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# Comparison of Multiprotocol Encapsulation, Unidirectional Lightweight Encapsulation and Generic Stream Encapsulation Protocol

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***Abstract* - The successor of Digital Video Broadcasting for Satellite systems (DVB-S) is the broadcast standard for television, the Second Generation- DVB-S2. The available encapsulation options are MPE and ULE for first generation as well as second generation. The model provides support to fixed size TS packets. The compatibility to BaseBand Frames(BBFs) is provided by GSE for DVB-S2 links and this native method(GSE) declines the double overhead of BBF Encapsulation. Transmission of fickle-length network layer (IP) packets over satellite links with fixed frame lengths requires IP encapsulation. This survey paper presents these three encapsulation protocols for DVB-S2 and the paralleling of MPE, ULE and GSE, representing their manually calculated efficiencies to refer to theoretical efficiency simulations.**

***Index Terms* - MPE, ULE, DVB-S2, Encapsulation, BBFrames, GSE**

## I. INTRODUCTION

DVB-S2 (Digital Video Broadcasting-Satellites 2nd Generation) is the second-generation DVB specification, developed on the success of the first generation specifications, DVB-S for broadcasting and DSNG for satellite news gathering services. It has been designed to facilitate broadcast services for TV and HDTV, Interactive services for consumer applications and Professional applications like news gathering, Internet Trunking. The DVB-S2 standard has been specified around three key concepts: best transmission attainment, total flexile and reasonable receiver complexity [1]. It include features of channel coding (adoption of LDPC codes), modulation up to 32APSK, additional code rates, introduction to generic transport mechanism including MPEG-4 supporting backward compatibility with existing MPEG-2 Ts based transmission. It results in 30 % capacity increase over DVB-S under the same transmission conditions. In addition, for broadcast applications, DVB-S2 can deliver significantly higher bit rates over high power satellites, thus increasing capacity boost with respect to DVB-S. Furthermore, when used for interactive applications (IP unicasting), the gain of DVB-S2 over DVB-S is even greater.

MPE(Multiprotocol Encapsulation) is an IP carriage but not native to DVB where as the Generic Stream Encapsulation enables IP natively on DVB. This paper provides features of these protocols and there importance along with the advantages of one over another. The protocols considered for this assessment are on one side MPE/MPEG-TS and ULE/MPEG-TS and Generic Stream Encapsulation (GSE) on the other side to represent the future generation of encapsulation protocols. Finally conclusions are drawn based on the theoretical evaluation and practical assessment results.

## II. MULTIPROTOCOL ENCAPSULATION OVER DVB-S SYSTEMS

MPE is data link layer protocol used for carrying IP packets where datagrams are encapsulated in datagram_sections which are compliant to the DSMCC_section format for private data [ISO/IEC 13818-6 (3)]. There is 12 byte section header before payload and a 4 byte CRC/Checksum at the end with optional stuffing bytes. For non-IP payload type there is 8 byte LLC/SNAP header. This LLC/SNAP structure shall indicate the type of the datagram conveyed. If this flag is set to "0", the section shall contain an IP datagram without LLC/SNAP encapsulation. The sections are packed in TS cells and the PUSI bit of TS header is set to indicate the start of new section in the TS cell. MPE Streams may be identified by the stream_type value of 0x3e9 [ATSC-REG] in a SI/PSI Table [ISO_MPEG2]. This information allow Receivers and Re-multiplexors to locate a specific MPE Stream (i.e., the PID value of the TS Logical Channel that carries a MPEStream) [2].

It has the IP/MAC platform concept: An IP/MAC platform represents a set of IP/MAC streams and/or receiver devices. Such a data platform may span several transport streams within one or multiple DVB networks and represents a single IP network with a harmonized address space [3]. The IP/MAC platform concept allows for the coexistence of several non-harmonized IP/MAC address spaces on the same DVB network. Note that several non-harmonized IP/MAC address spaces (IP/MAC platforms) may co-exist on a single transport stream. To handle information about IP/MAC streams within DVB networks it defines IP/MAC Notification Table (INT) to provide a flexible mechanism for carrying information about the location of IP/MAC streams within DVB networks. Through the use of a flexible syntax, extensive targeting and notification descriptor mechanisms, the table can be easily extended to cover additional requirements in the DVB IP/MAC domain.

