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A comparative study of cloud platforms for scalable infrastructure in food distribution supply chains

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Abstract

Logistics and transportation problems are major contributors to greenhouse gas emissions and inefficiencies. The food industry, as the largest component of the Logistics and Transportation sector, relies on physical supply chain networks that contact local producers, execute cold chains, and arrange the timely and safe delivery of food products – usually using third-party distributors. The coronavirus disease 2019 pandemic highlighted the vulnerability of food supply chains, sometimes resulting in lost sales and wasted food, and created a social demand for innovative intermediaries and new sales channels. Popularly called AgTech – technologies for Agriculture – new business models and resources have emerged that seek to solve some of these problems, such as local sales networks directly connecting final customers to small to medium size producers.

Several of these AgTech resources are digital platforms hosted in the Cloud, that support current food distribution supply chain characteristics, and are easy to launch and profit from their owners. However, a deeper review demonstrates a research opportunity barrier that consists of a lack of frameworks to evaluate and compare different Cloud Platforms for this specific Class of Services. IT Infrastructure capabilities differ, considering current capabilities or drivers and specific Service-Level Requirements pre-defined by Platform owners or final Customers and would affect their performance in providing non-functional service quality required for this class of Services. This paper fills this gap, by proposing three main objectives. First, to identify and describe the current capabilities and challenges of Cloud provider solutions applied to the Food AgTech Industry, to identify and characterize the proposed driving Capability dimensions and the proposed requirements to the SLA for Food Industry Digital Platforms for Distribution, Customer Aggregation and Intermediation, and finally, to propose some Cloud Infrastructure Solutions that could deliver the technological characteristics focused on these attributes.

Keywords: Logistics, Transportation, Greenhouse Gas Emissions, Food Industry, Supply Chain Networks, Cold Chain, COVID-19 Impact, AgTech, Local Sales Networks, Cloud Platforms, Digital Distribution, Small Producers, IT Infrastructure, Service-Level Requirements, Platform Performance, Cloud Capabilities, Food Supply Resilience, Customer Aggregation, Intermediation Platforms, Technological Solutions.

1. Introduction

The food distribution supply chain (FDSC) is a complex multi-level infrastructure that connects food producers, distributors, intermediaries, and retailers with consumers. From growers' fields to consumers' tables, food distribution has to satisfy food safety, security, and bio-hygiene conditions to support healthy and wealthy living. The FDSC is a providential domain for the intervention of information technology like Cloud Computing which offers new opportunities, new business models, and a new perspective on the world. Cloud Computing is integrating everything into a scalable infrastructure that enables the real-time use of a range of resources and functionalities. The attributes of Cloud Computing solutions such as scalability, pliability, and ease of entry, exit, and use recommend their implementation in the FDSC to increase its flexibility and facilitate dimensions like seasonality fluctuations. While with a high volume order load the ramps of distribution centers, the local stocking keeps people busy, for low demand volumes and without consumers' punctuality, waiting for the delivery time is tedious, unpleasant, and risky. E-business systems can enhance FDSC connectivity on both sides of the order by reducing waiting times and allowing consumers to keep track of the shipment delivery.

The role of resource and service on-demand use dimension in ameliorating the FDSC responsiveness is important, but work has to be done regarding more concrete aspects of emerging infrastructure. Which cloud platform to choose? Which application to run? How to dimension the use of resources in order to reach the desired efficiency? How to evolve the architecture of the application and the utilization pattern of resources for new order, delivery, and product balance? Do these concrete questions have qualitative and quantitative answers? Do the Cloud Computing services and public platforms already encode this experience? The difficulty of the above questions is not only due to missing experience in cloud systems modeling, monitoring, or simulation, but also due to the volatility and variability of the Cloud Computing domain.

1.1. Purpose and Scope of the Study

This study provides a comparative analysis of cloud platforms in the context of fish distribution supply chains. Growing demand both for new distribution systems and for newer information technology are imposing significant pressures on existing food management and distribution infrastructures. Businesses that want to remain competitive are increasingly turning to distributed solutions to better manage their supply networks. Moreover, the requirement for traceability of food products coming from a large variety of suppliers is asking extra support from the choice of reusable, and scalable information systems.

Food distribution has always been a vital part of feeding any population, and has grown to be a sector in itself economically. Events in less developed regions, such as the waves of fish and meat distribution poisonings that have hit product industries in the past few years affect overall food commerce. Developing better systems and networks for overseeing the different steps in the food supply chain, from producer to distributor, to retailer and finally consumer, have proven beneficial in allowing for quick response to the information gathering and reassessment needs imposed when required.

Cloud computing has recently emerged to provide the tools and capabilities supporting infrastructure construction in an efficient, cost effective way. Easy access to an on demand scalable back end, ready to handle problems such as data collecting and central storage sifting described above, allows IT architects to focus on usability. New technologies for worker specific devices, such as smartphones and ultra portable tablets are perfect candidates to handle the monitoring and data collection needs and keep the whole process from becoming a burden for workers. Rather, the new tools could help boost the possible advantages from implementing a detailed fish monitoring system.

