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GARTNER'S TOP STRATEGIC TECHNOLOGY TRENDS

Abstract: *The last two decades have seen a dramatic shift in use of technology to drive improvements in manufacturing operations. Just twenty years ago, many small and mid-size manufacturers relied on paper-based systems to run their businesses. The application of advanced technologies in manufacturing such as nanotechnology, cloud computing, the Internet of Things (IoT) are changing the face of manufacturing in ways unimaginable a few decades ago. In addition to cutting the costs, these technologies create speed, precision, efficiency and flexibility for manufacturing companies. Technologies that have the greatest impact include cloud, mobile, big data and analytics, internet of things (IoT), robotics, cognitive computing/artificial intelligence (AI), 3D printing, augmented reality/virtual reality (AR/VR), and even blockchain.*

In the paper is presented top 10 strategic technology trends for 2012 to 2019 that the every year company Gartner, Inc. from the IT Symposium/Xpo stage, we unveil our for the following year that CIOs and other senior executives should be paying attention to.

Keywords: *Technology trends, Intelligent digital mesh, Artificial intelligence, Digital twins*

1. Introduction

From computer vision in warehouses to robotics in R&D labs, technology is having an impact on every step of the manufacturing process. Today, many factories operate autonomously and require no human presence. While this may sound futuristic, such factories have been a reality for over a decade now. From warehouse equipment to unmanned transport vehicles to machining equipment, everything in factory is operated by computer-controlled robots and a central control system allows the technical staff to monitor the activities of these machines.

You no longer required hundreds of workers to keep a factory operational. Automation and robotics have helped to reduce that

workforce by almost ten times and all predictions are that it will be reduced by 20 times in the future. Today, a host of technologies are driving the future of manufacturing. These include IoT devices that are expected to reach fifty billion by 2020. and predictive data analytics—an advanced manufacturing technology required for driving future competitiveness.

The development and integration of smart factories and industry 4.0 are other important developments too look at when considering the future of manufacturing technologies, with analysis of industry 4.0—the new wave of automation and digitization, being of particular importance (Percentotech; Bolat and Temur, 2019).

These times, it feels like everything is

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becoming intelligent: smart homes, smart cars — and now, smart factories.

Like other smart things, smart factories use the Internet of Things (IoT) to create an information network that shares rich, real-time analytics and empowers autonomous tasks and decision-making capabilities.

Smart manufacturing transforms businesses into proactive, autonomic organizations that predict and fix potentially disruptive issues, evolve operations and satisfy customers.

Smart manufacturing comprises all aspects of business, blurring the boundaries among plant operations, supply chain, product design and demand management. Enabling virtual tracking of capital assets, processes, resources and products gives smart manufacturing enterprises full visibility — streamlining business processes and optimizing supply and demand.

In its latest report Gartner said that Artificial Intelligence (AI) and machine learning have reached a critical tipping point and will increasingly augment and extend virtually every technology enabled service, thing or application (Gartner, 2019).

Increasingly, the world is becoming an intelligent, digitally enabled mesh of people, things and services. Technology will be embedded in everything in the digital business of the future, and ordinary people will experience a digitally-enabled world where the lines between what is real and what is digital blur.

Rich digital services will be delivered to everything, and intelligence will be embedded in everything behind the scenes. We call this mesh of people, devices, content and services the intelligent digital mesh.

Every year company Gartner from the IT Symposium/Xpo stage, we unveil our Top 10 Strategic Technology Trends for the following year that CIOs and other senior executives should be paying attention to.

Gartner, officially known as Gartner, Inc. is a global research and advisory firm

providing insights, advice, and tools for leaders in IT, Finance, HR, Customer Service and Support, Legal and Compliance, Marketing, Sales, and Supply Chain functions across the world. The company was founded in 1979 by Gideon Gartner. Today company Gartner has over 15,000 employees located in 100+ offices around the world (Gartner, 2019). They are a member of the S&P 500 (Businessinsider). Its headquarters are in Stamford, Connecticut, United States. The firm changed its name from Gartner Group, Inc to Gartner in 2000.

Research provided by Gartner has historically targeted CIOs, senior IT, marketing, and supply chain leaders. Gartner clients include large corporations, government agencies, technology companies and the investment community. Their client base consists of 12,000 organizations in over 100 countries (Gartner, 2019).

2. Gartner Inc. prediction analysis

Table 1 shows the top 10 technological trends for 2012 to 2019, and it is interesting to note that these trends are changing.

