Hype Cycle for Emerging Technologies, 2016

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Our 2016 Hype Cycle reveals three distinct technology trends that profoundly create new experiences, with unrivaled intelligence, and offer platforms that propel organizations to connect with new business ecosystems in order to become competitive over the next five to 10 years.

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What You Need to Know

Organizations will continue to be faced with rapidly accelerating technology innovation that will profoundly impact the way they deal with their workforces, customers and partners. Three technologies in particular are poised to be the highest priority: ecosystem-expanding technologies such as Blockchain and digital platforms, intelligent systems such as Smart Robots and Virtual Personal Assistants, along with a rapidly expanding API-driven economy.

Emerging technologies are enabling highly disruptive business models that compel organizations to pursue digital business innovation (see "Building the Digital Platform: The 2016 CIO Agenda"). The CIOs and CEOs we surveyed responded that large percentages of their processes and revenue are already derived from digital products and services, and they expect those percentages to increase significantly through 2020 (see "2016 CEO Survey: The Year of Digital Tenacity"). Digital business innovation is the "new normal," not a one-and-done project or passing trend.

To survive and thrive in the digital economy, enterprise architects who are focused on technology innovation must continue to work with their CIOs and business leaders to look for emerging technologies that can help create competitive advantage, generate value, overcome legal and regulatory hurdles, reduce operating costs, and enable transformational business models. This Hype Cycle provides a high-level view of important emerging trends that organizations must track, as well as the specific technologies that must be monitored.

This year, three trends stand out at a high level:

- Perceptual smart machine age
- Transparently immersive experiences
- Platform revolution

Enterprise architects who are focused on technology innovation must evaluate these high-level trends and the featured technologies, as well as their potential impact (value and risk) on their businesses. In addition to the potential impact on businesses, these trends provide a significant opportunity for enterprise architecture (EA) leaders to help senior business and IT leaders respond to the digital business opportunities and threats by creating signature-ready actionable and diagnostic deliverables that guide investment decisions.

The Hype Cycle

The Hype Cycle for Emerging Technologies is unique among most Hype Cycles because it distills insights from more than 2,000 Gartner technologies into a succinct set of must-know emerging technologies and trends. This Hype Cycle specifically focuses on the set of technologies that is showing promise in delivering a high degree of competitive advantage over the next five to 10 years.

Emerging Technology Trends

The emerging technologies on the 2016 Hype Cycle reveal three distinct technology trends that profoundly create new experiences, with unrivaled intelligence, and offer platforms that allow organizations to connect with new business ecosystems, including:

- **Transparently immersive experiences:** Technology has and will continue to become more human-centric to the point where it will introduce transparency between people, businesses and things. This relationship will become much more entwined as the evolution of technology becomes more adaptive, contextual and fluid within the workplace, at home, and interacting with businesses and other people.

  Critical technologies to be considered include 4D Printing, Brain-Computer Interface, Human Augmentation, Volumetric Displays, Affective Computing, Connected Home, Nanotube Electronics, Augmented Reality, Virtual Reality and Gesture Control Devices.

- **Perceptual smart machine age:** Smart machine technologies will be the most disruptive class of technologies over the next 10 years due to radical computational power, near-endless amounts of data, and unprecedented advances in deep neural networks that will enable organizations with smart machine technologies to harness data in order to adapt to new situations and solve problems that no one has never encountered previously.

  Enterprises that are seeking leverage in this theme should consider the following technologies: Smart Dust, Machine Learning, Virtual Personal Assistants, Cognitive Expert Advisors, Smart Data Discovery, Smart Workspace, Conversational User Interfaces, Smart Robots, Commercial UAVs (Drones), Autonomous Vehicles, Natural-Language Question Answering, Personal Analytics, Enterprise Taxonomy and Ontology Management, Data Broker PaaS (dbrPaaS), and Context Brokering.

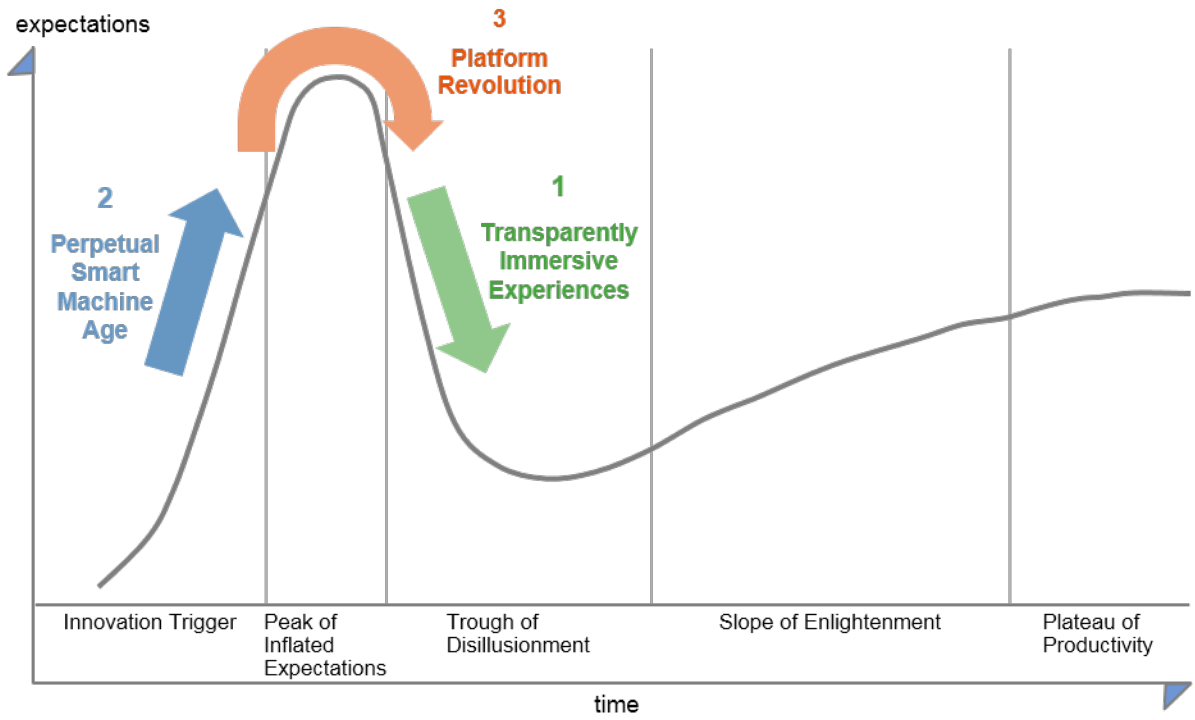
- **Platform revolution:** Emerging technologies are revolutionizing our concepts of how we define and use platforms. The shift from technical infrastructure to ecosystem-enabling platforms is laying the foundations for entirely new business models that are forming the bridge between humans and technology. Within these dynamic ecosystems, organizations must proactively understand and redefine their strategy to create platform-based business models, and to exploit internal and external algorithms in order to generate value.

  Key platform-enabling technologies to track include Neuromorphic Hardware, Quantum Computing, Blockchain, IoT Platform, Software-Defined Security and Software-Defined Anything (SDx).

When we view these themes in aggregate, we can see how the transparently immersive experience technologies (such as Affective Computing, Connected Home, Augmented Reality, Virtual Reality

and the growing Human Augmentation) are pulling the other trends along the Hype Cycle (see Figure 1 [visible only in the noninteractive version of this report]).

Figure 1. How Emerging Technology Trends Move Along the Hype Cycle



Source: Gartner (July 2016)

Fifty percent of the transparently immersive identified within this theme are at or over the peak, which means they are well on their way to the trough. The platform revolution technologies are near, at or just crossing the peak, which shows that they are a key enabler of human-centric technologies. Finally, smart machines are rapidly moving up the Hype Cycle, illustrating the new realities that are possible by bringing intelligence to transparently immersive technologies.

The trends illustrate that the more organizations are able to make technology an integral part of their employees', partners' and customers' experience, the more they will be able to connect their ecosystems to platforms in new and dynamic ways. Also, as smart machine technologies continue to evolve, they will become part of the human experience and our digital business ecosystem.

Major Hype Cycle Changes

Understanding the new emerging technologies being introduced on the Hype Cycle for the first time in 2016 provides enterprise architects with the leading indicators of what technology trends will be strategic in the coming years.

Understanding the 16 new technologies below will support EA practitioners in how they can apply smart machines, transparently immersive experiences and platform revolution themes:

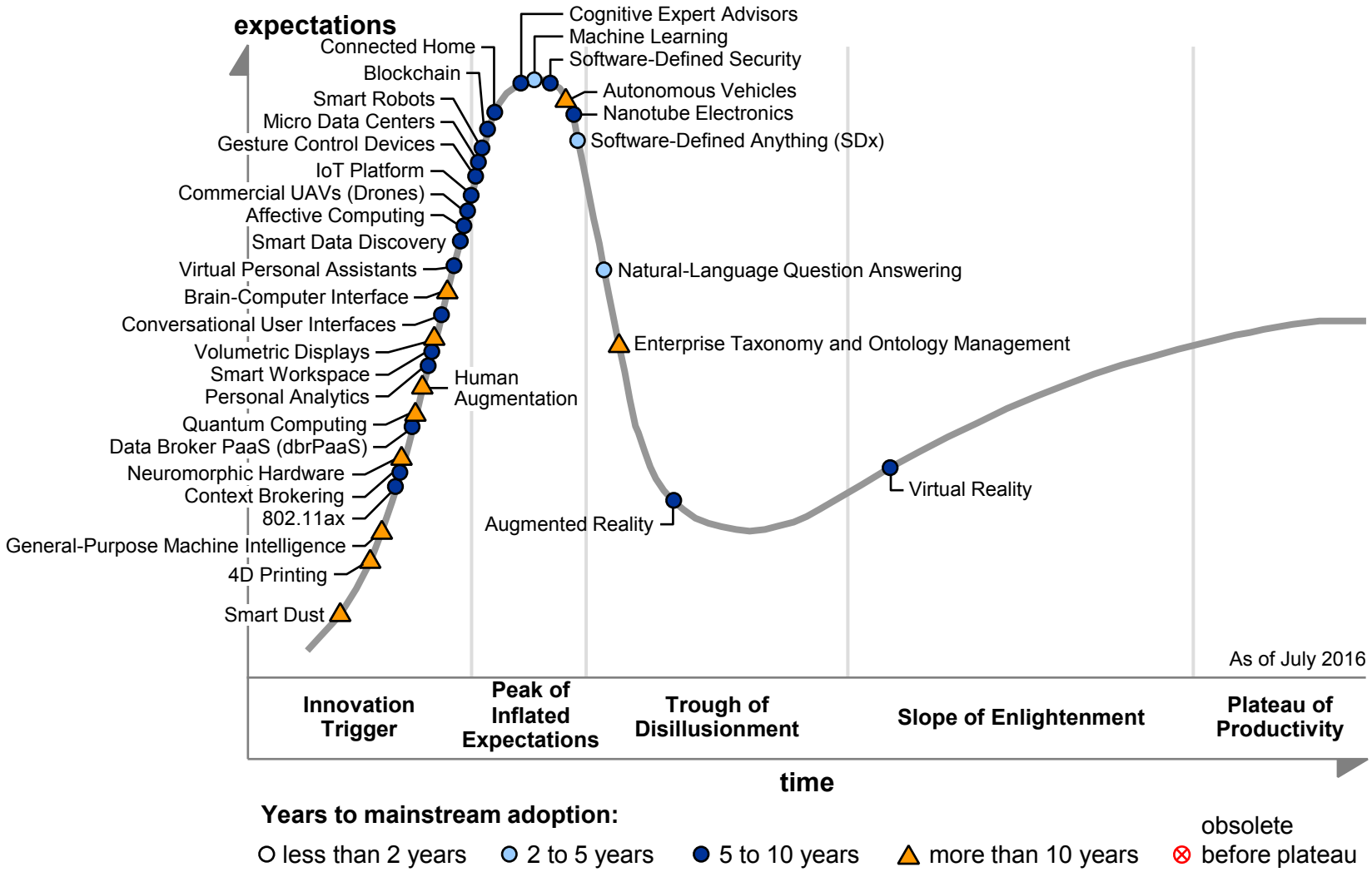
- 4D Printing
- Blockchain
- General-Purpose Machine Intelligence
- 802.11ax
- Context Brokering
- Neuromorphic Hardware
- Data Broker PaaS (dbrPaaS)
- Personal Analytics
- Smart Workspace
- Smart Data Discovery
- Commercial UAVs (Drones)
- Connected Home
- Machine Learning
- Nanotube Electronics
- Software-Defined Anything (SDx)
- Enterprise Taxonomy and Ontology Management

In addition, evaluate the technologies that have moved significantly along the Hype Cycle since 2015:

1. **Virtual Personal Assistants (VPAs):** VPAs continue to become more unobtrusive and ubiquitous across platforms. Their increasing usefulness with context awareness has resulted in growing adoption by users as they become more comfortable with VPAs, as the technologies improve, and as the variety of approaches multiplies with the potential to transform the nature of work and structure of the workplace.
2. **Software-Defined Security (SDSec):** Security vendors continue to shift more of the policy management out of individual hardware elements and into a software-based management plane for flexibility in specifying security policy, regardless of location. As a result, SDSec will bring speed and agility to the enforcement of security policy, regardless of the user's location, the information or the workload.
3. **Smart Robots:** These have progressed further in their life cycles because of several key vendors' acquisitions, which will continue over the next few years as vendors execute on their plans to expand their offerings and deliver solutions across the wider spectrum of industry-specific use cases and enterprise sizes. To date, smart robots have had significantly less

adoption, but received great hype in the marketplace — which is why they are positioned as climbing the Peak of Inflated Expectations.

Figure 2. Hype Cycle for Emerging Technologies, 2016



Source: Gartner (July 2016)

The Priority Matrix

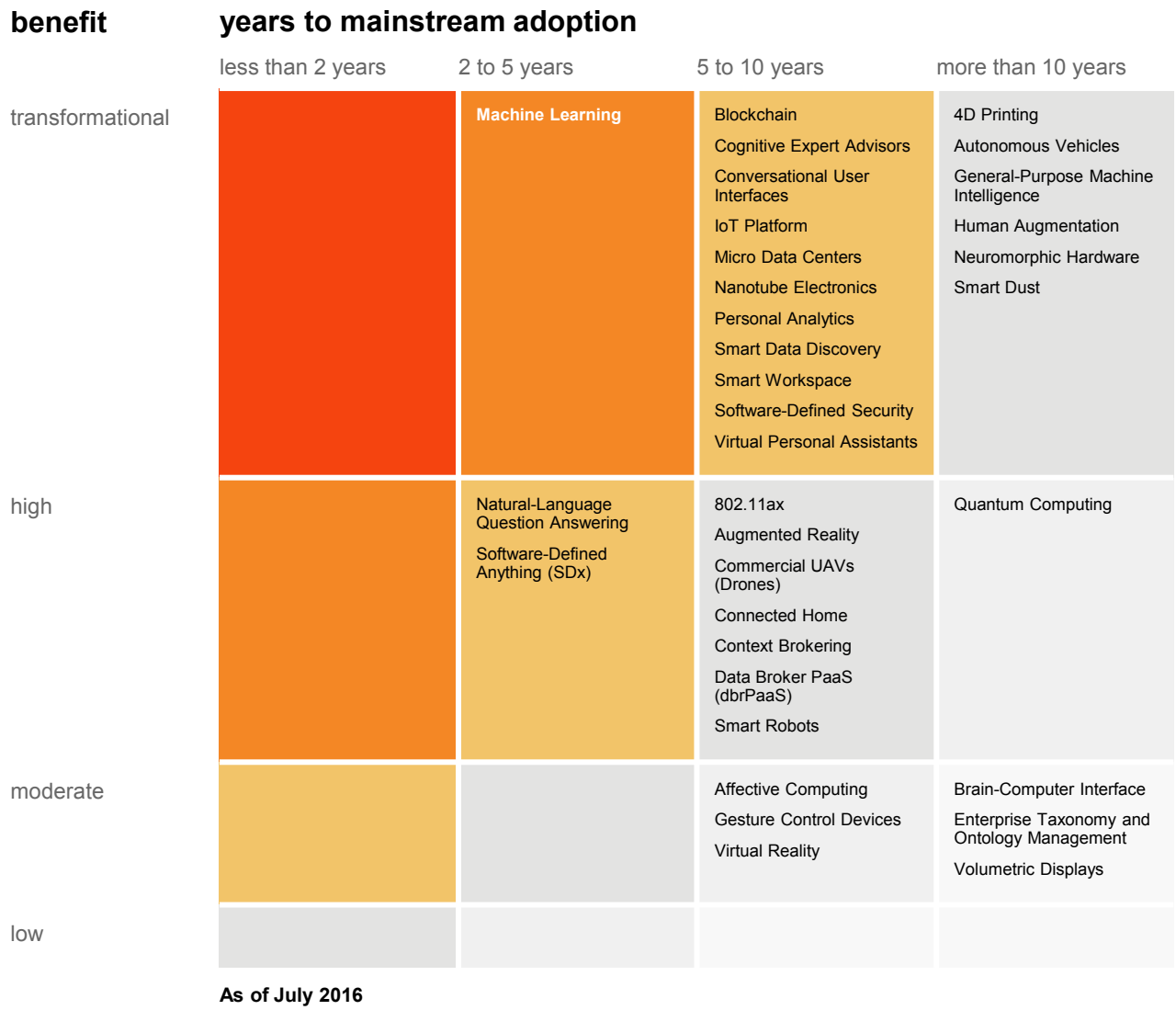
Emerging technologies are disruptive by nature, but the competitive advantage they provide is not yet well-known or proved in the market. However, most will take more than five to 10 years to reach the Plateau of Productivity. These examples illustrate the impact of key emerging technologies in the near term and the longer term.

