CLOUD COMPUTING IN SPORTS INDUSTRY

SEMINAR REPORT

Submitted in partial fulfillment of the requirements

for the award of the degree of

BACHELOR OF COMPUTER APPLICATIONS

2021 – 24

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CERTIFICATE

*This is to certify that the seminar work titled "**Cloud Computing in Sports Industry "submitted** to Mahatma Gandhi University in partial fulfillment of the requirements for the award of the Degree of Bachelor Of Computer Applications is a record of the original work done by **Nandakumar S** under my supervision and guidance.*

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ACKNOWLEDGEMENT

I consider it a privilege to express my sincere gratitude and respect to all those who guided and inspired me in the successful completion of this seminar.

I convey my reverential salutation to **Almighty God**, for enabling me to take up and complete the seminar successfully.

I would like to express my sincere thanks to **Rev. Dr. Mathew Vattathara CMI**, Director and **Prof. Dr Laly Mathew,** Principal, Rajagiri College of Management and Applied Sciences for providing the necessary infrastructure and support for the completion of this seminar.

I would like to express my sincere thanks to **Mr. Sijo Jacob**, HOD, Department of Computer Science, Rajagiri College of Management and Applied Sciences for his valuable advice and support which have helped me greatly in the accomplishment of the seminar.

I would like to express my sincere thanks to the seminar coordinator and guide **Mr**. **Joby Jacob**, Assistant Professor, Department of Computer Science, Rajagiri College of Management and Applied Sciences for his consistent guidance and inspiration throughout the period for the completion of my seminar.

I would like to thank all the teaching and non-teaching staff of Rajagiri College of Management and Applied Sciences for their valuable guidance and suggestions rendered during the seminar.

Finally, I thank my parents and all my friends for their help, encouragement and moral support given to me during this course.

Nandakumar.S

SYNOPSIS

Cloud computing has revolutionized the sports industry by providing a platform for enhanced performance, analytics, and fan engagement. In the sports sector, cloud computing offers scalable, on-demand access to a wide range of resources, enabling teams, leagues, and organizations to streamline their operations and improve their competitive edge.

One key area where cloud computing has made a significant impact is in performance analysis. Teams can now utilize cloud-based platforms to collect, store, and analyse vast amounts of data related to player performance, game statistics, and opponent strategies. This data-driven approach allows coaches and analysts to gain valuable insights into player strengths and weaknesses, optimize training regimens, and develop effective game strategies.

Moreover, cloud computing has transformed the fan experience, enabling sports organizations to deliver personalized content and interactive experiences to their supporters. Through cloud-based platforms, fans can access real-time updates, live streams, and immersive multimedia content from anywhere in the world, enhancing their engagement with their favourite teams and athletes.

Additionally, cloud computing has streamlined back-end operations for sports organizations, enabling them to manage ticketing, merchandise sales, and marketing campaigns more efficiently. Cloud-based solutions offer scalability and flexibility, allowing sports entities to adapt to fluctuating demand and scale their resources as needed.

Overall, cloud computing has become an indispensable tool for the sports industry, driving innovation, improving performance, and enhancing fan engagement. As technology continues to advance, we can expect cloud-based solutions to play an increasingly central role in shaping the future of sports.

TABLE OF CONTENTS

OBJECTIVE

INTRODUCTION

HISTORY

WORKING

TECHNICAL SPECIFICATIONS

ADVANTAGES

DISADVANTAGES

APPLICATIONS

CONCLUSION

FUTURE ENHANCEMENT

REFRENCES

1.OBJECTIVE

This article aims to elucidate the transformative impact of cloud computing on the sports industry, providing a comprehensive overview of its applications, benefits, and challenges within a succinct framework. By delving into the multifaceted ways in which cloud technology is reshaping sports management, fan engagement, and revenue streams, this piece seeks to offer readers a nuanced understanding of the role played by cloud computing in driving innovation and efficiency across the sports ecosystem.

Through real-world examples and insights drawn from industry trends, the objective is to highlight the opportunities presented by cloud computing while also addressing the associated challenges. By examining the ways in which cloud technology facilitates tasks such as data storage, analytics, and operations management, this article aims to underscore its potential to streamline processes, enhance decision-making, and optimize resource allocation within sports organizations.