Three technologies have a direct and positive impact on an advanced manufacturing technology required for driving future competitiveness:

1. **Cloud computing** is the on demand availability of computer system resources, especially data storage and computing power, without direct active management by the user (the term is generally used to describe data centers available to many users over the Internet. Large clouds, predominant today, often have functions distributed over multiple locations from central servers).
2. **The internet of things (IoT)** is a system of interrelated computing devices, mechanical and digital machines, objects or people that are provided with unique identifiers (UIDs) and the ability to transfer data over a network without requiring

human-to-human or human-to-computer interaction.

3. **Artificial intelligence (AI)** is an area of computer science that emphasizes the creation of intelligent machines that work and react like humans. The modern definition of artificial intelligence (or AI) is "the study and design of intelligent agents"

where an intelligent agent is a system that perceives its environment and takes actions which maximizes its chances of success. Some of the activities computers with artificial intelligence are designed for include: speech recognition, learning, planning and problem solving.

Table 1. Top 10 strategic technology trends 2012-2019

	2012	2013	2014	2015	2016	2017	2018	2019
1	Media tablets and beyond	Mobile Device Battles	Mobile Device Diversity and Management	Computing Everywhere	The device mesh	Artificial Intelligence and Advanced Machine Learning	Ai foundation	Autonomous things
2	Mobile-centric applications and interfaces	Mobile applications & HTML 5	Mobile Apps and Applications	The Internet of Things	Ambient user experience	Intelligent Apps	Intelligent apps and analytics	Augmented analytics
3	Contextual and social user experience	Personal Cloud	The Internet of Everything	3D Printing	3D-printing materials	Intelligent Things	Intelligent things	AI-driven development
4	Internet of Things	Internet of Things	Hybrid Cloud and IT as Service Broker	Advanced, Pervasive and Invisible Analytics	Information of everything	Virtual and Augmented Reality	Digital twins	Digital twins
5	App stores and marketplaces	Hybrid IT and Cloud Computing	Cloud/Client Architecture	Context-Rich Systems	Advanced machine learning	Digital Twin	Cloud to the edge	Empowered edge
6	Next-generation analytics	Strategic Big Data	The Era of Personal Cloud	Smart Machines	Autonomous agents and things	Blockchain and Distributed Ledgers	Conversational platforms	Immersive technologies
7	Big data	Actionable Analytics	Software Defined Anything	Cloud/Client Computing	Adaptive security architecture	Conversational Systems	Immersive experience	Blockchain
8	In-memory computing	Mainstream In-Memory Computing	Web-Scale IT	Software-Defined Applications and Infrastructure	Advanced system architecture	Mesh App and Service Architecture	Blockchain	Smart spaces
9	Extreme low-energy servers	Integrated Ecosystems	Smart Machines	Web-Scale IT	Mesh app and service architecture	Digital Technology Platforms	Event-driven model	Digital ethics and privacy
10	Cloud computing	Enterprise App Stores:	3-D Printing	Risk-Based Security and Self-Protection	IoT architecture and platforms	Adaptive Security Architecture	Continuous adaptive risk and trust	Quantum computing

Of the 2017 year Gartner calls the entwining of people, devices, content and services the intelligent digital mesh. It's enabled by digital models, business platforms and a rich, intelligent set of services to support digital business. In the table 2, 3 and 4 presented

top 10 strategic technology trends classified into three groups.

1. Intelligent: The first group strategic technology trends explore how artificial intelligence (AI) and machine learning are seeping into virtually everything and

represent a major battleground for technology providers over the next five years.

2. Digital: The next group trends focus on blending the digital and physical worlds to create an immersive, digitally enhanced environment.

3. Mesh: The last group refer to exploiting connections between an expanding set of people and businesses, as well as devices, content and services to deliver digital business outcomes.

Table 2. Top 10 strategic technology trends for 2017

Intelligent	Digital
- Artificial Intelligence and Advanced Machine Learning - Intelligent Apps - Intelligent Things	- Virtual and Augmented Reality - Digital Twin - Blockchain and Distributed Ledgers
Mesh	
- Conversational Systems - Mesh App and Service Architecture - Digital Technology Platforms - Adaptive Security Architecture	

Table 3. Top 10 strategic technology trends for 2018

Intelligent	Digital
- Ai foundation - Intelligent apps and analytics - Intelligent things	- Digital twins - Cloud to the edge - Conversational platforms - Immersive experience
Mesh	
- Blockchain - Event-driven model - Continuous adaptive risk and trust	

Table 4. Top 10 strategic technology trends for 2019

Intelligent	Digital
- Autonomous things - Augmented analytics - AI-driven development	- Digital twins - Empowered edge - Immersive technologies - Digital ethics and privacy - Quantum computing
Mesh	
- Blockchain - Smart spaces	

3. Technology trends

Strategic technology trends have deliver significant opportunity and have the result to drive significant improvement. Enterprise architecture and technology innovation leaders must evaluate these top trends to identify opportunities, counter threats and create competitive advantage.