Two to five years to mainstream adoption: Software-Defined Anything (SDx) indicates the platform revolution is near-term. Machine Learning is already providing widespread and significant benefits, while Natural-Language Question Answering makes Machine Learning more accessible to the masses.

Five to 10 years to mainstream adoption: Technologies such as Software-Defined Security (SDSec) indicate that the platform revolution is in full force. SDSec brings speed and agility to the enforcement of security policy, regardless of the user's location, the information or the workload. Virtual Personal Assistants provide unobtrusive, ubiquitous and contextually aware advisor-based solutions, while Blockchain will expand distributed ledger concepts that promise to transform industry operating models.

More than 10 years to mainstream adoption: Neuromorphic hardware emulates the functions of biological neurons. Quantum Computing provides unprecedented compute power, and General-Purpose Machine Intelligence will drive ubiquity and AI as a service that will ultimately be a key factor in the convergence between transparently immersive experiences, the platform revolution and perceptual smart machine age.

Figure 3. Priority Matrix for Emerging Technologies, 2016



Source: Gartner (July 2016)

Off the Hype Cycle

Because this Hype Cycle pulls from such a broad spectrum of topics, many technologies are featured in a specific year because of their relative visibility, but are not tracked over a longer period of time. This is not intended to imply that they are unimportant — quite the opposite. In many cases, these technologies are no longer "emerging," but rather are becoming more integral to business and IT (such as big data and cloud computing). In other cases, technologies were removed from the Hype Cycle in order to highlight other new emerging technologies.

Technology planners can refer to Gartner's broader collection of Hype Cycles for items of ongoing interest. Some of the technologies that appeared in the "Hype Cycle for Emerging Technologies, 2015," but do not appear in this year's report, are:

- 3D Bioprinting Systems for Organ Transplant
- Advanced Analytics With Self-Service Delivery
- Bioacoustic Sensing
- Citizen Data Science
- Consumer 3D Printing
- Digital Dexterity
- Digital Security
- Enterprise 3D Printing
- Hybrid Cloud Computing
- Internet of Things
- Neurobusiness
- People-Literate Technology
- Speech-to-Speech Translation
- Wearables

On the Rise

Smart Dust

Analysis By: Ganesh Ramamoorthy

Definition: Smart dust refers to motes, which are tiny wireless micro-electromechanical systems (MEMS), robots or other devices that can detect everything from light, temperature and pressure to vibration, magnetism and chemical composition. They run on a wireless computer network and are distributed over an area to perform tasks, usually sensing through RFID. As they do not use large antennas, these systems have ranges measured in just a few millimeters.

Position and Adoption Speed Justification: At present, much of the activity surrounding smart dust is concentrated in research laboratories, such as the U.S. Defense Advanced Research Projects Agency (DARPA)-funded project at the Robotics Research Laboratory at the University of Southern California and JLH Labs. The main purpose of this research is to make motes as small as possible, which involves both evolutionary and revolutionary advances in miniaturization, integration and energy management. They also aim to make motes available at as low a price as possible. Because a complete sensor/communication system integrated into a cubic-millimeter package is

still a long way off, we have yet to see major commercial applications for smart dust. However, some reasonably small motes are commercially available for building controls, industrial monitoring and security applications. Given its wide range of potential applications and benefits, this technology will, we believe, have a transformative effect on all areas of business and on people's lives in general. However, due to the lack of any major activity in terms of commercial implementations, smart dust remains in the same position.

User Advice: Smart dust that is available "off the shelf" can be configured with sensors that detect and measure a variety of properties, such as temperature, barometric pressure, humidity, light intensity, acceleration, vibration, magnetism, acoustic level and location (using GPS). The combination of these capabilities in a well-designed sensor network could create opportunities to deliver numerous services.

Business Impact: The potential benefits of smart dust are compelling and transformational. Given the embryonic stage of this technology's development, vendors should stake their claims via patent development for commercial applications, direct funding for research projects or equity funding for companies engaged in R&D. Smart dust will transform the way humans interact with their surroundings and create new ways for businesses to deliver services, while reducing costs in the process. This will have wide-ranging implications for businesses' technological, social, economic and legal practices across the globe.

Benefit Rating: Transformational

Market Penetration: Less than 1% of target audience

Maturity: Embryonic

Sample Vendors: Linear Technology; MEMSIC; Millennial Net; Moog

4D Printing

Analysis By: Michael Shanler; Miriam Burt

Definition: Four dimensional printing (4DP) is a technique where the materials are encoded with a dynamic capability — either function, confirmation, or properties — that can change via the application of chemical, electronic, particulate or nanomaterials. The printing technology has extra functionality to sequence, mix and place specific materials that will have a calculated effect.

Position and Adoption Speed Justification: 4DP is an emerging technology in the embryonic stages. It was triggered a few years ago with concepts in academic and technology labs among very few practitioners, for example, the MIT Self-Assembly Lab. Two vendors — Stratasys and Autodesk — created 4D-printed concepts leveraging multimaterial parts with shape-transformation capabilities and a new process for printing customizable smart materials. Skylar Tibbits, a TED Fellow and research scientist at MIT, has described 4DP where the fourth dimension is transformation in a TED Talk. He showed concepts of printed pipe valves that can expand or contract and printed cubes that unfold. The Wyss Institute for Biologically Inspired Engineering and the John A. Paulson School of Engineering and Applied Sciences (SEAS) at Harvard collaborated with other universities to create microscale 3D-printed objects where the fourth dimension, time,

yields a property change. Inspired by things that occur in nature with external stimuli, they've created hydrogel composite structures that change shape while immersed in water. Meanwhile, the U.S. army research office, DARPA, is also incentivizing 4DP concepts.

While 4DP is recently on the radar for 3DP technologists, smart materials have actually been around for several decades. Recent scientific advancements in biology, chemistry, electronics and 3D printing will accelerate the discipline. Over the next few years, 4DP research will generate interest and "hype."

Challenges persist with bringing precision to objects' transformations after they've been printed. Material science research for 3DP is still an underserved market, software is still "niche" for both nanoscale and human-scale programmable materials, with self-assembly environments. Modeling the geometries, determining interactions for changing states, and calculating the energy (from heat, shaking, pneumatics, gravity, magnetics, etc.) that impacts materials is no easy task. Engineering software vendors are just beginning to get interested.

User Advice: Business and R&D IT leaders with science, technology and engineering responsibilities for new product innovation should explore the business and technical opportunities for 4D printing, and begin to educate peers on how 4D printing can add new functions. Building an internal 4D capability will present significant computer, scientific and engineering hurdles. Focus on strategic partnerships to advance the technique and develop proofs of concept (POCs) to build the capabilities to run experiments and manage the entire laboratory infrastructure. The in-silico requirements can be shared. More engineering and modeling software vendors, academic laboratories and 3DP vendors will need to be included for sharing technical research. There are also opportunities for engaging via open innovation or consortium approaches.

R&D groups will need to focus on the evolving IP landscape. Materials science is a complicated space and there are an immense number of scientific and formulation-based patents that may impact business cases.

Business Impact: Today, 4DP is an opportunity to create future technology-based products that could disrupt your industry. Shape-shifting materials have already been leveraged in the automotive, aerospace, defense and medical industries. Dynamic and self-assembling materials have already begun to disrupt the way engineers think about designing components and delivering value.

Initially, the examples of "what's possible" will be technology-focused, but will have unclear revenue impacts. Shape-shifted materials that can reduce the drag coefficient of an airplane or vehicle during different environments might help optimize efficiency. The sole of an adaptive running shoe may adjust to wet versus dry pavements and improve grip. A self-assembling medical stent may reduce surgery times and improve patient outcomes. A dynamic valve in an irrigation system could improve irrigation on a farm. A roof on a house could change form to facilitate draining, and walls could increase in thickness during the winter to elevate insulation values.

The business case becomes much more attractive when considering how the technology could be leveraged across an entire product family. Making a fleet of airplanes or cars more efficient by even 1% could result in billions in global fuel savings. An adaptive shape-shifting shoe represents

innovation opportunities for sports apparel across the massive retail market. Improved patient procedures have broad impacts on healthcare costs and quality of care and extend life. Better technology for smart plumbing in farms and cities has global resource implications.

The business impacts for 4D are still murky, and most will be determined after 4D technology has been refined and scaled into businesses. Until then, don't be fooled by the anticipated "hype" as the technology is still in its infancy. However, now is the time to evaluate if the technology is worth exploring to build into future product and service roadmaps.

Benefit Rating: Transformational

Market Penetration: Less than 1% of target audience

Maturity: Embryonic

Sample Vendors: Autodesk; Geosyntec Consultants; Stratasys

Recommended Reading: "Maverick* Research: Make Profits by Preparing Your Business for Global Climate Change"

"Lessons From Leaders: Insights on High Performance From 10 Years of the Supply Chain Top 25"

General-Purpose Machine Intelligence

Analysis By: Tom Austin

Definition: Machines appearing to have capabilities similar to people in areas such as learning, reasoning, adapting and understanding are labeled "intelligent." General-purpose machine intelligence (GPMI; aka "strong AI") is applicable to a very broad range of use cases. Special-purpose machine intelligence ("weak AI") is limited to specific (narrower) use cases. GPMI is not fundamental to smart machines. Machines with GPMI that are able to control their own means of maintenance and reproduction exist only in science fiction.

Position and Adoption Speed Justification: Progress on machine intelligence has been limited to special-purpose smart machines. Thus, position and adoption speed remain unchanged year over year.

No AI system today can pass a general-purpose test for equivalence to human intelligence (there is also no fully acceptable measure of human intelligence against which to test them). This is not to say it will never be possible to build a machine that approximates the cognitive capabilities of humans, but we are likely decades away from having completed the necessary research and engineering.

GPMI is often entangled in cognitive-computing discussions. Cognitive computing means different things to different people. It's either a set of machine capabilities (GPMI), a specialized type of hardware (as in neuromorphic or other highly parallel, short propagation path processors), or the use of information and communication technology (ICT) to enhance human cognition (Gartner's preferred use of the term "cognitive computing").

User Advice: Focus on special-purpose smart machines or technologies that appear to perform some tasks previously thought of as the domain of only humans, that are capable of autonomous operation, that learn from experience and that appear as though they understand what they have learned (by virtue of acting on it, in at least a semiautonomous fashion). These machines operate on "big data," employ at some level deep neural networks (precursors may be based on expert systems instead) and make probabilistic predictions of future states.

Examples include autonomous vehicles, virtual personal assistants, smart advisors and selected conversational agents. Special-purpose smart machines will have a huge and disruptive impact on business and personal life.

End-user organizations should ignore GPMI until such time that GPMI researchers and advocates demonstrate significant progress.

Business Impact: General-purpose machine intelligence will likely not emerge in the next 10 years. When it does, it will likely be the result of the combination of many special-purpose smart machines. In the next 10 years, we will see continued research, and in the long run, when general-purpose machine intelligence is available, the benefits will likely be enormous (and some of the economic, social and political implications will be disruptive and likely not all positive).

Because this is an embryonic area, there are no vendors selling systems exhibiting general-purpose machine intelligence. There is an active area of basic research, but it has not yet advanced to the point where there are real products.

Benefit Rating: Transformational

Market Penetration: Less than 1% of target audience

Maturity: Embryonic

Recommended Reading: "Smart Machines See Major Breakthroughs After Decades of Failure"

"How to Define and Use Smart Machine Terms Effectively"

802.11ax

Analysis By: Mark Hung

Definition: 802.11ax is the successor to 802.11ac, the most commonly deployed Wi-Fi network today. Its main enhancement is to improve the efficiency of existing 2.4GHz and 5GHz spectrum, thereby increasing throughput in densely populated areas. As such, its goal is not only to raise the peak performance of Wi-Fi devices (as past Wi-Fi technologies have done), but also to simultaneously support a larger number of devices. Therefore, one of its largest targets is the emerging IoT market.

Position and Adoption Speed Justification: IEEE, the standards body of 802.11-based technologies, started the High Efficiency WLAN (HEW) study group in May 2013 to examine the

most pressing needs for the next-generation Wi-Fi technology. It was determined that, while successive Wi-Fi technologies have increased per-device throughput at an impressive rate through the years (from 11 Mbps at the start to more than 3 Gbps today), the issue of interdevice interference (thereby lowering overall system performance) had not been adequately addressed. Coupled with the onslaught of new IoT devices expected in the next few years (Gartner estimates that there will be more than 21 billion connected "things" by 2020), this situation will only be exacerbated. Therefore, in May 2014, the 802.11ax task group was officially launched in the IEEE to determine the necessary technologies for next-generation Wi-Fi.

802.11ax technology development is still in early stages: draft 0.1 was approved in March 2016, draft 1.0 is expected to be completed (not approved) in November 2016, and final ratification is expected for January 2019. Given past IEEE and Wi-Fi alliance timelines, if this schedule holds, it is expected that 802.11ax products will be on the market at the end of 2018.

User Advice:

- Consumer device and semiconductor OEMs should participate in the standards-setting (IEEE) and certification program (Wi-Fi Alliance) processes to make sure that their requirements are being incorporated into the technology.
- For enterprise architects, 802.11ax represents an opportunity to significantly improve performance for dense device deployments, and they are advised to monitor the standardization timeline and product availability to find the right entry point for future infrastructure upgrades.

Business Impact:

- 802.11ax is the first Wi-Fi technology that will natively support IoT usage scenarios using existing 2.4GHz and 5GHz spectrum. It is expected to be a key enabling communication technology for IoT toward the end of the decade.

Benefit Rating: High

Market Penetration: Less than 1% of target audience

Maturity: Embryonic

Sample Vendors: Broadcom; Cisco; Huawei; Intel; Qualcomm

Context Brokering

Analysis By: Yefim V. Natis; Mark A. Beyer

Definition: Context brokering is a data-processing model aimed at discovery and analysis of the context of data — both in the originating (create) use case and preparing it for new use cases — to understand the derived states of entities (such as people, things or places) relevant to human or automated decision making. Context data is generally obtained from various sources that are otherwise external to a well-defined and cohesive business process.

Position and Adoption Speed Justification: Context brokering initially emerged with the data broker market (through providers of prepared context data such as Dun & Bradstreet and Experian) to provide customer credit ratings, scoring of businesses and other prepared context data. Rapid digitalization of business has created massive new context-data mining opportunities, including the potential of coincidental data collection.

The potential sources for context brokering include:

- Devices such as mobile phones (location data)
- Communication networks (capacity and utilization)
- Sensors (temperature, pressure, device on or off)
- Personal analytic devices (condition of a person)
- Social sites (such as Twitter or Facebook) along with web businesses (such as Match.com)
- Enterprises' own application systems (bank balances, records of recent transactions)
- Publicly available datasets such as open data (many government sites) and commerce sites (retail statistics)

While local context data is present in much enterprise application software, processing the abundance of new information is beyond the scope of custom designs in most existing applications. However, with the potential for discovery that significant additional information was available at the time of a given decision, task, activity or event, the risk of ignoring all of this newly available data is unacceptable to businesses.

Context brokering as a repeatable systematic architectural approach is just beginning to emerge, driven by the tension between the increasingly urgent requirement for better-informed business decisions and the increasingly complex workflow required to support them. The demand for reuse of data integration and transformation as a "fait accompli" (or already complete) is increasing — especially with regard to businesses engaged in data brokering (creating and marketing data products), and for coordinating shared data assets across the Internet of Things. Context brokering will eventually be embedded within other architectural solutions (by 2020), but the impact and effects of it will enhance data management and integration implementations whether for transactional or analytic data needs.

User Advice: For strategic architects and IT planners:

- Identify use cases in your business where additional context data can provide significant additional business advantage, reduce risk or improve your evidence of compliance. Identify open data, public data, business partner data and additional internal data as sources of context data. Then, design a model of ingestion and preparation of that data to gradually improve the intelligence of your critical business processes.
- Look for available context-brokering platform software or platform as a service (PaaS) before embarking on building your own in-house context-brokering solution. Potential context data

sources include commonly known data brokers that provide market data, viewership data, consumer data, and so on.

- Engage top architecture and data science talent to devise the architectural model and technology selection for context-brokering design and deployment, whether internal design or third-party tools are used to facilitate.
- Apply the early context-brokering initiatives against a limited number of data sources as a proof of concept to develop best practices for managing the complexity of deployment while building relevant skills.

Business Impact: Adoption of web-scale context brokering greatly expands the ability of enterprise systems to make more precise, better-informed, current and context-aware decisions. The outcome is a broad increase in the IT-driven intelligence of business operations. With competent use, context brokering can dramatically increase the business value of IT.

