Intra Frame Coding In Advanced Video Coding Standard (H.264) to Obtain Consistent PSNR and Reduce Bit Rate for Diagonal Down Left Mode Using Gaussian Pulse

Manjanaik N\textsuperscript{a}, Parameshachari B D\textsuperscript{b} Hanumanthappa S N\textsuperscript{c}, Reshma Banu\textsuperscript{d}

\textsuperscript{a,b} UBDTCE, ECE Dept, Davangere, India
\textsuperscript{a,c} GSSS Institute of Engg Technology, TCE Dept, Mysuru, India

Abstract: Intra prediction process of H.264 video coding standard used to code first frame i.e. Intra frame of video to obtain good coding efficiency compare to previous video coding standard series. More benefit of intra frame coding is to reduce spatial pixel redundancy with in current frame, reduces computational complexity and provides better rate distortion performance. To code Intra frame it use existing process Rate Distortion Optimization (RDO) method. This method increases computational complexity, increases in bit rate and reduces picture quality so it is difficult to implement in real time applications, so the many researcher has been developed fast mode decision algorithm for coding of intra frame. The previous work carried on Intra frame coding in H.264 standard using fast decision mode intra prediction algorithm based on different techniques was achieved increased in bit rate, degradation of picture quality (PSNR) for different quantization parameters. Many previous approaches of fast mode decision algorithms on intra frame coding achieved only reduction of computational complexity or it save encoding time and limitation was increase in bit rate with loss of quality of picture. In order to avoid increase in bit rate and loss of picture quality a better approach was developed. In this paper developed a better approach i.e. Gaussian pulse for Intra frame coding using diagonal down left intra prediction mode to achieve higher coding efficiency in terms of PSNR and bitrate. In proposed method Gaussian pulse is multiplied with each 4x4 frequency domain coefficients of 4x4 sub macro block of macro block of current frame before quantization process. Multiplication of Gaussian pulse for each 4x4 integer transformed coefficients at macro block levels scales the information of the coefficients in a reversible manner. The resulting signal would turn abstract. Frequency samples are abstract in a known and controllable manner without intermixing of coefficients, it avoids picture getting bad hit for higher values of quantization parameters. The proposed work was implemented using MATLAB and JM 18.6 reference software. The proposed work measure the performance parameters PSNR, bit rate and compression of intra frame of yuv video sequences in QCIF resolution under different values of quantization parameter with Gaussian value for diagonal down left intra prediction mode. The simulation results of proposed algorithm are tabulated and compared with previous algorithm i.e. Tian et al method. The proposed algorithm achieved reduced in bit rate averagely 30.98% and maintain consistent picture quality for QCIF sequences compared to previous algorithm i.e. Tian et al method.

Keywords: AVC, Bitrate, Gaussian pulse, Intra frame.
I. INTRODUCTION

Advanced video coding standard (H.264/AVC) is developed by Video Coding Expert Group (VCEG) and Moving picture Experts Group (MPEG). This standard has advanced features than other video coding standards. The advanced features of AVC standard increases more complexity with loss of picture quality. The previous work carried using fast mode decision intra prediction algorithm on Intra frame coding were achieved saving of encoding time at degradation of picture quality with increment in bit rate under different quantization parameters with Gaussian value. Previous algorithms for intra frame coding were carried using different approach such as RDO, calculating features of macro block such as variance, histogram, local edge, enhanced, approximating and partial computation of cost function of macro block and early block type selection [1-10]. Therefore previous methods were achieved increased in bit rate, degradation of PSNR and reduction of computational complexity. So far, in previous fast mode decision intra prediction algorithm on Intra frame coding were not achieved reduction in bit rate, to get consistent of picture quality (PSNR) and high compression.

II. METHODOLOGY

The problem formulation for Intra frame coding to achieve the performance parameters of proposed method are discussed in the section. The problem formulated as the loss or degradation of reconstructed picture quality (PSNR) and increase bit rate for Intra frame coding using fast mode decision intra prediction algorithms of AVC under different quantization parameters. The objective the proposed work is to achieve consistent picture quality (PSNR) and avoid an increase of bitrate. In order to achieve objective of the proposed work the methodology was followed. The International standard yuv video sequences in QCIF and CIF resolution which is available as open source downloaded from the website www.codervoice.com as input. Extracting Intra frame of yuv video sequence and processed in terms of macro block which is further divided into 4x4 sub blocks. Each 4x4 sub macro block of intra frame is processed using proposed functional blocks such as intra prediction, integer transformer, Gaussian pulse, quantization, context adaptive variable length coding to get compressed bit, inverse quantization and inverse transform to get reconstructed frame. Measuring performance parameters such as PSNR, and Bit rate of reconstructed frame of proposed algorithm.

