A survey of mobile edge computing in developing countries: challenges and prospects

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Abstract. Mobile Edge Computing (MEC) is a technology for mobile services. MEC integrates the cloud computing into the mobile environment and overcomes obstacles related to distance and the performance such as energy efficiency, storage, bandwidth, scalability and privacy in mobile computing. With the growing adoption of 5G technology, MEC offers a lot of technological and economic advantages to the developing economies amidst challenges associated with its implementation. This paper gives a survey of MEC, which helps every reader to have an overview of the concept and architecture of mobile edge computing. The challenges and prospects of its implementation in developing economies and the future research directions of MEC are presented.

1. Introduction
With the growth of embedded systems and high-speed wireless network connections, mobile devices are steadily becoming indispensable in our daily activities as communication tools are not bounded by time and space. A survey of joint radio-and-computational resource management in mobile edge computing was reported in [1-2]. Gathering the massive volume of the untapped computation power and storage space that abound at the network edges can provide sufficient capacities for performing computation-intensive and latency-critical jobs at end users’ devices. MEC stands out as a promising solution for prolonging battery lives of Internet of Things (IoT) devices. Specifically, computation-intensive tasks can be offloaded from IoT devices to edge devices so as to reduce their energy consumption.

MEC has evolved as a key driving technology for deployment of IoT and 5G visions [3-5]. It is imperative to closely study the fundamental requirements and prospects that will take the concept of MEC to reality. A comparison of traditional mobile computing systems with mobile edge computing that highlighted some complex challenges that emanate from diverse computing environment, dynamic network environment, and node mobility was carried out in [6-9]. In this paper, we discuss the application challenges and prospects associated with the design and deployment of mobile edge computing in commerce, education, internal security and precision agriculture. The paper offers readers a simplistic understanding of advances in mobile edge computing and shows how the technology can profit lower-and middle-income countries.

Cloud computing plays key roles in modern network architecture. However, Internet of Things (IoT) enabled devices offer exciting possibilities with the capacity to process collected data that are closer to the source and are informing IT frontiers to rethink their approach to IT infrastructure. In reality, IoT services can be easily deployed and accessible on MEC platform since MEC services are easily reachable by the mobile device users because of their proximity to the nearby servers [10]. Mobile edge computing is an emerging technology that provides cloud and IT services within the close proximity of mobile subscribers.
Mobile edge computing platform is aimed at reducing network latency by enabling computation and storage capacity at the edge of the network. [11-12] reported an investigation of technological advancements and its implication in the realization of MEC platform. Proximity and location awareness are the most important features of MEC. In MEC, more network devices will be equipped with massive computational power [13].

[14-15] presented a survey on recent advances in mobile edge computing and content caching, including the behavior of the caching system, caching optimization based on wireless networks and caching insertion and expulsion policies.

2. MEC Implementation
Implementing MEC in either high-income or low-income economies presents a lot of challenges. However, the challenges are more pronounced in less developed economies.

2.1 Challenges of MEC Implementation
Lack of incentives for network service providers, notable limitations of wireless networks. Research challenges in MEC gives researcher directions for further investigations.

2.1.1 Cost effective and Rapid Service Development. Users’ demands within the MEC network coverage is diverse within a limited time and different users request for different services. Variety in users’ requirement will lead to a corresponding rapid service change. Therefore, it is imperative to develop a cost effective and rapid service.

2.1.2 Standard Protocol. Standardization allows researchers and industries to work in an open environment based on a single agreement among the key players. Since MEC implementation is in its infancy, there is a need to create standards that support integration of conventional applications across the Mobile Edge Computing platforms. It is a challenging task to create a standard protocol for a new technology that would be generally accepted by the native and future stakeholders of such technology. Without loss of generality, creating standard protocols that can accommodate both the current demands on the network infrastructure and the future demands as the network scale up requires complex algorithms.

2.1.3 Resource Utilization Optimization. There is limited resource on the MEC server than the cloud server. Therefore, better performance can be achieved with the limited resources through resource optimization. The resource utilization optimization is a multi-objective function and varying users’ requirements, users’ demands, and different applications make it a challenging task to solve [16-18].

2.1.4 Mobility Management. Mobility of users on MEC network can lead to frequent disconnection of devices on the edge computing platform. Service quality of applications degrades in the moving state of connected devices due to variation in delay, bandwidth, and jitter.

2.2 Prospects of MEC Deployment
MEC implementation offers many advantages to the computing world. MEC will drive a major paradigm shift in the world of computing. This shift presents many socio-economic growth and business opportunities for small and medium scale enterprises to explore.

2.2.1 Convergence of Connectivity. The core of MEC system is located between wireless access point and wired network. There is significant enhancement of users’ devices performance as computation-intensive tasks are offloaded to nearby MEC servers in terms of battery life and latency [19]. Convergence of connectivity allows base stations to provide computation and communication services for better performance of the applications that run on the system [20].
2.2.2 *Increase Revenue for Service Providers.* Mobile edge computing provides a platform for deploying new services for mobile users. MEC allows the introduction of new service categories by the context-awareness of local network to enhance the features of services that are provided to mobile users. Increase in services also mean increase revenue for the service providers. As applications and services are deployed on the local network, traffic volume is reduced on the core network thereby reducing the operational costs of the mobile service providers.

2.2.3 *Reduced Cost of Implementation.* Since edge computing does not rely on a central location that can be farther away from the users, it brings data processing and storage closer to the collecting devices which implies that IT companies can save money through local processing. If Internet service providers spend less money on data processing, it means the end users of the services will also be charged less which will appear to be reasonably affordable for users in developing economies as a result of tremendous decrease in the cost of bandwidth.