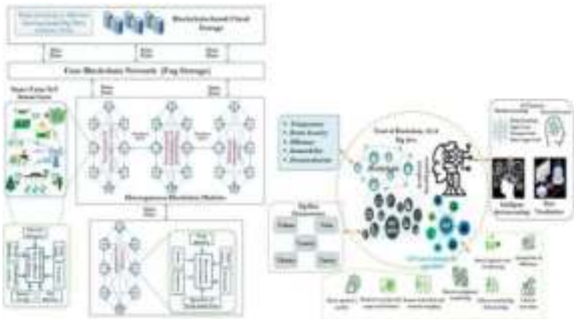

Fig 1 : Agriculture-Food Supply Chain Management Based on Blockchain and IoT

2. Background and Motivation

Supply chains are crucial in making sure both the center and the areas function efficiently. What is provided to the areas can have an effect on their growth. A cloud-based infrastructure that is both flexible and scalable can provide powerful computing for the data involved in logistics and enable low operating costs. The Internet of Things allows for real-time and on-demand data gathering with very durable and reliable low-cost sensors. The cloud platform enables on-demand access to those large amounts of data for the in-depth analyses that make scenarios possible. Combined with communication and networking technologies, real-time communication and networking can optimize low-cost data collection and actuation if needed.

Food distribution in particular is an area where one in three is not optimal. Over 30% of the consumed food is actually wasted. Demand is notoriously fluctuating and hard to forecast but the vendors have to provide more and more product variety to satisfy the customers. Food supply chains rely on materials with capacities and properties that need to be understood in order to optimize temperatures and time to make sure they are delivered on time and in the desired condition both from safety and product quality perspectives. On the vendor side, controlling the point-to-point model of distribution using a fleet of drivers working independently and on-demand using technology that has become available and affordable in only a few years is definitely creating an impact.

Optimizing transport methods is an area where cloud technology can help tremendously, for all sorts of transport: Air, land, sea, and rail. Using constant data feedback in real-time from location-based technology. Constantly surveying the short-term weather forecasts and optimizing routes during delays creates a smart network that can guarantee timings in supply chains.

$$\mathrm{SCS}_p = \frac{\sum_{t=1}^{T} U_{p,t}}{C_p \cdot T}$$

Equation 1 : Platform Scalability Score (SCS)

SCS_p: Scalability score of platform p

$U_{p,t}$: Utilization (CPU, storage, bandwidth) at time t

C_p: Baseline cost per unit resource

T: Time period considered

2.1. Rationale for Study and Its Importance

With the complexity and scale of food distribution chains growing rapidly with the general discussion and support of growth along the Internet of Things and Industry 4.0 paradigms, and the majority of foods perishable by nature, the need for investment into increased flexibility and optimization methods for the food distribution chain is greater than ever, with the support of scalable information infrastructure a necessity for successful market growth. This investigation examines six different cloud providers by implementing two benchmark applications and using the analysis of ease of development, deployment and scalability, as well as performance and cost, to evaluate their suitability for scalable infrastructure of the food distribution supply chain.

The results suggest that the decision of the infrastructure service provider intended for food distribution problems in need of scalable solutions should not be decided based solely on performance, but other aspects need to be taken into account as well. The combination of easy development with competitive pricing has a significant influence on the size of the market for general cloud services, and the specific collaboration between the market leader in terms of performance, and a specialized education focused regional company, should be a wake-up-call for both large providers as well as local players in the market for cloud services. As the difference in solutions targeting specialized markets compared to generic solutions either removing development effort through automated intelligent tools, or offering great prices, is still so considerable in terms of price and ease of use for the developer, there is great economic potential for the market players and their customers, willing to invest into optimized business intelligence decision support for both local and international markets.

3. Literature Review

Emerging technologies are key drivers of process and systems innovation in logistics and supply chains. Nevertheless, regardless of how disruptive technology impacts the logistics sector, poor adoption hinders the ability to push the boundaries regarding consolidation, integration, visibility and execution. It was found that there are unique process requirements in food distribution. The freshness and perishability of food, complemented by the large variety available have traditionally characterized the food sector, which consequently has largely deconsolidated distribution. In the last decade, there has been an informative move to consolidate flows in intense centralization through cross docking. The cloud concept offers the ability to centralize distribution in an innovative way using a system to integrate multiple suppliers and demand points. Such centralization allows for transport capacity sharing, load optimization and demand-supply integration which all reduce environmental impacts. Research to date has concentrated on selecting candidates for emerging technology in logistics and supply chain research. Furthermore, few studies exist on the cloud concept and none specifically for supply chain logistics.

This paper presents a case study in the food sector, characterizing traditional DC and cloud concentrates, and we present a qualitative model to assess cloud or traditional DC implementation. Interactive simulation results show that this innovative concept is attractive in a relatively limited niche of products with high margins, freshness and perishability discounts. However, requirements on the cloud operator are high as margins average 15% of revenue, given the risks and the infrastructural costs involved. Nonetheless, a one stop shop balance is available for a collaborative chain of food partners. Interestingly, this collaborative supply chain supports interest alignment throughout the chain, as the cloud transport operator aims to maximize revenue and income, with balanced risks and margins for all chain partners.

3.1. Cloud Computing Overview

Cloud computing is today's most dynamic service platform, offering a new service delivery and consumption model, rendering scalable solutions over the internet. This allows for reduced expense in adopting various IT services by end-users that are not their expertise, allowing providers to take care of the security, privacy and data reliability components. Further innovation in current strategy can promote business without any buffer, as there is no budget limit and investment needed in services required to provide for business. Resource pooling in large scales with "on-demand" service is another effect of cloud services, which benefits the specialized packaged AS-IS services to the end customers. But moving IT services out to third-party cloud providers is not trivial as several security, data isolation, regulatory and requirement concerns still exist. It has also been reported that a major concern for choosing a cloud provider is the cloud services cost.