III. PROPOSED DIAGRAM

Figure 1 Shows the proposed system consists of different functional modules. It has two data paths such as forward and reconstruction path. In forward path, an input frame is processed in terms of a macro block (MB) which is further divided into sub macro block. Each sub macro block is encoded using intra prediction process. A prediction formed within current frame using intra prediction process is known as intra frame coding. Prediction P is obtained using previously reconstructed pixels of reconstructed block. The residual block is obtained by subtraction prediction block P with the current sub macro block. This residual block is transformed into transformed coefficients using 4x4 integer transform. The transformed coefficients are multiplied with Gaussian pulse to get Gaussian transformed coefficients. These Gaussian transformed coefficients are quantized using quantization process of AVC to get quantized coefficients. These coefficients are reordered and entropy encoded using Context Adaptive Variable Length Coding (CAVLC) to get the compressed bits. In the reconstruction path the quantized coefficients are inverse quantized and inverse transformed to get residual block. The prediction macro block P is added to residual block to reconstructed block, which can use for prediction of next current block of intra frame. This process repeat till at the end of last sub block of intra frame to get reconstructed block. Finally measure the performance parameters of proposed algorithm.
V. INTRA FRAME CODING AND GAUSSIAN PULSE

Intra prediction process used to code intra frame. Prediction formed within is the same frame is called intra frame coding. Intra prediction process used to remove spatial redundancy, lower the complexity and provides better coding efficiency. Figure 2 shows eight directional and one non directional prediction modes for 4x4 intra frame coding such as vertical, horizontal, diagonal down left, horizontal down, diagonal down right, vertical left, horizontal up and vertical right. The proposed algorithm is based on the Gaussian pulse. A pulse has the waveform of a Gaussian distribution which is described by equation

\[ G(v) = \exp(-v^2) \]  

(1)

This Gaussian pulse provides mechanism for generating abstract frequency domain samples without inter mixing frequency domain information among the samples. The degree of abstraction level is controlled through a simple Gaussian scaling parameter. After frequency domain transformation the samples are multiplied with Gaussian pulse which smoothen the signal. Each such multiplication scales the information content of information signal in reversible way, resulting signal would turn abstract. This Gaussian operation implemented before quantization process of advanced video coding standard.

Figure 3 shows operation involved in diagonal down left prediction mode for intra frame coding, there are three steps involved in diagonal down left prediction mode for intra frame such as order of processing of sub block, prediction block and encoding and reconstructing intra frame. In diagonal down left prediction mode, all the pixels of current sub block is predicted by linearly weighted average of reconstructed pixels A to M of reconstructed block. Prediction equations generated for diagonal down left prediction mode are:

\[ a_1 = ((A+B) + (B+C)+2) >> 2 = (A+2B+C+2) >> 2 = S, \]
\[ a_2 = a_5 = ((C+D) + (B+C)+2) >> 2 = (B+2C+D+2) >> 2 = T \]
\[ a_3 = a_6 = a_9 = (C+D) + (D+E)+2 >> 2 = C+2D+E+2 >> 2 = U \]
\[ a_4 = a_7 = a_10 = a_13 = (E+F) + (D+E)+2 >> 2 = (D+2E+F+2) >> 2 = V \]
\[ a_8 = a_{11} = a_{14} = (E+F) + (F+G)+2 >> 2 = (E+2F+G+2) >> 2 = W \]
\[ a_{12} = a_{15} = (G+H) + (H+H)+2 >> 2 = (G+3H+2) >> 2 = X \]
\[ a_{16} = (G+H) + (F+G)+2 >> 2 = (F+2G+H+2) >> 2 = Y \]

(2)
Fig. 2 Intra prediction modes

Fig. 3. Diagonal down left Intra prediction mode

$a_1, a_2, a_3, a_4, a_5, a_6, a_7, a_8, a_9, a_{10}, a_{11}, a_{12}, a_{13}, a_{14}, a_{15}$ and $a_{16}$ are pixels of current sub block. These pixels are predicted using previously reconstructed pixels $A$ to $M$. Now the pixels $S T U V W X Y$ are the predicted pixel.

