International Journal of Management, IT & Engineering
Vol. 9 Issue 3, March 2019,
ISSN: 2249-0558 Impact Factor: 7.119
Journal Homepage: http://www.ijmra.us, Email: editorijmie@gmail.com
Double-Blind Peer Reviewed Refereed Open Access International Journal - Included in the International Serial Directories Indexed & Listed at: Ulrich's Periodicals Directory ©, U.S.A., Open J-Gate as well as in Cabell's Directories of Publishing Opportunities, U.S.A

Edge Computing

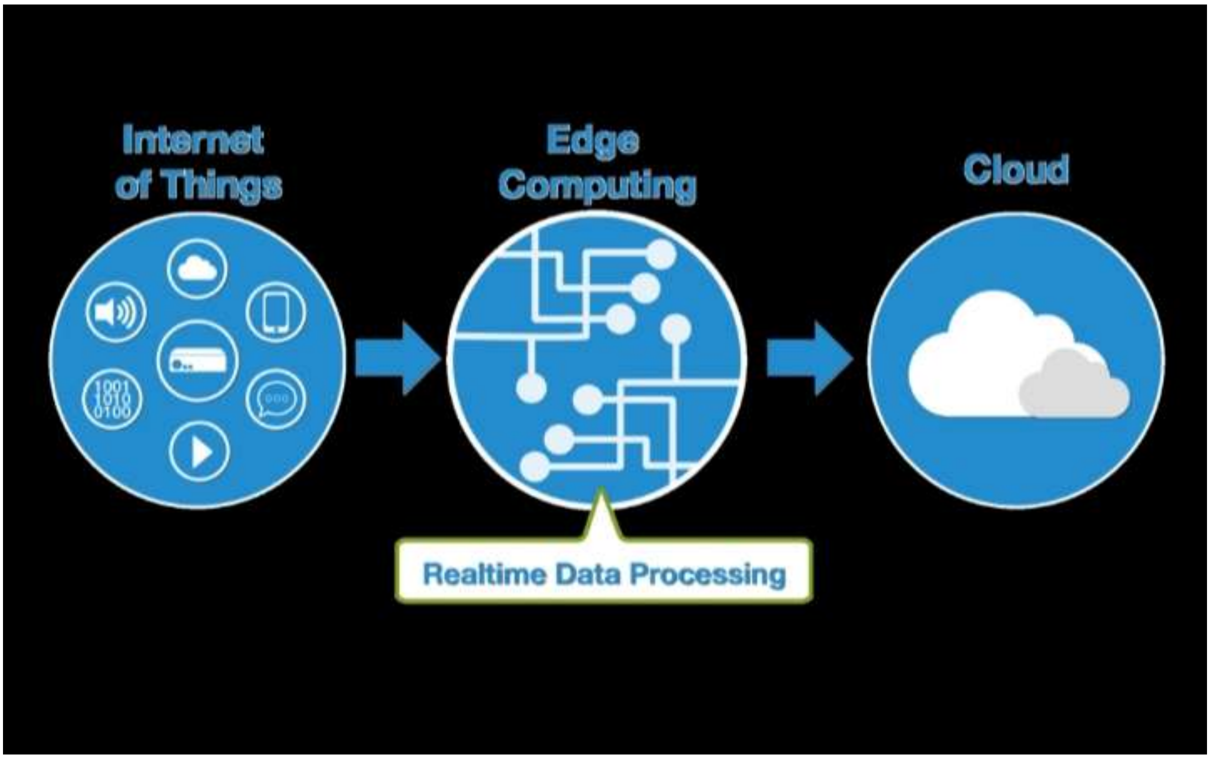
Manjinder Kaur
Master Of Computer Application
IGNOU, New Delhi (India)

