordinate the various infrastructure tools used to plan, implement, operate and monitor underpinning technology and services for applications and digital products. They support digital business, regardless of the environments used or who owns them. DPC tools provide a unified view of underpinning technologies and their connection to applications. This augments strategic decision making and improves the value obtained from technology investments.

Why This Is Important

Traditional and hybrid infrastructure management tools fall short of the requirements of "anywhere operations." Moreover, as infrastructure and operations leaders struggle to manage their portfolio of investments to enable composable business, while optimizing costs and reducing risks, they need help to fill the gaps in visibility, assurance and coordination. These pressures are fueling the rise of DPC tools, which help organizations close these gaps in functionality.

Business Impact

DPC tools address the following gaps in infrastructure management toolsets:

- Providing visualizations of digital platform performance across all life cycle stages — planning, implementing, operating and monitoring.
- Enabling continual optimal performance and placement of workloads across all environments — on-premises, in the cloud or at the edge.
- Ensuring that improvement initiatives show tangible business value across all technology architectures — compute, storage, middleware and network layers.

Drivers

- Difficulty in maintaining an inventory of all technology infrastructure resources and their dependencies, aligned with changes to services, applications, and components and configurations of their promised performance levels.
- Lack of transparency into spending for hybrid digital infrastructure and how resource capacity aligns to actual application workload demand.
- Need to guide where workloads are processed (data center, public cloud, colocation facility, etc.) based on requirements, including capacity, cost and dependency dynamics.
- Challenges with estimating the value, efficiency, quality and compliance delivered by hybrid digital infrastructure based on aggregated data from performance analysis tools and other hybrid digital infrastructure management (HDIM) toolset data feeds.
- Desire for a single point of entry and reporting for digital platform resource requests, and routing them to appropriate HDIM tooling for fulfillment.
- Gaps, duplication and conflicts in data to support application workload migration and business continuity goals, as well as protection of data from accidental deletion or malicious activities.
- Inability to confirm compliance of application workloads and digital platforms to identity requirements and security baselines as part of the organization's cybersecurity mesh approach.
- Poor credibility of business cases for digital platform improvements, including: assessing business impact; measuring gaps between current and desired performance; providing oversight of improvement efforts; and validating benefits delivered.

Obstacles

- Lack of interoperability: Tool sprawl and difficulties in integration will limit DPC tool adoption. The technology landscape is littered with failed approaches that were intended to support data sharing between vendors.
- Lack of data credibility: The desire for a complete, accurate view of all technology as a precondition for decision making has been around for decades, yet is no closer to being realized. Customers that require perfect data before they act, and vendors that design their DPC tools to only work with complete and accurate data, will continue to co-create expectations that will not be met.

- Lack of budget: DPC tools may be viewed as “overhead” that does not have a compelling business case. No one likes paying for something that does not address specific pain points felt today.
- Lack of vendor commitment: Many vendors will be tempted to “DPC wash” their existing offerings and claim that these capabilities are already addressed or can be added for very little cost.

User Recommendations

- Build a DPC tooling strategy that supports digital business ambitions by defining the management elements, environments and technology layers required to meet the organization’s infrastructure needs now and in the future.
- Address measurement and coordination gaps by working with key stakeholders to identify infrastructure value, risk and cost objectives, and making targeted investments in integration, dependency mapping and continuous improvement capabilities.
- Plan for DPC tooling investments by determining which DPC capability aspects are needed in the short, medium and long term. Compare these capabilities to current and future vendor offerings for infrastructure management tooling that can provide initial DPC tool functionality.
- Ensure that DPC tooling investments can deliver sustained value by requiring that DPC tool marketers show how the tool will address current organizational pain points and how it will adapt to future needs as organizational requirements evolve.

Sample Vendors

Amazon Web Services (AWS); Cloudsoft; Flexera; LeanIX; Microsoft; OpsRamp; ServiceNow; Snow Software

Gartner Recommended Reading

Innovation Insight for Digital Platform Conductor Tools

Rethink Your Infrastructure Management Tool Selection Strategy

AI-Augmented Design

Analysis By: Brent Stewart

Benefit Rating: Transformational

Market Penetration: Less than 1% of target audience

Maturity: Embryonic

Definition

AI-augmented design, or generative 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

AI-augmented design is in its infancy. Conceptually, the design community sees the bold, fascinating — and even frightening — future that AI-augmented design will enable. Gartner expects to see AI at work in the digital product design platform market soon, leading to major leaps in efficiency, quality and time to market. AI will appear first as feature-level support (e.g., intelligent design recommendations) and will rapidly transition to full digital product design capabilities.

Business Impact

In a future powered by AI-augmented design, 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, user experience (UX) teams will shrink, and the remaining practitioners will be focused on research, strategy and design curation, rather than design production.

Drivers

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

- Tell the AI that you want an online store; the AI will automatically generate the standard structural elements of an online store from the homepage to product detail templates to the shopping cart.
- Apply your style guide, giving the AI inputs on color, typography, iconography, photographic 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 will produce three high-fidelity design directions on which you can evaluate and iterate.

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 AI-augmented design. Key drivers in this category include:

- **Product delivery** — AI-augmented design promises to accelerate digital product delivery more than any technology in recent history.
- **Accessibility** — AI-augmented designs and code 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.
- **UX/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.

AI-augmented design 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 AI-augmented design will be continually inhibited by three key factors:

- **Cost** — AI-augmented design is a heavy lift that requires deep talent, long timeframes and deep pockets.

- **Jobs** — AI-augmented design 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 AI-augmented design pulls from established product types and design patterns, it will not be notable for its originality. Many UX practitioners are concerned that our UX will become too uniform and lack originality.

User Recommendations

Software engineering leaders responsible for UX design should:

- Assess developments in AI-augmented design, specifically at Adobe, followed by Figma and InVision.
- Prepare digital product teams for the emergence of AI-augmented design, 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 XD; Figma; InVision

Gartner Recommended Reading

Emerging Technologies: Critical Insights Into AI-Augmented Software Development

Top Strategic Technology Trends for 2021: AI Engineering

Artificial Intelligence Maturity Model

Hype Cycle for Artificial Intelligence, 2020

Predicts 2020: Artificial Intelligence Core Technologies

Quantum ML

Analysis By: Chirag Dekate, Martin Reynolds

Benefit Rating: Transformational

Market Penetration: Less than 1% of target audience

Maturity: Embryonic

Definition

Quantum machine learning is a type of machine learning that uses quantum computing techniques to potentially accelerate training of ML systems. Currently, only a limited number of quantum ML algorithms exist, with no confirmed evidence of speedup.

Why This Is Important

Theoretically, quantum machine learning (quantum ML) enables a subset of ML algorithms to be run on an entirely new computing paradigm — quantum computing. We have yet to see any evidence that ML could benefit from quantum computing over traditional alternatives. However, the parallel nature of some ML techniques could make quantum computing a viable path to explore.

Increasing awareness of quantum ML capabilities plays a key role in determining its potential value.

Business Impact

Quantum ML continues to be in an embryonic stage, with most R&D activities clustered around devising quantum algorithms for key ML kernels. However, the scale of the systems and algorithms and the challenges associated with “data loading” will limit adoption in the near term. Potential applications of quantum computing in artificial intelligence and ML include quantum search, recommendation algorithms, quantum algorithms for game theory, and quantum algorithms for decisions and learning.

Drivers

- Early research in developing quantum ML initially indicated the potential for applicability across a growing set of ML algorithms, including k-means, k-medians, hierarchical clustering, principal component analysis, neural networks, support vector machines, nearest neighbors, regression and boosting.
- However, new research in this ever-evolving field seems to call into question the potential applicability of quantum computing in ML. Additionally, considerable hardware and software challenges remain.
- R&D today is focused on developing different quantum algorithms for ML kernels. Vendors such as IBM have prototype ML algorithms implemented for very select use cases.
- Developing scalable ML systems will require many qubits and fundamental advances in applicable quantum algorithms.

Obstacles

While quantum ML is theorized to work effectively in noisy intermediate-scale quantum (NISQ) computers, it is not ready for mainstream adoption today. Key obstacles include:

- A nascent quantum computing ecosystem — Quantum computing is still at a very early stage of development, with many systems offering scaling limited to tens of qubits. As a result, algorithms executed on these systems are primarily exploratory in nature.
- Data encoding — Although quantum computing can hypothetically deliver dramatic boosts for certain classes of data, one of the challenges is encoding input data. For quantum ML to work at scale, large amounts of data must be encoded and loaded into the quantum system.
- Lack of mature algorithms — New algorithms that can take advantage of capabilities offered by near-term noisy quantum systems will need to be discovered.

User Recommendations

Data and analytics leaders seeking to leverage risk-minimized quantum ML should:

- Reinvest budget in your classical ML ecosystems, where the value return will be demonstrably higher than in simulated quantum environments. Explore quantum ML environments at your own risk.

- Increase your awareness of quantum computing capabilities and the potential for applicability in ML use cases by exploring early quantum ML algorithm prototypes on current systems.
- Prepare for quantum ML by partnering with quantum computing solution providers and consulting experts to devise new ML algorithm kernels.
- Leverage quantum-as-a-service capabilities for validating hypotheses involving quantum ML to minimize risk and maximize the accessibility of quantum computing resources.

Sample Vendors

D-Wave; Google; IBM; Microsoft Corporation; Pennylane; Xanadu

Gartner Recommended Reading

Predicts 2021: Disruptive Potential During the Next Decade of Quantum Computing

Innovation Insight for Quantum Computing for the Automotive Industry

Cool Vendors in Quantum Computing

AI-Driven Innovation

Analysis By: Arun Chandrasekaran, Brian Burke

Benefit Rating: Transformational

Market Penetration: Less than 1% of target audience

Maturity: Embryonic

Definition

AI-driven innovation refers to the use of artificial intelligence technologies in the process of innovation. AI-driven innovation could either be in the form of new inventions like new drugs or material discovery in specific domains, or could be used to boost agility and efficiency in an end-to-end innovation process pipeline across use cases and industries.

Why This Is Important

Advancements in the field of AI have the potential to directly influence both the creation and optimization of a wide range of products and services, with important implications for organizations through better productivity, agility, workforce rebalancing and ability to outpace competition. While these changes themselves are critical, AI also has the potential to change the innovation process, making it more efficient, streamlined, data-driven and responsive to changing market needs.

Business Impact

The near-term business impact of AI will be in these innovation process areas:

- Trend identification, pattern matching and technology scouting
- Idea generation and testing practical feasibility of an idea based on potential and constraints
- Prototyping an idea, often using agile, lean methodologies
- Generative designs for the idea by iterating against user preferences by target customers (demographics, gender, race)

AI's long-term impact will be in the area of generative product/service development.

Drivers

Increasingly, organizations are turning to AI technologies to accelerate the innovation process overall, and perhaps most significantly to augment the ideation process with generative AI approaches.

The following are key business drivers for AI-driven innovation:

- **Faster and better ideation and prototyping:** The usage of AI removes data and information processing constraints in the ideation process. Recent advances in areas such as synthetic data and AutoML have made it feasible to apply AI to the ideation process to increase its overall robustness and augment human decisions. By poring through massive quantities of information, and through pattern recognition and other techniques, AI systems can generate more ideas. Innovation is about generating ideas so that there is a wide pool of hypotheses that can be tested before moving into a prototype phase — the usage of AI can create a wider funnel of innovative ideas.

- **Ability to create breakthrough products:** Recent advancements in areas such as reinforcement learning have given rise to exciting new use cases in areas such as robotics (contextual awareness), chemistry (optimizing molecular reactions) and autonomous vehicles.

- **Generative AI being used to augment ideation processes:** While there are game-changing opportunities like drug discovery and material science, generative AI is also being used to optimize the engineering of prototype parts or in designing buildings to optimize for light, space and efficiency.