After processing of order of sub block, first block encoded and decoded using forward and reverse path of AVC. Predicted pixels ($STUVWX$) are obtained using the diagonal down left intra prediction mode. Residual block is obtained by subtraction of predicted pixels with current block pixels. The residual pixels are transformed, Gaussian multiplied, quantized, inverse quantized, inverse transformed and add prediction to get reconstructed block. This process repeats till end of last sub block of intra frame.

V. PROPOSED ALGORITHM

To achieve the objective of the proposed algorithm the following steps are required

- open source yuv video sequences as an input
- From yuv video sequences extracting the first Intra frame and process in terms macro blocks of size 16x16
- Macro block is divided into 4x4 sub block
- First 4x4 sub block of Macro block is processed by forward path
- By using reconstruction path first sub macro block is reconstructed, it serves as prediction for next sub block of Intra frame
- Difference block obtained by subtracting prediction block with current sub block
- Applied 4x4 integer transform for difference block to get transformed coefficients
- Transformed coefficients are obtained by the followed equation

$$W = AXA^T$$

Where $W$ is transformed coefficients, $A$ is integer constant matrix, $A^T$ is transpose integer constant matrix and $X$ is difference/residual coefficients

- Transformed coefficients are multiplied with Gaussian Pulse to get abstract frequency samples without intermixing information i.e. Gaussian coefficients by the followed equation

$$G(N) = W * G(v)$$

Gaussian coefficients are quantized with quantization process i.e.

$$Z = \text{round}(G(N)/\text{Qstep})$$

- Quantized coefficients are scanned in zig zag manner and reorder
- Reordered quantized coefficients are encoded using Context Adaptive Variable Length Coding i.e. CAVLC
- Measure performance parameter bit rate of proposed method by

$$\Delta B = \frac{\text{Bit rate (proposed)} - \text{Bit rate (JM 18.6 reference)}}{\text{Bit rate (JM 18.6 reference)}} \times 100$$

- Quantized coefficients are inverse quantized the following equation

$$W = Z \times \text{Qstep}$$

Where $W$ are inverse quantized coefficients, $Z$ quantized coefficients
- Inverse quantized coefficients are inverse transformed to obtain difference block using equation
\[ X' = A_i^* W'^* A_i \]  

(8)

\( X' \) are residual or difference coefficients, \( W' \) are inverse quantized coefficients, \( A_i \) is a constant inverse integer matrix, \( A_i^* \) is a transpose constant inverse integer matrix

- Add prediction to difference/residual block to get reconstructed block
- Repeat all the above steps till at end of last sub block of intra frame
- Measure performance parameters bit rate and PSNR under different values of quantization parameter with Gaussian value
- Compare the performance parameters of proposed algorithm with previous algorithm

VI. RESULTS AND DISCUSSION

The proposed work has been carried out using MATLAB and JM 18.6 reference algorithm of AVC. JM reference algorithm is used to code decode the video sequences and to test the various features of H.264/AVC standard. JM reference algorithm is used for the measuring the performance parameters such as picture quality i.e. Peak Signal to Noise Ratio, encoding time and bit rate of intra frame in AVC standard.

JM reference manual is available which describes operation, parameters and features of AVC standard and also contain installation and execution procedure of JM reference algorithm. The input International yuv video sequences in QCIF and CIF resolution. All the functional blocks of intra frame coding are coded and verified experimental results using MATLAB.

In order to verify performance of the proposed algorithm, the performance parameters such as Bit rate, picture quality, and encode time are measured. The performance parameters are measured using the following formulas.

\[ \Delta P = \text{PSNR}_{(\text{Proposed})} - \text{PSNR}_{(\text{JM of AVC})} \]  

(9)

\[ \Delta B = \frac{\text{Bit rate}_{(\text{proposed})} - \text{Bit rate}_{(\text{JM})}}{\text{Bit rate}_{(\text{JM})}} \times 100 \]  

(10)

\[ \Delta T = \frac{\text{Encode Time}_{(\text{proposed})} - \text{Encode Time}_{(\text{ JM of AVC})}}{\text{Encode Time}_{(\text{JM of AVC})}} \times 100 \]  

(11)

Simulation conditions of the intra prediction algorithm as

- Sequence Type is Intra Frame (I – frame), its Frame resolution is CIF 352x288 and QCIF 176x144
- Quantization parameters are set to different values (0 to 51)
- Rate Distortion Optimization technique enabled
- Total frames of sequences is 150 or 300 which depends upon video sequences
- All the frames of sequences are coded in Intra form if period of Intra frame is set to one