Abstract:-Edge computing is rooted in decades-old ideas of remote computing -- such as remote offices and branch offices -- where it was more reliable and efficient to place computing resources at the desired location rather than rely on a single central location.Edge computing is transforming the way data is being handled, processed, and delivered from millions of devices around the world. The explosive growth of internet-connected devices – the IoT – along with new applications that require real-time computing power, continues to drive edge-computing systems.Faster networking technologies, such as 5G wireless, are allowing for edge computing systems to accelerate the creation or support of real-time applications, such as video processing and analytics, self-driving cars, artificial intelligence and robotics, to name a few.Edge computing was developed due to the exponential growth of IoT devices, which connect to the internet for either receiving information from the cloud or delivering data back to the cloud. And many IoT devices generate enormous amounts of data during the course of their operations.Edge-computing hardware and services help solve this problem by being a local source of processing and storage for many of these systems. An edge gateway, for example, can process data from an edge device, and then send only the relevant data back through the cloud, reducing bandwidth needs. Or it can send data back to the edge device in the case of real-time application needs.These edge devices can include many different things, such as an IoT sensor, an employee's notebook computer, their latest smartphone, the security camera or even the internet-connected microwave oven in the office break room. Edge gateways themselves are considered edge devices within an edge-computing infrastructure.For many companies, the cost savings alone can be a driver towards deploying an edge-computing architecture. Companies that embraced the cloud for many of their applications may have discovered that the costs in bandwidth were higher than they expected. Increasingly, though, the biggest benefit of edge computing is the ability to process and store data faster, enabling for more efficient real-time applications that are critical to companies. Before edgecomputing, a smartphone scanning a person's face for facial recognition would need to run the facial recognition algorithm through a cloud-based service, which would take a lot of time to process. With an edge computing model, the algorithm could run locally on an edge server or gateway, or even on the smartphone itself, given the increasing power of smartphones. Applications such as virtual and augmented reality, self-driving cars, smart cities and even building-automation systems require fast processing and response.

Keywords:-Edge computing, edge computing Vs. cloud computing,edge computing use cases,benefits of edge computing,challenges of edge computing.

International Journal of Management, IT & Engineering
Vol. 9 Issue 3, March 2019,
ISSN: 2249-0558 Impact Factor: 7.119
Journal Homepage: http://www.ijmra.us, Email: editorijmie@gmail.com
Double-Blind Peer Reviewed Refereed Open Access International Journal - Included in the International Serial Directories Indexed & Listed at: Ulrich's Periodicals Directory ©, U.S.A., Open J-Gate as well as in Cabell's Directories of Publishing Opportunities, U.S.A

Introduction:-Edge computing lie in content delivery networks that were created in the late 1990s serve web and video content from edge servers that were deployed close to users.In early 2000s,these networks evolved to host applications and application components at the edge servers,resulting in the first commercial edge computing services that hosted applications such as dealer locators, shopping carts, real-time data aggregators and insertion engines. Edge computing is a distributed information technology (IT) architecture in which client data is processed at the periphery of the network, as close to the originating source as possible.Data is the lifeblood of modern business, providing valuable business insight and supporting real-time control over critical business processes and operations. Today's businesses are awash in an ocean of data, and huge amounts of data can be routinely collected from sensors and IoT devices operating in real time from remote locations and inhospitable operating environments almost anywhere in the world. Edge computing moves some portion of storage and compute resources out of the central data center and closer to the source of the data itself. Rather than transmitting raw data to a central data center for processing and analysis, that work is instead performed where the data is actually generated -- whether that's a retail store, a factory floor, a sprawling utility or across a smart city. Only the result of that computing work at the edge, such as real-time business insights, equipment maintenance predictions or other actionable answers, is sent back to the main data center for review and other human interactions. Edge computing is all a matter of locations.



