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Cloud Computing in Enterprise Business Application

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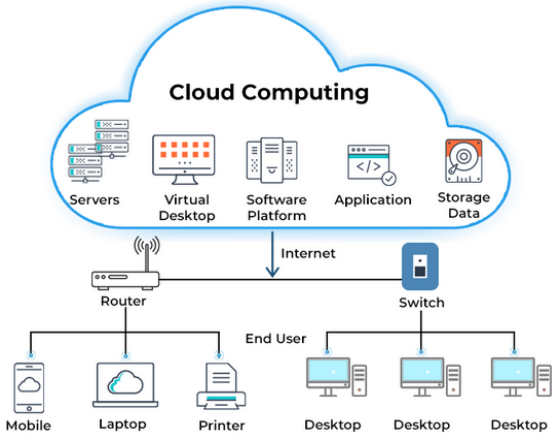
Abstract: ***The purpose of this article is to highlight the Concept of Cloud Computing, its capabilities, evolution, and different Cloud Computing offerings in enterprise business applications. A detailed and descriptive approach is adopted to illustrate Cloud Computing, its evolution, architecture, and the current offerings with examples. Furthermore, the impact of the Cloud on various enterprise business applications aka ERP Software's were elaborated with a focus on SAP Software. The origin of SAP and its Journey and the adoption of this popular Software across the globe are detailed. The article provides the context and the relevance of Cloud Computing in SAP Software by emphasizing the advantages of On-demand delivery of IT resources over the internet in terms of Cost, Scalability, Security and Flexibility. The article also focuses the need of Cloud Computing and provides Organizations the context to adopt this technology while choosing SAP ERP applications to stay ahead of the game and focus more on the core capabilities by taking advantage of these trends.***

Keywords: IT, SAP, On-demand, ERP, Cloud.

I. INTRODUCTION

Cloud Computing, in simple words is - on-demand availability of computing resources as services over the internet. The "cloud" is a term that simply means "the internet." Computing involves the infrastructures and systems that allow a computer to run and build, deploy, or interact with information. In cloud computing, this means that instead of hosting infrastructure, systems, or applications on your hard drive or an on-site server, you're hosting it on virtual/online servers that connect to your computer through secure networks. Cloud computing relies on sharing of resources to achieve coherence and typically uses a "pay as you go" model, which can help in reducing capital expenses but may also lead to unexpected operating expenses for users. Cloud Computing allows companies to avoid or minimize up-front IT infrastructure costs and enterprises can get their applications up and running faster, with improved manageability and less maintenance, and that it enables IT teams to rapidly adjust resources to meet fluctuating and unpredictable demand.

Figure 1. A Simple Cloud Computing Model



The main goal of cloud computing is to make a better use of distributed resources, combine them to achieve higher throughput and be able to solve large scale computation problems.

Evolution – The Journey of Cloud Computing

During the 1960s, the initial concepts of time-sharing became popularized via RJE (Remote Job Entry) [1] this terminology was mostly associated with large vendors such as IBM and DEC. Full-time-sharing solutions were available by the early 1970s on such platforms as Multics (on GE hardware), Cambridge CTSS, and the earliest UNIX ports (on DEC hardware). Yet, the "data center" model where users submitted jobs to operators to run on IBM's mainframes was overwhelmingly predominant. In the 1990s, telecommunications companies, who previously offered primarily dedicated point-to-point data circuits, began offering virtual private network (VPN) services with comparable quality of service, but at a lower cost. As computers became more diffused, scientists and technologists explored ways to make large-scale computing power available to more users through time-sharing. They experimented with algorithms to optimize the infrastructure, platform, and applications, to prioritize tasks to be executed by CPUs, and to increase efficiency for end users.[2]. The use of the cloud metaphor for virtualized services dates at least to General Magic in 1994, where it was used to describe the universe of "places" that mobile agents in the Telescript environment could go.

In July 2002, Amazon created subsidiary Amazon Web Services, with the goal to "enable developers to build innovative and entrepreneurial applications on their own." In March 2006 Amazon introduced its Simple Storage Service (S3), followed by Elastic Compute Cloud (EC2) in August of the same year.[3][4] These products pioneered the usage of server virtualization to deliver IaaS at a cheaper and on-demand pricing basis. In April 2008, Google released the beta version of Google App Engine.[5] The App Engine was a PaaS (one of the first of its kind) which provided fully maintained infrastructure and a deployment platform for users to create web applications using common languages/technologies such as Python, Node.js and PHP. The goal was to eliminate the need for some administrative tasks typical of an IaaS model, while creating a platform where users could easily deploy such applications and scale them to demand.[6]

In early 2008, NASA's Nebula,[7] enhanced in the RESERVOIR European Commission-funded project, became the first open-source software for deploying private and hybrid clouds, and for the federation of clouds.[8]. By mid-2008, Gartner saw an opportunity for cloud computing "to shape the relationship among consumers of IT services, those who use IT services and those who sell them [9] and observed that "organizations are switching from company-owned hardware and software assets to per-use service-based models" so that the "projected shift to computing ... will result in dramatic growth in IT products in some areas and significant reductions in other areas [10]. In 2008, the U.S. National Science Foundation began the Cluster Exploratory program to fund academic research using Google-IBM cluster technology to analyze massive amounts of data[11] In 2009, the government of France announced Project Andromède to create a "sovereign cloud" or national cloud computing, with the government to spend €285 million.[12][13] The initiative failed badly and Cloudwatt was shut down on 1 February 2020.[14][15]