Enabled diagonal down left intra prediction mode of 4x4 Intra prediction modes

The simulation conditions of proposed algorithm are specified in table-I. Table-I shows the simulation results of proposed algorithm for six QCIF Intra frames such as Mobile, Tempete, Coastguard, Bus, Football and Foreman, under different Quantization Parameters 36, 30, 28 and 24, Gaussian value 0.1 with diagonal down left intra prediction mode. In table-I negative sign indicates that reduce and positive sign represents increasing. The simulation result of the proposed method was compared with previous work i.e. Tian Song method. From the Table I it observed that compared to previous work i.e. Tian Song et al method the proposed method gives better performance. The proposed algorithm achieves bit rate reduction average about 30.98% compared to Tian Song method (previous work bit rate about 16.34%) and also gives PSNR is consistent. Thus the proposed algorithm achieves more bit rate reduction with consistent PSNR then Tian Song et al method.

The Figure 4 to 5 shows bit rate performance of proposed algorithm for foreman and mobile QCIF intra frame under different quantization parameters, Gaussian value 0.1 with diagonal down left intra prediction mode. In these figures there are two curves, one curve for JM reference algorithm and the other one for the proposed, if bit rate curve of proposed method is below the bit rate curve of JM method that results better reduction in bit rate. If bit rate curve of proposed method is above the bit rate curve of JM method results increase complexity. From these figures
(bit rate curve) it observe that proposed algorithm gives more reduce in bit rate compared with JM reference 18.6 algorithm and Tian Song method.

Table I: Simulation Results of proposed algorithm

| Sequence QCIF | Method | Parameter | Quantization Parameter | Bit rate | Tian Song et al Method | Bit rate | Proposed Method | Inference |
|---------------|--------|-----------|------------------------|----------|------------------------|----------|-----------------|-----------|
|               |        |           | 36         | 30     | 28     | 24          |          |                 |           |
| Tempeste      | JM18.6 | PSNR(dB)  | 33.53      | 36.52  | 37.95  | 38.67        |          |                 | 17.30 %   |
|               |        | Bit rate (kbps) | 1464.64   | 1742.76 | 2039.04 | 2370.32     |          |                 | -37.64 %  |
|               |        | PSNR(dB)  | 35.40      | 35.37  | 35.36  | 35.35        |          |                 | -30.98 %  |
|               |        | Bit rate (kbps) | 1009.39   | 1104.72 | 1216.27 | 1363.05     |          |                 | -34.09 %  |
| Coastguard    | JM18.6 | PSNR(dB)  | 33.21      | 34.95  | 36.51  | 38.64        |          |                 | 17.28 %   |
|               |        | Bit rate (kbps) | 1005.20   | 1269.84 | 1522.08 | 1821.16     |          |                 | -17.07 %  |
|               |        | PSNR(dB)  | 34.96      | 34.93  | 34.90  | 34.89        |          |                 | -17.28 %  |
|               |        | Bit rate (kbps) | 948.88    | 1065.13 | 1194.44 | 1354.33     |          |                 | -17.28 %  |
| Bus           | JM18.6 | PSNR(dB)  | 33.02      | 35.60  | 36.78  | 38.64        |          |                 | 14.94 %   |
|               |        | Bit rate (kbps) | 1804.08   | 2163.84 | 2546.24 | 2968.12     |          |                 | -41.49 %  |
|               |        | PSNR(dB)  | 35.64      | 35.62  | 35.60  | 35.60        |          |                 | -41.49 %  |
|               |        | Bit rate (kbps) | 1181.16   | 1284.89 | 1406.57 | 1568.49     |          |                 | -41.49 %  |
| Foreman       | JM18.6 | PSNR(dB)  | 34.21      | 37.43  | 38.64  | 39.88        |          |                 | 14.94 %   |
|               |        | Bit rate (kbps) | 712.72    | 870.64  | 1044.88 | 1256.08     |          |                 | -23.28 %  |
|               |        | PSNR(dB)  | 39.02      | 38.98  | 38.93  | 38.92        |          |                 | -23.28 %  |
|               |        | Bit rate (kbps) | 588.15    | 673.72  | 774.05  | 914.77      |          |                 | -23.28 %  |
| Mobile        | JM18.6 | PSNR(dB)  | 33.22      | 35.20  | 37.05  | 38.90        |          |                 | 19.59 %   |
|               |        | Bit rate (kbps) | 1892.88   | 2208.40 | 2551.36 | 2924.10     |          |                 | -43.16%   |
|               |        | PSNR(dB)  | 34.81      | 34.80  | 34.79  | 34.79        |          |                 | -43.16%   |
|               |        | Bit rate (kbps) | 1186.09   | 1277.66 | 1388.87 | 1530.26     |          |                 | -43.16%   |
| Football      | JM18.6 | PSNR(dB)  | 33.80      | 35.48  | 37.08  | 38.77        |          |                 | 14.28 %   |
|               |        | Bit rate (kbps) | 1144.96   | 1409.20 | 1678.40 | 1996.08     |          |                 | -23.25 %  |
|               |        | PSNR(dB)  | 35.51      | 35.51  | 35.05  | 35.44        |          |                 | -23.25 %  |
|               |        | Bit rate (kbps) | 988.78    | 1096.57 | 1218.29 | 1373.11     |          |                 | -23.25 %  |
| Average       |        | Simulation condition: JM 18.6, Intra frame, frame rate 30 fps CAVLC | | | | | | -16.34% |