Edge Computing with Realtime Data Processing

International Journal of Management, IT & Engineering
Vol. 9 Issue 3, March 2019,
ISSN: 2249-0558 Impact Factor: 7.119
Journal Homepage: http://www.ijmra.us, Email: editorijmie@gmail.com
Double-Blind Peer Reviewed Refereed Open Access International Journal - Included in the International Serial Directories Indexed & Listed at: Ulrich's Periodicals Directory ©, U.S.A., Open J-Gate as well as in Cabell's Directories of Publishing Opportunities, U.S.A

In traditional enterprise computing, data is produced at a client endpoint, such as a user's computer. That data is moved across a WAN such as the internet, through the corporate LAN, where the data is stored and worked upon by an enterprise application. Results of that work are then conveyed back to the client endpoint. This remains a proven and time-tested approach to client-server computing for most typical business applications. But the number of devices connected to the internet, and the volume of data being produced by those devices and used by businesses, is growing far too quickly for traditional data center infrastructures to accommodate. Gartner predicted that by 2025, 75% of enterprise-generated data will be created outside of centralized data centers. The prospect of moving so much data in situations that can often be time- or disruption-sensitive puts incredible strain on the global internet, which itself is often subject to congestion and disruption.Edge computing puts storage and servers where the data is, often requiring little more than a partial rack of gear to operate on the remote LAN to collect and process the data locally. In many cases, the computing gear is deployed in shielded or hardened enclosures to protect the gear from extremes of temperature, moisture and other environmental conditions. Processing often involves normalizing and analyzing the data stream to look for business intelligence, and only the results of the analysis are sent back to the principal data center.

2. Edge Computing Vs. Cloud Computing

The process of edge computing differs from cloud computing because it takes time, sometimes up to 2 seconds to relay the information to the centralized data center, delaying the decision-making process. The signal latency can lead to the organization incurring losses, hence organizations prefer edge computing to cloud computing.Cloud and edge computing are different, non-interchangeable technologies that cannot replace one another. Edge computing is used to process time-sensitive data, while cloud computing is used to process data that is not time-driven. Besides latency, edge computing is preferred over cloud computing in remote locations, where there is limited or no connectivity to a centralized location. These locations require local storage, similar to a mini data center, with edge computing providing the perfect solution for it. Edge computing is also beneficial to specialize and intelligent devices. While these devices are akin to PCs, they are not regular computing devices designed to perform multiple functions. These specialized computing devices are intelligent and respond to particular machines in a specific way. However, this specialization becomes a drawback for edge computing in certain industries that require immediate responses.Though many companies are adopting edge computing and are predicting

International Journal of Management, IT & Engineering
Vol. 9 Issue 3, March 2019,
ISSN: 2249-0558 Impact Factor: 7.119
Journal Homepage: http://www.ijmra.us, Email: editorijmie@gmail.com
Double-Blind Peer Reviewed Refereed Open Access International Journal - Included in the International Serial Directories Indexed & Listed at: Ulrich's Periodicals Directory ©, U.S.A., Open J-Gate as well as in Cabell's Directories of Publishing Opportunities, U.S.A

the end of cloud computing, Bernard points out that this is not substantiated because there is currently no analytical framework to prove it. Edge computing is not the only solution for the challenges faced by IT vendors and organizations and does not handle all applications across every environment, thus, cloud computing will still remain a crucial part of an organization's IT infrastructure.

Edge-to-Cloud architecture layers

To demonstrate this, Bernard city the example of an IoT device with computing power attached to it, along with Azure functionality. Thedevice-deployed code responds in real-time by shutting down the IoT machine in case of a damaging failure condition, while the rest of the application runs in Azure. The million-dollar machine is no longer dependent on cloud loop for emergency response due to its utilization of edge computing and still works in harmony with cloud computing to run, deploy, and manage the IoT devices remotely. This sustains that cloud computing will remain relevant and work alongside edge computing to provide data analytics and real-time solutions for organizations.