Furthermore, by exploring how cloud computing enables seamless fan engagement through personalized content delivery, social media integration, and online event hosting, this piece seeks to demonstrate its role in fostering deeper connections between sports entities and their global fan base. Additionally, the objective is to shed light on how cloud-based solutions can drive revenue growth through targeted marketing campaigns, sponsorship opportunities, and e-commerce initiatives.

However, the article also aims to address the challenges and considerations associated with cloud adoption in the sports industry, including data security concerns, implementation complexities, and reliance on internet connectivity. By providing a balanced perspective on both the benefits and limitations of cloud computing, the objective is to empower sports organizations to make informed decisions regarding their digital infrastructure and strategic initiatives.

In summary, this article endeavors to serve as a concise yet comprehensive resource for readers seeking to understand the pivotal role of cloud computing in shaping the future of the sports industry, while also navigating the opportunities and challenges inherent in its adoption.

2.INTRODUCTION

In the dynamic landscape of modern sports, where every fraction of a second and every data point can make a difference, the integration of cutting-edge technology has become paramount. Among the myriad technological advancements shaping the industry, cloud computing stands out as a game-changer, revolutionizing how sports are managed, experienced, and monetized. Over the past two decades, the rise of cloud computing has transcended boundaries, permeating virtually every aspect of our lives, from entertainment to business operations. In the realm of sports, its influence has been nothing short of transformative.

The sports industry has undergone a profound evolution, propelled by the flexibility, scalability, and cost-effectiveness that cloud computing offers. This evolution extends from the backend operations of sports organizations to the front-end experiences of fans worldwide. With cloud computing, tasks that were once cumbersome and resource-intensive, such as data storage, analytics, and operations management, have been streamlined to unprecedented levels of efficiency and accessibility.

At the heart of this transformation lies the unparalleled connectivity and accessibility that cloud computing affords. No longer bound by physical constraints, stakeholders across the sports ecosystem – from athletes and coaches to fans and marketers – can seamlessly access, analyze, and leverage data from anywhere in the world, at any time. Whether it's tracking athlete performance through wearable devices, engaging fans through personalized content and social media integration, or hosting online sports events with global reach, cloud computing has become the bedrock of innovation in the sports industry.

Moreover, the benefits of cloud computing extend beyond operational efficiency to encompass strategic decision-making and revenue generation. By harnessing the power of data-driven insights stored in the cloud, sports organizations can make informed decisions, optimize marketing strategies, and cultivate deeper connections with their fan base. This not only enhances the overall fan experience

but also drives revenue growth through targeted marketing campaigns, sponsorship opportunities, and online merchandise sales.

In this era of digital transformation, the convergence of cloud computing and sports represents a paradigm shift, ushering in a new era of possibilities and opportunities. As we delve deeper into the applications, benefits, and challenges of cloud computing in the sports industry, it becomes evident that the future of sports is intricately intertwined with the boundless potential of the cloud.

3.HISTORY

1. **1960s-1970s**:
    - Early concepts of time-sharing and utility computing laid the groundwork for cloud computing.
    - Development of interconnected computer networks.

2. **1990s**:
    - Emergence of the internet enables the sharing of computing resources.
    - Initial experimentation with remote data storage and processing.

3. **2008**:
    - Google launches Google App Engine, providing a platform for developing and hosting web applications in Google-managed data centers.
    - Cloud computing gains traction across industries for its potential to streamline operations and reduce costs.

4. **2010**:
    - Sports organizations begin exploring cloud computing for digitizing sports content and enhancing fan engagement.
    - Initial integration of cloud technology in sports analytics and athlete performance tracking.

5. **2012**:
    - Microsoft Azure enters the cloud computing market, offering a comprehensive suite of cloud services.
    - Fantasy sports platforms begin leveraging cloud computing for hosting online events and managing user data.

6. **2015**:
    - Adoption of cloud computing accelerates in the sports industry, with organizations utilizing cloud-based solutions for broadcasting, ticketing, and event management.
    - Increasing reliance on cloud technology for real-time data analytics and fan engagement initiatives.

7. **2018**:
    - Wearable technology becomes more prevalent in sports, driving the need for cloud-based platforms to analyse and manage the vast amounts of data generated by athletes.
    - Cloud computing plays a crucial role in facilitating remote training sessions and performance tracking for athletes.