Mainstream context-brokering practices and tools will help organizations take advantage of the massive "internet of data." Data that informs a business regarding entities that are available from other internal and external sources enhances any evaluation, analysis or use of those entities (for example, a credit rating may allow for a property loan approval, but an indictment for criminal activity involving the seizure of property obtained from public records could disqualify the loan seeker). This additional insight will, in turn, amplify the business value of data, creating information exchange markets and providing opportunities for many businesses to turn their data collections into revenue centers. Selling and buying information will become a common personal and business activity. A repeatable systematic architectural model — in place of custom modeling by developers — will reduce the cost of context brokering over time.

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Sample Vendors: Alooma; Arimo; Bottlenose; Flybits; IBM; MIOsoft; Oracle; Rage Frameworks; Reltio; Treasure Data

Recommended Reading: "Architecture Strategy Guide for Context-Aware Algorithmic Decisions"

"Platform as a Service: Definition, Taxonomy and Vendor Landscape, 2016"

"Understand the Data Brokerage Market Before Choosing a Provider"

"The Platform Architect's Guide to Designing IoT Solutions"

"Context Brokers for Smarter Business Decisions"

Neuromorphic Hardware

Analysis By: Martin Reynolds; Tom Austin

Definition: Neuromorphic hardware uses nonbinary signaling to emulate the function of biological neurons. Examples of nonbinary signaling include analog levels and spike-based signaling. These methods transmit more information, but at a slower rate than digital signaling. Slower rates enable high scalability at very low power. Biological neurons exhibit slow processing (100ms cycles) across thousands of inputs, and billions of neurons (100 billion for a human, 71 million for a mouse, and a million for a cockroach).

Position and Adoption Speed Justification: Neuromorphic systems are at the very early prototype stage. IBM has delivered a system to Lawrence Livermore Laboratories. Qualcomm's Zeroth processor is driving a software environment that runs on Qualcomm's conventional processor cores. There are three major barriers to the deployment of neuromorphic hardware.

- Conventional computing, through graphic processing units (GPUs), field-programmable gate arrays (FPGAs) and custom application-specific integrated circuits (ASICs), is advancing deep learning at a remarkable rate. Furthermore, once the weights for a deep neural network (DNN) are calculated, the run time DNN can be compact; modern smartphones can run the layers needed for speech recognition. Neuromorphic silicon will have to leapfrog advances in these systems. Conventional systems have at least five years of fast advancements ahead.
- Knowledge gaps. People with the mathematics and technology knowledge are needed to fully understand the operation of neuromorphic silicon at large scale. The gap will be closed by the emergence of software and hardware that can use neuromorphic technology to run deep learning at scale.
- Scalability. The large numbers of neurons and deep interconnect will challenge the ability of semiconductor manufacturers to create viable neuromorphic devices.

User Advice: GPU-based systems have demonstrated 100,000-fold performance improvements between 2008 and 2016, leveraging silicon, packaging system technology and high-performance memory to create dense, high-performance processors. These gains raise the number of nodes or neurons that can be trained. Dramatic improvements in hardware may be in the offing for neuromorphic, GPU, FPGA and custom ASIC designs over the next several years, potentially leading to overnight breakthroughs in performance, quality and breadth of smart machines as various hurdles are overcome.

Semiconductor design groups, system research, design and engineering firms, and military and intelligence organizations should continue to research neuromorphic and competing hardware designs that could dramatically improve the speed and scope of deep neural network machine-learning projects.

Other enterprises should take a more conservative "wait and see" approach on novel hardware designs.

All organizations should maintain competencies in related software (deep neural network) technologies that are already practical for certain applications and can exploit existing massively parallel GPU designs.

Business Impact: Neuromorphic hardware faces the largest barriers in advancing deep learning, but also may unlock the most powerful results. There are likely to be major leaps forward in hardware in the next decade, if not from neuromorphic hardware then from other radically new hardware designs.

We are in the midst of a "big bang"-type change in smart machines, enabled by radically new hardware designs, suddenly practical deep neural network algorithms and huge amounts of big data used to train these systems. This big bang will result in machines being able to tag, contextualize and react to language, content and people's behavior; add substantial value to what people do; and improve on some things we used to think only people could do (drive automobiles, for example).

Every major industry will be ripe for disruption by these smart machines. Early adopters will have the best opportunity to drive their own destiny.

Benefit Rating: Transformational

Market Penetration: Less than 1% of target audience

Maturity: Embryonic

Sample Vendors: AMD; IBM; Nvidia; Qualcomm

Data Broker PaaS (dbrPaaS)

Analysis By: Yefim V. Natis; W. Roy Schulte

Definition: A data broker platform as a service (dbrPaaS) enables the development of data broker services (also referred to as data as a service [DaaS]) for private or public use. The objective of a data broker service is to develop insights in order to support more intelligent business decision making. A custom-designed data broker service uses public and private data sources for the discovery, preparation, analysis and delivery of insights in the form of derived context data.

Position and Adoption Speed Justification: Businesses' demand for intelligent decisions, processes and operations is fast increasing, but achieving the higher levels of intelligence requires expertise that is hard to find or develop. Much of the work of data scientists in enterprise IT and line of business organizations is dedicated to insight discovery across an increasing scope of data sources, inside and outside the organization, using increasingly advanced data preparation and analytics. Some vendors offer data services (data brokers or DaaS) to provide some prepared context data to data scientists. Gartner tracks hundreds of data broker services, including those offered by D&B, Rage Frameworks and Axciom (see "Understand the Data Brokerage Market Before Choosing a Provider"). Few of these offerings include any significant development capability for the subscribers. Without the necessary tools, customers get general-purpose prepared data and are on their own when it comes to developing a differentiated custom insight. dbrPaaS enables customers to create their own custom data discovery and brokering services. dbrPaaS shares some capabilities with data discovery, insight engine and business analytics platform services.

The complexity of the task slows down the adoption of tools offered by the few early innovators such as Bottlenose, Flybits or MIOsoft. The market needs tools of greater productivity and a validation of the approach by the industry-leading vendors. In 2015, Oracle launched its Data Management Platform (DMP) service as part of its Data Cloud offering. Also, IBM's collection of Cloud Data Services fulfils most of the requirements of context data discovery, and SAP formed a division to deliver its own data broker and data broker platform services. Many business analytics platform services (baPaaS) and big data management services — which currently deliver only some parts of the data broker pipeline of services — are extending their capabilities to encompass the full end-to-end data broker platform capability. With more offerings, growing demand and the entry of industry megavendors in the market, the technology is bound to continue to generate increasing attention, leading it up the Hype Cycle and eventually to greater maturity and mainstream adoption.

User Advice: CIOs, CTOs and IT leaders should:

- Invest in understanding the types of decisions that are critical to the business, and the types of context data that can improve the intelligence of those decisions.
- Evaluate the costs of obtaining the necessary context data against the value it may deliver by improving the quality of the relevant business decisions (or the cost of the lost opportunity as a result of having no access to the context data).
- Seek improved intelligence of key business decisions in a systematic way: deploy technologies, cloud services and application designs that are dedicated to insight discovery.
- Look first for available data broker services that may deliver some or all of the sought data. Then, if still necessary, turn to data broker platforms to develop custom algorithms for insight discovery.
- Even a small new insight can make a significant business difference. Proceed gradually to minimize setbacks. Start with familiar data sources before venturing into new territory.

Business Impact: dbrPaaS allow organizations access to uniquely discovered insights, ingesting both public and private data sources. Unique access to context data can amount to strategic business advantage, including more efficient operations, reduced decision risk and improved customer experience. The ultimate outcome is a broad increase in the quality of business decisions and greater recognition of the business value of IT.

Benefit Rating: High

Market Penetration: Less than 1% of target audience

Maturity: Emerging

Sample Vendors: Alooma; Arimo; Bottlenose; Flybits; IBM; MIOsoft; Oracle; Rage Frameworks; Reltio; Treasure Data

Recommended Reading: "Architecture Strategy Guide for Context-Aware Algorithmic Decisions"

"Platform as a Service: Definition, Taxonomy and Vendor Landscape, 2016"

"Understand the Data Brokerage Market Before Choosing a Provider"

"The Platform Architect's Guide to Designing IoT Solutions"

"Context Brokers for Smarter Business Decisions"

"Eight Dimensions of Process IQ Determine How Smart Your Process Needs to Be"

"Use Intelligent Business Operations to Create Business Advantage"

Quantum Computing

Analysis By: Jim Tully; Martin Reynolds

Definition: Quantum computing is a type of nondigital computing that is based on the quantum state of subatomic particles. The state of the particles represents information, denoted in single elements known as qubits (quantum bits). A qubit can hold all possible results simultaneously until read, an attribute known as superposition. Qubits can also be linked with other qubits, a property known as entanglement. Quantum computers manipulate linked qubits to solve a problem, fixing the final result in the qubits by reading them.

Position and Adoption Speed Justification: Hardware based on quantum technology is unconventional, complex and leading-edge. To date, the largest demonstration of entanglement is about five qubits, which is little more than a lab curiosity. Even so, most researchers agree that hardware is not the core problem. Effective quantum computing will require the development of algorithms (quantum algorithms) that will solve real-world problems, while operating in the quantum state. The lack of these algorithms is a significant problem, although a few have been developed. IBM recently opened its quantum platform for external use, with the goal of raising awareness of quantum computing. Today, with five qubits, the system solves only trivial problems, but IBM expects to continue to increase its scale.

In the few known applications, quantum computers can operate exponentially faster than conventional computers. One example is the reduction of search time in a dataset, known as Grover's algorithm. Grover's algorithm can complete searches in about the square root of the time that a conventional computer takes. However, this advantage is meaningless for computers with a small qubit count.

The technology continues to attract significant funding, and a great deal of research is underway at many university and corporate labs. D-Wave Systems, a manufacturer of a class of quantum computers that does not rely on fully entangled qubits, continues to deliver systems. Google, a user of a D-Wave quantum computer, believes that it might accelerate deep learning using the machine. Intel announced a 10-year partnership with the Delft University of Technology to investigate quantum computing.

User Advice: Given the focus and achievements of research in quantum computing, our view is that general-purpose quantum computers will never be realized; they will instead be dedicated to a narrow class of use. This suggests architectures where traditional computers offload specific calculations to dedicated quantum acceleration engines. A lack of programming tools, such as

compilers, is another factor restricting the broader potential of the technology. Specific applications include optimization, code breaking (as prime number factoring), image analysis and encryption.

If a quantum computer offering appears, check its usefulness across the range of applications that you require. It will probably be dedicated to a specific application and this is likely to be too narrow to justify a purchase. Check if access is offered as a service. D-Wave Systems has now moved in this direction, and it may be sufficient at least for occasional computing requirements. Some user organizations may require internal computing resources, for security or other reasons. In these cases, use of the computer on a service basis — at least initially — would offer a good foundation on which to evaluate its capabilities.

Business Impact: Quantum computing could have a huge effect, especially in areas such as optimization, code breaking, DNA and other forms of molecular modeling, large database access, encryption, stress analysis for mechanical systems, pattern matching, image analysis, and (possibly) weather forecasting. Analytics is likely to be a primary driver as the technology becomes useful, but this is outside the planning horizon of most enterprises.

Benefit Rating: High

Market Penetration: Less than 1% of target audience

Maturity: Embryonic

Sample Vendors: D-Wave Systems; Delft University of Technology; IBM; Stanford University; University of Bristol; University of Michigan; University of Southern California; Yale University

Human Augmentation

Analysis By: Jackie Fenn

Definition: Human augmentation creates cognitive and physical improvements as an integral part of the human body to deliver performance that exceeds normal human limits. Augmentation examples include increased physical strength (for example, through exoskeletons) and improved perception (for example, a hearing aid with a phone app to optimize directionality, or an implanted magnet that detects electrical current).

Position and Adoption Speed Justification: Human augmentation runs along a spectrum of spontaneity (Does the user have to deliberately interact with the technology, or are the benefits achieved as a side effect of normal activity?), and detectability (Would another person know that a person is augmented?). Technology to augment human capabilities has primarily been focused at the point along the spectrum where assistance is deliberate and detectable (for example, using a smartphone or smartwatch). Technology offering more spontaneous and less detectable interaction (for example, a contact lens display, or brain stimulation to enhance concentration) raises new issues, particularly toward the extreme ends of the spectrum (for example, surgical implants or genetic manipulation). Organizations and society must confront a growing range of opportunities and challenges relating to employees who choose — or in some cases are required or are financially motivated — to enhance their bodies and minds though technology.

Increasing specialization and job competition are demanding levels of performance that will drive more people to experiment with enhancing themselves, triggering a multibillion-dollar human augmentation market during the next quarter-century. Based on elective augmentation trends (in particular, the popularity of cosmetic surgery) and the growing range of augmentation opportunities available, we are positioning human augmentation midway between the trigger and the peak, even though it will be well over a decade before a significant number of organizations and individuals are affected. In the meantime, some organizations will contemplate offering their staff augmentation opportunities to increase performance, or will create policies to govern augmentation trends.

User Advice: Organizations aiming to be very early adopters of technology, particularly those whose employees are engaged in physically or mentally demanding work, should track lab advances and early commercialization in fields such as exoskeletons for strength, endurance and worker safety, and sensory enhancement or transference to improve information processing (for example, by changing visual input into tactile signals). Cognitive enhancement through technology is already represented by the growing use of — and dependence on — instant mobile access to information and community, and organizations must also continue to be ready for consumer- and employee-led adoption of the latest wearable or even implantable technologies.

Ethical controversies regarding human augmentation are emerging even before the technology becomes commonplace. Several states have already passed bills banning employers from requiring chip implants as a condition of employment. Future legislation will need to tackle topics such as whether a person has a right to certain types of augmentation as a medical service, and whether an employer is allowed to prefer a candidate with augmented capabilities over a "natural" one. Employers will need to weigh the value of human augmentation against the growing capabilities of robot workers, particularly as robots may involve fewer ethical and legal minefields than augmentation.

Organizations can gain an early understanding of some of the opportunities and issues by tracking the quantified self/personal analytics movement, which promotes self-monitoring through sensors and devices to improve physical and mental well-being.

Business Impact: The impact of human augmentation — and the ethical and legal controversies surrounding it — will first be felt in industries and endeavors demanding extreme physical performance, such as the military, emergency services and sports, followed rapidly by those requiring intense mental focus and stamina, such as financial trading and high-stakes sales.

Technology and talent management leaders will find themselves at the intersection of technology, biology and ethics as they support and manage people who are prepared or required to augment themselves. Highly competitive work environments and performance-based incentives may require new risk measurement and monitoring techniques to detect instances of covert augmentation — for example, by monitoring for anomalies in performance and achievements.

Benefit Rating: Transformational

Market Penetration: Less than 1% of target audience

Maturity: Embryonic

Recommended Reading: "Maverick* Research: The Future of Humans: Get Ready for Your Digitally, Chemically and Mechanically Enhanced Workforce"

"Technology Overview: Quantified Self"

Personal Analytics

Analysis By: Melissa Davis

Definition: Personal analytics is the use of data by an individual to help achieve objectives across a range of domains, including personal healthcare (fitness tracking); safety (alertness and focused enough to drive); financial management (on track to reach financial saving objectives); employment (prioritize work schedule to fulfill daily job role requirements); social connection (spending time with others), self-esteem (personal development) and ultimately, self-actualization (am I the person I always wanted to be?).

Position and Adoption Speed Justification: Personal analytics is not the same thing as quantified self; quantified self is one of the several sources of data that can be analyzed as part of personal analytics — an emerging concept. Although quantified self has entered mainstream consumer awareness with the availability of wearable devices for personal fitness and sleep management, the analytical usage of that much data these systems can generate remains a niche activity for many consumers. The disassociation of hardware and software (for example, Nike's move to end hardware production while increasing its investment in software development), and the eventual emergence of standards to facilitate quantified-self data integration will drive adoption of personal analytics in years to come. Time to plateau has moved from 10 years to five years as we forecast mainstream adoption of virtual personal assistants (VPAs) beginning in 2017 and convergence with smart advisor category from 2020. VPAs and smart advisors are the platforms that deliver personal analytics.

User Advice: Consider personal analytics to be the latest development in the use of consumer data. Traditionally, organizations collected data, and used it to analyze and understand their customers better, primarily for their own (marketing or risk) purposes. The growth of the web has pushed organizations to share the value of the insights they have captured as a benefit for customers (for example, Amazon's cross-selling recommendations have become an indispensable source for people to use the acquired data to expand their reading habits). We are now entering a phase where the consumer is responsible for capturing much of their own data (quantified-self) and the question is whether this data will remain valuable to only the individual or whether organizations will also be able to exploit this data to achieve their own objectives. Investigate the quantified-self data that is becoming available to actual or potential customers. Consider how this data can be used by them to achieve personal objectives, then identify what role your organization could play in providing analytic services to support them. In many jurisdictions, it is not possible to link personal data across systems without having explicit permission from the person involved, so consumer opt-in is required for the sharing of this information for marketing purposes.

Business Impact: Organizations can benefit from personal analytics in five ways, by:

1. Directly monetizing the provision of analytic services via the sale of software or applications.
2. Offering analytic services as an additional feature or benefit to encourage the adoption of other products and services.
3. Using the data collected as a part of personal analytic service to personalize other products and services, and to deepen and extend the customer relationship.
4. Using the data collected as a part of personal analytic service to assist with planning future corporate capabilities so as to meet emerging or any likely future requirements.
5. Providing personal analytic capabilities to employees to improve their productivity and effectiveness.

