After decades of failed attempts and underwhelming results, enterprise architects in leading organizations are partnering with business leaders to reinvent business models, create new business ecosystems, and reinvent the customer experience with advanced machine learning technologies.

Key Findings

- Enterprise architecture (EA) leaders ensure that advanced machine learning has information architects who can partner with chief data officers, data scientists, and, in some cases, mathematicians in order to identify and design algorithms that maximize business outcomes, while also creating plans to avoid pitfalls and limitations.

- Nearly all industries are showing signs of advanced machine learning implementations, especially for enabling business scenarios spanning customer engagement, through digital production, smart cities, self-driving cars, risk management, computer vision, and language and speech recognition, to healthcare.

- EA leaders are using advanced machine learning as a viable recommendation to organizations, due to the explosion of new information sources, the miniaturization of and increases in compute power, open availability of machine-learning tools, and new and advanced algorithms.

Recommendations

- Organizations seeking to stay competitive must use EA leaders to create five to 10 viable business scenarios over the next six to 12 months, through inspiration from how the immediate and broader markets are using advanced machine learning.

- EA leaders must create social and ethical roadmaps as an impact analysis tool to understand the cultural, social and ethical challenges that will arise as a direct result of advanced machine learning, thereby changing the relationship between technology and humans, displacing knowledge workers, and challenging existing compliance laws.
EA practitioners must work with business and HR leaders to create or integrate a competency-driven strategy to nurture and foster advanced machine learning in order to stay competitive and retain top talent.

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Strategic Planning Assumptions

By 2020, smart machines will be a top five investment priority for more than 30% of CIOs.

By 2020, CFOs will need to address the valuations derived by smart machine data and "algorithmic business."

By year-end 2018, 25% of durable goods manufacturers will utilize data generated by smart machines in their customer-facing sales, billing and service workflows.

By year-end 2018, R&D-based end-user approaches to smart machine deployment will be three times more likely to produce business value than IT project-based approaches.

By 2018, more than 3 million workers globally will be supervised by a "roboboss."
Analysis

Why Advanced Machine Learning Is a Top 10 Trend

Advanced machine learning has become so pervasive that most of us use it in our daily routines without even realizing it. This includes everything from checking the weather to getting directions, searching the Internet, asking your smartphone a question, and, in the near future, driving your car for you. Machine learning is a key example of the brain running in the background, enabling smart machine technologies. This field is currently considered to be a key catalyst in redefining and expanding what is possible in computer science (see "The Disruptive Era of Smart Machines Is Upon Us" and "Hype Cycle for Smart Machines, 2015").

After decades of failed attempts and underwhelming results, advanced machine learning has made unprecedented progress. Although some of the advancements are directly due to machine learning, many of the key drivers (see Figure 1) are a result of enabling technologies, information, connectivity and raw compute power.

Figure 1. Key Drivers of Advanced Machine Learning

![Figure 1. Key Drivers of Advanced Machine Learning](image)

Source: Gartner (February 2016)

The following key drivers are why advanced machine learning is in the top 10 strategic trends:

- **Information explosion**: With access to an explosion of increasingly growing sources of information from sensors and other edge computing devices, mesh machine-learning technology can now have the essential data to fuel its algorithms.

- **Increased compute power**: The availability of advanced system architectures, in-memory storage, and more powerful and efficient chipsets that are in a highly scalable, cloud-based architecture has removed many of the infrastructure implementation inhibitors for organizations, which makes advanced machine learning solutions vastly more powerful and affordable.
- **Availability and ubiquity:** Software development tools were once prohibitively expensive and complex, but they have become relatively inexpensive or even free, and researchers now have the opportunity to work with them.

- **Advanced algorithms:** Advanced machine learning algorithms are composed of a set of many technologies — including deep learning, neural networks and natural-language processing — used in unsupervised and supervised learning in order to understand information, activities and the world.

**Where Advanced Machine Learning Fits in the Top 10**

This trend falls into the smart machines grouping (see Figure 2), along with information of everything and autonomous agents and things. Advanced machine learning complements the rest of the smart machines trends by providing the core intelligence required to make information of everything actionable, and autonomous agents and things self-guided and intuitive.