3.Edge computing use cases

In principal, edge computing techniques are used to collect, filter, process and analyze data "in-place" at or near the network edge. It's a powerful means of using data that can't be first moved to a centralized location -- usually because the sheer volume of data makes such moves cost-prohibitive, technologically impractical or might otherwise violate compliance obligations, such as data

International Journal of Management, IT & Engineering
Vol. 9 Issue 3, March 2019,
ISSN: 2249-0558 Impact Factor: 7.119
Journal Homepage: http://www.ijmra.us, Email: editorijmie@gmail.com
Double-Blind Peer Reviewed Refereed Open Access International Journal - Included in the International Serial Directories Indexed & Listed at: Ulrich's Periodicals Directory ©, U.S.A., Open J-Gate as well as in Cabell's Directories of Publishing Opportunities, U.S.A

3.1 Manufacturing:-An industrial manufacturer deployed edge computing to monitor manufacturing, enabling real-time analytics and machine learning at the edge to find production errors and improve product manufacturing quality. Edge computing supported the addition of environmental sensors throughout the manufacturing plant, providing insight into how each product component is assembled and stored -- and how long the components remain in stock. The manufacturer can now make faster and more accurate business decisions regarding the factory facility and manufacturing operations.

3.2Farming:- Consider a business that grows crops indoors without sunlight, soil or pesticides. The process reduces grow times by more than 60%. Using sensors enables the business to track water use, nutrient density and determine optimal harvest. Data is collected and analyzed to find the effects of environmental factors and continually improve the crop growing algorithms and ensure that crops are harvested in peak condition.

3.3Network optimization:- Edge computing can help optimize network performance by measuring performance for users across the internet and then employing analytics to determine the most reliable, low-latency network path for each user's traffic. In effect, edge computing is used to "steer" traffic across the network for optimal time-sensitive traffic performance.

3.4Workplace safety:- Edge computing can combine and analyze data from on-site cameras, employee safety devices and various other sensors to help businesses oversee workplace conditions or ensure that employees follow established safety protocols -- especially when the workplace is remote or unusually dangerous, such as construction sites or oil rigs.

3.5 Improved healthcare. The healthcare industry has dramatically expanded the amount of patient data collected from devices, sensors and other medical equipment. That enormous data volume requires edge computing to apply automation and machine learning to access the data, ignore "normal" data and identify problem data so that clinicians can take immediate action to help patients avoid health incidents in real time.

3.6 Transportation. Autonomous vehicles require and produce anywhere from 5 TB to 20 TB per day, gathering information about location, speed, vehicle condition, road conditions, traffic conditions and other vehicles. And the data must be aggregated and analyzed in real time, while the vehicle is in motion. This requires significant onboard computing -- each autonomous vehicle becomes an "edge." In addition, the data can help authorities and businesses manage vehicle fleets based on actual conditions on the ground.

3.7Retail. Retail businesses can also produce enormous data volumes from surveillance, stock tracking, sales data and other real-time business details. Edge computing can help analyze this diverse data and identify business opportunities, such as an effective endcap or campaign, predict sales and optimize vendor ordering, and so on. Since retail businesses can vary dramatically in local environments, edge computing can be an effective solution for local processing at each store.

International Journal of Management, IT & Engineering
Vol. 9 Issue 3, March 2019,
ISSN: 2249-0558 Impact Factor: 7.119
Journal Homepage: http://www.ijmra.us, Email: editorijmie@gmail.com
Double-Blind Peer Reviewed Refereed Open Access International Journal - Included in the International Serial Directories Indexed & Listed at: Ulrich's Periodicals Directory ©, U.S.A., Open J-Gate as well as in Cabell's Directories of Publishing Opportunities, U.S.A

4. Benefits of edge computing

Edge computing is powerful resource and strategy in the modern data center.Wireless networking made these processes even faster with IT administrators able to add more storage space, computing power and other capabilities at the push of a button.

