Monetizing IoT: Enabled via LTE Broadcast

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***Abstract* - This paper proposes the mechanisms for Communication Service Providers (CSP) to boost the M2M/IoT monetization, enabled via upcoming Long Term Evolution (LTE) broadcast technology. LTE Broadcast will play a crucial role in delivering the multimedia services efficiently to smart devices (sensors, connected vehicles, smart phones) for long range communication including mission critical services. Relevant contents can be positioned strategically across different network nodes and accessed in an optimized manner to provide economical delivery model for business to business (B2B) and business to consumer (B2C) ecosystem. This paper further suggests mechanisms by which operators can monetize the cached data in the network by providing economical charging plans to the end customer. LTE broadcast based commercial deployment has already started since 2014 and is gaining traction across different verticals enabling reduced expenditure and providing enhanced customer experience.**

Keywords-LTE Broadcast;Content Caching;Internet of things (IoT);Communication Service Provider;Mission critical services, etc.

I. INTRODUCTION

There has been tremendous growth in data traffic, particularly multimedia contents, over mobile broadband networks in the last couple of years. This growth has been fueled by the increase in the number of users and variety of applications delivering multimedia contents e.g., movies, songs, sports, video on demand etc. In addition, launch of smart devices with higher media capabilities, and advancements in 3G/4G technologies have further complemented this growth.

The mobile networks are constantly evolving to cater to the needs of new business models across different services. For example, LTE Cat-M1 or LTE-M as it is commonly known and Narrow-Band IoT (NB-IoT) emphasize on low bandwidth communication while LTE Broadcast enables high speed multimedia content delivery e.g., live Sport events. LTE network architecture is further evolving to support Machine to Machine e.g., M2M/IoT communication so that billions of new devices can be connected to support IoT specific use cases. While LTE-M/NB-IoT primarily focuses on low power/cost and low bandwidth communication requirements, LTE Broadcast enables delivery of contents to millions of devices in an efficient and cost effective manner.

Multimedia Broadcast Multicast Services (MBMS) is a point-to-multipoint unidirectional service in which data is transmitted from a single source entity to multiple recipients. The MBMS service offers two modes: Broadcast mode and Multicast mode. Broadcast mode is supported for LTE and 3G, and Multicast mode is supported for 3G. The specification is referred to as Evolved Multimedia Broadcast Multicast Services (eMBMS) when transmissions are delivered through an LTE network. eMBMS is also known as LTE Broadcast. This paper will emphasize on LTE broadcast as it is upcoming and will act as a baseline technology for future deployments.

The multicast services can only be received by those users which have subscribed to that specific service and are part of the multicast group associated with the service for 3G subscribers only. Both broadcast and multicast services across 3G/4G technology are unidirectional, point to multipoint transmissions of multimedia content and involve transmission of text, audio, video, pictures, emergency alerts like Tsunami warning, firmware upgrade of sensors/devices associated with smart meters/homes/cities, Live Streaming of sports event etc.

For delivering multimedia content to the multiple users, LTE Broadcast (eMBMS) is technically positioned as more effective and efficient technology than ubiquitously used unicast mode for data communication. This technology further optimizes the network resources to reduce the overall operational expenditure and exploits the network for mission critical activities. Moreover, LTE Broadcast could be instrumental in maximizing the network utilization including radio interfaces. LTE broadcast services enable delivering content in densely and crowded location efficiently and therefore free up the capacity for other services including voice services, proximity services, etc.

LTE broadcast has the potential to lead to commercial pay-per-view TV channels from mobile operators. It could also enable many more use cases, including the delivery of device updates to smartphones and tablets, distributing data to connected cars or broader IoT applications including important emergency alerts. The operators can either create their own services or enable the delivery of third party services via Application servers (as suggested by 3GPP specification in Release 13 or onwards).

In this paper, we will propose new mechanisms that CSPs can use, by leveraging on LTE Broadcast technology along with innovative caching techniques. CSPs can adopt differential charging for their customer based on the location of the content which the customers are accessing. We also suggest in the paper, about the benefits of having a content registry node in the network which can greatly reduce the signaling needed to update all cached data in the network.

The remainder of the paper is organized as follows: Section II describes LTE Broadcast Network Architecture details along with major network nodes in the system. Section III deals with various caching mechanisms used in the network. Each caching mechanism has its own pros and cons. We will have a detailed look on them and propose ways to monetize LTE Broadcast services in the network along with some real-life examples in Section IV. We conclude our paper in Section V.

