Visual Cryptography Tool for Embedded Halftoned Shares

GRADUATE PROJECT PROPOSAL

Submitted to the Faculty of

The School of Engineering and Computing Sciences

Texas A&M University-Corpus Christi

Corpus Christi, TX

in Partial Fulfillment of the Requirements for the Degree of

Master of Science in Computer Science

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Spring 2012

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ABSTRACT

Visual Cryptography is a technique, which is used to conceal the secret image into transparencies (which will vary with the user) and these transparencies are distributed to the intended recipients. In Extended Visual Cryptography Scheme, the transparencies are embedded into the meaningful images so that the intended recipient will have a transparency, which is a meaningful image. Without much computation, only the qualified set of participants can reveal the secret image by simply stacking transparencies. The tool can be used in both ways, to encrypt the secret image into transparencies and also to decrypt the embedded images. Simple steps and operations perform encryption and decryption of images. Halftoning algorithm is used to divide the secret image into transparencies with the help of dither matrix. Dither matrix stores the information of all pixels in the secret image. Using this tool, user can send encrypted images that are in the format of GIF and PNG. The encrypted transparencies can be saved in the machine and can be sent to the intended person by other means. Experimental results reveal that the tool works with gray-scale images in the format of .png and .gif.

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1. Background and Rationale

The principle of visual cryptography scheme (VCS) was first introduced by Naor and Shamir. VCS is for sharing secret information that focuses on sharing secret images. In the proposed mechanism, using visual cryptography scheme, the idea is to split a secret image into two random shares (printed on transparencies), where individual transparencies reveal no information about the secret image other than the size of the secret image. The secret image can be reconstructed by stacking the two shares. The underlying operation of this scheme is logical operation. Traditional VCS takes a secret image as input, and outputs shares that satisfy two conditions:

1) Minimum number of shares can recover the secret image, these shares are qualified shares.

2) Other than qualified subset of shares, no other shares can produce or reveal the secret image other than size of the original image.

VCS recovers the secret image from qualified subset of shares. In this scheme, shares are distributed to two participants secretly, and each participant cannot get any information about the secret image, but after stacking shares, the secret image can be observed visually by the participants. VCS can be used in military for soldiers who doesn't have the knowledge of cryptography and don't have any devices to compute the secrets. There are many other applications existing other than the VCS original purpose, those are, password sharing, secret information sharing, watermarking and identification verification etc.

1.1 Visual Cryptography Scheme for Secret Hiding

Using Visual cryptography, image is encrypted in such a way that no one apart from the sender and intended recipient even realize the original image, this is a form of security through obscurity. Cryptography hides the secret image in other images, but it does not reveal the fact that it is not the actual image to others besides the sender and the recipient.

Based on cryptography, ‘n’ images are encoded and only the human naked eye can decrypt the hidden message without any cryptographic computations. This is achieved when encrypted image shares are stacked one over other using Visual Cryptography. An improved algorithm based on Chang’s and Yu visual cryptography scheme is proposed to hide a colored image in the form of multiple colored cover images as in fig-1 by computing $F(k_i, Ѓ_p)$. As ‘I’ image encrypted into ‘k’ number of shares and the function denotes each share by k_i and $Ѓ_p$ is to perform the image shared operation as in described in fig-1. Original image is encrypted into shares, and the shares are also layered one after another to reveal secret image. Using ‘S’ matrix and the shares we form original image without computation. This mechanism or approach results loss less recovery and the noise reduction techniques are efficient enough in covering the images without adding any computational complexity. This is the basic principle, which is developed for further improvement of visual cryptography schemes.

$$k_i = S_{1\,j} \text{ XOR } S_{2\,j} \qquad \qquad \begin{cases} i & \text{if } i < r \text{ --------[15]} \\ i+1 & \text{if } i > r \end{cases}$$

where $k_i = S_{1\,j}$ XOR $S_{2\,j}$ and j=

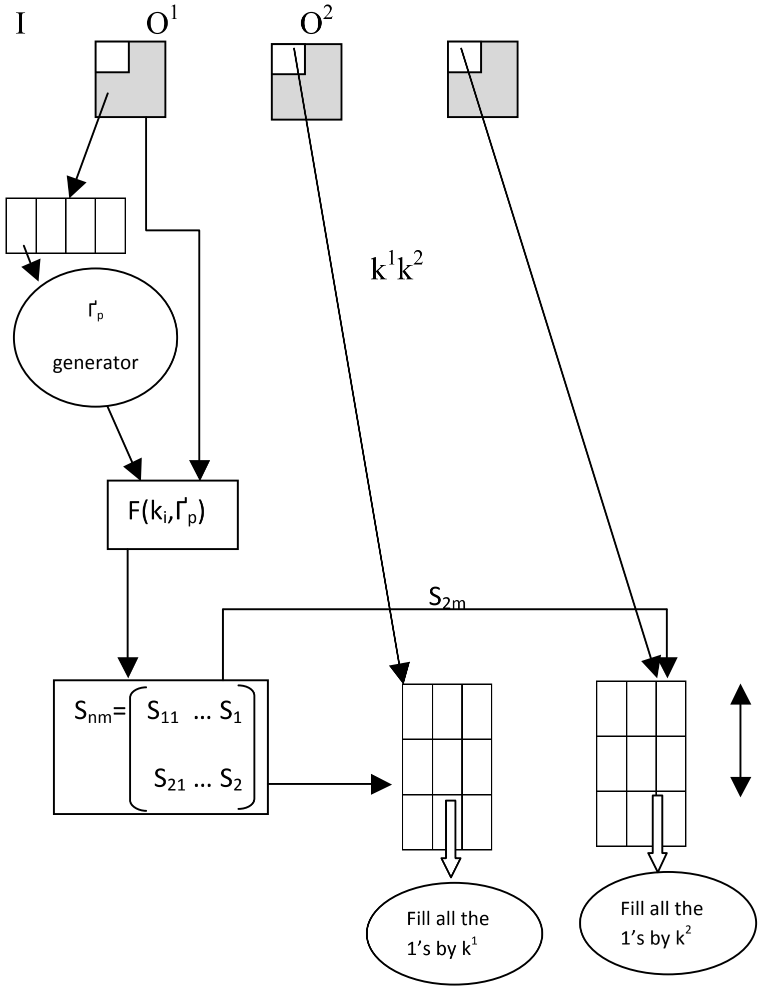


Fig 1: Chang and Yu's secret sharing algorithm flowchart

1.2 Halftone Visual Cryptography via Error Diffusion

Naor proposed an algorithm for visual cryptography in which secret image is obtained by just stacking shares without computation. Secret image is encoded into 'n' shares as shown in fig-2.

Any share is nothing but a random binary pattern. All these ‘n’ shares are copied on to transparencies respectively, and distributed among ‘n’ meaningful images. Bundling all the transparencies together, will reveal the secret image without any computation being required as shown in fig-3. However, by inspecting less than the specified shares, no one can gain any information about the secret image even if higher computational power is available for image processing.

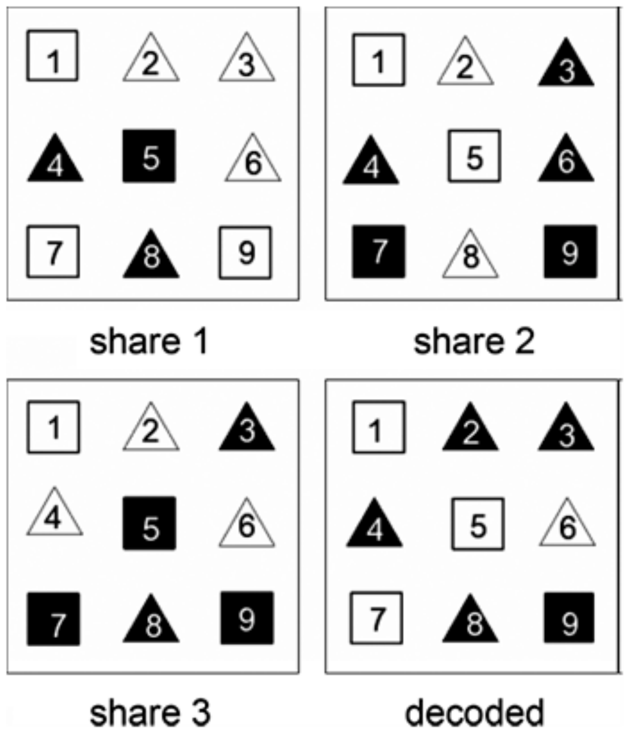


Fig 2: Example of halftone cells with size q=9 in a 3-out-of-3 scheme [3]

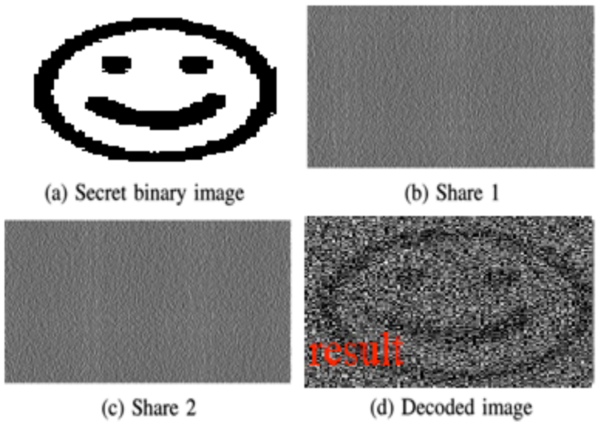


Fig 3: Random pattern of encoded image with two shares. Resulted image is decoded image by the overlaying of generated transparencies [17]

1.3 Sharing Multiple Secrets Using Visual Cryptography

To generate perfect ciphers or secret images Visual Cryptography is used. An image can be divided into multiple shares, and that multiple shares can be stacked again to get original image. Using VC the encrypted messages can be decrypted directly by the human visual system. Without computation VC can generate the original image and this is a distinguishing quality of the VC. The previous works on visual cryptography assume that the image or message is a collection of black and white pixels where in each pixel is handled individually. The encryption technique evaluates using ‘k’ shares out of ‘n’ secret shares. For a given image or message, ‘n’ transparencies are generated. If any ‘k’ of them is stacked together then the original image (message) is visible. The image will not appear or be made visible to end-user if less than ‘k’ transparencies are stacked. Visual cryptography shares binary images only. Research works introduced halftone and color halftone mechanisms in visual cryptography in order to share color and grayscale images. Rather than considering only one secret, it will focus on how to share multiple secrets using visual cryptography. This mechanism will merge two secrets into shares using the master key, and then combine the two shares to form a new share ‘S1’. After that, master key is modified to generate a key share ‘S2’. The new share ‘S1’ and the key share ‘S2’ are employed to recover the secrets by shifting the key share ‘S2’ to various positions on ‘S1’. For sharing individually, this mechanism has one key and two secrets. With the same master key the secrets are encrypted and placed one after another. When the key is used on the secret the first secret is made visible to user. The same is true for the second secret. In order to open the next secret, the key has to be shifted by the images width or height. All secrets can be revealed using the same key. The joint sharing scheme works in a similar way of the above process. Shares are generated using the master key. All shares are read row by row and merged as single image by writing these read rows from the encrypted shares. When the key share is used on the merged image, the first secret share is revealed to end user, when the key is shifted down, the second secret is revealed.

1.4 An Extended Visual Cryptography Algorithm for General Access Structures

This paper proposes a two-phased encryption algorithm of ($Γ_{Qual}$, $Γ_{Forb}$), EVCS for GASs. In the solution procedures first phase, it generates intermediate shares of ($Γ_{Qual}$, $Γ_{Forb}$) VCS. These intermediate shares have no appropriate appearance and no pixel expansion. In the second phase, cover images I_1, I_2 will be added in these I-shares to yield the resultant shares of ($Γ_{Qual}$, $Γ_{Forb}$) as shown in fig-4. In phase-II, the stamper will stamp the shares on images I_1, I_2. The Secret image is encrypted in Phase-I as in fig-4 started from GAS Solver by taking secret image it encrypts the image and forward to share synthesizer and this synthesizer will encrypt the images into shares.

These shares are embedded into the images I_1, I_2 by the stamper.

The solution provided with the following structure

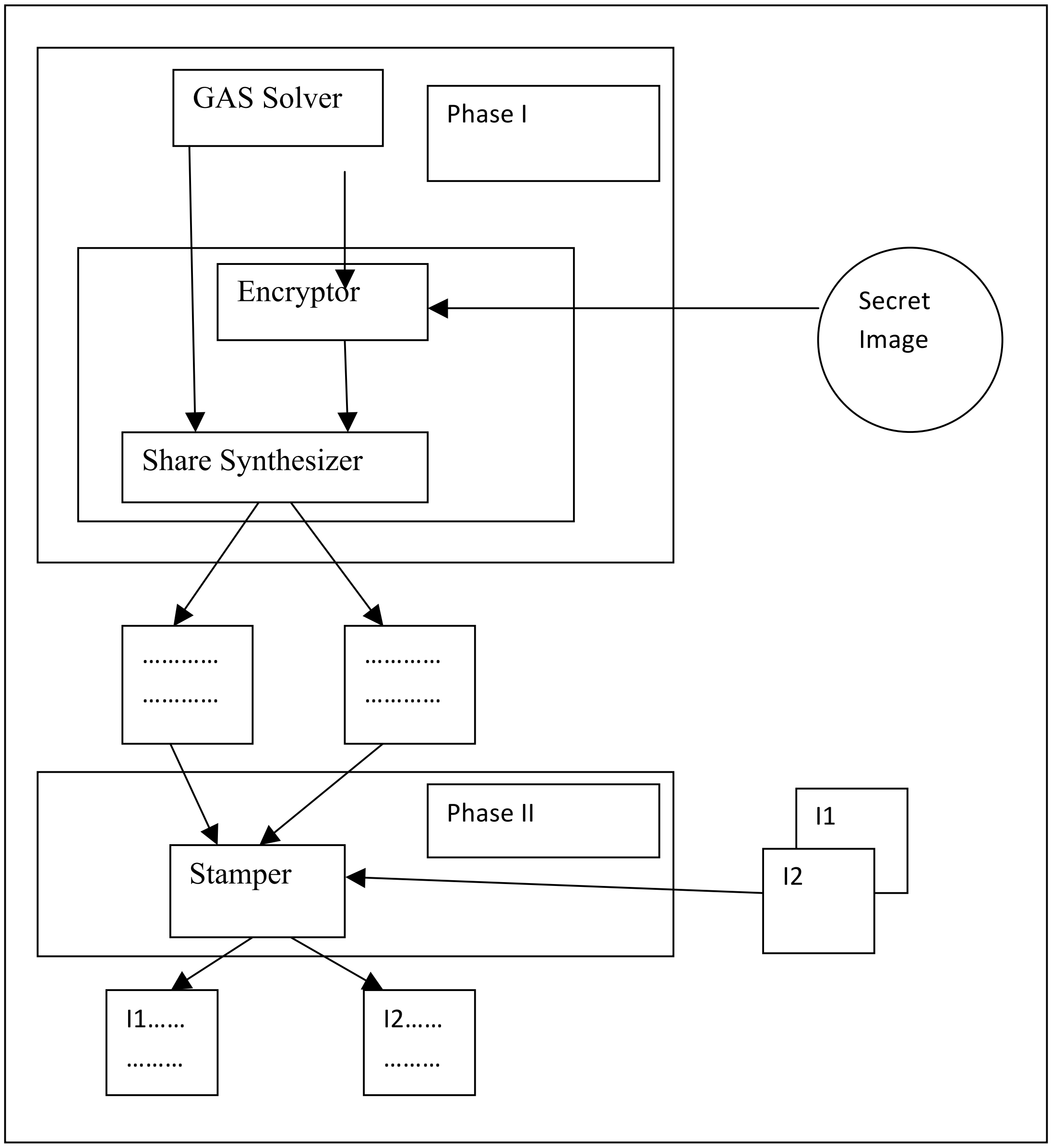


Fig 4: Solution procedures for EVCS.

1.5 Embedded Extended Visual Cryptography Schemes

Embedded Extended Visual Cryptography EVCS can also be treated as a technique of steganography. To avoid custom inspections on the encrypted images or shares EVCS is used, because the shares of EVCS are not just shares but meaningful images, hence there are fewer chances for the shares to be suspected and detected.

Proposed tool for Embedded Halftoned shares provides a user-friendly environment to work with images. This application supports .gif and .png (portable network graphics) formatted images and this application has been developed using swing and applet technologies, hence provides a friendly environment to users.

Problem Definition: Whenever user transmits the data (image) in the network, any unauthenticated person can read data (image). In order to provide security to data (image) generally sender will encrypt the data (image) and send it the intended person and the receiver will decrypt the encrypted data (image) and uses it.

2. Objective

The aim of this project would be to hide the knowledge in the data where sender and recipient only knew the real one. The aim of this project is achieved using Halftone algorithm for data hiding an image with in an image. Hence, the sender and recipients can have a tool to encrypt and decrypt the transformed images, as provided.

3. Implementation of EVCS mechanism

3.1 Halftone technique using dither matrix

The drawback of the VCS is, it cannot deal with the gray-scale image. VCS to deal with the gray-scale images was originally proposed by MacPherson. It has large pixel expansion like c x m. ‘c’ is the number of the gray-levels and ‘m’ is the pixel expansion of the corresponding black and white pixels. To deal with the gray-scale image, the halftoning technique was introduced into the visual cryptography. This technique is used to convert the gray-scale image into the binary image. In printing applications, this technique has been extensively used which has been proved efficient. VCS technique can be applied directly to the binary images. But in this process the concomitant loss in quality of image is unavoidable. This paper will make use of the patterning dithering. The patterning dithering makes use of a certain percentage of black and white pixels, often called patterns, to achieve a sense of gray scale in the overall point of view. The pattern consists of black and white pixels, where different percentages of the black pixels stand for the different grayness’s. The halftoning process is used to map the grayscale pixels from the original image into the patterns with certain percentage of black pixels. The halftoned image is a binary image. However, in order to store the binary images one needs a large amount of memory. A more efficient way is by using the dithering matrix. The dithering matrix is a c x d integer matrix. The entries, denoted as $D_{i,j}$ for $0 \leq I \leq c-1$ and $0 \leq j \leq d-1$.of the dithering matrix are integers between 0 and cd-1 which stand for the gray-levels in the dithering matrix. Denote gϵ $\{0, \ldots, cd\}$ as the gray levels of a pixel in the original image.

3.2 Halftoning process for each pixel i

Input: The c x d dithering matrix D and a pixel with gray-level g in input image I.

```
Process:[1]

For i=0 to c-1 do

If g<=Dij  then print a black pixel at position (i,j);

else print a white pixel at position (i,j);
```

Output: The halftoned pattern at the position of the pixel

D_0 Matrix [1] is expected Dither Matrix with 10 gray levels for 1st transparency.

D_0=

7	0	5
2	4	6
3	8	1

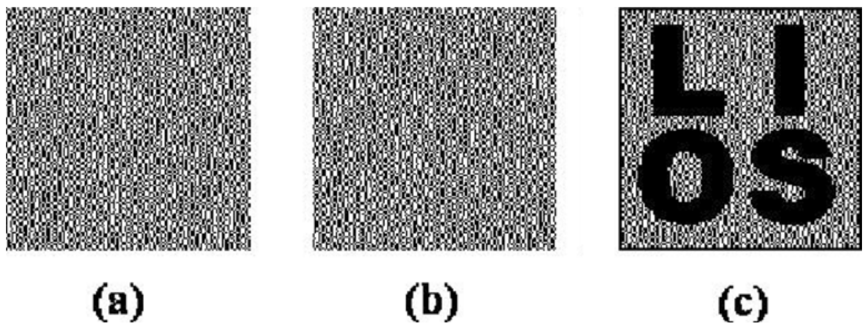


Fig 5: Traditional Halftone Transparencies a) 1st transparency b) 2nd transparency c) Recovered image from transparency

Using c x d dither matrix, user will generate halftoned transparencies by computing secret image. By comparing the value at each pixel with the threshold value of the dither matrix from pixel (0,0) position to complete image. Program will form color on the selected pixel. That color may be white or black depending upon the pixel value. After generating the transparency, the transparency looks like figures 5.a and 5.b.

3.3 Embedding Shares

The idea of our embedded EVCS contains two main steps:

1) Generate ‘n’ covering shares.

2) By embedding the corresponding VCS into the ‘n’ covering shares generation of the embedded shares.

1) Generate the covering shares for an access structure take gray-scale original share images, and output ‘n’ binary meaningful shares. The stacking results of the qualified shares are all black images. The information of the original share images are all covered images. The advantage of covering shares is that, when the qualified subsets are stacked, all the information of the patterns in the original share images is covered. So the visual quality of the recovered secret image is not affected. Otherwise, in secret image, the information of the original share images may appear, so might results in bad visual quality.

2) First make use of the corresponding VCS to encode a secret image, and then embed the shares of the corresponding VCS into the covering shares that were generated in step 1. The output shares of step 2 are the embedded shares. In this way, when stacking a qualified subset of embedded shares, decryption to transparencies will result in the secret image, because the

stacking result of decrypted covering shares covers all the information of the original share images.

3) Decrypt the embedded share and stack them again using application to get original image.

3.4 The embedding process [1]:

Input: The 'n' covering shares constructed as the corresponding VCS (C_0, C_1) with pixel expansion and the secret image 'I' is as in fig-6.

1. Dividing the covering shares into blocks that contain t(≥m)sub pixels each.

2. Choose 'm' embedding positions in each block in the 'n' covering shares.

3. For each black (respectively, white) pixel in I, randomly choose a share matrix $M \in C_1$ (respectively, $M \in C_0$).

4. Embed the 'm' sub pixels of each row of the sharematrix M into the 'm' embedding positions chosen in step 2.

Output: The 'n' embedded shares e_0, e_1, ..e_{n-1} as in fig-6.

As in figure-6, the image is encrypted in to 'n' number of transparencies. Each transparency is embedded into e_0, e_1, ..e_{n-1} Embedding images. These embedding images will be separated and decrypted to original by the tool.