4.1 Speed and Latency

Speed is absolutely vital to any company 's core business.Edge computing's most significant benefit is its ability to increase network performance by reducing latency.The longer it takes to process data, the less relevant it is. In the case of the autonomous vehicle, time is of the essence and most of the data it collects and requires is useless after a couple of seconds. Milliseconds matter, especially on a busy roadway. Milliseconds also matter in the digital factory where intelligence based systems perpetually monitor all aspects of the manufacturing process to ensure data consistency. In many cases, there isn't time to round trip data back and forth between the cloud. Situations such as equipment failures and hazardous incidents call for the instantaneous analysis of data. Confining data analysis to the edge where it is created eliminates latency, which translates into faster response times.Current commercial fiber-optic technology allows data to travel as fast 2/3 the speed of light, moving from New York to San Francisco in about 21 milliseconds.

4.2 Security

When data is moving between different fragments,itmust cross various layers of security.The data exchange is between the internet, servers and nodes. At each of these ,we can implement additional security measures such as firewalls and security scans.When all of your data must eventually feed to its cloud analyzer through a single pipe, the critical business and operating processes that rely on actionable data are highly vulnerable. As a result, a single DDoS attack can disrupt entire operations for a multinational company. When you distribute your data analysis tools across the enterprises, you distribute the risk as well. While it can be argued that edge computing expands the potential attack surface for would be hackers, it also diminishes the impact on the organization as a whole. Another inherent truth is that when you transfer less data, there is less data that can be intercepted. When data is analyzed locally, it remains protected by the security blanket of the on premise enterprise. Edge computing also helps companies overcome the issues of local compliance and privacy regulations as well as the issue of data sovereignty.

4.3 Cost Savings

Edge computing allows you to categorize your data from a management perspective. By retaining as much data within your edge locations, you reduce the need for costly bandwidth to connect all of your locations, and bandwidth translates directly into dollars. Edge computing isn't about eliminating the need for the cloud, it is about optimizing the flow of your data in order to maximize your operating costs. Edge computing also helps to reduce some level of data redundancy. Data that is created at the edge must be stored there at least temporarily. When sent to the cloud, it must be stored again, creating levels of redundancy. When you reduce redundant storage, you reduce redundant cost.

4.4 Greater Reliability

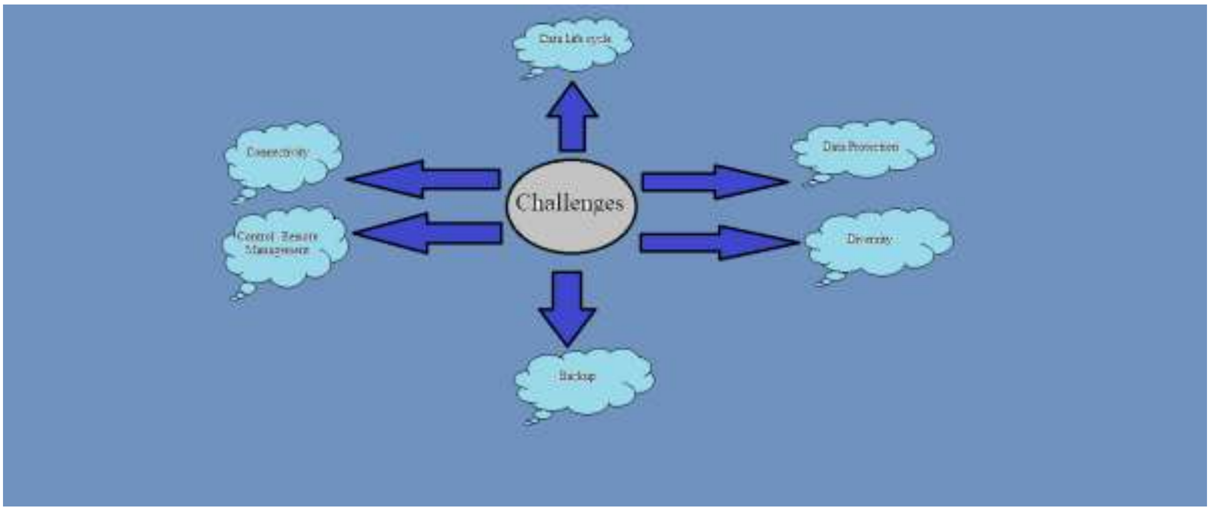
Edge computing handles reliability part very well. User do not need to worry about network failures or slow internet connections. The world of IoT includes some pretty remote territories comprised of rural and less than optimal environments concerning internet connectivity. When edge devices can locally store and process ensuing data, it improves reliability. Prefabricated micro data centers are built today to operate within just about any environment. This means that temporary disruptions in intermittent connectivity will not impact smart device operations just because they lost connection to the cloud. In addition, every site has some built-in limitation to the amount of data that can be transmitted at one time. Although your bandwidth demands may not be tested as of yet, the exponential growth in generated data will push bandwidth infrastructure to the limit in the future for many enterprises.