8. **2020**:
    - COVID-19 pandemic accelerates the adoption of cloud-based solutions for remote collaboration, virtual events, and fan engagement in sports.
    - Cloud computing proves essential for maintaining continuity in sports operations amidst lockdowns and social distancing measures.

9. **2022**:
    - Cloud computing becomes ubiquitous in the sports industry, powering everything from live streaming platforms to interactive fan experiences and e-commerce initiatives.
    - Sports organizations increasingly rely on cloud-based analytics for data-driven decision-making and revenue generation strategies.

4.WORKING

Collaborative Filtering (CF) can be categorized into two main types based on the approach used to calculate similarities between users or items: User-Based Collaborative Filtering and Item-Based Collaborative Filtering.

1. **User-Based Collaborative Filtering (UBCF)**:

- In User-Based Collaborative Filtering, similarities between users are calculated based on their interactions with items.
- The idea is to find users who have similar preferences or behaviours, and recommend items liked by those similar users.
- Steps involved in UBCF:
  - Calculate similarity between users based on their ratings for items
  - Select a subset of similar users, known as the neighbourhood.
  - Predict the ratings of items for the target user by aggregating ratings from the neighbourhood, often using weighted averages.

2. **Item-Based Collaborative Filtering (IBCF)**:

- In Item-Based Collaborative Filtering, similarities between items are calculated based on the ratings they receive from users.
- The idea is to recommend items that are similar to those already liked or rated highly by the user.
- Steps involved in IBCF:
  - Calculate similarity between items based on the ratings they receive from users.
  - Select a subset of similar items for each item.
  - Predict the ratings of unrated items for the target user by aggregating ratings of similar items, often using weighted averages.

- **UBCF** is intuitive and easy to implement, but it may suffer from the sparsity of user-item interactions and scalability issues with a large number of users.
- **IBCF** tends to perform well in scenarios where the item space is less dynamic compared to the user space, and it can handle larger datasets more efficiently. However, it may struggle with the cold-start problem for new items.

Comparison between User-Based Collaborative Filtering and User-Based Collaborative Filtering

Aspect	**User-Based Collaborative Filtering (UBCF)**	**User-Based Collaborative Filtering (IBCF)**
Focus	Finds similar users based on past interactions	Finds similar items based on past interactions
Advantages	Effective for stable user preferences	- Efficient for large numbers of users and items
	Works well when more users than items	- Handles the "new user" problem better
Challenges	- Scalability issues with large user populations	-Requires precomputation of item similarities
	- Prone to "cold start" problem for new users	May not handle changes in item popularity well
Example	If User A and User B have similar preferences and User A hasn't watched movie Y, then movie Y might be recommended to User A	If a user has interacted with items X and Y, and item X is highly similar to item Z, then item Z might be recommended to the user

5.TECHNICAL SPECIFICATION

Hardware Specifications:

1. **Servers**:

   Cloud computing relies on a vast network of servers housed in data centers. These servers range from high-performance machines equipped with multicore processors and ample RAM for compute-intensive tasks to storage servers optimized for data storage and retrieval.

2. **Networking Equipment**:

   Networking infrastructure, including routers, switches, and load balancers, ensures reliable connectivity between servers, storage systems, and client devices. High-speed fiber-optic cables and networking protocols support fast data transmission and low-latency communication within and across data centers.

3. **Storage Systems**:

   Cloud providers deploy various storage systems to store sports-related data, including player profiles, match statistics, video footage, and fan interactions. These storage systems may include traditional hard disk drives (HDDs), solid-state drives (SSDs), distributed file systems, and object storage solutions optimized for scalability, durability, and performance.

4. **Security Appliances**:

   Hardware-based security appliances, such as firewalls, intrusion detection systems (IDS), and encryption appliances, protect cloud infrastructure against cyber threats and unauthorized access. These appliances may be deployed at network entry points, within data centers, and at the edge to safeguard data and applications from malicious actors.

5. **Power and Cooling Systems**: Data centers require robust power and cooling systems to ensure continuous operation and prevent equipment overheating. Backup generators, uninterruptible power supplies (UPS), and precision cooling units provide redundancy and resilience, minimizing the risk of downtime and service disruptions for sports organizations relying on cloud services.