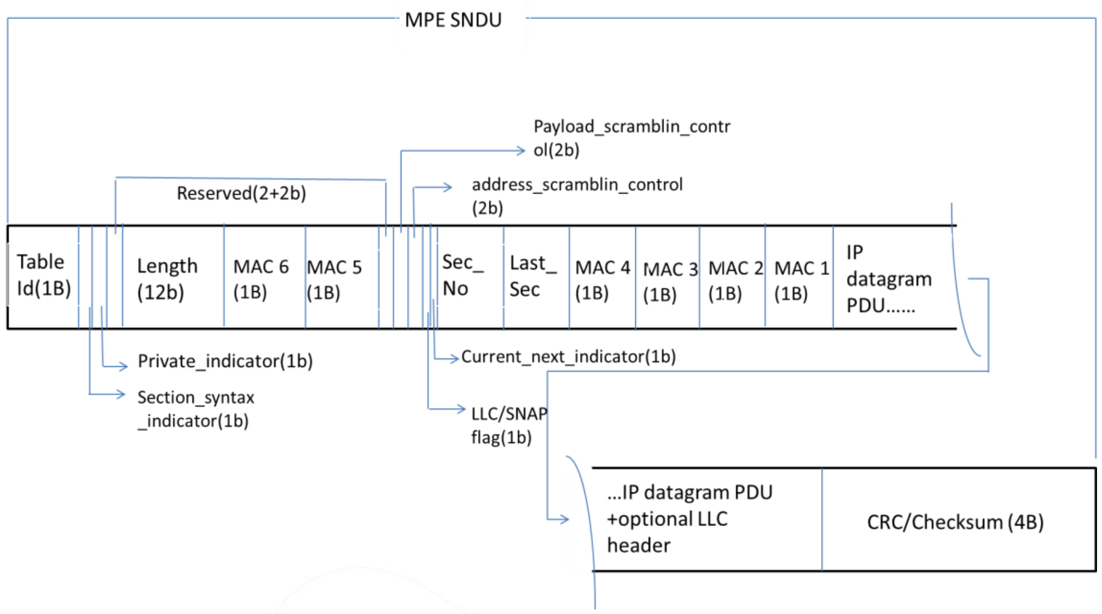


Fig. 1 Header format of Multiprotocol Encapsulation Protocol

### III. ULE ENCAPSULATION OVER DVB-S SYSTEMS

The Unidirectional Lightweight Encapsulation (ULE) is a new surrogate to MPE, providing simplicity, organizability and efficiency. The name itself clears out the feature of the protocol that it is feather weight since its header structure is simpler to parse and process. A comparative performance evaluation, carried out through modeling and also through real-life tests in a dual-protocol, is shown in [4]. A state-of-the-art solution for efficient DTV broadcasting was proposed and implemented, using MPEG-4/H.264 over IPv6 and ULE. The configurability, simplicity and efficiency introduced by ULE gives it a significant advantage over its predecessor and strengthens its wide adoption, especially in the cases where the cost of migration is negligible.

ULE appliances the transport of IPv4, IPv6 Datagrams and other network protocol packets directly over the ISO MPEG-2 Transport Stream as TS Private Data [5]. It has an encapsulation format along with extension format to carry additional header information that assists in receiver processing. The Ethernet Frames, IP datagrams or other network layer packets are the Protocol Data Units , passed to Encapsulator. It summates an encapsulation header and an integrity check trailer. PDUs (IP packets, Ethernet frames or packets from other network protocols) are encapsulated to form a Subnetwork Data Unit (SNDU). The SNDU is fragmented into a sequel of one or more MPEG-2 Transport Stream (TS) Packets that are sent over a single TS Logical Channel. The SNDU is transmitted over an MPEG-2 transmission network either by being placed in the payload of a single TS Packet, or, if required, by being sliced into a series of TS Packets. Where there is aplenty space, the method permits one TS Packet to carry more than one SNDU (or part thereof), a practice sometimes known as Packing. If a Payload Unit (SNDU) finishes before the end of a TS Packet data, but it is not intended to outset another Payload Unit, a stuffing procedure (known as Padding) fills the remainder of the TS Packet payload with bytes with a value 0xFFAll. TS Packets having SNDU must be assigned the same PID, and so it forms a part of the same TS Logical Channel.