Obstacles

AI can augment the innovation process in many areas with varying success, largely dependent on the maturity of the technique:

- Creating a decision framework on where to use AI in the innovation process and what techniques to employ, and ensuring adequate availability of data and other resources is a major obstacle.
- Trend identification and pattern matching tools are based on natural language processing technologies, which Gartner classifies as emerging, with some commercial products available but not yet fully proven.
- Many opportunities that exist for ideation leverage generative AI techniques, which Gartner classifies as embryonic and are mainly in lab development, and in many cases are unstable.
- AI tools to test feasibility are domain-specific and at varying levels of maturity.
- Using generative design for prototyping is viable and the technology is relatively stable, but critics argue that, among other design issues, too many options result in “overchoice” and slower decision making.

User Recommendations

- Shortlist specific areas where the usage of AI will augment your innovation process and allow you to bring products to market faster and less expensively. Start with more proven areas, such as trend identification, technology scouting and idea generation, which have higher business relevance and easier operationalization.
- Focus on solving the two critical challenges with the application of AI for innovation — managerial and employee training on AI, and demystifying the AI decision process through better access to quality data and model explainability.
- Focus on AI as a tool for human augmentation in the innovation process and set expectations regarding generative AI being a futuristic scenario.
- Encourage experimentation to gather hands-on experience on the feasibility of various AI use cases for innovation.
- Work with startups and vendors that can offer commercial solutions to address specific innovation process challenges, rather than “building AI.”

Gartner Recommended Reading

Innovation Insight for Generative AI

Top Strategic Technology Trends for 2021: AI Engineering

Influence Engineering

Analysis By: Andrew Frank

Benefit Rating: Transformational

Market Penetration: Less than 1% of target audience

Maturity: Embryonic

Definition

Influence engineering (IE) refers to the production of algorithms designed to automate elements of digital experience that guide user choices at scale by learning and applying techniques of behavioral science.

Why This Is Important

The abundance of data sources and machine learning capabilities enables new systems of influence. Though still largely theoretical, breakthroughs in areas such as emotion detection and language generation show clear potential to automate influential aspects of communication. Examples have shown how AI can amplify bias and other harmful effects, yet beneficial goals may accelerate positive social change. This suggests a need for new forms of governance to oversee IE research and deployments.

Business Impact

Alongside profitable growth, businesses face growing demands to deliver on environmental and social goals, responsibly and transparently. The success of transformative initiatives needed to address these demands depends on market adoption. As IE techniques mature, their power to shape opinions and choices will increase to the benefit or detriment of these transformations. The long-term health of enterprises is thus impacted by their ability to wield these tools effectively in beneficial ways.

Drivers

Evidence of AI's power in marketing:

- Investments and breakthroughs in AI from global platform providers (such as Google, Apple, Facebook and Amazon) and martech vendors (such as Adobe, Salesforce and Oracle) remove barriers to AI adoption in marketing.
- The emergence of technologies such as deepfakes and chatbots illustrate AI's ability to synthesize lifelike experiences.
- Academic work confirms the applicability of machine learning in experiments on influence.
- Use of AI is strongly associated with marketing automation, recommendations and personalized digital experience, all high-priority initiatives in marketing, commerce and communication.

Commercial goals:

- Pressure is mounting on marketing organizations to deliver better results with lower costs and the loss of key data sources such as browser cookies.
- The shift of consumer behavior toward digital channels for work and commerce creates more opportunity for automated experience elements.

Social goals:

- Pressure is also mounting on corporations to explicitly address societal impacts, as expressed in investors' environmental, social and corporate governance (ESG) ratings by nudging consumer choices toward more sustainable and equitable lifestyles.
- Social fractures create widespread desire to find common ground and unify digital society in ways beyond the capabilities and scope of regulation.

Obstacles

- Widespread popular condemnation of manipulative technologies is evident, for example, in the recent backlash against Spotify's patent on vocal emotion detection and in popular exposés such as "The Social Dilemma" and "The Great Hack."
- The deprecation of popular personal data collection mechanisms such as browser cookies and mobile device IDs that provide behavioral datasets used to train personalization algorithms creates the need to establish new sources of training data.
- Government action is increasing, including: restrictions on use of personal data and unexplained profiling; oversight of AI's role in propagating bias and discrimination.
- There is a lack of established approaches or tools. The market is characterized by divergent approaches and conflicting claims as investors and entrepreneurs seek to exploit a building wave of hype.
- General skepticism is common, as the actual potential of these technologies remains speculative and many experts question assumptions of viability.

User Recommendations

- Establish or locate the governance structure within your organization where the opportunities for IE are best investigated. Discover use cases and debate the goals and extent of potential commitments. Assure broad, cross-functional representation and ethics committee participation.
- Assure that statements of purpose are translated into measurable goals used to train machine learning algorithms involved in IE.
- Recruit friendly user test groups for research and experimental projects. Be transparent about goals and technologies. Be aware when research activities require advance informed consent.
- Embed longer-term business metrics in operational dashboards and monitoring processes used to measure and motivate performance. Make opinion sampling and goodwill measurement regular features of your organization's health check.
- Build your organization's knowledge center for IE, and include organizational learning, assessment of competitors' and platform providers' activities.

Gartner Recommended Reading

Why the Voice of Society Is Getting Louder

Digital Marketing Survey 2021, Part 3: Marketers Test Emerging Technologies to Drive Personalization

Tech Providers 2025: Rise of the AI-Enhanced Agile Marketing Practice

Top Strategic Technology Trends for 2021

Predicts 2021: Balance Privacy Opportunity and Risk

Machine-Readable Legislation

Analysis By: Bill Finnerty

Benefit Rating: Transformational

Market Penetration: Less than 1% of target audience

Maturity: Embryonic

Definition

Machine-readable legislation (MRL) is developed by creating the text for legislation or policy simultaneously with the computer code that will be used to implement them. Through concurrent development, technical challenges to the implementation of policy are reduced; however, systems must be built in a modular approach that allows for the implementation of this business logic. MRL enables governments to implement a more consistent and equitable application of the law.

Why This Is Important

MRL ensures policy is designed and implemented as intended, reflected in subsequent administrative rules and automatically carried out by various systems. Implementing laws as computer programs is often difficult, as laws are not necessarily written with binary logic in mind. However, the policy is the technology and technology is the policy and the two are inseparable in a digital society. Society will benefit as systems across industries are implemented in a more consistent manner.

Business Impact

Implementing MRL will be a cross-disciplinary activity, requiring the necessary skills in policy and IT shops, technology implementation and ecosystem engagement to ensure the developed “business logic” is created and used to improve the regulatory process and promote economic benefits. MRL will be a fundamental technical element in creating a composable government to support a digital society by making the writing of laws more data-driven and their implementation more consistent.

Drivers

As an emerging innovation, the drivers for MRL are more aspirational than concrete. However, there are a number of existing challenges that governments face in the transition to digital government that can be addressed through the implementation of MRL.

- **The gap between legislative intent and implementation.** By implementing MRL, the room for interpretation of legislative or executive intent is eliminated from the process, instead making the law that is passed the same as that which is implemented.

- **Limitations in existing legislative processes to respond quickly to needed change.** The ability for governments to iterate, expediently, laws to maximize societal outcomes is difficult in existing legislative processes. MRL, when coupled with other emerging technologies, such as machine learning and digital twins of government, can enable iteration of a large number of scenarios impacting multiple public programs. This approach enables a broader use of data-driven policy and decision making.
- **The need to reduce the cost of developing new laws or updating existing ones.** Implementing MRL and exposing the approved "business logic" as APIs to the partner community, governments will be able to reduce the costs of implementing policy changes and auditing systems. Removing the economic burden related to implementing changes in policy and law can make updating laws more palatable for the broader ecosystem.
- **The needs of a digital society require an updated approach to making laws.** Ultimately, as Estonia's X-tee platform revolutionized government and demonstrated what is possible for digital government, a country that is able to effectively establish MRL will reduce friction in their economy and create a competitive advantage. Countries that accomplish this will be in the position to best meet the needs and evolving expectations of a digital society.

Obstacles

- MRL will require a shift in how policies and laws are developed and implemented; this is beyond the span of control for most CIOs. For those in the position to influence the adoption of MRL, obstacles will need to be dealt with at the executive and legislative levels.
- MRL will change the existing dynamics and power structures related to the development of laws and policy, which may cause those currently in leadership positions to resist its adoption.
- The lack of digital skills in policy teams can generate resistance to the concept of MRL.
- Governments will need to invest in testing capabilities to allow for testing of frequent system updates.
- The private sector may have concerns that MRL will eliminate competitive advantage in their market.

- Society may have concerns related to consolidation of power in what can be perceived as a digital black box.

User Recommendations

- Engage political leadership in establishing a roadmap to adopt MRL. Begin by enacting a law requiring digital-ready legislation, then determine the skills and technology gaps that need to be addressed to implement MRL, and finally educate lawmakers, activists, lobbyists and the public on benefits and risks related to implementing MRL.
- Work with legislative and executive policymakers to adopt a plan for embedding digital capabilities in policy development shops.
- Engage with private-sector partners early in the process of developing machine-readable laws to ensure they understand the shift, are able to provide input and are prepared to make the necessary changes to their solutions to leverage the new capability.
- Refactor existing systems to leverage the business logic of an MRL as an API.
- Gain input from the public on the opportunities and concerns they have with MRL by working with government leaders on a constituent engagement plan.

Named Data Networking

Analysis By: Sylvain Fabre

Benefit Rating: Transformational

Market Penetration: Less than 1% of target audience

Maturity: Embryonic

Definition

Named data networking (NDN) is an architecture for the future internet that associates unique names (similar to URLs) to blocks of data that can be stored, digitally signed and transmitted across nodes, rather than naming endpoints. The current system transports data containers (packets) between two endpoints using an IP address.

Why This Is Important

NDN can improve expert and citizen data scientist productivity. NDN simplifies processing and mining the huge datasets generated by new scientific fields such as climate science, genomics as well as Internet of Things (IoT) devices, across multiple repositories in various geographies, at the network layer. NDN, by performing all operations such as forwarding requests to data sources, content discovery, access and retrieval using content names, eliminates the need for a location layer.

Business Impact

NDN addresses some of the fundamental weaknesses of the Internet Protocol (IP), such as security and efficient content distribution. But it will need to support current services and applications. To succeed, NDN will need strong support not only from academia, but also from the IT and telco industries — which it would disrupt. NDN could have a major impact on the networking industry, not just routers and switches, as well as the application layers such as search, social and web browsing.

Drivers

- The National Science Foundation (NSF) began development of named data networking (NDN) in 2010 and it evolved into a consortium of academic and industry members.
- In telecom applications, the use cases, as well as the benefits of NDN could complement those of edge computing, at least regarding caching, video optimization, application acceleration and bandwidth saving, but adoption remains uncertain even within a 6G time frame.
- NDN will also provide an architecture with the ability to effectively and securely support broadcast/multicast of content (with native caching) and the IoT.
- Being a clean-slate design, NDN has the opportunity to introduce leapfrog innovation in networking, but this might also hinder its adoption.

Obstacles

- The overhead of naming everything would be onerous when looking at small nodes such as IoT devices and wearables.
- Defining and agreeing on a global naming strategy and standards would be challenging, especially with current fragmentation.
- As IPv6 has demonstrated, introducing large-scale changes in the network is not easy.
- Inertia associated with IP: even a new protocol (v6) has taken 20+ years to get to 30% adoption.
- Although the Named Data Networking Consortium has several members from the telecom industry (see Sample Vendors section below), there is no evidence of adoption of NDN in 5G commercial implementations (which started back in 2018), or investment in its future.
- There are no commercial implementations of NDN yet, only some early interest from academic researchers, and none from enterprises.
- There doesn't appear to be any strong commercial demand for NDN from any key stakeholders, probably because the disruption would be extreme and the benefits uncertain.

User Recommendations

- Evaluate how NDN could impact your networking portfolio strategy in the long term.
- Evaluate the pros and cons of playing an early innovator role in NDN development.
- Use NDN to simplify data discovery for scientific research for institutions that generate and mine large datasets (petascale and over) over multiple locations.
- Fasten data retrieval by using NDN for in-network caching of popular datasets.
- Empower your research community to create infrastructure that supports operations by using NDN to enable creation of federated content repositories, retrieval from multiple sources and remote data subsetting.