2.2.4 *Security.* Though securing the edge server is challenging however, there is a high level of security in MEC. Since MEC computing is closer to the end users, it offers better privacy when compared to cloud computing.

2.2.5 *Academic-Industry Collaboration.* When it is difficult for research communities to gain access to industry and government owned infrastructure, researches and ideas cannot be easily validated and refined therefore, assumptions that would not transform to reality can be made easily [21]. However, established academic institutions that receive good relationships with industry and government stand to produce validated and impactful research outputs [22]. Mobile edge computing research can drive a consortium of partners in academia and industry.

![Figure 1. Mobile Edge Computing Architecture [22].](image)

Electronic commerce has become the choice of many business owners and daily online transactions add to the volume of traffic generation in the information superhighway. However, if node devices are equipped
with enough processing capacity to handle nearby requests, delay in processing becomes minimal and there will be great reduction in the bandwidth utilization of the global network.

A new normal of minimizing physical contacts to reduce the spread of acute respiratory diseases have come to stay. Of course some learning activities are done over the Internet before now but running some complex scientific and engineering simulations on the Internet requires special configuration of machines and high-speed processing devices for efficiency and accuracy. These can be achieved if computation is brought close to the users.

National security is a pronounced challenge that confronts many developing countries. As long as this challenge prevail, investors will find such societies unattractive for investments. However, MEC and IoT technologies can be deployed to tackle the security challenges through aerial surveillance, installation of high-quality sensors and cameras for fast data transmission. Any internal security system is classified as a time critical application and must be supported with devices with the capacity to process a large volume of data and return meaningful information in nanoseconds. IoT services are easily rendered on MEC platform.

Most developing countries with massive agricultural production potentials can grow their production with the adoption of precision agriculture which will in turn contribute largely to the nation’s gross domestic product (GDP). Challenges surrounding food security can be speedily addressed by smart farming techniques which can be achieved with IoT and MEC implementations. IoT powered devices such as robots, drones and other sensor can be used to monitor major farming activities which can help to identify early changes, help farmers to monitor the growth and other major developments with the production cycle. This technique can stabilize farming operations and facilitate the migration of subsistence farming to commercial/mechanized farming that will place the GDP of the country on a growing curve. New opportunities brought about by IoT in the context of precision agriculture include crop monitoring, weather forecasting, predictive analytic among others with the goal of increasing yields and build investment.

The applications of IoT in precision agriculture comes with functions that support the monitoring of crop growing environment such as humidity, temperature, soil pH level and many more to increase productivity, profitability and efficiency in diverse agricultural production processes. A technology such as sensor unit is needed to build any agricultural environment for increased productivity.

Mobile Cloud Computing (MCC) is the merger of cloud computing in the mobile environments. But MCC faces major problems when many mobile devices are requesting for access simultaneously (which will become a significant problem for the next generation of mobile networks [24].

3. Resource Allocation and Modeling in MEC
Sensitivity of applications’ request considering resource types, time variation in their demand for resources and space, capabilities of the available compute resources and QoS requirements are major factors that constitute resource allocation problems in MEC platforms.

3.1 Application Modeling
MEC provides services to a wide range of applications. Therefore, resource allocation has to be modeled in a way that it will capture application variations with respect to resource type, time and space. Resource demands of an application can be modeled in terms request quality which is the number of resources such as bandwidth and computing power that are required to serve an application's request. Modeling request quality provides an insight into the resource type and the quantity of capacity that will be needed to handle an application's requests in order to satisfy the application's key performance indicators at a given time.

An application's resource demands can also be modeled in terms of request variation that corresponds to the distribution of the number of requests that are received per unit of time and possibly per region of space. Request variation is modeled in terms of time and location. Request variation and request quality can take place at the same time. For instance, the distribution of users across the banking networks may vary across the day and the access point locations. Periodic or non-periodic variations are experienced by diverse applications such as web applications in the resource demands over time. For example, Wikipedia servers experience periodic increase in workload [25]. More so, external events significantly affect the
resource requirements of some applications [26]. For example, a major sports season attracts a large number of people to a specific location, which has the tendency of consuming higher resource requirements within that location for some applications.

3.2 Infrastructure Modeling

There is a steady increase in the number of IoT connected devices in recent times. The rise in numbers in the network space poses the challenges of low communication latency and consistent performance requirements to IoT-enabled applications. MECs are proposed to provide access to information superhighway, storage and network resources as close as possible to IoT devices and end-users [27]. Infrastructure modeling concerns in MEC include computing, storage and bandwidth capabilities of all data centers. Infrastructure modeling also includes cost models based on the capacities of the computing, bandwidth and storage units.

3.3 Computation Offloading Modeling

Offloading is an effective method that executes some components of applications remotely (e.g., on the server in a data center or in a cloud) for the purpose of extending the lifetime of mobile devices. Offloading algorithms are therefore required to determine which software components to execute remotely in any given wireless network connectivity [28].

Connectivity may change from place to place, and the data transmission bandwidth (i.e., the uplink and downlink) fluctuates due to multiple factors (such as mobility, weather and channel fading) [2].

MEC server is computationally different from offloading scheduling to another device. Key parameters for consideration include offloading link capacity, CPU cycles, energy consumption, cache size, etc.

4. Conclusion

IoT devices generate volume of data every day. The computation demands on this volume of data cannot be efficiently covered by traditional cloud architecture anymore. The primary objective of Mobile Edge Computing is to provide application and services with less latency and minimum bandwidth. In this paper, we have presented a survey on the evolution of MEC computing. In the survey, we have highlighted the benefits and open research challenges in MEC. In the future, we plan to design task offloading mechanism and simulate the framework. We foresee emerging economies migrating their local businesses to edge platform to stimulate their economies and grow their GDP.

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