II. LTE BROADCAST/eMBMS NETWORK ARCHITECTURE

Content via LTE Broadcast is delivered by collaboration of three core network elements. eMBMS is realized by enhancing capabilities of existing functional entities of the 3GPP architecture and by addition of new functional entities like BM-SC node [6].

A. Broadcast Multicast Service Centre (BM-SC)

The BM-SC provides functionality for MBMS related user service provisioning and delivery. Typically, it serves as an entry point for content provider, used to authorize and initiate MBMS Bearer services including schedule and delivery management. Typically, the multimedia content for MBMS is placed outside the core network. The BMSC schedules the MBMS session and is also responsible for monetizing the services enabled via offline and online charging interfaces.

B. Multimedia Broadcast Multicast service Gateway (MBMS GW)

Another new network element is the MBMS-GW, which provides the gateway functionality between the radio and service networks. It forward streams from the BM-SC to all participating eNodeB in the single frequency network (SFN) transmission. MBMS Gateway (MBMS-GW) delivers MBMS traffic using IP multicast to multiple cell sites in single transmission. SFN technology is used to distribute broadcast streams into well-defined areas – where all contributing cells send the same data during the same radio time slots [4].

In general, LTE broadcast can deliver multimedia content to a broad area, ranging from a shopping street to a part of city e.g., in case of sporting events, musical concerts etc. but can also be extended to entire network covering many cities e.g., emergency alerts etc. The size of broadcast area is often decided by the type of content and the intended audience.

C. MCE/MME

Multi-cell/multicast coordination entity (MCE) is responsible for administration of radio resources for MBMS to all radios that are part of the MBMS service area. The same is not explicitly highlighted in the diagram below. The mobility management entity (MME) performs the MBMS session control signaling including session start, update, and stop, as well as delivering additional MBMS information to the MCE including QoS and MBMS service area.

With the wide deployment of Content Distribution Networks (CDNs), delivery of multimedia content to the users has been optimized to some extent. Deployment of CDNs has reduced the backhaul issues faced by Communication service providers. Additionally, with different caching mechanisms, operator can further cache the content from CDN or external servers within the operator's network for enhanced content management. This will further reduce the dependency and latency introduced by accessing content external to the operator's network. Fig. 1 below provides the network architecture for LTE Broadcast network.

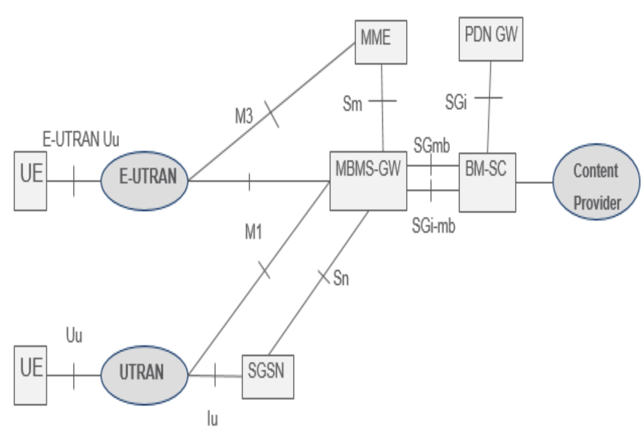

Figure 1. Reference architecture for Evolved Packet System with E-UTRAN and UTRAN (MBMS Broadcast Mode only) 3GPP 23.246

III. CACHING MECHANISMS

Caching is a mechanism to store the content for future or simultaneous requests enabling faster access. Content stored in the cache might be the result of an earlier access or copy of data available in the network.

Caching, in general is extensively used in IP and telecom networks for faster access of relevant content. Typically, the contents were stored and accessed from content providers network which was external to the operator's network. Due to ever growing demand for multimedia content, operators were forced to devise innovative ways to deliver contents which reduces network load and provides superior customer experience. LTE Broadcast services provide an effective method to deliver content to multiple users. LTE Broadcast, complemented by caching techniques could further optimize the network resource utilization, which could be used by other real time services such as Voice over LTE (VoLTE) services.

Deploying caches in mobile networks is regarded as a promising way to improve user experiences and reduce the signaling within the network nodes as data traffic is expected to increase many folds in future. Caching within the network can be done on different network nodes e.g., Radio Access Network (RAN) nodes or core network nodes. Caching on RAN nodes has more advantages in comparison to caching on core network nodes in terms of reduction of back-haul traffic and improvement of user experience, since contents can be retrieved at base stations. Content can also be pushed to the cache of user equipment and the user is provided a preview of the content. Caching reduces the cost of content delivery by optimum usage of radio and network resources, which can be utilized for other critical communications.

