DIGITAL TRANSFORMATION AND TECHNOLOGY INTEGRATION WITH EDGE COMPUTING, 5G AND AIoTs

CMA (Dr.) Paritosh Basu
Senior Director (Sevices)
Stragility Consulting Pvt. Ltd.
Mumbai
paritosh13286@outlook.com

Introduction

One of the most cerebral political economists and philosopher Adam Smith (1723-1790) first posited his doctrine of 'Division of Labour'. This ground-breaking doctrine postulated that speed of economic progress would be faster with improved cost efficiency if the total work content for each result or goal to be achieved is divided into their recognisable component of tasks and distributed amongst doers according to their abilities. This fundamental principle of division of labour started being adopted by industrial organisations by splitting simple repetitive and homogeneous tasks and allocating those to individual workers according to the need for skill set. This obviated the need for one performer getting into next identified task after finishing the previous one by handling a different machines or tool. The big question that one can ask is, whether Adam Smith's doctrine of division of labour is equally applicable when jobs are done by ICT devices and whether distribution and allocation of computing job loads can improve efficiency and reduce costs.

With the overwhelming speed of computerisation riding on the power of internet since 1970s ICT systems of large enterprises and governmental network started proliferating. This caused convergence of various widely dispersed ICT systems into one ERP system and/or Platform in a centralised network infrastructure. From around the first decade of present century digital technologies started being adopted for designing solutions for business operations and services deliveries. This resulted in manifold increases in number of computing devices, including hand-held devices of customers and field level workers, Internet of Things (IoTs), etc.

To accommodate the resultant requirement for humongous data storage the world first witnessed private data centres, followed by proliferation of cloud computing both in private and public environment. This facilitated

Image Source:
https://www.wtrade.com/2021/05/3151/

handling of voluminous transactions for scalability with business continuity and growth, effective technology collaboration, shared facilities for storage, processing, etc. But the world of computing did not stop there. Innovative applications and adoptions of digital technologies kept on multiplying which in turn saw applications of IoT, IIoTs, and IoRTs, drones, blockchain, AI and ML. Readers may recall the author's paper on IoTs published in October 2020[1].

Such peripheral devices are required to connect and interact with each other, which in the given cloud computing system and architectural framework can happen via the central server(s). For example, in an integrated health care system doctors' and clinicians' devices like, smart stethoscope, ECG, radiography, condition monitoring devices, etc., and patients' medical devices fitted with IoTs and IoBs have to be integrated[2] for interactions at local level. Another example could be use of drones in a blockchain platform for agriculture or integration of other digital technologies as narrated by the author in his paper under this Column, published in May, 2022[2]. All these would suffer from latency in varying number of seconds if internet speed were of lower than expected or planned for. Moreover, due to the limitations of 4G communication technology and such centralised design need emerged for huge data storage in central servers. This also created enormous load for data processing by the central system.

In such a technologically troubled situation the old axiom, 'Necessity is the mother of invention' and Adam Smith's doctrine of 'Division of Labour' once again proved to be true. Scientists started working with ideas for off-loading the humongous computing burden of central servers by distributing and decentralising to relatively smaller servers at filed levels. This ushered in the era of Edge Computing (EC).

Objective

This article has been written keeping in view the single objective of bringing together the fundamental dimensions of edge computing system in a three-layer information and communication (ICT) ecosystem. It would briefly narrate various features of edge computing so that readers can familiarise themselves with this relatively new development in the ever-dynamic domain of digital transformation. This article will also examine how emergence of 5G technology and artificially intelligent of things (AIoTs) would provide the much-needed momentum for edge computing.

Genesis of Edge Computing

It is popularly believed that genesis of Edge Computing (EC) can be traced back to 1990s when Akamai Technologies Inc., a content delivery network company of the USA, took computing network geographically nearer to the point of service delivery where end users are located. Case in point is Automatic Teller Machines (ATMs) of Banks which were placed in populous corners of urban and semi-urban locations. Those machines relate to the central computing systems of banks through telecom network. Customers can access their savings bank accounts for drawing cash from the ATM or performing certain other transactions. These transactions are instantly processed by the ATM in collaboration with the central computing system of the bank.

