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Hiding of Data using 4*4 Block-Wise Embedding Strategy for Images

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***Abstract*— This study explores how to enhance the perceptual appearance of shortened pictures containing content concealed within them by integrating natural visual abilities with a two- phase data concealment approach. In intelligent capitals, where various sources of visual data are gathered for enhanced administration, the graphical network of things, also known as the IoT, is essential. Safety concerns are crucial when using a public network for transmission. Furthermore, picture reduction is commonly utilized to improve the bandwidth utilization. In this paper, we introduce a unique information concealing procedure for picture decompression using AMBTC as a way to satisfy both requirements. Photographic safeguards include picture authorization, thwarting forgery attempts, and protectingproprietary information. The proposed detection method is classified into AMBTC which is an alternative to Block Truncation Code whereby the initial actual moments are maintained inaddition to the average in place of utilizing the variance. AMBTC is substantially easier to implement than BTC and generally yields smaller mean squared errors (MSE).The ability to restore the initial picture following data concealing is emphasized by reversing information concealment techniques. Nevertheless, the quantity of knowledge which is capable of being associated will either be reduced or more knowledge might be needed for recovery fromthe stego picture in order to retain the ability to revert associated with the stego (i.e., the data-embedded) image. By altering the LSB of the images to create the stego picture, the approachknown as LSB incorporates digital hidden info into the picture being hosted. Despite thestego picture will not be recovered to its original state using the irreparable content concealing approach, it typically requires no any extra information for restoration and information recovery.**

***Index Terms*— Absolute Moment Block Truncation Coding (AMBTC), least significant bit, two-phase data concealment, image compression, tampering chunks.**

I. INTRODUCTION

The fast growth of electronic multi-media has resulted in an enormous surge in huge amounts of information. Every day, several programs generate recordings, photos, and movies. The two key challenges raised by this pattern are the security of crucial data and the enormous amount of information. To improve data transfer secrecy, the person who sends it can secure information using traditional methods of cryptography or content-hiding approaches so that content may be sent invisibly [2, 3, and 5]. Eventually, data-hiding studies in the reduction sector will become a significant issue since it is critical to maintain concealment capability with reduced picture quality. Information concealment is defined as an extremely efficient means of concealing private information

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within other forms of media, such as digital photographs, movies, and music. A geographical field, a frequency field, and a compressed region are the three areas of a picture information concealment system [4].It is now feasible to obtain a lot of knowledge on the web because of the lightning-fast developments in networking technologies. Private data cannot be securely saved on the web due to its insufficient security. Content concealing strategies are helpful in the IoT and visual Internet of Things [7] to prevent the theft or harmful distribution of private data. Because of the safety concerns with several picture encryption techniques that are enumerated, [8] content concealment is a crucial field of study for enhancing the safety of network-related data. The statistical masking approach is currently being researched and presented by numerous academics. There are two primary categories of information hiding: reversible and irreversible. The initial picture is able to be restored following information concealment, which is emphasised by reversible information concealment techniques [9-11, 25]. Reversible pattern concealing is therefore used in graphics requiring high levels of specificity, such as those used in machine drawing and healthcare photography. But the quantity of content that is able to be contained will be reduced, or more content will be necessary for recovery from the stego picture in order to retain the ability of stego pictures to be reversed. For irreversible data [12, 13], exploiting modification directions (EMDs), pixel value differencing (PVD), and concealing the least significant bit (LSB) are three popular methods. The LSB technique replaces the LSB of the pixels in the source picture with digital encrypted information to create the stego picture [14], since it may incorporate information into the picture while modifying the pixels just slightly, LSB is employed. The EMD technique can only change the contents of a single stego pixel by 1 (i.e., ±1) since it incorporates the (2n+1) -ary bit information into n stego pixel and keeping everything else same [14]. EMD's main benefit is that it reduces the number of pixels which must be changed for integrating information; as a result, it enhances the stego picture's consistency. The pixel value differencing approach modifies the variance among each of the pixel sets to place a predetermined quantity of information in the host picture, minimizing the pixel-to-pixel difference that significantly degrades the appearance of the stego image [16], the Pixel Value Differencing approach typically separates the pixel data to numerous identically sized parts. Despite the fact that the stego picture is unable to be restored to its original state using the non-reversible information concealing approach, typically does not require more information for gathering and retrieval if it exists. We can insert concealed information into a picture using picture information concealing methods to safeguard one's proprietary information and stop misuse or manipulation. Picture information concealment is frequently based on a particular image compression standard [17- 20, 23]. A picture may be transmitted over the web more effectively and with less memory use when it has been reduced. Lossy image compression and lossless image compression are two categories of picture reduction methods. Despite losing information, we cannot restore the original picture; it considerably decreases the dimensions of the image, meaning that it performs better than lossless compression in terms of reduction rate. AMBTC, a lossy picture reduction technique, is used in this work to efficiently compress the picture.