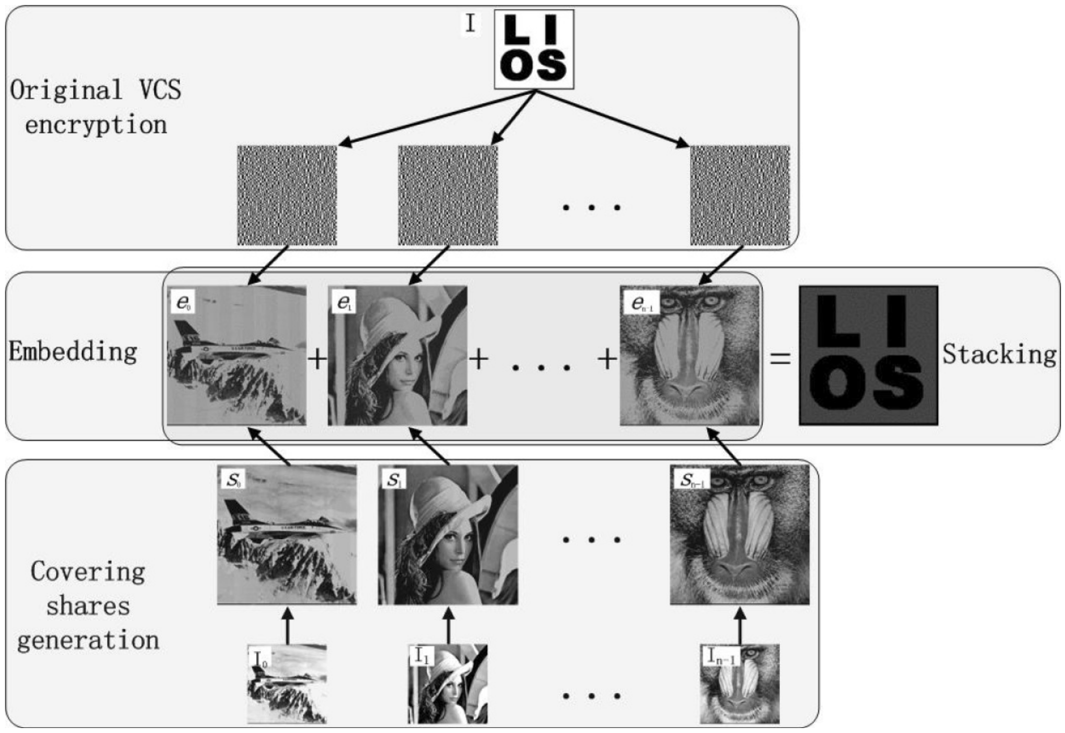


Fig 6: Embedding Algorithm Presentation

4. System Design

4.1 System and Software Used in this project

This project was implemented on a personal computer.

The hardware and software involved are as follows.

- Intel Pentium IV 2.2GHz
- Windows XP Service Pack II
- JDK v1.6
- Netbeans v6.8

4.2 System Requirement

Processor should contain 2.2 GHz speed for better performance and System required 40GB hard disk space for the Software and Operating System and 128MB free RAM space for the application; however RAM space varies because of the image operations and image size.

4.3 User Interface Design

4.3.1 Main Window

It is written in java swings. It is to open the operational window or frames to perform set of operations on images using the specified techniques. It consists of basic window operations like closing and minimizing but restoring or rescaling is not possible.

4.3.2 Visual Cryptography Window

This is written in Applet as well as Swing framework. In this, user consists of various Visual Cryptography options. User can perform Loading Image, Loading Transparencies, Saving Transparencies, Visualizing transparencies to original images, and Individual transparency visualization.

This window consists of all kinds of operations related to image processing, which are required for visual cryptography proposed in the algorithms.

4.3.3 Embedding Window

It is purely written in java swings. In this window we can encrypt and embed saved transparencies to the meaningful shares (images). And again, we can regain them by simply making the decryption process for the specified location with the specified filename. Results of each operation can appear simultaneously on the window result area.

4.4 Software Engineering Techniques

4.4.1 Requirements

4.4.1.1 Software Tools

Integrated Development Environment tool like Netbeans IDE is used in this project. Because of this tool project construction of user interface becomes easier and we can represent interface in Rich Graphical representation. It gives feasibility for the inbuilt classpath and path settings and resource links. We can view the interface design without running the code. And modifications can be done within no time by using this tool.

4.4.1.2 Functional and Non-Functional Requirements

The 'functional requirements' of the project are as follows:

1. Main window is used for navigation purpose in the application window. Using this, we can perform individual operations like visual cryptography and also embedding images in separate manner or individually.

2. Visual Cryptography window is used to perform cryptography operation on images or steganography operations. We can transform images into transparencies and we can save all the

transparencies. After embedding and decrypting the images we can combine transparencies to get original image.

3. Embedding window is used to perform the embedding operations on transparencies. The transparencies can be encrypted and embedded. By this tool we can separate the embedded images into original share and transparencies. And saving the transparency at specified location and with specified filename.

Among many ‘non-functional requirements’, the project must be very user-friendly. People will likely use such software tools with just a little more knowledge in using computers other than for everyday tasks.

4.4.1.3 Structured Requirements

The project is to provide user-friendly operational tool for the embedded extended visual cryptography. This should allow user to operate easily on images for the EVCS operations

1. Give Self-explanative user interface.
2. On clicking encrypt/decrypt button visual cryptography window should appear.
3. User allowed closing visual cryptography window individually.
4. On clicking embedding window button-embedding window should appear.
5. User allowed closing embedding window individually.
6. When user closes the main window all operational windows are stop the actions and closed.

Visual Cryptography window

1. User can load the images for the transparencies generation.

2. After generation transparency user can visualize the resulted transparency images individually or after grouping them.

3. User is allowed to save all the transparencies in the hard disk.

4. After saving the entire transparencies, user can embed them with meaningful images using embedding window.

Embedding Window

1. User is allowed to load specified transparency during the embedding process with real or meaningful image.

2. User can specify the image location where image name is same as the meaningful image name. The format of the image is PNG so that it will be easy to transfer in any network.

3. With this tool, user can separate the meaningful image and transparency by providing location and filename.

4. After separating all transparencies, user has the visual cryptography tool for transparency visualization.

4.5 Analysis

The requirement of this project is to compute the images into halftoned images and embed these transparencies into meaningful images and share them on network. By the proposed system code, this requirement is fulfilled by the gray-scaled image conversion into halftoned image transparencies, and these transparencies can be embedded with real images. After embedding, they are automatically stored in portable network format for the sharing purpose on network. Hence, the input is a gray scale for the visual cryptography window and gives out halftoned transparencies. Embedding window has the inputs as halftoned transparencies and real share image is considered for embedding. The output of this window is in encrypted embedded image. Embedding window can be used for the decryption and separation of real share image and transparency.

4.6 Design

System design consist of various operations and user operational flows as follows

1. Halftone Image Generation Process

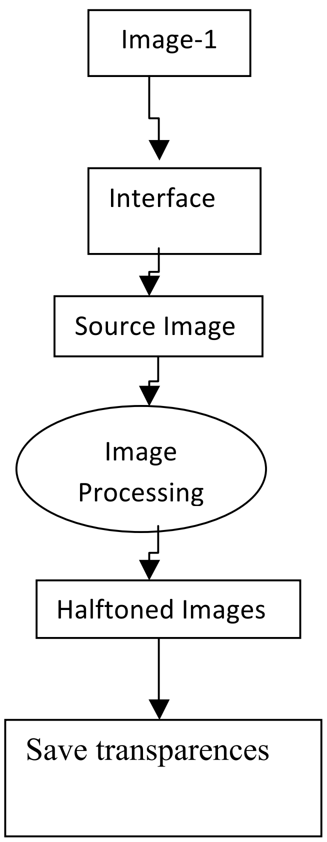


Fig 7: Flow diagram of Halftone transparency generation

Fig-7 explains the process of halftoned transparency generation. Select a gray level image using user interface, then application will take care about the image processing and generates halftoned transparencies. Save all those transparencies for further processing.

2. Embedding Process of Transparencies

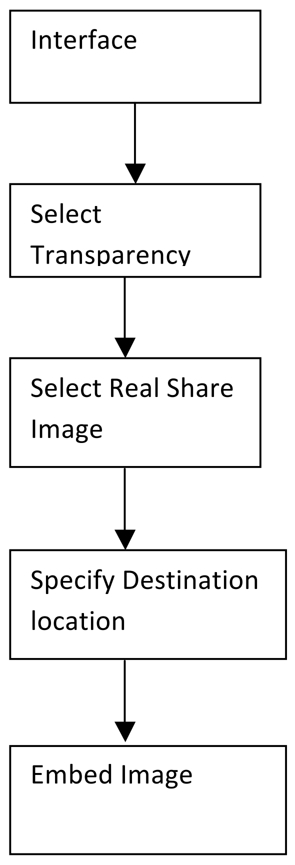


Fig 8: Flow diagram of Halftone transparency embedding in original share images

As in Fig-8 from user interface select transparency, next select original image then specify the location in local system where to store the embedding image. After generating embed image that image automatically named with embedding image name with png extension.

3. Separate Transparencies from real Share Images Process

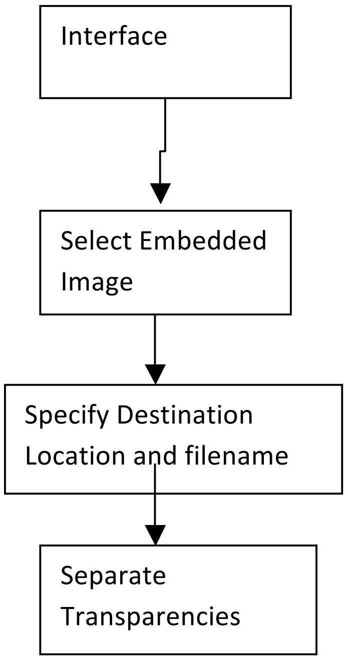


Fig 9: Flow diagram of Separation of embedded images and transparencies

Fig-9 explains the process of separation of transparency from embedded image. From user interface select embedded image, then specify the destination path with valid file name. Application will extract the transparency from the embedded image.

4. Decryption of Halftoned Transparencies

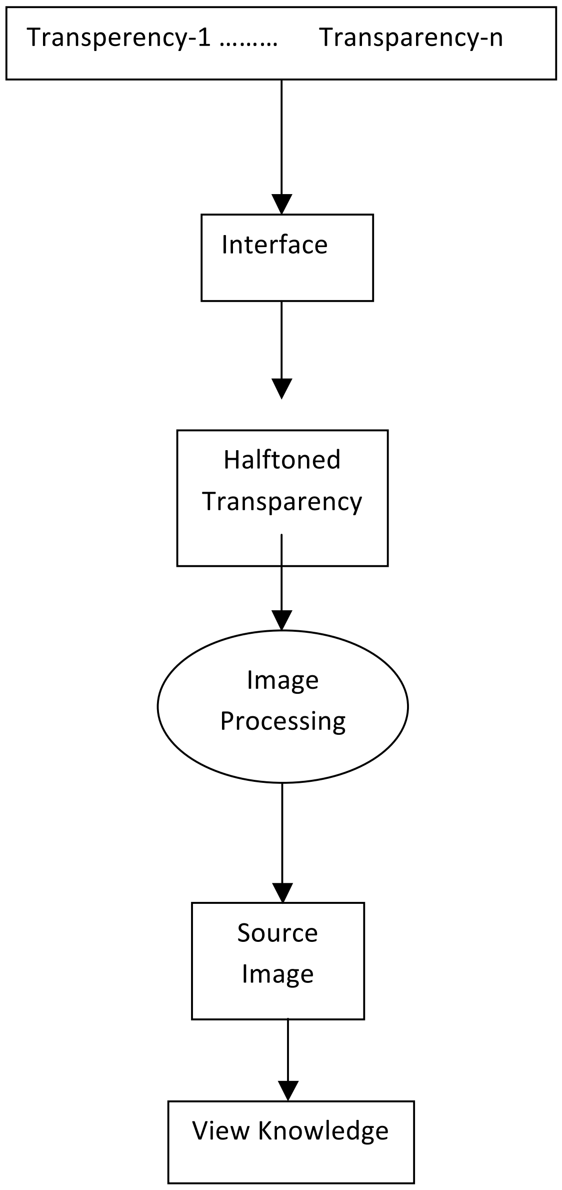


Fig 10: Flow diagram of Halftone transparency selection and Viewing Knowledge

As shown in fig-10 user has to select all transparencies, which are extracted from embedded images into the application. Application will store all the transparencies in local variables and stacks them one on another to generate the secret image.

Use Case Diagrams:

1. Users and System

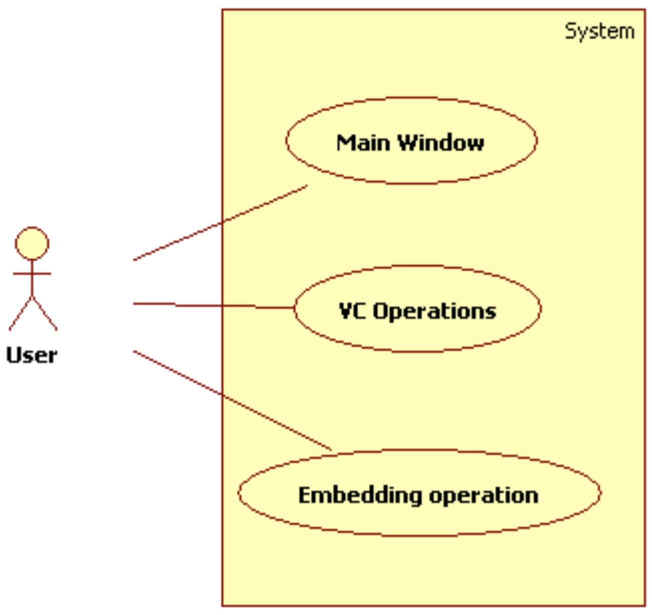


Fig 11: Usecase diagram of User and System

User can access the System with Main Window. All Visual Cryptography Operations can be performed using Visual Cryptography Window, and Embedding Operations can be performed using Embedding Window the user access the system operations through the user interface.

2. User Operations

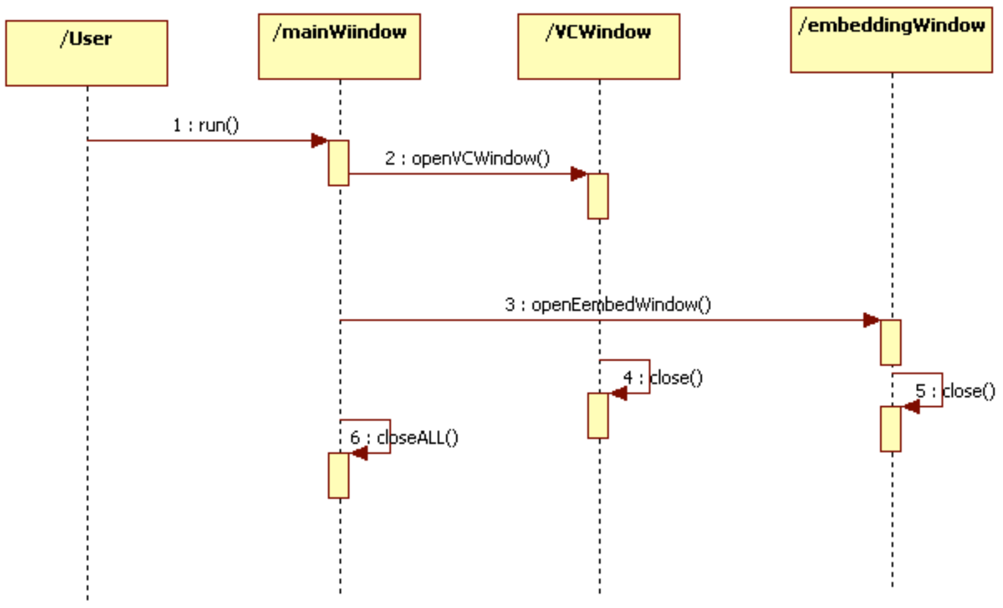


Fig 12: Sequence Diagram of User and User Interface operations

User runs the project then the main window opens; user can open either Visual Cryptography operations window or embedding operations window to perform cryptography operations.

3. Halftone Process

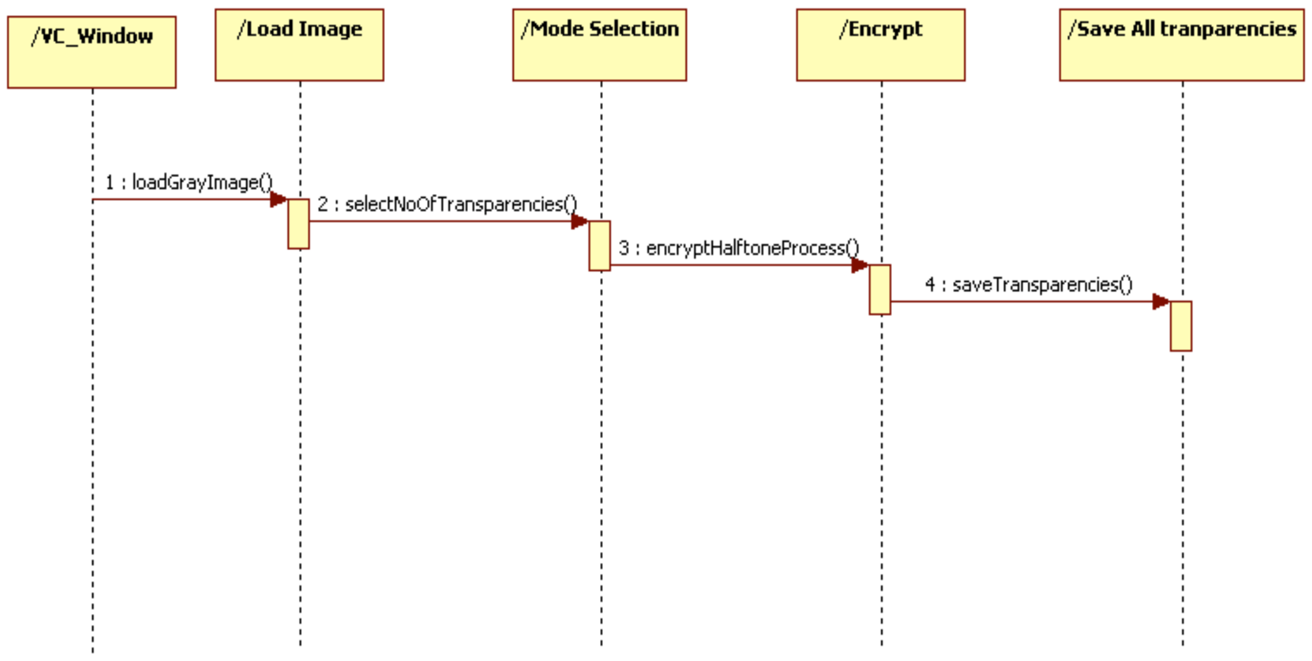


Fig 13: Halftone transparencies generation sequence diagram

User runs Visual Cryptography window and to generate transparencies user has to load grayscale image into system and select the number of transparencies then encrypt the gray scale image into number of selected halftoned images and save all generated transparencies.

4. Embed Process

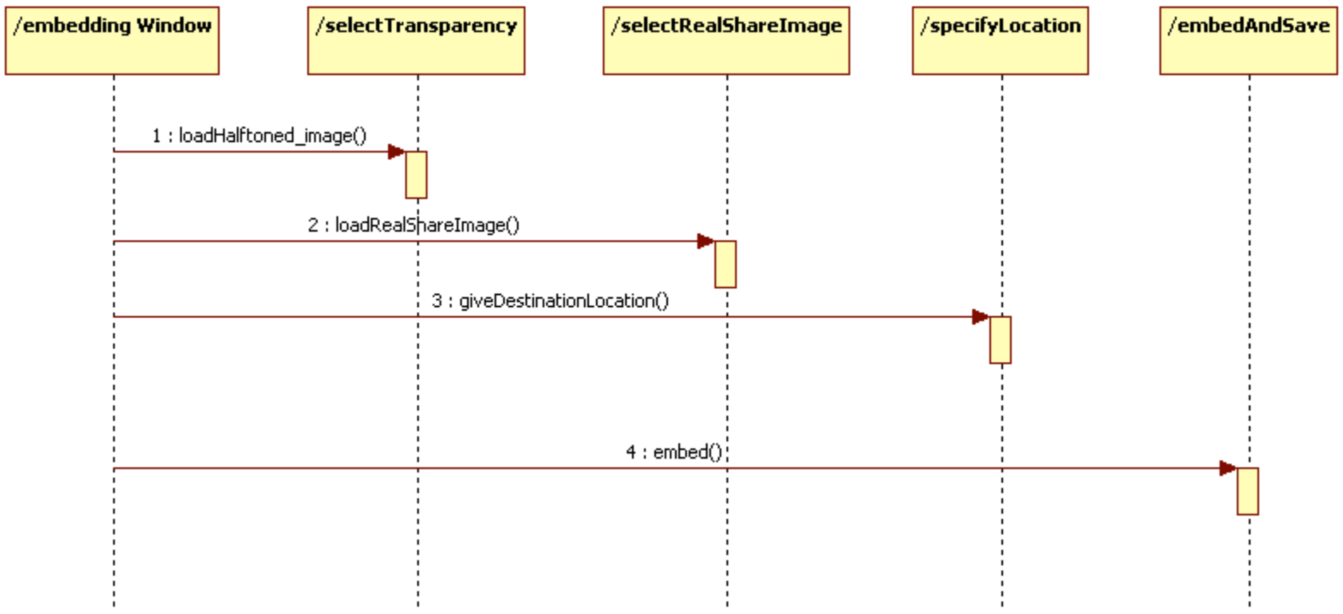


Fig 14: Embedding process of halftoned transparencies

User chooses the halftoned transparencies and next real share image to embed. In the specified location the embedded and encrypted images are saved. By the above sequence user can perform all operations from embedding window sequentially.