In February 2010, Microsoft released Microsoft Azure, which was announced in October 2008.[16]. In July 2010, Rackspace Hosting and NASA jointly launched an open-source cloud-software initiative known as OpenStack. The OpenStack project intended to help organizations offering cloud-computing services running on standard hardware. The early code came from NASA's Nebula platform as well as from Rackspace's Cloud Files platform. As an open-source offering and along with other open-source solutions such as CloudStack, Ganeti, and OpenNebula, it has attracted attention by several key communities. Several studies aim at comparing these open-source offerings based on a set of criteria.[17][18][19][20][21][22][23]

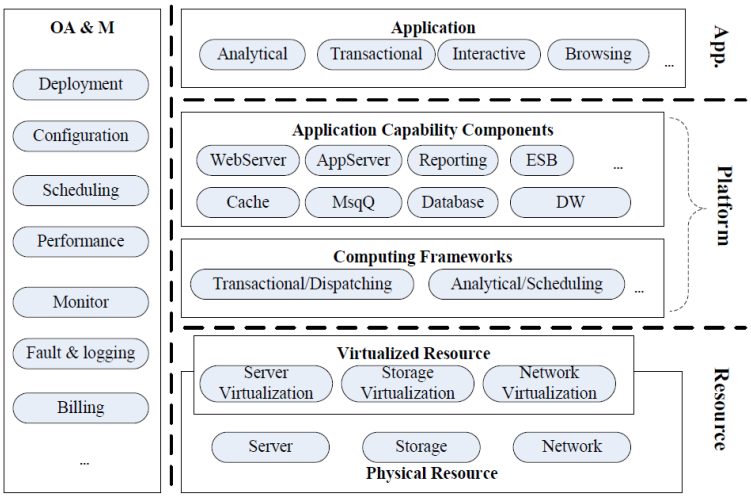
On March 1, 2011, IBM announced the IBM SmartCloud framework to support Smarter Planet.[24] Among the various components of the Smarter Computing foundation, cloud computing is a critical part. On June 7, 2012, Oracle announced the Oracle Cloud.[25]. In May 2012, Google Compute Engine was released in preview, before being rolled out into General Availability in December 2013. In 2019, Linux was the most common OS used on Microsoft Azure.[26] In December 2019, Amazon announced AWS Outposts, which is a fully managed service that extends AWS infrastructure. Today all major corporations across the globe have a full suite of Cloud offerings covering every business model.

According to IDC, the global spending on cloud computing services has reached $706 billion and expected to reach $1.3 trillion by 2025.[27] While Gartner estimated that the global public cloud services end-user spending forecast to reach $600 billion by 2023.[28] As per McKinsey & Company report, cloud cost-optimization levers and value-oriented business use cases foresees more than $1 trillion in run-rate EBITDA across Fortune 500 companies as up for grabs in 2030.[29] In 2022, more than $1.3 trillion in enterprise IT spending is at stake from the shift to cloud, growing to almost $1.8 trillion in 2025.

Cloud Computing – Architecture, Offerings & Deployment Models

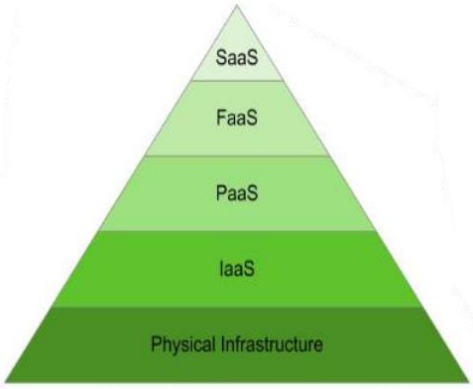
The Architecture for cloud computing is divided into the core stack and the management. In the core stack, there are three layers: (1) Resource (2) Platform and (3) Application. The resource layer is the infrastructure layer which is composed of physical and virtualized computing, storage, and networking resources. The platform layer is the most complex part which could be divided into many sublayers. E.g., a computing framework which manages the transaction dispatching and/or task scheduling. A storage sub-layer provides unlimited storage and caching capability. The application layer consists of other components that support application logic via on-demand capability or flexible management, such that no components will become the bottle neck of the whole system. Based on the underlying resource and components, the application could support large and distributed transactions and manage of huge volume of data. All the layers provide external service through a web service or other open interfaces.

