Apex as an "Approximate" Communication System in Wireless Network for video transmission

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Abstract—**Communication systems are prone to error weather wired or wireless. The error in wireless communication system has well defined structure. The receiver decode this erroneous symbol in such a way that the erroneous symbol is good approximation of the transmitted symbol as compare to a randomly chosen symbol among all possible transmitted symbols .This a "approximation property" which is used in proposed paper to remove the error structure and to exploit the error structure to natively provide unequal error protection to data bit. In contrast to this the traditional methods of unequal error protection consume additional network and spectrum resources to encode redundant data, the approximate communication technique achieves this property at the PHY layer without consuming any additional network or spectrum resources (apart from a minimal signaling overhead). This method provides unequal error protection at the PHY layer without the need of any additional network or spectrum resources. It is use for the media delivery applications It can improve video quality by 5–20 dB [peak signal-to-noise ratio (PSNR)] across a diverse set of wireless conditions when compared to traditional approaches.**

Keywords—Algorithms,design,measurement,modulation, coding, performance evaluation.

I. Introduction

In the design of networked system it has been assumed that all communication channels are error prone and the network system is designed in such a way that they are able to handle this error. Usually a checksum field is added in each and every data unit. In it receiver compare the value of received checksum with the expected checksum to validate correct reception.

Conventional designs of networked systems have assumed that communication channels are error-prone and handle them in various ways. Often, a checksum field is added to each data unit. A receiver verifies the received checksum against the expected checksum for the data bits to validate correct reception. Higher layers deal with these errors in different ways.

At the MAC layer, some protocols (such as 802.11) typically discard packets received with checksum errors. A newer class of MAC-PHY mechanisms attempt to recover correct bits from packets with partial errors. Examples include partial packet recovery (PPR) [4], SOFT [6], and Maranello [7].Similarly, at the transport layer, TCP would retransmit erroneous or lost segments. UDP simply discards them silently .UDP-lite delivers erroneous packets to applications and allows applications to recover correct portions of these packets using partial checksums.

The PHY layer have a well define structure of the error which can be used by higher layers for minimizing the error structure and for exploit the error structure to natively provide unequal error protection to data bit, this is the main reason for making changes in PHY Layer. IEEE 802.11 is a set of media access control (MAC) and physical layer (PHY) specifications for implementing wireless local area network (WLAN) communication. There are various types of the 802.11 standards like and in the proposed algorithm changes are made in 802.11 a which is an established IEEE standard for wireless networking that improves on the performance limitations of 802.11b.

The wireless errors have a systematic structure at the PHY layer and transmitter of wireless system uses this structure to make sure that some bit position are more protected than other bit positions. If the transmitter has idea regarding the relative importance of data bits than transmitter can place more important bits in more protected area than compare to less important bits which it will place in less protected area. It means by simply placing more important bits to more important place transmitter can provide UEP i.e unequal error protection. Unlike in previous methods of UEP in which there is need to add redundant bits to higher-priority data. In our scheme there is need of any redundant data bits to be transmitted to achieve UEP.

The PSNR of video compression are between 30 and 50 dB, where higher is better and apex provide the increase in its value by 5-20 dB so the new value will be in between 35-70dB.

II. RELATED WORKS

In this section there are various methods are shown for providing error recovery in wireless system.This methods are available at different layers of the system which are as follows:

Network Layer Approch: Symbol level coding for wireless mesh network [2] is a method which provide error recovery .This method is available at the Network layer. It operates in anetwork wide scale. It discards the symbol received with error which is unlike to the proposed scheme which operates in single wireless hop.

*Transport Layer Approch:*The method available at Transport layer for providing error recovery is "The lightweight user datagram protocol(UDP-Lite)[3]". This

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method allow application layer to accept corrupted data values so that it can recover some content from them. This method leads to the better media streaming performance. Again, such schemes complement to proposed scheme.

*Application Layer Approch:*There have been severalresearch efforts to improve the quality of streaming content,mainly at the application layer through effective data prioritization. The primary technique in this regard is addition of FEC to different data components to make them more resilient than others. Other techniques have also uses hybrids of ARQ-based and FEC-based mechanisms for loss recovery. These techniques do not take advantageof the natural properties of the wireless channel, which iseffectively exploit in Apex.