The AMBTC compression technique has the benefit of requiring relatively little computational resources while yet producing images of a satisfactory standard. It is hence appropriate for low-energy gadgets. Several academics have been concentrating on AMBTC- based data masking techniques. An approach of steganography that separates the AMBTC chunks into simple and complex chunks was put out by Ou and Sun [24]. Two integrating methods are created in [24] based on the kind of block, which aids the writers in more effectively utilising the various block features. Identical to [24], Huang et al. [21] developed a hybrid secret hiding approach to information concealing in AMBTC pictures. In order to reduce the level of deformation in the stego picture, Hong et al. [22] suggested an AMBTC- related concealing approach that makes use of a suppressing cut-off system and an alteration methodology. In 2020, Lee et al. [6] demonstrated reversible data hiding based on Turtle-shell for AMBTC-compressed images. Their method provided lower computation complexity, and the resolution of the picture was acceptable. Yet, the strategy fails to deliver a great level of concealment as it is unable to incorporate the sensitive data into the complicated picture. Kurnia Anggriani [1] introduced a novel content concealing strategy for AMBTC encrypted pictures using combination theory in 2023. The results of experiments demonstrate that our suggested strategy delivers great concealment capability and picture clarity, despite complicated pictures.

II. Related Work

As previously indicated, AMBTC is a lossy picture reduction technique that employs relatively little computational power [21]. As a result, AMBTC can produce a good reduced picture quality and is appropriate for real-time embedded system programs. The source picture in AMBTC is initially separated into non-overlapping elements that are square and have n sides. The mean of every block's individual pixel values is determined in order to compress the image by:

$$\bar{x} = \frac{1}{n^2}\sum_{i=1}^{n*n} x_i$$

Where xi is the block's i-th pixel value

After that, through comparison of xi with the pixel values in a chunk, a n_n bit map is produced using the mean pixel value as a criterion. If xi is greater than the pixel value, the bitmap output is set to 0 (and then substituted by the small average number in the AMBTC compacted chunk) at the beginning of the process; otherwise, it is set to 1 (and the maximum average number in the AMBTC compacted chunk is substituted for it).

A set of pixels having values smaller than xi is referred to as the low-mean bit (NL), whereas a set of pixels with pixel values exceeding or equivalent to xi is known as the high-mean bit (NH). The following are the low mean and high mean quantization settings for AMBTC reduction:

$$LM = \frac{1}{NL}\sum_{xi<x} xi \qquad (1)$$

And

$$HM = \frac{1}{NL}\sum_{xi>x} xi \qquad (2)$$

87	88	107	77
86	97	88	84
88	92	82	87
88	88	86	83

(a)

0	1	1	0
0	1	1	0
1	1	0	0
1	1	0	0

(b)

84	92	92	84
84	92	92	84
92	92	84	84
92	92	84	84

(c)

Fig1. AMBTC reduction depiction. (a) Using (1), the mean pixel value x = 88 in its initial picture chunk (b) AMBTC's bit mapping, in which NH = 8 and NL = 8. (c) The AMBTC reduced chunk, where BS = 4, HM = 92, and LM = 86.

III. Proposed Methodology

The suggested approach outlines a method for incorporating information into an Absolute Moment Block Truncation Coding block. This technique allows for hiding data within the image while minimizing the visual impact on the original content. The process divides the picture into not-interconnected 4x4 chunks, calculates the mean value for each block, converts the pixel values to binary based on this mean, and then embeds the hidden data by altering the encoded picture to include the least significant bit of each pixel. By reversing the procedure, the concealed data may be safely recovered.