Figure 2. Cloud Computing Architecture



Cloud Computing Service Offerings, benefits, and key players in each of the segment. Cloud Computing offerings can be divided into 4 types based on their functionality. **A. Infrastructure as a Service - IaaS, B. Platform as a Service - PaaS C. Function as a Service - FaaS D. Software as a Service - SaaS**

Figure 3. Types of Cloud Services [30]



Infrastructure as a Service (IaaS) is the most comprehensive and flexible type of cloud service. Essentially, it provides a fully virtualized computing infrastructure that is provisioned and managed over the Internet. An IaaS provider manages the physical edge of the infrastructure (servers, data storage space, etc.) in a data center, but allows customers to fully customize those virtualized resources to meet their specific needs. With IaaS, the customer can purchase, install, configure, and manage any software they need to use, including items such as operating systems, middleware, applications, business analytics, and development tools. IaaS eliminates the capital expense of building internal infrastructure. The most popular offerings are - Microsoft Azure, Amazon Web Services (AWS), Cisco Metacloud, Google Compute Engine (GCE). [31]

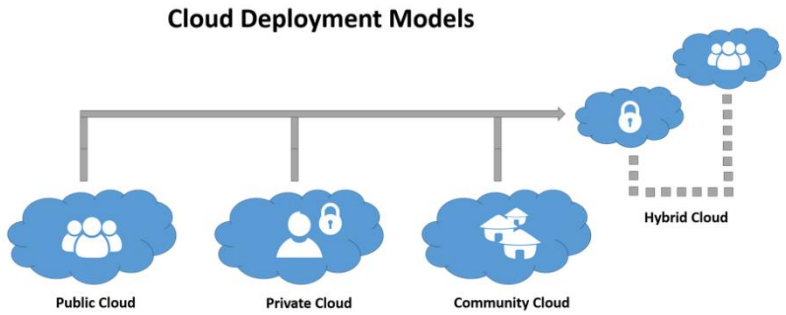
Platform as a Service (PaaS) provides the framework to create, test, deploy, manage, and update software products. It uses the same basic infrastructure as IaaS, but also includes the operating systems, middleware, development tools, and database management systems necessary to create software applications. PaaS is extremely useful for any company that develops web-based software and applications. Many of the tools required to develop for multiple platforms (computers, mobile devices, browsers, etc.) can be quite expensive hence customers can access the development tools using PaaS cloud service. The most popular offerings in this space are - AWS Elastic Beanstalk, Apache Stratos, Google App Engine, Microsoft Azure. [31]

Function as a Service – (FaaS) allows customers to read code reactively, without the need to allocate processing resources ahead of time. The cloud service provider handles the infrastructure, allowing the customer to focus strictly on the application of codes. Functions are scaled automatically, making them excellent for adapting to dynamic workloads that vary in terms of resource consumption. Customers only pay for the resources they use, making FaaS the truest form of "pay-as-you-go" cloud computing. Most FaaS applications are quite simple and can be deployed very quickly. The cloud customer just needs to upload the complied function code and tell the platform how to provision resources when it executes. The examples in this space are - AWS Lambdas, Azure Functions. [31]

Software as a Service – (SaaS) is a fully developed software solution ready to buy and use over the Internet by subscription. The SaaS provider manages the infrastructure, operating systems, middleware, and data necessary to deliver the program, ensuring the software is available on demand. Many SaaS applications run directly through web browsers, eliminating the need for downloads or installations. SaaS applications allow businesses to get up and running swiftly and scale operations quickly. Organizations are not required to purchase or implement the hardware and software used to deliver the services. The examples in this space are - Microsoft Office 365, Salesforce, Cisco WebEx, Google Apps. [31]

As the Service offering were laid out and understood clearly, we now try to understand the Cloud Computing Deployment Models. There are many interpretations of the Deployment Models, but the most popular and commonly referred are five types - Private Cloud, Public Cloud, Hybrid Cloud, Community Cloud, Inter-Cloud. Inter Cloud Deployment Model is further classified as Federated Clouds, Multi-clouds. Below figure illustrates the various Clod models.

Figure 4.



Private Cloud – This deployment model is also called as the internal or corporate model. A private cloud belongs to a specific organization. That organization controls the system and manages it centrally. While a third party (for example, a service provider) can host a private cloud server. Most companies choose to keep the hardware in their local data center and manage internally on their own for better control. [32]

Public Cloud - The public cloud model is well-known cloud service. This type of cloud is a popular choice for web applications, file sharing, and non-confidential data storage. Public clouds are recommended for software development and collaborative projects. The service provider owns and operates all the hardware necessary to run a public cloud. Vendors keep the devices in massive data centers. The public cloud delivery model plays an important role in development and testing. Developers frequently use public cloud infrastructure for development and testing purposes. Its virtual environment is inexpensive and can be easily configured and quickly deployed, making it perfect for test environments. [32]

Hybrid cloud – This is a combination of public clouds with private clouds. They are designed so that data and applications move smoothly and can interact. It is the perfect solution for a business or organization that needs a bit of both, which are generally industry and size dependent. [2] In essence, a hybrid cloud generally starts out as a private cloud which then extends the integration to use one or more public cloud services. This deployment model makes sense when companies have sensitive data that cannot be stored in the cloud or regulatory requirements that call for data protection and storage. [33]