*PHY-MAC Layer Approach:*There are lots of methods available which are using the mechanisms at the PHY and MAC layers, in order to recover more data out of erroneuos packets, this methods are PPR[4], SOFT[5], Maranello[6], Softcast[7], ZipTx[8] .The above methods are applicable to all types of data but in all this methods the transmitters do not exploit the unique approximation properties of wireless errors. In contrast, transmitters in Apex learn about and utilize the structure in wireless symbol errors to improve the performance of media delivery applications.

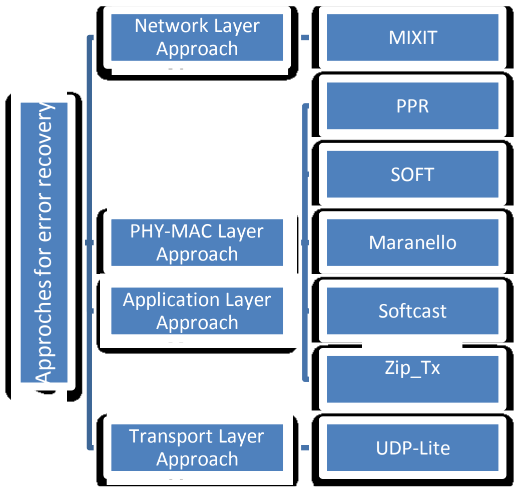

Fig.1.Different methods available in survey

III. METHODS AVAILABLE DURING SURVEY

MIXIT[2]: The MIXIT is a system which utilizes the mechanism at the Network layer to recover error and it provide significant amount of throughput of wireless mesh networks. The basic property of mesh networks is: "even when no node receives a packet correctly, any given bit is likely to be received by some node correctly". This property of mesh network is used by MIXIT. In MIXIT instead of insisting on forwarding only correct packets, it's routers use physical layer hints to make their best guess about which bits in a corrupted packet are likely to be correct and forward them to the destination. Even though this approach inevitably lets erroneous bits through, still it can achieve high throughput without compromising end-to-end reliability.

Novel network code is the core component for MIXIT. The novel network code operates on small groups of bits, called symbols. The MIXIT allows routing of the group of bits to their destination with low overheads. MIXIT's network code also incorporates an end-to-end error correction component that the destination uses to correct any errors that might seep through.

Two additional techniques which is incorporated by MIXIT:

- Increased concurrency: In the design of the channel access protocol, there is a flexibility that nodes are no longer required to ensure correct packet delivery and MIXIT take the advantage of this to allow many more concurrent transmissions than CSMA. Whenever the transmitted symbol is received correctly by some node closer to the final destination, the protocol achieves good throughput.
- Congestion-aware forwarding: The forwarding algorithm of the MIXIT forwards the coded symbols through the path which have both high delivery probabilities and small queues, whether the previous schemes does not consider the congestion information.

Some specifications of MIXIT:

- ❖ Used in multihop wireless settings.
- ❖ It discards symbols received with errors.
- ❖ It uses PHY Layer hints to make guess about which bits in a corrupted packets are likely to be correct and forward them to the destination.

UDP-Lite[3]: It is a connectionless protocol. In it the potentially damaged data is to be delivered to the application layer rather than being discarded by the receiving station. In it decision regarding the data integrity is made in application layer or in codec and in this the significance of the bits is understood so this is very useful property. It is based on the UDP but not similar to UDP. In UDP either all or none of a packet is protected by a checksum. UDP-Lite allows for partial checksums that only covers part of a datagram (an arbitrary count of octets at the beginning of the packet), and will therefore deliver packets that have been partially corrupted.

The UDP-Lite is designed for the multimedia protocols, it include Voice over IP or streamed video. IN multimedia protocols which receiving a packet with a damaged payload is better than receiving no packet at all.

A single bit in error causes bad checksum which mean that the whole packet must be discarded and this happen for conventional UDP and TCP. For computing the checksum UDP-Lite uses the same checksum algorithm used for the UDP.