*Figure 2. Where Advanced Machine Learning Fits in the Top 10 List of Strategic Technology Trends*

**Advances in Machine Learning**

Although the basic concepts of machine learning have existed for decades, interest in this approach is at a high. At Stanford University, Machine Learning is the most popular graduate-level course, with 760 students enrolled.¹ In addition, Gartner research shows that advanced analytics (which
spans machine learning) is the fastest-growing segment in the business analytics software market (see "Market Share Analysis: Business Intelligence and Analytics Software, 2014").

Advanced machine learning algorithms are composed of many technologies (such as deep learning, neural networks and natural-language processing), used in unsupervised and supervised learning, that operate guided by lessons from existing information. Advanced machine learning has moved beyond previous attempts at creating algorithmic-based solutions to become more insightful, self-directed and autonomous. It has strong ties to information-of-everything technologies, such as mathematical optimization, text mining, statistical analysis, search engines and dynamic ontologies. The explosion of data sources and the complexity of information make manual classification and analysis unfeasible and uneconomic. Machine learning automates these tasks and makes it possible to address key challenges related to the information-of-everything trend.

Advanced machine learning's most prevalent usage in the industry is in the supervised learning area, which covers approximately 95% of machine learning use cases. Supervised learning requires "training data," which is used to "teach" a machine learning model by describing a desired mapping between observations and outcomes that the machine learning system should produce. Those mappings can be used to predict quantities (for example, revenue or demand predictions), or to classify or predict the likelihood of certain events happening (for example, machine failures and customers buying or churning).

Google's acquisition of AlphaGo highlights the power of advanced machine learning's supervised learning area. AlphaGo used information to teach itself to play the Chinese game Go and then make its own decisions. This allowed AlphaGo to discover how to do tasks on its own, such as recognize and respond to facial expressions, respond to speech, and translate between languages.

Interest from large corporations and in research are the reasons why advanced machine learning is in significant focus. IBM is one of many organizations that has made substantial investments in machine learning, describing it as its greatest potential growth area. In addition, Facebook has built a way to describe images to individuals with visual impairment, and Microsoft is using machine learning to translate from one language to another.

Contributions from major corporations open up new possibilities, such as:

- **Specialized hardware:** Facebook is releasing (for free) the designs of powerful new hardware called Big Sur, which is intended to put more power behind artificial intelligence software.

- **Speech and image recognition:** Google has open-sourced software called TensorFlow, which is used to power the company's speech recognition and image search.

- **Communication and data standards:** IBM has open-sourced SystemML, which was developed to use machine learning to find useful patterns in corporate databases.
Advanced Machine Learning Enables New Digital Realities

The advanced machine learning technology trend enables foundational capabilities for organizations to be successful in the future. The following cross-industry business scenarios highlight the many possibilities of advanced machine learning (for more examples, see “Machine Learning Drives Digital Business”):

- **Retail product recommendations:** Machine learning can pull disparate information sets from online purchase histories, product likes and dislikes — from eye-gazing technologies in retail stores to sensory data from smartphones — in order to create propensity-to-buy models that predict which product a customer is most likely to buy.

- **Insurance dynamic pricing:** Based on the conditions of a specific market, such as a surge of burglaries, housing economic bubbles, historical sales, natural disasters, or opted-in data sharing of the consumer, prediction models can be created to dynamically adjust insurance rates.\(^\text{11}\)

- **Hospitality online risk mitigation:** As new business ecosystems emerge and redefine industries, such as hospitality, the defrauding of those ecosystems and their communities becomes an increasing risk. Companies such as Airbnb use machine learning to create risk models to protect their customers.\(^\text{12}\)

- **Optimized lending:** Advanced machine learning solutions can map a loan applicant’s details (such as demographics, as well as credit and payment history) to predict the likelihood that he or she will default on a given loan.\(^\text{13}\)

- **Retail banking fraud detection:** Algorithms can be created to assess and model current real-time transactions as well as predictive models of transactions based on their likelihood of being fraudulent.

- **City utilities real-time decisioning:** Advanced machine learning can create probabilistic models from, for example, wind turbines, solar panels and soil actuators, to predict when failures will occur, to dynamically redirect power or water, to decrease maintenance costs and to minimize downtime.\(^\text{14}\)

- **Medical patient diagnostics:** Advanced machine learning can provide doctors with a more accurate classification of a medical condition, including recommendations for therapy or treatment, by assembling data from some of these possible sources: current vital signs, symptoms, home lab tests, or historical vital signs from algorithmic medical devices.\(^\text{15}\)

- **Creating safe working conditions:** For organizations that have labor forces in environments where there may be unsafe conditions, machine learning can detect the early-warning signs — based on sensor data from the measurement of air quality, equipment performance, employee productivity or even atypical behavior — in order to predict the likelihood of accidents.