Fig 2 : Cloud Computing in Logistics and Supply Chain

It is important to note that cloud computing affects collaboration across all players in the chain from suppliers and manufacturers to distributors and retailers to customers. The adoption trends and adoption rates of cloud computing services vary across industries, as do the drivers for adoption. Cloud services vary from platform to infrastructure services to distributed micro infrastructures to third-party services addressing specialized vertical business activities. Much hype surrounds cloud computing today, and the cloud service market is highly fragmented. While a plethora of smaller niche players and open-source options abound in various cloud categories, the key vendors offering cloud services include major companies. Cloud computing has to leverage the distributed processing and storage services spread across large systems connected over the internet. Virtualization is the core technology in cloud computing which allows pooling of services offered by using subsystems on-demand and associated management costs lower. Therefore, security and reliability are key aspects of the adoption decision about moving data and services away from in-house solutions.

3.2. Supply Chain Management in Food Distribution

A food distribution supply chain encompasses all phases required to converge input materials into finished goods for an end customer. Typically, it involves three key stages: the first stage collects raw materials from suppliers and the second phase concentrates on transforming the raw ingredients into finished food products at factories. The last phase serves to deliver the finished meal products to the end customer, which is typically a logistic service company. Food products are usually classified as either perishable or non-perishable. A perishable item has a short life span and at the end of it is usual for the food products to be unfit for human consumption. Non-perishable goods are less time-sensitive and do not spoil or decay as rapidly. Due to the high perishability of the products, the food distribution supply chain is distinguished from other manufacturing SCs in terms of strict lead time, transportation conditions, and production scheduling. Additionally, in contrast with other sectors, the food supply chain is subject to strict traceability requirements and is highly volatile and prone to distortion.

The objective of supply chain management is to balance the supply network's conflicting objectives and optimize the global supply chain's operations. The food supply chain has some unique characteristics, including the uncertainty of demand and supply, such as freshness and price level changes; the wholesaler's supply decision; uncertainty of demand; characteristic of competitive structure; and uncertainty of lead time and price, as well as consumer preferences. Any disruption or disturbance in the food supply chain will generate negative impacts on the customer, supermarket, or manufacturer by increasing costs, affecting time commitments, or damaging the company's image, thus putting the brand at risk. Accordingly, it is important to streamline the different steps within the food distribution supply chain so that it can function correctly within the shortest time.

3.3. Previous Studies on Cloud Platforms

The cloud has evolved into a more friendly platform for users. However, not all users are satisfied with owned cloud platforms due to costs, security, performance, and control of information. This led some organizations to offer cloud-like services that are publicly accessible to any user. In this case, the user has to know the capabilities and limitations of each of the infrastructures. These platforms come in several flavors, and we can also say that there is a flavor for each user. A cloud platform is evaluated on the basis of nine specific attributes corresponding roughly to the functionalities and services of an infrastructure. These attributes are: storage, processing power, service models, types of deployment and administration, associated costs, implementation, scalability, elasticity, and available services.

There have been some studies that addressed the problem of evaluating different infrastructures. One study addressed commercial cloud computing services, dividing these services into five clusters (computing, web hosting, page and web mail, storage, and backup), and then provided a deep analysis of their resources and costs. Another study compared existing public infrastructures to provide a basis for researchers selecting an infrastructure for their data-intensive applications. It provided a rigorous performance comparison among various cloud platforms using three super-computing application classes from the areas of astronomy, healthcare, and physics.

4. Research Methodology

This section describes the research methodology, why a comparative analysis is the most suitable approach, and why those particular case studies combined with qualitative content analysis are appropriate techniques for this kind of research. Subsequently, the evaluation metrics, which are derived from the seven design principles for a scalable infrastructure in food distribution SC, are explained and justified. As a part of design science research, an explorative and qualitative exploratory study seems an appropriate approach because it aims to understand and explain the context of a design artifact. In detail, the study aims at gathering information that helps to develop a deeper understanding of infrastructure scalability in food distribution SC in order to propose theoretical design principles for a scalable infrastructure in a subsequent step. The technical development of design principles for scalable infrastructure design that are based on a qualitative explorative study are explored.

Choosing a qualitative exploratory study is also based on the assumption that the requirements of a scalable infrastructure for food distribution SC may differ from differences in the level of maturity and the company size within the food supply chain. Hence, new ideas and information are needed that explain how these dimensions may influence the scalability requirements of a design artifact. However, the initial theoretical basis of the qualitative exploratory study is derived from the existing literature. For the qualitative content analysis, we chose only established cloud providers. The selection is based on a detailed literature review regarding cloud market study reports from enterprises. Empirical reports show that the market share of the established and leading public cloud providers is constantly increasing. New entrants have only marginal market share participation.

4.1. Comparative Analysis Framework

Growing consumer concern with the world economy and its impact on social equality and the environment requires that Subsistence Economic Activity (SEA) strive for new economic models for food distribution. With growing demand for local sustainable products, the transformation of food systems toward this direction not only lowers consumers' risk of contracting protein-related diseases, but also promotes the practice of local economies. To support these new demands, we propose a comparative study of scalable cloud infrastructures suitable to serve Food Distribution Supply Chains (FDSC). Cloud computing as a new and growing approach to delivery information technology services is the supply and management of a scalable grid of distributed resources that are available to users on demand. We evaluate and compare five of the most well-known clouds according to specific criteria applicable to FDSC environments.