Software Specifications:

1. **Virtualization Software**:

   Virtualization software enables the creation and management of virtual machines (VMs) and containers on physical servers. Hypervisors like VMware vSphere, Microsoft Hyper-V, and KVM (Kernel-based Virtual Machine) partition physical hardware into multiple virtual instances, allowing efficient resource utilization and workload isolation in cloud environments.

2. **Operating Systems**:

   Cloud providers offer a variety of operating systems for virtual machines and containers, including Linux distributions (e.g., Ubuntu, CentOS, Debian) and Windows Server editions. These operating systems provide the foundation for running applications, services, and middleware within cloud environments, offering flexibility and compatibility with diverse workloads.

3. **Cloud Management Platforms**:

   Cloud management platforms (CMPs) enable centralized management and orchestration of cloud resources, including compute instances, storage volumes, and networking configurations. Platforms like AWS Management Console, Google Cloud Console, and Azure Portal provide intuitive interfaces for provisioning, monitoring, and scaling cloud infrastructure in the sports industry.

4. **Containerization and Orchestration Tools**:

   Containerization technologies like Docker and Kubernetes simplify the deployment and management of microservices-based applications in cloud environments. Containers encapsulate application code, dependencies, and configuration, enabling portability, scalability, and resource efficiency for sports-related applications and services.

5. **Database Management Systems**:

   Cloud-based database management systems (DBMS) provide scalable and reliable storage solutions for sports-related data, including player profiles, match statistics, and fan interactions. Database platforms like Amazon RDS, Google Cloud SQL, and Azure SQL Database offer managed database services with features such as automatic backups, replication, and high availability.

6. **Development Tools and Frameworks**:

   Cloud computing supports a wide range of development tools and frameworks for building and deploying sports-related applications, analytics, and services. Integrated development environments (IDEs) like Visual Studio Code, IntelliJ IDEA, and Eclipse facilitate software development, while frameworks like Flask, Django, and Node.js streamline web and mobile app development.

7. **Security and Compliance Software**:

   Cloud providers offer security and compliance software to protect sports organizations' data and applications from cyber threats and regulatory risks. This software includes identity and access management (IAM) tools, encryption services, security information and event management (SIEM) solutions, and compliance management platforms tailored to the unique requirements of the sports industry.

User based Collaborative filtering algorithm:

```
# Install surprise library using pip if you haven't already
# pip install scikit-surprise

from surprise import Dataset
from surprise import Reader
from surprise.model_selection import train_test_split
from surprise import KNNBasic
from surprise import accuracy

# Load the dataset (replace this with your own dataset)
reader = Reader(line_format='user item rating', sep=',')
data = Dataset.load_from_file('ratings.csv', reader=reader)

# Split the data into training and testing sets
trainset, testset = train_test_split(data, test_size=0.2)

# Use user-based collaborative filtering with k-NN
algo = KNNBasic(sim_options={'user_based': True})
```

```
# Train the model

algo.fit(trainset)



# Make predictions

predictions = algo.test(testset)



# Evaluate the model

accuracy.rmse(predictions)
```

1. **Install Surprise Library**: This step installs the Surprise library if it's not already installed. Surprise is a Python scikit for building and analyzing recommender systems.
2. **Import Necessary Modules**: Import the required modules from Surprise library. These include **Dataset**, **Reader**, **train_test_split**, **KNNBasic**, and **accuracy**.
3. **Load the Dataset**:
    - **Reader** is instantiated to specify the format of the data. Here, it's configured to expect lines with 'user item rating' format separated by commas.
    - **Dataset.load_from_file()** loads the dataset from the 'ratings.csv' file using the specified **Reader**.
4. **Split the Data**: The dataset is split into training and testing sets using **train_test_split** function from Surprise. Here, 80% of the data is used for training (**trainset**) and 20% for testing (**testset**).

5. **Configure the Algorithm**:
    - **KNNBasic** is instantiated for user-based collaborative filtering with k-NN.
    - The **sim_options** parameter is used to configure similarity options. Here, it's set to user-based collaborative filtering (**'user_based': True**).
6. **Train the Model**: The model is trained on the training set using the **fit()** method.
7. **Make Predictions**: Predictions are made for the test set using the trained model and the **test()** method.
8. **Evaluate the Model**: Model performance is evaluated by calculating the Root Mean Squared Error (RMSE) between the predicted ratings and the actual ratings in the test set using the **accuracy.rmse()** function.

