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RESEARCH ARTICLE

EDGE COMPUTING: THE PROMISES IT HOLDS AND MARKET DYNAMICS

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Abstract

The data driven societies pushes for more decentralized management to overcome data storage overhauls and faster transmission spreads in various data streams. As wireless technology is getting more advanced, there is a need to reconsider data hierarchical restructuring through edge computing, to pave the way for better latency, operation efficiency, speed, reliability, and versatility. Already, video and gaming technologies have benefited from edge technologies by streamlining their services delivery as well as boosting their revenue growth. However, lack of standard thwarts unified development and application of edge computing at global level due to defragmented standards. As such, enterprises that have already purged into edge computing such as AWS, Google and Microsoft need to embark on more collaborative approaches to ensure unified standards in edge computing developments.

Introduction:-

Even though computing system have highly relied on centralized data system in the last decades, emergence of data-driven technologies in the recent past have called for decentralizing network topologies to better the latency, speed, privacy, and reliability. With the increased deployment of IoT devices and rapid development of the 5G network, there is a seamless connection and need to place computing devices and analytics close to the point of data generation – a typical case of what edge computing is. Edge refers to geographical aspects or location, and hence edge computing is a distributed computing topology in which information processing near its end. That is, at a point where data consumer is based. In a typical case, edge computing brings computation nodes and data storage units close to system inputting devices rather than relying on centralized location, as in the case of cloud computing, thereby saving cost, boosting performance, increasing network scalability, performance and reducing latency issues.

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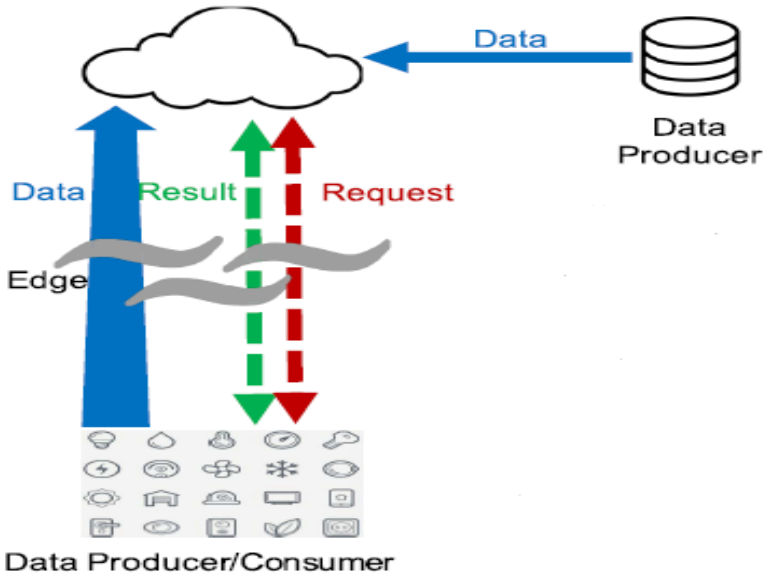


(Image source - IEEE Explore.com)

Driving Forces of Edge computing:-

Edge computing is becoming increasingly popular due to its five key benefits; scalability, versatility, reliability, security and privacy, and speed. Increasing data generated at the consumer ends creates congestion of data (compromised speed), increased data security, and lower operations efficiency. The rapid growth of IoT, mobile applications, and rapid growth of networks for various operations, overwhelms the traditional centralized networks, creating a need for a more scalable, secure, and reliable network. Thus, technologies with high data propensities like IoT, meteoric rise of mobile application, need of better efficiency in enterprise data managements are springboard to edge computing growth. Equally, development and maturity of the 5G network play a significant role in encouraging edge computing.A study conducted in North America(NA), Asia-Pacific(APAC) and Western Europe(WE) agrees that edge technology is a direct function of 5G roll out, need for reducing backhaul traffic, IoT and consumer use case pressures.