The first step is to divide the image into 4x4 blocks. This step allows us to work with smaller chunks of the image and process them independently. Each block consists of 16 pixels, and the image is divided without any overlapping regions. The next step involves calculating the mean of each block. For each 4x4 block, the average pixel value is computed, and this mean value is stored as x-bar ($\bar{x}$). This step helps in determining a representative value for each block, which will be used later to decide which pixels should be replaced with 1 and which ones with 0.

With the mean values determined, the pixel values of each block are compared with the x-bar. If a pixel value is larger than x-bar, it is replaced with 1; otherwise, it is replaced with 0. The resulting binary values are stored in another variable, creating a binary image. This binary image serves as a key to encode the hidden information. Pixels with values of 1 will represent the higher mean, while pixels with values of 0 will represent the lower mean.

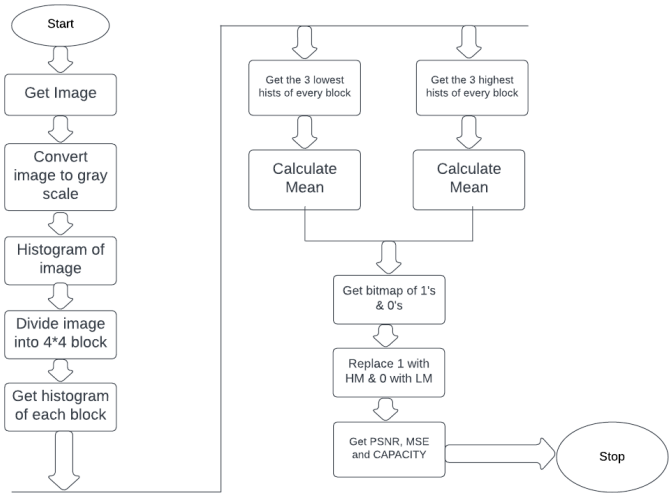
Next, the high mean and low mean are calculated based on the binary image. The high mean is the average of the pixel values at the positions where the binary image is 1 (higher mean pixels), and the low mean is the average of the pixel values at the positions where the binary image is 0 (lower mean pixels). These two values will be used later to replace the 1s and 0s, respectively, in the binary image.

$$High\ mean = \frac{1}{no\ of\ ones}\sum_{k=0}^{16} pixel\ value\ at\ ones\ position$$

$$Low\ mean = \frac{1}{no\ of zeros}\sum_{k=0}^{16} pixel\ value\ at\ zeros\ position$$

To ensure a secure and robust embedding of data, the histogram of the high mean is obtained. The histogram represents the frequency pattern of pixel corresponding to the high mean in the binary image. By creating a histogram, we can analyse the pattern of pixels and calculate the average value of the histogram's higher values. This mean will represent the higher histogram values and is used in the embedding process. Similarly, a histogram of the pixel values corresponding to the low mean in the binary image is created. The average value of the histogram's lower values is calculated, representing the lower histogram values. This will replace all zeros in the binary image during the embedding process.
Now, the actual data embedding process begins. The 1s and 0s in the binary image are replaced with the calculated higher and lower means, respectively. This means that all ones in the binary image will be replaced with the higher mean, and all zeros will be replaced with the lower mean. By performing this replacement, the binary image is now transformed into a new matrix that contains only the high mean and low mean values, representing the 16 pixel values of the original 4x4 block.
The next step involves iterating through each pixel of the combined matrix and clearing the least significant bit of each pixel. This process ensures that the data embedding does not significantly impact the picture's appearance. By modifying only the LSB of each pixel, the changes introduced are minimal and generally imperceptible to the human eye.
If the original data was in string format, it is converted to uint8 format, representing unsigned 8-bit integers. This conversion is necessary for data embedding since each pixel in the image is represented by an 8-bit integer value. With the converted data, the actual embedding process takes place. The converted information is included in the LSB of each pixel in the combined matrix. By modifying the LSB, the hidden data is effectively hidden within the picture. Since the changes are minor (only the LSB is altered), the picture's appearance is not significantly affected, and the hidden data is not easily noticeable.
To obtain the secret information, the reverse process is performed. The LSB of each pixel in the combined matrix is extracted, revealing the embedded data. This extraction process retrieves the data that was previously hidden within the image. After extracting the hidden data, it is essential to convert it back to the original format. For example, if the original data was in string format before embedding, it needs to be converted back to string format after extraction.