Benefit Rating: Transformational

Market Penetration: Less than 1% of target audience

Maturity: Emerging

Sample Vendors: Fitbit; FutureAdvisor; Mint; Openhour; Spire; Strava; Tictrac

Recommended Reading: "Defining Personal Analytics — Consumers Meet Smart Agents"

Smart Workspace

Analysis By: Mike Gotta; Paul Miller; Carol Rozwell

Definition: A smart workspace leverages the growing digitalization of physical objects brought about by the Internet of Things (IoT) to deliver new ways of working, sharing information and collaborating. Programmability of physical environments enables smart workspaces to contextually work with mobile devices, software applications, digital workplace graphs and smart machines to improve workforce efficiency and effectiveness. Any location where people work can be a smart workspace.

Position and Adoption Speed Justification: Smart workspaces primarily reflect advances in and synergies between six trends:

1. The IoT
2. Digital workplace graphs
3. Smart machines
4. Digital signage/electronic whiteboards
5. Indoor mapping
6. Smart buildings

A smart workspace is a key aspect of a digital workplace initiative, bringing strategists involved in facilities and real estate in as key stakeholders. It applies to physical environments such as:

- Conference rooms
- Huddle rooms (small spaces where people congregate)
- In-building open spaces
- Retail and shop floors
- Manufacturing assembly lines

"Things" participate in a smart workspace. Examples include applications and devices, such as electronic whiteboards, building interfaces (HVAC), large digital displays, workstations, mobile devices and wearables. Fully taking advantage of a smart workspace will require organizations to revisit design strategies to include methods for better understanding how people participate in a physical space/place. Adoption rates will vary based on the need for organizations to support flexible work models that optimize physical and interactive aspects of places and things. Technology advances in nonenterprise environments — in consumer electronics and appliances as well as in homes, cities, transportation, fashion, security and so on — will influence smart workspace innovation. Smart workspaces will also be constrained by the pace of the dependent contributors from those sectors.

User Advice: Enterprise strategists focusing on a digital workplace strategy and digitalized business processes should follow smart workspace trends and look for deployment opportunities, such as meeting rooms, huddle rooms and in-building open spaces. Emerging applications will expand beyond traditional productivity scenarios to include situations that are more industry- and process-specific, such as an insurance professional using a digital pen that interacts directly with back-end processing systems, or a patient being remotely monitored via a wearable interface in their home that interfaces with diagnostic systems and advises healthcare professionals to improve care delivery. IT organizations will need to work much more closely with real estate and facility teams, and vice versa. Identity, access management and security teams will also play a critical role.

Additionally, electronic whiteboards are becoming integrated with traditional collaboration and content software systems, providing more opportunities for experimentation. Meeting artifacts can be better captured and connected into digital workplace graphs to become more widely searchable. Beacons and sensors placed in key locations within a workplace can interact with mobile apps to deliver personalized information to workers based on proximity. These can be used to improve employee learning, provide relevant information on products, or communicate safety procedures based on employee location.

The smart workspace will emerge at an uneven pace as organizations prioritize potential solutions independently from one another. For instance, building upgrades may take longer than expected and some market sectors will be laggards in terms of smart workspace adoption. Localization needs will also influence smart workspace adoption.

Business Impact: Business impact from smart workspaces will be diverse, ranging from improved employee productivity and cultural perception of the workplace by workers, to improved customer experience as employees make better use of smart workspaces to serve clients.

The digitalization and programmatic evolution of places and things will impact IT methodologies related to system design, requiring new skills for design teams to understand how people use places and things. Smart workspaces will also have organizational impacts as traditional software teams now need to work with facilities management teams in ways not envisioned. The digitalization and programmability of the workplace will create new integration opportunities. For instance, smart workspace activities will signal information to digital workplace graphs and smart machines, and vice versa. Finally, adoption of smart workspace will trigger its own form of consumerization — bring your own thing (BYOx) — as employees will add their own objects to a smart workspace environment. Organizations will need to adjust BYOx policies accordingly.

Benefit Rating: Transformational

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Sample Vendors: AgilQuest; Condeco; Estimote; Microsoft; Oblong; Planon; Prysm

Recommended Reading: "The Rebirth of Office Space: What Every CIO Needs to Know and Do"

"Cool Vendors in the Digital Workplace, 2016"

Volumetric Displays

Analysis By: Brian Blau

Definition: Volumetric displays create visual representations of objects in three dimensions, with a 360-degree spherical viewing angle in which the image changes as the viewer moves. Unlike most 3D planar displays, which create the illusion of depth through stereoscopic or autostereoscopic technique, volumetric displays create lifelike images in 3D space.

Position and Adoption Speed Justification: Volumetric displays have barely emerged from the laboratory, but are often thought of as the iconic volumetric image of Princess Leia created by R2-D2 in the first "Star Wars" movie. Volumetric displays remain an elusive yet aspirational goal.

Volumetric displays fall into two categories: swept volume and static volume displays. *Swept volume* uses the persistence of human vision to recreate volumetric images from rapidly projected 2D "slices." *Static volume* displays rely on a 3D volume of active elements. Swept and static volumetric displays suffer from the significant dangers of rapidly moving parts or ionized particles in the vicinity of people, especially because the volumetric nature of the generated image convinces the brain that it is solid and "real" and, therefore, can be touched. In all cases, the physical volume of data required to generate a volumetric image is considerable, which will limit its overall advancement in the coming years.

User Advice: Outside of specialized areas where budgets are not significant constraints, this technology remains firmly in the lab rather than in commercial applications. Current technologies limit the size of volumetric space that can be displayed, and the mechanical solutions create potentially dangerous, rapidly moving parts. Until alternative approaches can be delivered (which

seems unlikely in the near future), volumetric displays will remain an extremely niche product but eventually could be used as a product display, or to view objects or even people who are not at the same location.

Business Impact: General applications are not well-developed for business use with volumetric displays. To date, simple applications in marketing have been deployed — usually targeted at high-end retail environments. There are some specialized applications for geospatial imaging to enhance 2D maps, and for use in architectural rendering. However, most of these can be achieved at much lower costs using other more-commercialized technologies, such as 3D displays. Concurrently, the rapid growth and continuing development of head-mounted displays and light field displays threaten to overwhelm the continuing development of volumetric displays outside of specialized markets. Potential application areas include medical imaging, consumer entertainment, gaming and design, but costs will need to fall dramatically for these to be viable options for using true volumetric displays.

Benefit Rating: Moderate

Market Penetration: Less than 1% of target audience

Maturity: Emerging

Sample Vendors: Leia; Musion; Realfiction; Voxiebox; Zebra Imaging

Recommended Reading: "Market Trends: Head-Mounted Displays for Virtual Reality and Augmented Reality"

Conversational User Interfaces

Analysis By: Tom Austin; Van L. Baker; Magnus Revang

Definition: Conversational UI (CUI) is a high-level design model in which user and machine interactions primarily occur in the user's spoken or written natural language. Typically informal and bidirectional, these interactions range from simple utterances (as in "Stop," "OK" or "What time is it?" "12:24") through highly complex interactions (collecting oral testimony from crime witnesses) and highly complex results (as in creating an abstract image for the user). As design models, CUI depends on implementation via applications and related services.

Position and Adoption Speed Justification: Vendor and open-source activity has been growing, making it easier to develop CUIs. More is promised to come in both CUIs and new business models that will shake up control of new UI paradigms to partly replace and supplement apps and APIs.

Recent CUI-relevant activity includes Alexa Skills Kits, better IBM Watson natural-language capabilities, Facebook's Messenger Platform, Microsoft Cortana Intelligence Services and numerous cloud-based natural-language processing (NLP) services and frameworks (such as Google's SyntaxNet).

Most CUI implementations are still primitive, selecting responses via pattern matching and simple decision trees. Increases in capabilities are largely due to improvements in natural-language understanding (NLU) and speech recognition that make matching user input to the appropriate output more effective. Leading bots today use human fallback to handle edge case queries. The potential for CUI is enormous, although at present the hype is definitively higher than the capabilities of actual implementations.

User Advice: Imagine the ultimate "clean screen" approach (or a no-screen approach as with Amazon Echo and skill kits) — workable on a desktop, a large screen, tablet, phone or watch — a blank screen with only one blank dialogue box to which the user can type or talk. It responds meaningfully, retaining and reusing previous information from earlier dialogs with this user and often asking qualifying questions before responding substantively to the user's wants or needs.

The need for literacy-related training and tools will significantly diminish during the next decade. Plan on CUIs becoming the dominant model. By 2020, at least 40% of people working in new applications will primarily interact with CUIs there, removing much of the perceived need to invest further in improving "computer literacy."

Be wary of overcommitting to CUIs too deeply. Conversational interfaces can make machines smarter and improve the ability of people to handle novel situations (people and machines collaborating will be better than either alone). But they carry an extra burden as well. For well-developed, repetitive skills that can be performed almost effortlessly, injecting conversation can degrade performance unless the technology is able to recognize the repetitive patterns and able to invoke many steps of a routine process with a single, user-generated command. We believe this autoprogramming capability will be one of the most critical — but last to emerge — in conversational interfaces.

(Avoid retrofitting CUI front ends to existing applications unless it improves usability and user delight.)

Business Impact: This approach will appear primarily in new applications. Enterprise IT leaders should be on the lookout for (and biased toward) CUIs to improve employee (and customer) effectiveness as well as cut operating expenses and time spent learning arcane computer semantics.

There will also be some retrofitting. Over the next five years, we do not expect large enterprises to invest heavily in retrofitting existing systems of record where the employee base is experienced and stable and the feature set well known to the user base. However, where there is employee turnover, significant rapid changes in feature sets, or where enterprises face a continuing burden of providing computer literacy training, enterprise IT leaders need to consider creating people-literate front ends to make it easier for employees to adapt and excel.

Benefit Rating: Transformational

Market Penetration: Less than 1% of target audience

Maturity: Emerging

Sample Vendors: Amazon; Baidu; Facebook; Google; IBM; IPsoft; Microsoft; NextIT; Salesforce

Recommended Reading: "Smart Agents Will Drive the Switch From Technology-Literate People, to People-Literate Technology"

"Maverick* Research: Machines Will Talk to Each Other in English"

"Predicts 2016: Smart Machines"

Brain-Computer Interface

Analysis By: Anthony Mullen

Definition: A brain-computer interface is a type of user interface, whereby the user's distinct brain patterns are interpreted by a computer. Data is either passively observed for research or used as commands to control an application or device. There are three methods used: (1) invasive, where electrodes directly connect to the brain; (2) partially invasive, where the skull is penetrated but the brain is not; and (3) noninvasive, where commercially available caps or headbands are worn to detect the signals from outside the skull.

Position and Adoption Speed Justification: Noninvasive methods cannot use higher-frequency signals as the skull blocks and disperses electromagnetic waves. Therefore, a major challenge for this approach is obtaining a sufficient number of distinctly different brain patterns to perform a range of commands. While control today is not very smooth or continuous, it is possible to control virtual objects in multiple dimensions, play interactive games and control hardware. Notably, the world's first mind-controlled drone race was held by the University of Florida in 2016, showing a potential path for consumer robotics.

Currently, the best neural interfaces are used for limb prosthetics, and use 100 channels to distill the neural signals of the brain. The Defense Advanced Research Projects Agency (DARPA) is investing $60 million over four years to improve this to a million channels with Neural Engineering System Design (NESD). This would be a transformational step for this technology with wide-reaching implications on not just more nuanced interfacing, but in deeply understanding the brain from a physical and psychological dimension. Initiatives such as the Obama administration's decade-long Brain Activity Map project will also drive forward knowledge benefiting this field.

While invasive techniques provide better results, it is expected that the noninvasive brain-computer interfaces (BCIs) will grow at a quicker rate as the method has no issues with infection and discomfort, and can be more easily accommodated by institutions, patients and consumers. Noninvasive methods make up the majority of research, however, to date there is no large corpus of data available or standards between providers and hardware. As a result, determining accuracy of readings based on user characteristics such as demographic traits and state of mind, and wider machine-learning, has not flourished.

Brain-computer interfaces remain at an embryonic level of maturity, although we have positioned them at the trigger-peak midpoint of the Hype Cycle in recognition of the gains made in prosthetics

control, maturing open-source communities, new use cases such as drone control, and increased usage for customer behavior research.

User Advice: Today, outside the medical domain, speech recognition, gaze tracking or muscle-computer interfaces offer faster and more-flexible interaction than brain-computer interfaces. The need to wear a headband or cap to recognize the signals is also a serious limitation in most consumer or business contexts. As a result, there is no significant market for the use of these devices in mainstream business IT. Ultimately, most users outside of the medical and rehabilitation domain should treat brain-computer interfaces as a research activity and experiment with noninvasive tools. Undertaking these projects will require a considered investment of time and expertise. Open-source communities for brain-computer interfaces and knowledge sharing are maturing with both OpenBCI and NeuroTechX in 2015 building a much-needed international network for neurotechnology.

Hardware manufacturers developing drones, robotics, virtual reality headsets and professional sports devices should explore the benefits of noninvasive methods to improve performance and experience immersion.

Platform developers in the physical and mental wellness space should consider these devices as part of innovation programs to better understand contextual conditions that give rise to mind states such as attention, joy and frustration.

Marketers, customer experience professionals and interaction designers can use these devices now to add more quantitative signals on mind state to better understand how consumers use products and view messaging.

Business Impact: The BCI market is typically segmented into neurogaming, neuroprosthetics, defense, and neuroanalysis (psychology). Neuroanalysis and neuroprosthetics are the largest commercial segments, driven by hospitals and rehabilitation centers. Psychological research centers and military applications are next, with neurogaming mostly nascent. These market sizes are likely to persist for five to 10 years.

As wearable technology becomes more commonplace, applications will benefit from hybrid techniques that combine brain, gaze and muscle tracking to offer hands-free interaction. Over the next five years, as virtual reality (VR) hardware develops, it is likely that noninvasive versions of this technology will be included in VR headset designs.

Benefit Rating: Moderate

Market Penetration: Less than 1% of target audience

Maturity: Embryonic

Sample Vendors: ANT Neuro; Blackrock Microsystems; Emotiv; InteraXon; MindMaze SA; neurowear; NeuroSky; OpenBCI; Personal Neuro Devices

Recommended Reading: "Maverick* Research: Read My Mind — Will Eavesdropping on the Human Brain Lead Marketers to the Holy Grail?"

"Cool Vendors in Human-Machine Interface, 2013"

"Market Trends: New Technologies Benefit Employees and People With Disabilities"

"Maverick* Research: The Future of Humans: Get Ready for Your Digitally, Chemically and Mechanically Enhanced Workforce"

Virtual Personal Assistants

Analysis By: Tom Austin; Van L. Baker

Definition: A virtual personal assistant (VPA) performs some of the functions of a human assistant. With a user's permission, it:

- Observes user content and behavior
- Builds and maintains data models (drawing inferences about people, content and contexts)
- May predict users' needs
- May act autonomously on the user's behalf
- Gradually learns from user behavior and as a result builds trust

VPAs make everyday tasks easier (by prioritizing emails, for example), and its users more effective (by highlighting the most important content and interactions).

Position and Adoption Speed Justification: VPA adoption grows as users get more comfortable with them, as the technologies improve and as the variety of approaches multiply:

- Unobtrusive VPA-like features such as Gmail's Smart Inbox, embedded in existing products, are growing, as are narrow-purpose VPAs (such as personal financial advisors, health and wellness coaches, and calendaring agents).
- VPAs are becoming centerpieces of cross-platform platforms (such as Microsoft's Cortana Intelligence Suite).
- General-purpose VPAs (such as Siri, Google Now, Alexa and Cortana) have room to grow and evolve. Today, they deliver only a fraction of what we expect by 2020.
- VPAs act on behalf of both consumer and business users, but more enterprise-oriented VPAs are now also emerging (such as Openstream's EVA).

Virtual customer assistants (such as IPsoft's Amelia and Go Moment's Ivy, which is a virtual hotel concierge) are similar to VPAs, but they serve, first and foremost, as agents of the businesses that employ them.

User Advice: IT leaders should:

- Anticipate that many different types of VPAs will be available and that a single "winner take all" success is unlikely to happen. Individuals may use several VPAs with different specializations, such as:
  - Health-related VPAs to help with diet, exercise, the quantified self, relationships and psychological well-being
  - VPAs to serve as personal shoppers
  - Personal-career development and financial-management VPAs
  - VPAs for office-specific tasks like calendar management, email handling and external information monitoring
- Encourage experimentation while creating opportunities for employees to share experiences and recommendations. Lead by doing.
- Prepare for mail-centered VPAs first, followed by blossoming of the full range of capabilities.
- Recognize that privacy, security and innovation are at odds, but encourage experimentation with guardrails. Imposing too many controls too soon due to a lack of trust in your employees could eliminate the opportunity to outflank competitors.
- Look for opportunities to leverage VPAs to improve the appeal of business apps for users especially in the mobile app segment.
- Carefully measure the impact of VPAs on people's behavior and performance. Use an ever-evolving set of metrics, identified by observation and crowdsourcing.