There are multiple caching techniques which can be implemented to reduce response time and network latency as described below:

A. Core Network Caching

In LTE networks, core network caching is typically deployed at the packet data network gateway or the PGW, within the evolved packet core (EPC). For LTE broadcast, this content can be cached at eMBMS core network nodes e.g., BM-SC and MBMS GW [1]. These cache servers offer huge data storage capacity and store content that is popular among large number of users. Caching at core network nodes reduces the uncertainties of latency and remote server response times towards content provider network, outside operators trusted domain. When a popular content is found in a networks cache, this information is no longer obtained from the content provider. This reduces the traffic between the EPC and the content providers, thus reducing the bandwidth and cost of the Internet connection.

B. RAN Caching

RAN caching position the content towards the edge of the network typically at RAN nodes. With caching at core network nodes, multimedia content still need to navigate through the backhaul links of an LTE network. For LTE broadcast RAN caching, the contents are cached at participating eNodeB (enabled by SFN). LTE macro, metro and pico base stations are ideal platforms to incorporate RAN caching because of their all-IP architecture and their proximity to the end user.

By positioning contents at multiple eNodeBs, backend signaling is considerably reduced. Since backend signaling and transport costs are often the largest parts of the LTE network OpEx, the savings can be remarkable [5][9]. Technical artifacts are already available suggesting different cache techniques at RAN level, cache content management (e.g., replicating the cache contents across eNodeBs), etc. and further enhancements are ongoing. One of the well identified use cases in IoT domain includes small amounts of non-critical data transfer to multiple IoT devices. Typically, Firmware updates for connected vehicles, smart meters, etc. are initiated simultaneously which might lead to network and RAN congestion. Connected cars require firmware updates and typically need to be downloaded while the cars have the ignition on typically during morning hours. LTE network can push the firmware updates to participating eNodeB at non-peak time (or night) and same can be broadcasted from eNodeBs to all the participating connected cars simultaneously. RAN caching techniques can support the above and other relevant IoT based use cases efficiently, releasing the bandwidth for LTE network for critical and real-time communication like VoLTE.

C. User Equipment (UE) Caching

Content can also be cached in user equipment, thereby providing fast access to popular videos, news, songs etc. When the network is comparatively less utilized, multimedia content is typically pushed into the cache memory of the User Equipment (e.g., Smartphone). User is provided with a preview of the content and the ability to purchase the content, if interested. In case the user does not purchase the content, then the content is purged from the cache memory and the user is not charged for the downloaded multimedia content pushed by the operator [3]. Artificial Intelligence (AI), along with customer experience management, will play a major role in providing the contextual analysis on user's behavior and preferences. Additionally, utilizing the network when it is less loaded will further support operators to monetize existing infrastructure and reduce busy hour spikes in the network. Events relevant to the geography, linguistics or global events like Olympic games highlights are some of the use cases where content can be pushed by operator to multiple users based on machine learning algorithms e.g., historical behavior.

Research is also ongoing on collaborative caching [8] e.g., caching at EPC and RAN to reduce costs and support more requests compared with existing caching schemes when fetching dedicated contents.

Table II gives the main differences between different caching mechanisms as explained in Section III.

TABLE II . TYPES OF CACHING IN NETWORK

	Core Caching	RAN Caching	UE Caching
Content Placement	Content is placed within EPC	Content is placed at eNODEBs	Content is pushed to UEs cache
Size of cache	It's generally tera bytes of cache.	It's few Giga bytes of Cache	The content size could vary from few KB to few MB
Benefits	Bandwidth and cost to ISPs are reduced for the operator	Backhaul signaling and transport cost is reduced	Reduction in busy hour traffic by pushing the content to UE at non-peak period.

IV. MONETIZING LTE BROADCAST SERVICES

Commercial deployment of LTE broadcast had been initiated few years back primarily in 2014. LTE broadcast technology was demonstrated during Global events like XX Commonwealth Games in Glasgow, FA Cup final UK, Super Bowl XLVIII in US. Tier-1 Operators like Verizon have commercially launched their Go90 service including both On-Demand and LiveTV offerings. LTE Broadcast alliance was formed in Apr 2016 include global operators and Vendors like Verizon, KT, Reliance JIO, Ericsson, Netgear, etc.