A. Algorithm



IV. Experimental Performance And Debate

The suggested approach's effectiveness is assessed by contrasting it with previously published approaches in [6] (2020) and [1] (2023). Additionally, blocks for the procedures in [21, 22, and 24] are divided into smooth and complicated blocks.
We suggest a quick approach for validating photos that have been reduced using absolute moment block truncation code, which may retrieve tampering chunks. Certain kinds of deliberate manipulation might be impossible to find with the current techniques. The tampering chunks can only be restored using their methods in the meantime, giving the scene a displeasing mosaic-like aspect. The suggested approach divides parts of images into units based on shared features, and the combined data is stored for use in restoration. The data from the set is duplicated, jumbled, and inserted in a pattern of uniform chunks to create a list of potential The LSBs of the quantization

stages include the codes with the lowest deformation. By aggregating the untampered blocks with the same measure, the manipulated chunks may be located. The results of the study demonstrate that the suggested approach additionally produces labeled images with outstanding clarity and detectability, yet additionally provides a good recovery outcome.
We calculate PSNR, MSE, SNR and Capacity.

A. PSNR (Peak Signal to Noise Ratio):

PSNR is a technical phrase that describes a signal's greatest achievable strength in relation to the power of interference that has an impact on the standard of its depiction. Because numerous signals possess an exceedingly broad dynamical window, PSNR is often expressed as a log value on a dB meter.
The PSNR (in decibels) is calculated as follows:

$$PSNR = 10.\ log_{10}(MAX_I^2/MSE)$$

$$= 20.\ log_{10}(MAX_I/\sqrt{MSE})$$

$$= 20.\ log_{10}(MAX_I)\text{-}10.log_{10}(MSE)$$

MAXI denotes the picture's highest achievable pixel count.

B. MSE (Mean Squared Error):

The MSE is the best way for defining PSNR. Provided a free of noise m*n monochromatic picture I as well as its imperfect estimate K, MSE is described as:

$$MSE = \frac{1}{mn}\sum_{i=0}^{m-1} xi \sum_{j=0}^{n-1} xj\ [I(i,j) - K(i,j)]^2$$

C. SNR (Signal to Noise Ratio):

Technological and scientific fields employ the SNR for contrasting the intensity of an impulse in comparison to the intensity of the surrounding undesired sound. SNR is commonly expressed in decibels. A proportion above 1:1 (more than 0 dB) indicates higher information over interruption. The Shannon-Hartley theorem refers to a route's SNR, connectivity, and network occupancy. The comparison of a signal power to background undesired sound power is known as the SNR.

SNR = P_signal/P_noise

Where P is average power.
It is necessary to measure the power of the signal and the noise at identical and comparable locations within an entity, as well as the confines of the identical network capacity. Regardless of whether the data point is a fixed value (s) or an arbitrary variable (S), the SNR for the unexpected, undesired sound N fluctuates

$$SNR = \frac{P_{signal}}{P_{noise}}$$

Where E denotes the anticipated quantity.

$$SNR = \frac{S^2}{E[N^2]}$$

The denominator represents the undesired sound's variance, or the square of its standard deviation, if the undesired sound has an anticipated zero rate, as is frequently the case. It is necessary to evaluate both the signal and the noise in the identical process, for instance, as voltages within the identical susceptibility range. As a substitute, RMS can be employed in the formula as shown in equation given below:

$$SNR = \frac{P_{signal}}{P_{noise}} = \left(\frac{A_{signal}}{A_{noise}}\right)^2$$

Wherein A is the Root mean square (RMS) amplitude, which might be voltage in this case.

D. Quality estimation with PSNR

The efficiency of rebuilding compressed data with lossy codes (such as those used for picture compression) is most frequently assessed using PSNR. The true data is the signal in this case, whereas the omission caused by reduction is the disturbance. PSNR is a substitute for human sense of rebuilding accuracy when comparing

reduction coding. If a bit range is 8 bits, standard PSNR values for lossy video and photo reduction range from 30 to 50 dB, with greater values being preferable. Normal PSNR metrics for 16-bit data, the spectrum is 60 to 80 dB. Even though a greater PSNR often denotes better restoration, this can sometimes not be the case. The spectrum of reliability consequences of this action needs to be cautiously taken into account because it is limited to being utilised for contrast outcomes from an identical codec (or codec type) and similar material. In general, it has been demonstrated that PSNR performs badly when compared to other quality measures for determining how well movies and, in particular, pictures are viewed by humans.