Business Impact: VPAs have the potential to transform the nature of work and structure of the workplace. They could upset career structures and enhance workers' performance, but they have challenges to overcome beyond simply moving from research labs to functional products. It is far too early to determine whether or how they will overcome privacy concerns (although opt-in requirements make sense). Individuals will think long and hard about what they want each VPA to see and who else might view that information. Similarly, enterprises will be concerned about employees exposing confidential information via VPAs and should determine the extent to which information is retained by VPA providers.

Benefit Rating: Transformational

Market Penetration: Less than 1% of target audience

Maturity: Embryonic

Sample Vendors: Apple; Google; IBM; Microsoft; Nuance; x.ai

Recommended Reading: "Smart Agents Will Drive the Switch From Technology-Literate People, to People-Literate Technology"

"IT Strategists Must Prepare for the Rise of Virtual Personal Assistants in the Workplace"

"Entering the Smart-Machine Age"

Smart Data Discovery

Analysis By: Rita L. Sallam; Cindi Howson

Definition: Smart data discovery is a next-generation data discovery capability that enables business users and citizen data scientists to automatically find, visualize and narrate relevant findings, such as correlations, exceptions, clusters, links and predictions, without having to build models or write algorithms. Users explore data via visualizations, natural-language-generated narration, search and natural-language query technologies.

Position and Adoption Speed Justification: Over the past five years, visual-based data discovery tools have disrupted the traditional business intelligence (BI) and analytics market, as they are easy to use and enable users to assemble data rapidly, and explore hypotheses visually, to find new insights in data. Although data discovery has been transformative in the way it enables business users to explore data (in comparison with traditional BI technologies), many of the activities associated with preparing data, finding patterns in large, complex combinations of data, and sharing insights with others remain highly manual. Data discovery tools are easy to use, but since users analyze data manually, it is not possible for them to explore every possible pattern combination, let alone determine whether their findings are the most relevant, significant and actionable. Relying on business users to find patterns manually may result in users exploring their own biased hypotheses, missing key findings, and drawing their own incorrect or incomplete conclusions, which may adversely affect decisions and outcomes.

Smart data discovery will advance rapidly along the Hype Cycle, to mainstream adoption, as a key feature of modern BI platforms. This is because this technology has the potential, as it matures, to grant a broader range of business users, citizen data scientists and nontraditional BI users access to insights from advanced analytics, for greater business impact.

IBM (with Watson Analytics), SAS and startup vendors such as BeyondCore, DataRobot, DataRPM and SparkBeyond are drivers of these new capabilities, which have the potential to transform how, and which, users derive insights from data.

By 2018, the multiple styles of data discovery, including smart, governed, Hadoop-based, search-based and visual-based, will converge as their unique features and benefits become standard requirements for modern BI platforms. They will include self-service data preparation and natural-language-generation capabilities.

User Advice: Data and analytics leaders should:

- Consider smart data discovery if there is a need to deliver more advanced insights to a broader range of users — including citizen data scientists — without expanding the use of data scientists.
- Monitor the smart data discovery capabilities and roadmaps of modern BI and analytics platforms, and of startups as they mature. They should do so particularly in terms of the upfront

setup required, the data preparation required, the types of data that can be analyzed, the types and range of algorithms supported, and the accuracy of the findings.

- Look for opportunities to use smart data discovery to complement existing data discovery and data science initiatives, particularly if analysts are exploring highly dimensional data that is very time-consuming to explore fully using current data discovery approaches. But they should be aware that citizen data scientists must collaborate with, and be coached by, specialist data scientists.
- Identify where automating algorithms to detect patterns in data could reduce the exploration phase of analysis and improve highly skilled data science productivity, while recognizing that they still need to validate models, findings and applications.
- Start with a small list of specific business problems that cannot be solved with traditional BI and data discovery tools, and launch a smart data discovery pilot to assess the viability of smart data discovery, prove its value and build trust in it.

Business Impact: Gartner predicts that, through 2017, the number of citizen data scientists will grow five times faster than the number of highly skilled data scientists. This growth will be enabled by smart data discovery, which has the potential to complement and extend existing modern BI platforms by putting insights from advanced analytics into the hands of business analysts, in order to drive new sources of business value. Since data scientists will focus on only statistically significant findings for further analysis, and on creating enterprise-grade models, only the most accurate and significant insights will be actioned, to optimize business impact. There will also be less error due to the bias inherent in manual exploration processes, and users will spend less time exploring and more time building the most relevant models.

Benefit Rating: Transformational

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Sample Vendors: BeyondCore; DataRobot; DataRPM; IBM (Watson Analytics); Maana; SAS (Visual Analytics); SparkBeyond

Recommended Reading: "Magic Quadrant for Business Intelligence and Analytics Platforms"

"Magic Quadrant for Advanced Analytics Platforms"

"Smart Data Discovery Will Enable a New Class of Citizen Data Scientist"

Affective Computing

Analysis By: Jan-Martin Lowendahl

Definition: Affective computing technologies sense the emotional state of a user (via sensors, microphone, cameras and/or software logic) and respond by performing specific, predefined

product and service features, such as simply changing a quiz or even recommending a set of physical activities to fit the mood of the learner.

Position and Adoption Speed Justification: True affective computing technology, with multiple sensor input, is still mainly at the proof-of-concept stage in education. However, it is gaining more interest as online learning expands and seeks the means to scale with retained or increased quality. A major hindrance in its uptake is the lack of consumerization of the needed hardware and software involved. It has to be inexpensively available for students, through the use of personal devices, for example. Products such as Affectiva's Affdex are promising because they enable relatively low-cost, packaged access to affective computing. Original use cases were for testing media and advertising impact on consumers.

Recently, Affectiva announced a patent "Using Affect Within a Gaming Context," which was implemented in the game Nevermind enabling players to experience emotion-based feedback on a minimum-specification Windows or Macintosh machine with almost any standard webcam. This is something very close to adaptive learning and could represent a breakthrough for affective computing for the masses. Affectiva markets its technology as "emotion AI," using deep learning capabilities on an emotion data repository of nearly 4 million faces analyzed from 75 countries, amounting to more than 50 billion emotion data points. This relates affective computing to the recent advances in smart machines.

Lenovo has released AirClass, a new distance education platform that has webcam-based emotion detection and emotion analytics as one of its features. AirClass is delivered as SaaS, and the subscription pricing is based on the number of instructors and number of classrooms per instructor, starting at $540 a year.

This makes it very accessible and again signals a breakthrough for affective computing in education.

A more specialized branch of affective computing involves "social robots." The Emote project used a commercially available robot called Nao introduced in 2008. Nao's sibling Pepper is designed to recognize the principal human emotions and adapt its behavior to the mood of the interacting human. Both IBM and Microsoft collaborate with SoftBank to enable smart-machine-type capabilities via the cloud. Even though most of the existing applications of Pepper are in commercial store settings, Pepper is now available for sale to private individuals in Japan.

As content (for example, textbooks) becomes more digitized and is consumed on devices that have several additional sensors (for example, tablets with cameras and accelerometers), interesting opportunities will arise to mash up the capabilities of, for example, an open adaptive learning platform, such as Cerego or CogBooks, and affective software such as Affectiva's Affdex, making affective computing for untutored learning more accessible. All this combined with several quantified-self-type sensors such as Fitbit trackers will increase the number of data points available for statistically based and eventually smart-machine-based adaptive learning. We now see many of these capabilities converging in many form factors, ranging from inexpensive webcam-based affective computing to robotic platforms increasingly supported by quickly developing cloud-based smart machine ecosystems.

Altogether, this merits a jump to just before the Peak of Inflated Expectations as we wait for increasing hype specifically in education, with five to 10 years until it reaches the Plateau of Productivity.

User Advice: Now is the time to start experimenting with affective computing solutions such as AirClass and Pepper to be prepared for the strategic tipping point of implementation. CIOs, together with academic leaders, should start estimating the potential impact in terms of possible pedagogical gains and financial impact, such as increased retention for online learning. Institutions with a large online presence, or that want to exploit the hype for brand recognition, should start piloting now. CIOs should partner with retail companies, consumer electronics companies and universities (particularly online universities) to further explore this field.

Affective computing can involve collecting sensitive data about students, which makes it important to make sure that any privacy laws and concerns of the users are met. Any use of affective computing should involve an opt-in process.

Business Impact: One important advantage of this technology is that, even if it is inferior to a face-to-face student-teacher interaction, it scales well beyond the physical lectures with over 100 students that today offer limited individual pedagogical adaptivity anyway. A potential complement or competitor to remedy the scalability problem is the social-media-based peer-mentoring approach, as exemplified by Rosetta Stone (formerly Livemocha) as well as by massive open online courses (MOOCs).

In general, affective computing is part of a larger set of approaches to further personalize the educational experience online. Another example is adaptive learning that depends on the statistical data of learners in the same pedagogical situation. It is also related to context-aware computing in general.

The ultimate aim of affective computing in education is to personalize and enhance the learning experience of the student, which should result in tangible results like higher grades, faster throughput and higher retention.

Benefit Rating: Moderate

Market Penetration: Less than 1% of target audience

Maturity: Emerging

Sample Vendors: Affectiva; Affective Media; IBM; Pearson

Recommended Reading: "Business Model Innovation Examples in Education"

Commercial UAVs (Drones)

Analysis By: Brady Wang; Kenneth F. Brant; Gerald Van Hoy

Definition: Commercial unmanned aerial vehicles (UAVs) resemble miniature helicopters, fixed-wing airplanes and multirotors that can be remotely controlled by human pilots on the ground or outfitted

for autonomous navigation and used to perform aerial surveillance. UAVs typically incorporate GNSS, camera, sonar sensors and navigation systems that guide them for imaging, thermal and spectral analysis. Memory caches and communications links allow UAVs to collect and transmit datasets, as well as transfer them to the cloud for record or instance calculation.

Position and Adoption Speed Justification: In 2016, commercial UAVs are climbing the "Peak of Inflated Expectations" because of technology improvement and increasing demand for commercial UAVs. More and more commercial applications have emerged and an increasing number of investments have been made by startups and big companies. Practical examples of commercial UAV applications include parcel delivery, pipeline inspection, disaster inspection, security inspection, and agriculture inspection. According to the U.S. Federal Aviation Administration (FAA) website, there have been 4,800 petitions for testing commercial UAV flights. China and Japan are also testing the application of UAV in agricultural and parcel deliveries. Also, all major e-retailers and package delivery companies, such as Swiss, Singapore and U.S. postal services are testing in-house parcel-delivery service. In the 2016 Canadian wildfire, the country used UAVs to identify the cause of the forest fire.

Although the number of UAV applications has grown, the actual shipment of commercial UAV has not significantly increased due to the immaturity of regulations. Several countries continue to amend their laws in order to accommodate UAVs and strike a balance between safety and development. In February 2016, the FAA changed its regulation to allow commercial UAVs to fly over crowds. In March 2016, the FAA allowed UAVs to fly up to 400 feet. In April 2016, the FAA approved nighttime commercial UAV operation. Although the flying of UAVs over populated areas is prohibited in Japan, test flights for UAV parcel delivery are approved in Chiba. In China, many parcel-delivery companies are testing UAVs for parcel delivery. The oil and gas industry has already started using drones in its operations, like in oil rig and turbine inspections. It's expected that such applications would be fairly commonplace within the next few years Research and development also continues in the private sector, such as the collaboration between DJI and PrecisionHawk for agricultural UAV and Amazon working on a delivery UAV prototype.

Given the increase in use cases, new technology investment, number of trial petition and mature regulations, Gartner has moved time to plateau from "two to five years" to "five to 10 years."

User Advice: Commercial and industrial firms in the agriculture, mining, construction, energy, and news-gathering and film-making sectors should actively participate in this technology closely. Firms in these industries that have economic motivations to increase process uptime, improve workers' safety, and avoid catastrophic events and financial liabilities should do feasibility testing. These UAVs are especially attractive for autonomous inspections in sparsely populated environments, where valuable assets are physically distributed and are costly and/or dangerous to inspect, such as the maintenance of solar and wind power generation equipment (which are highly sensitive to equipment misalignment and are difficult for humans to efficiently inspect), offshore rigs, oil and gas pipelines, power distribution lines, process manufacturing plants, and agricultural and construction work sites. U.S.-headquartered multinational firms in these sectors should seek an airworthiness exemption from the FAA to explore the cost-benefit analysis of operating commercial UAVs until final rules are written in 2016-2017 and/or use overseas subsidiaries to perform these tests.

Business Impact: Commercial UAVs are replacements for human surveyors, inspectors and cameramen who previously had to perform costly jobs in unsafe conditions — so they offer productivity improvements by reducing and/or redeploying head count, while improving real-time data capture and worker' safety. The greater diagnostic capability of UAV payloads coupled with the increased availability/reliability of surveillance resources can reduce operating costs, missed opportunity costs and the risk of catastrophic events while improving project management and resource allocation.

Benefit Rating: High

Market Penetration: Less than 1% of target audience

Maturity: Emerging

Sample Vendors: Aeryon Labs; Amazon; Boeing; DJI; Facebook; Google (Titan Aerospace); Parrot; PrecisionHawk; Skycatch; Trimble

Recommended Reading: "Market Trends: Multirotor Drone Evolution Will Demand Increased Semiconductor Content"

"Competitive Landscape: Personal Drones, 2015"

"Market Trends: Commercial Drones — New Market for Semiconductors"

IoT Platform

Analysis By: Alfonso Velosa; Yefim V. Natis

Definition: An Internet of Things (IoT) platform is software (suite and/or platform as a service [PaaS]) that facilitates operations involving IoT endpoints (sensors, devices, multidevice systems and systems of systems) and enterprise resources. The platform provisions and controls IoT endpoints, monitors event streams, enables specialized analysis and application development, and integrates with back-end IT systems — all to support IoT business solutions. Its responsibilities may be distributed and fulfilled in part in the cloud or near the devices.

Position and Adoption Speed Justification: Enterprises continue to engage with an increasingly diverse variety of IoT endpoints, seeking traditional benefits like condition-based asset optimization, while discovering new business opportunities and revenue models like product subscriptions. The sophistication, scale and business value of these interactions call for specialized technology resources. The IoT platform capabilities can enable basic and advanced IoT solutions and digital business operations. The IoT platform will be deployed in a hybrid fashion; it will incorporate cloud-based elements (either private or public) and on-premises software that is distributed between the endpoints and gateways.

Enterprises' increasing adoption of IoT and digital business amplifies the hype around IoT platforms, as well as propels vendor and user investments in IoT platforms and services. The increased deployment of IoT projects is pushing up IoT platforms toward the Peak of Inflated Expectations, before the buildup of practical experience will eventually bring them to mainstream productivity and

maturity. 2016 sees many of the megavendors bringing their solutions to market, even if incomplete or first-generation offerings, and raising the marketing volume yet again.

User Advice: CIOs and IT leaders:

- Establish or contribute to an IoT program management office or center of excellence (COE) composed of IT, operational technology (OT) and business personnel. This IoT COE can set objectives, coordinate planning and tactical vendor negotiations, collaborate, and share best practices, resources and people.
- IoT projects are likely new to your organization; thus, budget for training and use the capabilities of IoT platforms. Start with smaller initiatives to allow for the learning period.
- Look for IoT platform offerings (software and/or services) that incorporate some support of:
  - Device provisioning and associated software management
  - Data aggregation, integration, transformation, storage, tagging and management
  - Event processing: rule engines/orchestration/business process management (BPM)
  - Programmability
  - Analysis and data visualization
  - Security
  - Multiple communications/message protocols
  - Adapters for endpoints, and OT and IT applications
  - A developer and user experience policy
- Build a training program for your developers and business analysts based on existing IoT platform capabilities, as well as perform an assessment of the skill set within your organization. Plan to leverage a service partner to ramp up as you train internal resources.
- Understand that an IoT platform is a starting point. No IoT platforms will work straight off-the-shelf. Customize the platform to build a solution for your unique circumstances (for example, adding third-party device support or analytics to meet special needs).
- Evaluate candidate IoT platforms in terms of their fit to your design, capabilities and business objectives, but expect roadmaps to change in the fast-changing IoT market.

Business Impact: There is a significant business opportunity to achieve greater value and make better decisions from the insights, information and data that are generated by instrumented devices, and to provide better control of things distributed across the enterprise and its external stakeholders. Unfortunately, this data has been largely locked into the devices — due mostly to lack of connectivity, but also lack of standards, systems and processes to obtain this data systematically; in some cases, it has even been due to ignorance.

IoT platforms act as the intermediary between the "thing" and the well-established IT world and business processes; therefore, they facilitate the introduction of a new, potentially transformative wave of innovation to enterprises and consumer businesses in the pursuit of digital business, smart business decisions and intelligent business operations. Most enterprises will need to experiment to determine their optimal IoT data and architectures, integration needs, cultural fit, and business models.