5. Separation of Transparency from Real Image

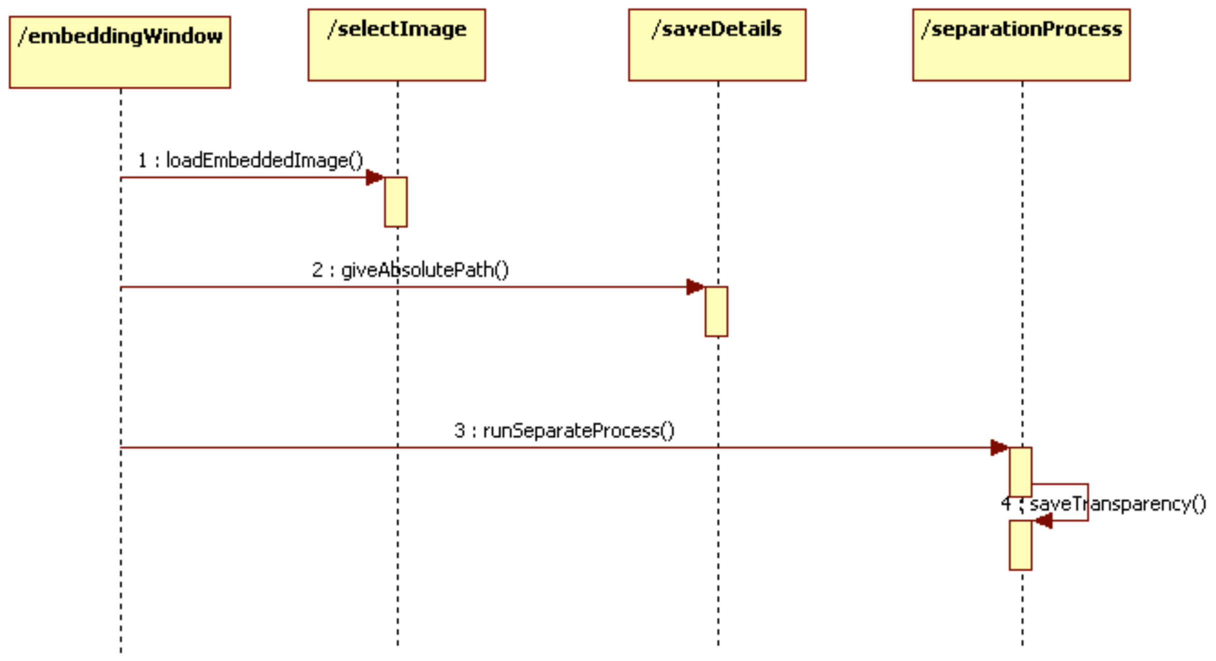


Fig 15: Separation of transparencies sequence diagram

To get the knowledge user should select the image, which is embedded and saved. From this tool user has the advantage of that system recognizes only embedded images and other plain images as usually rejected. After selection of embedded image user has to specify the absolute path for the transparency. When user runs the separation process the transparency images will store automatically by provided details.

6. Visualization of Knowledge

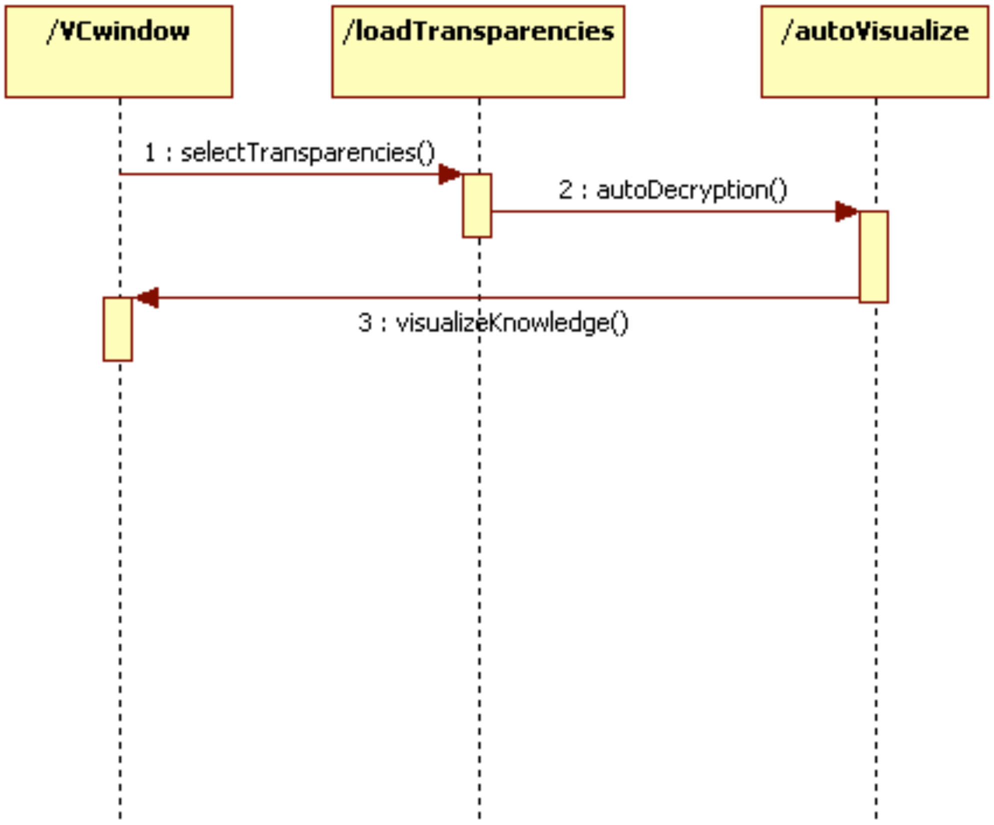


Fig 16: Visualization process sequence diagram

User loads all transparencies using Visual Cryptography window. User has the feasibility that system recognizes how many transparencies present for this specified image after loading 1st transparency itself. Open window dialog box appears until all transparencies loading completed. After loading all transparencies automatically all halftoned transparencies decrypted and user can visualize the original image or knowledge.

7. Components of System

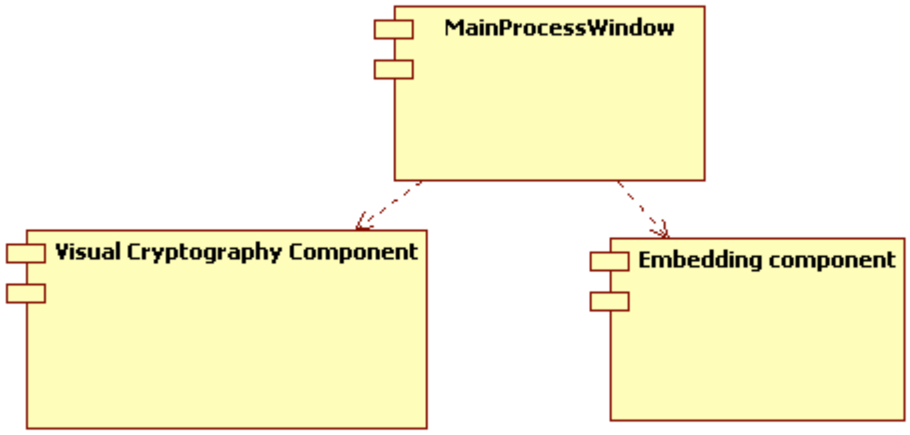


Fig 17: Component Diagram of System components

Proposed System consists of three major components MainWindow, VisualCryptographyWindow and EmbeddingWindow. Visual Cryptography component can individually run and reuse as the subsystem for external usage and it applies also for embedding window component. Hence these two are dependent on main window to run and associated with the main window for user operations.

5. Results and Testing

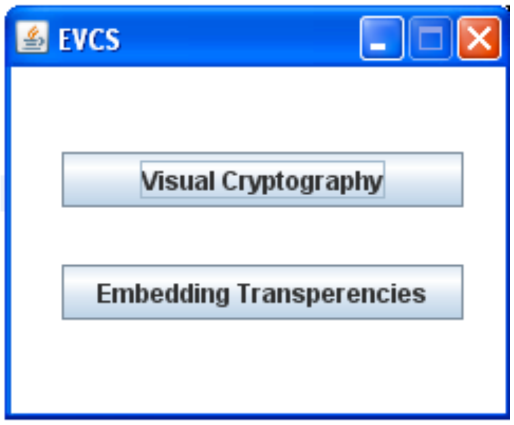
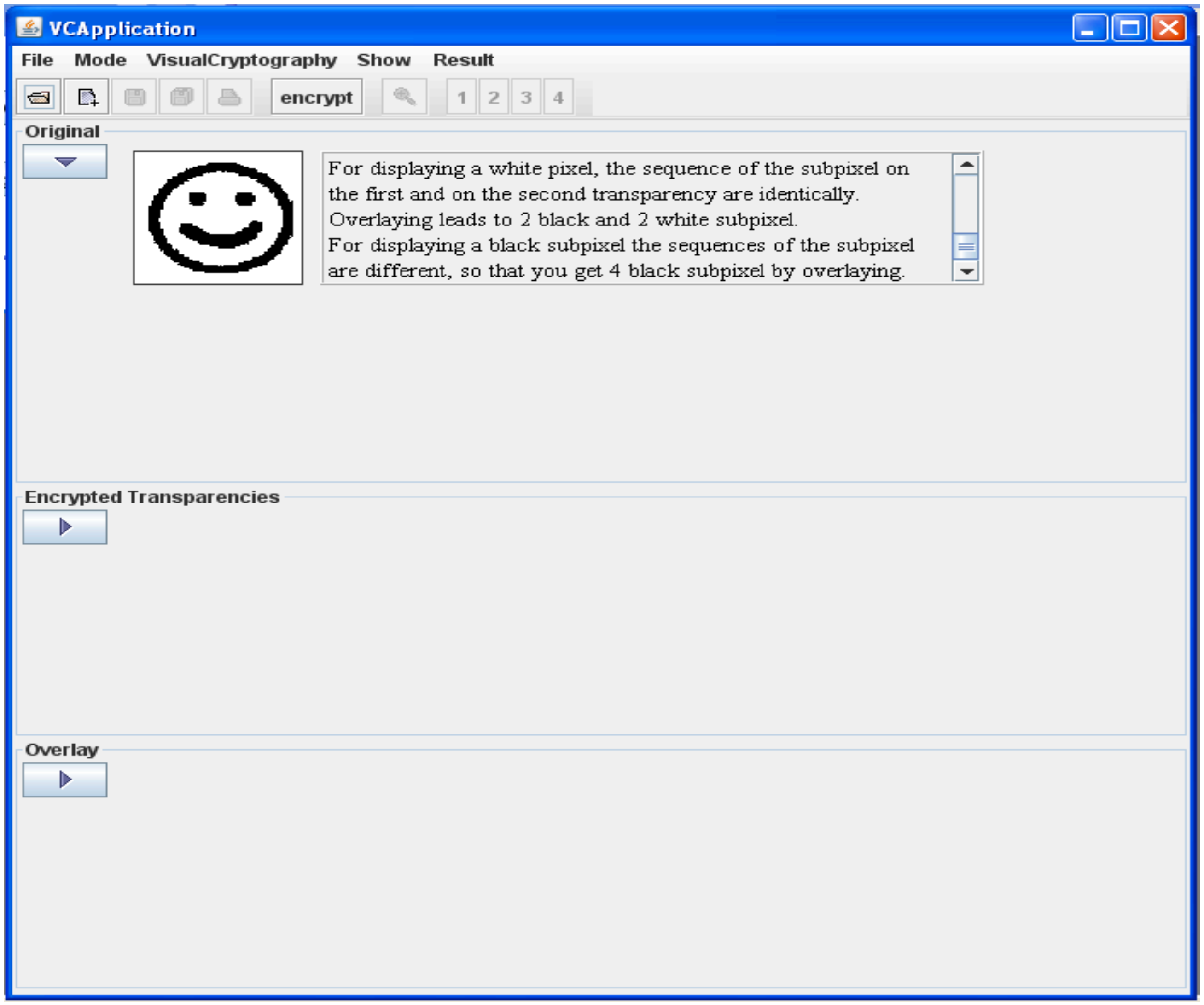


Fig 18: Main window Screen

Main window consists of two options: visual cryptography and embedding transparencies, for the user to select one among them or both, to perform desired operations according to their individual features and limited operations.

To implement main window in this application, JFrame is used from Swings Framework. This JFrame object is used to perform window-based operations like iconifying, deiconifying, and restoring.

To this main window ContentPane, two buttons are added using swing JButton objects. To perform the Visual Cryptography operation, user need to trigger the Visual Cryptography button from the main window JFrame object. To perform embedding operations on transparencies, user must trigger the Embedding Transparencies button.

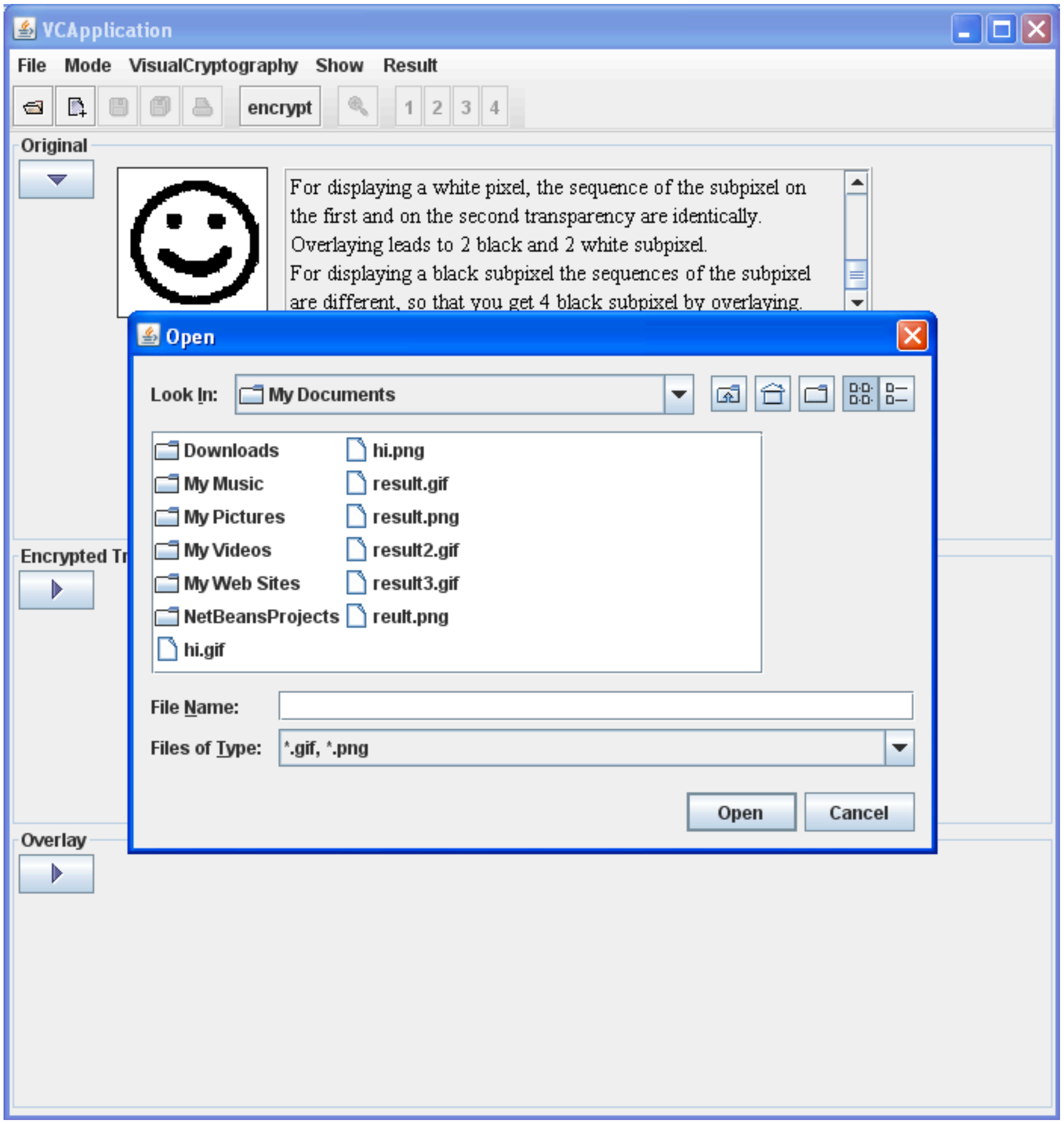


For displaying a white pixel, the sequence of the subpixel on the first and on the second transparency are identically.
Overlaying leads to 2 black and 2 white subpixel.
For displaying a black subpixel the sequences of the subpixel are different, so that you get 4 black subpixel by overlaying.

Fig 19: Visual Cryptography window [20]

This is the visual cryptography window, to perform image cryptography operations to generate halftoned images. This application is developed using the swing framework and applet framework.

This application consists of JMenu, JMenuItem, JButton, JPanel, JFrame and Image resources as a part of User-Friendly Interface for the end user.

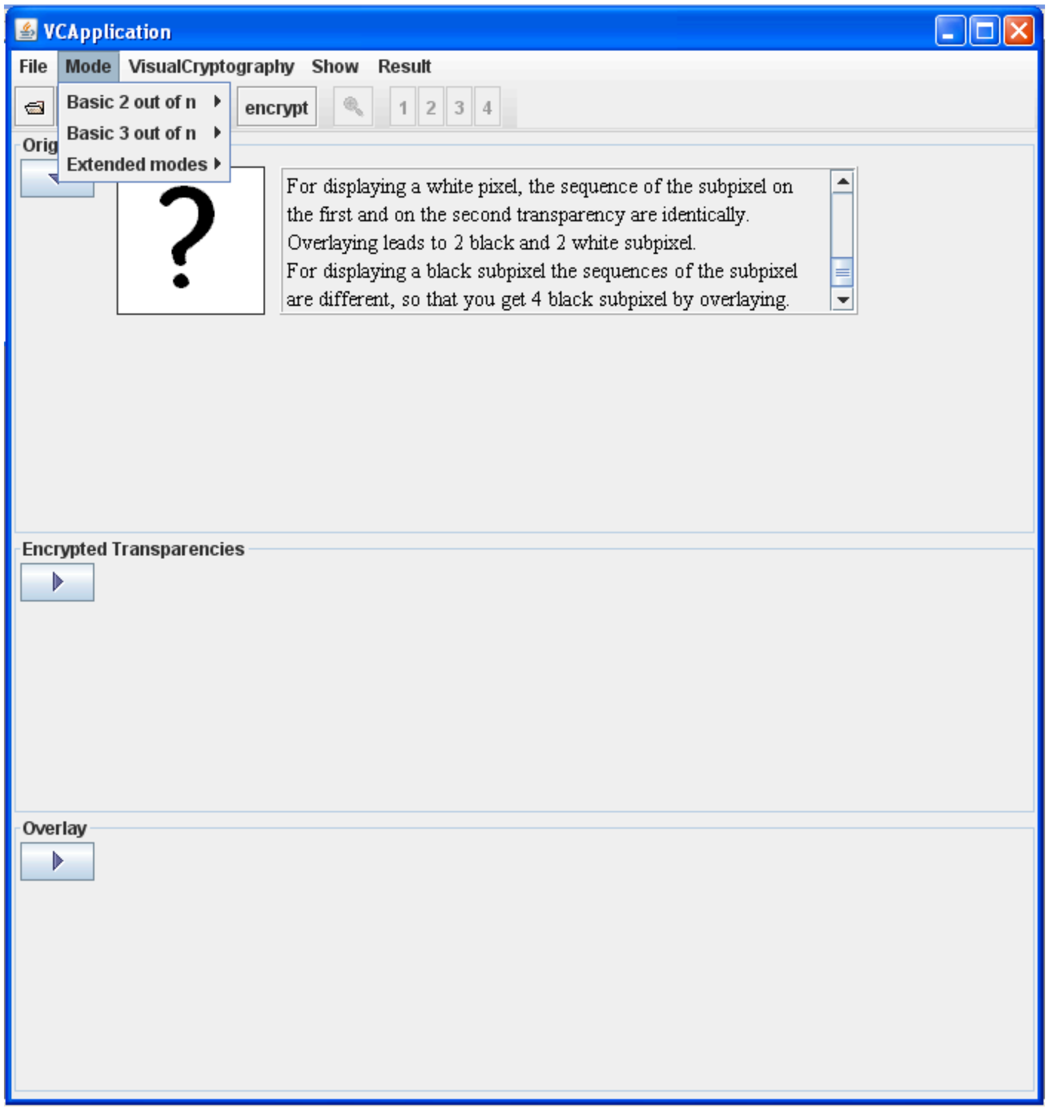


For displaying a white pixel, the sequence of the subpixel on the first and on the second transparency are identically. Overlaying leads to 2 black and 2 white subpixel. For displaying a black subpixel the sequences of the subpixel are different, so that you get 4 black subpixel by overlaying.

Fig 20: Loading Gray scaled image

Select Gray scale PNG or GIF image into the system for generation of transparencies. After selecting, the image is rendered into 100x100 pixel panel to fit and display in the Applet framework system.

File Menu consists of Load Image JMenuItem to open JFileChooser object to choose the appropriate image from the hard disk. Using JFileChooser_Object.show() the File chooser window will open, to make the user, choose an image.



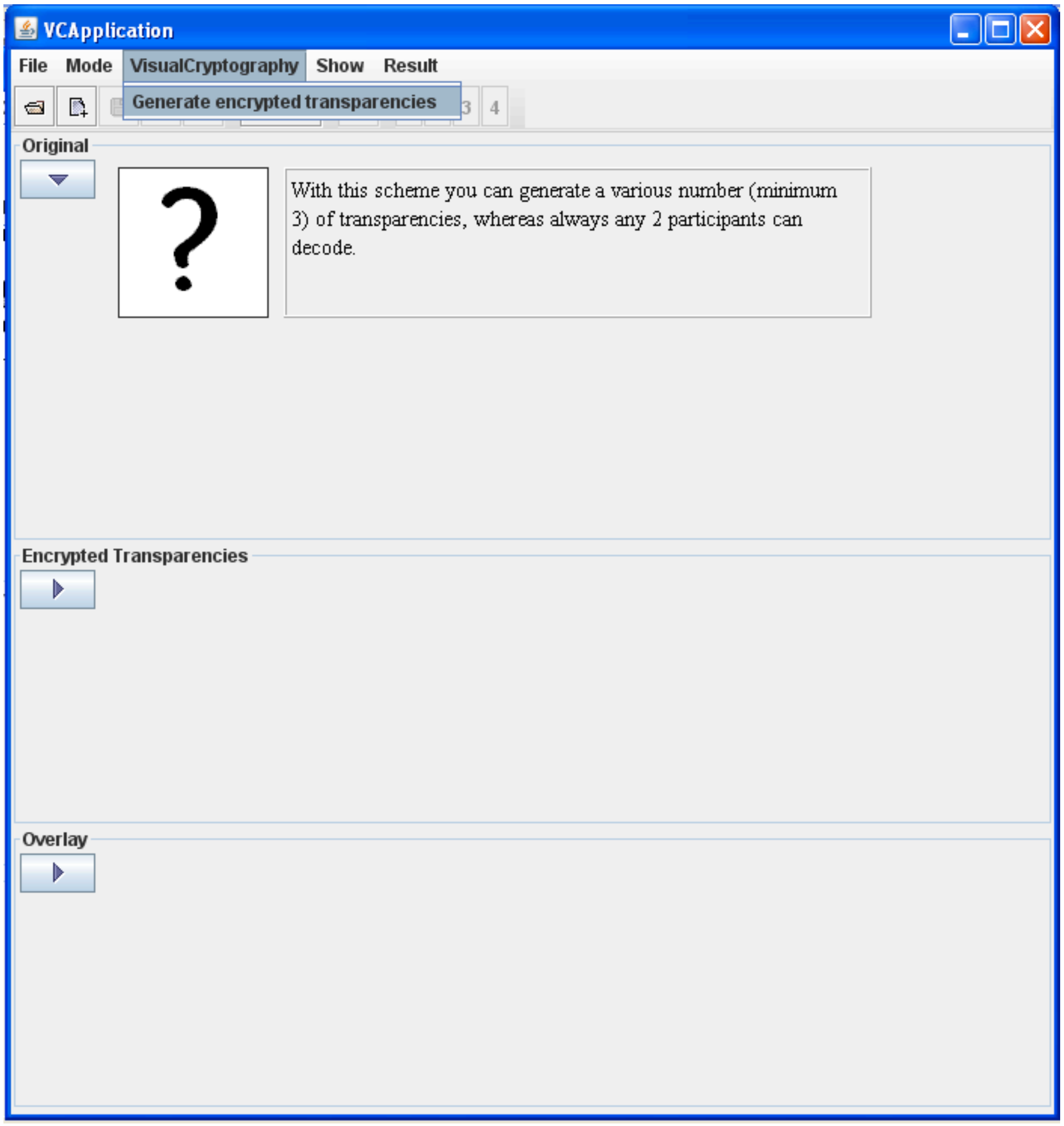
For displaying a white pixel, the sequence of the subpixel on the first and on the second transparency are identically. Overlaying leads to 2 black and 2 white subpixel.
For displaying a black subpixel the sequences of the subpixel are different, so that you get 4 black subpixel by overlaying.