The Figure 6 and Figure 7 shows rate distortion performance of proposed algorithm for bus and foreman QCIF intra frame under different quantization parameters, Gaussian value 0.1 and diagonal down left mode. In these figures if the both curves are over lap each other then performance of proposed and previous method are same. If curve of proposed method is above the previous method then performance of proposed is better than previous. If
curve of proposed is below the previous then performance of proposed is worse than previous. From rate distortion curve it observes that proposed algorithm provides better rate distortion performance that is consistent picture quality (PSNR) compared with JM 18.6 reference algorithm and Tian Song method. Figure 8 shows reconstructed intra frames of football in QCIF resolution for diagonal down left mode under different quantization parameters with Gaussian value $\nu = 0.1$. From the reconstructed intra frame it observe that proposed algorithm provide picture quality (PSNR) consistent under different quantization parameters compared to Tian Song algorithm.

VII. CONCLUSION
The proposed work carried on diagonal down left intra prediction mode for Intra frame coding in advanced video coding standard using Gaussian pulse. The Proposed algorithm achieved consistent picture quality (PSNR) and reduced bit rate averagely about 30.98% for QCIF sequence under different quantization parameters (24 28 30 and 36) with Gaussian value $\nu = 0.1$. Therefore proposed method was compared to Tian song method. Compared to previous (Tian song) method, the proposed algorithm maintains consistent picture quality i.e. PSNR and achieved more bit rate reduction (about 30.98%).

REFERENCES
1. Chan-Ling YANG, Lai-Man PO, Wing-Hong LAM, “A Fast H.264 Intra Prediction Algorithm Using Macro block Properties,” IEEE International Conference on Image Processing, pp.461-464 2004.
2. E.Arura, L.Del Vecchio, R. Lancini, L. Nisti, “Fast Macro Block Intra and Inter Modes Selection for AVC,” IEEE Transactions, 2005.
3. Huang Hui, Cao Tie-Yong, Zhang Xiong-Wei, “The Enhanced Intra Prediction Algorithm for H.264”, IEEE Congress on Image and Signal Processing, pp.161-165, 2008.
4. Pengyu Liu, Kebin Jia, “A Novel Intra-frame Prediction Algorithm Based On Macro-block’s Histogram for H.264/AVC,” IEEE Sixth International Conference on Intelligent Information Hiding and Multimedia Signal Processing 2010.
5. Thomas Wiegand, Gory. Sullivan, Seniour Member, IEEE, Gisle Bjontegaard and Ajay Luthra, “Overview of the H.264/AVC Video Coding Standard”, IEEE Transactions on circuits and systems for video Technology, Vol. No 7 2003.
6. Rein van den Boomgaard and Rik van der Weij, “Gaussian Convolutions Numerical Approximations Based on Interpolation”, Intelligent Sensory Information Systems, University of Amsterdam, and The Netherlands.
7. Pascal Gwosdek, Sven Grevenig1, Andr`es Bruhn, and Joachim Weickert, “Theoretical Foundations of Gaussian Convolution by Extended Box Filtering”.
8. Jijun Shi, Yunhui Shi, Baocai Yi, “Fast intra prediction mode decision for AVC based on edge direction detection” 2008 The Institution of Engineering and technology.
9. K.Bharanitharam, An-Chao Tsai, “Efficient Block Size Decision Algorithmn for intra mode decision in AVC encoder” 2009 IEEE International Symposium on Multimedia.
10. Tian Song, Akashi Shimamoto, Takafumi Bando, Wenjun Zhao, “Novel Intra modes with Temporal-Spatial Prediction for H.264/AVC”, IEEE International Conference on Consumer Electronics-Berlin (ICCE-B), 2011.
11. Haitao Li, Jianjun Li, G.S. Shokoush refik Samet, “A Low Complexity Algorithm for H.264/AVC Intra Prediction”, IEEE International Conference on Cyber worlds, 978-1-4799-2245-1, 2013
12. Iain E. Richardson, “The H.264 Advanced Video Compression Standard,” John Wiley & Sons, Second edition 2010.
13. Parameshachari B D et al, Security Mechanism for Image Authentication Based on Pixels Adaption, CitT International Journal of Digital Image Processing, pp 146-149, Vol 8, No 5, May 2016.