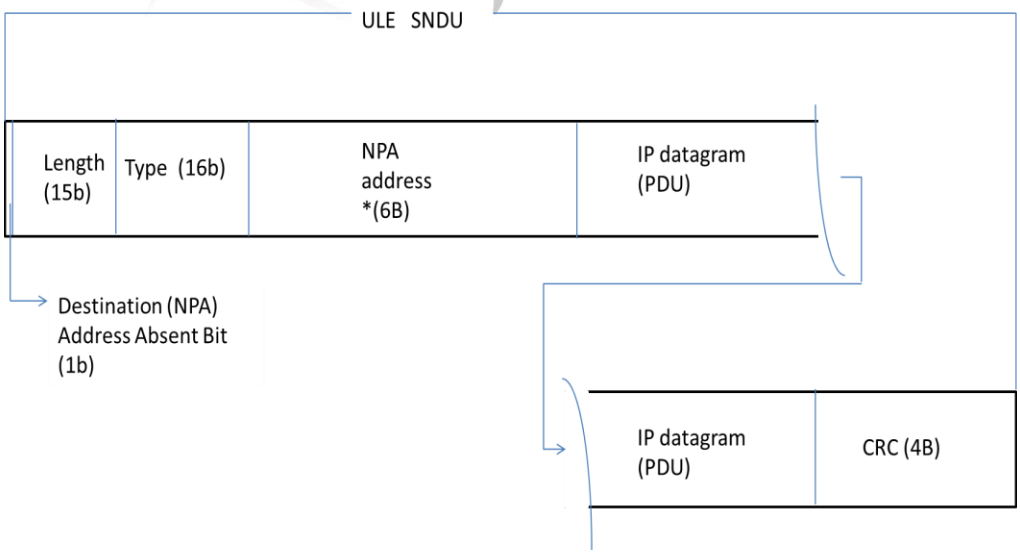


Fig. 2 Header format of Unidirectional Lightweight Encapsulation Protocol

## IV. GSE ENCAPSULATION OVER DVB-S2 SYSTEMS

The 1st generation of DVB standard supported data transport using MPEG format(ISO/IEC 13818-1[2]), with MPEG-TS. MPE is the DVB standard for encapsulation of audio/video and other content on MPEG-TS packets. The 2nd generation of DVB standards features backward compatibility modes for carrying MPEG-TS as well as generic modes for carrying fickle length packets. These are referred to as Generic Streams (GS). DVB-GSE enables IP natively on DVB too [6]. It works as an adaptation layer to provide network layer packet encapsulation and fragmentation functions over Generic Stream. GSE provides efficacious encapsulation of IP datagrams over fickle length Data Link layer packets. These are then directly scheduled on the layer 1 into Base Band frames. It provides efficient encapsulation and maximizes the efficiency of transporting IP datagrams as there is declination in the overhead by factor of 2 to 3 with respect to MPE/ULE over MPEG-TS. The effectiveness of GSE is achieved without compensating with the functionalities provided by the protocol suited to IP traffic characterstics. In DVB-S2 the forfeit is reduced on an average of about 10% for MPE/MPEG-TS to 2% to 3% for GSE, yielding an overall throughput gain of about 5% to 15%.The gain is also dependent on system and traffic characterstics. GSE also utilizes advance physical layer techniques.

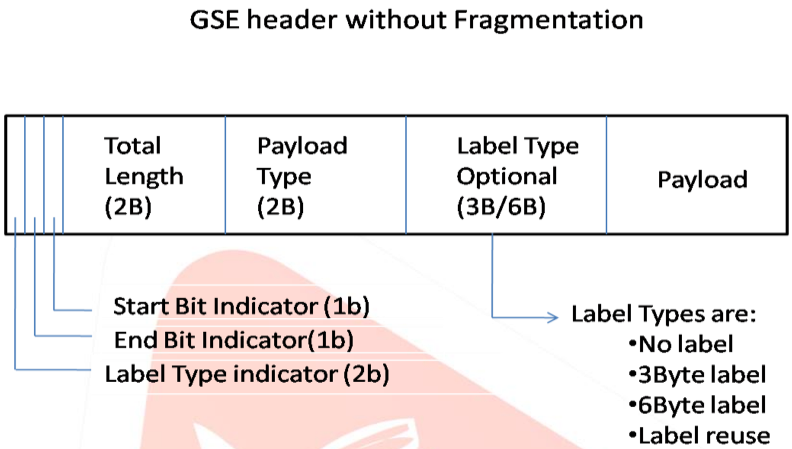


Fig. 3 Header format of Generic Stream Encapsulation Protocol without fragmentation.