This is considered as the very first application of edge computing. The next example is the network of geographically distributed servers which are used to accelerate streaming of web content for delivery to widely dispersed users. This is also called as content delivery network (CDN). Until mid of 1990s any common man could not even imagine that she/he would not have to stand in queues at the bank for withdrawing of cash from bank account.

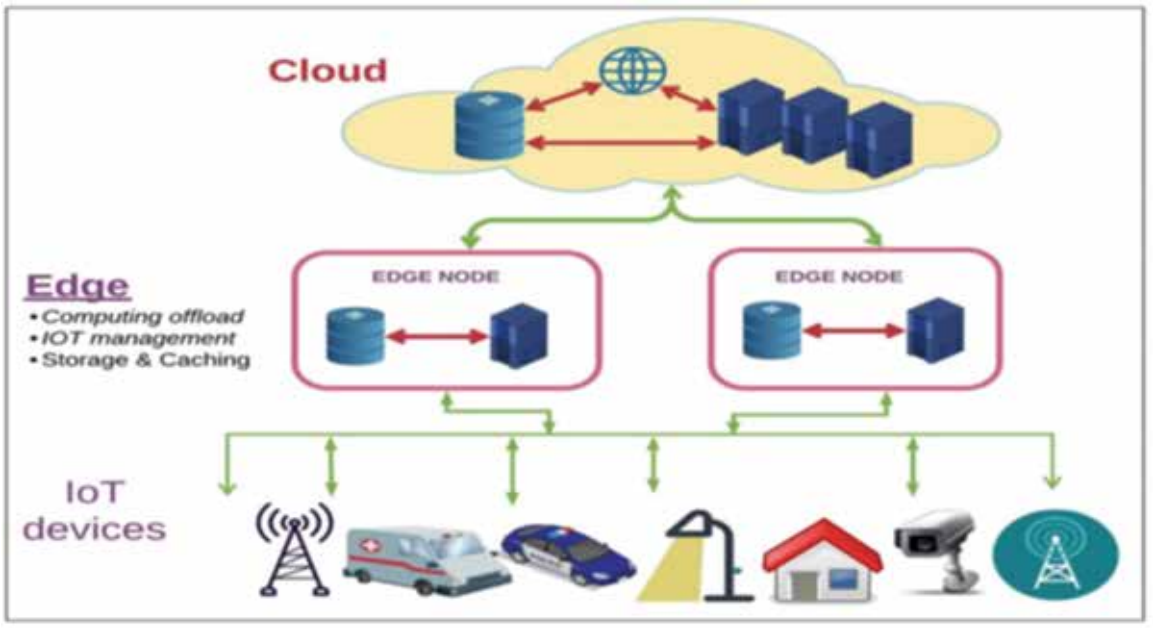
Edge computing, as an extension of cloud computing at the field level has received momentum from around 2015 when limitations of centralised cloud computing system started being observed by users of ICT ecosystems with operations spreading over wide geographical territories transcending sovereign boundaries. For some of those users the facilities for cloud computing and data storage may even be in different overseas territories. Edge computing system has transformed a common man's way of handling solutions, using the Apps on their smart phoned, created by innovative applications of digital technologies.

Definition of Edge Computing

Deloitte, UK[3] has in one of their recent publications defined edge computing as *"…… the decentralisation of computing that moves data processing from the core infrastructure, where computing processing traditionally occurs, closer to the person or item creating the data."* EC, therefore, takes advantage of smaller computing and storage facilities, which are available beyond and away from the central cloud computing and storage system by harnessing their processing powers instead of carrying everything to the central cloud computing system. It is widely accepted that cloud computing is suitable in cases where data generated by ICT and IoT devices at dispersed field levels, e. g., factories, warehouses, operating branches, etc. are relatively smaller and delay in transfer do not cause any fatal consequences.