PPR[4]:PPR has the potential to change the way PHY,link, and MAC protocol designers think about protocols. Today's wireless PHY implementations employ significant amounts of redundancy to tolerate worst-case channel conditions. If noise during one or more codewords is higher than expected, existing PHY layers will generate incorrect bits, which will cause packet-level CRCs to fail and require retransmission of the whole packet. Since noise fluctuations are often large, and the penalty for incorrect decoding is also large, PHY layers tend to conservatively include lots of redundancy in the form of a high degree of channel coding or Conservative modulation. Similarly, MAC layers tend to be quite conservative with rate adaptation because the consequences of errors are considered dire. The mind-set seems to be that bit errors are bad, and must be reduced (though eliminating them is impossible).As a result, they operate with comparatively low payload bit-rates.PPR reduces the penalty of incorrect decoding, and thus for a given environment allows the amount of redundancy to be decreased, or equivalently the payload bit-rate to be increased. With SoftPHY and PPR, it may be perfectly fine for a PHY to design for one or even two orders-of-magnitude

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higher BER, because higher layers need no longer cope with high packet error rates, but can decode and recover partial packets correctly.PPR has the potential to improve the performance of mesh networkprotocols such as opportunistic routing and network coding.It incorporates two ideas:

- SoftPHY, an expanded physical layer (PHY) interface that provides PHY –independent hints to higher layers about the PHY's confidence in each bit it decodes. The key insight in SoftPHY is that the PHY should pass up information about how close each received symbols or codeword was to the symbol or codeword the PHY decided upon. The layer can then use this information as a hint, independent of the underlying details in the PHY.
- A postamble scheme to recover data even when a packet preamble is corrupted and not decodable at the receiver. The main idea is to replicate the information in the preamble and packet header in a postamble and a packet trailer, allowing a receiver to lock on the postamble and then roll back in time to recover data that was previously impossible to decode.

SOFT[5]:SOFT, a architecture that makes the physical layer convey its confidence that a particular bit is "0" or "1" to the higher layers. Access points that hear the same transmission communicate their confidence values over the wired Ethernet and combine their information to correct faulty bits in a corrupted packet. A single receiver may also combine the confidence estimates from multiple faulty retransmissions to obtain a correct packet. It can reduce loss rate by up to 10x in comparison with the previous approach, and significantly outperforms prior packet combining proposals. SOFT introduces a simple modification of the interface to export this confidence measure from the physical to the data link layer. It shows that this new interface can combat dead spots and dramatically increase the packet delivery rate.

SOFT works by combining confidence values across multiple faulty receptions to recover a clean packet.

- On the uplink, SOFT leverages the abundance of wired bandwidth in comparison to wireless bandwidth. Access points that hear a particular transmission communicate over the local Ethernet and combine their confidence estimates to maximize the likelihood of correctly decoding a corrupted packet.
- Similarly, on the downlink, a node that receives a faulty packet combines the received packet with a later potentially faulty retransmission to obtain a correct packet. This strategy eliminates the need for any one retransmission to be completely correct, thus drastically reducing the number of retransmissions in a lossy environment.
- SOFT provides large boosts to wireless reliability. In environments with moderate to good delivery rate, SOFT almost eliminates any packet loss over the wireless channel. In environments with high loss rates, SOFT increases the delivery rate by an order of magnitude.
- SOFT shows significantly higher delivery rates than prior cooperation proposals that do not use physical layer information. It can provide up to 9-fold reduction in loss rate.
- SOFT also reduces the number of retransmissions. In lossy networks, with just one retransmission, SOFT achieves94% reliability, while it takes the current approaches 18 retransmissions to obtain similar performance.
- The values about which the PHY layer is confident can be expressed using only few bits , keeping the overhead of communicating them over the Ethernet within an acceptable bound.

Maranello[6]: For 802.11, maranello is a novel partial packet recovery mechanism. In Maranello, the receiver computes checksums over blocks in corrupt packets and bundles these checksums into a negative acknowledgment sent when the sender expects to receive an acknowledgment. Now the retransmission of those blocks are happen for which checksum is incorrect and this retransmission is done by sender and this partial retransmission is repeated till that time it receives an acknowledgment, Successful transmissions are not burdened by additional bits and the receiver needs not infer which bits were corrupted.

Maranello has the following features:

(a) It introduces no extra bits in correct transmissions,

(b) It reduces recovery latency, except in rare cases,

(c) It is compatible with the802.11 protocol, and

(d) It can be incrementally deployed on widely available 802.11 devices.