Sample Vendors

Cisco Systems; Fujitsu; Huawei; Intel; Juniper Networks; Panasonic; Viasat

Physics-Informed AI

Analysis By: Erick Brethenoux, Svetlana Sicular

Benefit Rating: Transformational

Market Penetration: Less than 1% of target audience

Maturity: Embryonic

Definition

Physics-informed AI (PIAI) incorporates physical and analog principles, governing laws and domain knowledge into AI models. By opposition, purely digital AI models do not necessarily obey the fundamental governing laws of physical systems and first principles — nor generalize well to scenarios on which they have not been trained. PIAI extends AI engineering to complex system engineering and model-based systems.

Why This Is Important

As AI becomes critical, greater demand is placed on AI's ability to abstract problems and better represent its context. Digital-only AI solutions cannot generalize well enough beyond the training data, limiting their adaptability. PIAI instills a more reliable representation of the context and the physical product, yielding more adaptive systems. A better ability to abstract leads to greater physical consistency, reduced training time, improved data efficiency and better generalization.

Business Impact

PIAI can:

- Build physically consistent and scientifically sound AI models, significantly improving their applicability.
- Increase data efficiency, i.e., train models with fewer data points.
- Accelerate the training process, i.e., help models converge faster to optimal solutions.
- Improve the generalizability of models to make reliable predictions for unseen scenarios, including applicability to nonstationary systems.
- Enhance transparency and interpretability to make models more trustworthy.

Drivers

- Among many lessons, the pandemic has shown how brittle our traditional business modeling approaches were. That brittleness also comes from the fact that the digital building blocks making up our solutions cannot generalize well enough beyond their initial training data, therefore limiting the adaptability of those solutions. PIAI approaches can instill a more flexible representation of the context and conditions in which our systems operate, allowing developers to build more adaptive systems.

- Traditional AI techniques, particularly in the machine learning family, have been confronted with severe limitations — especially when it comes to causality and dependency analysis, context flexibility and memory retention mechanisms. Increasing demand on those techniques calls for new methods to overcome those limitations. PIAI approaches provide additional physical knowledge presentations, such as partial differential equations or active metadata, to guide or bound AI models. Asset-centric industries have already started leveraging these methods in physical prototyping, predictive maintenance or composite materials analysis also in conjunction with Augmented Reality/Virtual Reality implementations.

- Complex systems like climate and environmental issues, large scale digital-twin modelization and complex health science problems have been particularly challenging to model. Composite AI approaches have helped and provide more concrete answers and manageable solutions to those problems, but their engineering remains a significant challenge. PIAI can provide more immediate answers to some of those problems.

- The need for more robust and adaptable business simulation systems will also promote the adoption of PIAI approaches. With a better range of context modelization and more accurate knowledge representations techniques, simulations will be more reliable and account for a wider range of possible scenarios — all better anchored in reality.

Obstacles

- From a diagnostic perspective, the development of systematic tests and standardized evaluation for these models — across benchmark datasets and problems — could slow down the adoption of PIAI capabilities.
- Computationally, the scaling of the training, testing and deployment of complex PIAI models on large datasets — in an efficient manner — so they perform well in a rapidly changing computational landscape will also be an issue.
- Resource-wise, the collaboration across many diverse communities: physicists, mathematicians, computer scientists, statisticians, AI experts and domain scientists, will also be a challenge.

User Recommendations

- Encourage reproducible and verifiable models by starting with small-scoped problems; complex systems and environments are generally good candidates for this approach.
- Enforce standards for testing accuracy and physical consistency applicable to state-of- the-art physics and first-principles-based models of the relevant domain, while characterizing sources of uncertainty.
- Set realistic development objectives by identifying errors that cannot be reduced and discrepancies that cannot be addressed — including the quality of training or synthetic data.
- Promote model-consistent training for PIAI models and train models with data characteristics representative of the downstream application, such as noise, sparsity and incompleteness.
- Quantify generalizability in terms of how performance degrades with degree of extrapolation to unseen initial conditions, boundary conditions and scenarios.
- Build interpretable models and use semantics and active metadata to inform the context where models operate.

Sample Vendors

Google (Deepmind); MathWorks; NNaisense; NVIDIA

Sovereign Cloud

Analysis By: Rene Buest, Tiny Haynes, Neville Cannon, Gregor Petri

Benefit Rating: Transformational

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition

Sovereign cloud is the provision of cloud services within a single geography meeting data residency and legislative requirements. Sovereign cloud helps ensure that data remains free from external jurisdiction control and provides protection from foreign legislatively enforced access. Countries engage a sovereign cloud to achieve digital and data sovereignty to provide rules and legal requirements to apply data protection controls, residency requirements, protectionism and intelligence gathering.

Why This Is Important

The importance of digital sovereignty has risen in step with growing discord within global economics, protecting intellectual property, expanding privacy legislation and the desire to be more self-sufficient due to the dominance of a small number of large Chinese and American technology and service providers. The public sector recognizes the value of the digital economy and seeks to develop infrastructure and ecosystems capable of delivering a digital citizen experience while maintaining autonomy.

Business Impact

Legislative mandates can and are being applied to limit the ability to use multinational vendors' services. This clearly impacts current investments and potential sales growth. National vendors may view the changing legislative landscape as a catalyst for further investment and growth. As a result, end users could find themselves in a regulated/fragmented market without access to the software and services that they need to support their ongoing digital business initiatives and drive innovations.

Drivers

- Digitization initiatives need secure and reliable access to data sources and the ability to contextualize and aggregate data from a large number of internal and external data sources. Platform businesses like Alibaba Group, Alphabet, Amazon or Tencent are beneficiaries of this.
- Platform businesses are heavily dominated by U.S. and Chinese companies due in part to their individual market sizes and the common language and currency. Other countries, especially in Europe, lag behind and have already lost national or regional control in core technology areas, such as e-commerce, microprocessors, 5G infrastructure and smartphones, which are necessary to build and run platform businesses. The same applies to the foundational technologies to drive digital transformation and build digital business models or a platform business.
- The market for digital and cloud technology and services is dominated by the U.S. and Asian technology and service providers. As a result, European companies mainly have to access non-European services and technology to build and run digital business models. Hence, data is being stored within non-European cloud and digital service providers, which creates political uneasiness.
- As digital services become increasingly important and system-relevant, companies and regional trade bodies worry about retaining control over their data to stay compliant with local regulations.
- Some more regulated industries and governments are particularly concerned by the U.S. and Chinese legal frameworks that might allow government access under specific circumstances to customers' data.
- In addition, dependence on non-local providers of cloud infrastructure and platform services also comes with economic concerns, such as providers not paying appropriate taxes on transactions conducted within a country or region.

Obstacles

- The range of services and capabilities of hyperscale cloud providers far exceeds pure virtualized infrastructure. Considerable technical obstacles exist if sovereign clouds are expected to deliver the maturity and level of scalability and functionality of hyperscale competitors.
- Too few skilled engineers exist to replicate the design capabilities across multiple countries, simultaneously. With lower levels of skills being available, security and operational maturity will be compromised, potentially leading to greater security and failure risks.
- To date, no non-U.S. or Chinese provider shows the capabilities to compete against one of the hyperscale providers. The market dynamics make it almost impossible for a national vendor to become a strong competitor. Local vendors typically invest significantly less than global players in new infrastructure and find themselves essentially playing catch-up.
- Due to lack of competition, companies will choose to build on technology platforms owned by providers from outside their country.

User Recommendations

- Subject proposals for sovereign cloud to the same level of risk assessment that current cloud computing providers are subjected to. Do not assume that the sovereign cloud conveys any additional security measures in itself.
- Make explicit decisions about your organization's digital sovereignty and track the cloud climate change. Base your plans on the assumption that changes in global cloud climate will potentially disrupt your business.
- Explore evaluating local cloud services for workflows that can be provided locally and leverage third-party solutions to protect data and ensure it is compliant with local requirements.

Gartner Recommended Reading

Market Trends: Europe Aims to Achieve Digital Sovereignty With GAIA-X

Tech Providers 2025: Strategic Responses to Disruption From Geopolitics and World Events

Tech Providers 2025: Strategic Impacts to the Competitive Landscape

Industry Clouds

Analysis By: Gregor Petri

Benefit Rating: Transformational

Market Penetration: Less than 1% of target audience

Maturity: Embryonic

Definition

Industry clouds leverage underlying cloud services to offer business and technical capabilities that are specifically relevant to an identified vertical industry. Industry clouds aim to address the unique and evolving functional, regulatory or technical requirements and use cases of the addressed vertical industry and offer a whole product.

Why This Is Important

Cloud adoption has been growing at record pace, but total cloud spend currently makes up only about 10% of global enterprise IT spend. The majority of organizations use one or more cloud services in a variety of areas. But broader 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.

Business Impact

Industry clouds will have a lasting impact on cloud customers, blurring the lines between established cloud services such as infrastructure as a service (IaaS), platform as a service (PaaS) and SaaS, and also between cloud providers and cloud SIs and MSPs. The market is taking a classic page from Geoffrey Moore's "Crossing the Chasm," by creating whole-product offerings that cater directly to the established needs of vertical industry enterprises.

Drivers

- Industry clouds have the potential to cover the full functional breadth required for a specific industry, from top (with a suite of applications) to bottom (middleware and infrastructure). So far, organizations bought cloud services as either specific point solutions, in the form of somewhat siloed top to bottom SaaS applications, or as an alternative for a horizontal layer of their technology stack, in the form of IaaS or PaaS services.
- Today, industry clouds are largely being initiated and created by large cloud and software providers, although we see some industry enterprises considering creating an industry cloud as the basis for a manufacturing, food or pharma ecosystem.
- Enterprises can gain value from industry clouds through shared best practices and thought leadership offered through 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 mine the data from their existing applications; industry-specific functionality applications and collections of industry-specific functional building blocks available in industry cloud marketplaces; choosing a combination of the above as a (pre-)composed industry solution.
- Industry clouds create value for enterprises by bringing traditionally separate purchased solutions together in a preintegrated solution. This can simplify the sourcing, implementation and integration process, but enterprises need to realize that providers will initially build out their offering from the infrastructure, application or analytics solutions they historically offered. Leaders in this space are expected to leverage composable cloud and edge approaches to create more holistic and comprehensive industry offerings, which enterprises will be able to recompose to meet unique or special requirements.

Obstacles

- Industry clouds are at risk to follow the same path as community clouds, such as dedicated government clouds. These provided a walled garden where providers added specific vertical functionality, which often led to breaking the compatibility and upgradability with the cloud it was derived from. This left enterprises on a long-term unsupported or unsupportable fork or copy of the cloud of their choosing.
- Initially, industry clouds will cater to the needs of individual enterprises, but to reach their full potential, they will evolve into something best described as ecosystem clouds. Enterprises can leverage these ecosystems by participating in shared (business) processes, such as shared procurement, shared distribution, shared payment procession, and maybe even shared R&D and innovation. This is a step beyond the initial sharing of infrastructure and technology that clouds traditionally brought to the table.

User Recommendations

- Assess the industry-specific features promoted by cloud providers, and distinguish between real technology or functionality offerings versus marketing messages.
- Take into account that vendors choose different paths to add industry value: some focus on compliance with industry regulations, some on adding analytical capabilities to existing or partner-sourced functionality, others invest in building or acquiring specific functional building blocks. Longer term, we expect composability to play a significant role in creating more comprehensive and adaptable industry clouds.
- Select industry cloud offerings that satisfy both your IT/cloud requirements and your vertical industry end-user or line-of-business requirements
- 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; Google; IBM; Infor; Microsoft; Oracle

Gartner Recommended Reading

7 Elements for Creating a Pragmatic Enterprise Cloud Strategy

Future of Applications: Delivering the Composable Enterprise

Predicts 2021: Navigating Through the Changes for Vertical Industries

Gartner's Vertical Strategy Framework: Your Roadmap for Successful Industry Go-to-Market Strategies

Tech Providers 2025: Strategic Impacts to the Competitive Landscape

Homomorphic Encryption

Analysis By: Mark Horvath, Mark Driver, Bart Willemsen

Benefit Rating: Transformational

Market Penetration: Less than 1% of target audience

Maturity: Emerging

Definition

Homomorphic encryption (HE) is a set of algorithms that enable computation on encrypted data. Fully homomorphic encryption (FHE) supports arbitrary mathematical operations, but has significant performance impact and is not yet practical. Partial homomorphic encryption (PHE) supports much more limited use cases with lower performance impact than FHE. Currently, commercial products are supported by some versions of PHE, but fast FHE over the Torus (TFHE) is beginning to appear in the market.