Fig 21: Mode of operation to select number of transparencies

After selecting image, it will be displayed in 100 x 100 pixel ratio. This is achieved using the ImageIO class read(file) method in java. This read(file) returns BufferedImage Object. And "ImageIO.read(f).getScaledInstance(WIDTH,HEIGHT,Image.SCALE_SMOOTH)" code to result the buffered image.

Mode menu is used to select the number of transparencies and also user has a choice of using number of transparencies, to reveal the original image. Menu 'Basic 2 out of n' consists of 2 out of 2, 2 out of 3 and 2 out of 4 menu items. And 'Basic 3 out of n' consists of 3 out of 3. In this, the first digit specifies the minimum transparencies required for generating the original image and the second digit specifies the number of transparencies user want to generate.

After selecting k out on n shares, the value of n and k will get stored in 'number of transparencies' and 'min_number of shares' variable respectively.



With this scheme you can generate a various number (minimum 3) of transparencies, whereas always any 2 participants can decode.

Fig 22: Generating operation of halftone images

By selecting Visual Cryptography Menu item, encrypted transparencies are generated. Specified number of transparencies are generated and stored in primary memory as Buffered images.

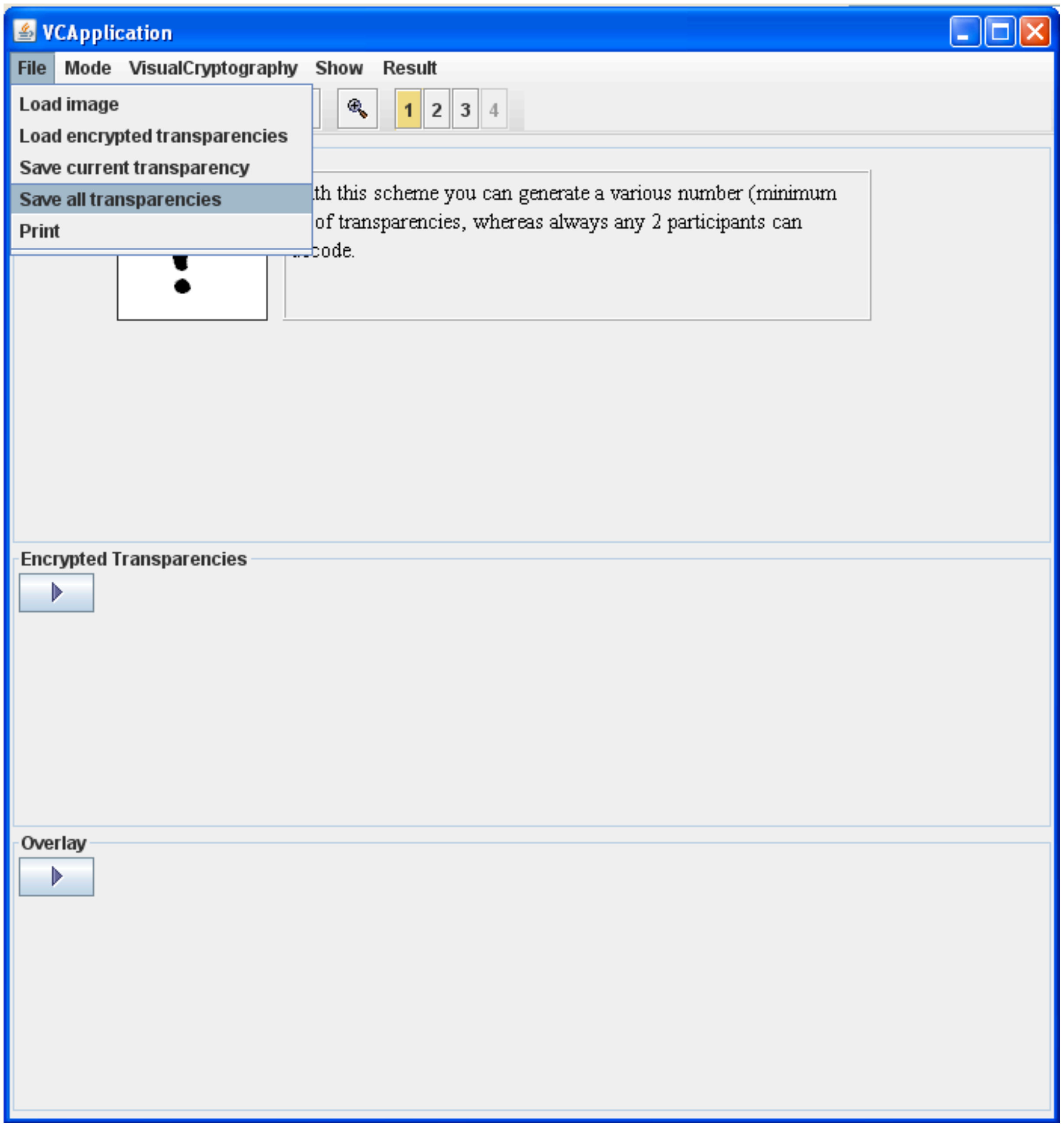
As specified above, in this process it uses k and n value to generate dither matrix. This dither matrix will be generated using following IntMatrix class. In IntMatrix class, user can set the color of pixel as black and white programmatically using threshold value.

SetElement(int[][]) method in IntMatrix class take the values as position x, y and color of pixel either WHITEPIXEL or BLACKPIXEL. This function will generate dither matrices according to the width and height of the secret image. These dither matrices are further used to generate the halftoned transparencies using Encryptor class. The encryptor class will encrypt the image for 8, 16 and 24 bit images. With left shift operator (<<), for WHITEPIXEL the code will be like "WHITEPIXEL = (255 << 24) | (255 << 16) | (255 << 8) | 255" and same for BLACKPIXEL.

Using Permutation class the encryption process will be done. Encryptor uses the Permutation class object as shown below

Up to max permutation of an image the below two statements will repeated.

```
m_Cwhite[i] = (IntMatrix)c0.get(i)// for white pixel

m_Cblack[i] = (IntMatrix)c1.get(i)//for black pixel
```

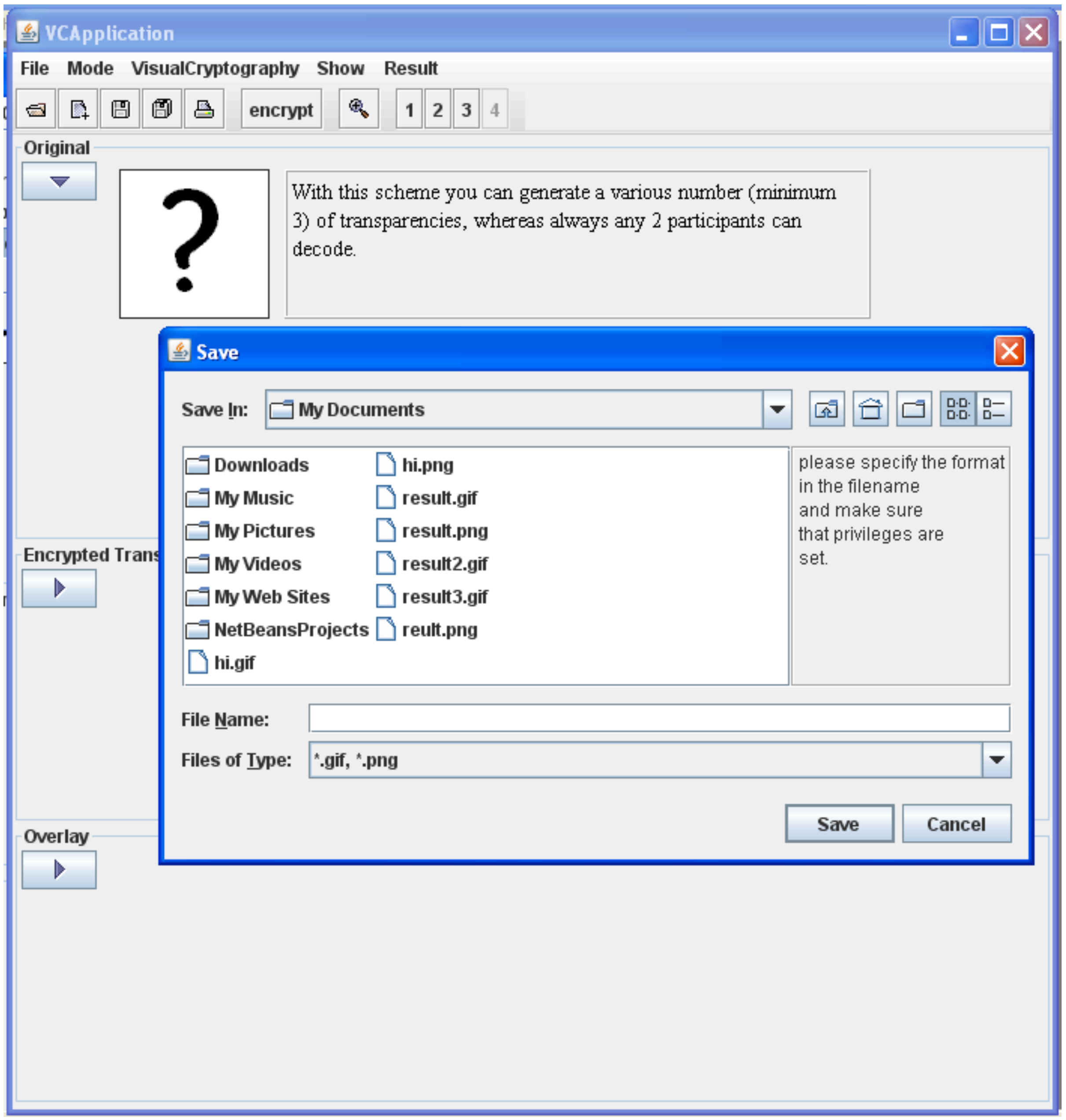


th this scheme you can generate a various number (minimum
of transparencies, whereas always any 2 participants can
code.

Fig 23: Save all transparencies screen

After generation of encrypted transparencies, user can save all transparencies by choosing save all transparencies JMenuItem from file menu.

By triggering this menu item, JFileChooser object gets visible to make the user to save the transparencies. JFileChooser window will appear up to n time, where n is the total number of transparencies.



With this scheme you can generate a various number (minimum 3) of transparencies, whereas always any 2 participants can decode.

please specify the format in the filename and make sure that privileges are set.

Fig 24: Location selection of transparencies to save

User can save the transparencies as images in gif or png format at the specified location in secondary memory device or hard disk. These transparencies will be stored in the format of gif or png. FileFilter is added to JFileChooser object to restrict the user, to give extensions as program specific.

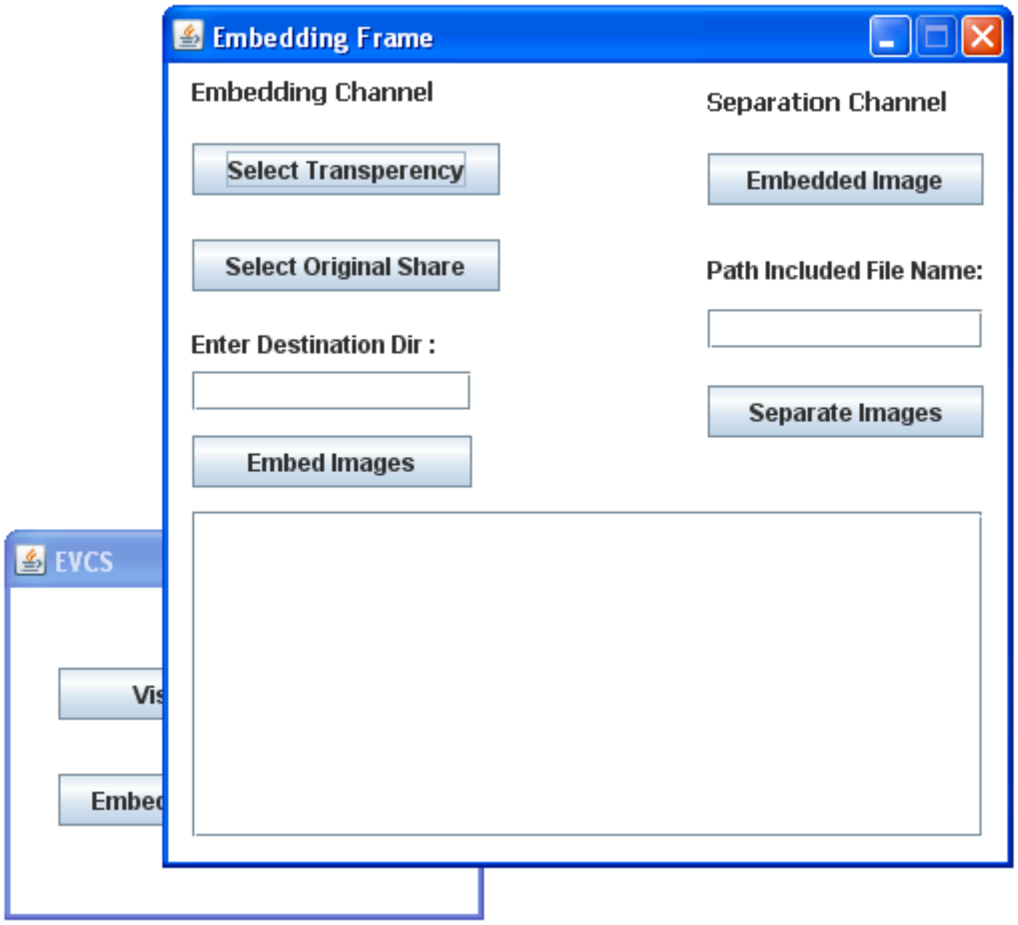


Fig 25: Embedding window for embed operations

User has the privileges like selecting transparency, selecting original share, providing location to store embedded image. If a specific location is not provided, the default location it takes is C: drive.

User can separate the embedded images from this window itself. So user can embed and separate the images from the same window.

This window is developed using JFrame of swing framework using java. The components added to this window are JTextField to retrieve destination addresses, which is used to save embedded image, and separated transparency. JTextArea is to display the content of the operation. JButton is used to create the buttons for the purpose of Selecting Transparency, Selecting original image, and to perform Embedding operation. JButton is used to create the components, which triggers separation and selection of embedded image. Here, JFileChooser is used to select the transparencies, original image and Embedded image. The File chooser contains File filter option for png and gif file.

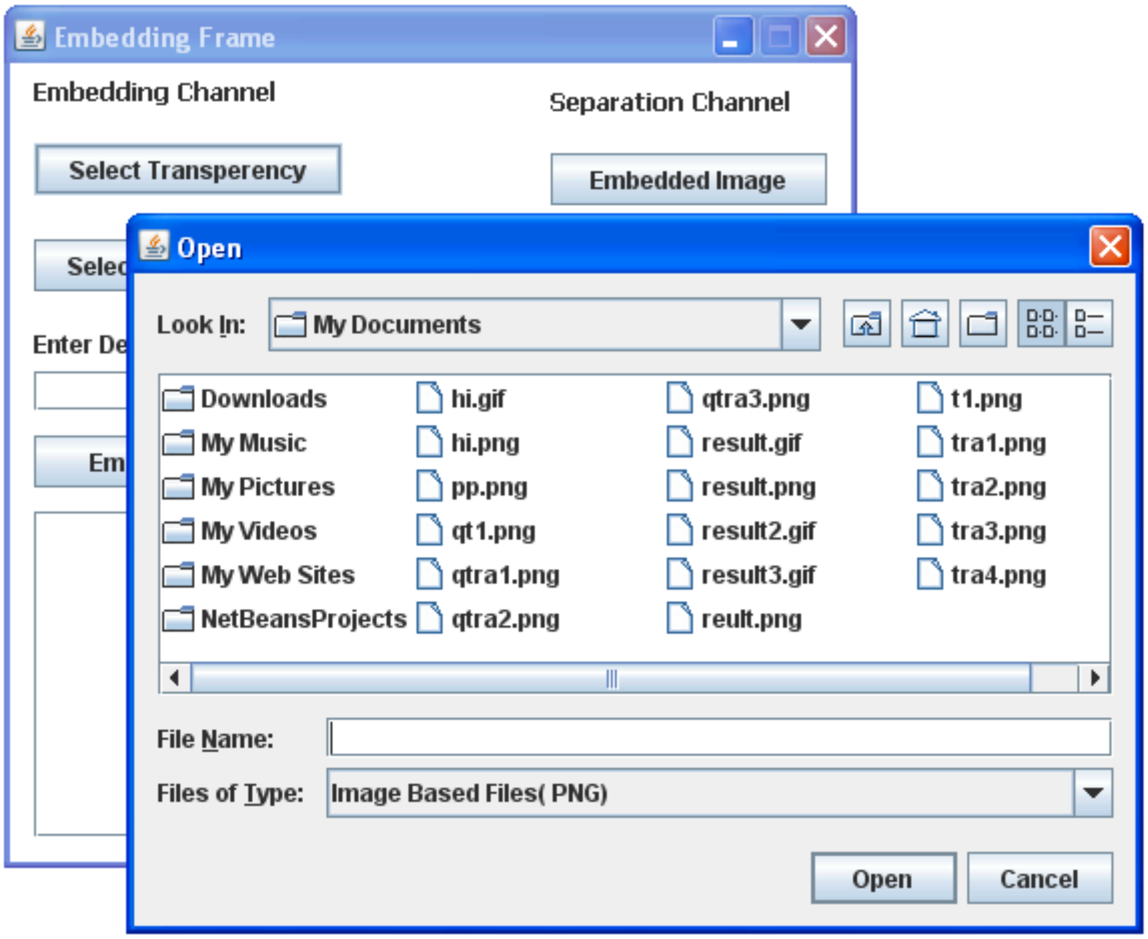
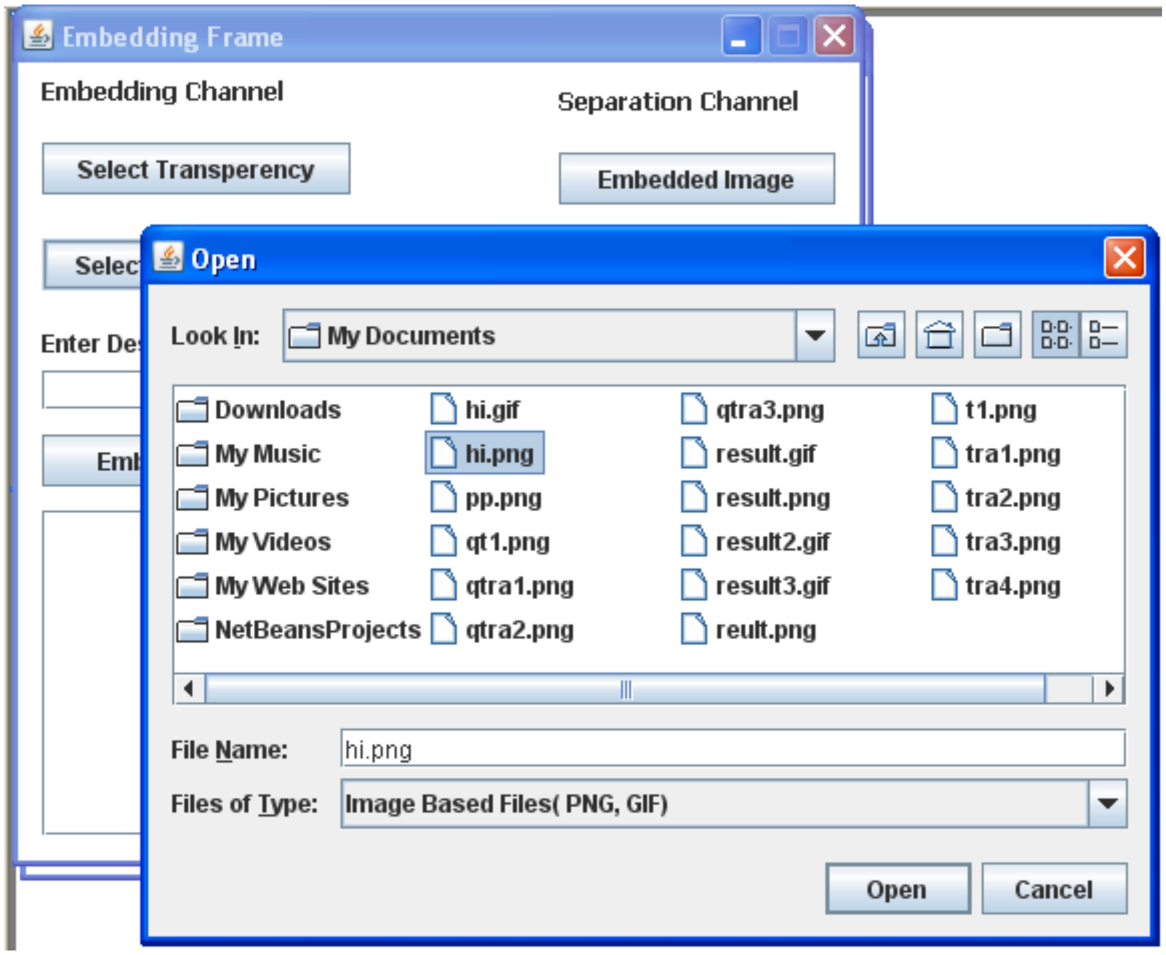


Fig 26: Select transparency from saved location

User can select the stored transparency from hard disk. As image is stored in PNG format by default, transparency can be selected from embedding window as PNG file. The file chooser window has file filter option as PNG.