SoftCast [7]: SoftCast is a recently proposed, related scheme that improves wireless media delivery performance in multicast settings by using properties of wireless errors in a manner similar to Apex. SoftCast represents data values in a "raw" numerical (analog) format and maps them directly to wireless symbols with specific transmit power levels. There are three main difference between proposed scheme and the softcast and those are as follows:

1. SoftCast requires that media content be represented and transmitted in the raw numerical format, different from what is used in popular standards, e.g., H.264. Media represented in these popular formats have to be converted into the SoftCast format (through a computationally intensive process) to achieve its performance gains.
2. SoftCast uses a static data representation format that is agnostic of wireless channel conditions. In Apex, our mappings between bit sequences to symbols, and between data bits to bit positions, are dynamically altered based on channel conditions.
3. SoftCast is designed specifically for multicast traffic in which no receiver feedback is assumed. In contrast, Apex focuses on unicast traffic, where immediate MAC-layer acknowledgments are used to dynamically fine-tune the mappings of bit sequences to symbols, and data bits to bit positions for improved performance. Such dynamic adjustments are precluded in SoftCast. Hence, SoftCast and Apex are applicable to video delivery in vastly different scenarios.

ZipTx[8]: It is a software-only solution that harvests gains from using correct bits in corrupted packets with existing hardware and it characterizes the gains of partially correct packets for the entire range of operation of 802.11 networks,

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and in the presence of adaptive modulation and forward error correction.

ZipTx, significantly increases wireless throughput and reduces dead spots by avoiding fate sharing of bits within a packet. ZipTx is implemented as a driver extension and hence is easy to deploy in existing WiFi networks. ZipTx turns off the checksum test and allows the hardware to pass up all packets including those that may contain bit errors. ZipTx uses error correcting codes to recover packets with low BER without knowing which bits in a packet are erroneous. However, given that error correcting codes have to add at least twice as much redundancy as the number of incorrect coding symbols, it is inefficient to use coding to recover packets with a high BER. ZipTx uses known pilot bits in each packet to identify high BER packets and recover them via retransmission instead of coding. This heterogeneous recovery strategy allows ZipTx to significantly increase throughput.

IV. VALIDATION

In order validate the approach of approximate communication is indeed possible, it is needed to identify one or more constellation maps that provide unequal error protection among different bit positions, across a range of wireless conditions—different transmit power levels, different degrees of interference at the receiver, and with and without PHY-layer convolutional codes.

Such confirmation of unequal protection will provide further evidence that approximation property holds true for a range of common scenarios, where approaches such as Apex can be quite worthwhile.

Given a constellation diagram of points, each symbol will represent a bit sequence of length bits. Overall, there are no more than different constellation maps possible, although some of them can be identical due to rotation and reflection based symmetries. Each constellation map is likely to protect individual bit positions differently. The above property can be leveraged by altering the constellation map during an ongoing transmission, based on the channel conditions and the relative priority of the application data bits.

In this section, there two constellation maps, each of which offer varying amount of error protection for different bit positions.

Example Constellation Maps

The two constellation maps use in approximate communication is explained below.

Gray Code: In Gray code, symbols that are immediate neighbors either along the I-axis or the Q-axis of the I/Q space differ in exactly one bit position; the rest of the bits are identical between the two neighbors. An example of a Gray code is shown in Fig.3 for a 16-QAM system. Gray codes can be constructed for any QAM scheme in a systematic manner based on the above observation. Gray code is widely used in many popular communication systems, including in 802.11a/g/n and 802.16-based systems.

Block Code: In block code, the constellation points on the same side of the I- (Q-) axis have the same value for the first (second) bit position. Hence, all points in a given I-Q quadrant have the same value for the first two bit positions. For each of these quadrants, the symbols are partitioned into four subquadrants, and the same process is repeated to assign bit values for the next two bit positions. The process is repeated iteratively for the remaining positions. Both of these schemes can be implemented on different QAM-based modulation schemes.

V. APPROACHES FOR APPROXIMATE COMMUNICATION

Fig.2. shows the data transfer in wireless communication First the content is encoded into bit sequence, after generating bit sequence it is packetized into small packets and then mapping into symbols which are use for transmission. After transmission, receiver tries to infer the symbols, but sometime error may happen, so when received symbol is map back into bit sequence error might occur. From above it is clear that when error happen in symbol not it's all bits are corrupted. In this example each symbol represents a set of three data bits.