Why This Is Important

When fully realized, homomorphic encryption will be an unparalleled advance in privacy and data processing. Benefits include:

- Performing data analytics on encrypted data such that the processor never sees the data in the clear, but delivers accurate results.
- Sharing and pooling data among competitors allowing them to accomplish joint tasks (e.g., sharing AML data) without giving up secrets or privacy.
- Allowing data subjects to share all or part of their sensitive data without giving up privacy.

Business Impact

Homomorphic encryption, even in its current restricted form (PHE), allows businesses to use data, send it to others for processing and return accurate results without fear that the data will be lost, compromised or stolen. Any data intercepted by a malicious actor will be encrypted and unreadable, even by the coming generation of quantum computers. Applications include:

- Encrypted search
- Data analytics
- ML model training
- Multiparty computing
- Secure, long-term record storage without worry of unauthorized decryption

Drivers

There are a few key drivers pushing HE into the market:

- Enhanced enforcement of data residency restrictions globally force organizations to protect data in use, rather than in transit and at rest only.
- Globally maturing privacy and data protection legislative frameworks demand more precise attention on sensitive data. As a result, data pooling, sharing and cross-entity analysis use cases increasingly benefit from forward-looking and sustainable technologies like HE.
- Aside from conventional use cases like AML and cross-entity fraud analytics in the financial realm, the fight against COVID-19 has benefited from analysis of sensitive health-related data analysis across various entities while that data is protected in use.
- Application of HE has been observed in combination with secure multiparty computation (sMPC) to benefit from both internal and external protection of data.

Obstacles

- The feasibility of application of (various forms of) HE in daily use cases leads to a certain complexity, reduced speed of operations, and requiring highly specialized staff.
- The unfamiliarity of the market with this technology stands in the way of speedy adoption.
- FHE is not a Turing-complete framework, meaning an arbitrary set of instructions can't be executed. By its mathematical formalism, it's limited to operations based on addition and multiplication (and their inverses).
- While still highly useful, some scenarios will never be a good fit for THE, but could be addressed using an alternative technology: confidential computing.

User Recommendations

- Brainstorm with your technical and executive teams on opportunities. For example, come up with a list of five to 10 use cases for HE to improve adoption and remove barriers to adoption of core solutions.
- Treat potential HE projects as experiments, keeping in mind both the early stage of the technology as a whole and the significant not-real-time nature of the products. Consider these experiments as proofs of concept until the technology matures.
- Continue existing security controls. PHE does not necessarily negate the need for other security controls (such as protecting decrypted text while in-memory), data residency requirements and access control.
- Assess the core benefits of using homomorphic encryption combined with quantum-safe and privacy-preserving computation techniques.
- Integrate in-use protection through forms of HE into messaging and third-party analytics services.
- Consider piloting HE through the use of a vendor solution, which can offer functionality without the time investment of a custom solution.

Sample Vendors

Duality Technologies; Enveil; IBM; Inpher; IXUP; LiveRamp; Ziroh Labs

Gartner Recommended Reading

Emerging Technologies: Homomorphic Encryption for Data Sharing With Privacy

Emerging Technologies and Trends Impact Radar: Security

Achieving Data Security Through Privacy-Enhanced Computation Techniques

Self-Integrating Applications

Analysis By: Keith Guttridge, Eric Thoo

Benefit Rating: Transformational

Market Penetration: Less than 1% of target audience

Maturity: Embryonic

Definition

Self-integrating applications will use a combination of automated service discovery, automated metadata extraction and mapping, automated process definition and automated dependency mapping to enable applications and services to integrate themselves into an existing application portfolio with minimal human interaction.

Why This Is Important

Integrating new applications and services into an application portfolio is complex and expensive. Gartner research shows that up to 65% of the cost of implementing a new ERP or CRM system is attributable to integration. The technology to enable applications to self-integrate exists in pockets, but no vendor has yet combined all the elements successfully. As applications develop the ability to discover and connect to each other, the amount of basic integration work will dramatically reduce.

Business Impact

- Improved agility, as the time to onboard applications and services is massively shortened.
- Cost savings of up to 65% when onboarding new applications and services.
- Reduced vendor lock-in, as platform migration becomes simpler.
- Greater ability to focus on differentiation and transformational initiatives, as the "keep the lights on" burden is dramatically reduced.

Drivers

- Cloud hyperscalers providing features such as service discovery, metadata extraction, intelligent document processing and natural language processing
- Automation/integration vendors providing features such as intelligent data mapping, metadata extraction, data fabric, next best action recommendations, process discovery and automated decisioning
- SaaS vendors providing features such as process automation, packaged integration processes, portfolio discovery and platform composability
- A new era in which intelligent application portfolio management is placed on top of augmented integration platforms, in order to be where the challenge is finally addressed

Obstacles

- Embedded integration features within SaaS being good enough to enable organizations to get started quickly, thus stalling investment in improving self-integration capabilities.
- A general lack of awareness of the availability of augmented integration technologies to enable self-integrating applications. Many organizations still view integration as a complex issue requiring specialist tools.
- The lack of a clear market leader that is looking to push this technology forward as the major application vendors look to protect their customer bases.

User Recommendations

Application leaders should:

- Ask their major application vendors about the interoperability of applications within their portfolios. This is the area where self-integrating applications are most likely to emerge first.
- Investigate integration vendors that have augmented artificial intelligence features to automate the process of onboarding applications and services into a portfolio.
- Manage their expectations. Self-integrating applications will provide just enough integration with the rest of the application portfolio to enable a new application to work efficiently.

Sample Vendors

Boomi; Informatica; Microsoft; Oracle; Salesforce; SAP; SnapLogic; Workato

Gartner Recommended Reading

Innovation Insight for Self-Integrating Applications

Data Fabrics Add Augmented Intelligence to Modernize Your Data Integration

Composable Networks

Analysis By: Susan Welsh de Grimaldo

Benefit Rating: Transformational

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition

Composable networks are composed of disaggregated, reusable network functions and elements that can be easily integrated and that serve as shared pools of resources. Composable networks are built with modular, automatable components to support the dynamic requirements of a composable digital business. Telecommunications network technology will evolve with modularity with microservices based on containers, and use open APIs to integrate with other interoperable components.

Why This Is Important

Composable networks for CSPs enable more agility to deliver DevOps and low-code/no-code value propositions to customers while reusing integratable and automatable network components to drive efficiency. Implementing composable networks supports broader composable business thinking and design to evolve how CSPs engage with customers and ecosystem partners. By using more granular and modular components to build a network architecture, CSPs can quickly compose workflows and service chains.

Business Impact

Composable networks provide CSPs:

- An open approach where network components can be provided by different players in the supply chain.
- Innovation/faster upgrades that can occur in specific areas as R&D occurs per function.
- Composable network elements that can be made available in digital marketplaces to facilitate discovery and incorporation into the composable technology stack.
- The ability to assemble elements to rapidly seize market opportunities and respond to disruption while being resilient.

Drivers

- Agility and faster time to market to address customer needs and react to competitive offers.
- Adoption of cloud-native architectures, with use of microservices and disaggregation of network functions.
- API-enabled architecture and broader adoption of open APIs (e.g., TMForum APIs); an API-first architecture that will also facilitate discovery, orchestration and automation is the path to modularity.
- Increasing levels of composability evolving over time as products mature and as the vendor community further adopts open frameworks, microservices/containerized solutions and open APIs
- Increasing commercial deployments of 5G stand-alone (5G SA), with the service-based architecture (SBA) in the 5G core.
- 5G network slicing, which enables increased agility for customer-centric service creation by creating a mechanism for composable services across network domains and elements. Using automated processes driven by slice templates to deliver desired service parameters that can be quantified in an SLA.
- Competition with hyperscalers and more digital competitors, and consequential shifts in demand to favor new business models for on-demand, consumption-based delivery and more digital experiences. CSPs will need to shift to sell solutions delivering business outcomes, not one-off products.
- Postpandemic awareness of the increasing need to be able to respond to uncertainty and pivot as needed with less risk, faster speed.
- CSPs increasingly participating in digital ecosystems to find new and differentiating value, and finding their traditional technical capabilities are barriers to such participation. CSPs rebalancing their technology portfolio to accelerate digital transformation to align their technical and nontechnical capabilities, old and new, to business outcomes (see 2021 CIO Agenda: A CSP Perspective).
- More CSPs are building networking, connectivity and IT capabilities agnostically of the services layer specifications and nuances, enabling on demand use.

Obstacles

- Challenges reaggregating functions to interoperate with high reliability.
- Orchestration across components, especially in a multivendor network environment.
- Slow movement toward cloud-native architectures, standard open APIs and 5G SA, all of which will enable increased network composability.
- Management of CI/CD pipelines across a wide range of composable/modular network elements from multiple vendors.
- CSP employee and vendor ecosystem mindsets.
- Siloed organizational structures at CSPs, with separate teams addressing IT and OT as well as network domains.
- Lack of comprehensive and consolidated real-time network inventories and discoverability of network elements.
- Legacy last mile and metro area networks inhibit multitenancy.

User Recommendations

- Plan your network roadmap with concrete steps to move toward composable networks, focusing on increasing automation and interoperability.
- Evaluate unique value propositions of different emerging technologies and vendor solutions/products to aid in developing a composable network.
- Select network vendors which have a vision toward supporting increasing levels of network composability, will work collaboratively and support integration of composable elements into your existing network environment.
- Focus on increasing adoption levels of enabling technologies, e.g., standard open APIs, cloud-native/microservices, 5G SA and real-time consolidated network inventory.
- Assess what aspects of your organizational structure, governance and mindset need to change to support a move toward a composable network.
- Conduct a comprehensive analysis of your available and required skills (business and technical) needed to design and operate composable networks. Identify gaps, and upskill where necessary.

Gartner Recommended Reading

Top Trends in Capturing New Value for Communications Service Providers in 2021

Use Gartner's Reference Model to Deliver Intelligent Composable Business Applications

Quick Answer: What Is Composable Business Architecture

Tech Providers 2025: CSP-Offered Composable Edge and 5G Services Will Enable Enterprise Agility and Growth

How to Prepare for the Rise in Digital Infrastructure Marketplaces Driven by Network Disaggregation

Decentralized Finance

Analysis By: Christophe Uzureau, David Furlonger, Ali Merji

Benefit Rating: Transformational

Market Penetration: Less than 1% of target audience

Maturity: Emerging

Definition

DeFi relies on a decentralized market infrastructure without the presence of a central intermediary. DeFi uses blockchain technology — notably tokenization and decentralization — to enable peer-to-peer exchanges for trading, fractionalizing, issuing, lending, settling or collateralizing a digital asset. This creates alternative sources of funding or capital for an individual or an organization, leading to new business models.

Why This Is Important

- DeFi provides and combines alternative capital, financing and value exchange mechanisms.
- DeFi disrupts existing financial intermediation constructs while providing more control of, and access to, opportunities to both investors and borrowers. Traditional financial providers are now attempting to integrate some DeFi elements such as DBS Bank with its Digital Exchange.
- DeFi enables the programmable economy and supports smart machines' evolution to autonomous economic agents.