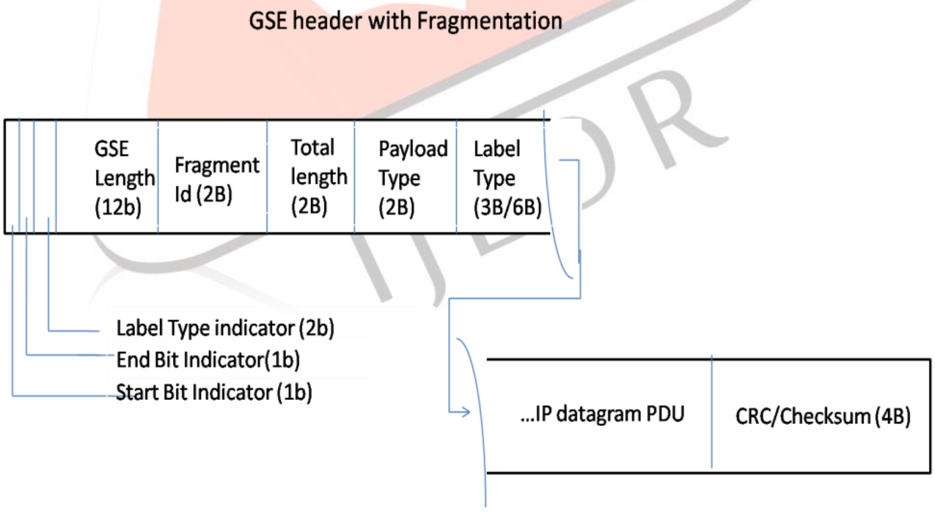


Fig. 4 Header format of Generic Stream Encapsulation Protocol with fragmentation.

Its main features are: Support for multi-protocol encapsulation (IPv4, IPv6, MPEG, ATM, Ethernet, 802.1pQ VLANs, etc.), Transparency to network layer functions including IP encryption and IP header compression, Support of several addressing modes (including multicast and unicast address), it supports a MAC addressless mode, and an optional 3-byte address mode [7]. A mechanism for fragmenting IP datagrams or other network layer packets over Base Band frames to support ACM/VCM, Support for hardware filtering, Extensibility,Low complexity. Hence GSE provides a flexible fragmentation and encapsulation method, which optimizes system fruition, either by increasing the total throughput and/or by improving the average packet end-to-end loiter. In addition, GSE's flexile feature leads to a reduction in packet loss under tone down variations, allowing the scheduler at the transmitter to dynamically change transmission parameters (for example modulation format, coding rate) for a particular network layer packet. The packing of GSE's in Base Band Frames is shown in Figure.5.

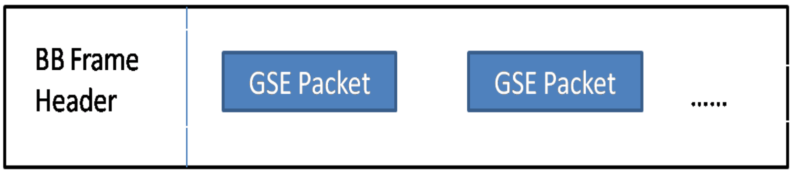


Fig. 5 Packing of GSE in BBFrame.

## V. ENCAPSULATION EFFICIENCY ASSESSMENT

An important characteristic of any encapsulation protocol is its framing efficiency, that is the ratio of useful bytes over total bytes. From this , we can deduce how much overhead is inserted by the encapsulation process. In communication networks and circuit-switched access solutions, the important but not so crucial part is the framing efficiency, since each user is given a certain amount of bandwidth, solely/dedicated to him/her. The downlink bandwidth is much more precious since it is shared in case of broadcast networks(digital television systems). It is important that the available capacity should be exploited at its peak, and not pulled down in unnecessary overhead / stuffing. In the case of IP-over-MPEG-2 networks, the efficiency factor is directly proportional to the bit rate of given IP data stream and inversely to rate of MPEG-2 TS that convey the stream. The ratio of these two rates is not constant and depends on size of IP datagram and encapsulation method used. In terms of formula the efficiency calculation is shown in [formula]. The MAC/LLC/SNAP header must also be summated in the case of bridged data, in the denominator .The efficiency factor increases in proportion with the datagram length.

