Deep Science Publishing
https://doi.org/10.70593/978-93-49910-08-9_2

DeepScience
Open Access Books

Chapter 2: Integrating artificial intelligence into cloud platforms for next-generation business intelligence solutions

2.1. Introduction

Artificial intelligence (AI) is a paradigm-shifting area of computer science. AI has delivered technological breakthroughs across applications, devices, and sectors. Some recent implementations of AI are, for example, the ChatGPT chatbot service and a no-code service. These implementations extend the availability of AI algorithms to millions of non-expert users. AI in cloud platforms can now be thought of as providing advanced business intelligence (BI) solutions that address self-service BI data processing in virtually all businesses. Cloud-based BI solutions complement on-premise solutions as they offer better access, less maintenance, and increased scalability. Their hassle-free use for users across companies favors the adoption of still more cloud-based AI solutions. Examples of the success of cloud BI solutions are various companies (Hellerstein; Kelleher, 2019; Stonebraker, 2005 & Ghosh, 2021).

Increasing access to reliable, high-speed cloud data and server hosting has made it possible for small- and medium-sized enterprises to efficiently share BI analytics with little or no in-house expertise. Pure-play AI algorithms that are adroitly adapted to data processing in the cloud can then go a step further by proposing alternate data analyses and/or improved data representations. Although non-experts can thus collaborate in determining the appropriate path to data insights, high-level AI-driven tools do not address the still-existing gap in expertise and trust in BI results. These include sensitivity assessments, analysis model selection, and result trustworthiness diagnostics. Building AI into a cloud BI platform to address sensitivity and trust issues in automated cloud BI

enables wider adoption and usage by organizations to accelerate getting actionable information from growing amounts of data of diverse complexity and rapidity.

Additionally, although the Internet is available to a vast amount of people throughout the world, there is still a large number of people with limited access to BI tools or ELTs due to high costs. Cloud BI platforms are taking BI tools and infrastructure and deploying them to the cloud where they can provide many companies with their BI requirements while keeping costs low. Cloud platforms offer a unified approach to enterprise data and BI, bringing together data from various internal and external sources, through an integrated cloud platform to ultimately join together to provide required BI dashboards or solutions. Unfortunately, these cloud platforms do not take advantage of AI within cloud BI applications to make applications much more efficient, effective, user-friendly, and powerful when it comes to data analytics.

Fig 2.1: Cloud Platforms for Next-Generation Business Intelligence Solutions

2.1.1. Background and Significance

Cloud platforms provide a wide range of capabilities, services, and tools that help in virtually all Business Intelligence (BI) capabilities ranging from data integration, data warehousing, ETL, reporting, and visualization. Organizations are developing data warehouses on cloud platforms to meet the need for improving business intelligence. Organizations are providing access to their data, data models, and more importantly intellectual property to cloud BI solution providers in return for a highly maintained, reliable, and low-cost alternative to what would be a very expensive on-premise solution for a fraction of the cost. Cloud BI is quickly becoming a fact of life for smaller organizations and a very major option for larger organizations. Cloud platforms offer a unified approach to enterprise data and BI, bringing together data from various data in the enterprise, as well as external sources, through an integrated cloud platform to ultimately join together to provide required BI dashboards or solutions. Unfortunately, these cloud platforms do not take advantage of AI within cloud applications to make applications much more efficient, effective, user-friendly, and powerful when it comes to data analytics business intelligence. In this paper, we investigate key cloud BI functions, focused on cloud data warehouses and dashboards, applying AI to the engines of critical BI functions for next generation Data Analytics, Intelligence, and Business Reporting Solutions.

Business Intelligence focuses on extraction, transformation, and loading of data from many different sources to cloud data warehouses for integration and provision of numerous static and interactive reports and dashboards for business meetings and decision making. Unfortunately, traditional BI solutions in the enterprise are limited, breaking down and becoming very costly when it comes to thousands or millions of users that need to analyze data for their own specific business functions.

2.2. Understanding Artificial Intelligence

The sudden surplus of interest in Artificial Intelligence (AI) in the last couple years has stimulated the emergence of hundreds of AI-based products into the different areas of business, government, and even daily life. In a world already filled with buzzwords and jargon, this new wave of technological disruption has only fueled a runaway AI hype train, flying over the lives of our young generation and leading them to the belief that the tasks will be entirely less tedious to them. In fact, studies show that, as AI infiltrates multiple industries and job roles, workers will actually be required to use AI. Even more surprising, task completion won’t necessarily be faster. Instead, modifying AI outputs and using artificial and human intelligence in tandem will become routine.