- **Automated customer service:** People calling customer support are greeted with a virtual assistant that uses cognitive abilities to listen to customers (speech recognition), and that maps to a guided training set and knowledge base, as shown by the city of Austin, Texas, and the USAA.
Actions

EA practitioners using advanced machine learning to drive digital innovation:

- **Learn how to spot business moments:** Inspire your organization to spot business moment opportunities, which will become one of the building blocks of new businesses as the lines between the physical and digital worlds begin to blur (see "Architect Your Business to Sense, Respond and Create Business Moments").

- **Use the machine learning industry's body of knowledge:** Over the next 12 months, create five or six possible business scenarios in which your organization might use advanced machine learning to achieve its future-state business and business outcomes. Consider experimenting with one or two of these scenarios. Seek inspiration from publicly available machine intelligence technologies by Microsoft, Google, Facebook or IBM to understand the competitive advantages your organization will gain if it adopts early.

- **Protect your intellectual capital:** Partner with risk experts within and outside the organization to understand the impacts of advanced machine learning on your organization’s intellectual property.

- **Devise a sustainable talent management strategy:** In a rapidly changing and competitive algorithmic-based economy, EA practitioners must create or integrate a competency-driven strategy to nurture and foster advanced machine learning in order to stay competitive and retain top talent.

- **Look at Cool Vendors and megavendors:** Use Gartner’s Cool Vendors reports (see "Cool Vendors in Smart Machines, 2015") and Hype Cycles (see "Hype Cycle for Smart Machines, 2015"). These powerful tools will help you compare and contrast the available capabilities.

- **Ensure that your organization addresses social and ethical challenges:** Create social and ethical roadmaps as an impact analysis tool (see "Toolkit: What Enterprise Architects Need to Drive Computing-Everywhere Strategies") to understand the cultural, social and ethical challenges that will arise as a direct result of advanced machine learning, thereby changing the relationship between technology and humans, displacing knowledge workers, and challenging existing compliance laws.

Appendix: The Other Top Strategic Technology Trends for 2016

For information on the other top strategic technology trends for 2016, see:

- "Top 10 Strategic Technology Trends for 2016: The Device Mesh"
- "Top 10 Strategic Technology Trends for 2016: Ambient User Experience"
- "Top 10 Strategic Technology Trends for 2016: 3D-Printing Materials"
- "Top 10 Strategic Technology Trends for 2016: Information of Everything"
- "Top 10 Strategic Technology Trends for 2016: Autonomous Agents and Things"
- "Top 10 Strategic Technology Trends for 2016: Adaptive Security Architecture"
- "Top 10 Strategic Technology Trends for 2016: Advanced System Architecture"
- "Top 10 Strategic Technology Trends for 2016: Mesh App and Service Architecture"
- "Top 10 Strategic Technology Trends for 2016: Internet of Things Architecture and Platforms"

Gartner Recommended Reading

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

"Smart Machines See Major Breakthroughs After Decades of Failure"

"Cool Vendors in Smart Machines, 2015"

"Hype Cycle for Smart Machines, 2015"

"Leveraging Enterprise Architecture to Enable Business Value With Smart Machine Innovations Today"

"Analytics and Learning Technology: CIOs, CTOs Should Rethink Art of the Possible"

"How to Maintain Smart Machines"

Evidence

1 See Stanford Online Machine Learning course.

2 See "Machine Learning Drives Digital Business."


4 See the Wikipedia article on "Go (game)."


6 See S. Wu and L. Adamic, "Visually Impaired People on Facebook," Facebook, 26 March 2014.

7 See "Automatic Translation and Microsoft Translator," Microsoft.

8 See K. Lee and S. Piantino, "Facebook to Open-Source AI Hardware Design," Facebook, 10 December 2015.

See SystemML from IBM Research.

See "Very Personal Finance," The Economist, 2 June 2012.


See Eko Core from Eko.

See Machine Learning and Artificial Intelligence from Microsoft Research.

See Machine Intelligence from Research at Google.

See Applied Machine Learning from Research at Facebook.

See Machine Learning Applications from IBM Research.

See "Leveraging Enterprise Architecture to Enable Business Value With Smart Machine Innovations Today."

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

- Top 10 Strategic Technology Trends for 2016
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