Benefit Rating: Transformational

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Sample Vendors: Bosch Software Innovations; Candi Controls; Eurotech; GE; IBM; LogMeIn; Microsoft; Oracle; PTC; SAP

Recommended Reading: "Market Guide for IoT Platforms"

"Platform as a Service: Definition, Taxonomy and Vendor Landscape, 2016"

"Survey Analysis: Users Cite Ambitious Growth — and Formidable Technical Challenges — in IoT Adoption"

"Best Practices in Exploring and Understanding the Full Scope of IoT Solutions"

"Market Trends: IoT Solution Providers in India Need a Sound Positioning and Messaging Strategy"

"Preparing, Planning and Architecting for the Internet of Things"

At the Peak

Gesture Control Devices

Analysis By: Werner Goertz

Definition: Gesture control devices are worn or held by the user in order to capture body movements, gestures and expressions. Gestures with specific semantic content can be interpreted by devices and software applications as a means to enhance the human-machine interface (HMI).

Position and Adoption Speed Justification: Natural, intuitive interaction between human and machine is driving innovation in hardware, OS and software interface. As a result, we assume that the majority of interaction will be biometric, eventually replacing a keyboard and a mouse. Gesture control, natural language, facial expression, emotion detection and touch form a portfolio of input/output (I/O) controls.

User Advice: The dexterity and natural means of human expression of the human hands and fingers suggest rings and bracelets as a form factor for gesture control. They are easy to put on and remove, and represent a logical extension of human expression. Devices such as the Logbar Ring

develop custom lexicons of semantics that allow for the typing of letters, enabling applications such as texting or social networking. Bird by MUV Interactive is also a finger-worn device used in gaming and public speaking to advance professional presentation slides. These early product examples are indicative of a nascent opportunity that will mature within two to five years. Gesture control impacts enterprise collaboration when used as an I/O device for spatial computing. Oblong uses a wand that allows collaborators to pick and move objects (text documents, spreadsheets) in an immersive collaboration environment. For industrial applications such as warehousing, the tracking of hand movements using sensors can provide insights into productivity and can be used to control robots or other equipment. Atheer's augmented reality (AR) head-mounted displays (HMDs) are gesture-controlled. For immersive virtual reality (VR) applications, gesture controllers such as Leap Motion's Orion replicate hand gestures in a virtual world that is rendered through head-mounted displays such as Oculus Rift. Commercialization of HMDs in 2016 will remove that barrier, which has stalled adoption so far. For a number of years now, game controllers such as Nintendo Wii's device track the gamer's body and arm movements to project direction and velocity of a golf swing or a tennis racket. Similarly, the controllers for the popular Guitar Hero game mimic the basic shapes of popular guitar models and capture body and gesture motion.

Providers of personal technologies should implement gesture control in its various forms, illustrated above as a means to augment the human-machine interface of their products, for a natural, intuitive use model.

Business Impact: Vendors of applications in productivity software, gaming and VR/AR can leverage gesture control and gesture control devices to enhance the user experience and differentiate. However, devices must be robust in materials, form factors and connectivity to ensure use beyond the novelty effect, and the vocabulary of semantic expressions must be intuitive and simple. Complex, predefined gesture sets have applications in specific enterprise use cases only.

Benefit Rating: Moderate

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Sample Vendors: Leap Motion; Logbar; MUV Interactive; Nintendo; Oblong; Rithmio

Recommended Reading: "Cool Vendors in Human-Machine Interface, 2016"

Micro Data Centers

Analysis By: David J. Cappuccio; Ron Blair; Jay E. Pultz

Definition: A micro data center is modular or containerized and is smaller than a computer room — usually no more than a rack of equipment or two — and typically one rack or less. All required IT functionalities (such as uninterruptible power supply systems for servers and facilities) are contained in the micro data center, designed to handle specific needs (for example, accumulating sensor data or small remote office support) at distributed locations and typically managed from a large data center.

Position and Adoption Speed Justification: For more than 20 years, small computer rooms (as small as a closet) have been subsumed into larger, consolidated data centers — a trend we see continuing unabated. Yet, not all IT capabilities need to be (or should be) local to business or for factors such as latency or site-specific operations. Additionally, with the distributed nature of the Internet of Things (IoT), there will be a need to accumulate and process data locally before it is sent to a larger data center for additional analysis.

Micro data centers are typically based on more mature IT and facilities technology — although new features, including integration, packaging, containerization and remote management, have been added. Trends such as the distributed nature of the IoT mean that micro data centers will be much more widely deployed than they are now. They can be located virtually anywhere, including as stand-alone centers in appropriate containers (for environmental protection), typically found in branch offices. Micro data centers use any available means for communication, but are typically connected into an office LAN/WAN.

User Advice:

- Design micro data centers to run autonomously, but controlled centrally.
- Create a standard, self-contained solution designed for easy deployment, simple replacement and remote monitoring and management.
- Focus on maximizing operational independence, while minimizing IT skills and risks at remote sites.

Business Impact: This functional capability widely exists (such as retail sites and bank branches), but micro data centers differ through their standardization, integration, remote management and enhanced security. These solutions promise significantly lower costs and enhanced manageability. We view micro data centers as transformative to supporting digital business development, with a particular focus on the IoT, and expect them to be deployed in their thousands (and possibly tens of thousands) across most enterprise verticals.

Benefit Rating: Transformational

Market Penetration: 1% to 5% of target audience

Maturity: Adolescent

Sample Vendors: AST Modular; Elliptical Mobile Solutions; Huawei; Panduit; Rittal; Schneider Electric; Zellabox

Recommended Reading: "Apply a Self-Contained Solution to Micro Data Centers"

Smart Robots

Analysis By: Kenneth F. Brant; Gerald Van Hoy

Definition: Smart robots are smart machines with an electromechanical form factor that work autonomously in the physical world, learning in short-term intervals from human-supervised training

and demonstrations or by their supervised experiences on the job. They sense conditions in local environments and recognize and solve problems. Some have a specialized functional form, such as warehouse robots, while others have more general forms and/or humanoid appearances. Because of their advanced sensory capabilities, smart robots may work alongside humans.

Position and Adoption Speed Justification: Industrial robots have progressed further in their life cycles than smart robots. Smart robots have had significantly less adoption to date, but they received great hype in the marketplace, which is why smart robots are positioned climbing the Peak of Inflated Expectations. Hype and expectations will continue to build around smart robots during the next few years, as providers execute on their plans to expand their offerings and deliver solutions across the wider spectrum of industry-specific use cases and enterprise sizes. Hype is quickly building for smart robots as a result of several key vendors' actions during the past few years:

- Amazon Robotics (formerly Kiva Systems) plans to deploy 10,000 robots to fill customer orders
- Google's acquisitions of multiple robotics technology companies
- Rethink Robotics' launch of Baxter and Sawyer, which can work alongside human employees
- SoftBank Robotics' introduction of the humanoid Pepper and creation of "Pepper for Biz" studios to expedite commercialization of business applications.

User Advice: Users in light manufacturing, distribution, retail and healthcare facilities should consider smart robots as both substitutes and complements to their human workforce. Begin pilots designed to assess product capability and quantify benefits. Examine current business and material-handling processes into which smart robots can be deployed; also, consider redesigning processes to take advantage of the benefits of smart robots with three- to five-year roadmaps for larger-scale deployment.

Business Impact: Smart robots will make their initial business impact across a wide spectrum of asset-centric, product-centric and service-centric industries. Their ability to do physical work, with greater reliability, lower costs, increased safety and higher productivity, is common across these industries. The ability for organizations to assist, replace or redeploy their human workers in more value-adding activities creates potentially high — and occasionally transformational — business benefits. Typical and potential use cases include medical materials handling, disposal of hazardous wastes, prescription filling and delivery, patient care, direct materials handling, stock replenishment, product assembly, finished goods movements, product pick and pack, e-commerce order fulfillment, package delivery, shopping assistance and customer care, and disposal of hazardous materials.

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Sample Vendors: Aethon; Amazon Robotics; ARxIUM; Google; iRobot; Panasonic; Rethink Robotics; SoftBank Robotics; Symbotic

Blockchain

Analysis By: David Furlonger; Ray Valdes; Martin Reynolds

Definition: Blockchain is a type of distributed ledger in which value exchange transactions (in bitcoin or other token) are sequentially grouped into blocks. Each block is chained to the previous block and immutably recorded across a peer-to-peer network, using cryptographic trust and assurance mechanisms. Depending on the implementation, transactions can include programmable behavior.

Position and Adoption Speed Justification: The "blockchain" term is hyped to include a loosely combined set of technologies and processes that variously spans middleware, database, security, analytics/AI, monetary and identity management concepts. Blockchain is also becoming the common shorthand for a diverse collection of distributed-ledger products, with more than two dozen offerings in the market.

Blockchain governance is a critical factor for adoption. Governance styles include:

- A public permissionless model, as found in the bitcoin technology stack
- A private permissioned environment, where the consensus model is jointly owned by the network participants (as in, for example, the Society for Worldwide Interbank Financial Telecommunication [SWIFT] system)
- A hybrid permissioned environment, where the consensus model is provided by a third party (such as IBM, MultiChain, Tendermint or other service provider)
- A private permissioned environment, where the consensus model is owned and operated by an institution for its own subsidiaries and partners

A critical aspect of blockchain technology today is the unregulated, ungoverned creation and transfer of funds, exemplified by bitcoin. It is this capability that funds much of blockchain development, but also scares regulators and governments.

Today, bitcoin is the only proven blockchain. Its permissionless (trustless) architecture supports bitcoin transactions, but also enables authoritative recording of events, immutable snippets of data and simple programmable scripts. These features are exciting, but come at a cost, including: lack of scalability; lack of full transparency; limitations concerning consumption of resources; operational risk from unintended centralization of resources (mining); and lack of alignment to, and accommodation of, existing legal and accounting frameworks.

Other blockchain technologies bring further adoption challenges, including the lack of: standards, robust platforms, scalable distributed consensus systems and interoperability mechanisms.

The debates surrounding permissioned, permissionless, hybrid, private ecosystems and governance will force a more robust analysis of distributed ledgers. As these analyses are completed, workable solutions will evolve.

User Advice:

- Recognize that the terminology surrounding blockchain is in flux. This uncertainty masks the potential suitability of technology solutions to meet business use cases. Consequently, use extreme caution when interacting with vendors that have ill-defined/nonexistent blockchain offerings.
- In your planning efforts, ensure you are clearly identifying how the term "blockchain" is being used and applied, both internally and by providers, in order to better understand the return on capital employed, especially compared to existing "proven" technologies.
- Take this opportunity to proactively understand the differences between the four styles of governance as part of your organization's strategic planning efforts, especially as they relate to specific business use cases and operational risk assessments.
- Closely monitor the evolution of blockchain, including related initiatives, such as consensus mechanism development, sidechains and distributed ledger.

Business Impact: Blockchain and distributed-ledger concepts are gaining traction because they hold the promise to transform industry operating models. Multiple business use cases are yet to be proven. While the hype is around the financial services industry, it is likely that manufacturing, government, healthcare and education will see more rapid evolution and acceptance. As a portent for the rise of the programmable economy, the potential of this technology to radically transform economic interactions should raise critical questions for society, governments and enterprises, for which there are no clear answers today.

Benefit Rating: Transformational

Market Penetration: Less than 1% of target audience

Maturity: Emerging

Sample Vendors: Accenture; Cognizant; Deloitte; Ethereum; IBM; Infosys; R3; Ripple; SWIFT; Tata Consultancy Services

Recommended Reading: "The Future of Money Is the Programmable Economy, Not Just Bitcoin"

"Maverick* Research: In a Post-Bitcoin World, Metacoin Platforms Enable the Programmable Economy"

"Hype Cycle for the Future of Money, 2014"

"The Bitcoin Blockchain: The Magic and the Myths"

Connected Home

Analysis By: Fernando Elizalde

Definition: A connected home is networked to enable the interconnection and interoperability of multiple devices, services and apps, ranging from communications and entertainment to healthcare, security and home automation. These services and apps are delivered over multiple interlinked and integrated devices, sensors, tools and platforms. Contextual, real-time, smart experiences are provided at the local or cloud level, enabling individuals and other connected services in the household to control and monitor the home remotely, as well as within it.

Position and Adoption Speed Justification: The connected home is a concept that overarches several technologies, devices, applications, services and industries. As such, it is defined in this technology profile to provide a framework for the Hype Cycle of the same name.

The concept has evolved from home security, home automation and energy management solutions to a much more complex concept that expands, without being exhaustive, to:

- Media entertainment
- Home security
- Monitoring and automation
- Health and fitness
- Education
- Energy management products and services

The interconnection of home electronics and devices has been simplified enormously in the past few years, with content and information being distributed throughout the home via a variety of devices. Solutions have also become less expensive largely because of:

- The commoditization of components and the enablement of cloud integration, which has brought down costs to technology providers
- The maturity of access technologies (such as broadband, Wi-Fi and 4G)
- The standardization of radio technologies, including low-energy networking standards (such as Bluetooth low energy [LE], ZigBee and Z-Wave), allowing for low-cost wireless connectivity in any device in the home
- The simplification of user interfaces

The connected home is evolving into the rendering of increasingly intelligent systems, which, by using smart learning algorithms and predictive analytics, deliver smart home experiences. This is resulting in a rapid progress in the Hype Cycle toward the Peak of Inflated Expectations. However, market fragmentation and dynamism in the market somewhat hinder faster consumer adoption. Among other things, consumers may be wary of spending on solutions that may soon become obsolete or whose value is not well-communicated by the vendors.

User Advice: The market is seeing a fast migration from closed and semiopen to open ecosystems and "certified" ecosystems through cloud integration and open APIs adoption. Open ecosystems are shaping up around Amazon's Echo and Alexa voice services, the Works with Nest program, Apple's HomeKit, and Samsung's SmartThings. In view of these developments:

- Develop partnership strategies to build your existing expertise in devices, services and customer relationships. Provide a unified user experience and compelling integrated connected-home solutions.
- Partner with software providers for a unified platform. Base your solutions on standardized protocols and home gateways to speed up market adoption.
- Offer ease of use and reasonable hardware costs, differentiating the quality of experience on the services you have on offer by providing efficient support.
- Provide real value and disruptive solutions to the consumer, rather than a novelty or just aesthetics.
- Add intelligence by using smart learning algorithms and predictive analytics or by cloud integration with a solution that can provide it.

Business Impact: Connected-home solutions affect a wide spectrum of manufacturers (of white goods, entertainment electronics and home automation, security, and fitness and health products), as well as providers of network infrastructure and services, ranging from energy utilities and surveillance to healthcare, communications and digital entertainment.

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Adolescent

Sample Vendors: ADT; Amazon; Apple; AT&T; Belkin; Deutsche Telekom; Google; Insteon; Samsung Electronics; Vivint

Recommended Reading: "MWC 2015: Increasingly Intelligent Mobile Apps Require Businesses to Reassess Connected-Home Strategies"

"Market Trends: CSPs Grow Their Offers to the Connected Home"

"Market Trends: Connected Home Platforms Unify Use Cases and the User Experience"

"Cool Vendors in the Connected Home, 2016"

"Market Trends: Choose a Functional Business Model for the Connected Home Market"

"Competitive Landscape: Connected Home Ecosystems, 2016"

"Market Trends: Biometric Technologies Create a Personalized Experience and Convenience in the Connected Home"

Cognitive Expert Advisors

Analysis By: Kenneth F. Brant

Definition: Cognitive expert advisors (CEAs) replace smart advisors this year. CEAs, at a minimum, possess a specialized algorithm, as well as machine-learning and natural-language processing functions tuned specifically to a purpose-built, curated body of big data to generate insights, discoveries, recommendations and decisions. CEAs must be purposely designed and built, then rigorously trained to produce "expert" advice — they are neither effective nor "cognitive" without the participation of human subject matter experts in development and operation.

Position and Adoption Speed Justification: This technology profile replaces what was previously published as "smart advisors" because the term "cognitive computing" has been more hyped and commonly accepted in the marketplace. Its position is now near the Peak of Inflated Expectations because of the prominence of IBM's Watson (a question-answering prototype playing Jeopardy, a TV game show in the U.S.) in popular culture and the subsequent creation of the IBM Watson Group that heavily promoted the term "cognitive computing" in association with its expert advisor offerings. Today, many major vendors have embraced the term "cognitive computing" with respect to their expert advisory platforms. The accuracy and productivity of these systems today is still being tested and proven. Even when initially successful and value is discovered, the systems can be fragile, requiring frequent troubleshooting, retraining and upkeep of the "big data" to produce desirable, actionable results. We believe it will take considerable time for these deployment and maintenance issues to become manageable and acceptable by the majority of enterprise users who want a dependable service level. The issues are not strictly technological, but also involve a considerable amount of vision, risk, leadership and commitment to change management on the part of enterprise champions. Furthermore, the skill sets and practices needed to be successful with this class of technology are not the same as those associated with the typical IT project, and they are not found in the typical line of business or strategic business unit leading the mission.

User Advice: Early adopters should begin trials of CEAs if they can identify a strong program champion who has visionary and change management leadership skills. These organizations should first verify that they are investigating applications that are suitable for CEAs and not for simpler technologies. Preliminary work should ensure that data/content can be sufficiently accessible (owned and or acquired), prepared and problem-specific to generate a rich and productive "corpus." Do not select one company and move immediately to pilot. Given the complexity and wide range of results seen in the earliest trials to date, we advise a broad trial involving many providers to see which combinations produce the best results with your data, industry application and corporate culture. Devote a considerable length of time to each provider trial, as initial results may not be satisfactory, and the matching of algorithms with your curated content and training methods will take time and multiple assessments. Ensure that your internal personnel and service providers have the requisite skills and mindset to do the initial content curation, system training, experimentation and maintenance.