Two of the most popular definitions propose that: AI is a sub-field of computer science that aims to create systems that can perform tasks requiring human intelligence; AI is the computer science behind the systems that mimic human cognitive processes; AI includes a diverse array of sub-fields that include natural language processing, cognitive computing, perceptual computing, speech recognition, machine learning, neural networks, and expert systems. The rapid rise of new AI algorithms and models has focused interest on whether or not large language models counting hundreds of billions of parameters trained on trillions of tokens are truly exhibiting 'smart' human-like intelligence.

2.2.1. Definition and Scope

Over decades of research and development, a large community of researchers has emerged, contributing to the fields of Artificial Intelligence (AI). Many of these researchers and teachers have published articles, textbooks, and conference rules specifying what Artificial Intelligence means and where it heads to. Several definitions have been provided throughout the years. While some consider that AI is just concerned with human intelligence, others define intelligence in a much broader scope, including non-human intelligence but also machine intelligence. Such diversity makes it difficult not only to reach a definition but also to delimit a clear scope of AI. This brings up yet another interesting question. That is, what differentiates AI from traditional computing?

The study of agents that receive percepts from the environment and perform actions is precisely the subject of AI research. The term agent refers to both humans and machines capable of perceiving and acting. Other researchers argue that intelligence cannot be abstracted to a single definition. Rather, AI research could be concerned with several properties and capabilities that are known to be difficult for traditional computer systems. Perception, vision, and speech recognition; physical motion; Natural Language Processing (NLP), planning, and reasoning are a few examples. Despite the wide range of definitions involved, we can still say that AI is considered to deal with how to automate tasks that inherently require intelligence when performed by people. In the general case, these tasks can be recognized by the degree of effort needed for human cognition to direct their realization.

2.2.2. Types of AI Technologies

A variety of types of Artificial Intelligence technology can be found, ranging from specialized AI function systems to generalized AI approaches. Specialized AI, which currently are the leading focus of much AI business investment and are the basis for many major Cloud service offerings in AI, offer specific automation capabilities of

significant value, with commonly implemented functions including: Visual Recognition; Natural Language Processing; Conversational Agents; Speech Recognition; Speech Generation; and Prediction Engines. Such applications often rely on machine learning techniques to implement their automation function, either supervised techniques or unsupervised.

Supervised training involves a model trained on labeled data with the goal of predicting the label of hidden data. In unsupervised training, no labeled training data is provided and the model attempts to learn the underlying structure from the data. Training data for supervised training can be expensive and time-consuming to obtain but it is available for many fields, such as visual recognition and language processing, because of the increasing volume of related data. Those data are an important asset for companies focused on AI development and deployment, allowing them to train their models towards a high level of accuracy. These supervised models work best on problems similar to those used in training and are widely used when that criteria is met.

Machine learning models are not the only way to implement these types of AI capability. Beyond supervised and unsupervised, other techniques are also available. Meanwhile, unsupervised has an important role in AI automation; providing a foundation to be built upon by the other types of AI tools once the AI has been trained, while also allowing AI without training to automate many tasks. Additionally, another significant AI approach is Generalized AI functions, such as Generative automation with Large Language Models.

2.3. Overview of Cloud Platforms

Cloud computing is one of the most favored technological advances of this millennium. Accessing IT resources via the Internet becomes a revolution, causing an accelerated popularization of computing and technologies enabling mankind to explore IT resources on-demand, ubiquitous, and at scalable levels. Cloud computing is highly capable of sharing large amounts of resources from a central location in a distributed manner to an extensive user population. Aimed at integration with wireless network infrastructures and mobile computing products, cloud computing raises new challenges and issues toward next-generation mobile computing and service provision such as privacy, energy consumption, and quality of service. Cloud computing is a rising model that provides IT resources as a utility. Instead of investing heavily on purchasing hardware and software, users can hire multiple types of IT resources from cloud computing service providers to create and run their applications on a pay-as-you-go basis.

