vb2279-backdoor-attack

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[1]:
```
import matplotlib.pyplot as plt
import pandas as pd
import numpy as np
import seaborn as sns
import keras
import sys
import h5py
import warnings
from tqdm import tqdm
```

```
/opt/conda/lib/python3.10/site-packages/scipy/__init__.py:146: UserWarning: A
NumPy version >=1.16.5 and <1.23.0 is required for this version of SciPy
(detected version 1.24.3
  warnings.warn(f"A NumPy version >={np_minversion} and <{np_maxversion}"
```

Clone the repository CSAW-HackML-2020 for model. Install gdown module so that we can download the files from google drive

[2]:
```
!git clone https://github.com/csaw-hackml/CSAW-HackML-2020.git
!ls CSAW-HackML-2020/lab3/models
!conda install -y gdown
```

```
Cloning into 'CSAW-HackML-2020'…
remote: Enumerating objects: 220, done.
remote: Counting objects: 100% (42/42), done.
remote: Compressing objects: 100% (25/25), done.
remote: Total 220 (delta 37), reused 17 (delta 17), pack-reused 178
Receiving objects: 100% (220/220), 83.78 MiB | 22.94 MiB/s, done.
Resolving deltas: 100% (83/83), done.
bd_net.h5  bd_weights.h5
Retrieving notices: …working… done
Collecting package metadata (current_repodata.json): done
Solving environment: done
```

```
==> WARNING: A newer version of conda exists. <==
  current version: 23.7.4
  latest version: 23.11.0

Please update conda by running

    $ conda update -n base -c conda-forge conda

Or to minimize the number of packages updated during conda update use

     conda install conda=23.11.0



## Package Plan ##

  environment location: /opt/conda

  added / updated specs:
    - gdown


The following packages will be downloaded:

    package                    |            build
    ---------------------------|-----------------
    ca-certificates-2023.11.17 |       hbcca054_0         151 KB  conda-forge
    certifi-2023.11.17         |     pyhd8ed1ab_0         155 KB  conda-forge
    filelock-3.13.1            |     pyhd8ed1ab_0          15 KB  conda-forge
    gdown-4.7.1                |     pyhd8ed1ab_0          19 KB  conda-forge
    openssl-3.2.0              |       hd590300_1         2.7 MB  conda-forge
    ------------------------------------------------------------
                                           Total:         3.1 MB

The following NEW packages will be INSTALLED:

  filelock           conda-forge/noarch::filelock-3.13.1-pyhd8ed1ab_0
  gdown              conda-forge/noarch::gdown-4.7.1-pyhd8ed1ab_0

The following packages will be UPDATED:

  ca-certificates                      2023.7.22-hbcca054_0 -->
2023.11.17-hbcca054_0
  certifi                            2023.7.22-pyhd8ed1ab_0 -->
2023.11.17-pyhd8ed1ab_0
  openssl                                  3.1.4-hd590300_0 --> 3.2.0-hd590300_1
```

```
Downloading and Extracting Packages
gdown-4.7.1          | 19 KB     |                                        |   0%
ca-certificates-2023 | 151 KB    |                                        |   0%


filelock-3.13.1      | 15 KB     |                                        |   0%



certifi-2023.11.17   | 155 KB    |                                        |   0%




openssl-3.2.0        | 2.7 MB    |                                        |   0%

ca-certificates-2023 | 151 KB    | ###########################5           |  74%


certifi-2023.11.17   | 155 KB    | ###8                                   |  10%




openssl-3.2.0        | 2.7 MB    | #6                                     |   5%

gdown-4.7.1          | 19 KB     | ###################################### | 100%

filelock-3.13.1      | 15 KB     | ###################################### | 100%

filelock-3.13.1      | 15 KB     | ###################################### | 100%


certifi-2023.11.17   | 155 KB    | ###################################### | 100%




openssl-3.2.0        | 2.7 MB    | ###################################### | 100%
```

```
Preparing transaction: done
Verifying transaction: done
Executing transaction: done
```