In the following text, this paper will review key trends in each of these three elements as identified by Gartner (intelligent, digital and mesh), and discuss how they can specifically impact a company deploying. Presented the top strategic technology trends for 2017 to 2019 (table 2, 3 and 4).

Artificial Intelligence (AI) & Advanced Machine Learning.

which include technologies such as deep learning, neural networks and natural-language processing, can also encompass more advanced systems that understand, learn, predict, adapt and potentially operate autonomously. Systems can learn and change future behavior, leading to the creation of more intelligent devices and programs. The combination of extensive parallel processing power, advanced algorithms and massive data sets to feed the algorithms has unleashed this new era.

Intelligent Apps. which include technologies like virtual personal assistants (VPAs), have the potential to transform the workplace by making everyday tasks easier (prioritizing emails) and its users more effective (highlighting important content and interactions). However, intelligent apps are not limited to new digital assistants – every existing software category from security tooling to enterprise applications such as marketing or enterprise resource planning (ERP) will be infused with AI enabled capabilities. Using AI, technology providers will focus on three areas — advanced analytics, AI-powered and increasingly autonomous business processes and AI-powered immersive, conversational and continuous interfaces. Gartner predicts most

of the world's largest 200 companies to exploit intelligent apps and utilize the full toolkit of big data and analytics tools to refine their offers and improve customer experience.

Intelligent Things is an intelligent piece of technology designed to make our lives easier and more efficient - like robots, drones, autonomous vehicles, IoT-connected refrigerators, and so on. Each of these areas will evolve to impact a larger segment of the market and support a new phase of digital business but these represent only one facet of intelligent things.

Existing things including Internet of Things (IoT) devices will become intelligent things delivering the power of AI enabled systems everywhere including the home, office, factory floor, and medical facility (like maybe your fridge will automatically tell your drone to go grab some milk from the store).

Virtual (VR) & Augmented Reality (AR) transform the way individuals interact with each other and with software systems creating an immersive environment. For example, VR can be used for training scenarios and remote experiences. AR, which enables a blending of the real and virtual worlds, means businesses can overlay graphics onto real-world objects, such as hidden wires on the image of a wall.

A Digital Twin is a digital representation of a physical product, service, or person. It acts as a mirror to the real world to simulate, predict, and forecast as a means to improve lives. With the growth in IoT and the amount of sensor data available for various products, services, and people, it's possible to create Digital Twins of just about anything now.

Within three to five years, billions of things will be represented by digital twins, a dynamic software model of a physical thing or system. Using physics data on how the components of a thing operate and respond to the environment, as well as data provided by sensors in the physical world, a digital

twin can be used to analyze and simulate real world conditions, responds to changes, improve operations and add value.

The digital twin potentially function in real time, leveraging AI and big data analytics to interact with and evaluate all kinds of 'what if' scenarios.

The big areas of opportunity right now are in medical health, sports, and education.

Blockchain is essentially a decentralized public digital ledger of electronic transactions that allows you to keep track of digital currency transactions without a centralized record-keeping system.

Blockchain and distributed-ledger concepts are gaining traction because they hold the promise of transforming industry operating models in industries such as music distribution, identify verification and title registry. They promise a model to add trust to untrusted environments and reduce business friction by providing transparent access to the information in the chain.

But blockchain has many potential applications beyond financial services, including government, healthcare, manufacturing, supply chain, content distribution, identity verification and title registry.

Conversational Systems can range from simple informal, bidirectional text or voice conversations such as an answer to "What time is it?" to more complex interactions such as collecting oral testimony from crime witnesses to generate a sketch of a suspect. Conversational systems shift from a model where people adapt to computers to one where the computer "hears" and adapts to a person's desired outcome.

Businesses currently use conversational platforms to connect with customers via vocal command or typing (e.g. chatbots). However, this AI-driven technology is quickly making its way into the consumer world. In the coming time, over 20 percent of an individual's interaction with their

smartphone will be through a VPA like Siri or Google Assistant.

Mesh App and Service Architecture, The intelligent digital mesh will require changes to the architecture, technology and tools used to develop solutions. The mesh app and service architecture is a multichannel solution architecture that leverages cloud and serverless computing, containers and microservices as well as APIs and events to deliver modular, flexible and dynamic solutions. Solutions ultimately support multiple users in multiple roles using multiple devices and communicating over multiple networks.