Authors:

Dr. Manjanaik N currently working as an Associate Professor and Chairman/Head of the Department of Electronics and Communication Engineering at University B D T College of Engineering Davangere, Karnataka. He has a total Research & Teaching experience of around 13 Years. He has obtained B.E degree in ECE at UBDTCE Davangere from Kuvempu University in 2000 and M. Tech degree in Computer Application in Industrial drives from Viteesvarayya technological University, Belagavi, India in 2003 and Completed Ph.D in Electronics and Communication Engineering from Jain University, Bangalore in 2016. He has published more than 05 papers in International Journals, 03 IEEE International Conferences and one Springer International Conference.

Dr. Parameshachari B D currently working as a Professor and Head of the Department of Telecommunication Engineering at GSSS Institute of Engineering & Technology for Women, Mysuru. Previously, he worked as Asst. Professor in the Dept. of ECE at KSIT, Bangalore. Worked as Associate Professor in ECE Dept. at NCERC, Kerala. Worked as a Senior Lecturer in the Department of ECE at JSSATE, Mauritius (Abroad). Before that he was Lecturer at KIT, Tiptur for Seven years. He has a total Research & Teaching experience of around 14 Years. He has obtained B.E degree in ECE and M. Tech degree in Digital communication Engineering from VTU, Belagavi, India and completed Ph.D in Electronics and Communication Engineering from Jain University. He is the First Research Scholar who completed the research work under the faculty of Engineering in Electronics and Communication Engineering from Jain University, Bengaluru. He has published more than 37 papers in International Journals/International Conferences. Received young scientist award from Auaufu internal Awards and Venus International Research Awards. He is serving as a reviewer for the various international Journals/conference also as a session chair for various National conferences. Member of various professional bodies such as IE, ISTE, IETE, IAEST, IAESC, IAENG and AIRCC. Three Research Scholars have been awarded Ph.D. Degree under his supervision.

Hanumanthappa S N currently working as an Assistant Professor in the Department of Electronics and Communication Engineering at University B D T College of Engineering Davangere, Karnataka. He has a total Research & Teaching experience of around 14 Years. He has obtained B.E degree in ECE at SJMIT Chitradurga from Kuvempu University in 2002 and M. Tech degree in Digital Communication from Visvesvarayya technological University, Belagavi, India in 2009 and Pursuing Ph.D in Electronics and Communication Engineering from VTU, Belagavi, India. He has published more than 02 papers in International Journals.
Dr. Reshma Banu working as an Professor & HOD in the Department of Information Science & Engineering at GSSS Institute of Engineering and Technology for women, Mysuru. She is having 15 years of Teaching and Research Experience. She pursued Ph.D., Computer Science & Technology, from Sri Krishna Devaraya University, Anantapur, Andra Pradesh. Master of Technology, Computer Science & Engineering, from Visvesvaraya Technological University, Belagavi, Bachelor of Engineering in Computer Science & Engineering, Kuvempu University, Shimoga, Currently Nominated as Coordinator for implementation of ICT initiative’s to VTU from GSSSIETW, Mysuru. She is Examiner/valuator/ Paper setter for Visvesvaraya Technological University, Belagavi. She has published several Research papers in International, National Journals/conferences. She is a Member of CSI, IAENG, IBM Academic Initiative, and LM ISTE. Received young scientist award from Aufau Internal Awards and Venus International Research Awards. Dr. Reshma Banu’s area of interest and research include Networking, Performance enhancement algorithms, Cloud Computing, cryptography and Communication. She was a session chair for the Paper presentation in 29th CSI Karnataka student convention, GSSITEW, Mysuru, and in various Conferences. Four Research Scholars have been awarded Ph.D. Degree under his supervision.