As it contains file filter option as PNG, user can only view PNG file extension files in file chooser window.

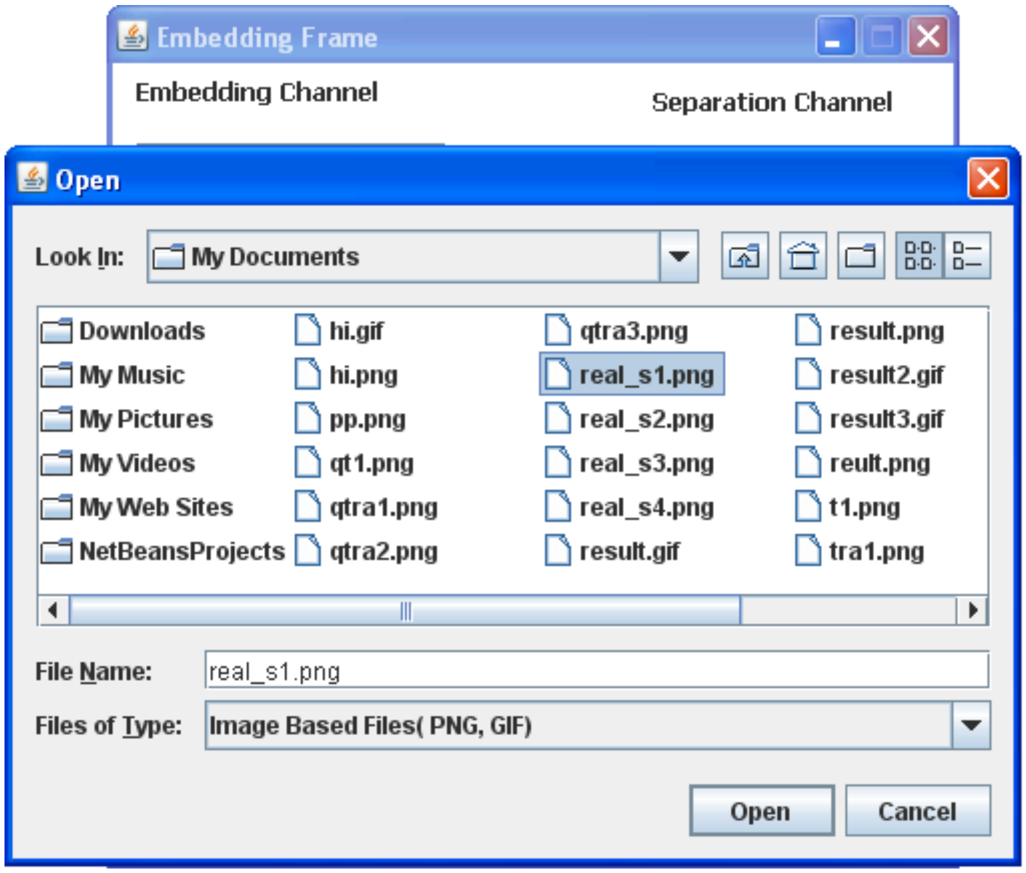


File Name: hi.png

Files of Type: Image Based Files(PNG, GIF)

Fig 27: Select the original share image

User can choose original share image by selecting "Select Original Share" button. Image selection is of any interest accordingly, but to transfer image on to network, only png or gif are preferable formats. The selected transparency is stored in image file called "transpFile". This is image type variable, which stores the selected or opened image using JFileChooser object.



File Name: real_s1.png

Files of Type: Image Based Files(PNG, GIF)

Fig 28: Real share image selection window

User has to select the Real Share image or Original Share image, which has more pixel ratio than the transparency. Otherwise the 'original image selection' window will appear again to select the valid original share image. This selected original image is stored in 'shareFile' image variable.

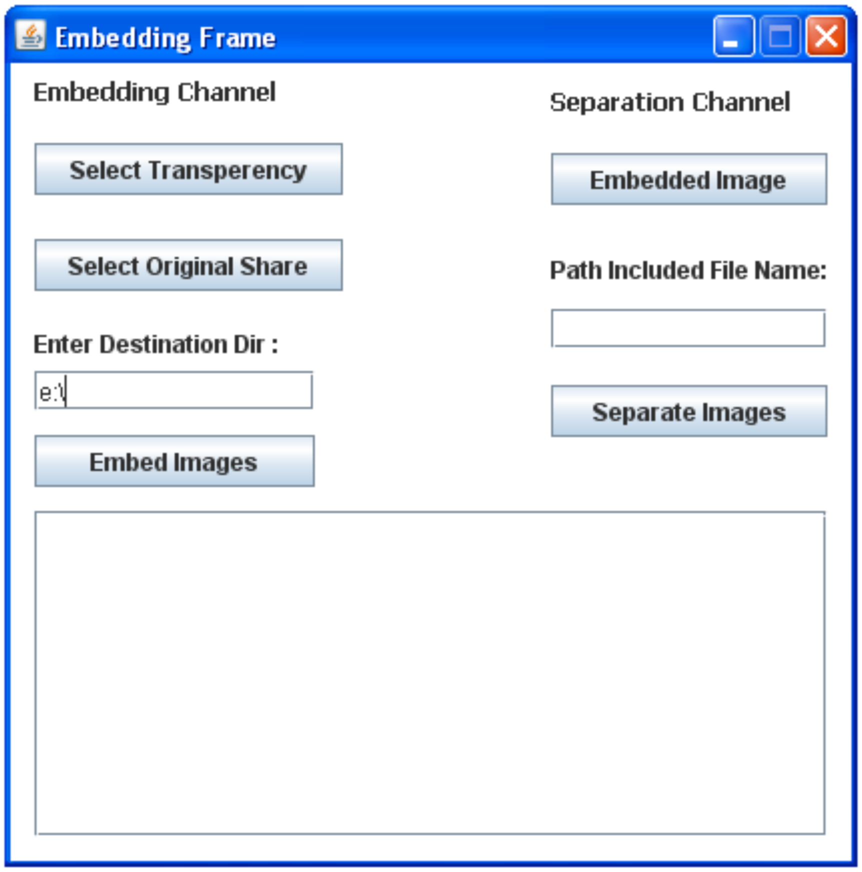
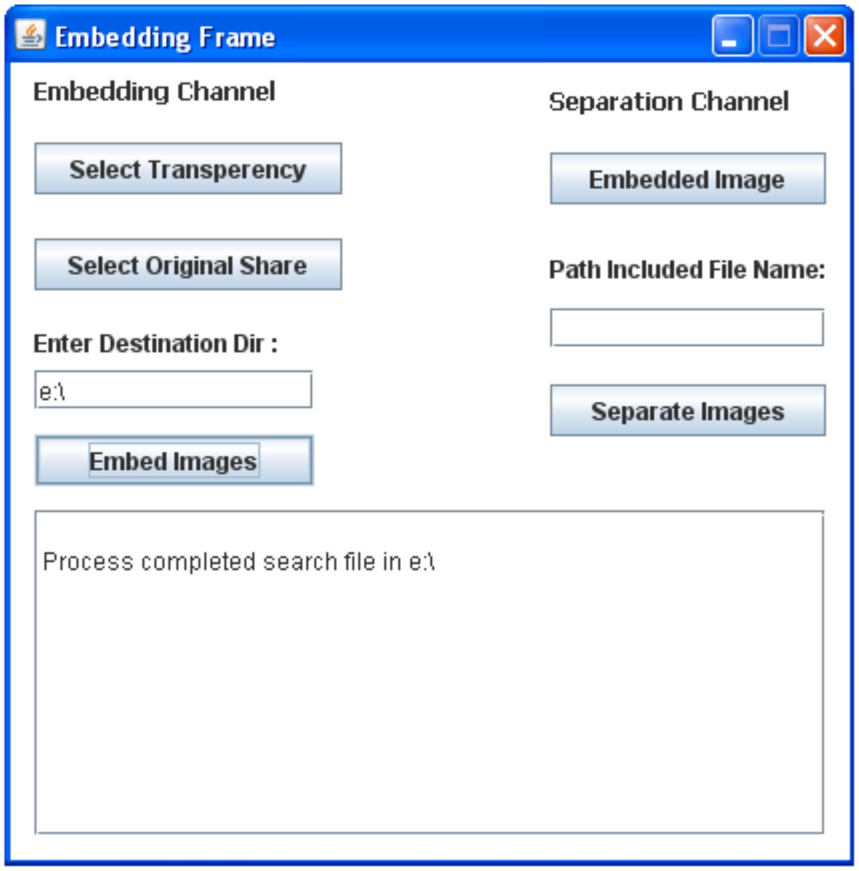


Fig 29: Giving Storage path to the embed image

User has to provide the location to store the embed image. If user doesn’t want to or forgets to provide this location, the image by default will get stored in C:\ drive with the name of original share image and with extension PNG. This path is stored in ‘destDir’ variable for further assistance.



Process completed search file in e:\

Fig 30: Embedding operation result

When embed image is triggered by clicking ‘Embed Images’ button the following operations are performed:

The selected files are stored in local variables and those file’s path will be read and stored in temporary variables for computation purpose like ‘temp1’ for transparency image, ‘temp2’ for original image, ‘temp3’ for resulting embedded image.

FileHider class is used for embedding and separation operations. ‘fh’ is an FileHider object which is used to call hideInImage(file,image) method.

hideInImage(file,image) method is used to embed the transparency in the original image which internally uses 'ImageConverter' class. This class converts an image in to byte array by calling method in getBytes(image). The following code is used to transform the image into bytes.

```
int[] bytes = new int[image.getWidth() * image.getHeight() * 3 + 2];

                    alpha = new int[image.getWidth() * image.getHeight()];

                    for (int i = 0, k = 0, l = 0; i < image.getWidth(); i++) {

                              for (int j = 0; j < image.getHeight(); j++, k += 3, l++) {

                                        rgb = image.getRGB(i, j);

                                        bytes[k] = (rgb >> 16) & 0xFF;

                                        bytes[k + 1] = (rgb >> 8) & 0xFF;

                                        bytes[k + 2] = (rgb >> 0) & 0xFF;

                                        alpha[l] = (rgb >> 24) & 0xff;

                              }

                    }
```

For computational purpose, few values are required to embed image like alpha values, rgb values from image. These values can be obtained by calling getRGB(positionX,positionY). These positionX and positionY are pixel positions of the image. Here rightshift operator is used to transform pixel values. Image bytes are taken according to its width and height. Also, alpha array size is taken as equal to the image size, so it can extract the original image size.

User can view the result within the embedding window result area. If there any exceptions and errors present, they will pop up for assistance.

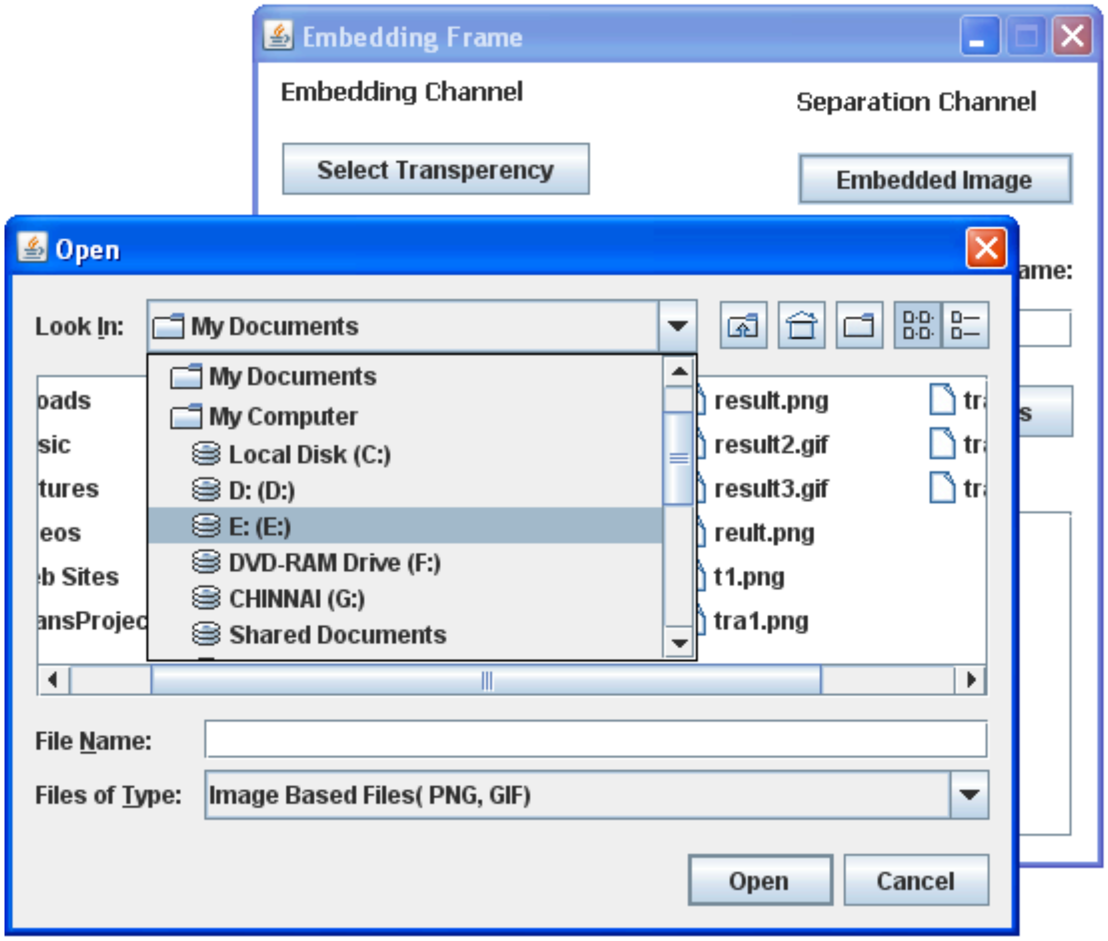
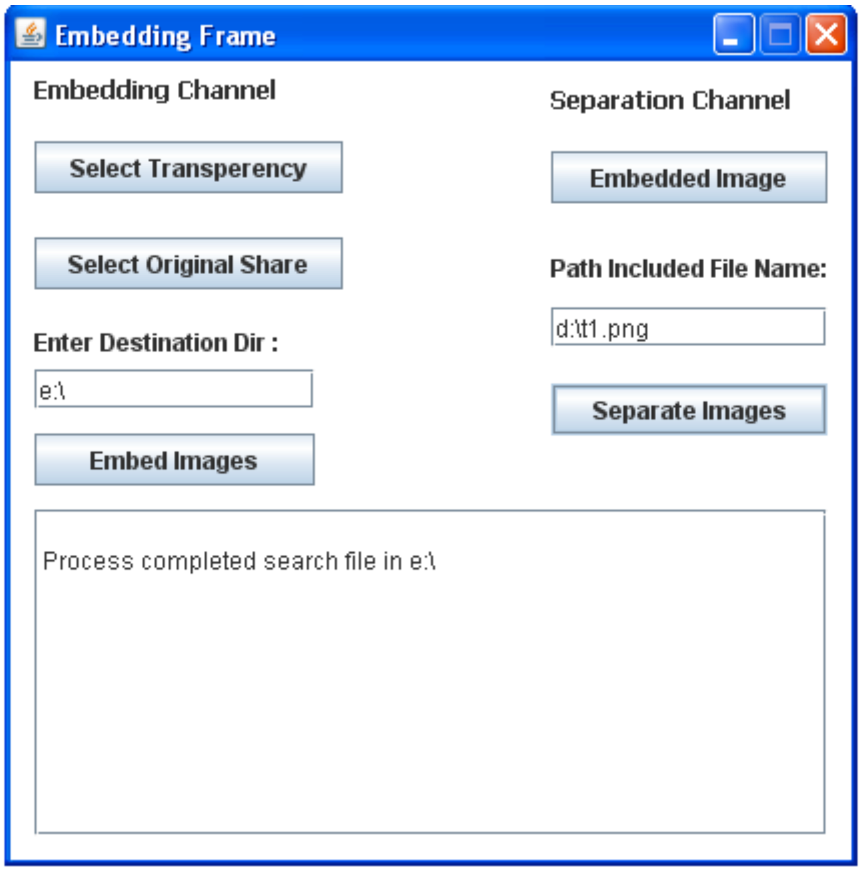


Fig 31: Separating window open file

To get transparency, user has to select embedded image from where he has downloaded or saved, in the system. This image may be png or gif. This operation is fired, when user clicks on 'Embedded Image' button. JFileChooser will appear and user has to select the appropriate embedded image.



d:\t1.png

e:\

Process completed search file in e:\

Fig 32: Giving absolute path

User has to provide the absolute path in the given text field. If user forgets or doesn't give information about the separated transparency saving, it will give error message.

The separation process will take place using following operations.

Selected embedded image is first stored in local variable 'image'. Then this local variable is passed to FileHider class to extract the transparency from the image.

This image is then computed with ImageConverter class to extract the byte array using getBytes (image) method.

Using BitManipulator class, the transparency will be extracted by using method getInformation(bytes[]) method.

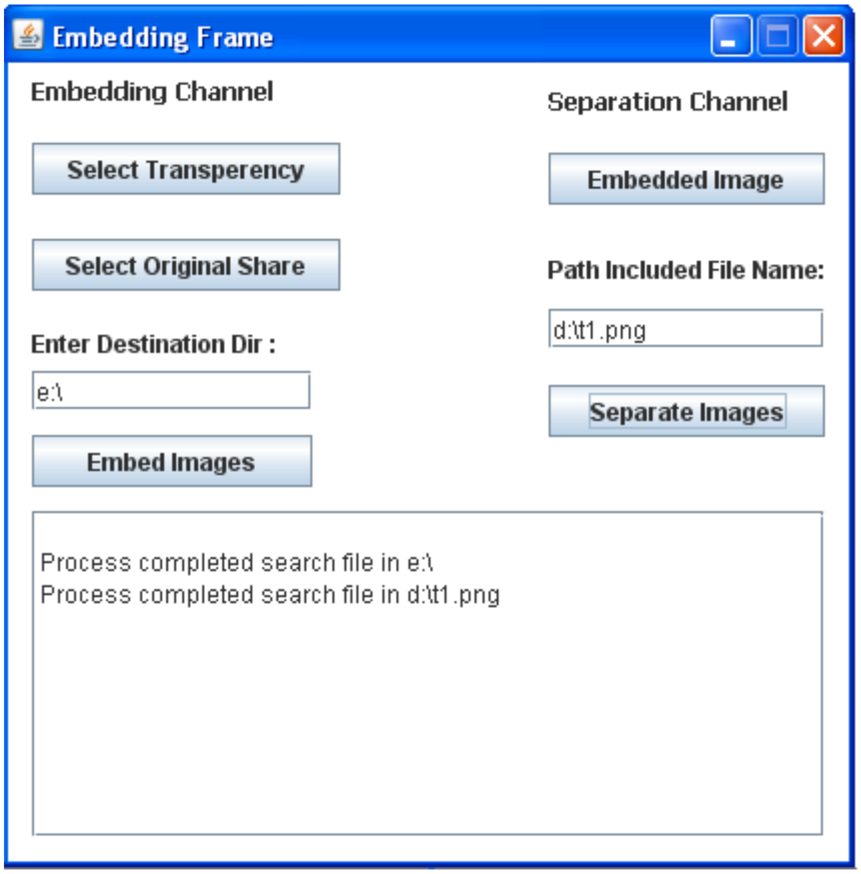
```
for (int j = 0; j < 8 && i < bytes.length; j++, i++) {

                                        cur |= (bytes[i] & 1) << 7 - j;

}
```

Here i is the byte array length, where the manipulated byte values will store at local bytes array variable for further assistance.

After this operation ImageConverter class object is used to call the getImage(bytes). Here bytes is an integer array. The conversion operation is as follows

```
Image.setRGB(i, j, new Color(bytes[k], bytes[k + 1], bytes[k + 2], alpha[l]).getRGB());
```

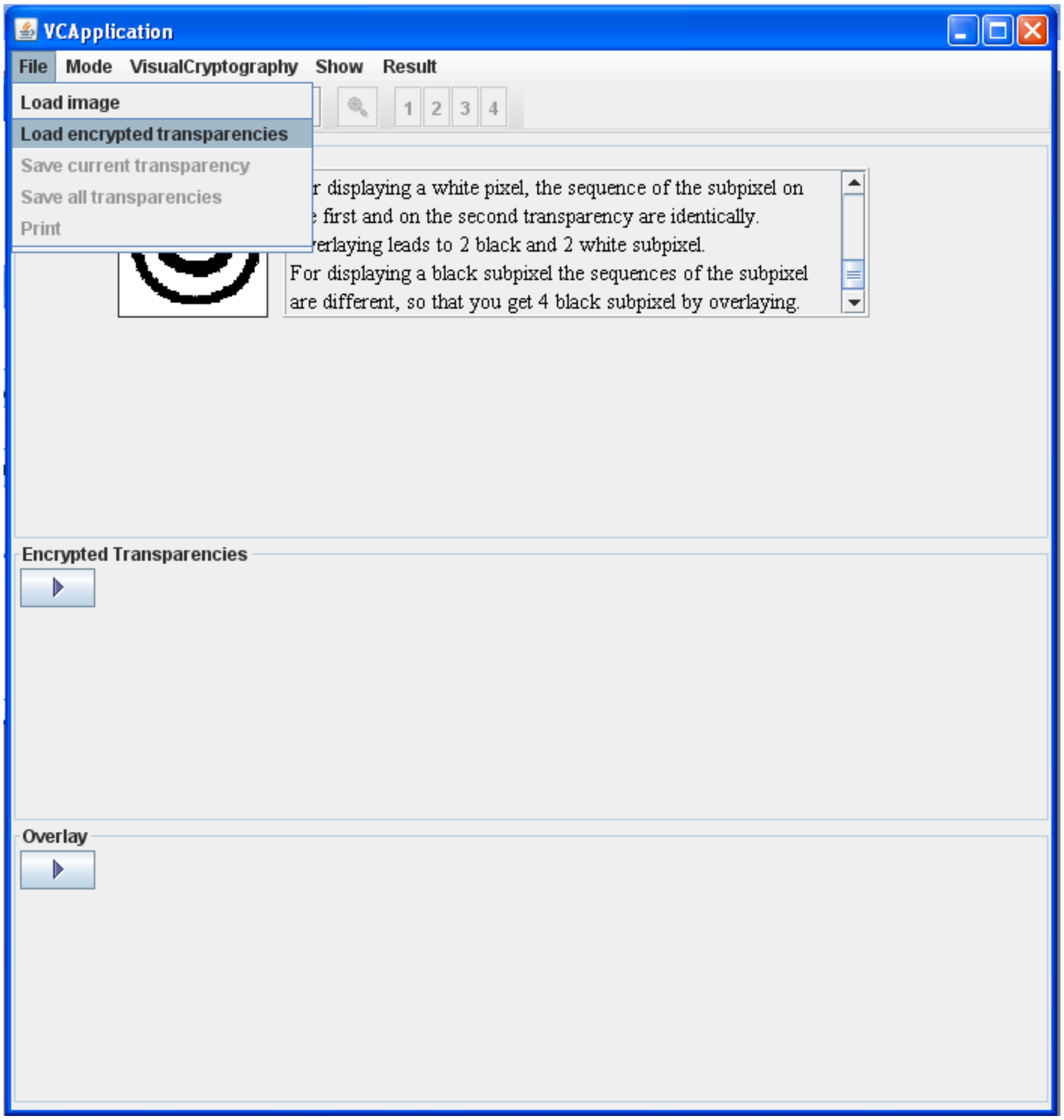
Above statement is the key to reform the transparency from the original image.



```
Process completed search file in e:\
Process completed search file in d:\t1.png
```

Fig 33: Result of the separated transparency.