Digital Technology Platforms are the building blocks for a digital business and are necessary to break into digital. Every organization will have some mix of five digital technology platforms: Information systems, customer experience, analytics and intelligence, the IoT and business ecosystems. In particular, new platforms and services for IoT, AI and conversational systems will be a key focus in the coming times. Companies should identify how industry platforms will evolve and plan ways to evolve their platforms to meet the challenges of digital business.

Adaptive Security Architecture, The evolution of the intelligent digital mesh and digital technology platforms and application architectures means that security has to become fluid and adaptive. Security in the IoT environment is particularly challenging. Security teams need to work with application, solution and enterprise architects to consider security early in the design of applications or IoT solutions. Multilayered security and use of user and entity behavior analytics will become a requirement for virtually every enterprise.

Cloud to the Edge, Edge computing describes a computing topology in which information processing and content collection and delivery are placed closer to the sources and sinks of this information.

Edge computing draws from the concepts of mesh networking and distributed processing. It tries to keep the traffic and processing local, with the goal being to reduce traffic and latency. As such, the notion of edge content delivery has existed for many years. The "where to process the data" pendulum has swung between highly centralized approaches (such as a mainframe or a centralized cloud service) and more decentralized approaches (such as PCs and mobile devices). Connectivity and latency challenges, bandwidth constraints and greater functionality embedded at the edge favor distributed deployment models. The advantages of processing power and low costs of operating at hyperscale, coupled with the complexity of managing and coordinating thousands of geographically separated endpoints, favor the centralized model.

There are three types of **Immersive Experience** technologies: virtual reality (VR), augmented reality (AR), and mixed reality (MR).

Virtual reality is often used with body tracking devices to give users a natural feel when they dive into the 3D world. While it's now primarily used for gaming, experts predict a dramatic increase in the number of businesses that will seek to give their customers an immersive experience.

Augmented reality uses many of the same technologies as VR, but with a different end goal in mind: to enhance life experience.

Mixed reality isn't new, but it's relatively less well-known than VR and AR. It's a merging of real and virtual worlds to produce new environments and visualizations, where physical and digital objects co-exist and interact in real-time.

While conversational platforms are changing the way in which people interact with the digital world, virtual reality (VR), augmented reality (AR) and mixed reality (MR) are changing the way in which people perceive the digital world. This combined shift in perception and interaction models leads to

the future immersive user experience.

Immersive technologies are those that attempt to emulate the physical world in a virtual environment, creating an immersive experience.

Event-Driven Models have been around for years. The prediction is that the leaders in both the IT and business space will join forces to unleash the next generation of this model by using technologies like IoT, cloud, AI, blockchain and in-memory data management. The ultimate goal is to help businesses detect and analyze events more quickly and accurately to reduce costs, improve efficiency and deliver a better customer experience.

Event-driven architecture optimizes for agility, resiliency, extensibility, lower cost of change, openended design and web scale. A dynamic event-driven approach is required to achieve user goals in conversational platforms.

The UI becomes more intelligent with conversational platforms, responding to a dynamic and shifting user context, and integrating various system elements on the back end. Data streams from the IoT represent streams of events. Real-time decision making and situational awareness demand continuous monitoring and assessment of events in real time.

Continuous Adaptive Risk and Trust. The intelligent digital mesh and related digital technology platforms and application architectures create an ever-more-complex world for security. The continuing evolution of the "hacker industry" and its use of increasingly sophisticated tools — including the same advanced technologies available to enterprises — significantly raise the threat potential. Relying on perimeter defense and static rule-based security is inadequate and outdated. This is especially so as organizations exploit more mobile devices, cloud-based services, and open APIs for customers and partners to create business ecosystems. IT leaders must focus on

detecting and responding to threats, as well as more traditional measures, such as blocking, to prevent attacks and other abuses. At the same time, digital business will require more advanced access protection when systems and information are opened up to the digital mesh. Security and risk management leaders must adopt a continuous adaptive risk and trust assessment strategic approach. This is vital to securely enable access to digital business initiatives in a world of advanced, targeted attacks. It will enable realtime, risk- and trust-based decision making with adaptive responses.

Autonomous things use AI to automate functions previously performed by humans. Their automation goes beyond the automation provided by rigid programming models, and they exploit AI to deliver advanced behaviors that interact more naturally with their surroundings and with people. As autonomous things proliferate, we expect a shift from stand-alone intelligent things to a swarm of collaborative intelligent things. Gartner defines autonomous things in five different types: vehicles, robotics, drones, appliances and agents.