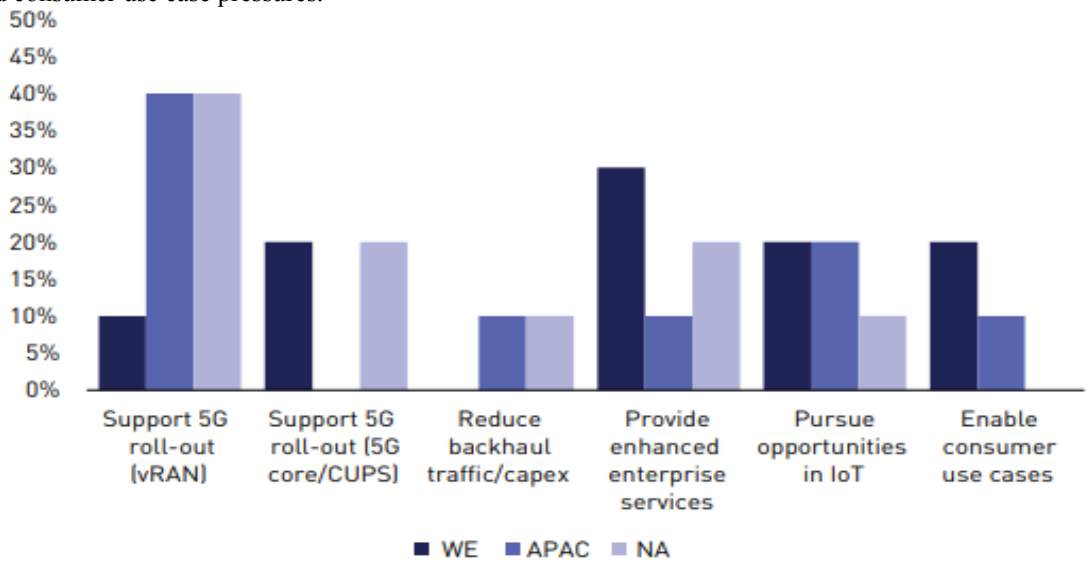


Figure Source -analysysmason.com

Edge Computing in Play:-

The business has already cast its nets wide to experience the benefits of edge computing. One of the most rocking business cases is the video gaming industry. Video developers like Konami Digital Entertainments (Pro Evolution soccer) and EA Sports (FIFA series producers) have developed PlayStation networks (PSN) that allow consoles to

connect for online gaming. Perhaps, esports are the greatest beneficiaries of low latency because network lag is a significant threat. PSN connects multiple devices at various nodes enabling streaming, gameplay, and opponent search among esports enthusiasts.

Content streaming, films, and TV production have benefited on edge technologies by enabling market segmentation for film streaming sites like Netflix. Initially, the Netflix suffered the setback of delivering content to its consumers due to the large volume but with edge computing, its deliveries to consumers have been made possible by on-location content distribution. Advertisements have also been the subject case of edge computing. Companies like Google divides the market into various segment – which provides accessible location bound ads. This means the management of ads is based on particular jurisdiction and not in the universal context. However, this is subject to history as other technologies like AI play a role in providing suggestions based on cache data or digital prints of users. Other existing business cases include; Telstra, Telefonica, Microsoft Azure, Google Cloud, and AWS Greengrass Edge computing service.

The best upcoming use cases include; autonomous driving, health care, AI virtual assists, space science, health, predictive maintenance, and intelligent cities. Space science, predictive maintained and autonomous driving is the most novel case. The recent venture of a space hotel and tourism will call for sophisticated edge computing system to relay information between ground and space station nodes(edges), eliminating wide bands of data as in case of traditional systems. In predictive maintenance, the edge can bring data processing closer to the machine for early detection and reduce the failure rate. Equally, the edge computing will help in the navigation of the autonomous vehicle by offering needed data from the nearby node other than from the central server.

Who is behind edge computing?

The global market for edge computing has a value of $3.6 billion is expected to grow at a CAGR of 34.1% to reach $15billionsby 2025.This is a contribution from different players who plays various role in software ,hardware and security development to make edge computing a real deal. According to Mordor Intelligence, the leading players in edge computing developments include; Microsoft Corporation, Google LLC(Coral), Huawei Technologies Inc., Amazon Web Services (AWS) Inc., and Dell EMC. With a high proliferation rate, major players like Microsoft, AWS, HPE, and Google remains the chief investors in edge computing. Microsoft alone rolled out a 4-year plan investment-worthy $4billions since 2018.

Each year, AWS, Microsoft, and Google injects a combined value of approximately $60 billion in edge computing developments, making them prime edge developers. Equally, Hewlett-Packard Enterprise (HPE) is expected to make a giant stride in its edge computing, with an estimated 70% of its data being on edge platforms by 2023.Other notable players include; Juniper Networks Inc., Foghorn Systems, Altran Group (Aricent), ADLINK Technology Inc., General Electric Company, Edge (MachineShop Inc.) while youthful entrants include;AlefEdge (2014), EdgeInfra (2018), German Edge Cloud (2019), Hangar (2018), Edge Gravity (2018), and MobiledgeX (2017).