6.ADVANTAGES

1. **Scalability:**

   Cloud computing allows sports organizations to scale their resources up or down based on demand. Whether it's handling a sudden surge in website traffic during a major sporting event or managing data-intensive analytics, cloud platforms can dynamically allocate resources to meet changing needs without the need for significant infrastructure investments.

2. **Cost Efficiency:**

   Cloud computing eliminates the need for upfront capital expenditures on hardware and infrastructure. Instead, organizations can leverage pay-as-you-go models, where they only pay for the computing resources and storage they use. This cost-effective approach makes cloud computing accessible to organizations of all sizes, including startups and smaller sports teams.

3. **Flexibility and Accessibility:**

   Cloud computing enables remote access to data and applications from anywhere with an internet connection. This flexibility allows athletes, coaches, and staff to access training programs, performance analytics, and collaboration tools from any location, fostering seamless communication and productivity.

4. **Low Latency and High-Quality of Service (QoS):**

   The adaptive nature of the offloading decisions, driven by the genetic algorithm, contributes to low-latency connections. Users experience improved QoS as the system dynamically optimizes offloading strategies based on proximity and workload considerations, resulting in reduced communication delays.

5. **Collaboration and Communication:**

Cloud-based platforms facilitate collaboration and communication among athletes, coaches, and support staff. Whether it's sharing training schedules, analyzing performance data in real-time, or conducting virtual team meetings, cloud computing enhances teamwork and coordination, leading to improved performance on and off the field.

6. **Operational Efficiency**:

Cloud computing streamlines various operational tasks, including ticketing, event management, and merchandise sales. Automated processes, centralized data storage, and analytics tools empower sports organizations to optimize resource allocation, improve decision-making, and deliver a seamless experience for fans and stakeholders alike.

7.DISADVANTAGES

1. **Data privacy:**

With the vast amounts of data generated and stored in the cloud, including sensitive personal data, health information, and performance metrics, it is crucial that these are securely managed and protected. Data privacy represents a significant concern, as information stored in the cloud can potentially be accessed from anywhere, by anyone with the correct credentials. This increases the risk of unauthorized access and privacy breaches. Especially in the big data context, the traditional centralized data processing paradigm with cloud is not efficient enough. Therefore, to alleviate the heavy burden of cloud platform, many edge servers are often used to make initial data preprocessing before the massive data are directly sent to the cloud platform. In this situation, private user data are probably disclosed to other parties during the data transmission among cloud, edge and users.

2. **Security:**

Security is another major challenge in cloud computing. Despite robust security measures, no system is completely immune to security threats. These threats can include hacking attempts, data breaches, and other cyber-attacks. Such incidents not only compromise the privacy of individuals but can also significantly damage the reputation of sports organizations. The use of third-party cloud service providers further complicates matters. Organizations often have limited control over their data security when using third-party services, which can result in potential vulnerabilities. This includes ensuring appropriate encryption, access controls, and intrusion detection systems are in place. They must also ensure they are transparent with their stakeholders about their data handling practices.

3. Cost and complexity of implementation:

Genetic algorithms are generally designed for optimization over a period of time and may not always meet the strict real-time constraints of certain applications. In scenarios where immediate decision-making is crucial, the inherent time complexity of the genetic algorithm may pose challenges.

4. **Dependence on internet connectivity:**

The sports industry's reliance on cloud computing also means a dependency on consistent and robust internet connectivity. This dependence on internet connectivity is one of the fundamental challenges associated with the adoption of cloud computing. For sports organizations, the reliance on internet connectivity means that any disruption in their internet service could potentially bring their operations to a halt. This is a particular concern for live events, where a disruption in internet service could affect everything from ticketing to live streaming, potentially damaging the reputation of the event and the organization.

8.APPLICATIONS

1. **Athletic performance tracking**:

This involves capturing, storing, and analysing vast amounts of data related to an athlete's physical and physiological performance. wearable devices can track parameters such as heart rate, acceleration, and GPS location, among others. This data, often substantial in volume, is then transferred to the cloud where it is securely stored and processed.