The term **Augmented Analytics** was first introduced on Gartner's 2017 report as a method to automate insights into data using machine learning and natural-language generation. Analytics by itself is useless in a business. There needs to be some insight, supplemented with additional data to find reasons for changes in the data, and actionable insights need to be created. Without these, all the data in the world is useless.

Autonomous things use AI to automate functions Augmented analytics focuses on a specific area of augmented. Augmented analytics uses automated machine learning to transform how analytics content is developed, consumed and shared. Augmented analytics capabilities will advance rapidly along the Hype Cycle to mainstream adoption, as a key feature of data

preparation, data management, modern analytics, business process management, process mining and data science platforms.

AI-Driven Development explores the evolution of tools, technologies and best practices for integrate AI capabilities into applications. This trend is evolving along three dimensions:

- The tools used to build AI-powered solutions are expanding from tools targeting data scientists (AI infrastructure, AI frameworks and AI platforms) to tools targeting the professional developer community (AI platforms and AI services).

- The tools used to build AI-powered solutions are themselves being empowered with AI-driven capabilities that assist professional developers and automate tasks related to the development of AI-enhanced solutions.

- AI-enabled tools in particular are evolving from assisting and automating functions related to application development (AD) to being enhanced with business-domain expertise and automating activities higher on the AD process stack.

Empowered Edge computing describes a computing topology in which information processing and content collection and delivery are placed closer to the sources and repositories of this information. Edge computing draws from the concepts of mesh networking and distributed processing. It tries to keep the traffic and processing local, with the goal being to reduce traffic and latency. As such, the notion of edge content delivery has existed for many years. The “where to process the data” question has raised between highly centralized approaches (such as a mainframe or a centralized cloud service) and more decentralized approaches (such as PCs and mobile devices).

Connectivity and latency challenges, bandwidth constraints, and greater functionality embedded at the edge favor distributed deployment models. The advantages of processing power and low costs of operating

at hyperscale, coupled with the complexity of managing and coordinating thousands of geographically separated endpoints, favor the centralized model.

A Smart space is a physical or digital environment in which humans and technology-enabled systems interact in increasingly open, connected, coordinated and intelligent ecosystems. Multiple elements - including people, processes, services and things - come together in a smart space to create a more immersive, interactive and automated experience for a target set of personas or industry scenarios.

This trend has been coalescing for some time around elements such as smart cities, digital workplaces, smart homes and connected factories. The market is entering a period of accelerated delivery of robust smart spaces, with technology becoming an integral part of our daily lives, whether as employees, customers, consumers, community members or citizens. AI-related trends, the expansion of IoT-connected edge devices, the development of digital twins of things and organizations, and the maturing of blockchain offer increasing opportunities to drive more connected, coordinated and intelligent solutions across target environments.

Digital Ethics and privacy are growing concerns for individuals, organizations and governments. Consumers are increasingly aware their personal information is valuable and are demanding control. Organizations recognize the increasing risk of securing and managing personal data, and governments are implementing strict legislation to ensure they do. Best practice means focusing not only on what you have to do but on what you should do ethically with regard to issues such as specific applications of AI or the creation of digital twins of people for marketing purposes.

Quantum computing are an exponentially scalable computing model, and are able to theoretically work on millions of computations at once. For example, today’s computer

would read every book in a library in a linear fashion, whereas a quantum computer would read all the books simultaneously.

Quantum computing is still an emerging technology, and apart from a small number of organisations where specific quantum algorithms would provide a significant advantage, most businesses could remain in exploration phase through 2022.

Quantum computing is an emerging trend with the potential for significant impact between 2023 and 2025. As such, it is included in the list of 10 best trends, which consists of the trends that we expect will have a significant commercial impact within five years. However, advances and the potential of Quantum Computing, and the challenges of understanding it and applying it to business problems make it an important trend to add to an organization's strategic roadmap. If Quantum Computing reaches its potential, it will influence the evolution of many aspects of the intelligent digital mesh.

4. Conclusion

We are witnesses of the new technologies such as big data, prognostics, faster and more accurate machine learning, cloud and

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AI applications and new exciting developments. The exponential improvement of technologies like the Internet of Things, NLP, and self-teaching AI will change every business industry,, factory efficiency and our everyday lives. Although this can create a certain threat to the data security, the new approaches and solutions are continuously evolving. All these technology trends have vast influence upon our creativity, intelligence and possibilities. Thanks to them, our digital mesh can be richer and have be greater business value in the future years.

Strategic technology trends have significant potential and set the base for innovation in companies over the next 5 years. Companies must examine the business impact of these trends and adjust business models and operations appropriately or risk losing competitive advantage to those who do. Therefore, information from Gartner.com should be used to identify the strategic technology trends that will have the biggest impact in next years and beyond.

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