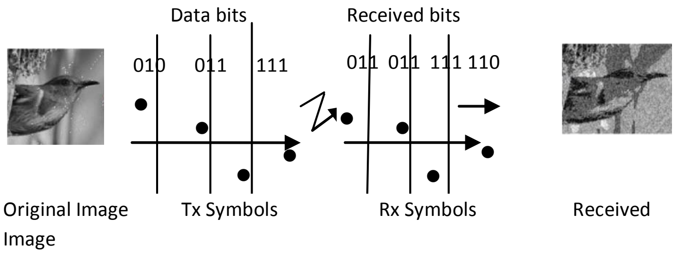

Fig. 2. An overview of wireless communication.

Explanation of Approximate Property by QAM:

In QAM, data elements are encoded at 90 out of phase. A QAM is represented by constellation diagram as shown in fig.3. In above fig 16-QAM there are 16 distinct symbols. Each such symbol encodes a 4-bit sequence of data to be transmitted. In the two-dimensional I/Q space, an erroneously decoded symbol tends to be a reasonable approximation of the transmitted symbol. As if error happens the corrupted symbol is the nearest neighbor of the transmitted symbol.

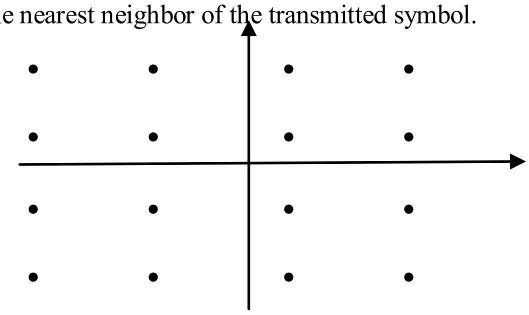

Fig. 3. 16 QAM constellation.

Consider a wireless system using 64 QAM and its transmitter emits a symbol C as shown in fig.4, so depending on the channel condition there may be possibility that may receiver will correctly decode C or it make some error but the error which occur are most likely to confine to the near neighbor of C, i.e., may be from A, B, D or E, as compare to faraway symbol, X. It means the decoded symbol is to be reasonable approximation of transmitted one.

TRADITIONAL Vs APPROXIMATE COMMUNICATION

In Traditional communication system, data bits are send which is corresponding to different frames (I, P, and B) downthe network protocol stack. In given fig.5, four video frames are shown in which 2 are I-frame, 1 is P-frame and 1 is B-frame. In traditional Communication system, each frame is as it is mapped into the wireless frame.

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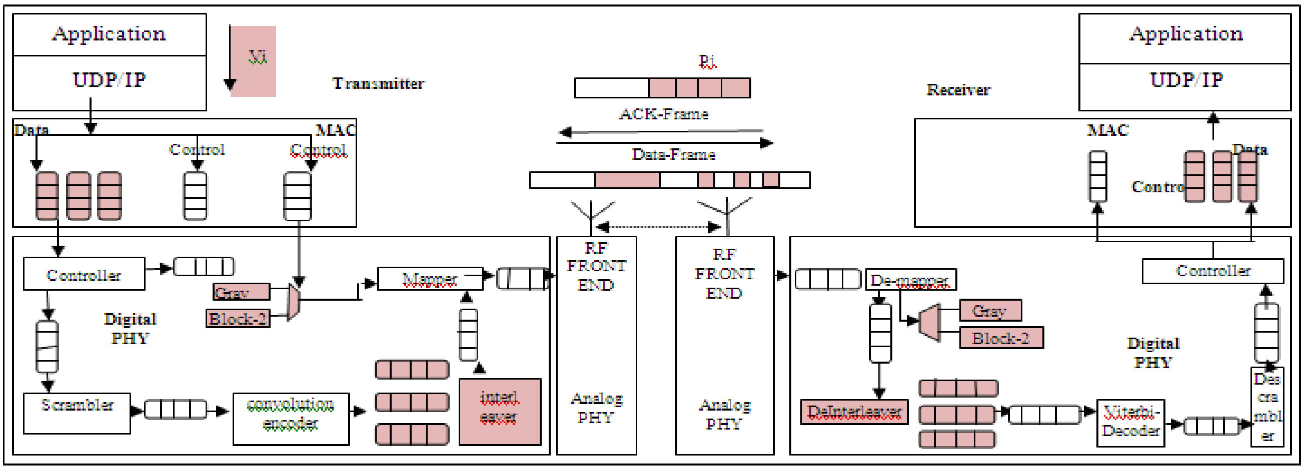