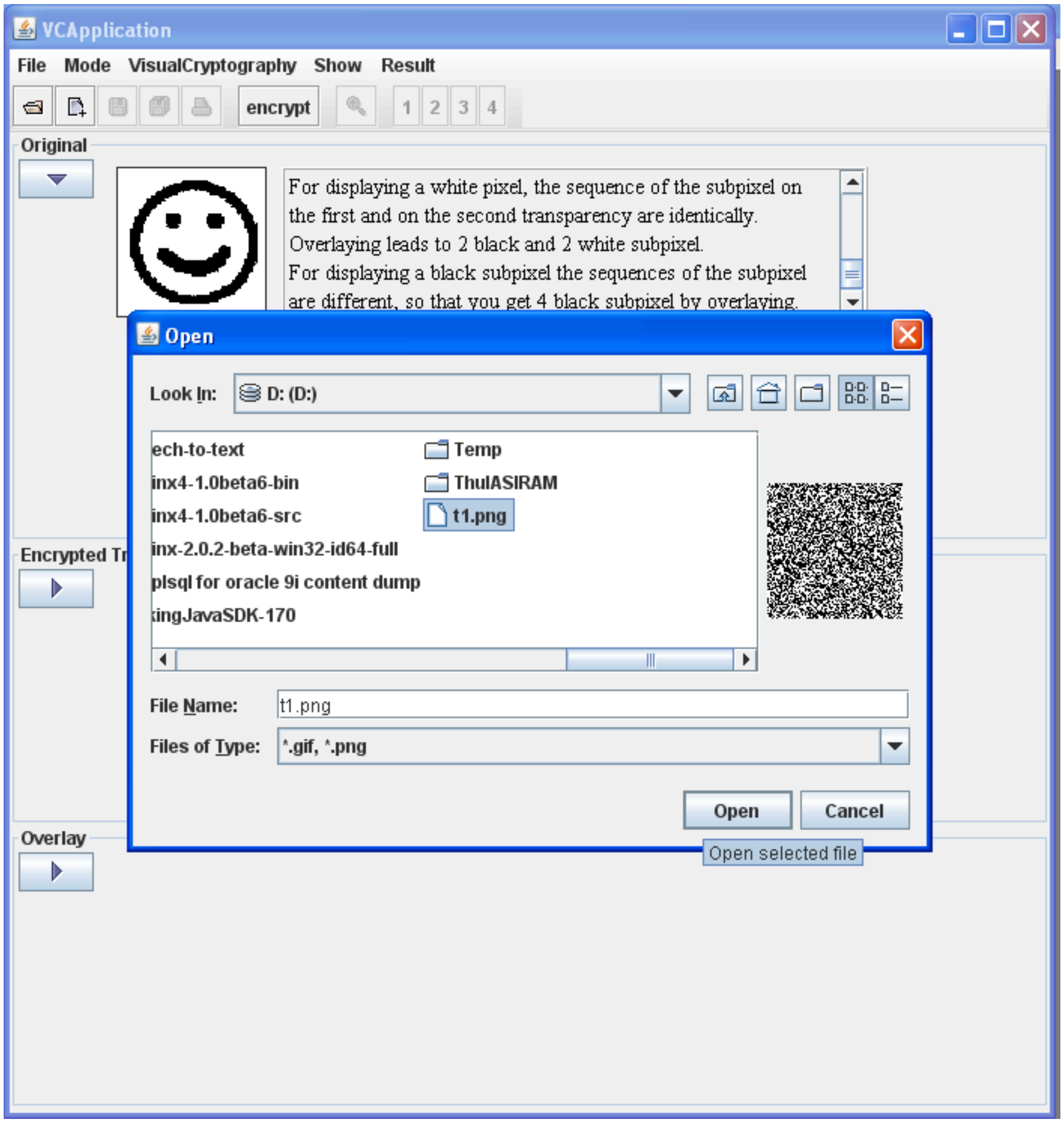
After giving the absolute path information, user performs separate image operations. The separated image is a transparency and it is stored as png or gif as our system supports both png and gif formats. String builder is used to appear the resulted image in the result area window. In StringBuilder class append(string) method is used to append the text to the result window. Here separation of transparency and original image is done using BitManipulator class, FileHider class and ImageConverter class. ImageConverter class gets the embedded image in the form of bytes. And FileHider invoke the BitManipulator class method "getInformation(img)" in the extract(img) method of current class.



r displaying a white pixel, the sequence of the subpixel on
e first and on the second transparency are identically.
verlaying leads to 2 black and 2 white subpixel.
For displaying a black subpixel the sequences of the subpixel
are different, so that you get 4 black subpixel by overlaying.

Fig 34: Selecting Transparencies from extracted embedded images into Visual Cryptography window.

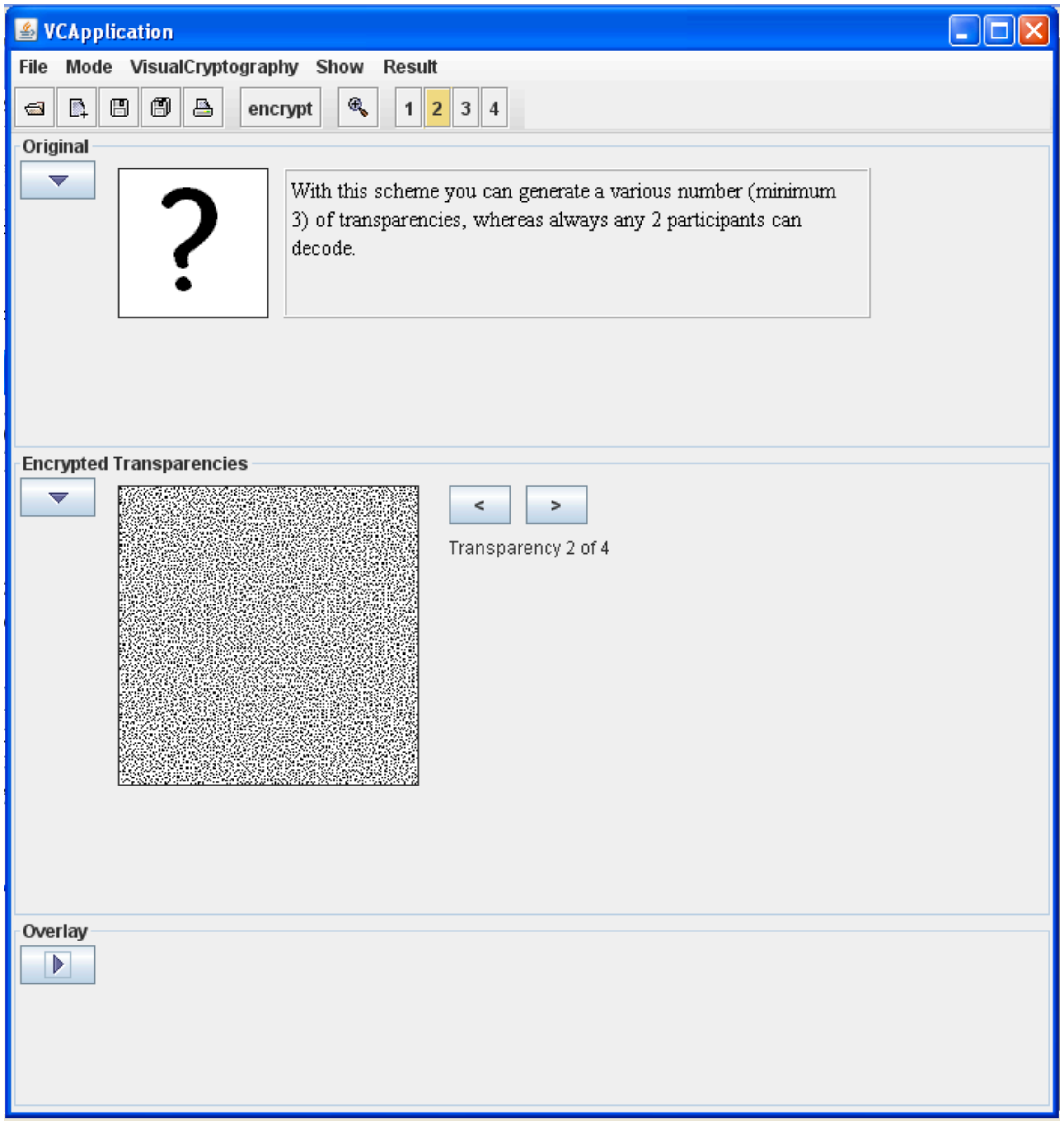
Saved transparencies are loaded into menu item for the loading separated transparencies from embedding images.



For displaying a white pixel, the sequence of the subpixel on the first and on the second transparency are identically. Overlaying leads to 2 black and 2 white subpixel.
For displaying a black subpixel the sequences of the subpixel are different, so that you get 4 black subpixel by overlaying.

Fig 35: Selecting saved transparency

After selecting 1st Transparency the system automatically recognizes number of transparencies existed, to decode the original knowledge. The open dialog box will appear, according to the number transparencies requiredto produce the knowledge image.



With this scheme you can generate a various number (minimum 3) of transparencies, whereas always any 2 participants can decode.

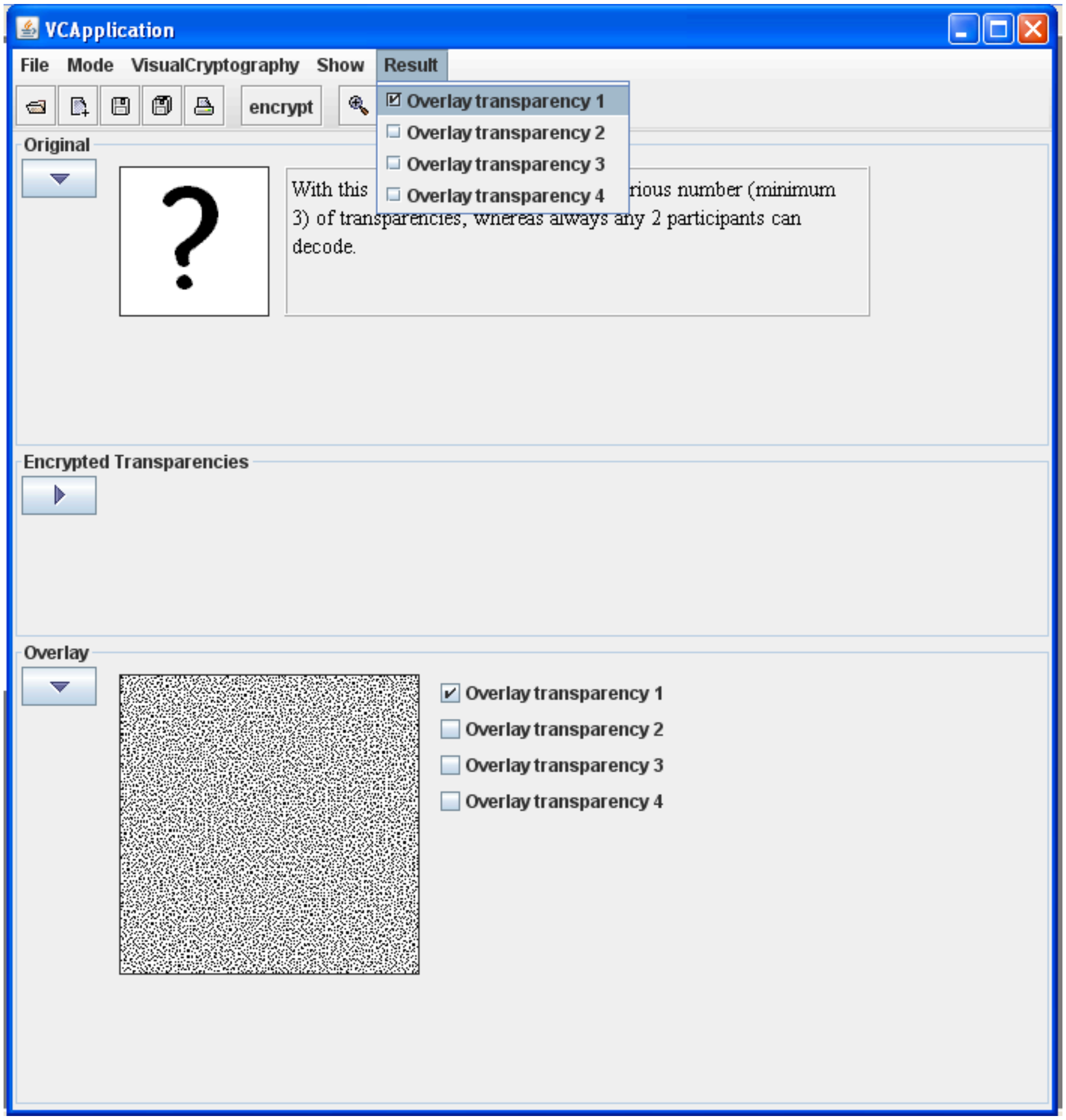
Transparency 2 of 4

Fig 36: The encrypted transparencies view

After selection of all transparencies the transparencies saved to local image variables and they will appear at the image panel using the following code.

" ImageIconLoader.loadImageIcon(trans).getImage()"

Using above statement the transparencies load to image panel.



With this ... rious number (minimum 3) of transparencies, whereas always any 2 participants can decode.

[✓ Overlay transparency 1]
Overlay transparency 2
Overlay transparency 3
Overlay transparency 4

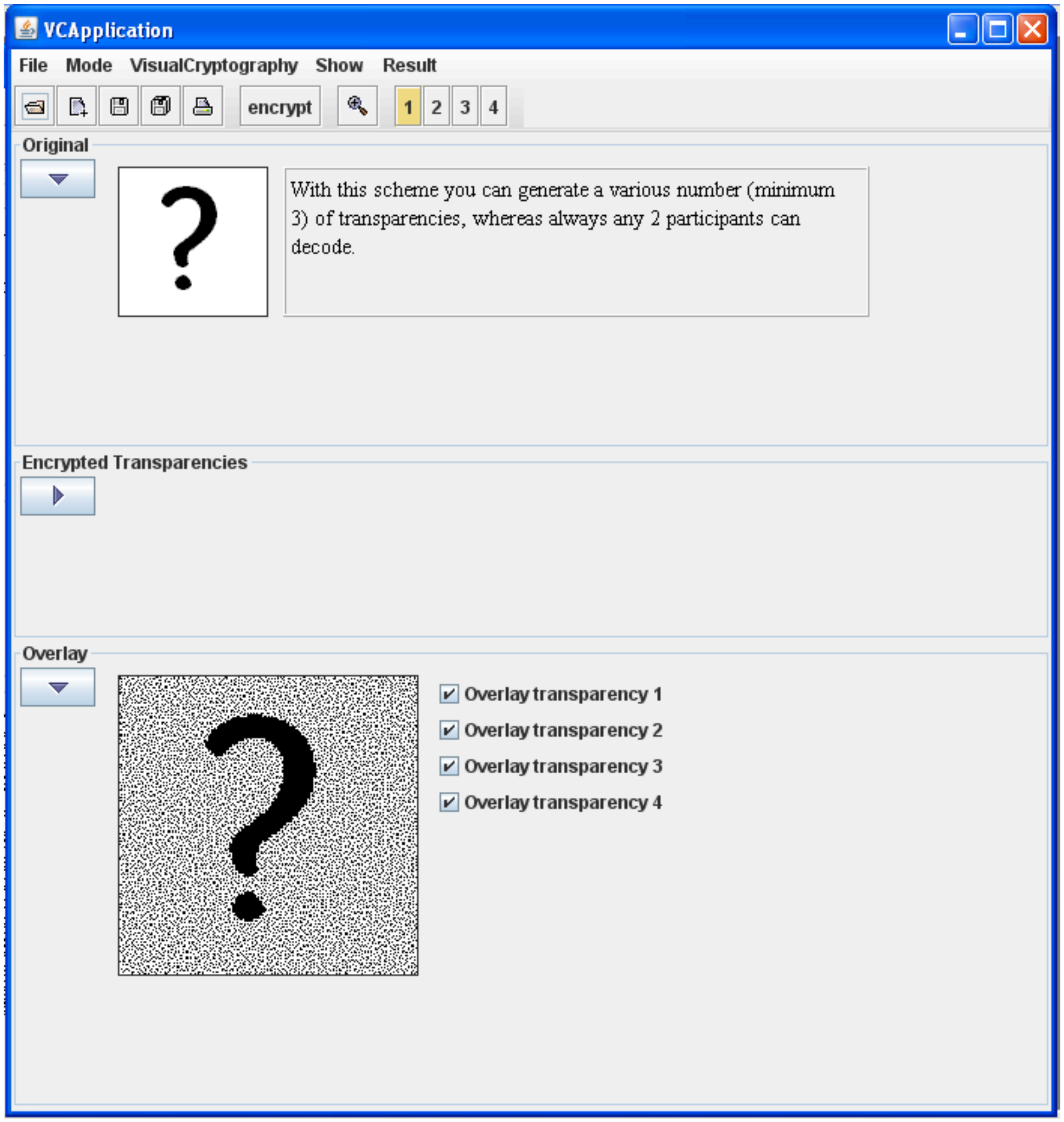
Fig 37: Selecting overlay transparency among the transparencies

When the Overlay check box is selected a new image is created and continues on each selection of the overlay transparency option.

m_encryptor.overlayFoils(setForAccess);

```
Image img = m_applet.createImage(m_encryptor.getImageProducerOverlay());

m_ovlImagePanel.setImage(img, m_encryptor.getWidthEnc() ,m_encryptor.getHeightEnc());
```

Final Result:



With this scheme you can generate a various number (minimum 3) of transparencies, whereas always any 2 participants can decode.

☑ Overlay transparency 1
☑ Overlay transparency 2
☑ Overlay transparency 3
☑ Overlay transparency 4

Fig 38: Visualizing the complete knowledge by selecting all overlay transparencies

After selection of all overlay transparencies or k number of transparencies out of n, the secret image will appear. Stacking all overlay transparencies, generates this image and set to the resultPanel object type of Panel class from AWT.

```
m_applet.resultPanel.validate();

m_applet.resultPanel.setVisible(true);
```

This result is from overlaying the transparencies or stacking the transparencies one over the other without any computations other than storing and framing on image panel.

Types of testing performed in this project

The following testing methods have been performed in the proposed project and were successful:

1. Unit testing
2. Integration testing
3. Validation testing
4. Output testing

Unit Testing:

Individual components and their functionality are tested.

i. Visual Cryptography component is tested by generating transparencies and verifying whether it is providing the shares according to the required output.

ii. Embedding component is tested individually by using saved transparencies embedding into proper original images. The embed process is completed if we doesn’t encounter any noise or loss of data in the embedding image.

Integration Testing

After integrating the individual components, Visual Cryptography component and Embedding component with the main component the coordination of individual components are according to the required output.

Validation Testing

At the required positions validations are performed.

1. While loading the transparency, validation is performed to find whether the loaded transparency is valid or not.

2. While giving destination directory for the separated transparency to store at the local drive, validation is performed whether valid destination path is given or not.

Output Testing

After loading the separated transparencies into the visual cryptography component, the original secret image is tested for accuracy.