Community Cloud - A cloud service that provides services to a community of users or organizations with shared interests or concerns. Organizations using this cloud service have shared missions, governance, security requirements, and policies. Cloud services can be hosted on the premises of the consumer organization, the peer organization, at one provider, or a combination of these. This community cloud term is often used in marketing to explain the target consumers of the service, although the actual cloud could technically be a VPC, private or hybrid cloud model. [33]

Inter-cloud - "cloud of cloud" is a term that refers to a theoretical model for cloud computing services based on the idea of combining many different individual clouds into one seamless mass in terms of on-demand operations. Inter-cloud would simply ensure that a cloud could use resources beyond its reach, taking advantage of pre-existing contracts with other cloud providers [34]. There are mainly two types of Inter-cloud - Multi Cloud and Federated cloud. (Cloud federation)

Multi-cloud – This is the use of two or more cloud computing services from several different cloud providers. A multi-cloud environment could be completely private, completely public, or a combination of both. Businesses use a multi-cloud environment to allocate computing resources and reduce the risk of downtime and data loss. They can also increase the computing power and storage available to businesses. Cloud innovations in recent years have led to a shift from single-user private clouds to multi-tenant public clouds and hybrid clouds. [35]

Federated cloud - is also called a cloud federation which manages multiple internal and external cloud computing services to meet business needs. A federation is the union of several small parties that perform a common action. [36]

Cloud Computing has transformed the way businesses are functioning around the world and how the IT Infrastructure, echo systems are selected, designed, and managed. Understanding the difference among various types of cloud computing offerings and identifying the best suited model for a growing business is tremendously important. Organizations can choose the above services and models based on the nature of the business, the Enterprise Applications they run, Cost, Scalability, Control, Security and other key KPI's which align with their IT strategy.

Below are the market figures showing Cloud Service and deployment model market size (Source www.T4.ai)

Figure 5.

II. Enterprise Business Application

Today's businesses, both large and small, are faced with a ton of challenges that might prevent them from running as smoothly and efficiently as possible. Like an individual might download an app on their smartphone to help them solve personal challenges like creating a schedule, establishing a financial budget, or navigating a new city, enterprise applications aim to do the same for a business or organization. Enterprise applications are defined as being "designed to integrate computer systems that run all phases of an enterprise's operations to facilitate cooperation and coordination of work across the enterprise." an enterprise application can bring together different aspects of an enterprise, such as accounting, human resources, finances, and inventory. From Fortune 500 companies to large NGOs, many big organizations could use some help from Enterprise application software to solve their business challenges. Apart from their unique scalability and elegant design, many other characteristics make them stand apart from any typical B2C app. Figure 5. illustrates the different Enterprise applications.

Figure 6. Enterprise Business Applications

Some of the most popular Enterprise business application in use around the globe are below…

Customer relationship management (CRM) systems - Enterprises use CRM software to make sure their team knows their client. A CRM system helps companies stay connected to customers, streamline processes, and improve profitability. When people talk about CRM, they are usually referring to a CRM system, a tool that helps with contact management, sales management, agent productivity, and more. CRM tools can now be used to manage customer relationships across the entire customer lifecycle, spanning marketing, sales, digital commerce, and customer service interactions.

Enterprise resource planning (ERP) systems – ERP systems are "brain" of the organization. An ERP system takes all the different parts of a business, digitizes them, and creates networks between them. In particular, an ERP system can integrate an organization's financial information. Without an integrated system, individual departments, such as finance, sales, and so on, need to rely on separate systems, each of which will likely have different revenue and expense numbers. Using an ERP ensures all members of the organization are working from the same core records and up-to-date information. One of the major perks of an ERP system is that it can integrate other enterprise applications, like CRM, supply chain management (SCM), or inventory management (IM) or Planning Systems to provide organizations an end to end 360 degrees view of each operation.

Project management systems - The most accessible enterprise apps are those geared towards creating efficient and communicative project management teams. As more members of the workforce begin to work remotely, these applications become vital. An enterprise app for project management is designed to help teams collaborate more effectively, no matter where the team is located. Project management apps give an overview of all active projects. They allow team members to dive into the specifics and check out every milestone, new detail, and upcoming task that may need to be completed to keep progress on schedule.

Human capital management (HCM) Systems - An HCM system helps organizations manage and maintain their workforce. The functions of an HCM system are often organized into categories, including talent management, workforce management, and service delivery. HCM tools help HR teams adapt to the ever-changing requirements of talent management and acquisition while simultaneously furthering productivity.

Now we understand the different Enterprise Applications and their contribution to Business community and Organizations, we slightly get deeper with **ERP Applications** and Software's. Out of thousands ERP software's available in the market the most significant and impactful one is SAP. SAP stands for Systems, Applications, and Products in Data Processing and is the product of SAP SE Germany

SAP AG was founded in 1972 by five German engineers with IBM in Mannheim, Germany; interestingly three of the founders, Hasso Plattner, Dietmar Hopp, and Klaus Tschira, were still with SAP in mid-2001. When an IBM client asked IBM to provide enterprise-wide software to run on its mainframe, the five engineers began writing the program only to be told the assignment was being transferred to another unit. Rather than abandon the project altogether, they left IBM and founded SAP in Walldorf, near Heidelberg. In 1976 SAP declared itself a GmbH (Gesellschaft mit beschränkter Haftung) corporation, or limited company. In 2005 it further restructured itself as SAP AG. Since 7 July 2014, its corporate structure is that of a pan-European (SE) [37] [38]