Operators must leverage upon the caching techniques discussed above and develop methods to boost the monetization of LTE Broadcast offerings to create mutually beneficial business models for operators and end customers. CSPs should enable differential charging mechanisms based on the content location, providing economical offering for (cached) contents to the customers. End customer should be charged based on location of the content and the network resource utilization for offered services from CSPs [2]. Operators can further exploit the content location information indicating the content location, as determined by the requested multimedia content, and sending the charging-related information to the charging node in the network. The charging-related information enables differentiated charging by the charging node.

In LTE Broadcast architecture, BM-SC node is responsible for generating the charging event towards Charging Data Function (offline) and Online Charging System (Online) node depending upon the Rf/Ro Interface [7]. Charging information generated by event produced by BM-SC nodes are S-BMSC-CDR and C-BMSC-CDR for subscriber and content provider charging respectively. For every MBMS bearer, the BM-SC would be aware of the location of multimedia content either through communication with MBMS-GW or a Content Manager. If the content is available in the internal cache or externally, BM-SC sets up the content location to a predefined value for each of the cases representing the logical location of the content cache e.g., device, eNodeB, local network provider, external content provider. Fig. 2 below provides the network architecture for LTE Broadcast network along with content Registry node which will contain the information regarding the cached content in the network.

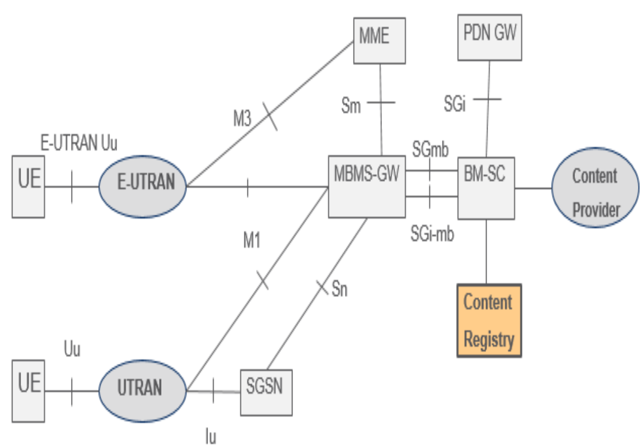

Figure 2. Introduction of new logical entity named Content Registry in LTE Broadcast architecture

We propose that BM-SC node should maintain a content registry (logical entity), that should keep the details of all the content which are cached at different core and RAN nodes. On signaling level, BM-SC would query each eNodeB periodically or eNodeB could send the information on the control plane to BM-SC regarding the content location so that BM-SC has the most updated information available in Content Registry. Information from Content Registry module would further be populated with “Content Location Information” while charging event would be generated from BM-SC towards the charging interface to OCS and CDF module.

Differential charging e.g., charging based on the content location provides CSPs a mechanism to minimize the dependency on content providers for multimedia content. The most watched movies, sports videos, events can be cached locally by the operators thereby offering economical rates to the subscribers.

Content location based charging would encourage the subscribers to use the locally cached content leading to efficient use of the network. This would in-turn result in lower Cap-Ex and Op-ex. Additionally, empowering subscribers with multiple as well as economical options for consuming multimedia content would lower the churn rate.

V. CONCLUSION

IoT’s evolution has been closely linked and complemented by the evolution of the mobile communication and Internet to enable a connected world. To enable faster IoT adoption, LTE Broadcast services will further support to monetize service models across B2B and B2C domain. For B2B segments, CSPs will support IoT offerings across multiple domains e.g., firmware/OS upgrades for IoT enabled equipment’s like health monitoring devices, smart home devices and sensors. Additionally, LTE broadcast will play a major role in broadcasting public safety communication for emergency as well as routine updates like traffic snarls at highways, extreme weather warnings.

CSPs can further optimize their offering in existing B2C ecosystem by streaming multimedia contents like Live events, next generation TV services, internet radio, video on demand providing enhanced user experience. LTE Broadcast enables the operators to charge premium rates for premium content with guaranteed quality, knowing that they can deliver always, no matter how popular any certain live event or media offering may become. This certainly allows the operators and its media partners to offer new services without the fear of congestion or failure to deliver to its customers. Additionally, the paper suggests innovative delivery model for proactively advertising the information cached at various nodes and promoting economical charging use cases.

The capability and the flexibility enabled by LTE Broadcast is a very powerful tool for operators wishing to embrace and evolve the non-traditional business models spanning across IoT offerings and media content delivery.

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