Our proposal aims to deliver analysis support in the decision process of entrepreneurs who are developing online consumption platforms for local commerce. They are small-sized companies targeted to serve local consumer needs with food verification systems that ensure fair practice for producers and their workers. Our framework has the following characteristics. One, we assume that the system is not yet developed – i.e. the entrepreneur has no data yet to resort on. The domain of analysis belongs exclusively to the initial concept of the online activity. Two, we use a minimal resource availability and pre-determined evaluation – i.e. seed capital is limited and the entrepreneur has only one in charge to fund. Three, we take into consideration cloud computing as the provisioning technology. Four, we analyze five small-scale and one mid-scale cloud computational providers. Cloud services are scalable, on-demand, and paid as used. All support the use of open-source programming tools.

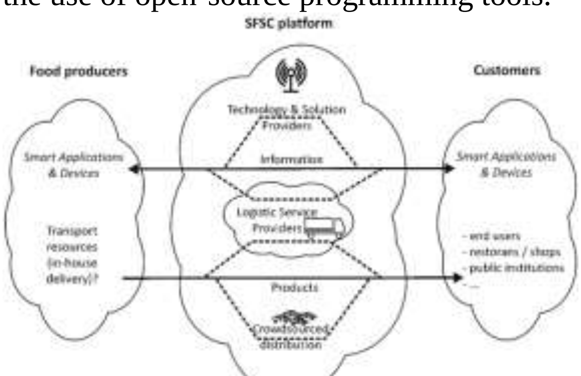

Fig 3 : Sustainable Distribution in the Short Food Supply Chains

4.2. Data Collection Techniques

Most of the data used in this research were collected from public cloud providers and Internet sources. First, services offered by major providers were collected and categorized. In addition, documents and reports related to these providers were consulted and examined in detail to collect data, such as services catalog segmentation, market share, and information related to Box 2. The same document was also taken into account to analyze distributed provider services to analyze their services' niche characteristics. The use of this methodology was due to the scarcity of documents that could directly relate the various cloud providers presented, considering the five areas established. Cloud service market analysis reports were needed to consider additional cloud providers, as a way of validating information symmetry.

In addition, documents containing information regarding the data storage methods of cloud providers were required. The reports and white papers published by these organizations contained classifications of the various data storage methods, their attributes, strengths, limitations, and examples of their use. In addition, research papers on cloud storage offered by providers were consulted to find information that could point to a comparison of the characteristics of cloud data storage. The experimental work of the papers, which verified and presented results of the actual cloud data storages designed considering consumer latency, were also taken into account.

4.3. Evaluation Metrics

Evaluation metrics for a comparative study can be mainly classified into two groups: primary and secondary metrics. The primary metrics are Quantitative metrics oriented toward providing measurable feedback about the Cloud providers, which is most useful for making evaluative comparisons and categorization decisions. The secondary metrics, which contain Quality metrics, focus on the quality aspect of the Cloud services and as such provide guiding relevance but can typically only be used to make which customers are served by the Cloud providers, but do not necessarily guide customers about which Cloud provider they choose.

To apply for comparing a set of Cloud providers with a set of relative attributes, all primary and secondary metrics need to be computed and expressed in relation to each Cloud provider in the set. The behavior of each Cloud provider is either good or bad in relation to the attributes. A Cloud provider that is good in relation to many attributes and bad in relation to as few attributes as possible is chosen. The Cloud provider with the maximum value for the net score function is selected. A small but sufficient credible set is chosen. The set of critical and credible data are then identified and input from qualitative and quantitative studies is gathered to shed light upon those data. Finally, cloud users have to compute the results on how the different Cloud providers were evaluated by different explanations and users. The goal is then to synthesize and produce an evaluation score for each Cloud provider for display, particularly to describe the differences in evaluation but also the overall evaluation.

Equation 2 : Latency Efficiency Ratio (LER)

$$\mathrm{LER}_p = \frac{1}{\bar{L}_p} \cdot \frac{D_p}{N}$$

LER_p: Latency efficiency of platform p

$\bar{L}_p$: Average network latency

D_p: Daily deliveries managed

N: Total distribution nodes

5. Overview of Selected Cloud Platforms

The Cloud Service Providers (CSPs) selected for the comparative analysis in this chapter are AWS, MS Azure, GCP, IBM Cloud, and Oracle Cloud. The primary reason for these selections is that they are leading cloud service providers in overall market shares and conditions, and blockchain-related solutions provided by these CSPs can be helpful in the further study of use case development.

AWS offers a comprehensive and broadly adopted cloud platform with over 200 fully featured services from data centers globally. Millions of customers include the fastest-growing startups, largest enterprises, and leading government agencies to lower costs, become more agile, and innovate faster. The AWS cloud platform enables customers of all sizes and industries to deliver secure, reliable, scalable, and economical solutions, and it accelerates IoT application development by eliminating infrastructure management burdens.