SAP Software Journey - In 1978 SAP began developing and released, R/2 (R for "real-time"), a mainframe-based, standard business software suite in which integrated modules for accounting, sales and distribution, and production enabled customers to consolidate their financial and operational data into a single database and eliminate costly paperwork and data entry. Because the modules were self-standing, businesses could selectively choose what they needed, which could then be customized to their unique requirements. The promise of real-time integration of mission-critical corporate data, viewable through the spreadsheet-like windows of specialized software, offered the potential for uniform data flow, streamlined business operations, and centralized decision-making. SAP had a huge success in implementing this R 2 for some of the greatest Corporations like Heinz, and Shell Oil. As R/2's potential began to peak in the mid-1980. With the advent of Systems

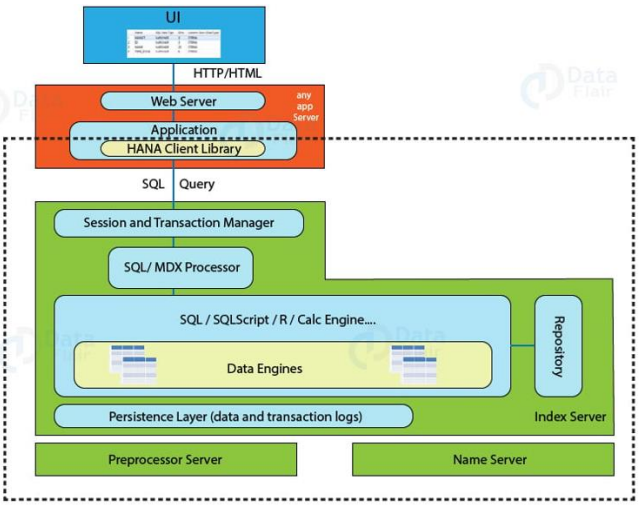
Application Architecture (SAA) and other technical changes SAP began developing R/3 in1987 for use in the decentralized, non-mainframe computing environment known as client-server. In client-server arrangements, data is processed not by a single costly mainframe but by many cheaper networked "server" computers, which display their data on flexibly arrangeable PCs called "clients. After five years in development, R/3 was launched and was hugely successful worldwide. Significantly, in 1994 SAP formed an alliance with American software giant Microsoft to make SAP software integrated with such Microsoft products as Windows NT, an operating system for networked computers, and SQL Server, a database product. In 1995 Microsoft returned the favor by selecting R/3 for its global finance and accounting data system. To rein in R/3's ever-increasing capabilities and complexities, SAP deployed a number of new customer initiatives, including a fast-track program to expedite the sales and installation process, and business units to tailor software packages for specific industries. By 1998, SAP's range of industry-specific applications extended to 17 different sectors including aviation, hospitals, automotive, and the military. There were various releases of this software throughout the 90s, before SAP's ERP (ECC) was launched in 2004 through its new mySAP.com platform, particularly its specialty applications in supply chain and customer relationship management, SAP appeared to have successfully positioned itself to capitalize on the flourishing e-business market. SAP ECC (also referred to as SAP ERP)'s main purpose is to incorporate the key business functions of an organization all in one place. SAP ECC and SAP ERP? The reason they are referred to as such (and sometimes interchangeably) is that ERP is simply a general term that stands for Enterprise Resource Planning. ECC is the name given to SAP's ERP software bundle and stands for SAP ERP Central Component.

SAP ECC is the core business product inside SAP Business Suite and provides an integrated and updated overview of an organization's core business processes–from financials to human resources and is used by various departments including IT and finance. SAP ECC laid the foundation for on-prem S/4 HANA and S/4 HANA Cloud editions. The Primary difference between SAP ECC and SAP HANA is that ECC is the core ERP product within the SAP Business Suite, whereas SAP HANA is a cloud-friendly, in-memory database designed to handle transactions and analytics on one system. SAP HANA is the database type that runs the most up-to-date versions of SAP's software–specifically SAP S/4 HANA. Prior to HANA, all SAP software was run on third-party databases such as Oracle and others, while HANA is SAP's own in-memory platform. This enables much faster access to and analysis of data. In software development, SAP HANA is also a platform for customer-defined applications. SAP HANA's primary function is to store and retrieve data as requested by applications. The software can also perform advanced analytics quickly and includes ETL (extract, transform, load) capabilities. SAP is following an aggressive release strategy for their new offerings. S/4 HANA (on-premise) edition is having a yearly upgrade whereas the S/4 HANA Cloud edition is having 2 upgrade releases per year.