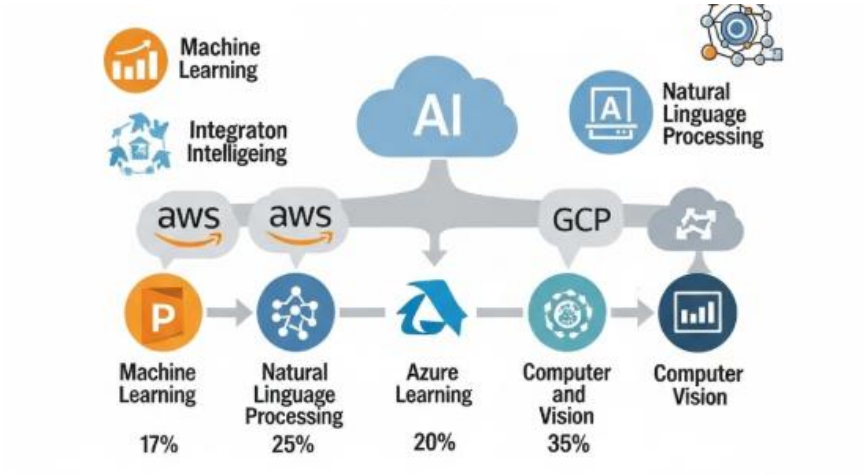

Fig 2.2: Overview of Cloud Platforms

Cloud computing is an unfamiliar paradigm that provides users with a huge, on-demand source of computing power. It fulfills the resource thirst of the modern digital lifestyles and enables cloud users to concentrate on their business with the benefit of economies of scale enabled by highly consolidated, shared data centers. Cloud computing essentially combines the service-oriented computing with utility computing concepts and provides real data-centric seamless remote data sharing and management services for cloud users to perform their business. Cloud services are becoming the foundation of everything in our life such as business, education, entertainment, and social interactions. Cloud computing is an effective base platform to support next-generation business intelligence by handling the ever-growing amount of structured and unstructured data of huge sizes.

2.3.1. Cloud Computing Models

As cloud computing technology matures and grows, several different models for the delivery of cloud computing services are emerging. There are different types of services that can be delivered through the cloud: Infrastructure as a Service (IaaS), which is the most basic service delivery in which the provider only supplies remote hardware; Platform as a Service (PaaS), which supplies the hardware along with the operating system; Software as a Service (SaaS), which provides the operating system and any applications needed by the client; and Business Process as a Service (BPaaS), which provides any business-specific workflow services that are needed.

Infrastructure as a Service, or IaaS, is the most basic model of cloud computing service delivery. The client purchases from the provider only computing hardware in the form of servers. This feature is the most immediately recognizable draw from the consumer

standpoint: remote hardware. The selected cloud provider uses a rack of physical computing servers. A company that uses IaaS can more easily expand its reach around the world, as they can use remote servers or server farms located anywhere in the world. There are fewer costs for supporting the expensive hardware components, keeping them secure from attacks, and maintaining the device for both physical damage and for technology upgrades.

PaaS, or Platform as a Service, provides the hardware and operating system needed for computing. PaaS is wider in scope than IaaS because the client does not have to also worry about the correct operating system. The characteristic operating system that PaaS customers are also using for the hardware servers is the client's choice, usually with the intention of being able to support a specific client base for the platform-hosted applications. PaaS clients use the remote servers just like they would the IaaS servers in order to build software applications to serve a specific need, but do not have to worry about using a server operating system that will force them to create a specific type of application.

2.3.2. Key Players in Cloud Services

Global cloud computing spending reached $378 billion in 2020 and is expected to grow more than 20 percent annually, reaching $832 billion by 2025. The pandemic accelerated the shift to cloud for various enterprises that previously were reluctant to do so owing to data residency, regulatory and other concerns. However, uncertainty remains with the major global cloud services providers increasingly under scrutiny from regulators over data privacy, security and competition concerns, and enterprise customers facing rising prices as discounts are gradually phased out.

Key players in global cloud services include Amazon Web Services, Microsoft Corporation, Google LLC, IBM, Oracle Corporation, Alibaba, Tencent, and Salesforce. Amazon Web Services was the first big mover in cloud computing infrastructure, opening its doors in 2006. The company provides Infrastructure as a Service (IaaS) solutions such as storage and networking, as well as Platform as a Service (PaaS) offerings such as AI services and cloud-native development solutions.

Microsoft Corporation followed AWS in launching its Azure cloud computing service in 2010. Microsoft also operates the largest software-as-a-services business. The company has focused on building its enterprise business, integrating its cloud services with its legacy on-premises business applications, which still has a large installed base. Public cloud infrastructure services are still a small part of Microsoft's overall business, but high growth rates in that segment likely have influenced the acquisition by CEO

Satya Nadella of LinkedIn and the company's investment in open-source platform GitHub.