This concept can be explained by the computing systems used for flying an aircraft which receives instructional and control signals from various external systems and emits digital signals from IoTs fitted in it. It also processes in its own system various flying related data being generated by its own operating

software coupled with external inputs. The concept of edge computing helps processing of all those signals at the ICT system of the aircraft instead to carrying forward to a cloud server. Processing those at the aircraft itself or at the nearest airport and reverting with instructions for the Pilot for manoeuvring the aircraft helps immediate response without any latency or delay. Readers can make out that latency in terms of a few seconds can prove to be fatal. Therefore, edge computing is essential in cases where real time processing is a paramount importance. Even the small computing device with a powerful processor, attached to a videography system, can also function as an edge computing node.



Source:
https://www.researchgate.net/figure/Hierarchy-of-Edge-Fog-and-Cloud-Computing_fig3_343859774

Readers can observe from the above graphics that at the bottom, or third level of the architectural design are the IoTs, including computing devices, sensors, actuators etc. attached to each object via which information are being connected from field level. These IoTs are also required to connect with each other and use/analyse the data generated/ collected. By introduction of Edge Computing Nodes (ECN), carriage of every transaction and related data to the central server is avoided. IBM[4] has provided the following definitions which may be found useful to appreciate the concept:

- Edge Device: *"An edge device is a special-purpose piece of equipment that also has compute capacity that is integrated into that device."*
- Edge Node: *"An edge node is a generic way of referring to any edge device, edge server, or edge gateway on which edge computing can be performed."*
- Edge Cluster or Server: "*An edge cluster/server is a general-purpose IT computer that is located in a remote operations facility such as a factory, retail store, hotel, distribution centre, or bank. An edge cluster/server is typically constructed with an industrial PC or racked computer form factor."*

According to a publication of Statista[5] the global edge computing market size by 2025 would be USD 274 Bln. 21.8% of the edge IT power footprint would be the share of mobile consumers by 2028 and Americas would be the largest edge computing Market.