SAP has a comprehensive portfolio of cloud solutions other than SAP S4 Hana, that can help your business run more efficiently and effectively. From analytics and data warehousing to manufacturing and logistics, SAP has a cloud solution that can meet every business needs. Following are few examples of SAP Cloud offerings - SAP Analytics Cloud - a powerful cloud-based analytics platform that provides real-time insights into business data. SAP Ariba - can streamline procurement process and improve supplier relationships. SAP Business By Design is a pre-configured ERP solution that offers flexibility and scalability for businesses of all sizes. SAP Concur - simplifies expense management and invoicing, while SAP Customer Experience helps to deliver an exceptional customer experience at every touchpoint. SAP Data Warehouse Cloud - provides a secure, cloud-based environment for storing and managing business data. SAP Digital Manufacturing Cloud - helps to manage manufacturing process more effectively, and SAP Fieldglass provides a comprehensive solution for managing contingent workforce programs. SAP Integrated Business Planning - can improve decision-making and planning processes across the organization. SAP SuccessFactors - can drive better business outcomes by aligning people strategy with business objectives. Finally, SAP S/4HANA Cloud - a complete, cloud-based solution that offers supply chain, supplier relationship management, finance, sales, and R&D functionality.

SAP HANA Architecture - The architecture of SAP HANA has several components working together. The main component of the entire SAP HANA architecture is the Index server which stores and processes all the data. All the other components or engines such as - Name server, Relational database engine, OLAP engine, etc. are linked to the index server and work with it. Once, the client is connected with the database, queries and data are launched in languages such as SQL and SQLScript. SQLScript is the scripting language of SAP HANA Database. Query statements sent by the user processes in the Index Server and a response sends back to the user accordingly. The queries then translate into a readable model and execute by the calculation engine. Along with the services in the index server, other servers like pre-processor server, name server, graph engine, text engine, statistics server, persistence layer also play important roles in SAP HANA functioning.

Figure 7. SAP HANA Architecture



SAP HANA is an in-memory database technology, which has optimized its performance by improving hardware and software capabilities. Some important innovations done in SAP HANA software and hardware are - Multicore architecture, 64-bit address space, Improved performance, Reduced prices, Row and Column store in the database.

III. Cloud Computing in Enterprise Application – SAP S4 HANA

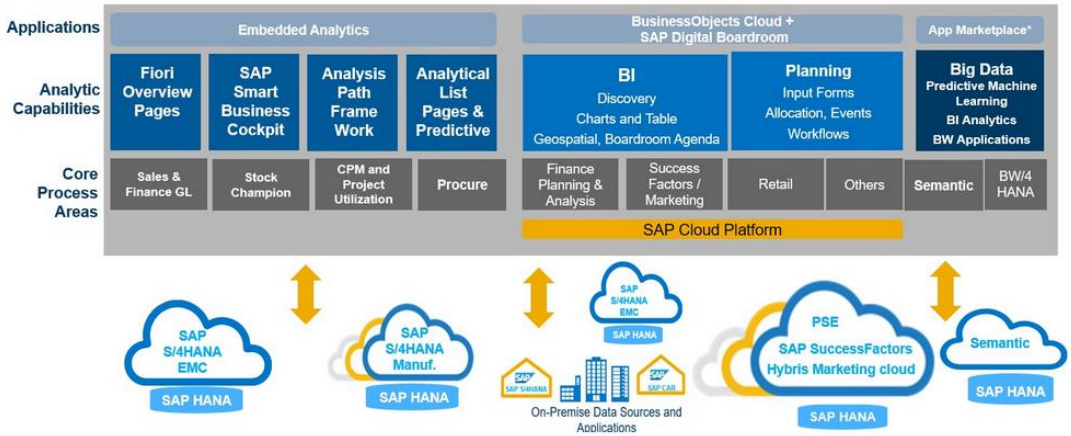
Cloud Computing has evolved as one of the most important technological innovations touching all Business Application's irrespective of the size and market penetration. All Major Enterprise applications Providers like SAP, Microsoft, Amazon, IBM Salesforce have rolled the Cloud enabled versions of their applications. Many organizations globally have started adoption of the technology and have seen great benefits already. As per the published report of IDC the worldwide public cloud services market, including Infrastructure as a Service (IaaS), Platform as a Service (PaaS), Software as a Service – System Infrastructure Software (SaaS – SIS), and Software as a Service – Applications, grew 29.0% year over year in 2021 with revenues totaling $408.6 billion. [39]. SAP AG has started releasing a suite of cloud offerings to their Customers since Year 2019 which attracted huge business in the form of new License purchases and also Upgrades for existing Customer to Cloud versions.

SAP S4 Hana - as a Software-as-a-Service (SaaS) offering - SAP S/4HANA Cloud is a Software-as-a-Service (SaaS) version of the SAP S/4HANA ERP system. It is a suite of integrated business applications that enable the planning of company resources according to the needs of the company. As the "intelligent ERP system of the new generation," the SAP S/4HANA Cloud was first launched in February 2017. With an ERP system as a cloud-based software version, the provider offers companies a solution that does not depend on their own resources such as internal hardware, databases, and IT expertise.