Business Impact: CEAs offer the biggest business impacts in industries and applications where the presence of big, dynamic and largely unstructured data is compounded by the need for highly individualized and complex business decisions and customer recommendations.

Some of the key benefits promised by CEAs are:

- Faster scientific discoveries and accelerated time to market with new products and services (for example, in pharmaceutical and biotechnology research)
- More timely, accurate and beneficial problem identification and solution decision making (for example, in medical diagnosis and treatment)
- Lower costs, higher customer retention and brand equity in complex customer service situations (for example, in retail, insurance and investment customer care)

The cost and complexity of developing CEAs put them out of the direct reach of the large majority of consumers for the near future. We expect consumer usage of CEAs through 2018 will be via enterprises that have deployed them for premium customer service offerings.

Benefit Rating: Transformational

Market Penetration: Less than 1% of target audience

Maturity: Emerging

Sample Vendors: CognitiveScale; IBM; Infosys; IPsoft; Saffron (an Intel company); Wipro

Machine Learning

Analysis By: Alexander Linden; Lisa Kart

Definition: Machine learning is a technical discipline that aims to extract certain kinds of knowledge/patterns from a series of observations. Depending on the type of observations provided, it splits into three major subdisciplines: supervised learning, where observations contain input/output pairs (aka labeled data); unsupervised learning, where those labels are omitted; and reinforcement learning, where evaluations are given of how good/bad a certain situation is.

Position and Adoption Speed Justification: Machine learning is one of the top two concepts in IT at the moment, as evidenced by Google's recent Founder's Letter (from CEO Sundar Pichai) and Nvidia's commitment here, and given its extensive range of effects on business; blockchain is the other top concept. A subbranch of machine learning called deep learning or deep neural nets gets even more attention, because it seemingly conquers cognitive domains that were previously the exclusive domain of humans: image recognition, text understanding and audio recognition.

Currently, machine learning supersedes older terms such as data mining, predictive analytics, and, to some extent, even advanced analytics. The drivers for continued massive growth and adoption are the growing surges in data volume and complexities that conventional engineering approaches are increasingly unable to handle. In the future, necessary advances in transportation, energy, medicine and manufacturing will not be possible without machine learning.

User Advice:

- Nurture the required talent for machine learning, and partner with universities and thought leaders to keep up to date with the rapidly changing pace in data science.
- Understand the capabilities of machine learning and its potential business impact across a wide range of use cases — from process improvements to new services and products.
- Track what initiatives you already have underway that have a strong machine-learning component: for example, customer scoring, database marketing, churn management, quality control and predictive maintenance.
- Monitor what other machine-learning initiatives you could be a part of and what your peers are doing.
- Assemble a (virtual) team that prioritizes those machine-learning use cases and establish a governance process to progress the most interesting use cases to production.

Business Impact: The more complex the problem, the more likely that monitoring and control of it cannot be effectively mastered by even the smartest engineers. Machine learning drives improvements and new solutions to business problems across a vast array of business and social scenarios:

- Automation
- Drug research
- Customer relationship management
- Supply chain optimization
- Predictive maintenance
- Operational effectiveness
- Workforce effectiveness
- Fraud detection
- Automated vehicles
- Resource optimization

Benefit Rating: Transformational

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Sample Vendors: Dato; Dell; H2O.ai; IBM; KNIME; Microsoft; Oracle; RapidMiner; SAP; SAS

Recommended Reading: "Magic Quadrant for Advanced Analytics Platforms"

"Machine Learning Drives Digital Business"

"Cool Vendors in Data Science, 2015"

Software-Defined Security

Analysis By: Neil MacDonald; Mike J. Walker

Definition: Software-defined security (SDSec) is an umbrella term covering a number of security technologies that benefit when the security policy management is abstracted from the underlying security policy enforcement points.

Position and Adoption Speed Justification: Information security infrastructure is too rigid and static to support the rapidly changing needs of digital business and to provide effective protection in a rapidly changing threat environment. Increasingly, security vendors are shifting more of the policy management out of individual hardware elements and into a software-based management plane for flexibility in specifying security policy, regardless of location. There are several areas within SDSec that are emerging — software-defined perimeters, software-defined segmentation and software-defined data protection.

User Advice:

- Look beyond the hype. There are several areas where organizations are finding value in SDSec use cases today.
- Don't make the mistake of assuming "software-defined" means software only. Security hardware will still be needed for deep inspection at demarcation points.
- Require all security platform vendors to open up via APIs for full programmability of their infrastructure.
- Pressure security platform vendors for their roadmaps to support OpenStack and other cloud management platforms.

Business Impact: Information security cannot be an inhibitor to the needs of digital business. SDSec will bring speed and agility to the enforcement of security policy, regardless of the location of the user, the information or the workload.

Benefit Rating: Transformational

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Sample Vendors: Catbird; Certes Networks; CloudPassage; Fortinet; Illumio; Security First Corp.; Trend Micro; Unisys; vArmour; Vidder

Recommended Reading: "Market Guide for Cloud Workload Protection Platforms"

"What Is the Value of a Software-Defined Data Center?"

Autonomous Vehicles

Analysis By: James F. Hines

Definition: An autonomous vehicle is one that can drive itself from a starting point to a predetermined destination without human intervention using various in-vehicle technologies and sensors, such as lidar, radar and cameras, as well as control systems, software, map data, GPS and wireless data communication.

Position and Adoption Speed Justification: Continued advancements in sensors, positioning, imaging, guidance, artificial intelligence (AI), mapping and communications technologies, combined with advanced software and cloud computing, are gaining in precision to bring the autonomous vehicle closer to reality. However, in 2016, complexity and cost challenges remain high, which is impacting reliability and affordability requirements.

During 2015, the efforts of autonomous vehicle manufacturers have been prominently featured by mainstream media, thus leading to unrealistic and inflated expectations. Key challenges for the realization of autonomous vehicles continue to be centered on cost reductions for the technology, but they increasingly include legal and ethical considerations, such as liability and driver-related aspects.

The pace of technology innovations and individual country, state and global legislation will likely initially result in specific, limited-use cases for self-driving vehicles in the short term (for example, low-speed city driving/highway driving). During 2016, GM invested $500 million in Lyft for autonomous vehicle development and acquired Cruise Automation. In 2015, Delphi Automotive acquired Ottomatika, and Uber hired key members of the Carnegie Mellon robotics team to work on its autonomous vehicle project.

User Advice: The adoption of autonomous vehicle technology will develop in three distinct phases: automated driver assistance, semiautonomous and fully driverless vehicles. Each phase will require increasing levels of technical sophistication and reliability that rely less on human driving intervention.

Automotive companies, service providers, governments and technology vendors (for example, software, hardware, sensor, map data and network providers) should collaborate on joint research and investments to advance the required technologies, as well as work on legislative frameworks for self-driving cars. Realize that the main implications of self-driving vehicles will be on economic, business and societal dimensions.

Furthermore, educate all constituencies of the benefits of self-driving vehicles. Consumer education is critical to ensure that demand meets expectations once autonomous vehicle technology is ready for broad deployment. For example, drivers will need to be educated on how to take over manually in case an autonomous vehicle disengages due to technical error or to changing environmental conditions. Specific focus must be applied to the transitional phase of implementing autonomous or partially autonomous vehicles with an existing older fleet of nonenabled vehicles. This will have implications for driver training, licensing and liability (as in insurance).

Business Impact: Automotive and technology companies will be able to market autonomous vehicles as having innovative driver assistance, safety and convenience features, as well as an option to reduce vehicle fuel consumption and to improve traffic management. The interest of nonautomotive companies highlights the opportunity to turn self-driving cars into mobile computing systems that offer an ideal platform for the consumption and creation of digital content, including location-based services and vehicle-centric information and communications technologies.

Autonomous vehicles are also a part of mobility innovations and new transportation services that have the potential to disrupt established business models. For example, autonomous vehicles will eventually lead to new offerings that highlight mobility-on-demand access over vehicle ownership, by having driverless vehicles pick up occupants when needed. Autonomous vehicles will deliver significant societal benefits, including reduced accidents, injuries and fatalities, as well as improved traffic management, which could impact other socioeconomic trends. For example, if people can be productive while being driven in an autonomous vehicle, living near a city center to be close to work won't be as critical, which could slow the process of urbanization.

Benefit Rating: Transformational

Market Penetration: Less than 1% of target audience

Maturity: Embryonic

Sample Vendors: Continental; Delphi Automotive; General Motors; Google; Mobileye; Nokia; Nvidia; Robert Bosch; Uber; ZMP

Recommended Reading: "Cool Vendors in Automotive and Smart Mobility, 2015"

"Uber Shifts Lanes, Aims to Pass Automakers Through Technology"

"Survey Analysis: Automotive Ethernet's Impact on the Automotive Industry"

"Predicts 2015: Connected-Vehicle and Mobility Innovations Inspire New Digital Business Opportunities"

"Maverick* Research: Crashing Industries and Our Societal Beliefs — The Real Implications of the Autonomous Vehicle"

Nanotube Electronics

Analysis By: Dean Freeman

Definition: Nanotubes are tiny cylinders of atoms that can be used for a wide variety of purposes. Properties can include high electrical conductivity, great mechanical strength, and insulator, semiconductor and conductor characteristics.

Position and Adoption Speed Justification: Carbon nanotubes with semiconductor properties offer the promise of small transistors with high switching speeds in future semiconductor devices. Carbon nanotubes with metallic (conducting) properties offer the promise of low electrical resistance

that can be applied to the interconnections within integrated circuits. Other nanotube materials being evaluated include silicon and compound semiconductor materials. Silicon versions (often referred to as silicon nanowires) are actively being researched for use in silicon anode batteries.

Despite its high visibility, this technology is still in the relatively early research and development stage. Individual nanotubes can be readily fabricated, but problems remain with their interconnection and the fabrication of arrays of transistors. As a transistor gate material, nanotubes will look very promising — once the industry determines how to purify them and either grow them or place them on a substrate in quantities of several billion. Nanotubes will begin to appear when the technology nodes reach below 5 nanometers (nm); perhaps a generation sooner for interconnect technology. In 2013, IBM successfully built a 10,000-nanotube transistor device, and the company thinks it can have a production-worthy device in 2020, but the purification and cost challenges are still significant. There is discussion of gate all-around transistors at 7 nm, however.

Interconnecting nanotube transistors present a different problem. There is the question of whether the nanotube bundles can support the required current densities. This is particularly critical in between layers. A 25-nm-diameter via will hold approximately 21 nanotubes, but it is unclear if this is sufficient to support current densities. Along with other issues, this will become clearer in the next year or two as further research is carried out.

Researchers are experimenting with new forms of, and new uses for, nanotubes. One team at the University of California, Berkeley, has developed a radio using a single nanotube; the 500 nm length of the nanotube acts as the antenna, while other functions amplify and demodulate the signal.

User Advice: Interested parties should monitor developments of this technology. Do not expect all advancements to occur during the same period. Pursue advances in energy-related applications first, such as batteries and solar cells and conducting materials in printed electronics.

Business Impact: There is the potential for a huge impact, particularly when silicon devices reach their minimum size limits — expected during the next 10 to 15 years.

Benefit Rating: Transformational

Market Penetration: Less than 1% of target audience

Maturity: Embryonic

Sample Vendors: Globalfoundries; IBM; Imec; Intel; Samsung Electronics; TSMC

Recommended Reading: "Emerging Technology Analysis: Carbon Nanotubes Will Drive the Next Generation of Semiconductor Devices"

"Emerging Technology Analysis: Carbon Nanotubes and Graphene Are Indispensable for Future Electronic Products, So Act Now"

Software-Defined Anything (SDx)

Analysis By: Philip Dawson

Definition: Software-defined anything (SDx) is a collective term that encapsulates the market momentum for improved standards for infrastructure programmability and data center interoperability that are driven by automation inherent to cloud computing, DevOps and fast bimodal infrastructure provisioning.

Position and Adoption Speed Justification: The trend to use the terminology "software defined" started with software-defined networking (SDN), which enables a separation of the networking logic and policies into software from the individual devices. Because SDN separates the hardware and software, it potentially decouples the purchasing decision and may allow the adoption of generic hardware, which would become very disruptive. As SDx matures, the scope to extend this concept to servers and storage will grow as well. While SDx is cloudlike, SDx does not generally include self-selection, metering and chargeback models.

SDx is seen by vendors as a way of abstracting infrastructure away from the software, management and high availability/disaster recovery (HA/DR) characteristics of a given workload. Across the spectrum of SDx definitions, true standards and interoperability are weak, and mechanisms for defining and policing standards are only slowly emerging. Many vendor differentiation claims focus on basic infrastructure positioning or, at best, infrastructure and platform delivery. To achieve its full potential, SDx messaging that is aimed at transforming hardware deployment must venture more aggressively into the application and software space. Some SDx definitions are more naturally suited to workload transformation. For example, OpenStack defines APIs and functionality of the infrastructure, and is supported by many vendors, thus delivering a standard interoperability layer that can counter Amazon APIs. An additional benefit of new APIs is that new applications can be written to bring new value at the automation layer. This will potentially create a whole new industry segment.

As a collective, SDx also incorporates various initiatives, such as OpenStack, OpenFlow, the Open Compute Project and Open Rack, which share similar visions. It is very easy for some vendors to blur the distinction between different SDx definitions, or between an SDx definition and its "open" stack counterpart.

User Advice: SDx provides a way for vendors to leverage their installed-base presence to drive broader ecosystem acceptance from users and partners in their own domains. Across domains, standards are patchy, but SDx represents a powerful set of trends that will become increasingly tangible over time — especially where they force vendor collaboration that benefits user choice and heterogeneity. Infrastructure and operations (I&O) leaders should look out for lock-in of management and tools of SDx frameworks, especially across domains (for example, compute and storage with the network or within the data center, but not all infrastructure). As individual SDx technology silos evolve and consortiums arise, look for standards and bridging capabilities to benefit your portfolio; however, challenge individual technology suppliers to demonstrate their commitment to true interoperability standards within their specific domains.

Business Impact: While openness will always be a claimed vendor objective, different interpretations of SDx definitions may be anything but open. Vendors of SDN (network), SDDC (data center), SDS (storage), SDC (compute) and SDI (infrastructure) technologies are all trying to maintain

leadership and defend margin in their respective domains, while deploying SDx initiatives to aid market adjacency plays between heterogeneity and lock-in.

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Sample Vendors: Cisco; EMC; Hewlett Packard Enterprise; IBM; Intel; Microsoft; NetApp; Symantec; VMware

Recommended Reading: "IT Market Clock for Server Technology and SDx, 2015"

"How Digital Business Affects I&O Investments"

Sliding Into the Trough

Natural-Language Question Answering

Analysis By: Tuong Huy Nguyen

Definition: Natural-language question answering (NLQA) technology is a type of natural-language processing technology, composed of applications that provide users with a means of asking a question in plain language. A computer or service can answer it meaningfully, while maintaining the flow of interaction.

Position and Adoption Speed Justification: Nonconversational, information-centered answers are already possible (for example, through Alexa, Cortana, Google Now and Siri). However, the ability to conduct even a brief conversation — with context, antecedent development and retention, and relevancy to individual users — is in its infancy. The challenges in effective interpretation of idiomatic interrogative speech, matching it to knowledge bases of potentially infinite scope, and the selection of a limited number of answers (even just one) remain profoundly difficult. Given the interest, speed of development and enabling technologies (such as deep neural networks), this technology will reach maturity in as soon as five years.

Adjacent technologies are providing NLQA with strong momentum. Cortana has been integrated into Windows 10, Skype and Outlook, as well as numerous third-party apps. Google Now has enabled custom voice actions for select third-party apps. Siri now uses its own web crawler (Applebot), and with iOS 9, is better leveraging contextual data such as location, app usage, known contacts and other information to assist with plain language queries. Baidu has hired noted artificial intelligence (AI) pioneer Andrew Ng. He is charged with overseeing the new R&D facility in Silicon Valley, aimed at expanding the company's capabilities around natural-language processing and human-machine interfaces, including voice recognition, semantic intelligence and machine translations. Amazon's Alexa service has expanded beyond its own branded devices. It has been integrated into various consumer products, such as home security, automation and management,

connected speakers, and ceiling fans. The Alexa Skills Kit (ASK) extends the potential to many other consumer products as well.

User Advice: NLQA is a distinct component among a broader set of technologies that enable cognitive expert advisors and virtual personal assistants. As such, it's positioned to be a strong enabler of these and other technologies, such as cognitive computing and speech recognition. Furthermore, it can serve as a two-way steppingstone toward building an effective NLQA system.

The computing power required to accomplish a genuinely effective "trivia competitor" is expensive, but will become less so with time. Any projects founded on such facility must be experimental, but in the foreseeable future will include diagnostic applications of many kinds, as well as commercial advice and merchandising, and strategic or tactical decision support. "Augmentation" of human activity and decision making is the key thought. No decision support application comes, fully formed, from nothing — it will be expert humans who build it, design the parameters and develop the interface. Humans will, similarly, evaluate its advice and decide how to proceed. A good idea is to begin with experimental technologies, such as chatbots, and to work toward more sophisticated technologies as they become commercially accessible.