Fig 1(i) Original uncompressed image

Fig 1(ii) Q=90, PSNR 45.53dB

Fig 1(iii) Q=30, PSNR 36.81dB

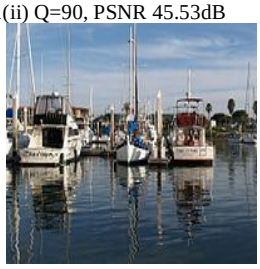


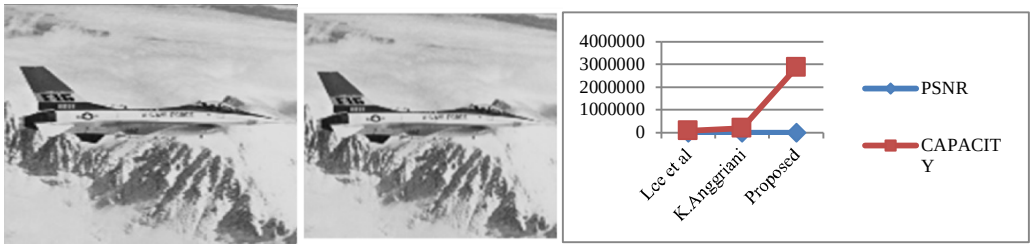
Fig 1(iv) Q=10, PSNR 31.45dB

V. RESULTS

TABLE 1 COMPARISON TABLE

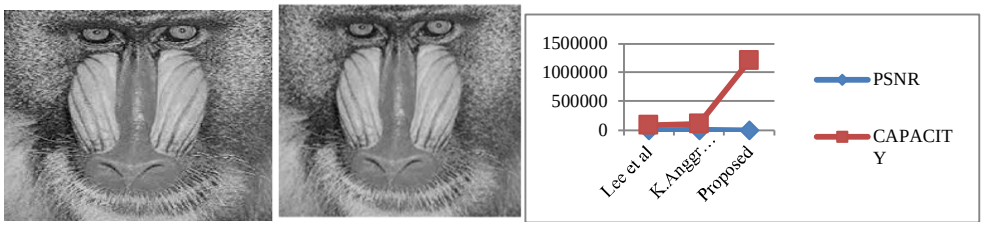
Image	Metrics	Lee et al scheme [6]							K.Anggriani[1]	Proposed
		TH 50	TH 40	TH 30	TH 20	TH 10	TH 5	TH 0		
Airplane	PSNR	33.89	33.86	33.86	33.90	33.87	33.83	33.86	38.25	42.46
	MSE	26.53	26.72	26.70	26.49	26.64	26.93	26.72	9.72	3.49
	Capacity	31980	311984	301424	285968	250432	188800	81920	195928	2881550.79
Baboon	PSNR	30.87	30.82	30.82	30.84	30.85	30.83	30.85	37.97	39.48
	MSE	53.17	53.80	53.86	53.60	53.41	53.76	53.41	10.36	7.32
	Capacity	281136	249920	216304	179504	128112	97424	81920	104284	1212199.80
Barbara	PSNR	31.94	31.93	31.95	31.94	31.93	31.99	31.97	37.59	35.41
	MSE	41.61	41.70	41.48	41.62	41.66	41.14	41.27	11.31	16.45
	Capacity	302544	285584	263808	232496	190128	131440	81920	151840	1191624.53
Boat	PSNR	31.73	31.71	31.70	31.70	31.77	31.72	31.74	36.27	38.58
	MSE	43.63	43.84	43.90	43.90	43.21	43.67	43.52	15.34	9.02
	Capacity	321520	311568	297024	269280	191600	113200	81920	158440	2846309.60
Lena	PSNR	33.43	33.43	33.40	33.42	55.47	33.38	33.42	37.42	38.23
	MSE	29.51	29.50	29.66	29.56	18.43	29.80	29.58	11.76	8.73
	Capacity	335680	329152	318032	298880	254976	175248	81920	201364	2874847.65
Pepper	PSNR	32.68	32.73	32.68	32.65	32.70	32.68	32.69	35.89	35.32
	MSE	35.00	34.66	35.019	35.29	34.86	35.01	34.96	16.72	15.94
	Capacity	329536	324208	315904	300720	242848	135440	81920	197632	2783733.15

The findings reveal that our suggested strategy outperforms others in terms of visual appeal as well as information concealing capability.