The SAP S/4 HANA Cloud runs on the SAP HANA in-memory database. This high-performance analysis application, which before the SAP cloud solution was only available in combination with various hardware, uses artificial intelligence to analyze large amounts of data, among other things. The in-memory technology of the development and integration platform

allows users to access their data faster and "in real time" to accelerate processes. With the SAP Cloud Platform, this also works virtually. Cloud deployment means users can access S/4HANA's functionality without committing resources to hardware, databases, or IT staff. S/4HANA Cloud includes technologies that can help bring "intelligence" into ERP applications, including machine learning, virtual and augmented reality, blockchain and voice-enabled technology. The main S/4HANA Cloud business modules include finance, sourcing and procurement, sales, professional services, and manufacturing.

Figure 8.



Pillars of SAP S/4 HANA Cloud's intelligent ERP - SAP S/4HANA Cloud incorporates three technologies that form the foundation of intelligent ERP, according to SAP.

Digital assistant. SAP S/4HANA Cloud uses SAP CoPilot, a conversational digital assistant (or virtual assistant) that lets users interact with ERP applications and functions. SAP CoPilot uses contextual data about the user and the task they are performing to provide information relevant to the task.

Machine learning. SAP S/4HANA Cloud includes machine learning technology that "learns" how to perform and automate tasks that can be repetitive and error prone when done manually, making them run more reliably and efficiently.

Predictive analytics. SAP S/4HANA Cloud includes embedded analytics that can help predict the outcomes of actions. The analytics tools are configurable to the user's needs and can be developed into apps, such as an inventory management app that can predict when stock will arrive or a sales quotation app that enables sales managers to determine the probability of converting sales quotations.

SAP is heavily investing on its Cloud capabilities to get as many Customers as possible on the cloud edition as part of their Digital Strategy. Since SAP has already huge market Share in ECC installations across the globe, the Organizations are more leaned towards to their Cloud offerings. S/4 HANA Cloud is available in several cloud editions, including public cloud, private cloud and hybrid or managed-cloud environments. The Rise with SAP initiative, which was launched in 2021, enables customers to deploy S/4HANA Cloud on a public cloud infrastructure provided by Alibaba, Amazon Web Services, Google Cloud Platform, IBM or Microsoft Azure under a simplified SaaS license structure from SAP.

SAP S/4HANA Cloud Public Edition - Commonly used by net new customers that want the full cloud approach with regular upgrades that include new configuration and new software. This is a SaaS public cloud offering. Also used for subsidiaries alongside SAP on-premises implementations. The Key highlights of this offering are -

- Infrastructure: Public Cloud shared with other customers and hosted and operated by SAP only.
- License: Subscription for Software as a Service (SaaS) available as RISE with SAP.
- Upgrades: Managed by SAP. fixed and mandatory (configuration and software). The upgrade of configuration is unique to the public edition. SAP and customer do automate and manual regression tests.

- Scope: Core ERP (subset of full ERP), specific industries and 42 countries.
- Extensibility: Key user (in-app) extensibility, developer extensibility and extensions through SAP Business Technology Platform Extension Suite (side-by-side extensibility) with whitelisted APIs.
- Configuration: Use SAP Central Business Configuration and Self Service Configuration User Interfaces (SSCUIs) based on fit-to-standard workshops in the Explore phase.
- Implementation: Greenfield only (new implementation).
- SAP Activate roadmap: SAP Activate Methodology for SAP S/4HANA Cloud.
- Partner content: Partners can add configuration manually.
- Use SAP Cloud ALM (Application Landscape Management).

Unlike all the other deployment options, the user interface is purely Fiori and configuration is done using SAP Central Business Configuration and not the IMG.

SAP S/4HANA Cloud Private Edition -Existing SAP ECC customers can move to private cloud using a system conversion and retain their configuration and extensions. Has standardized infrastructure processes, services, and SLAs.

- Infrastructure: Dedicated landscape on cloud infrastructure operated by SAP and running at a Hyperscaler e.g., Microsoft Azure, AWS, Google Cloud).
- License: Subscription for software but not SaaS (available as RISE with SAP).
- Upgrades: Available like on-premises but Organizations chose their own speed to stay in mainstream support. The customer must manage the upgrade process. SAP does specific technical aspects of the upgrade only.
- Scope: On-premises S/4HANA functional scope. 64 countries, 39, languages and 25 industries. Some third-party add-ons limitations.
- Extensibility: Key user (in-app) extensibility, developer extensibility and extensions through SAP Business Technology Platform Extension Suite (side-by-side extensibility). Classic ABAP extensibility is still available, but modifications are not recommended.
- Configuration: IMG based on fit-to-standard workshops in the Explore phase.
- Implementation: Greenfield (new implementation), system conversion or selective data transition.
- SAP Activate roadmap: SAP Activate Methodology for SAP S/4HANA Cloud private edition.
- Partner content: partners templates allowed.
- Customers use SAP Solution Manager and/or Cloud ALM to manage their project design.
- Also see this blog on the 5 golden rules to adopt some of the lessons learnt from public cloud.

SAP S/4 HANA On-Premises Managed by SAP (HEC) - An on-premises solution with individual and private hardware and infrastructure hosted by SAP, a Hyperscaler or in your own data center. Infrastructure management is delegated to SAP with flexible service offerings. This can be used for combinations of solutions that are not available in SAP S/4 HANA cloud, private edition.