	Service areas	amazon web services	Microsoft Azure	Google Cloud	Description
Global Cloud / Core	IoT services	• Machine learning • Kinesis • Data Pipeline	• Machine learning • Stream analytics • Power BI	• Machine learning • Stream analytics • Data warehouse	• Provides a preconfigured solution for monitoring, maintaining, and deploying common IoT scenario
	Cloud gateway	• AWS IoT	• Azure IoT Hub	• Google Cloud IoT	• A cloud gateway for managing bidirectional communication with billions of IoT devices, securely and at scale
Telco Network Edge	Bulk data transfer	• AWS Snowball Edge • AWS Snowmobile	• Azure Databox	• N/A	• PB to EB-scale data transport solution that uses secure data storage devices to transfer large amounts of data in and out of Cloud, at lower cost
Devices / On-premise aggregation & processing	Edge computing for IoT	• AWS Greengrass	• Azure IoT Edge	• Cloud IoT Edge • Edge TPU	• Managed service that deploys cloud intelligence directly on IoT devices to run in on-premises scenarios
	Real time data processing	• Kinesis Firehose • Kinesis Stream	• Event Hubs	• Cloud functions available for real-time processing	• Services that allow the mass ingestion of small data inputs, typically from devices and sensors, to process and route the data

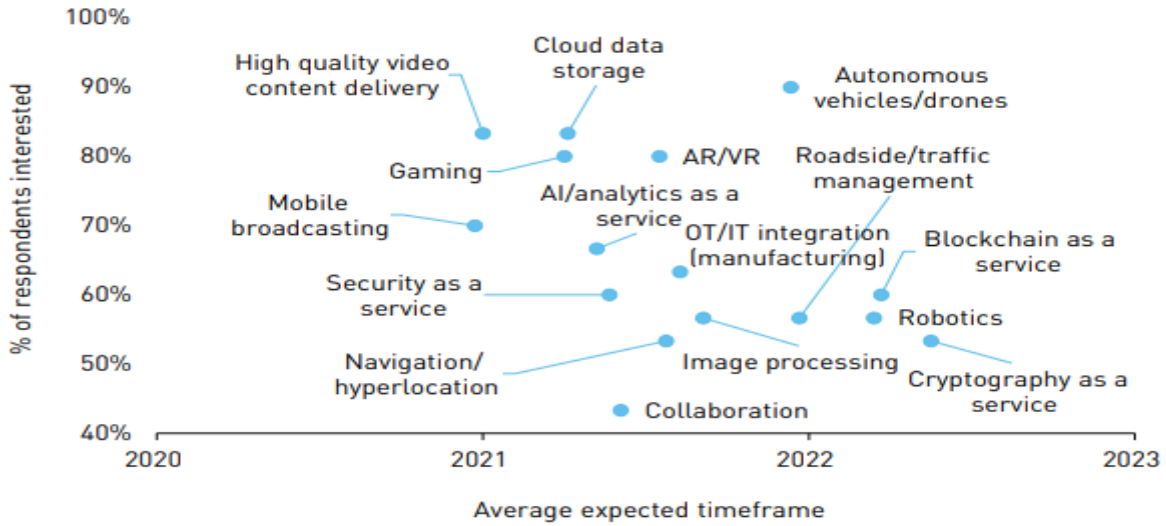
(Image source -Delta partners.com)

Most companies opt to invest early to capture the market at its early stages by controlling edge computing copyrights. For instance, due to earlier developments, Microsoft owns more than 60 patents in edge computing and related fields – this gives it a better competitive edge in edge computing markets.
Already, edge computing is threatening traditional cloud systems. Edge computing has already taken over videos and gaming mainstream and is expected to be implemented in robotics, cryptocurrencies, and blockchain by early 2022.

(Figure source -STL Partners.com)

Company	Facility	Hardware	Network	Cloud Infrastructure	Application /Software	Systems Integration	Funding $ Million
DataBank	x						410
vXchnge	x						405
Compass Datacenters	x						403.4
C3.ai					x		331
Docker				x			307.9
D2iQ				x	x		247.3
Mavenir					x		159.2
EdgeConneX	x						122
Big Switch Networks			x				119.5
Vapor IO	x						90
FogHorn			x	x	x		72.5
Iguazio					x	x	72
Qwilt			x		x		65.1
Zephyr (Vasona Networks)					x		36.6
Flexenclosure	x						35.9
Kontron		x					38.67
EDGE (DADI)				x	x		30
VANTIQ					x		28.3
Wirepas			x				20.4
Rigado		x	x	x			20.2
Golem					x		17.2
iExec					x		12
Litmus Automation				x	x		10.7
Swim.ai					x		10
ClearBlade			x		x		9.05
AirMap (Hangar Technology)					x		6.5
EdgeMicro	x						6
DartPoints	x						5.5
Crosser					x		5.2
Camgian Microsystems		x			x		1.6
Total	**8**	**3**	**6**	**6**	**17**	**1**	**3,098.72**

Roadmap of Edge Computing:-
Since edge computing doesn't rely on a specific company, there is no specific maturity timeline as most developmental progress is given as a projection of a particular period- thus cannot exhaustive or complete as it will need further analysis discussion and redevelopments. For example, blockchain and robotics are expected to be functional by the end of 2022. Other sectors are expected to mature at various timeframes (opinion-based).