The two ways Padding and Packaging procedure results in different outputs. The Padding method although is easy to implement, is independent of the encapsulation protocol used and it results in a waste of bandwidth. Its efficiency fluctuates with packet size, is maximized when the SNDU fits exactly into an integer number of transport packets. A protocol with less overhead than ULE/MPE/GSE with padding option enabled would perform the same since the gain is wasted in stuffing bytes. So in our assessment we have considered only the packaging option. GSE packs data directly to baseband frames. The Packing approach is more efficient and reveals the differences among the various encapsulation methods. These differences are observable at different packet lengths. The SNDU format for GSE is similar to ULE with 4 byte header but no checksum. In the case where SNDU is fragmented the 3 Byte header to sequel the fragment and CRC is appended and for no-fragment case no extra bits are appended unlike fragmented SNDU. There is an optional support for label. In our analysis we had taken 3B and 6B label into consideration.

The Calculation of Efficiency is as followed:
No of Transport Streams= n(TS)
No of Fragments= n(F)

Transport Stream Factor= f(TS)
BBFrame Factor= f(BBF)

f(TS)= 188/184
f(BBF)= length of BBF/( length of BBF-10)

n(TS)= Length of packet/ 184
n(F)= Length of packet/374

Length of SNDU= $L_{SNDU}$
Length of Total Fragments = total(F)

$$n(TS) = (\text{Packet Length}) / 188$$
$$n(F) = \text{Packet Length} / (\text{Length of BBF} - 10)$$

$$f(BBF) = \text{Length of BBF} / (\text{Length of BBF} - 10)$$

$$f(TS) = 188 / 184$$

$$\text{Efficiency (MPE/ULE)} = \frac{\text{Packet Length}}{(L_{SNDU} + \text{Overhead})}$$

$$\text{Efficiency (GSE)} = \frac{\text{Packet Length}}{\text{total(F)}}$$

The length of SNDU for calculating the efficiency for different cases are:
$L_{SNDU}$ for MPE without SNAP/LLC = (Packet Length + 16) * f(TS)
$L_{SNDU}$ for MPE with SNAP/LLC = (Packet Length + 24) * f(TS)
$L_{SNDU}$ for ULE without NPA = (Packet Length + 8) * f(TS)
$L_{SNDU}$ for ULE with NPA = (Packet Length + 14) * f(TS)

While calculating efficiency of GSE protocol the total(F) is:
total(F) without fragmentation = [n(F)*3 + 4 + Length of packet + label(optional)] * f(BBF)
total(F) with Fragmentation = [n(F)*3 + 8 + Length of packet + label(optional)] * f(BBF)

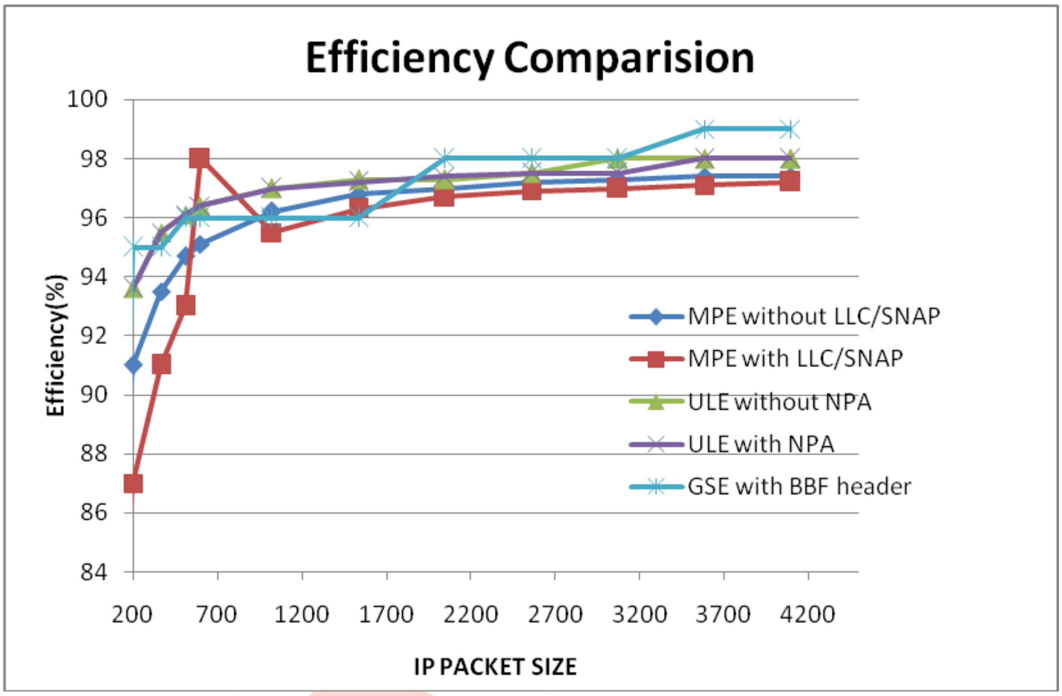


Fig. 6 Comparison without including BBFrame for MPE andULE.