2.4. The Intersection of AI and Cloud Computing

Cloud computing has become a platform that hosts numerous services to enhance users, enterprises, small and medium businesses, and micro-businesses productivity by utilizing technology services as per their requirements and pay-per-use policy. However, cloud computing still lacks gaining interests in data intelligence, especially for specially designed applicable technologies for businesses and relatively smaller companies due to absence of cost-effective and performance-oriented services. Although cloud computing has innumerable applications for businesses and enterprises, we still face some execution drawbacks for which initial-level tools are yet to be launched. Nowadays, the huge amount of collected data needs realistic chances to become actual intelligence to take the aspect of being an intelligent company becoming viable and real. Although numerous dedicated commercially available technologies provide businesses and enterprises with smart tools, the accessible services in the cloud still lack a designed specifically for them range of tools that will allow for actual intelligent decisions to be made with solid confidence.

In the case of AI, several technologies concerning intelligent tools creation are quickly arriving on the market, from evident users' services to complex dedicated ones for professional use. Businesses and companies generally do not have the possibility to have in-house specific technologies for data intelligence, making the integration of external platforms with the dedicated models for their respective needs inadequate sometimes. The distributed technology in the cloud could allow them to overcome the limits of physical capabilities, giving the chance to companies and businesses to access tools that are otherwise too expensive or require too much effort. The possibility for businesses to utilize intelligent services can potentially enable the AI to go through a new phase of real usage, not only with big players but also with micro and small players that could increment the overall usage benefits.

2.4.1. Benefits of Integration

Cloud computing has transformed the way we store, process, and analyze large sets of data. The integration of AI capabilities into cloud computing platforms benefits the end users on many fronts, including the availability of best-in-class services, high scalability, and collaboration across the enterprise as well as the massive research and development effort and investment made by cloud computing service providers. The business intelligence industry is only beginning to realize this power. Next-generation business

intelligence solutions with deep integration into AI-supported cloud platforms will power many of the critical insights for organizations solving key business problems in performance management, predictive analysis, customer service, supply chain management, workforce management, and resource planning. Business intelligence capabilities such as planning, reporting, analysis, and data integration are finding their way into cloud services, and enterprise security and implementation support into active directory. By embedding business intelligence into cloud platforms, organizations achieve a variety of goals, including better collaboration, more complete enterprise data using enterprise models, and enterprise security. Acquiring the embedded business intelligence capabilities speeds time to solution, especially in highly collaborative operations. Decision-makers can be confident in the enterprise significance of the answers they are sharing. Developers can create solutions seamlessly connected to enterprise data. Connections from embedded business intelligence are managed for users. There are no issues in deploying drivers or creating data source connections for every user or group. Simple roles take care of security, and no other management is needed.

2.4.2. Challenges and Considerations

Various challenges exist preceding the actual integration of Artificial Intelligence and Cloud Computing. Due to such challenges, the connection of AI and CC is hard to achieve. Some of these challenges arise from the technological sphere, other challenges come from ethical, policy and management issues. These challenges generate a negative impact on both Cloud and AI adoption and consolidation. A brief summary of these challenges is provided by the following sections.

Due to the intrinsic differences that exist between Cloud and AI, especially during the decision-making step of creating a cloud service, and optimizing, deploying and increasing the size of an AI service, precise management is required. There also exists the possibility of a lack of interoperability between Cloud and AI platforms. It also should be noted that, in comparison to traditional Machine Learning, DNNs are characterized by a different performance-per-cost ratio. Other potential risks, in association with sensitive data that may be addressed jointly with Cloud and AI services, are the data and service emergence during the association step of AI and CC technologies, where sensitive data can be accessed. During this stage, those technologies have not yet been implemented operationally and it is not clear what will be the effect of the association.

Cloud and AI services use different technologies to reach their objectives. AI would be able to optimize cloud service management, monitoring, usage and development. While the use of Cloud will allow making easier usage of AI services through better

management and development of AI services. AI acts as a mechanism to facilitate the emergence of a broad set of CC services while at the same time, CC acts as a technology to facilitate the emergence of different AI services.

2.5. Business Intelligence: An Overview

Decision-making within organizations is generally a complex activity, composed of multiple stages and involving different interrelated aspects. During these stages, all types of information relative to various aspects involved in the decision need to be analyzed in order to choose the most suitable strategy to reach the objectives defined during the planning stage. Furthermore, during the operational phases of the organization's activity, real-time data must be measured and compared with the relevant objectives in order to understand how the organization is performing. This process, known as monitoring, consists of the systematic measurement and control of key organizational performance indicators and is an important activity that allows organizational managers to have a clear and updated picture of organizational operations, leading to possible corrective actions if needed.