Business Impact: Ultimately, the ability for line workers or unschooled consumers to achieve effective responses from machines without using expertise in framing queries will generate new kinds of information exploitation by diminishing information friction yet more. Given a limited set of answers and an effective means of capturing plain language requests, it is easy to see computers more effectively providing guidance in various environments. Business use cases include diagnostic support in healthcare (whether for expert or nonexpert users), customer care and call center, and consumer services (such as those that Siri provides).

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Sample Vendors: Amazon; Apple; Cognitive Code; EasyAsk; Expect Labs; IBM Watson; Microsoft; MindMeld (Expect Labs); Nuance; Sherpa Software

Recommended Reading: "Emerging Technology Analysis: Natural-Language Question Answering"

"Siri and Watson Will Drive Desire for Deeper and Smarter Search"

Enterprise Taxonomy and Ontology Management

Analysis By: Mark A. Beyer; Guido De Simoni

Definition: The management of the taxonomy (classification) and ontology (nature) of information consists of practices and implemented technology solutions. Ontology is a classification approach that groups similar items together based upon some affinity or parallel function. Taxonomy is the

distinctive nature of particular concepts, physical things or even language structure. This definition is specific to data, rather than a general definition.

Position and Adoption Speed Justification: Generally, ontology implies how data can be used; for example, data about an individual may have been originally used to identify a customer — but later the same data can be used to identify an individual who is also an employee. Taxonomy defines the components and relationships that are used in data to create a useful data object. All data points have dependency and reference to other data points and taxonomy explains both the components (first name and last name) and their relationship to each other. It is possible for data to belong to multiple taxonomies and ontologies simultaneously. In the previous example, surname and given name are more accurate globally than first or last name, but both can be accurate depending on the ontology rules in place.

Data can exist under multiple taxonomy and ontology (T&O) pairs. The ability to manage existing pairs and to discover new, useful pairs is becoming increasingly important. T&O methods can be used to allow many different use cases to access and utilize information in a "data lake" or detailed layer of an enterprise data warehouse (EDW). The logical data warehouse relies upon T&O capabilities. Some T&O pairs or even overlapping layers can be specified (two taxonomies to one ontology or one taxonomy participating in two ontologies), others emerge dynamically from data discovery, data science modeling, business process evaluation or even content analytics (text, document, audio, image and video). As data is recombined by analysts, new affinity or sympathy between information assets is discovered and has the potential for benefits and reuse by other information systems.

The most basic form of T&O management is a canonical model. Dynamically evolving ontology/taxonomy pairs and combinations should be discovered through new use cases. Eventually, tools will be reduced, in terms of targeted functionality, and adoption will be extremely slow as ontologies struggle for proof of value. We see the market developing less in the direction of general-purpose, cross-platform semantic modeling and more toward T&O management that will be used in specific cases and for specific projects. This raises the question of whether general-purpose T&O management will ever reach the Plateau of Productivity. Glossaries and other rudimentary T&O approaches are currently exhibiting false, early adoption; expectations for significant introspection from these tools are overly optimistic. The bulk of ontological work will remain human-driven, using tools that present metadata to human users who then develop personal ontology use cases.

User Advice: Data administrators and information stewards should look for opportunities to federate the various metadata support efforts that are being established in different disciplines and begin to build a registry of shared taxonomies and ontologies. Metadata that catalogs the taxonomies and ontologies and (more importantly) ensures that they are shared, records the extent to which they are held in common, can support service-oriented deployments and could become a key component of context brokers.

Business glossaries encourage predominant definitions, they also allow for localized and domain-specific definitions and terminology management. Determine whether significant cross-purpose communication is taking place in your organization and consider using a glossary tool (one area of interest here is big data catalogs).

Educate designated or selected business personnel in roles for the creation of information assets and in the importance of metadata as a precursor to introducing these T&O practices. Exercise extreme caution, however, as end users should not be subjected to the rigor or terminology involved in metadata management. The focus here should be on ensuring the business understands the process, the benefits and the users' levels of commitment.

Business Impact: Enterprise T&O management will bring a faster, more agile mode of integration between business process changes and IT system changes. It will also enable better assessment (by business analysts) of the risks and benefits that accrue in the business regarding the maintenance and security of information assets. Ontologies are dynamic — in that they emerge not only as the business process is better defined, but also as it changes or absorbs activity from adjacent processes. Additionally, the data taxonomy that originates within a business process expands as ontology concepts become better defined (see "Top 10 Strategic Technology Trends for 2016: Information of Everything"). The CDO will find T&O capabilities critical as new forms of data architectures emerge, such as "governed" or "smart" data lakes, graph analysis, and so on (see "How Chief Data Officers Can Use an Information Catalog to Maximize Business Value From Information Assets").

The pursuit of T&O management will begin the process of aligning risk management with operations management, finally bridging the gap between compliance and margin management. In managing T&O resolution, data quality efforts will be easier to manage; for example, nonshared terms will be resolved to each other and sources will recognize common models for data quality resolution and master data management (MDM) support. New advances were noted in 2015 through the beginning of 2016, with regard to enterprise data management in the financial services and banking industry. One such advance that will present a partial solution is MDM, but from an ontology perspective it is almost mandatory that it remain within industry silos.

Benefit Rating: Moderate

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Sample Vendors: Adaptive; Digital Harbor; Global IDs; IBM; Mondeca; SAS; Smartlogic; TopQuadrant

Recommended Reading: "Innovation Insight: Leveraging Ontology to Exploit Business Value Hidden in Information"

"Top 10 Strategic Technology Trends for 2016: Information of Everything"

"How Chief Data Officers Can Use an Information Catalog to Maximize Business Value From Information Assets"

"Avoid a Big Data Warehouse Mistake by Evolving to the Logical Data Warehouse Now"

"Survey Analysis: Customers Rate Their Advanced Analytics Platforms"

Augmented Reality

Analysis By: Tuong Huy Nguyen; Marty Resnick; Brian Blau

Definition: Augmented reality (AR) is the real-time use of information in the form of text, graphics, audio, and other virtual enhancements integrated with real-world objects and presented using a head-mounted-type display or projected graphics overlays. It is this "real world" element that differentiates AR from virtual reality. AR aims to enhance users' interaction with the environment, rather than separating them from it.

Position and Adoption Speed Justification: Current technology is best-suited for purpose-built, specialized solutions. As such, position and adoption speed will vary by vertical and industry. This profile represents a homogenized view of AR implementations across market segments.

Market interest remains fairly steady according to Google Trends. AR is currently struggling with mismatched expectations (vendors promising solutions beyond current capabilities) and poor implementations (for example, solutions delivered without immersive development knowledge, workflow integration, or mapped to business value or need). B2C implementations are still struggling to show consumers value. Better and more transparent hardware, coupled with more compelling use cases, are needed before further progress can be made. Based on Gartner inquiry and industry news, B2B AR continues to gain traction as more enterprises are discovering and seeing the value of using AR in their workflow. HMD sales reflects the burgeoning pilot deployments. Numerous, high-profile acquisitions and investments indicate the ongoing interest and development in this area — for example, Apple's acquisition of Metaio, PTC's acquisition of Vuforia, Daqri's acquisition of ARToolworks and Microsoft's launch of HoloLens.

Furthermore, developments and announcements from leading IT vendors (such as Intel, Google, Facebook, Amazon and Microsoft) serve as a two-way steppingstone for AR development. Advancements in head-mounted display hardware will provide more compelling hands-free use cases for AR, as well.

User Advice: Decide on the audience for your AR solution. Internal- and external-facing solutions are not transposable. Restrict initial trials to a specific task or goal. Set benchmarks against unaugmented solutions to understand risks and benefits. Set the business goals, requirements and measurements for your AR implementation before choosing a provider. Rich and robust offerings can bring value only if you have a clear intention for the deployment. For external-facing implementations, use AR as an extension of your brand and experience. For internal-facing implementations, use AR as a tool that will enhance employee job function (for example, delivering context-specific information at the point of need for mobile workers, reduction of head count in plant and maintenance operations, or enhancing business processes via AR-based training and instruction).

Business Impact: By leveraging device sensors, AR acts as a digital extension of users' senses, and it serves as an interface for humans to the physical world. It provides a digital filter to enhance the user's surroundings with relevant, interesting and/or actionable information.

AR bridges the digital and physical world. This has an impact on both internal- and external-facing solutions. For example, internally, AR can provide value by enhancing training, maintenance and

collaboration efforts. Externally, it offers brands, retailers and marketers the ability to seamlessly combine physical campaigns with their digital assets.

As such, AR is broadly applicable across many markets, including retail, marketing, mining, engineering, construction, energy and utility, automotive, logistics, manufacturing, healthcare, education, customer support, and field service.

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Adolescent

Sample Vendors: Blippar; Catchoom; Daqri; Google; Kudan; Microsoft; Wikitude

Recommended Reading: "Market Guide for Augmented Reality"

"Maverick* Research: Goodbye Smartphones, Hello HMDs"

"Market Trends: Head-Mounted Displays for Virtual Reality and Augmented Reality"

"What Product Developers Need to Know About New Sensing and Recognition Capabilities in Augmented Reality"

Climbing the Slope

Virtual Reality

Analysis By: Brian Blau; Tuong Huy Nguyen

Definition: Virtual reality (VR) provides a computer-generated 3D environment that surrounds a user and responds to an individual's actions in a natural way, usually through immersive head-mounted displays (HMDs). Gesture recognition or handheld controllers provide hand and body tracking, and haptic (or touch-sensitive) feedback may be incorporated. Room-based systems provide a 3D experience for multiple participants.

Position and Adoption Speed Justification: Immersive VR applications are more advanced than other types of graphical simulations, and the time to plateau of five to 10 years is consistent with awareness, exposure to the technology, and overall adoption with consumers and more-traditional consumerlike usage for businesses.

VR experiences are typically used with HMDs. The most well-known is the Oculus Rift, but others, such as Sony's PlayStation VR, Valve/HTC Vive, Samsung Gear VR and Google Cardboard, will be some of the more prominent display devices for virtual worlds. These HMD devices will come to market in 2016.

User Advice: Virtual reality can be used in a variety of business scenarios:

- Complex simulation and training applications
- Military simulation and training, such as flight simulators
- Telepresence in scenarios such as remote medicine
- Equipment operator training
- Entertainment, such as video games or 360 surround video or interactive movies
- Product marketing to extend in the brand interaction or in product design
- Architectural walkthroughs and scientific visualization, such as genome mapping
- Modeling, such as geomodeling in the oil industry

While VR can be amazingly sophisticated and beneficial, the level of customization can come at a high cost. Recent advances in HMD technologies may help ease these obstacles, so developers should focus on building effective and quality experiences. Standards for artificial intelligence scripting, object metadata and social identity data are becoming more popular, due to the increased use of personal and social networking technologies, which will help developers make VR more personalized and intelligent. Technologies like cloud graphics processing and mobile video games, as well as the proliferation of broadband access, will allow application developers to integrate VR more easily into their products.

VR developers should consider targeting immersive video game development; interactive movies; and new storytelling experiences, live events and business-focused scenarios where using advanced visualization and HMDs can benefit the task or customer interaction point due to their ability to offer higher degrees of visual fidelity and personalization over what flat screen-based systems can provide.

Business Impact: VR can support a wide variety of simulation and training applications, including rehearsals and response to events. VR can also shorten design cycles through immersive collaboration, and enhance the user interface experience for scientific visualization, education and entertainment. Businesses will benefit due to VR's immersive interfaces, helping create task efficiencies, or reducing costs associated with new product design, or can enhance the understanding of information through advanced graphical visualization and simulation technologies.

Benefit Rating: Moderate

Market Penetration: 1% to 5% of target audience

Maturity: Adolescent

Sample Vendors: HTC; Mechdyne; NextVR; Oculus VR; Samsung; Sony; Valve; Virtual Heroes; WorldViz

Recommended Reading: "Market Trend: Head-Mounted Displays for Virtual Reality and Augmented Reality"

"Market Guide for Augmented Reality"

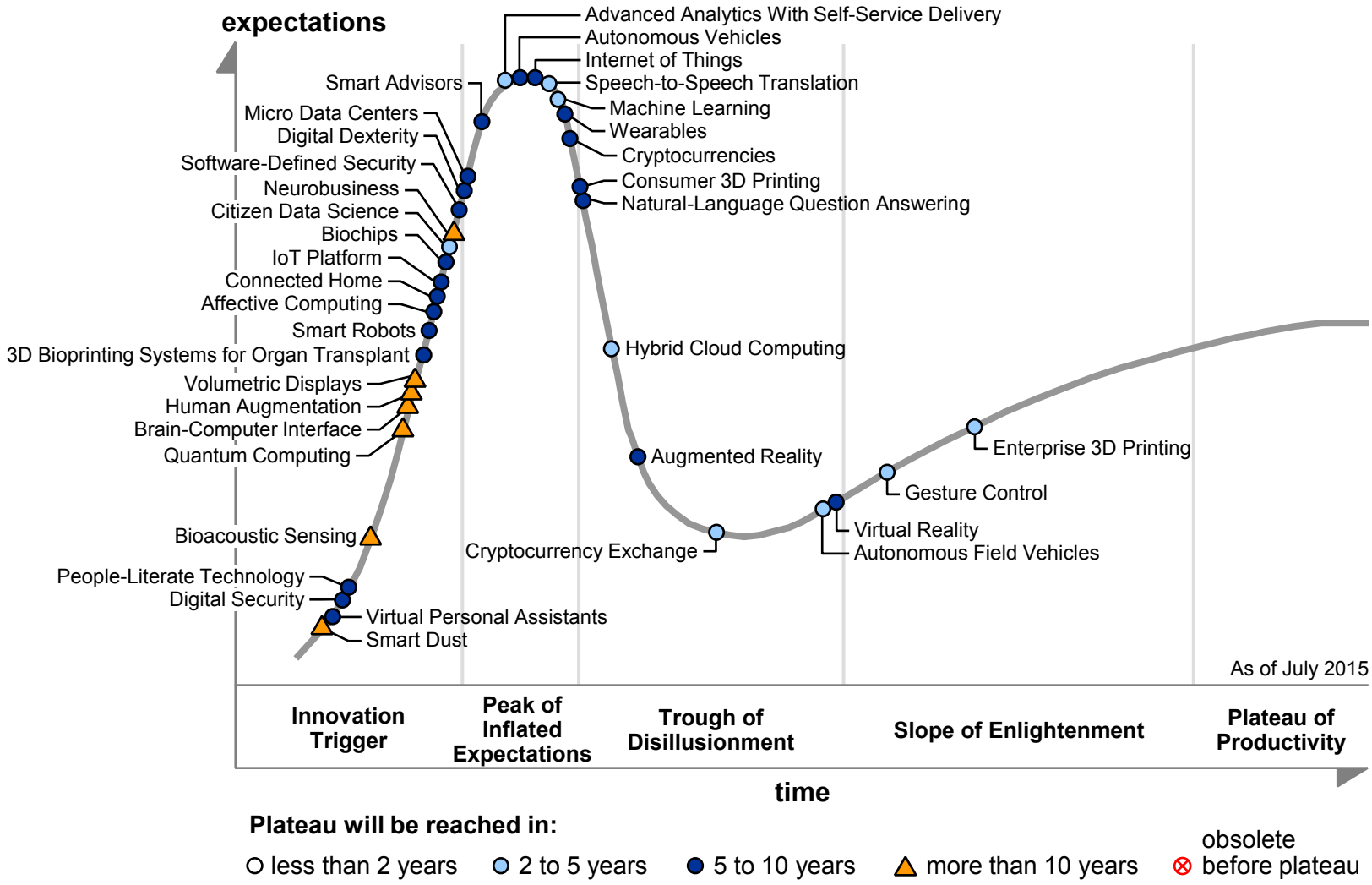
"Cool Vendors in Human-Machine Interface, 2016"

"Top 10 Strategic Technology Trends for 2016"

"Forecast: Wearable Electronic Devices, Worldwide, 2016"

Appendixes

Figure 4. Hype Cycle for Emerging Technologies, 2015



Source: Gartner (July 2015)

Hype Cycle Phases, Benefit Ratings and Maturity Levels

Table 1. Hype Cycle Phases

Phase	Definition
Innovation Trigger	A breakthrough, public demonstration, product launch or other event generates significant press 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 technology is pushed to its limits. The only enterprises making money are conference organizers and magazine publishers.
Trough of Disillusionment	Because the technology 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 technology'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 technology 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 technology to reach the Plateau of Productivity.

Source: Gartner (July 2016)

Table 2. Benefit Ratings

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

Source: Gartner (July 2016)

Table 3. Maturity Levels

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

Source: Gartner (July 2016)

Gartner Recommended Reading

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

"Understanding Gartner's Hype Cycles"

"Hype Cycle for Emerging Technologies, 2015"

"Building the Digital Platform: The 2016 CIO Agenda"

"2016 CEO Survey: The Year of Digital Tenacity"

More on This Topic

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

- Gartner's 2016 Hype Cycles Highlight Digital Business Ecosystems

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