The analysis is done by comparing MPE(TS),ULE(TS) and GSE(BBFs). Another comparison is done by encapsulating MPE ULE in BBFrames and comparing it to the efficiency of BBFs of GSE protocol. The overhead of encapsulating data to BBFrames is calculated followed by the efficiency calculation. The size of BBFrame is decided by the LDPC , where the size is fixed on the basis of modulation used i.e for LDPC ¼ the length is 384 bytes (including 10 Byte BBF header). GSE outputs BBFrames directly where as in MPE/ULE the extra overhead will be added to output the BBFrames. For example, taking BBFrame length 1991 Byte the efficiency of GSE is ~98% whereas for MPE,ULE is ~96% and ~97%.

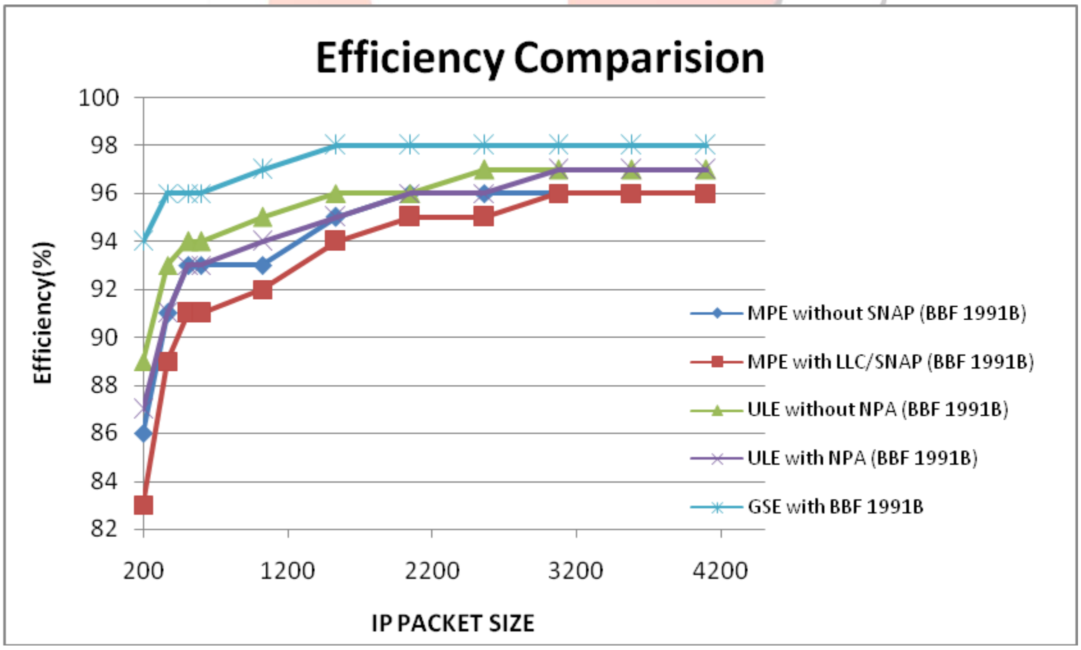


Fig. 7 Comparison including BBFrame for MPE andULE.

## VI. Conclusion

In wireless and mobile sector, IP-DVB network plays an important role for data access solution. In this paper a model for calculating the encapsulation efficiency of MPE, ULE and GSE on DVB. The result shows that GSE is more efficient than MPE and ULE. The efficiency gain ranges from 1% to 3.8%. The manually done calculations using theoretical formulas (in section V) illustrates the overhead of three protocols for different packet lengths and for different LDPC codes for BBFrames. ULE is lightweight yet enhanced protocol to fulfill the need of IP over MPEG-2. The extension headers make ULE and GSE flexible. GSE over the two protocols provide efficient broadcasting. The configurability and efficiency introduced by GSE gives significant advantage over its predecessor. The next generation standards are also arising for return channels. The major factor for the emerging standards is that how the transmission properties and channel corresponds to DVB 2nd generation. These presented methods are optimal for DVB links.

## VII. ACKNOWLEDGMENT

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