(Figure Source **-analysysmason.com)**

The fact is that edge computing is collaborative is a continuous process of development that will continue over an indefinite period. However, if viewed in perspectives of sustainability, its roadmap can be considered to be in a matrix that addresses; security and privacy issues, real-time capacities, learning, and intellectual capacities, and management capacities against social, economic, and ecological sustainability.

Dimensions of Sustainability / Edge Computing Concerns		A Social Sustainability	B Ecological Sustainability	C Economic Sustainability
1	Security & Privacy Issues	(+) Fairness and social stability (-) Self-determination and personal freedoms	(-) Increase of energy consumption through security measures	(+) New business models supported by norms and regulations (-) Cybercrime
2	Real-Time Capabilities	(+) Responsiveness (-) Ubiquity	(+) Reduction of energy consumption through process optimization (-) Increase of energy consumption through data processing	(+) Competitive advantage (-) Stable control loops
3	Learning and Smart Capabilities	(+) Flexibility and autonomy (-) Bias on social groups, discrimination or exclusion of individuals	(+) Reduction of energy consumption through process acceleration (-) Increase of energy consumption through training	(+) Economy of scale (-) Data validity and quality
4	Management Capabilities	(+) Monitoring and traceability (+) Variability (-) Accessibility	(+) Monitoring and traceability (+) Use of renewable energies (-) Material consumption and recycling of devices and sensors	(+) Monitoring and traceability (+) Standards and interoperability

(+) Rather beneficial
(-) Rather detrimental

(Figure source-arxiv.org)

Standardization Progress of Edge computing:-

The edge computing ecosystem is extensive. A complete ecosystem is collaborative between various players. Close beneficiaries include application developers, blockchain technologies, IoT developers, and networking systems such as Cisco. Video games have already benefited from edge infancy, with autonomous vehicle developments likely to be better due to edge computing. Other vital beneficiaries include the health sector, fintech, and robotics. In general, edge computing technologies are collaborative and bound to extend in any industry.

However, its infancy especially in IoT developments derails unified development progress and collaboration among developers due to lack of standardizations. Most development and collaboration will rely on computer, network, and telecommunication standards maugre complexities and symbolism from multiple technologies deployed in edge computing- hardware, software, IoT, security, Artificial intelligence, and analytics. Nevertheless, there exist few specially designed standards for edge computing developments.

The Multi-access Edge Computing (MEC) is one of the most referenced standards in edge computing. MEC was developed by ETSI groups and help in defining reference architectures, edge computing management system, its application programming interfaces (API) standards, and a standard covering regulatory requirements. The ISO/IEC TR 23188:2020 standards advocate for sustainable edge computing developments, while DIN SPEC 92222 set standards for reference models for industrial edge cloud computing. Other notable set of standards are the IEC series of standards such as IEC 62541 and IEC 61499 (for OPC Unified Architecture and distributed programming controls, IEEE 1934, and 802.1(for Open Fog Reference Architecture for Fog Computing and Time-Sensitive Networking (TSN) Task Group related standards). The paucity of standards set for edge computing is problematic since there is no unified developmental path for edge computing. With edge computing cutting across hardware, software, data, and connectivity, there is a need to developing a specific standard that cuts across these critical areas. Reliance on existing standards will always result to chaos especially if different region adopts their standards. Edge computing lacks more extensive standards, and regulators need to focus on standardizing APIs, data exchange formats, resource descriptions, Federated identity and security policy APIs, and data storage and processing APIs for a better future of edge computing.

Conclusion:-

With a lot of developmental progress in edge computing, the greater success remains on standardization which in turns will dictate its rate of adoption. A more unified standards will ensure better interoperability of edge technologies by different consumers spurring its growth. Also, with better standards, organisation can collaborate and accelerate its adoption as well as reducing failures and loopholes that exist in edge technologies, particularly security and interoperability. Nevertheless, edge technologies are expecting to unrealism its full potential in various verticals at different timeline – which depends on standards, literacy levels and collaborations.

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