Fig.6.Modification in 802.11 for Apex

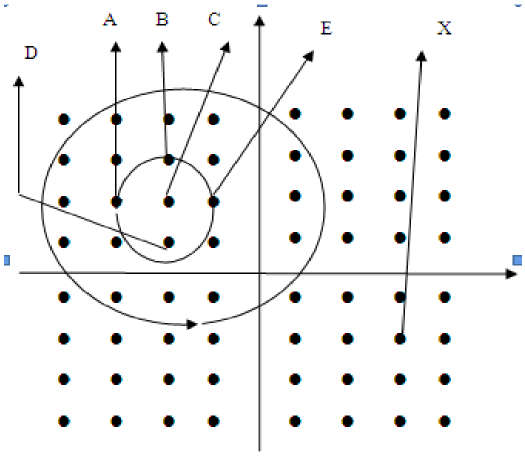

Fig.4. 64 QAM Constellation

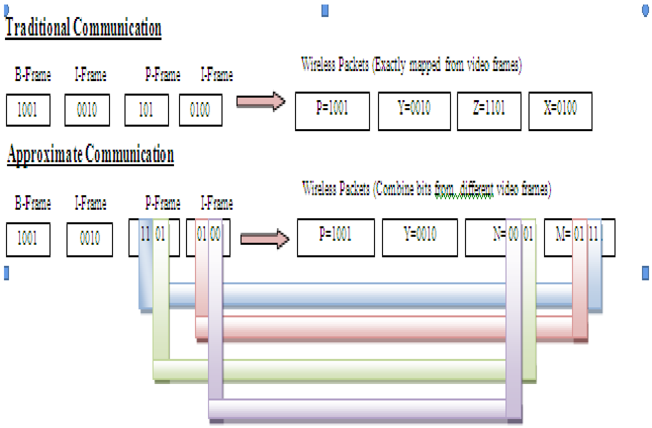

Fig. 5.Difference in video transmission in Traditional and Approximate

In Approximate communication system, data bits of different priority level will be placed together and combine into single symbol, due to this most protected bit positions are occupied by the higher-priority data bits (say, I bits), and the least protected bit positions are occupied by the lower-priority data bits (say, P and B bits).

VI. PROPOSED ALGORITHM

In wireless system there are lots of scheme in order to achieve UEP but in all those method consume additional network and spectrum resources to encode redundant data, but our scheme achieve the approximation property at the PHY layer without consuming additional network and spectrum resources. Depending on the value of different data units in apex have to make three simple decisions:

- Selecting the value of data unit.
- Have to place application data bits to bits position for the desired level of protection.
- Selection of constellation map.

Selection of the value of data unit: In Apex, data unit is proportional to the number of data bytes which is require for decoding the symbols at the receiver. On it we are going to use value of data unit is frames within a GOP .This will make computation easy for each GOP because all bytes of a frame type in a GOP has the same value. As in MPEG –based video stream I-frame data is most important as it require to decode tthe highest number of dependent frame hence they have highest priority . As there is no other dependency on B-frames so they have the least priority.P-frame has a priority that is intermediate of the two other.

*Placement of Application Data Bits to the Bit Positions:*In it placing of application bits depending on their priority i.e. bits with highest priority are placed in more protected position of each of the symbols than have to towards the next important bits which will be placed in next protected position this process is going on till all bits are get exhausted In apex, each frame carries data bits from an I-frame, P-frame and B-frame.

Selection of constellation map: At different bit positions, constellation Maps have different level of protection , hence its selection depend upon the utility of it for protecting different bits.

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For this need to evaluate the constellation map utility, will require estimating the BER for different constellation maps at different bit positions. For estimating the BER, have to add pilot symbols (which a well known) into each wireless frame and receiver will decode these symbols with the either gray or block constellation map. The computation of BER occurs at transmission speeds, because such computation is already done for frame decoding and ACK generation.

Modifications Require for Apex:

- Data bit mapping at the MAC layer.
- Modifications in PHY PLCP Header and in Payload.
- Modification in Digital Component of PHY – Layer Pipeline.

Data bit mapping at the MAC layer: For the Design of apex mapping of data bits is required at MAC layer and other than this rest of MAC layer as work as same as IEEE 802.11protocol.So this will make system's external properties is completely compatible and compliant to 802.11. *Modifications in PHY PLCP Header and in Payload:* There are some modification need to made in PHY-layer PLCP header which is shown in given fig.6.

Addition of two bit constellation map selector in PLCP header: It inform the receiver which encoding scheme is to used. As two bit is used so it will limit the the numbers of constellation map alternative to four. This two bit is transmitted at the base rate.