2. **Fan Engagement:**

By providing fans with personalized and immersive experiences, cloud computing is transforming how fans consume sports. One of the primary areas where cloud computing impacts fan engagement is through the use of social media. Cloud computing enables these platforms to handle massive amounts of data and deliver personalized content to individual users. For example, the use of data analytics can help sports organizations understand fans' behavior, allowing them to provide fans with tailored content that meets their preferences and enhances their engagement.

3. **Operation Management:**

The application of cloud computing in operations management is shaping the sports industry by introducing efficient, scalable, and flexible solutions that transform traditional operational processes. From inventory management to ticketing systems, cloud computing's robust capabilities are driving operational efficiency and improving overall performance

4. **Event Hosting:**

Cloud-based event management tools simplify the planning process by providing a central platform where all aspects of event planning can be coordinated. Tasks such as scheduling, resource allocation, volunteer management, and participant registration can all be managed effectively on these platforms. By using the cloud,

these processes can be automated, tracked, and updated in real-time, enhancing efficiency and communication among the event management team.

5. **Sports Marketing:**

With regard to sponsorship opportunities, sports organizations can now offer prospective sponsors comprehensive, data-driven insights into their fan base thanks to the adoption of cloud computing. Sponsors find sports organizations more attractive when they can quantify fan engagement levels and demographic breakdowns. This is because sponsors can more accurately determine the potential return on investment and target the right audience with their marketing efforts. Moreover, cloud technology can enable dynamic sponsorship opportunities during live events.

9.CONCLUSION

The purpose of this review was to provide a comprehensive overview of the applications of cloud computing in sports, discuss the challenges faced, and identify future trends and potential developments. The research highlights several key applications of cloud computing in sports, including athlete performance tracking, fan engagement, operations management, sports marketing, and event hosting. These applications illustrate how cloud computing has transformed traditional sports practices by facilitating data collection and analysis, enhancing communication, and optimizing operations.

Cloud computing often works well in business systems involving big data processing due to the high computational capability of cloud platforms. Inspired by this observation, cloud computing technology is introduced in sport industries in this paper to deal with big sport data and has achieved good performances in sport industries. However, not all sport items can produce big volume of data that need to be processed by powerful cloud platforms; in such cases, cloud computing platforms are not a necessity since small sport data can be processed by local clients such as computer or laptops.

Alongside the benefits of cloud computing, the research also illuminated several challenges associated with the adoption of cloud computing in the sports industry, including issues of data privacy and security, cost and complexity of implementation, and dependence on internet connectivity. In addition, how to extend the traditional cloud-based sport data processing systems to more flexible and cost-effective edge-based systems to adapt time-efficient and cost-efficient business applications is still a challenging task in future study. These challenges underscore the need for careful planning, robust security measures, and continuous monitoring and adjustment of cloud solutions.

10.FUTURE ENHANCEMENT

1. Integration with other technologies (AI, IoT, etc.):

This integration can amplify the benefits of each technology, driving innovation and creating new ways to enhance athletic performance, fan engagement, and operational efficiency. AI and cloud computing are increasingly becoming interdependent. AI applications, ranging from predictive analytics to automated decision-making systems, rely on the vast computational resources offered by the cloud. On the other hand, the cloud benefits from AI's ability to process and analyze large datasets, optimize system performance, and improve data security . In sports, AI can enhance cloud-based athlete performance tracking systems, allowing for real-time analysis and feedback.

2. Customization and personalization

As the volume of available data continues to increase, there is a growing opportunity for sports organizations to create personalized experiences and offerings for their stakeholders, including athletes, fans, and sponsors. For athletes, cloud-based tools can provide personalized training plans, nutritional advice, and injury prevention strategies. These customized solutions can be developed based on a variety of data, including historical performance data, real-time tracking data, health data, and even genetic information. Such personalization can optimize athlete performance and promote long-term athlete health and wellbeing

3. Sustainability and green IT:

Cloud computing can contribute to sustainability in several ways. Firstly, it reduces the need for physical IT infrastructure, which in turn reduces the energy consumption associated with running and cooling these systems. Cloud data centers benefit from economies of scale and can operate more efficiently than smaller, organization-specific data centers, leading to a smaller carbon footprint. Secondly, the scalability of cloud computing means that resources are only used when needed, preventing the waste associated with underutilized infrastructure.