Microsoft Azure is a rapidly expanding set of cloud services to help your organization meet your business challenges. It is the only cloud designed for and trusted by enterprises to manage all your IT needs. Partner with a leader in cloud research and development that invests more than $1 billion per year in security. Build apps and services from the cloud you trust with the most certifications. As industries evolve, Microsoft Azure evolves with it to provide the best cloud platform for any industry. From compliance to integration, it has what it takes to help you navigate your industry challenges. Whether you are moving to the cloud or need a hybrid solution to connect your on-premises data with cloud services, our commitment to enterprise-scale innovation has you covered. We are ready to help you innovate faster, respond quicker, and save money.

5.1. Amazon Web Services (AWS)

Amazon Web Services (AWS) is a pioneer cloud provider. AWS's Elastic Compute Cloud (EC2) service, launched in 2006, was the first service to provide on-demand processing power at scale. With AWS, service consumers can rely on thousands of virtual servers hosted in highly available data centers all over the world. These virtual servers can be provisioned and de-provisioned in minutes or seconds at a fraction of the cost of their physical counterparts. AWS is particularly prevalent in the startup scene, and also has an extensive array of available services. AWS's cloud computing solutions include Elastic Cloud Compute (EC2), the Simple Storage Service (S3), Simple Queue Service (SQS), Simple Notification Service (SNS), Relational Database Service, DynamoDB, Elastic MapReduce (EMR), Lambda, Kinesis, CloudFront, Simple WorkFlow, CloudFormation, CloudTrail, AWS Directory Service, CloudWatch, and Identity and Access Management (IAM).

In addition to being the most mature cloud computing vendor, AWS is the largest, and in some areas of functionality, leading the market. Other vendors point to a lack of capabilities in their own clouds, but AWS has an extensive ecosystem of ISV applications built upon it, and is continuing to attract new customers in larger and larger market segments. Customers in the Global Fortune 1000 doing business in every industry sector have adopted AWS: government; utilities; financial services; consumer products; telecom; education; healthcare; transportation; manufacturing; media and entertainment; retail; technology; service providers; and travel.

5.2. Microsoft Azure

Microsoft Azure utilizes two factors for pricing: deployment and resource consumption. On-demand pricing is available for most deployment types and resources, while discounts vary by resource and type. Microsoft Azure charges customers based on virtual machine-size, bandwidth, storage facilities used, and the operating system and software utilized in the machines, while disk operations per second and virtual IP addresses are additional costs. Various Azure resources support different deployment options. The most basic is pay-as-you-go, in which no reservations or prepayment are required and bills are issued monthly. Azure also allows users to purchase preemptible virtual machines at reduced prices. Users can also reserve infrastructure ahead of time at reduced costs with Azure's instances. Azure also combines pay-as-you-go with a credit system. As some examples of the costs of using Microsoft Azure, 1-dist Ubuntu LTS 16.04 with 1 processor at 2.97 GHz would cost USD 144.75/month if deployed as a pay-as-you-go or reserved instance with fixed monthly costs. Payment would be USD 241.72 if a spot virtual machine. A Virtual Hardened Linux – 4-core, 2.62 GHz with additional high throughput I/O would cost USD 119.56/month if deployed as pay-as-you-go instance, and USD 331.75/month with variable monthly costs.

Azure is somewhat more limited in options than AWS. Infrastructure for giant data processing programs is built with specialized machine-architecture. The most basic are NT-series machines, which are likely intended to compete with the virtual machine offerings of AWS. Such NT-series machines are "ideal for a large number of workloads," including small and medium datasets, which are mostly written or read and do not require a quick response. Azure also issues G5-instance specialized machines, which consist of hosts integrated with an onboard server with GPUs, which would work fast for training tasks and rapid predictions. There are special servers with direct connections when machine-development programs need to be parallelized.

5.3. Google Cloud Platform (GCP)

In 2008, Google leveraged its expertise in developing internal infrastructure for large-scale services to deliver GCP, which offers a narrow and deep portfolio of cloud services focused primarily on high-performance computing, big data analytics, machine learning and other advanced workloads. GCP markets itself as having high-performance storage and networking, and provides competitive pricing and flexible contracts to help enterprises deploy applications only. GCP's big data tools are now key sales drivers in growing its customer base. GCP is also investing heavily in the infrastructure necessary to compete with public cloud providers for the machine learning and AI workloads. Offering specialized processors for accelerating AI workloads, GCP is attracting more developers into its ecosystem to utilize new technologies with the benefit of zero-ops training of AI models alongside technical differentiation for high-performance production – although there are risks around lock-in due to them being proprietary.

GCP is also increasingly looking to monetize AI tools as a service, although detractors note that these vendor-neutral options are unlikely to be a credible threat to multi-cloud models built on partnerships around serverless or open standards technologies. GCP’s infrastructure and facilities and network investments are highly specialized. Backed by its superior security monitoring and operations expertise, GCP is targeting enterprise workloads with an emphasis on pure and hybrid AI and ML applications, as well as Data Warehouse as a Service capabilities. Overall, GCP has positioned itself to compete on capabilities and partnerships across high-value areas such as AI and ML, IoT and Data Analytics.

Fig 4 : Google Cloud Platform (GCP)

5.4. IBM Cloud

IBM Cloud is an advanced cloud platform that combines hardware, software, services, and expertise to solve even the most complex data challenges. Its managed services and integrations with containers and Kubernetes allow businesses to optimize spend using multiple clouds and avoid vendor lock-in. IBM Cloud enables the development and deployment of cloud-native applications on industry-leading infrastructure and cloud services. It allows the creation of highly scalable apps and services in the world's most secure public cloud, with no capital outlays. IBM Cloud Technology Services also provides enterprise-grade security infrastructure, business continuity, and reliable service for applications.