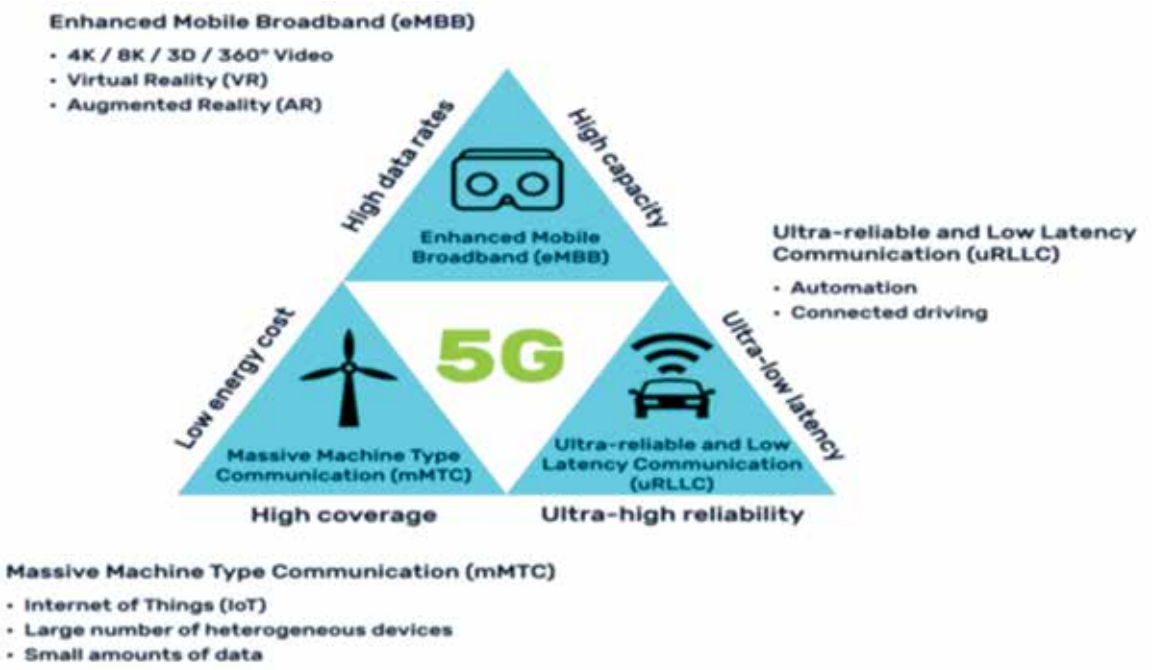
5G, AIoT and Edge Computing

Readers might have understood by now that cloud computing and EC are mutually exclusive in terms of work to be done based on orchestrated allocation as decided by the systems design and positioning of software and hardware. But given all these as they are, the second most important requirement for success is speed of carrying data through internet. While processing power and capacity of computing devices have gone many folds up, communication technology was found to be wanting and hindering speed of all computing activities for any wide area networked ICT ecosystem. Again, digital technologists also felt that Internet of Things (IoTs), which facilitates generation and collection of data, need to be also improved in terms of their own intelligence while participating as members of the ICT

ecosystem.

5G Technology

While revolutionary developments are taking place in this ever-dynamic Industry 4.0 era, digital transformation has entered a new paradigm called Web 3.0 success of which is dependent on effective implementation of EC. The author in his article of June 2022[6] under this Column, while covering digital assets and tokenisation, has introduced the concept of Web 3.0. One of the primary requirements for this is accelerated speed of mobile network. In this context 5G stands for fifth generation cellular telecommunication technology.



Source: https://www.myrasecurity.com/en/what-is-5g/

Readers can make out from the above graphics that the 5G version of mobile technology has many more high-end differential qualities over its predecessor 4G long term evolution version (4GLTE). The 5G version is superior in terms of energy savings and thus greener and environment friendly. It is powered with enhanced speed and higher capacity of broadband data carriage with extremely low latency. Thus, it promises for much higher degree of reliability, and superior coverage. However, 5G at its present stage of development, needs help of 4G network for establishing connection. Hence it is presently called as the non-stand-alone of 5GNSA version. All these qualities of 5G are ideally suited for successful applications of edge computing. The world is witnessing more innovative applications of EC riding on much improved performance and reduced exposure to risks due to reduction in latency. The author's research reveals that India is in advanced stage of indigenously developed 5G telecommunication gears, the pilot run of which has recently been successfully tested by IIT Madras.

Artificially Intelligent of Things (AIoT)

The two stand-alone digital technologies, viz., Artificial Intelligence and Internet of things (IoT) like wearable smart devices, digital assistants, industrial and medical sensors, etc. are by themselves doing wonders in various spheres of digital transformation. One can imagine what more innovations are possible if these two technologies can suitably be integrated and called artificial intelligence of things or AIoT. Bernard Marr, a digital influencer of international eminence, wrote in Forbes[7] journal the following about AIoTs,

" ..... *those devices can analyze data and make decisions and act on that data without involvement by humans. These are "smart" devices, and they help drive efficiency and effectiveness. The intelligence of AIoT enables data analytics that is then used to optimize a system and generate higher performance and business insights and create data that helps to make better decisions and that the system can learn from."*

The author wrote about such an artificially intelligent personal assistant 'Olly' in his article of September 21[8] under this column. Its maker has claimed that Olly would have versatile capabilities in terms of understanding the requirements

and personality of its master and assist accordingly. Therefore, the performance and versatility of one piece of Olly for say user X would be different from another piece of Olly being used by say Y. Because each piece would be able to appreciate the nature and requirements of their respective masters in course of time because artificially abled cognitive intelligence and self-learning abilities have been embedded into the device Olly. Hence capability of the software used in this AIoT is not unidirectional as is presently being seen in certain similar applications like that of Alexa by Amazon.