- Infrastructure: Customer specific landscape on SAP HANA Enterprise Cloud (HEC) in SAP data center, at a hyperscaler or in your own data center: SAP S/4HANA Cloud, private edition, customer data center option.
- License: Bring Your Own License and infrastructure subscription.

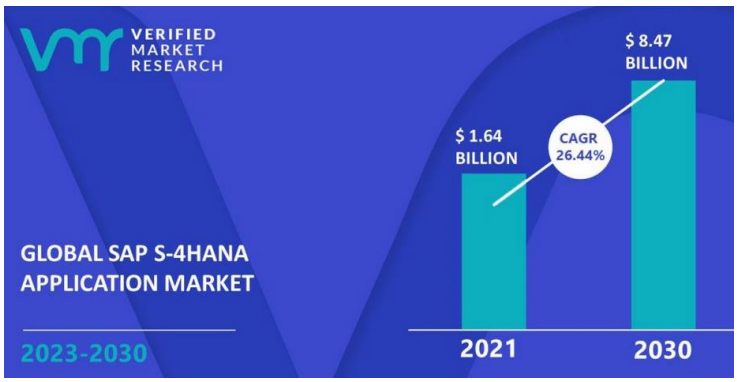
- Upgrades: You choose your own speed of adoption of software upgrades. Customer is responsible for managing the upgrade.
- Scope: Full S/4HANA functional, country and industry scope and partner add-ons.
- Extensibility: Customization, modification, and extensibility possible as with ERP.
- Configuration: Use the full IMG based on a fit-to-standard approach in the Explore phase.
- Implementation: New implementation, system conversions or selective data transition.
- SAP Activate roadmap: Transition to SAP S/4HANA.
- SAP Best Practices: All SAP Best Practices are available. https://rapid.sap.com/bp/BP_OP_ENTPR
- Partner content: Partner templates allowed.
- Customers use SAP Solution Manager to manage their project design. Most customers use SAP Best Practices activated using SAP Solution Builder or set up by SAP through a "Enterprise Management Layer" service.

SAP S/4HANA On Premise: On-Premise or managed by cloud providers Hyperscaler - Classic on-premise SAP S/4HANA managed by the customer in their own data center or managed by a third party.

- Infrastructure: Customer data Centre or hosted by hyperscaler (e.g., Microsoft Azure, AWS, Google Cloud).
- License: Perpetual or Bring Your own License.
- Upgrades: You choose your own speed of adoption of software upgrades. Customer is responsible for managing the upgrade.
- Scope: full S/4HANA functional, country and industry scope and partner add-ons.
- Extensibility: Customization, modification, and extensibility possible as with ERP.
- Configuration: IMG based on a fit-to-standard approach in the Explore phase.
- Implementation: New implementation, system conversions or selective data transition.
- SAP Activate roadmap: Transition to SAP S/4HANA.
- Partner content: Partner templates allowed.
- Customers may use SAP Solution Manager to manage their project design. Many customers use SAP Best Practices activated using SAP Solution Builder or set up by SAP.

SAP has created a strong echo system using the latest Cloud Computing technology which can be leveraged by both existing and new customers. The SaaS solution offerings of SAP on different deployment models gives great flexibility to Customers to choose from. Improving Productivity, simplifying tasks, and cost-effectiveness by running many modules on a single computer are a few of the factors fueling the growth for SAP Cloud offering. As per VMR Market report SAP S4 HANA application market size was valued at USD 1.64 Billion in 2021 and is projected to reach USD 8.47 Billion by 2030, growing at a CAGR of 26.44% from 2023 to 2030.

Figure 8.



IV. Conclusion

The article clearly articulates the Cloud Computing concept by highlighting the architecture, different service offerings, and deployment models available to Business Community. The evolution of cloud computing at different stages of lifecycle and the players involved at each stage are stated. Different enterprise applications highlighting ERP were illustrated to understand the need and advancement of Cloud Computing in each of the offerings. SAP ERP and in particular SAP S4 Hana Cloud offering capabilities as SaaS were discussed with emphasis on the technical aspects of each deployment model. At a high level we can strongly say that the potential for this trending technology is immense, but the penetration may take some more time. Though Cloud Computing has been around for approximately two decades and despite the data pointing to the business efficiencies, cost-benefits, and competitive advantages it holds, a large portion of the business community continues to operate without it. A recent report published by Dell says companies that have invested in big data, cloud, mobility, and security enjoy up to 53% faster revenue growth than their competitors. As this data shows, an increasing number of tech-savvy businesses and industry leaders are recognizing the many benefits of the cloud-computing trend. With all major corporations like Amazon, Microsoft, IBM pushing the limits of innovation and investing huge amounts of money, should increase the momentum for adoption. Many ERP solutions like CRM- Salesforce, Oracle, SAP, NetSuite, Sage have great Cloud based offering which Customers across the globe are leveraging. Hence, we can say beyond doubt that Cloud Computing is here to stay and eventually all future Business Applications will enfold into this at some stage of their trajectory.

V. Declaration

Competing Interests.

There are no conflicts of interest that are relevant to this study for the authors of this manuscript.

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IBM Consultant Profession Certification - Experienced