IBM Cloud provides substantial support for data handling from various locations and unifies tools and services for data science, data management, data governance, business analytics, and data catalogs. Powerfully backed by IBM Watson tools and services, businesses can harness and build intelligent solutions. Featured services include virtual servers for classic infrastructure and scalable virtual servers that support lightweight workloads, generated from various business dimensions. The platform operates for economical hosting and maintenance of the platform and for hosting of fast-digitized website services, primarily conducting cloud infrastructure planning and configuration on relevant businesses. Malaysia and Singapore are the primary connection hubs, and per requirements services are hosted in various international data center facilities.

5.5. Oracle Cloud

Provider Overview

Oracle provides a wide range of cloud computing services but is most known for its integration of IaaS and PaaS services with Oracle Software as a Service (SaaS)—the latter being both the most mature service offering and the bulk of Oracle's revenue. Most large food processors, distributors, and retailers already pay Oracle for subscriptions to their ERP products. As a result, companies looking to modernize their supply chain tech stack may have a head start: the resources to perform any heavy lifting involved in integrating tech stacks are already aligned toward Oracle products. Despite that advantage, Oracle has a much smaller market share than AWS or Azure—indeed, the fact that nearly all enterprises already use some Oracle solutions is one of the main distinctions that make it a niche player in the cloud provider sector.

Oracle Cloud is enterprise-oriented, offering dedicated hardware and infrastructure on-demand. For companies whose security or regulatory requirements dictate that sensitive data must not be mixed into the same virtualization resources as any other client's data, Oracle bare metal solutions are the only way to provision fast, secure cloud infrastructure economically. Every cloud provider offers physical servers with virtualization/partition management software to improve resource allocation, but Oracle Cloud is the only major vendor focused on providing dedicated servers available for instantaneous provisioning. The wide range of supported use cases makes Oracle bare metal solutions a single point of failure; and offering no higher fidelity or more complex infrastructure would do away with centralized resource management inefficiencies, driving deployment speed and lowering costs. However, Oracle's model may make sense for certain organizations looking to hedge their commitment to highly multifaceted cloud infrastructure merges, or simply require greater flexibility writing more bespoke policies.

6. Scalability Features of Cloud Platforms

Cloud computing has brought a new era of flexibility, scalability and pay-per-use models to distributed computing. Scalability and elasticity are essential requirements for any cloud service, as they allow users to allocate resources on demand. Web hosting cloud services that are available in the market provide for optimal allocation of resources and scalability for service-intensive computing. But there is still a need for additional features in load balancing, configuration and management in these services. The load balancing necessary involves not only the uniform distribution of load among available nodes, but also the dynamic allocation of services among available nodes, during the life of the services. Existing load balancing mechanisms do not sufficiently consider the various constraints such as quota on physical machines or resources during the load balancing.

When workloads which require intensive computation are submitted to the cloud, performance degradation can occur if cloud service users do not use the resources that are suitable for their workloads. Resource allocation to accommodate both the highly dynamic nature of user workloads and the diverse performance requirements is a major emerging research challenge. The performance of various workloads significantly varies with the choice of clouds, and cloud service providers still have limited or no tools to monitor resource performance dynamics. Although cloud providers specify the performance of the given virtual machine instances, users may still require advanced tools to monitor the dynamic resource performance of virtual resources, in order to obtain better allocation and make the cloud services elastic. We explore some of the above topics in a general manner. These capabilities can have a significant impact on making the cloud platform more attractive to other classes of workloads.

6.1. Elasticity and Load Balancing

Scalability is considered one of the most important features of cloud platforms. As demand for food services fluctuates, it is important that the platforms can scale dynamically, increasing their capacity when needed and reducing it to save costs when not needed. This flexibility requires intelligent load balancing at different hierarchical levels of the cloud ecosystem: across users, between Virtual Machines running on the cloud's physical devices, and among the services provided by each VM. Without an effective load balancing strategy, the system may become overloaded and unresponsive, or waste resources and money.

Load balancing has other consequences for the real-time operation of applications in the cloud. While the responsiveness, availability, and throughput of any given cloud application relies on the correct allocation of resources by the service provider, the latency and response time of specific requests are also affected by the load balancing strategy used. The way these latency metrics evolve during the duration of a service, especially when bursts of high activity take place, is called service performance then relates to elastic cloud service properties, and in general depends on the router employed by the input queueing switching architecture of each VM.

6.2. Resource Allocation Strategies

Resource allocation is one of the major issues when using cloud resources. In general, resource allocation is able to use a guideline of QoS metric in order to make the meaning of needs and fulfill requirements of clients. QoS metric is significant to cloud application, because cloud may put many kinds of services, then they are competing for resources and they have various characteristics in time and space. Moreover, the allocation approach could consider some QoS metrics, for example monetary cost, performance, utility and so forth. Or, the allocation method could consider the characteristics of the OS such as time delay. Therefore many mechanisms are implemented to identify the desired resources that are able to enhance performance for cloud users. For overhead, the relying OS resizes the resources based on utilization of cloud OS.