Business Impact

- Investor control over their assets
- Lower market costs
- Greater market flexibility
- Market transparency and fairness
- Open frameworks, technologies and nonproprietary capabilities
- Innovation and new distribution and collaborative models
- Rapid deployment of technology-based enhancements to trial new financial products and assets
- Automated execution via smart contracts and settlement of larger asset pools

Drivers

- Nonfungible tokens operate on the principle of DeFi, and their increase in popularity in the art and gaming industry is now an important driver of DeFi. Nonfungible tokens provide an alternative way to finance projects, as well as opportunities for trading and investing in a new digital asset class. Cryptocurrencies tend to be the preferred medium of exchange for the asset, and the intention, at least, is that there will be no centralized intermediaries involved in the market.
- Higher cryptocurrency valuations have created a new class of investors that are looking to invest in blockchain-related ventures; especially markets associated with blockchain-enabled tokens such as nonfungible tokens. In turn, this further contributes to the DeFi.
- The current interest in Bitcoin and nonfungible tokens is driving a wave of development of digital asset marketplaces from startups and traditional financial providers, such as DBS Bank's Digital Exchange in Singapore. DBS Bank is developing cryptocurrency trading and custody services, but this will not be limited to bitcoin and other cryptocurrencies. This will also support the development and adoption of other blockchain-based digital assets such as security tokens. Hence, this is creating alternative sources of funding for SMBs in the region.
- The transition to Ethereum 2.0 — while it will not deal with all technical challenges facing DeFi — will provide a protocol to embed more programmability into token constructs and potentially deliver performance that will drive adoption and, therefore, standardization. This is fundamental to realizing the promise of digital assets issuance, payments and trading. It marks a new cadence for digital acceleration by allowing new participants to issue, invest, access and govern new forms of digital assets and, therefore, commercial interactions.

Obstacles

- There is technology risk. Participants have to trust smart contract codes as reminded by the experience of the DAO in 2016, and more recently, the YAM protocol failure.
- DeFi is also not currently subject to the same levels of regulatory oversight or fail-safe devices.
- The market is also directly impacted by well-known personalities such as Elon Musk's decision to accept bitcoin for purchasing Tesla and then reversing this decision.
- Market correction in the price of cryptocurrencies could damage the perception of DeFi initiatives.
- DeFi also requires a level of investor sophistication and diligence in their own financial management.
- One of the challenges facing DeFi is that the existing tokens and smart contracts are not programmable or fungible enough.

User Recommendations

- Ensure finance and blockchain project and innovation teams have a solid grasp of asset types and token standards beyond ERC-20 to enable adequate accounting for, and fungibility of, new digital asset classes.
- Allocate sufficient business and IT resources to follow this emerging market as part of your digital acceleration initiatives.
- Track the evolution of global and local regulation, including accounting and tax treatment of digital asset holdings. Regulators are increasingly focused on flexing oversight to accommodate innovation, while trying to maintain control.

Sample Vendors

ByeleX; ConsenSys; DBS Bank; Liqwith; Polymath; Saxo Bank; SBI Digital Asset Holdings; SIX Digital Exchange; Sygnum; Taurus

Gartner Recommended Reading

What Is Ethereum 2.0 and How Does it Relate to Digital Business Acceleration and a New Programmable Economy?

Non-Fungible Tokens (NFTs) Create New Digital Products and Business Models

Incentivize and Engage With Digital Tokens to Aid Recovery in a Reset COVID-19 World

How to Make Sense of Tesla's Purchase of Bitcoin?

Current Use of Blockchain for Investment Management and Digital Assets

For Cryptocurrency Payments, First Explore Demand Factors

Real-Time Incident Center as a Service

Analysis By: Michael Brown

Benefit Rating: Transformational

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition

A real-time incident command center fuses information from various sources and provides visualization to improve situational awareness capability. It is a type of command-and-control (C2) enabling service used by public safety agencies to coordinate responses to emergencies and other events. Typically created and managed by public safety organizations through integration of databases, sensor, video and communications systems, that outcome is becoming available in as-a-service form.

Why This Is Important

Information fusion and C2 are ubiquitous to public safety. Early examples include real-time crime centers. Full-spectrum incident management, enabled by information fusion and C2 technology, has emerged. Service providers now offer real-time incident management as a service. Jurisdictions with earlier crime-focused capabilities will seek next-generation full incident management capability. Jurisdictions lacking wherewithal for a command center now have opportunities with as-a-service offerings.

Business Impact

Public safety mission operators and their technology support organizations are primary stakeholders. Citizens are stakeholders regarding surveillance aspects such as video or license plate readers. Use of the technology can alter deployment and focus of resources. Improved citizen service through better emergency response is the leading advantage. With an as-a-service offering simplifying the creation of a real-time function, some agencies may gain capability where formerly unable.

Drivers

Real-time incident command center as a service is an outgrowth of earlier approaches and is enabled by supporting technology advancements:

- Next-generation real-time crime centers (RTCC) — RTCCs are the forerunner for real-time incident management. Earliest implementation of an RTCC dates to 2005 with many jurisdictions subsequently adopting some form of information fusion and C2 technology. The growth has been driven by citizen expectations to achieve crime reduction and government budget constraints that demand efficient use of public safety resources. While law enforcement was the initial use of information fusion and C2 to improve situational awareness and deployment of limited resources, more generalized use cases demand the same approach. Wildfire management, natural disasters, special events and pandemic response are some nonpolicing examples where real-time incident management is necessary.

- IP-enabled everything — The IP enablement of much of the communications, sensor and surveillance capabilities of public safety fosters integration. Bringing together information assets like databases, radio, video, IoT, mass notification, geographic information systems, license plate readers and geolocation tracking cannot be trivialized, but with each of these sources being digitized, the integration problem is made more simple. The lower cost of integration, IoT and SaaS delivery model is enabling and driving the ability for public safety jurisdictions to have a more sophisticated, near-military-level operational picture and C2 capability.

Obstacles

- Interagency cooperation — The information fusion aspect and unified C2 of real-time incident management inherently means sharing. The information assets will be owned by multiple agencies. For regional cooperative approaches, the information assets will not even reside in a single jurisdiction.

- Cost — This will limit deployment to larger jurisdictions or entail cooperative relationships among smaller jurisdictions. Grants or other forms of capital investment often used for new public safety capabilities will not address recurring cost of incident management center staffing and technology subscription or maintenance fees.

- Citizen privacy concerns — Civil liberties advocates may have issues relative to surveillance. Increased use of video or other surveillance technology that occurs in real-time incident command centers will encounter public resistance wherever such resistance is politically permissible.

User Recommendations

Growth of the real-time incident management, increasingly enabled by as-a-service offerings is critical to satisfy mission needs and resource utilization efficiency. CIOs supporting public safety agencies should:

- Begin interagency collaboration by itemizing information assets and owners, determining the information value and the willingness to share.
- Estimate costs by conducting market analysis for integration products and services, and developing staffing profiles for the incident management center.
- Address possible citizen privacy concerns by engaging in outreach efforts to explain use, benefits and protections for surveillance capabilities.

Sample Vendors

Fusus; Hexagon; Mutualink; Rave Mobile Safety; Verizon

Active Metadata Management

Analysis By: Mark Beyer, Guido De Simoni, Alan Dayley

Benefit Rating: Transformational

Market Penetration: 1% to 5% of target audience

Maturity: Embryonic

Definition

Active metadata is the continuous analysis of user, data management, systems, infrastructure and data governance experience to determine the alignment and exceptions between data as designed versus operational experience. Its utilization includes operationalizing analytic outputs, operational alerts and recommendations. It identifies the nature and extent of patterns in data operations, resulting in AI-assisted reconfiguration of data and operations and use cases.

Why This Is Important

Active metadata management uses machine learning, data profiling and graph analytics to help determine data's relevance and validity. It enables cross-platform orchestration of data tools, cross-industry validation and verification processes, and the identification of flawed data capture, inappropriate usage, logical fallacies and even new data. At mature levels, it supports the evaluation of analytic and data biases (unintentional or intentional) as well as transparency, auditing and DataOps.

Business Impact

- Support self-service and application development by automating data content and structures and the availability discovery of data assets.
- Identify similarities among users, use cases, and reporting and analysis models across an organization to build social networks of users based on common data needs and operational and analytic requirements.
- Automate orchestration for data access, locations, processing requirements and resource allocation by enabling a balance between optimization and cost.

Drivers

- Changing requirements from both business and IT are driving demand for data quality tools, data catalogs, metadata management solutions and data integration tools in one comprehensive solution.
- Human-driven data utilization cannot adapt quickly enough to the demand for the rapid discovery, access and incorporation of new data assets throughout an enterprise or organization.
- Data management is further complicated by third-party data and data utilized from adjacent and distantly removed industries.

- Organizations need a portfolio of capabilities and the ability to manage them across a range of use cases.
- The large-scale capabilities in cloud-based deployments have enabled the broadest diversity of data structures, processes and use cases to date. Intercloud demands determine the best data management approaches based on statistical analysis of the data.
- Demands are newly emerging to continuously compare experience statistics with design expectations to separate data into zones of concern: harmonic, dissonant or discordant.

Obstacles

- Active metadata management requires access to design and runtime metadata, usage and utilization statistics, user or user-group identification, graph analytics, continuous data profiling and machine learning. Prohibited or limited access to any of these assets or capabilities can inhibit the implementation of active metadata approaches.
- Automated cross-platform and tools orchestration will inhibit growth due to a reluctance among data management solution providers to make their metadata assets available to — much less accept metainstructions from — external or third-party optimization and resource allocation platforms.
- Human designers, implementers and users might resist AI-based data management approaches based on the concept that data is a valuable resource. However, the use of data is what makes it valuable. It is the combination of AI-based data management and human modulation that makes the active metadata management approach valuable.

User Recommendations

- Begin accumulating runtime logs from as many tools as possible. Analyze the logs for patterns of data used together, frequency of use, user or connection strings, queries and views executed, and even resource allocation to create a graph of which data is used, how often, by whom, for what purpose and on which platform.
- Introduce a data catalog strategy, and expand it to ingest metadata from master data management, data quality, data integration and data preparation tools and attach it to the catalog entries.
- Acquire or deploy at least one prototype combining at least three disciplines from data management to enable metadata notification between tools to be added to the runtime logs and design metadata repositories as notes. Deploy a user interface to reconfigure metadata repositories for analysis by data engineers and architects.

Sample Vendors

Alation; Alex Solutions; Ataccama; Atlan; Datalytyx; data.world; Informatica; OneTrust; Orion Governance; Semantic Web Company

Gartner Recommended Reading

Modern Data and Analytics Requirements Demand a Convergence of Data Management Capabilities

The State of Metadata Management: Data Management Solutions Must Become Augmented Metadata Platforms

5 Ways to Use Metadata Management to Deliver Business Value From Data

Digital Humans

Analysis By: Marty Resnick, Nolan Hart

Benefit Rating: Transformational

Market Penetration: Less than 1% of target audience

Maturity: Embryonic

Definition

Digital humans are interactive, AI-driven representations that seem to have some of the characteristics, personality, knowledge and mindset of a human. These traits make them appear to be humans and behave in a “humanlike” manner. Digital humans are digital twin representations of people, typically rendered as digital avatars, humanoid robots or conversational user interfaces (e.g., chatbot, smart speaker).

Why This Is Important

Digital humans can interact, learn and express themselves in humanlike ways. These capabilities are driven by conversational UI, CGI and 3D real-time autonomous animation, and open up a host of opportunities for organizations that embrace the technology early. Digital humans (e.g., licensed personas, avatars, customer service agents, chatbots and VAs) 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 a set of 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 customer touchpoint.

Drivers

- COVID-19 has accelerated research and progress in digital humans to enable no-touch experiences, combat social isolation and provide care to the elderly.
- 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, etc.
- 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.

Obstacles

- The act of creating and utilizing digital humans could raise ethical concerns, and regulatory bodies could look to stifle the industry and the innovation.
- The foundations of the technology are present, but the capability to fully replicate the personality and characteristics of a nondigital human will still take years to hone.
- Some customers will reject the idea and demand a real human, and it may take at least a decade before they're unable to tell the difference.
- Customers may treat digital human representatives differently and in ways that have undesirable CRM implications.
- Creating high-quality digital humans requires functional improvements in a number of technologies.
- To capitalize on the ecosystem opportunities, corporations need to share key capabilities and allow others to add value, rather than hoarding the best technology.