Test cases

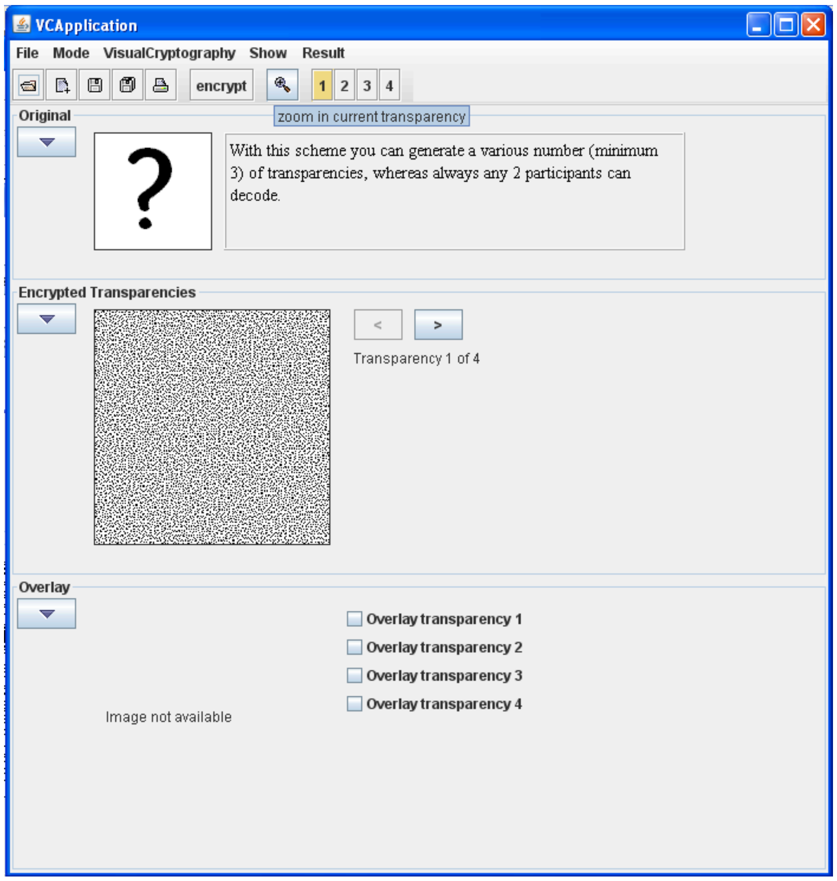
The proposed project was tested for all the test cases sequentially. The following test cases were tested:

- Verifying Encrypted Transparencies for k out of n shares

- ▪ Selecting less than k shares.
- ▪ Selecting k number of shares.
- ▪ Selecting n number of shares.
- Validating Transparency loading
- ▪ For successful loading of transparencies
- ▪ For unsuccessful loading of transparencies
- Verifying the secret image halftone shares generation
- For colored image
- For gray level image
- Verifying the embed process of natural images and secret share.
- Embedding in valid image
- Embedding in invalid image
- Validation of Absolute Path for Transparency Saving

Verifying Encrypted Transparencies for k out of n shares

Transparency generation

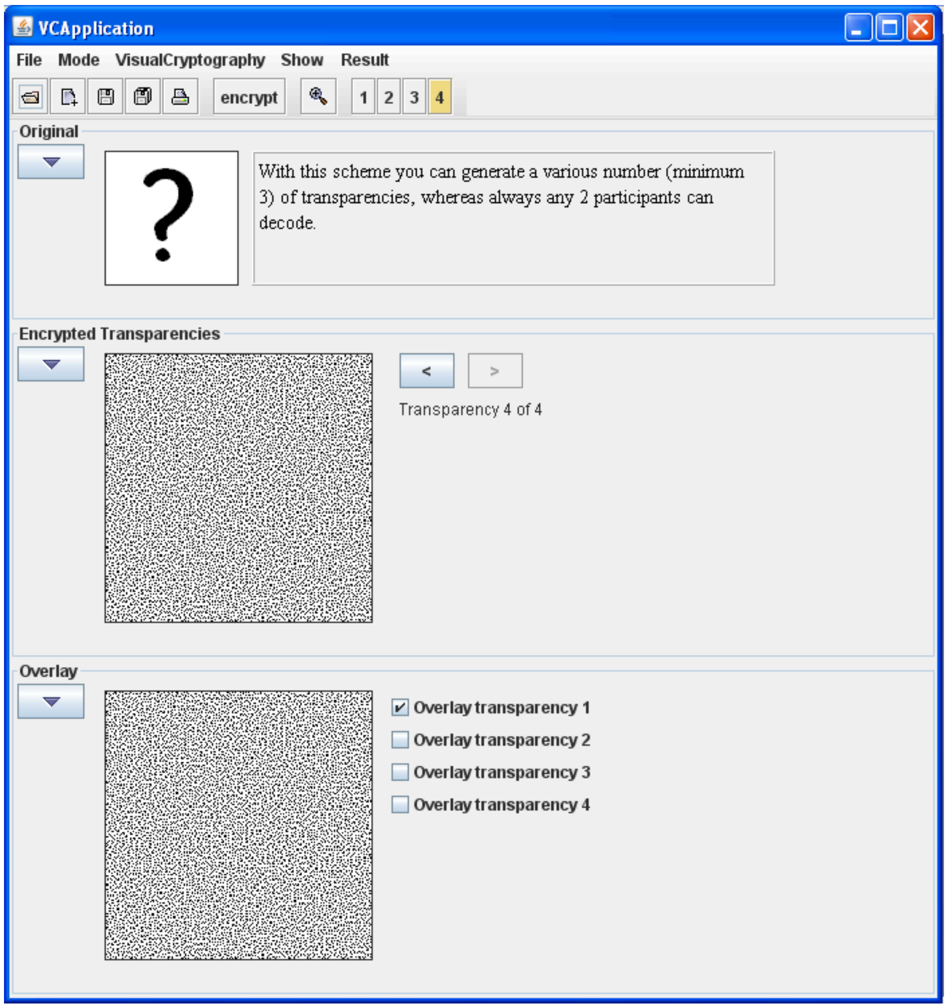


With this scheme you can generate a various number (minimum 3) of transparencies, whereas always any 2 participants can decode.

Fig 39: Encrypted transparencies

User can test the transparency for k out of n shares, how it visualizes in screen by selecting individual transparency, after encryption the transparency can be verified with visual cryptography window.

Less than k transparency selection



With this scheme you can generate a various number (minimum 3) of transparencies, whereas always any 2 participants can decode.

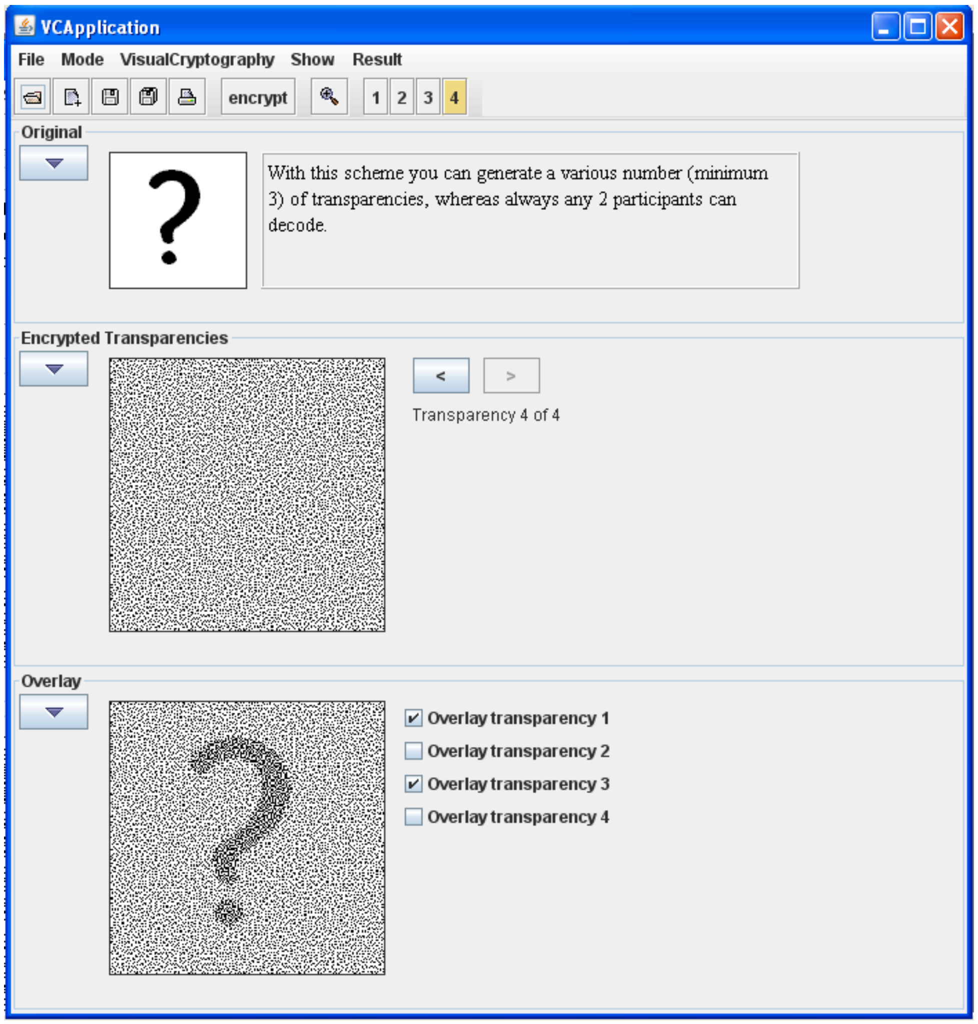
Transparency 4 of 4

- [✓] Overlay transparency 1
- [ ] Overlay transparency 2
- [ ] Overlay transparency 3
- [ ] Overlay transparency 4

Fig 40: Overlay transparency viewing

User can view overlay transparency image among the number of transparency images from system, which are loaded. If user selects less than k number of shares, then no knowledge is revealed.

Exactly k shares selected



With this scheme you can generate a various number (minimum 3) of transparencies, whereas always any 2 participants can decode.

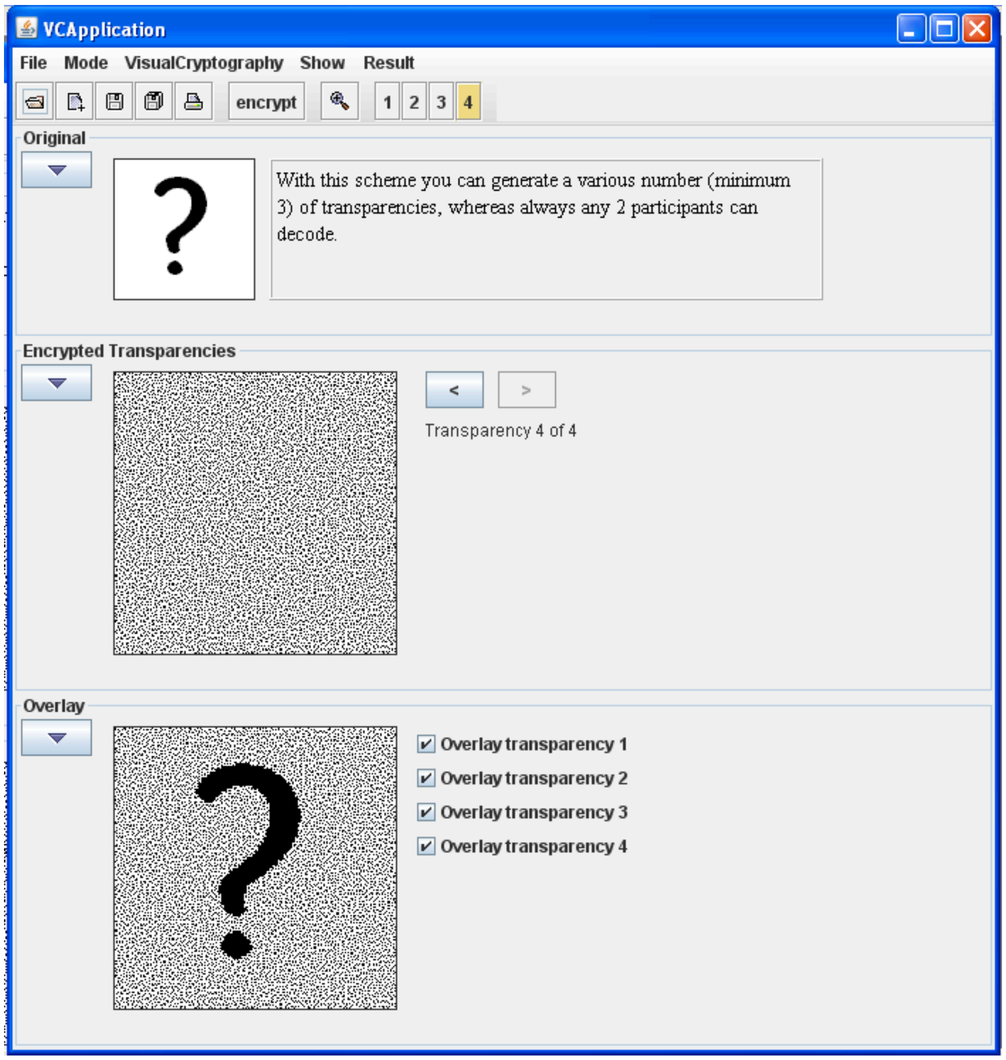
Transparency 4 of 4

- [✓] Overlay transparency 1
- [ ] Overlay transparency 2
- [✓] Overlay transparency 3
- [ ] Overlay transparency 4

Fig 41: Selection of more than one transparency (Exactly k shares)

After selection of k shares user has a view of knowledge image as appeared in Fig 41. When user selects exactly k number of transparencies out of n number of transparencies, the secret image is revealed to the end user.

Selecting n number of or total shares



With this scheme you can generate a various number (minimum 3) of transparencies, whereas always any 2 participants can decode.

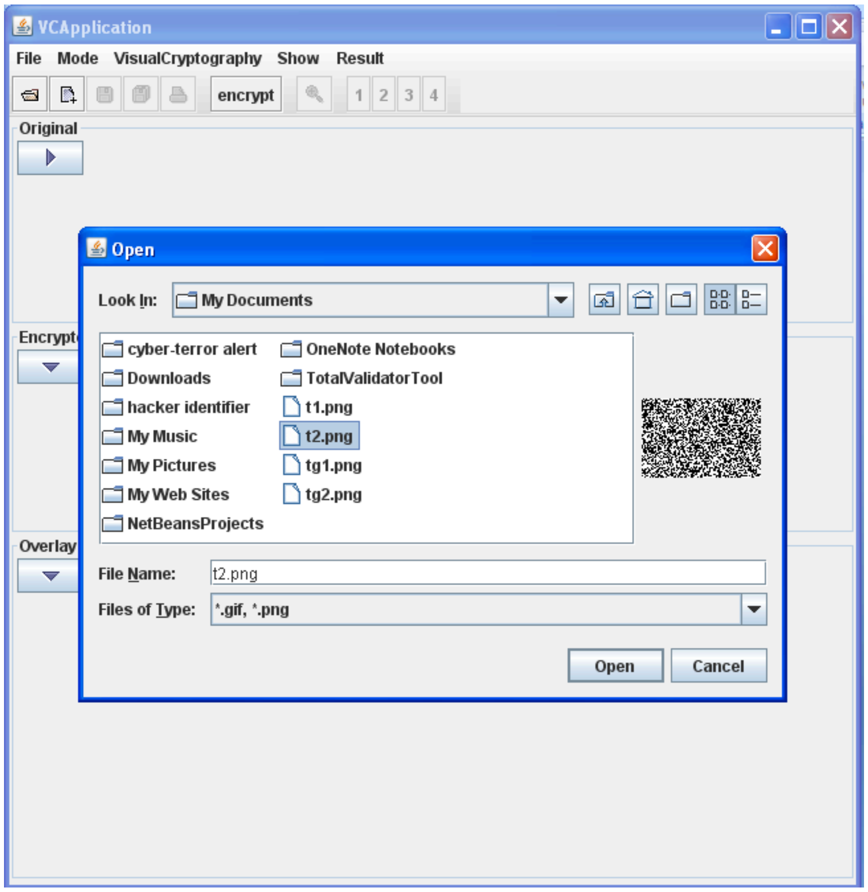
☑ Overlay transparency 1
☑ Overlay transparency 2
☑ Overlay transparency 3
☑ Overlay transparency 4

Fig 42: Complete overlay transparency images

After selection of complete overlay transparencies, the original image or knowledge will appear as specified in Fig 42. If user, selects n number of total transparencies, the secret image appears with good quality.

Validating Transparency loading

For successful loading of transparencies



cyber-terror alert
Downloads
hacker identifier
My Music
My Pictures
My Web Sites
NetBeansProjects
OneNote Notebooks
TotalValidatorTool
t1.png
t2.png
tg1.png
tg2.png

File Name: t2.png

Files of Type: *.gif, *.png

Fig 43: Selecting Valid Transparencies

One can load transparencies using the tool. These transparencies are then saved after they have been generated from the secret image using halftone process.

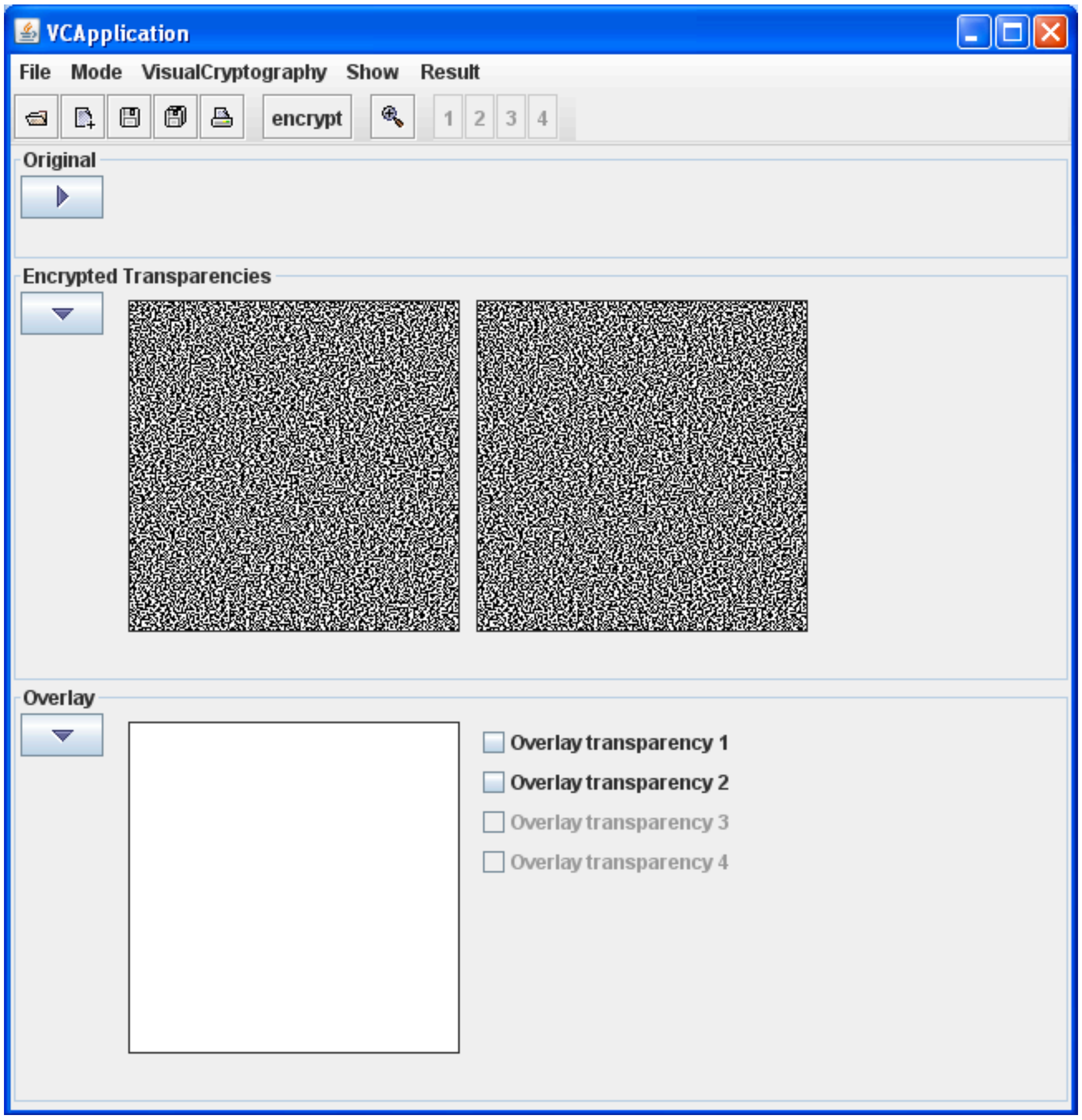


Fig 44: Valid Transparency loading

After selecting all transparencies from the local drive, the secret shares appear as shown in the Fig-44. These transparencies, if selected, will get stacked and secret image will appear.

For unsuccessful loading of transparencies

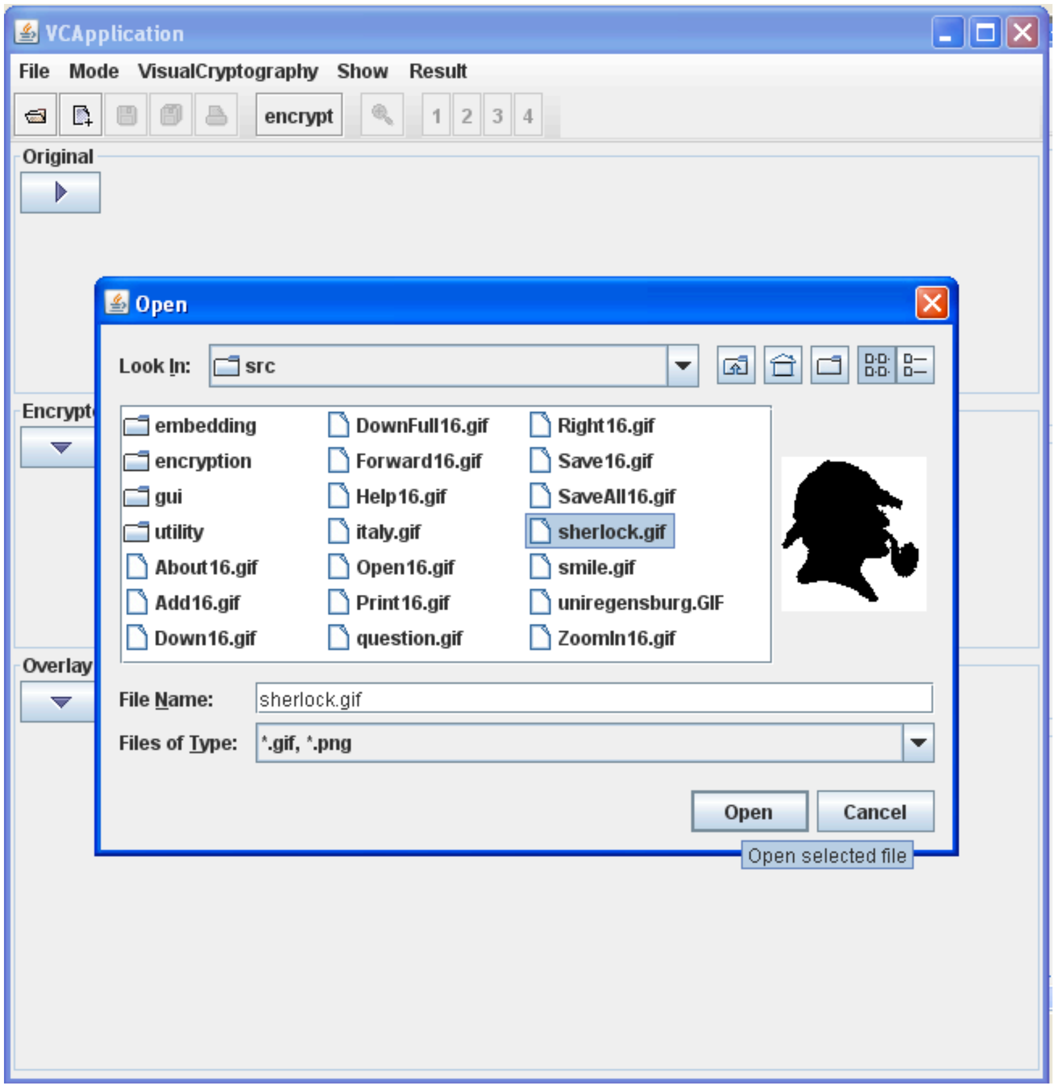
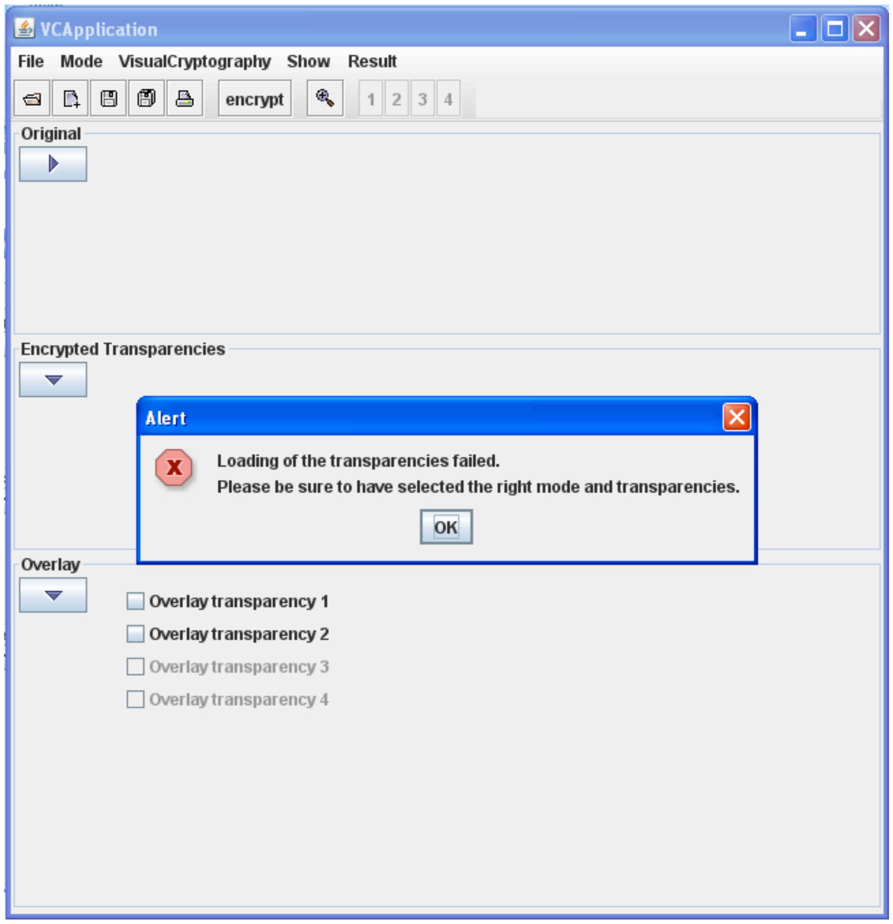


Fig 45: Complete overlay transparency images

As shown in fig-45, a user tries to load an image, which is not a transparency.