Cloud service providers have many resources, and end users have a high demand for diverse applications and services requiring various QoS necessities. Thus, multiple data centers with different identities like services, costs, and numbers of data centers are available to users at the same time. Global cloud resource allocation is the process of providing strategies for satisfying QoS necessities of multiple users in multiple cloud computing data centers. An important part of GCRA strategies is which datacenter is suitable for the query. Cloud service providers including public/private clouds attract users by providing services like offering resources at different prices. This multi-PCC offers the users a large variety of applications and services at abstracted multi-layer levels. Some users upload their jobs to the cloud, while others put them in a private cluster on behalf of high-sensitivity applications. Resource allocation tends to refer to tasks such as resource prediction, request forecasting, workload allocation, resource procurement, service credit lease, and pricing function design.

6.3. Performance Monitoring Tools

The choice of tools to monitor the performance of distributed systems and/or applications deployed in the cloud could also impact on the actual economics of running cloud-enabled supply chain systems. In particular, cloud infrastructure services provide resource on-demanding and scalability functionalities, which are two factors that increase the number of unique and burst requests that can be serviced within a defined time window for some specific supply chain activities, e.g., order management, transport and logistics, etc. Performance monitoring tools need to use these functionalities in the right way so that the benefits associated with the two factors, which are two factors particularly relevant for applications sustaining short periods of high workload in large (and increasing) volumes of transactions, could be effectively exploited. Some tools make it possible to view the monitoring data in real-time, allowing immediate detection of issues that could affect application/service performance or availability, and provide simple user interfaces as well as set and forget policies designed to minimize configuration and management overhead. Support for automatic root-cause diagnosis may be implemented through the integration of anomaly-detection algorithms with alerting tools; options for automatic recovery from the detected anomalies could also be provided by some monitoring solutions. In addition, these tools allow alarm thresholds to be set and triggered according to the automatic scaling of resources offered by the cloud provider. On the other hand, other tools provide a more flexible and exhaustive analysis of the performance of hosted applications, which however requires more profound knowledge of the monitored applications/services infrastructure structure and resource consumption characteristics.

7. Cost Analysis

Because of the growing popularity of cloud computing services, companies that wish to use cloud computing for its applications should perform a detailed cost analysis of cloud services before moving their applications to the cloud. In this section we focus on cost analysis from an enterprise level. We identify cloud provider pricing structures and build models to analyze the cost based on customer patterns of utilization of the provider resources. Then we develop tools to compute the TCO for application migration. Finally, we use the TCO tool to analyze the cost of executing Internet supply chain applications to provide a cost-benefit evaluation of using the cloud.

Fig 5 : Cloud Cost Analysis

Cost analysis of cloud computing services is challenging to perform at the enterprise level since cloud providers incur many different types of costs and most of these costs are usage-driven and complex, leading to significant computation effort to arrive at costs incurred for the enterprise application. Some of the cloud providers operate on a simple hourly pay-as-you-go model on resource usage. Other providers charge a membership fee and may have tiered pricing for resource usage. In addition to tier-based service offerings, other providers also offer specialized instance configurations for enterprises with predictable workloads. Cloud computing can be cost-prohibitive for these applications. In fact, for several application domains, dedicated on-premise servers or even co-location mechanisms are more economical than cloud computing since cloud computing incurs substantial latency through the Internet and the parallelization and load balancing overheads can increase total execution time for applications.

7.1. Pricing Models of Cloud Providers

Cloud computing has changed data applications from departmental costs to financial statement items. This has created a revolution of startup businesses, freeing them from the burden of high capital investments in acquiring computing resources and allowing them to invest, instead, in the development of innovative business ideas. Besides innovative and useful services offered to consumers, this revolution has also shifted the burden of managing huge infrastructures from the amount of companies to the technology giants, allowing those companies to specialize in the area of data-centric services on which the future business economy is projected. In this scenario, hyperscale cloud services were born. They allow Economies of Scale to be achieved through many factors such as the provisions of low-cost servers, with minimal provisioning time and error rates, and very high-utilization rates.

Today, the leading on-demand IaaS providers provide the necessary tools for any kind of application. They have different approaches to doing business with differentiated price models and with related service level agreements. Pricing is one of the key activities to be considered in decisions related to any service portfolio. Cloud computing pricing policies are not limited to resource pricing alone. The companies involved in offering cloud services propose very different strategies in terms of type and number of offered services, for instance, tiered pricing, chargeable services included in the offer, and discount conditions.

Equation 3 : Adaptive Load Management Index (ALMI)

$$\mathrm{ALMI}_p = \frac{\delta R_p}{\delta D_p} \cdot A_p$$

$\delta R_p / \delta D_p$: Resource scaling rate per delivery increase

A_p: Automation level of load balancing on platform p

7.2. Total Cost of Ownership (TCO)

In the following, we look at various factors that influence the overall cost of using the platforms. Different cloud service providers offer comparable services at different costs. However, solely focusing on these direct costs may lead to a misleading conclusion regarding the best service provider. So-called Total Cost of Ownership models analyze direct operation costs including licensing, provisioning, security, and maintenance but also indirect costs in order to provide a comprehensive overall cost for using a particular system. These indirect costs may arise from the fact that there may be employee training costs, costs incurred in failure or downtime, and costs because of performance deficiencies.