User Recommendations

- Track and engage early with digital human technology, especially if you're looking to undertake potentially disruptive, "moonshots" initiatives.
- Scenario-plan how digital humans fit within your organization as brand ambassadors, service agents, salespeople, developers or leaders.
- Decide on the rules and ethics that the organization will follow in pursuit of digital humans when governmental guidance is not available.
- Decide the role (platform, creator, consumer, provider, etc.) your organization is best positioned to play in the digital human ecosystem.
- Invest in nascent digital human technology to experiment with use cases and find adoption challenges.
- Keep an eye out for undesirable and unexpected consequences in early digital human deployments.

Gartner Recommended Reading

Maverick* Research: Digital Humans Will Drive Digital Transformation

Multiexperience

Analysis By: Jason Wong

Benefit Rating: Transformational

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition

Multiexperience describes interactions that take place across a variety of digital touchpoints (such as web, mobile apps, conversational apps, AR, VR, MR and wearables) using a combination of interaction modalities in support of a seamless and consistent digital user journey. Modalities include no-touch, voice, vision and gesture. Multiexperience is part of a long-term shift from the individual computers we use today to a multidevice, multisensory and multilocation ambient computing experience.

Why This Is Important

Multiexperience (MX) is the new "omnichannel" for a digital-first world. Through 2030, the digital user experience (UX) will undergo a significant shift in terms of how customers, partners, citizens and employees experience their environments. MX is about the shift both in UX perception and in interaction models, which leads to a multisensory, multidevice, multilocation and multitouchpoint digital journey.

Business Impact

To achieve digital business transformation, it is essential to understand and exploit multiexperience. Applying multiexperience design to digital experiences removes friction and effort for the users — both customers and employees. Adopting MX will allow organizations to be more agile — delivering positive business outcomes by serving customers and employees in ways that best suit their needs and expectations.

Drivers

- Organizations are shifting their delivery models from projects to products, but beyond products is the experience — the collection of feelings, emotions and memories. Web and mobile apps are already commonplace, but they are undergoing UX changes driven by new capabilities like progressive web apps, WebXR and artificial intelligence (AI) services. Conversational platforms allow people to interact more naturally and effortlessly with the digital world. Virtual reality (VR), augmented reality (AR) and mixed reality (MR) are changing the way people interact with and perceive the physical-digital world.
- As organizations continue to invest in customer experience (CX) and employee experience (EX), they will need to apply MX front-end architecture and technology strategies to be more agile at serving business needs and user expectations. When MX discipline is applied with great UX in support of CX and EX strategies, total experience (TX) transformation is achieved. TX requires MX to be executed with CX, EX and UX in harmony and synchronicity.
- The long-term manifestation of MX is a composable digital experience that is adaptive, seamless, collaborative, consistent, personalized and ambient. This will happen over the next five years — and has already been accelerated by the COVID-19 pandemic, which has increased reliance on digital touchpoints and no-touch modes of interaction. In this new decade, MX is needed to deliver transformative and memorable experiences for customers, employees and all users of your digital products and services.

Obstacles

- Privacy concerns may dampen the enthusiasm and impact of MX adoption. Users will need to consent to sharing their location, accepting notifications and being tracked across their devices.
- On the technical front, the fragmentation of many consumer devices and the inconsistency of interoperability standards are enormous barriers to seamless MX integration of front-end technologies.
- The skills needed for MX development, such as immersive interaction design, are still lacking in most enterprise software engineering teams.
- Don’t expect automatic plug-and-play of off-the-shelf devices, applications and services for MX. Instead, proprietary ecosystems of MX solutions will exist in the near term.

User Recommendations

Application and software engineering leaders should:

- Identify three to five high-value, proof-of-concept projects in which MX design can lead to more effortless, compelling and transformative experiences.
- Use personas and journey mapping to address the requirements of diverse business use cases. Use external-facing and internal-facing scenarios to support a unified digital experience.
- Collaborate with UX design teams to create a design system that spans desired MX touchpoints and modes of interaction. This ensures that MX development teams can accurately and consistently apply visual, behavioral and written guidelines.
- Establish a multidisciplinary fusion team including (but not limited to) IT, product managers, UX designers and business stakeholders.
- Focus on understanding how unified digital experiences impact the business, and use evolving MX technologies to create targeted solutions for customers or internal constituencies.

Gartner Recommended Reading

How to Apply Design and Architecture to Multiexperience Application Development

Transcend Omnichannel Thinking and Embrace Multiexperience for Improved Customer Experience

Multiexperience Will Be the New Normal for Consuming Analytics Content in the Augmented Era

Generative AI

Analysis By: Svetlana Sicular, Brian Burke, Avivah Litan

Benefit Rating: Transformational

Market Penetration: Less than 1% of target audience

Maturity: Emerging

Definition

Generative AI refers to AI techniques that learn a representation of artifacts from the data, and use it to generate brand-new, completely original artifacts that preserve a likeness to original data. Generative AI can produce totally novel media content (including text, image, video and audio), synthetic data and models of physical objects. Generative models also can be used in drug discovery or for the inverse design of materials having specific properties.

Why This Is Important

Exploration of generative AI methods is growing and proving itself in life sciences, healthcare, manufacturing, material science, media, entertainment, automotive, aerospace, defense and energy industries. It is embraced for creative work in marketing, design, architecture and creative media content. Synthetic data that is created using generative AI supports the accuracy and speed of AI delivery. Generative AI is becoming more common and accessible.

Business Impact

- The field of generative AI will progress rapidly in both scientific discovery and technology commercialization.
- It is currently as futuristic as it gets, and, at the same time, successful in a wide range of applications, from creating new molecules to preserving data privacy.
- Negative use of generative AI, such as deepfakes, will increasingly cause problems in the future.
- Technologies that provide AI trust and transparency will become an important complement to the generative AI solutions.

Drivers

- The hype around generative AI is accelerating. The fast progress of transformers is top of mind in the AI community. Notably, GPT-3 by OpenAI and AlphaFold 2 by Google's DeepMind, both of which use transformers, were the main AI news in 2020. Generative adversarial networks (GANs), variational autoencoders, autoregressive models and zero/one/few-shot learning have been rapidly improving generative modeling while reducing the need for training data.
- Machine learning and NLP platforms are introducing generative AI capabilities, along with transfer learning for reusability of generative models, making them accessible to data science teams.
- Industry applications of generative AI are growing. For example, in healthcare, generative AI creates medical images that depict the future development of a disease. In consumer goods, it generates catalogs. In e-commerce, it can help customers "try on" various makeups and outfits. In manufacturing, quality inspection models use synthetic data. A growing number of life sciences companies are examining generative AI to accelerate drug development.
- Content creation and improvement, such as text, images, video and sound, is already penetrating marketing, media, entertainment and more. Examples include personalized copywriting, and noise cancellation and visual effects in videoconferencing. A combination of generative techniques, like audio to video generation, inspires new creative and business applications.
- Creative AI, such as music, produces artwork that typically requires imagination.
- Synthetic data draws enterprises' attention by helping augment scarce data, mitigate bias or preserve data privacy. For example, Duke Health will use synthetic data to protect the privacy of patients and their data in the institution's research efforts.
- Generative AI will disrupt software coding. When combined with existing development automation techniques, it has the potential to automate up to 70% of the work done by programmers.

Obstacles

- Regrettably, generative AI can be used for fraud, malware, disinformation and instigation of social unrest. Full and accurate detection of generated content will remain challenging for years and may not be completely possible.
- Generative AI technologies underpin deepfakes, content that is dangerous in politics, business and society. Technical, institutional and political interventions combined will be necessary to fight deepfakes. We will see unusual collaborations, even among competitors, to solve the problem of deepfakes and other ethical issues rooted in generative AI.
- Reproducibility of generative AI results will be challenging in the near term.
- Fragmented and specialized technology offerings (such as generating only images or only text) currently lead to a combination of tools rather than a single solution.
- Compute resources for training large transformer models are high and are not affordable to most enterprises. It is possible to exploit them, but not develop your own models.

User Recommendations

- Determine how synthetically generated data could accelerate the analytics development cycle, lessen regulatory concerns, facilitate data monetization and lower the cost of data acquisition, especially if you lack data for rare events.
- Investigate how generative AI techniques benefit your industry or sector. Determine initial use cases where you can rely on purchased capabilities or partner with research institutions.
- Examine and quantify the advantages and limitations of generative AI. Supply guidelines in cases where generative AI could bring breakthroughs, as they require skills, funds and caution. Weigh technical capabilities with ethical considerations.
- Prepare to mitigate the impact of deepfakes, which can cause serious disinformation and reputational risk. Methods like algorithmic detection and tracing content provenance to do this are evolving.
- Pay close attention to the generative AI techniques, as we expect their rapid adoption.

Sample Vendors

Adobe (Sensei); Bitext; Dessa; Diveplane; Google (DeepMind); Landing AI; MOSTLY AI; OpenAI; Phrasee; Rosebud; Spectrm; Tanjo; Textio

Gartner Recommended Reading

Innovation Insight for Generative AI

Predicts 2021: Artificial Intelligence and Its Impact on People and Society

How to Benefit From Creative AI — Assisted and Generative Content Creation

Emerging Technologies: Critical Insights Into AI-Augmented Software Development

At the Peak

Composable Applications

Analysis By: Yefim Natis

Benefit Rating: Transformational

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition

Composable applications use business-defined modularity to enable business-IT fusion teams to safely and rapidly compose and recompose application services in the moments of need. The modularity of applications that is suitable for fusion teams is expressed in business terms, is accessible programmatically, and maximizes autonomy and preparedness of its modules for governed orchestration and discovery.

Why This Is Important

Without a model for application design that supports safe, efficient and fast business change, modern organizations risk losing their market momentum and loyalty of their customers. Composable application architecture empowers such adaptable businesses. It resolves the agility constraints of monolithic applications by first partitioning them into self-contained business capabilities and then encapsulating the isolated capabilities using the microservices model of API-/event-based interfaces.

Business Impact

Composable business applications enable a better match of application experiences to a changing, operational context of the business. Composable business, founded on composable application technology and built with composable thinking throughout the organization, is well-positioned to recognize and exploit business opportunities, respond to unexpected disruptions, and meet customers' changing demands at their pace, retaining their loyalty.

Drivers

- In the continuously changing business context, demand for business adaptability directs organizations toward technology architecture that supports fast, safe and efficient application change.

- The demand for active participation of business decision makers in the design of their digital experiences promotes adoption of technology models that are accessible and useful to business experts, in addition to the technical professionals.
- Increasing number of vendors offering API-centric SaaS (also known as API products or “headless” SaaS) builds up a portfolio of available software-encapsulated business capabilities — the building blocks of composable business applications.
- Increasing mainstream use of low-code application, integration and automation platforms supports composition of applications using API products and other forms of packaged business capabilities, preparing organizations for composable business engineering.
- Fast-growing competence in mainstream organizations for management of broad collections of APIs and event streams creates a technology foundation for safe operation of a composable business technology environment.

Obstacles

- Limited experience of composable thinking and planning in most software engineering organizations complicates the design efforts and transition plans of seeking the benefits of a composable application architecture.
- Limited practice of business-IT collaboration for application design in some organizations delays the effectiveness of composable design that benefits from the complementary expert talents in multidisciplinary fusion teams.
- Most legacy applications can participate in composition via their APIs and event streams, but their architecture provides only minimal autonomy to simulated encapsulated business capabilities and therefore delivers limited enterprise agility, as compared to the native composable applications.
- Lack of development and platform tools dedicated to composable application architecture limits the early success with composition to the more-advanced design teams, capable of adapting precursor technologies to their objectives.

User Recommendations

- Build competence in API and event stream management to prepare to catalog, protect and administer access to the encapsulated business capability services — the building blocks of composable applications.