4.5 Scalability

Edge computing offers high scalability to the network.For extending the network as and when required ,we can increase the devices, data centres and the processors without affecting other parts of the network.A huge network is not easy to handle in a cloud where the whole burden is on one centralised server.An IoT system generates large volumes of data.On the other hand,a vast network with edge computing can work efficiently at different fragments simultaneously. The size of network will not affect its quality ,as many fragments have their separate processing. A distributed processing reduces the traffic and processing burden on central data repository. Therefore, edge computing is best solution for networks which have an enormous span and are expected to keep growing with time.

5.Challenges of edge computing

Overwhelming data generation and increase in digital business projects will also come with a set of challenges,which the companies will have to tackle in bid to provide seamless and secure services to its customers.



Challenges Of Edge Computing

5.1 Data Lifecycle

Most of the data involved in real-time analytics is short-term data that isn't kept over the long term. A business must decide which data to keep and what to discard once analyses are performed. And the data that is retained must be protected in accordance with business and regulatory policies.Gartner states that "by 2022, more than half of enterprise-generated data will be created and processed outside the Data Center or cloud." And the amount of data collected increases daily. But data is only valuable when it can be used to gain insight. Much of the data collected at the edge is related to things like asset monitoring in industries like manufacturing and is not acted on unless it is outside normal parameters. So, the challenge for organizations is analyzing data and being able to quickly see what data needs to be saved and what can be deleted.

5.2 Data Protection

Edge Computing is a distributed model, it brings with it security concerns that are very different from a centralized model. Each end point or edgedevice can be a point of entry for malicious entities. Plus, Edge devices are often in remote locations or harsh environments, which brings up physical security concerns. These harsh conditions also may mean unreliable network connectivity. Apart from cyber security,businesses will also need to physically protect their edge computing infrastructure from unauthorized access.However,in trying to make the infrastructure secure, it may not remain edge computing.

5.3 Connectivity

Connectivity is another issue and provisions must be made for even access to control and reporting even when connectivity for actual data is unavailable. Some edge deployment use a secondary connection for backup connectivity and control.Edge computing overcomes typical network limitations, but even the most forgiving edge deployment will require some minimum level of connectivity. It's critical to design an edge deployment that accommodates poor or erratic connectivity and consider what happens at the edge when connectivity is lost. Autonomy, AI and graceful failure planning in the wake of connectivity problems are essential to successful edge computing.

5.4 Control Remote Management

Control remote management deal with skilledpersonnel are not available to deploy & manage the solution on a regular basis. An unskilled operator may need to perform simple plug and play deployments. This includes delivering secure edge application updates, debug-ability in the case of problems and deployment of additional devices. The Edge applications need to be highly sophisticated and should be able to provide a range of features: data caching in case of lost connections, raw data stream processing to filter, analyze relevant data, message brokering for event-based applications, device management, fault tolerance, etc. Saving bandwidth costs of constrained networks is also another important consideration.