We particularly analyze the effect of two expense categories on the overall cost: downtime costs and infrastructure management costs. First, we analyze costs that arise from idling inventory, especially perishable food. This cost may be especially sensitive in the food distribution supply chain. Assets may remain idle for a certain period of time after a disruption or cyberattack has affected the network. For larger-scale disruptions, the downtime might last several weeks or even longer due to issues like the recovery of consumers not returning to the public after the attack. Disruptions could have an impact on the company for days or weeks. Cyber threats could also involve an attack to the physical infrastructure leading to the company needing many days or weeks to restore operations.

Second, we analyze costs incurred from infrastructure management. Infrastructure resilience could add costs to ensuring continued function of an operational network. Software and labor costs might need to substantially increase when downtime becomes prohibitively expensive. Companies might choose to hire rather than outsource because of latency risks if downtime becomes very costly.

7.3. Cost-Benefit Analysis

Thomas and Barlow defined cost-benefit analysis in a widely applicable way: a decision-making method that compares the total costs of a decision against the total expected benefits in order to ascertain the decision's feasibility. In other words, you'll want to perform CBA to aid in the decision-making process for moving onto a cloud-based platform. If CBA shows the move could net measurable benefits at significantly low costs – or at least, provide it over a reasonable period of time – the next step will be to put together a business case document to present to company leadership. For sophisticated cloud designs, labor can account for 70% or more of the total cost of ownership. Automating the deployment of a cloud-enabled software environment is often key to rapidly enabling time-to-market and guarantees the solution will be deployed and configured in the same manner, every time a new environment is deployed. In fact, deploying an application or system in one of the environments takes less than an hour to complete. Once the deployment parameters are confirmed, you can sit back and let the environment complete the automated workflow. In this case, the total cost of ownership is minimized because of rapid, repetitive deployment cycles. Automating the infrastructure provisioning tasks using tools reduces the costs of labor and ensures the deployment is repeatable, predictable, and error-free every time. Another cost factor to keep an eye on is the development of the software; cloud-enabled solutions can take less time, allowing the development costs to be smaller. In other words, if your developers can be productive, you can minimize the time to release the application to customers. And if you can get it to market faster than your competitors, you've put yourself in a good position to respond to customer needs.

8. Conclusion

Recent demands from consumers for better visibility in food supply chains challenged players within the perishable area to seek better control of their distributional flow. Informatics infrastructures are an essential worry for the implementation of a higher service level perceived by customers. By modeling food supply chains and verifying transport decisions influence on their competence and success, we verified that IT capabilities are directly responsible for IT/information sharing and better support food logistics. On the other side, collaborative logistics, built with the utilization of cloud-based tools, are essential to determine better flows of products between members of the fruit and vegetable supply chain. Different cloud-based tools available in the market could permit high efficiencies to information sharing and the utilization of logistics links by members of the supply chain. However, support offered by the providers for the implementation of better tools embedded with cloud-based solutions is different among important providers. The PaaS model is the better solution to be employed in sharing IT capabilities between players within the supply chain. There is an essential relationship between the food supply chain and cloud service providers, and the relationship must work with the same focus in delivering and exploring the information that goes and comes within the supply chain that has the fruit and vegetable logistics as a core game. Cloud computing can be considered a more scalable solution for food supply chains than the on-premise-based model. The important economic issues related to tool development and utilization must be better discussed by food supply chain players and cloud computing service providers. With the exponential growth of the utilization of mobile devices and sensor data generating several gigabytes of information a day, discussing new approaches and considerations for developing reliable and lower-cost applications supporting the implementation of high-efficiency logistics is a major requirement.

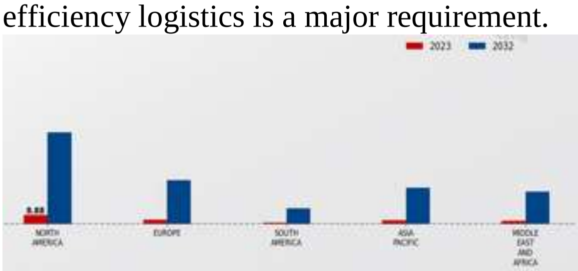

Fig 6 : Cloud Supply Chain Management Market Size

8.1. Final Thoughts and Future Directions

With the advancement of technology, big data usage is also rising tremendously. The businesses in every sector are accumulating immense amounts of data on cloud platforms but many firms are still unaware of the capabilities of advanced technology, such as cloud computing and big data. In the digital era, firms must realize that digital transformation is no longer a choice but a necessity. Cloud platforms can facilitate food distribution sectors with several benefits. Cloud platforms provide a distribution infrastructure that can easily expand and flexibly allocate the required distribution capacities and resources to meet the demand fluctuations of end customers. The process of the food industry is rapidly computerized, but the infrastructure supporting the food supply chain cannot follow up as fast as demand. With the help of cloud platforms, as an innovative distribution infrastructure, efforts of transportation, storage, and processing to fulfill customer demand timely can be enhanced.

Although cloud platforms are still evolving, an increasing number of solutions are migrating to cloud platforms as the way to facilitate business activities. The original advantages of cloud platforms are mainly in cost and time reduction. However, as technology improves, more value-added benefits such as improved flexibility, greater scalability, enhanced quality, and shared resources, are turned into reality. Each type of solution operating in a cloud environment can be compared to other alternative kinds of infrastructure solutions. Firms have to assess a proportion of what services to deal with cloud platforms and what services to internalize, and choose the best offering of cloud platform for the outsourced activities. More studies addressing real cases and concrete numbers over different firms from several industries will be needed to give better answers to firm managers with cloud platform choice and planning problems.

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