- Use low-code development and integration technologies to facilitate design collaboration of business and technology experts.
- Prioritize formation of business-IT fusion teams to support faster and more effective adaptive change of business applications.
- Build an investment case for composability by identifying opportunities that address urgent points of friction, hindering the organization's ability to achieve short-term business goals.
- Use API-centric SaaS, where available, to practice application composition.
- Catalog the outer APIs of older applications along with the accessible APIs of external applications to support the initial stages of composable applications.

Sample Vendors

Contentful; Treasury Prime; Snipcart; Twilio; Modularbank; Evervault; Claudinary

Gartner Recommended Reading

Strategic Architecture Roadmap for Composable Enterprise Applications (Presentation)

Use Gartner's Reference Model to Deliver Intelligent Composable Business Applications

Kick-Start Your Composable Business Journey With 2 Key Strategies

How to Design Enterprise Applications That Are Composable by Default

Redefine Your Business-IT Relationship Continuum to Deliver Greater Business Agility

Employee Communications Applications

Analysis By: Mike Gotta

Benefit Rating: Transformational

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition

Employee communications applications (ECAs) enable organizations to plan, create, manage, execute and analyze internal communications. The employee value of ECA is based on delivery of relevant content, bottom-up feedback to leadership, and unified access to key applications.

Why This Is Important

Effective communications is strategic in a digital workplace, especially for making frontline workers feel informed and included. ECA enables leadership and those in communicator roles to flexibly interact with workers via multichannel, multidevice experiences and personalized audience segmentation. ECA solutions can positively affect employee experience by creating a sense of belonging, keeping staff aware of safety topics, providing organizational information, and reinforcing business goals.

Business Impact

- ECA solutions help organizations reach the entire workforce, especially staff with limited technology options, so they understand what's going on and what's being asked from them.
- ECA tools provide communicators (those in formal roles responsible for certain types of messaging) the means to plan, manage and analyze communication efforts.
- Workforce value of ECA is based on staff receiving content, providing feedback, and gaining streamlined access to key applications (payroll, benefits and shifts).

Drivers

- ECA tools are part of a broader collection of employee-facing solutions designed to influence and improve both employee experience and organizational culture.
- Leadership teams have largely recognized the value of more effective technology and information sharing with frontline workers who have generally been technologically disadvantaged. While ECA tools are often used across the workforce, they can focus on certain workforce segments. Objectives include better engagement, retention and operational effectiveness.
- Dissatisfaction with email and legacy intranets is encouraging leadership to explore modern ECA tools designed for multichannel and multidevice experiences (including digital signage) with the ability for personalized experiences based on workforce segmentation.
- Campaign-style features enable sequences of messages to be coordinated and delivered to employees following a “journey” concept to “tell a story” related to strategic goals. The concept of communication journeys shifts the focal point of communications from broadcast and delivery to understanding and behavior change to work in new ways and identify with the enterprise mission.
- ECA solutions are primarily used for organizational communications. However, ECA usage is slowly shifting to include operational communications with more emphasis on collaboration and work management (creating synergies with workstream collaboration tools).
- Advanced ECA analytics creates workforce insights that appeal to new stakeholders outside those deciding on ECA strategies, such as those involved in voice or employee and people analytics.
- Vendors in the ECA and emergency or mass notification service (EMNS) are slowly maturing to handle certain types of crisis and urgent communication use cases but differences remain entrenched as to EMNS unique value.

Obstacles

- Business and cultural value from ECA is not commonly known outside those in communicator roles (often in HR and Corporate Comms.), making cost vs. value debates common.
- Deep analytics creates suspicion over tracking or misuse of data, which causes staff (especially frontline workers) to not download the mobile app to personal devices.
- Strategists involved in ECA tool selection can have imperfect market awareness of vendors or insight to features needed to construct effective evaluation criteria.
- ECA vendors come from many different adjacent markets, which makes decision-making complex to find a single solution. Some vendors offer a general intranet option with specific ECA capabilities. Other vendors support broad mobile ECA scenarios with focused intranet features. Some vendors handle ECA needs from other domains such as workforce management, well-being, cloud office or collaboration-related solutions.

User Recommendations

- Establish use cases; identify audience segments, channels, media and content types, campaign objectives, integration needs, application access and analytics by working with stakeholders focused on hybrid work, frontline workers and urgent/crisis communications.
- Assess technical requirements of ECA vendors and select them by including more subjective qualities, such as usability and employee experience. Sustain business value by leveraging employee feedback on ECA usage.
- Ensure operational readiness by taking advantage of ECA vendor consulting options including strategy, proof-of-concept (POC), training and establishing internal support. Execute pilots to assess impact and expand use. Address governance by defining content and administration frameworks to ensure consistency and quality.
- Connect efforts with ECA technology by making use of adjoining strategy areas such as digital workplace, intranet packaged solutions and emergency mass notification services.

Sample Vendors

Akumina; Beekeeper; Dynamic Signal; Facebook; Four Winds Interactive (FWI); Microsoft; SocialChorus, Staffbase

Gartner Recommended Reading

Market Guide for Employee Communications Applications

Toolkit: Employee Communications Applications Vendor and Product Data

Eight Steps for Modernizing Employee Communications in the Digital Workplace

Market Guide for Intranet Packaged Solutions

AI-Augmented Software Engineering

Analysis By: Arun Batchu

Benefit Rating: Transformational

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition

AI-augmented software engineering (AIASE) is the use of AI technologies such as machine learning (ML), natural language processing (NLP) and similar technologies to aid software engineering teams in creating and delivering applications faster, more consistently, and with higher quality. AIASE commonly integrates with an engineer's existing tools to provide them with real-time, intelligent feedback and suggestions.

Why This Is Important

Today's software engineering methods involve writing boilerplate code that saps expert engineers' creativity, limiting their productivity. Novice developers are challenged by the complexity of modern software they need to deliver. Moreover, engineers need to master multiple fit-for-purpose languages that are used to realize a complex software system. AIASE helps in resolving these issues, by acting as an intelligent assistant, a pair-programmer, an expert coach and quality control inspector.

Business Impact

AIASE is enabling creative business problem-solving by automating boilerplate software engineering tasks. It is increasing developer velocity by recommending highly relevant code and library recommendations in a fraction of the time it would take otherwise. It is augmenting quality and testing engineers by allowing tests to self-heal and by automatically creating tests. AIASE models continuously improve their utility by learning from its regular interactions with the engineers and environment.

Drivers

- Increasing complexity of software systems to be engineered.
- Increasing demand for developers to deliver high-quality code faster.
- Continuous modernization of existing systems via replacement or refactoring.
- Increasing impact of software development on business models.
- Development of language server protocols for easy integration into widely adopted integrated development environments.
- Application of deep learning language models to software code.
- Increase in usage of high-quality open source software as model-training data.
- Application of machine learning to models, used within model-driven development platforms.
- Increasing availability of GPUs and TPUs needed to run machine learning workloads in the cloud.
- Increasing computational power of developer machines, especially for running and training machine learning models.

Obstacles

- Lack of deep understanding of generated solutions.
- Limited awareness of the existence of production-ready tools.
- Minimal evidence proving ROI of AIASE.
- Resistance from software engineers who fear job obsolescence
- Lack of transparency and provenance of data used for model training.
- Trade-off between relevance and latency of real-time suggestions.

User Recommendations

- Make the engineering teams aware of, evaluate, and adopt, AIASE tools with a sense of urgency.
- Identify the programming languages within the enterprise best suited to start with.
- Evaluate funding needed to obtain necessary licenses for AIASE, and develop a business case to obtain them.
- Establish a method to measure productivity gains.
- Check the maintainability of AI-generated code, tests, and models (in development platforms).
- Reassure their software engineers about AIASE augmenting — not replacing them.
- Track the rapidly evolving and highly impactful market to identify new products that minimize development toil and improve experience of software engineers.

Sample Vendors

Codota; Diffblue; IBM; Kite; Mendix; Microsoft; NerdVision; OutSystems; SeaLights; Tabnine

Gartner Recommended Reading

Emerging Technologies: Critical Insights Into AI-Augmented Software Development

Infographic: Artificial Intelligence Use-Case Prism for Software Development and Testing

Nonfungible Tokens (NFT)

Analysis By: David Mahdi, Avivah Litan, Michael Kelly

Benefit Rating: Transformational

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition

An NFT is a unique blockchain-based digital asset that links to real-world digital assets, such as digital art or music, or physical assets that are tokenized, such as houses or cars. Most NFTs today are unique ERC 721 tokens that live on Ethereum, but other blockchain platforms support them as well.

Why This Is Important

Nonfungible tokens (NFTs) offer the promise of digital ecosystems where owners of digital content (and in some cases physical content), such as artwork, music and games, can use NFTs to allocate digital ownership and rights. Hype and criticism of NFT as a concept has grown dramatically over the last month as the market valuation of NFTs went over $300m. NFTs have much broader applicability in many markets and will open up new types of marketplaces not possible without them.

Business Impact

NFTs present new ways for content creators to manage, promote and monetize their assets via ecosystems. Entities can depend on the validity, integrity and uniqueness of NFTs. Blockchain technology brings tamper resistance to the notion of NFTs, which is traditionally hard to do with many other kinds of digital assets.

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 lieu 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.

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
- Ability to authenticate/validate digital (and in some cases physical) goods. For example, authenticating artwork can be a tedious process today. By leveraging NFT's, 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 the crazed CryptoKitties

Obstacles

- NFTs have yet to demonstrate lasting business models and monetization for content creators, sellers and buyers, meaning that adoption is currently low.
- At this point in time, Ethereum leads the charge with NFT approaches and bridges for interoperability with other blockchains. This means that interoperability will need to expand to include direct connections between other blockchain networks and ecosystems. This will ensure that content is truly valid across digital ecosystems.
- With NFTs just starting to become a reality from a product and solution perspective, business models and approaches haven't fully been realized.
- 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.

User Recommendations

- Conduct POCs. IT leaders that are interested in their potential, should conduct early stage research, and consider investigating how they are made, in addition to NFT ecosystems.
- 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 (see Garbage in, Garbage Forever: Top 5 Blockchain Security Threats). NFT storage should use a distributed file system, for example IPFS; nodes should be replicated across many servers. While NFTs are cryptographically secured on a blockchain it does not mean that the NFT is legitimate. Early reports of “sleepminting” attacks show that NFTs are minted to a well-known user/artist wallet and transferred to a hacker’s wallet, without triggering smart contract security checks.

Sample Vendors

Animoca Brands; Fortunafi; OpenSea; Rarible; Ethereum; Kudelski Group; WISeKey

Gartner Recommended Reading

What You Need to Know About Blockchain DeFi

Garbage in, Garbage Forever: Top 5 Blockchain Security Threats

Data Fabric

Analysis By: Ehtisham Zaidi, Robert Thanaraj, Mark Beyer

Benefit Rating: Transformational

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition

A data fabric is an emerging data management design for attaining flexible and reusable data integration pipelines, services and semantics. A data fabric supports various operational and analytics use cases delivered across multiple deployment and orchestration platforms. Data fabrics support a combination of different data integration styles and leverage active metadata, knowledge graphs, semantics and ML to automate and enhance data integration design and delivery.

Why This Is Important

A data fabric leverages both traditional and emerging technologies in enterprise architectural design and evolution. It is composable and supports flexibility, scalability and extensibility in an infrastructure used by humans or machines across multiple data and analytics use cases. It abstracts data management infrastructure to disintermediate any incumbent platforms, and enables data integration and delivery regardless of the number of on-premises or CSP-based data assets in use.

Business Impact

Organizations benefit as data fabric:

- Provides insights to data engineers and ultimately automates repeatable tasks in data integration, quality, data delivery, access enablement and more.
- Adds semantic knowledge for context and meaning, and provides enriched data models.
- Evolves into a self-learning model that recognizes similar data content regardless of form and structure, enabling broader connectivity to new assets.
- Monitors data assets on allocated resources for optimization and cost control.

Drivers

- A data fabric enables tracking, auditing, monitoring, reporting and evaluating data use and utilization, and data analysis for content, values, veracity of data assets in a business unit, department or organization. This results in a trusted asset capability.