5.5 Backup

The edge computing model is typically driven by the location of data creation. Enterprises need an overall data protection strategy that can comprehend data,regardless of location. Network bandwidth requirements will be just as critical as storage media considerations when deciding how protect these assets because backup over the network may not make sense.

5.6 Diversity

Each organization has different Edge Computing needs and there are many edge technology solutions on the market, which leads to a wide diversity of options. Partly due to this diversity, there are no common standards. Early projects tend to be unique and the requirements driven by specific goals. To successfully navigate this diversity, enterprises should develop strategic, long-term plans.

6. Conclusion

Edge computing could be the solution for faster,cheaper and more reliable data processing. With edge computing,things have become even more efficient.As a result , the quality of business operations has become higher.Edge computing has a ability to analyse data closer to the source will minimize latency,reduce the load on internet,improve privacy and security and lower data management costs.The combination of edge and cloud computing will help you better manage and analyse your data and significantly increase the value of your IoT efforts. The cloud will continue to play role in aggregating important data and performing analyses on this massive set of information that can be distributed back to the edge devices.

7. References

[1] Hamilton, Eric (27 December 2018). **"What is Edge Computing: The Network Edge Explained"**. cloudwards.net. *Retrieved 2019-05-14.*

[2] Gartner. **"Gartner Trend Insights report 2018"** ***(PDF)***. Gartner. *Retrieved 2021-05-26.*

[3] **"Globally Distributed Content Delivery, by J. Dilley, B. Maggs, J. Parikh, H. Prokop, R. Sitaraman and B. Weihl, IEEE Internet Computing, Volume 6, Issue 5, November 2002"** ***(PDF)***. **Archived** ***(PDF)*** from the original on 2017-08-09. *Retrieved 2019-10-25.*

[4] Davis, A.; Parikh, J.; Weihl, W. (2004). "EdgeComputing: Extending Enterprise Applications to the Edge of the Internet". 13th International World Wide Web Conference. **doi**:**10.1145/1013367.1013397**. **S2CID 578337**.

[5] **MIT MTL Seminar: Trends, Opportunities and Challenges Driving Architecture and Design of Next Generation Mobile Computing and IoT Devices**

[6] **"ETSI - ETSI Blog - What is Edge?"**. etsi.org. *Retrieved 2019-02-19.*

*[7]***"CloudHide: Towards Latency Hiding Techniques for Thin-client Cloud Gaming"**. ResearchGate. *Retrieved 2019-04-12.*

[8] **"ETSI - ETSI Blog - What is Edge?"**. etsi.org. *Retrieved 2019-02-19.*

*[9]***"CloudHide: Towards Latency Hiding Techniques for Thin-client Cloud Gaming"**. ResearchGate. *Retrieved 2019-04-12.*

[10] Anand, B.; Edwin, A. J. Hao (January 2014). "Gamelets — Multiplayer mobile games with distributed micro-clouds". 2014 Seventh International Conference on Mobile Computing and Ubiquitous Networking (ICMU): 14–20. **doi**:**10.1109/ICMU.2014.6799051**. **ISBN 978-1-4799-2231-4**. **S2CID 10374389**.

[11] Ivkovic, Jovan (2016-07-11). **"[Serbian] The Methods and Procedures for Accelerating**

Operations and Queries in Large Database Systems and Data Warehouse (Big Data Systems)". Hgpu.org.