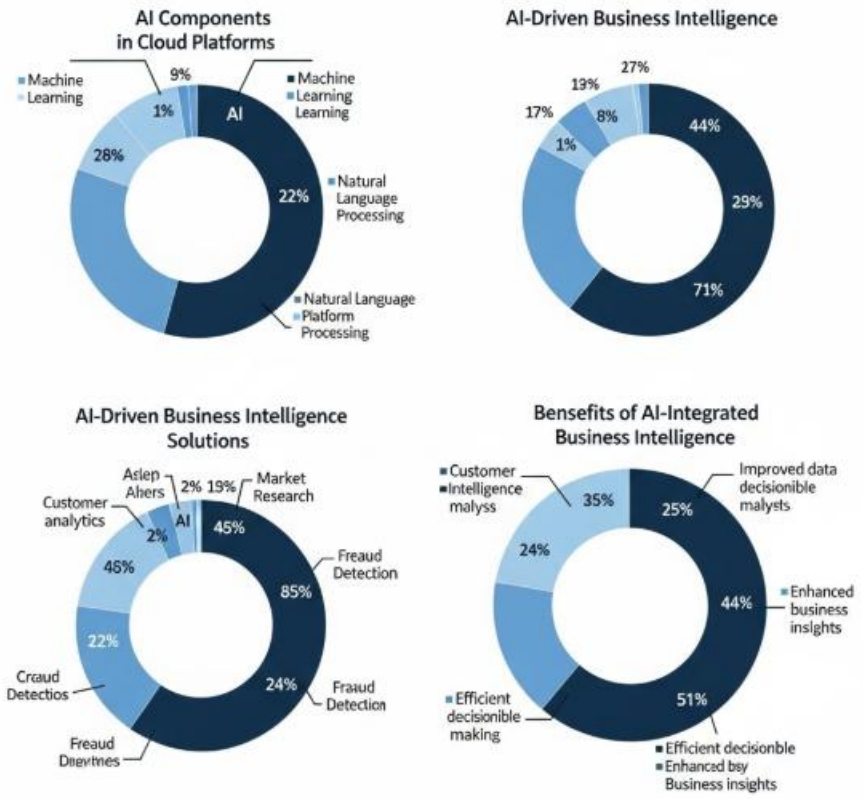

Fig : Integrating Artificial Intelligence into Cloud Platforms

Business Intelligence systems have been developed to help organizations with the decision-making and monitoring functions. These systems facilitate the selection, acquisition, and analysis of internal and external information in order to support planning, decision-making, and monitoring operations. In short, BI encompasses IT systems used for decision support. These systems are also called Decision Support Systems, and in addition, they use different methodologies and IT tools, including expert systems, Executive Information Systems, online analytical processing, and data mining technologies. Furthermore, BI is referred to as Business Analytics when it uses predictive models contributing to forecasting development in the future.The annual growth of Business Intelligence is outpacing other markets. The importance of BI is emphasized by the position of certain vendors at subsequent trade events. Business Objects and MicroStrategy have significant presences at both the Applications and Data Warehousing shows. In fact, Business Objects has been a key factor in promoting the assimilation of data warehousing, Decision Support Systems, executive information systems, and other BI technologies. For other major Warehouse vendors like IBM, data delivery/consultative decision support services are integral components of their data architectures. Business Intelligence is, or should be, a critical component of any executive strategy. BI allows organizations to stay ahead of the competition by actively watching for changes in the marketplace and reacting to those changes before the competition does.

2.5.1. Definition and Importance

Business intelligence (BI) is a technology-driven process for analyzing data and presenting actionable information to help corporate executives, business managers, and other end users make informed business decisions. BI aims to support better business decision-making. In every organization, various types of decisions must be taken at various levels in order to pursue the organizational objectives successfully. In the early 1980s, business intelligence became part of the popular lexicon with the advent of executive information systems and computer-aided decision-making, which allow for retrieval and organized presentation of data. More recently, business intelligence, data warehousing, and enterprise resource planning systems have begun to merge. Business intelligence provides the business world with buzzwords and phrases like "query," "reporting," "dashboards," "scorecard," "pivoting," "drill-down," "data mining," and "knowledge management." Business intelligence leverages software and services to transform data into actionable intelligence that informs an organization’s choices and drives direction. Business intelligence technologies provide historical, current, and predictive views of business operations in reporting, online analytical processing, analytics, data mining, and querying and reporting.