- Demand for rapid comprehension and adaptation of new data assets has risen sharply and continues to accelerate — regardless of the deployed structure and format. The data fabric provides an operational model that permits use cases, users and developers to identify when data experience varies from the data expectations depicted in system designs.

- A shortage of data management professionals is increasing the demand for accurate and actively utilized metadata to make system design, data availability and data trust decisions.

- Catalogs alone are insufficient in assisting with data self-service. Data fabrics capitalize on machine learning to resolve what has been a primarily human labor effort using metadata to provide recommendations for integration design and delivery.

- Business delivery and management professionals find it difficult to identify adjacent, parallel and complementary data assets to expand their analytical models. Data fabrics have the capability to assist with graph data modeling capabilities (which is useful to preserve the context of the data along with its complex relationships), and allow the business to enrich the models with agreed upon semantics.

- Significant growth in demand and utilization of knowledge graphs of linked data as well as ML algorithms to provide actionable recommendations and insights to developers and consumers of data can be supported in a data fabric.

- Organizations have found that one or two approaches to data acquisition and integration are insufficient. Data fabrics provide capabilities to deliver integrated data through a broad range of combined data delivery styles including bulk/batch (ETL), data virtualization, message queues, use of APIs, microservices and more.

Obstacles

Data fabrics are just past the Peak of Inflated Expectations. The main challenges surrounding broad adoption are:

- Diversity of skills and platforms to build a data fabric present both technical and cultural barriers. It requires a shift from data management based upon analysis, requirements and design to one of discovery, response and recommendation.

- Intentional market hype by providers and services organizations purporting a data fabric delivery is adding to market cynicism.

- Misunderstanding and lack of knowledge in how to reconcile and manage a data fabric and a legacy data and analytics governance program that assumes all data is equal will lead to failure.
- Proprietary metadata restrictions will hamper the data fabric, which is wholly dependent upon acquiring metadata from a wide variety of data management platforms. Without metadata, the fabric requires analytic and machine learning capabilities to infer missing metadata, and while possible, will be error prone.

User Recommendations

Data and analytics leaders looking to modernize their data management with a data fabric should:

- Invest in an augmented data catalog that assists with creating a flexible data model. Enrich the model through semantics and ontologies for the business to understand and contribute to the catalog.
- Invest in data fabrics that can utilize knowledge graph constructs.
- Ensure subject matter expert support by selecting enabling technologies that allow them to enrich knowledge graphs with business semantics.
- Combine different data integration styles into your strategy (bulk/batch, message, virtualization, event, stream, replication and synchronization).
- Evaluate existing tools to determine the availability of three classes of metadata: design/run, administration/deployment and optimization/algorithmic metadata. Rate existing and candidate platforms and favor those that share the most metadata.
- Focus on a similar transparency and availability of metadata between PaaS and SaaS solutions.

Sample Vendors

Cambridge Semantics; Cinchy; CluedIn; Denodo; IBM; Informatica; Semantic Web Company; Stardog; Talend

Gartner Recommended Reading

Top Trends in Data and Analytics for 2021: Data Fabric Is the Foundation

What Is Data Fabric Design?

Top Trends in Data and Analytics for 2021: Data Fabric Is the Foundation

Emerging Technologies: Data Fabric Is the Future of Data Management

Decentralized Identity

Analysis By: David Mahdi, Michael Kelley

Benefit Rating: Transformational

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition

Decentralized identity (DCI) leverages technologies such as blockchain or other distributed ledger technologies (DLTs) to allow an entity to create and control its own digital identity. Thus, it provides an alternative to centralized IAM architectures by establishing trust in identities and resilience within the overall system, with little reliance on centralized arbiters or identity stores.

Why This Is Important

Isolated digital identities will not scale with the needs of digital business. Online and mobile identities continue to be in a fragmented state due to service providers (banks, retailers, social networks, etc.) forcing consumers to create individual identities for each and every service. DCI offers an alternative approach that does not have the security, privacy and usability issues associated with traditional, fragmented, digital identity approaches.

Business Impact

With DCI, users gain control of their identities and data, enabling service providers to interact with users with greater speed and confidence. Currently, providers typically hoard identity information about users. Leveraging DCI, identity and service providers will be able to increase security and access convenience for end users, while reducing exposure to data breaches and potential privacy compliance violations.

Drivers

- **Vendor investments in DCI:** Due to the ubiquity 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. Other major developments in this space include the acquisition of ShoCard by Ping Identity, and funding received by vendors such as 1Kosmos and InfoCert.
- **Investments in BYOI:** Including investments in overall BYOI could also act as a precursor to DCI adoption. E.g., Microsoft enabling "external identities" with Azure Active Directory (Azure AD).
- **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.
- **Standards enabling consistency:** Standards are currently emerging, led by entities such as the World Wide Web Consortium (W3C) and Decentralized Identity Foundation (DIF), to create a consistent approach to DCI. These standards will help propel this technology forward.

Obstacles

- Despite a lot of promise and hype, adoption is slow due to lack of progress and inaction by most large ecosystem players, CIAM vendors and various IDPs including governments.
- Standards are still in the development stage.
- Lack of core DLT/blockchain performance, interoperability, scalability and maturity.
- Lack of clear security standards for DLTs, such as crypto-agility, wallet standards/adoption and security.
- Lack of production-level solutions, which prevents some organizations from deploying due to concerns of having to "rip and replace" in the near future when the solutions stabilize.

User Recommendations

- Deliver attainable use cases as POCs, such as a DCI solution focused on business partners (i.e., limited deployments, low in scale). Plan for, but don't rush, long-term, large-scale initiatives such as consortium and/or DCI interoperable global identity.
- Leverage market vendors, such as IBM, Microsoft or Ping Identity, to understand the possibilities and potential of DCI.
- Be cautious of overoptimistic 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.

Sample Vendors

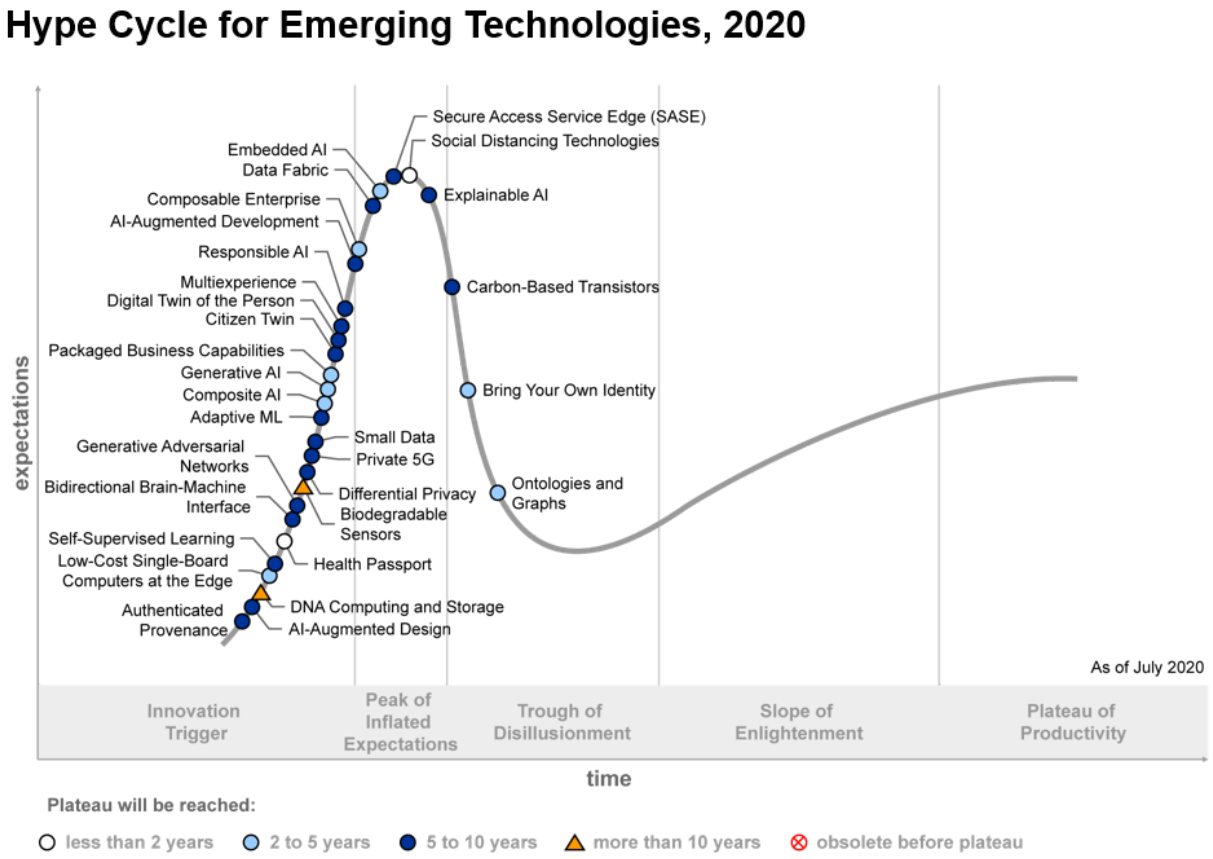
1Kosmos; Evernym; Finema; IBM; InfoCert; Microsoft; Ping Identity; SecureKey

Gartner Recommended Reading

Guidance for Decentralized Identity and Verifiable Claims

Appendixes

Figure 2: Hype Cycle for Emerging Technologies, 2020



Source: Gartner
ID: 450415

Gartner

Source: Gartner (July 2020)

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 (August 2020)

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 (August 2020)

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 (August 2020)

Evidence

2021 Hype Cycle Refinements

Gartner Hype Cycles produced in 2021 feature a number of refinements to the Hype Cycle methodology and presentation designed to make the Hype Cycle more accessible and useful. These refinements include:

- Hype Cycle graphic: The Hype Cycle graphic has been updated to provide increased clarity and differentiation between the various phases.
- Interactive Hype Cycle: The Interactive Hype Cycle can be filtered to show results by time to plateau.
- Priority Matrix: The Priority Matrix is now interactive. It can be used to navigate to various innovation profiles both within the Interactive Hype Cycle and the full document.
- Innovation profiles:

- The structure of the innovation profiles has been revised to provide a more consistent experience.
- Innovation profile status data has been moved to the beginning of each profile.
- New or revised sections (Why This Is Important, Drivers, Obstacles) provide clearer, more focused analysis.

Document Revision History

Hype Cycle for Emerging Technologies, 2020 - 24 July 2020

Hype Cycle for Emerging Technologies, 2019 - 6 August 2019

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

Some documents may not be available as part of your current Gartner subscription.

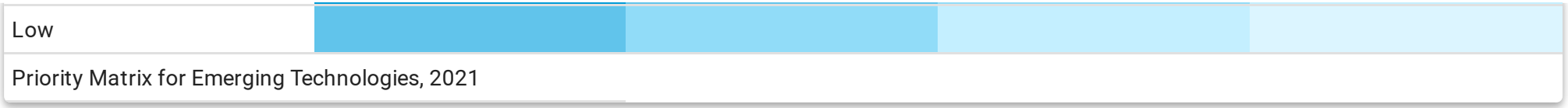
Understanding Gartner's Hype Cycles

Solution Scorecard for Colocation Provider: QTS

Assessing Emerging Technology Adoption Readiness

Table 1: Priority Matrix for Emerging Technologies, 2021

Benefit	Years to Mainstream Adoption			
	Less Than 2 Years	2 - 5 Years	5 - 10 Years	More Than 10 Years
Transformational		Composable Applications Decentralized Identity Employee Communications Applications Generative AI Nonfungible Tokens (NFT) Real-Time Incident Center as a Service	Active Metadata Management AI-Augmented Design AI-Augmented Software Engineering Composable Networks Data Fabric Decentralized Finance Digital Platform Conductor Tools Homomorphic Encryption Industry Clouds Influence Engineering Machine-Readable Legislation Multiexperience Physics-Informed AI Self-Integrating Applications Sovereign Cloud	AI-Driven Innovation Digital Humans Named Data Networking Quantum ML
High				
Moderate				



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