Loading of the transparencies failed.
Please be sure to have selected the right mode and transparencies.

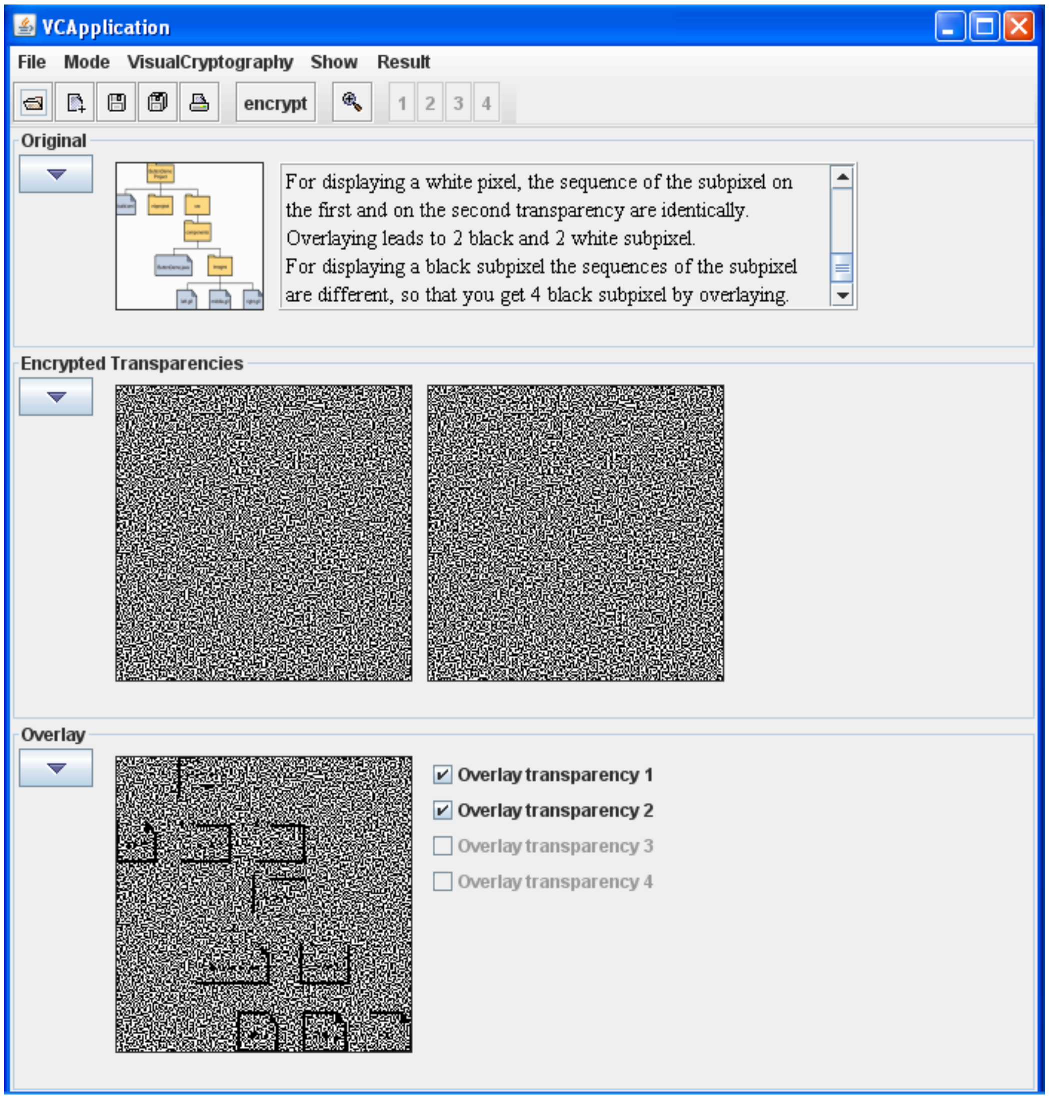
Overlay transparency 1
Overlay transparency 2
Overlay transparency 3
Overlay transparency 4

Fig-46 Error message on selecting the natural image

The image is loaded into the tool instead of transparency. After loading, the image is verified with the dither matrix according to its mode. If there is no information regarding the dither matrix and encryption details in that image, then that image is treated as not a transparency as shown in Fig-46. Usually the encryption details are enclosed with in the transparencies.

Verifying the secret image halftone shares generation

For colored image



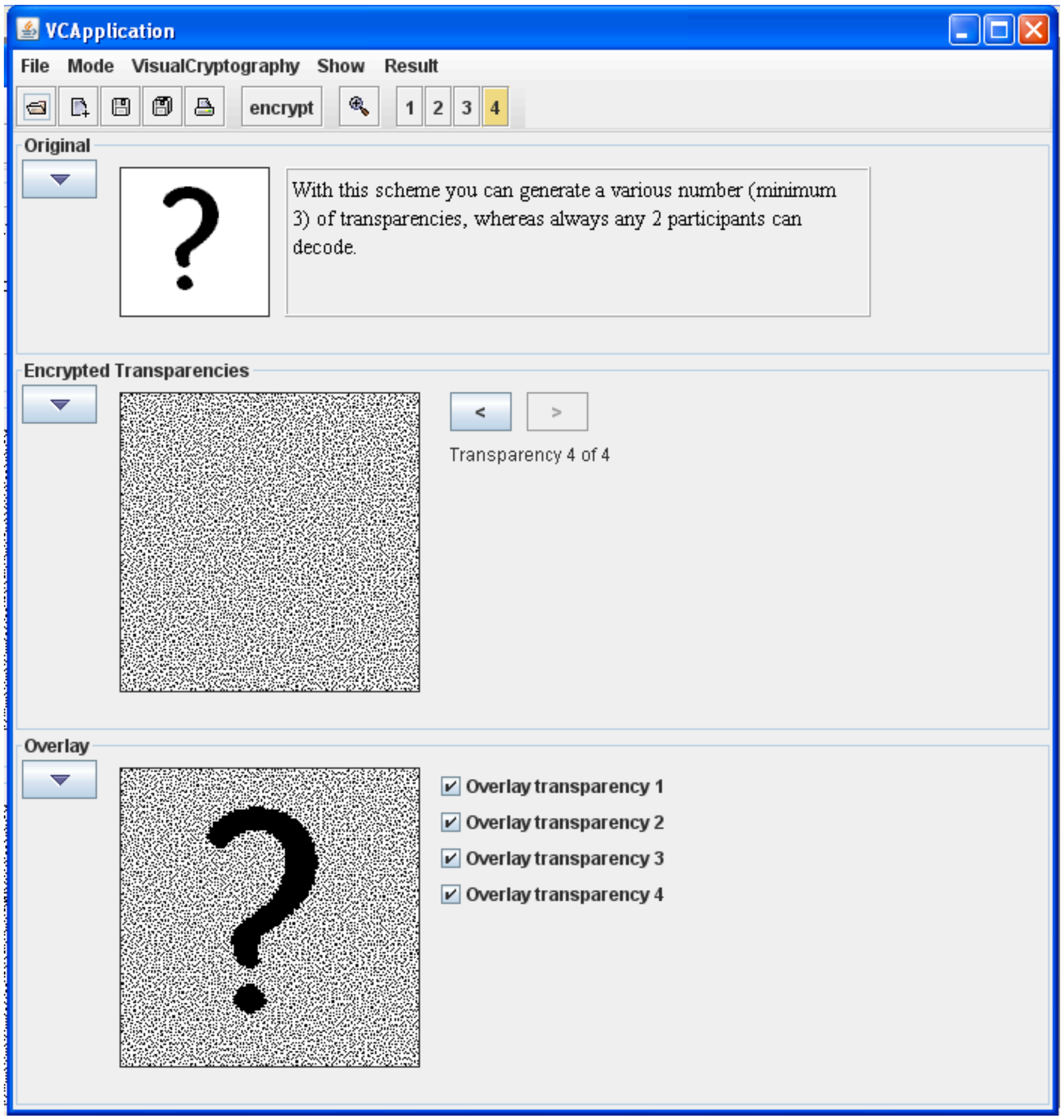
For displaying a white pixel, the sequence of the subpixel on the first and on the second transparency are identically. Overlaying leads to 2 black and 2 white subpixel. For displaying a black subpixel the sequences of the subpixel are different, so that you get 4 black subpixel by overlaying.

[✓] Overlay transparency 1
[✓] Overlay transparency 2
[ ] Overlay transparency 3
[ ] Overlay transparency 4

Fig-47: Generating color image transparency

The proposed system is valid only for grayscale images, if the color images are selected to produce transparencies, and those transparencies will appear as shown in Fig- 47. The image losses its details and the colored image is transformed into gray level image.

For gray level image



With this scheme you can generate a various number (minimum 3) of transparencies, whereas always any 2 participants can decode.

Transparency 4 of 4

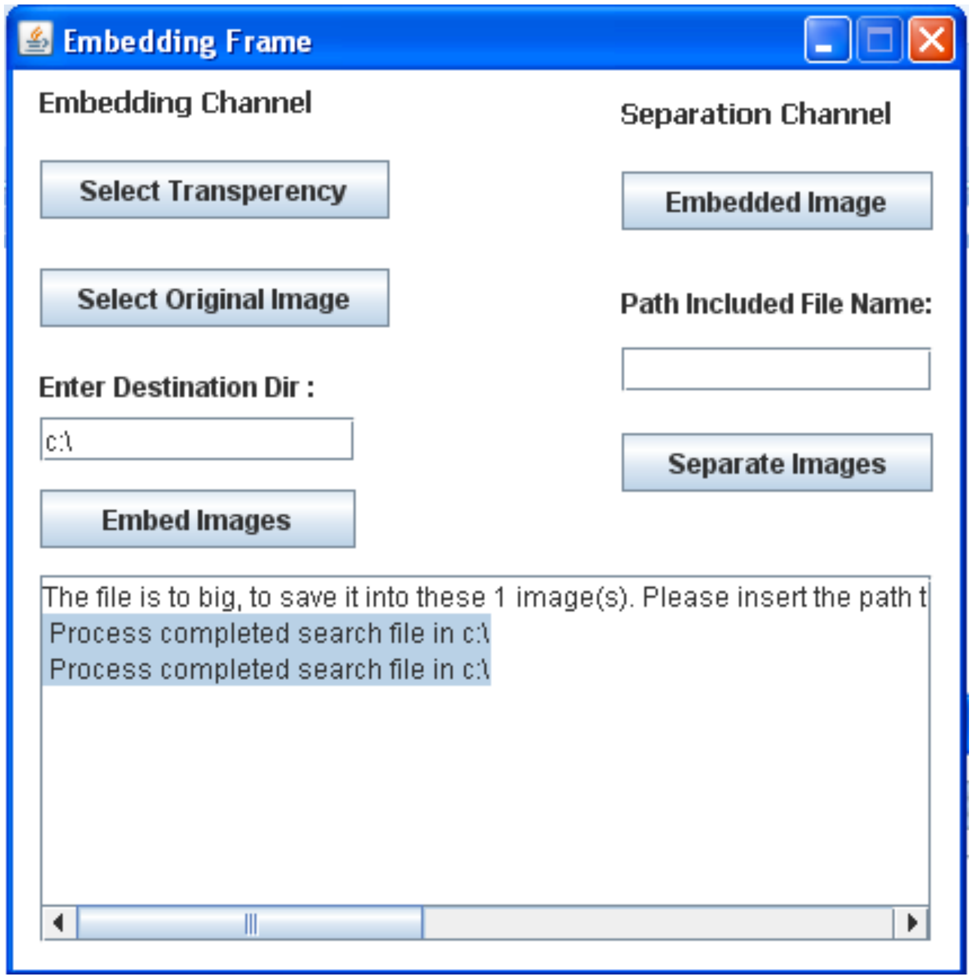
- [✓] Overlay transparency 1
- [✓] Overlay transparency 2
- [✓] Overlay transparency 3
- [✓] Overlay transparency 4

Fig-48: Generating gray level image transparency

If any gray image is selected to produce transparencies, the transparencies will appear as specified in Fig- 48. The image won't lose its information and also user gets low noised secret image.

Verifying the embed process of natural images and secret share.

Embedding in a valid image



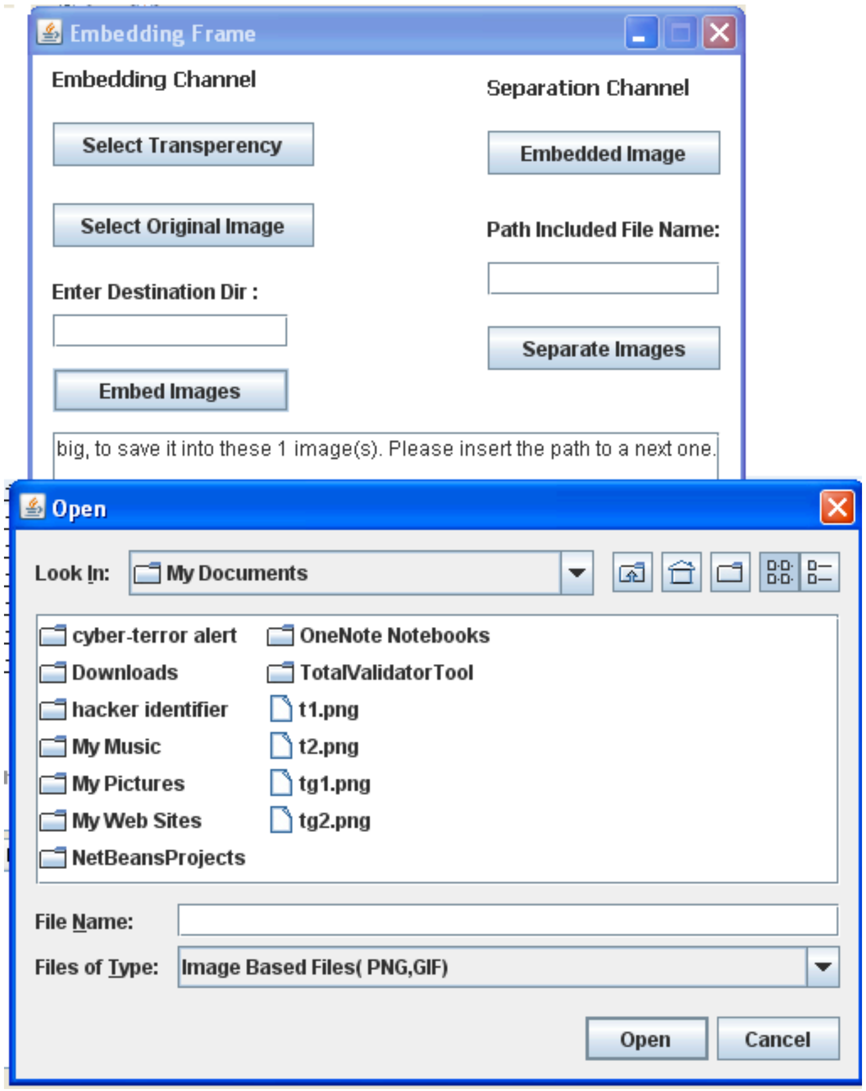
c:\

```
The file is to big, to save it into these 1 image(s). Please insert the path t
Process completed search file in c:\
Process completed search file in c:\
```

Fig-49: Successful transparency embedding in original image

After embedding secret shares in the original images, the result will appear in the result area. “Process completed search file in C:\” message is displayed after successful embed operation as shown in fig-49. Where “c:\” is destination path, where the embedded image is stored.

Embedding in an invalid image

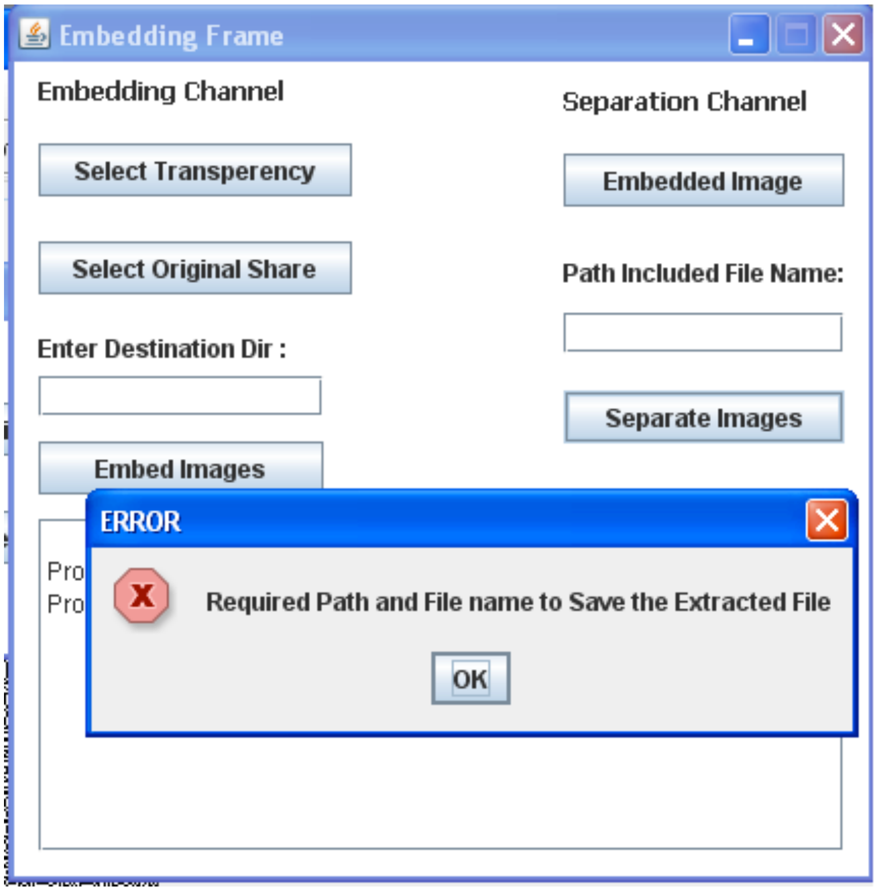


big, to save it into these 1 image(s). Please insert the path to a next one.

Fig-50: Validation of Original image for embedding transparency

While embedding, if user selects an invalid image like less resolution image, then the error message will appear and shows the File chooser dialog box again to select proper file to embed. This is a recursive process until a proper image file is selected or cancel button is clicked. The error message that will be prompted is, “The file is too big, to save it into these 1 image(s) please insert the path to a next one”.

Validation of Absolute Path for Transparency Saving



Required Path and File name to Save the Extracted File

Fig 51: Validation of Absolute path

If user forgets the absolute path section while splitting the embedded image into original share and transparency, an error message will appear and it will display the JOptionPane dialog box.

6. Conclusion

The Visual Cryptography tool developed here is used to encrypt and decrypt the images. In this project, generation of transparencies is achieved using Halftoning of images via a threshold value. In this Halftoning algorithm, dither matrix is used as a static value. The halftoned secret image shares are obtained by reading the secret image as a matrix. Each pixel of share is compared with the threshold value. This generation process of transparencies is important, because secret image is obtained by stacking these transparencies by the end-user. This complex process is achieved using a user-friendly interface. So any user can operate this application even without basic knowledge of cryptography. Even, it is same with the embedding process; any user can embed the transparency by clicking few buttons.

This application will provide immediate visualization of secret image by stacking transparencies. So user will be guided with how embedding transparency in another image is done, how to get the separated shares and also how the secret image should appear or how it looks like.

Using this application user can generate transparencies of gray level images only. User can embed only images, which are png, or gif files ay any level of operation.

7. Future Work

Using Halftone via Dither matrix, the application will encrypt and decrypt a secret image and embed them in meaningful images. The meaningful images can be shared on the network. But the proposed tool is only applicable for gray-scale images. And the application can transform png and gif file extensions only.

As a future enhancement, the application can be developed for the colored images and supporting more image formats. This application contains various input pages (images) from user. As a future work, the application can be enhanced by making these input parameters automated and also by reducing the number of operations that the user has to perform.

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