2.5.2. Current Trends in BI

Business Intelligence (BI) solutions have evolved into multi-dimensional systems consuming a variety of data sources which not only help report on the current state of businesses but also analyze past events for a better understanding of business behaviors, conduct analysis on likely future events to help predict business outcomes, and run simulations to recommend the best course of action depending on future events. Businesses today are more globally connected, and workforces more decentralized, than ever before; data from all conceivable sources is being captured by businesses, both first-party sources breathing into the businesses systems, second-party sources from the businesses' partners systems, as well as third-party data sources for demographics information, and using it to present customers with better offerings, and advertising with greater targeting. As a result, the volume and variety of data available for analytics has grown enormously, causing BI solutions to push the extremes of technological advancements, trying to leverage available systems, and cloud infrastructure, to serve businessmen fast, and intelligently; and display dashboards with real-time updates and recommendations.

Driven by, and fueled on by, the meteoric rise of the Big Data ecosystem, the Big Data wave has now slowly and steadily begun to positively influence the BI landscape. BI customers are increasingly looking at ways to leverage the availability of these technologies, as well as the availability of specialized, lower-cost Big Data tools and products that can easily connect to leading BI platforms and are best positioned to enable their BI needs.

2.6. Conclusion

Business intelligence is increasingly finding its way into the cloud with the offer of cloud BI vendors and SaaS offers of traditional BI vendors. Their services and solutions are key enablers to help organizations manage the complex environment they are linked with. The added value perceived by organizations has been driving the growth of cloud BI solutions drastically in recent years. Organizations can access the infrastructure, technology, and knowledge of major cloud BI solution vendors that are fulfilled to overcome the infrastructural, technological, and financial barriers they face. Cloud providers are enriching their BI offerings by integrating higher value-added versions of basic BI functionalities, improving performance and bringing new features, encouraging organizations to rely on their capacity and expertise.

Emerging cloud BI trends shed light on the fact that we are in a transitional moment of the growth history of BI. The future of cloud BI will look different than the past, as part of that future will be shaped by this new generation of cloud BI solutions. This shift was

spurred by the new generation of cloud BI fundamentals, new data and usage use cases, technology and channels convergence, the new information consumption habits, and the maturing of technology and vendor enterprise capabilities. New groups of users support the new use cases, that are from lower to higher layers if we consider a cloud BI solution. Cloud BYOD triggers the offloading of the corporate BI contents from the corporate information system towards lower layers, feeding them into the cloud. The trend in the consumption of BI information by users focuses on the combination of the cloud with easy-to-use mobile devices to access, visualize, explore, and socialize previously defined BI contents. With these trends, BI will become a new layer of the cloud where services and solutions will offer a higher value-added on information delivered to the upper layers. Organizations will increasingly see BI core offered by cloud players.

2.6.1. Emerging Trends

Integrating Artificial Intelligence into Cloud Platforms for Next-Generation Business Intelligence Solutions

Cloud computing is ushering in a new era of Business Intelligence systems and solutions. The next-generation Business Intelligence systems will converge in one place to collect and clean data if necessary, publish, maintain, secure, and monitor data quality, share, analyze, visualize, and consume associated information through interactive dashboards, notifications, and mobile applications. Services will allow tools from different vendors to interoperate with ease and share information from disparate sources. Business Intelligence will become part of every line of business software solution instead of just being an afterthought added on once every year or so. The rich analytical results will help steer the path of the transactions themselves.

The Business Intelligence platforms of the next generation will have to provide self-service data preparation capabilities built on collaborative, enterprise-grade semantic layers. Data preparation will become like spreadsheet manipulation–a task performed by the business user rather than IT professionals. Business users, whether analysts or line of business personnel, will want to prepare their data quickly without relying on IT. The underlying infrastructure must dynamically scale to handle the unpredictable workloads of billions of small, short-run analytical jobs performed by hundreds of thousands of users. The infrastructure needs to service interactive requests coming from web browsers running on laptops and tablets as well as mobile devices, all while performing longer-running batch jobs. Departments deficient in their ability to optimize hardware utilization cannot afford to invest in separate infrastructures to handle the unique requirements of analytics and transactions. AI capabilities will further augment the ability of the end-users to create appropriate visualizations based on the data they want to analyze without needing their services.

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