When such AIoTs work in a digitally transformed ecosystem, edge computing would further be facilitated because the AIoTs by themselves would first process data acquired by them and then pass on information to the connected EC Node for further processing. Therefore, load of data processing on the Node would further be reduced. This in turn would enhance speed of the entire ICT ecosystem as can be seen from the first graphic of this paper. IoTs, AIoTs as well as their connected EC Nodes, attached to large digitally enabled devices like drones, can be also integrated to blockchain platforms for both controlling and monitoring transactional data collections in a created safety net and exacting lots of performed deliverables. The author has ideated about such applications in his Kisan Blockchain Platform.

Sung-Ho Sim and Yoon-So Jeong in their research paper[9] has mentioned that *"AIoT edge computing has seen a surge in the amount of data as IoT devices have become popular in earnest, which has pushed cloud computing to its limits. To compensate for this, edge computing technologies have been developed, and .... critical data are processed in real time. Edge computing can guarantee three things: data load reduction, security, and fault response. ... In order to easily control a large number of locations of IoT devices, we perform cross-distributed and blockchain linkage processing under constant rules to improve the load and throughput generated by IoT devices."*

Risks and Benefits of Edge Computing

In the light of the above discourse the Taxonomy of edge computing can be grouped under the following six broad groups:

- Objectives,
- Computational Platform,
- Attributes,
- Use of 5G technology,
- Performance Measures, and
- Roles of Edge Computing in 5G.

Due to shortage of space the above are not being further analysed. Major benefits of edge computing also can logically be articulated from the above in the following lines:

- Significant reduction in latency which in turn reduces risks from delayed movement of data, processing, and on forwarding of information/ computed instruction for next action,
- Lower pressure on network due to avoidance of long-distance carriage to the central cloud computing system which in turn results in faster movement of data,
- Faster processing of data by division of processing loads to several EC Nodes and improved analyses powered by AIoTs which help faster delivery of results with logically crafted information/ inferences,
- Higher safety and privacy of sensitive data with reduced vulnerability due to over dependence on only one centralised cloud computing system,
- Improved disaster recovery and business process continuity management in the event networks and the central cloud computing system is disrupted for any reason whatsoever, and
- Integration of EC Nodes, IoTs and AIoTs with Blockchain platforms can render all possible benefits that blockchain technology offers.

Despite all these benefits edge computing system is not devoid of risks. Risk exposures can occur due to the following:

- The risks to which the main cloud computing system are exposed,
- The risks from vulnerabilities of the safety, security, and privacy related measures deployed for the entire computing ecosystem of which EC Nodes are parts,
- Vulnerabilities of use cases for which the edge computing system is deployed,
- Risk exposures arising from dependencies on and/or integration with third party systems,
- Legal and regulatory compliance related risks, and
- Risks of disruptions in services to which telecom service providers are exposed to even after implementation of 5G technology.

All these needs to be further researched on and can further be dealt with in some of the future articles if opportunities are available for writing more.

Conclusion

This article is the thirty-sixth piece to embellish this Column titled 'Digital Transformation' in a row since September 2019. Edge computing

technology is increasingly serving as the fountain of energy for acceleration in the pace of digital transformation by integration of many more digital technologies. Therefore, this article has been positioned at this stage. Readers would enjoy it if they were familiarised with some of the other digital technologies like Artificial Intelligence, IoT, Blockchain, etc. and integration thereof for applications in various industrial and service rendering activities. Reference of some of those earlier articles have been provided at appropriate places. The author will consider his efforts have met success if readers can gather first hand idea about edge computing and the added advantages it can provide in digital transformation when aided by AIoTs and 5G technology. MA

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