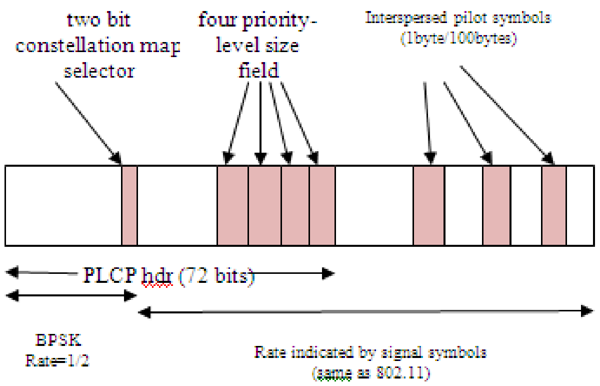

Fig.7.Changes in PHY PLCP header and Payload

Addition of four priority-level size field: It give information of how the data of different priority levels are placed into various bit positions. It can be transmitted at higher data rate.

Addition of pilot symbols (1byte/100bytes): It is use to estimate the BER at different bit position.

Modification in PHY-Layer pipeline by making some changes in its digital components: In order to implement apex some changes are needed at PHY-Layer pipeline of 802.11 .The changes which are required are shown by shaded region in given fig.7. In it the interleaver limt the interleaving of bits within a single subcarrier, the bit positions allocated to data from same priority class. In it Read Controller is introduce which generate read signal for packet buffer. In it after interleaver 3-B shift register is introduced which store interleaved bytes of corresponding type. After this logic component is added, this will merge bits from different shift registers.

RESULTS AND DISCUSSIONS

The comparision between the traditional and apex in respect to PSNR with iteration, PSNR with and without FEC, PSNR with and without retransmission is shown below has been taken from [1].

Apex versus Traditional: From fig.8 it is clear that the difference between the value of PSNR is nearly about 16 dB and this is shown for each iteration in fig.8 (a) and for average and standard deviation in fig.8 (b).

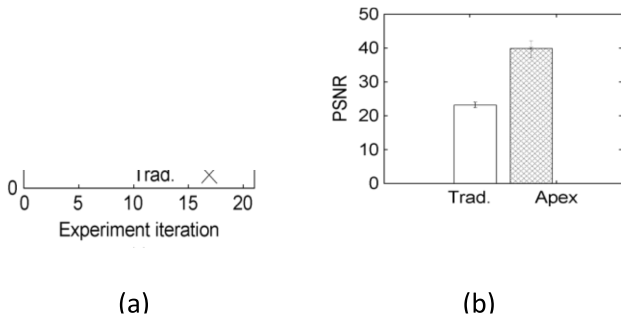

Fig.8PSNR difference between traditional and approximate system

Apex versus Traditional with FEC: The Fig.9 shows that the weather with FEC or without FEC the PSNR obtain from the Apex is more than the traditional methods and the gap in PSNR is somewhat similar in both comparisons.

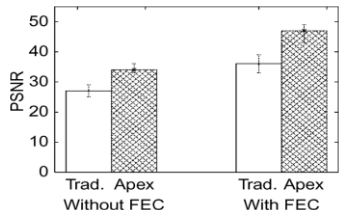

Fig.9.PSNR difference between traditional and Approximate system with and without FEC

Apex System versus Traditional system with Retransmission: The shaded region of the graph shown in fig.10 shows that the PSNR of apex will be equal to the PSNR of traditional when traditional system is with three time retransmission which is very time consuming. From this it is also clear that it save the retransmission traffic.

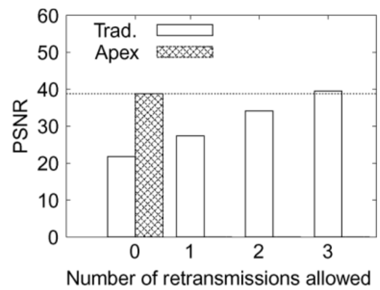

Fig.10.PSNR difference between Approximate system And traditional system with retransmission