*[12]*Shi, Weisong; Cao, Jie; Zhang, Quan; Li, Youhuizi; Xu, Lanyu (October 2016). "Edge Computing: Vision and Challenges". IEEE Internet of Things Journal. **3** (5): 637–646. **doi:10.1109/JIOT.2016.2579198. S2CID 4237186.**

[13] Merenda, Massimo; Porcaro, Carlo; Iero, Demetrio (29 April 2020). **"Edge Machine Learning for AI-Enabled IoT Devices: A Review"**. Sensors. **20** (9): 2533. **doi:10.3390/s20092533. PMC 7273223. PMID 32365645.**

[14] Garcia Lopez, Pedro; Montresor, Alberto; Epema, Dick; Datta, Anwitaman; Higashino, Teruo; Iamnitchi, Adriana; Barcellos, Marinho; Felber, Pascal; Riviere, Etienne (30 September 2015). **"Edge-centric Computing"**. ACM SIGCOMM Computer Communication Review. **45** (5): 37–42. **doi:10.1145/2831347.2831354.**

[15] Liu, S.; Liu, L.; Tang, B. Wu; Wang, J.; Shi, W. ***"Edge Computing for Autonomous Driving: Opportunities and Challenges"***. Proceedings of the IEEE, vol. 107, no. 8, pp. 1697-1716. *Retrieved 2021-05-26.*

[16] Yu, W.; et al. (2018). ***"A Survey on the Edge Computing for the Internet of Things"***. IEEE Access, vol. 6, pp. 6900-6919. *Retrieved 2021-05-26.*

*[17]*Satyanarayanan, Mahadev (January 2017). ***"The Emergence of Edge Computing"***. Computer. **50** (1): 30–39. ***doi:10.1109/MC.2017.9. ISSN 1558-0814.***

[18] Yi, S.; Hao, Z.; Qin, Z.; Li, Q. (November 2015). "Fog Computing: Platform and Applications". 2015 Third IEEE Workshop on Hot Topics in Web Systems and Technologies (HotWeb): 73–78. ***doi:10.1109/HotWeb.2015.22. ISBN 978-1-4673-9688-2. S2CID 6753944.***

[19] Verbelen, Tim; Simoens, Pieter; De Turck, Filip; Dhoedt, Bart (2012). ***"Cloudlets: Bringing the Cloud to the Mobile Uly 2019ser"***. Proceedings of the Third ACM Workshop on Mobile Cloud Computing and Services. ACM: 2936. ***doi:10.1145/2307849.2307858. hdl:1854/LU-2984272. S2CID 3249347.*** *Retrieved 4 July 2019.*

[20] **It's Time to Think Beyond Cloud Computing** Published by wired.com retrieved April 10, 2019

[21] Verbelen, Tim; Simoens, Pieter; De Turck, Filip; Dhoedt, Bart (2012). ***"Cloudlets: Bringing the Cloud to the Mobile User"***. Proceedings of the Third ACM Workshop on Mobile Cloud Computing and Services. ACM: 29 36. ***doi:10.1145/2307849.2307858. hdl:1854/LU-2984272. S2CID 3249347.*** *Retrieved 4 July 2019*

[22] Taleb, Tarik; Dutta, Sunny; Ksentini, Adlen; Iqbal, Muddesar; Flinck, Hannu (March 2017). ***"Mobile Edge Computing Potential in Making Cities Smarter"***. IEEE Communications Magazine. **55** (3): 38–43. ***doi:10.1109/MCOM.2017.1600249CM. S2CID 11163718.*** *Retrieved 5 July 2019.*

[23] Chakraborty, T.; Datta, S. K. (November 2017). "Home automation using edge computing and Internet of Things". 2017 IEEE International Symposium on Consumer Electronics (ISCE): 47–49. ***doi:10.1109/ISCE.2017.8355544. ISBN 978-1-5386-2189-9. S2CID 19156163.***

[24] https://searchdatacenter.techtarget.com/definition/edge-computing

[25] Q.Li,S. Meng,S. Zhang,J. Hou, L. Qi, Complex attack linkage decision-making in edge computing networks, IEEE Access 7 (2019) 12058–12072.
[26] W. Z. Khan,M. Y. Aalsalem, M. K. Khan, Q. Arshad, Data and privacy:Getting consumersto trust products enabled by the internet of things, IEEE Consumer Electronics Magazine8 (2) (2019) 35–38.