Moreover, cloud computing can also support sustainability in the sports industry beyond IT practices.

The data processing and analysis capabilities of the cloud can support the implementation of other environmentally friendly practices. For example, it can help optimize travel schedules for teams and fans, reducing carbon emissions associated with transportation

11.REFERENCES

1. Mach P, Becvar Z (2017) Mobile Edge Computing: A Survey on Architecture and Computation Offloading. IEEE Commun Surv Tutorials 19(3):1628–1656. https://doi.org/10.1109/COMST.2017.2682318.Chellappa, R., & Sarathy, R. (2005). Service-Oriented Computing and Cloud

2. Hsieh H-C, Chen J-L, Benslimane A (2018) 5g virtualized multi-access edge computing platform for iot applications. J Netw Comput Appl 115:94–102. https://doi.org/10.1016/j.jnca.2018.05.001.

3. Tomkos I, Klonidis D, Pikasis E, Theodoridis S (2020) Toward the 6g network era: Opportunities and challenges. IT Prof 22(1):34–38.

4. Bhushan N, Li J, Malladi D, Gilmore R, Brenner D, Damnjanovic A, Sukhavasi RT, Patel C, Geirhofer S (2014) Network densification: the dominant theme for wireless evolution into 5g. IEEE Commun Mag 52(2):82–89.

5. Du J, Yu FR, Chu X, Feng J, Lu G (2019) Computation offloading and resource allocation in vehicular networks based on dual-side cost minimization. IEEE Trans Veh Technol 68(2):1079–1092. https://doi.org/10.1109/TVT.2018.2883156.

6. Sun H, Zhou F, Hu RQ (2019) Joint Offloading and Computation Energy Efficiency Maximization in a Mobile Edge Computing System. IEEE Trans Veh Technol 68(3):3052–3056. https://doi.org/10.1109/TVT.2019.2893094.

7. Qi Q, Wang J, Ma Z, Sun H, Cao Y, Zhang L, Liao J (2019) Knowledge-Driven Service Offloading Decision for Vehicular Edge Computing: A Deep Reinforcement Learning Approach. IEEE Trans Veh Technol 68(5):4192–4203. https://doi.org/10.1109/TVT.2019.2894437.

8. Poularakis K, Llorca J, Tulino AM, Taylor I, Tassiulas L (2019) Joint Service Placement and Request Routing in Multi-cell Mobile Edge Computing Networks. Proc IEEE INFOCOM 2019-April:10–18. https://doi.org/10.1109/INFOCOM.2019.8737385.

9. Tran TX, Pompili D (2019) Joint task offloading and resource allocation for multi-server mobile-edge computing networks. IEEE Trans Veh Technol 68(1):856–868. https://doi.org/10.1109/TVT.2018.2881191.

10. Li G, Cai J (2020) An online incentive mechanism for collaborative task offloading in mobile edge computing. IEEE Trans Wirel Commun 19(1):624–636. https://doi.org/10.1109/TWC.2019.2947046.

11. Li C, Tang J, Luo Y (2019) Dynamic multi-user computation offloading for wireless powered mobile edge computing. J Netw Comput Appl 131:1–15. https://doi.org/10.1016/j.jnca.2019.01.020.

12. Bai T, Wang J, Ren Y, Hanzo L (2019) Energy-efficient computation offloading for secure uav-edge-computing systems. IEEE Trans Veh Technol 68(6):6074–6087. https://doi.org/10.1109/TVT.2019.2912227.

13. Alghamdi I, Anagnostopoulos C, Pezaros DP (2019) On the optimality of task offloading in mobile edge computing environments In: 2019 IEEE Global Communications Conference (GLOBECOM), 1–6, Hawaii. ISBN 9781728109626. https://doi.org/10.1109/GLOBECOM38437.2019.9014081

14. Shiraz, Muhammad, et al. "A Review on Distributed Application Processing Frameworks in Smart Mobile Devices for Mobile Cloud Computing." *IEEE Communications Surveys & Tutorials*, vol. 15, no. 3, 2013, pp. 1294–1313, https://doi.org/10.1109/surv.2012.111412.00045.