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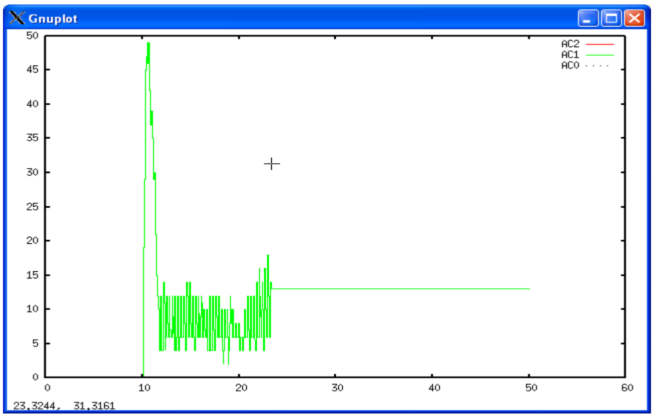

Fig.11.a.Graph between queuelength and simulaion time

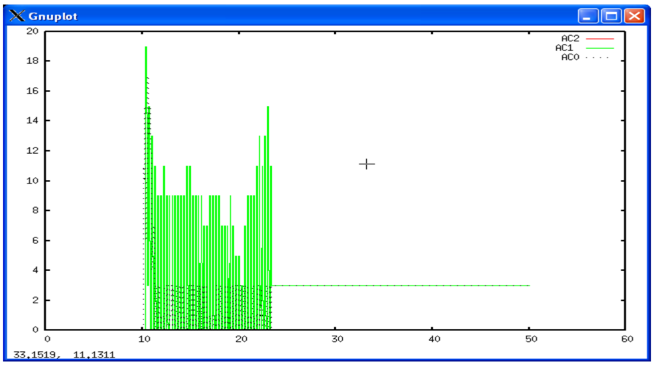

Fig.11.b.Graph between queuelength and simulaion time

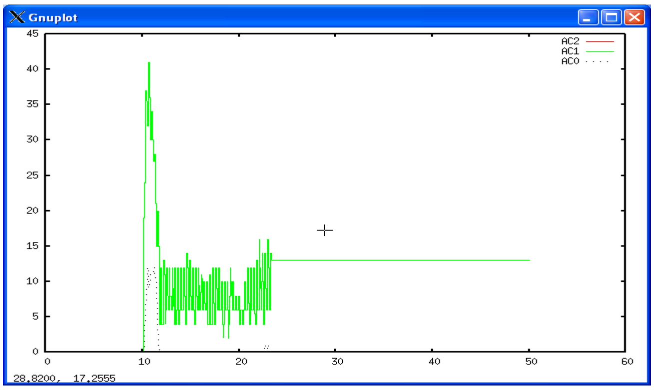

Fig.11.c.Graph between queuelength and simulaion time

Fig.11. a,11.b, 11.c shows the result of implementation of apex in NS-2 using Cygwin enviorment and the result of this implementation shows performance of queuelength Vs simulation time ,queuelength is on X-axis and simulation time is on Y-axis.. According to the incoming video packets the queuelength changes.

Expected Result: The work of this paper is to implement the algorithm in such away that the graph will come as shown in fig.12.which is given below.

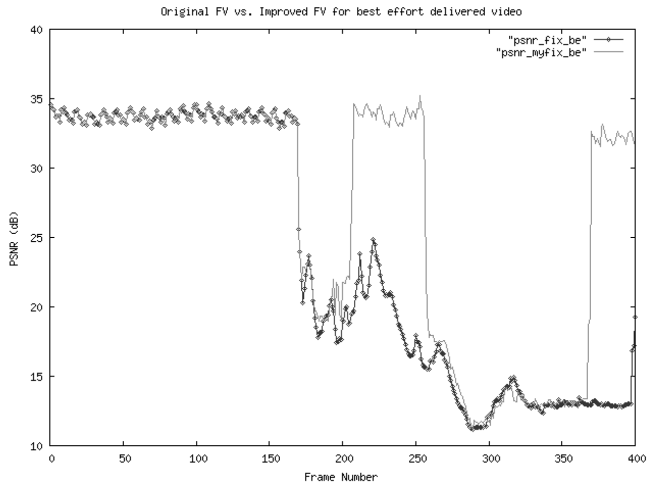

Fig.12. Expected Graph between PSNR and frame number.

CONCLUSIONS

Approximate communication system provides significant improvement in video quality (ranging from 5 to 20 dB in different scenarios). However, this is a small first step in realizing the full capability of this system. This work leaves open a few optimization problems that should lead to further performance gains. For example, a joint construction of data modulation schemes and constellation map selection might lead to further performance gains.

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