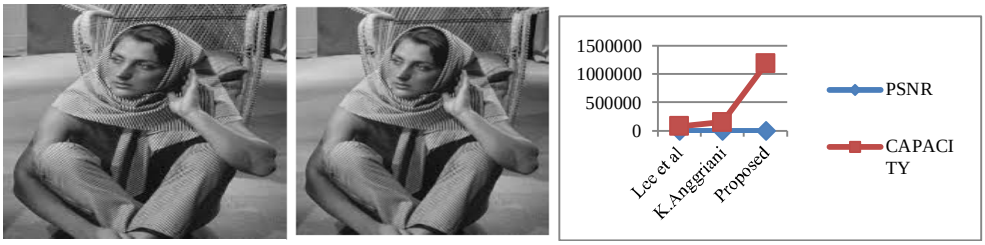
(a): Original Image (b): Resultant Image (c): Graphic Comparison

Fig 3(i): Airplane Image



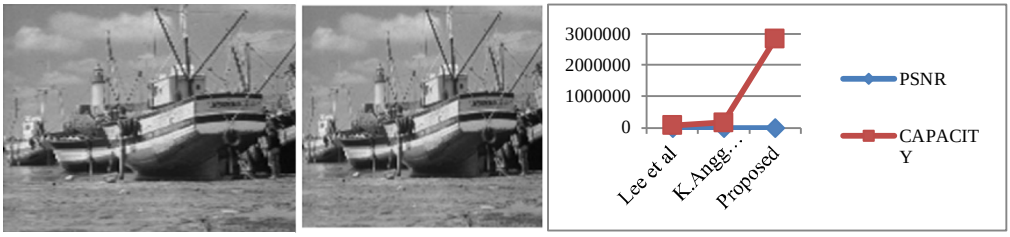
(a): Original Image (b): Resultant Image (c): Graphic Comparison

Fig 3(ii) Baboon Image



(a): Original Image (b): Resultant Image (c): Graphic Comparison

Fig 3(iii) Barbara Image

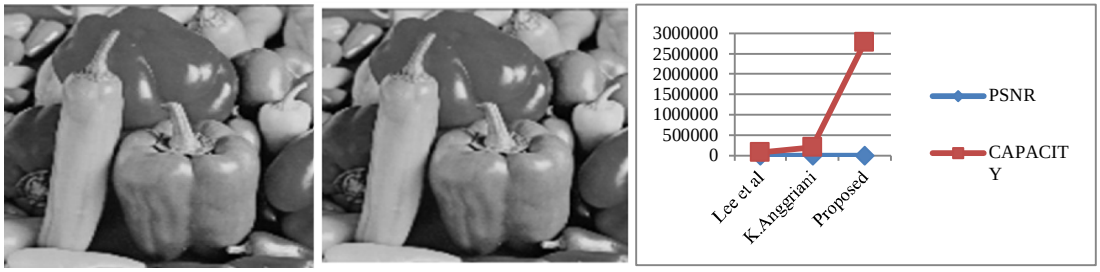


(a): Original Image (b): Resultant Image (c): Graphic Comparison

Fig 3(iv) Boat Image

(a): Original Image (b): Resultant Image (c): Graphic Comparison

Fig 3(v) Lena Image



(a): Original Image (b): Resultant Image (c): Graphic Comparison

Fig 3(vi) Pepper Image

VI. Conclusion

Every day, a sizable number of electronic photos are sent around via the web to different parts of the planet thanks to the growth of intelligent towns and virtualization. The safety of data, which forbids unauthorised consumption, copying, and openness, is crucial and serves many purposes. This paper suggests a removable information concealing mechanism for the AMBTC-reduced pictures since the majority of photos on the web are resized pictures. The suggested content concealing technique is complemented with a chaos-based picture encoding system. As a result, their privacy is preserved and increased while being transported via the internet. Considering several reliable metrics and comparisons with other approaches, we show from the research results that the suggested technique is efficient.

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