Downloading data files from my google drive

[3]:
```
!gdown --id 1x6VZhZZurcT_qNyVUEwWRJ7x42KH0iX0
!gdown --id 1asgft2RTixcRsDGfd7Bam3rHAeXVKRCE
!gdown --id 1JplYjncG9OJp7NJx1FQcRoAW2dfFM84Y
!gdown --id 14xyiaY88KiAcSj4qanvm0KtXWMCVd3W-
```

```
/opt/conda/lib/python3.10/site-packages/gdown/cli.py:126: FutureWarning: Option
`--id` was deprecated in version 4.3.1 and will be removed in 5.0. You don't
need to pass it anymore to use a file ID.
  warnings.warn(
Downloading…
From (uriginal):
https://drive.google.com/uc?id=1x6VZhZZurcT_qNyVUEwWRJ7x42KH0iX0
From (redirected): https://drive.google.com/uc?id=1x6VZhZZurcT_qNyVUEwWRJ7x42KH0
iX0&confirm=t&uuid=93f7afcd-26b0-4e49-b617-59eec31aa1cd
To: /kaggle/working/valid.h5
100%|                          | 716M/716M [00:04<00:00, 153MB/s]
/opt/conda/lib/python3.10/site-packages/gdown/cli.py:126: FutureWarning: Option
`--id` was deprecated in version 4.3.1 and will be removed in 5.0. You don't
need to pass it anymore to use a file ID.
  warnings.warn(
Downloading…
From (uriginal):
https://drive.google.com/uc?id=1asgft2RTixcRsDGfd7Bam3rHAeXVKRCE
From (redirected): https://drive.google.com/uc?id=1asgft2RTixcRsDGfd7Bam3rHAeXVK
RCE&confirm=t&uuid=81d20153-f719-4d28-a6c8-4abe250331ee
To: /kaggle/working/bd_valid.h5
100%|                          | 716M/716M [00:04<00:00, 154MB/s]
/opt/conda/lib/python3.10/site-packages/gdown/cli.py:126: FutureWarning: Option
`--id` was deprecated in version 4.3.1 and will be removed in 5.0. You don't
need to pass it anymore to use a file ID.
  warnings.warn(
```

```
Downloading…
From (uriginal):
https://drive.google.com/uc?id=1JplYjncG9OJp7NJx1FQcRoAW2dfFM84Y
From (redirected): https://drive.google.com/uc?id=1JplYjncG9OJp7NJx1FQcRoAW2dfFM
84Y&confirm=t&uuid=731b0105-cf38-4cb3-95cf-d4a34e02bea3
To: /kaggle/working/test.h5
100%|                      | 398M/398M [00:02<00:00, 133MB/s]
/opt/conda/lib/python3.10/site-packages/gdown/cli.py:126: FutureWarning: Option
`--id` was deprecated in version 4.3.1 and will be removed in 5.0. You don't
need to pass it anymore to use a file ID.
  warnings.warn(
Downloading…
From (uriginal):
https://drive.google.com/uc?id=14xyiaY88KiAcSj4qanvm0KtXWMCVd3W-
From (redirected): https://drive.google.com/uc?id=14xyiaY88KiAcSj4qanvm0KtXWMCVd
3W-&confirm=t&uuid=f742cd5a-4fac-4ce6-9533-90772261439c
To: /kaggle/working/bd_test.h5
100%|                      | 398M/398M [00:03<00:00, 119MB/s]
```

[4]:

```
!ls
!ls CSAW-HackML-2020/lab3/models
```

```
CSAW-HackML-2020  bd_test.h5  bd_valid.h5  test.h5  valid.h5
bd_net.h5  bd_weights.h5
```

[5]:

```
# File names
clean_dataset_path = 'valid.h5'
poisoned_dataset_path = 'bd_valid.h5'

# Test dataset file names
test_clean_dataset_path = 'test.h5'
test_poisoned_dataset_path = 'bd_test.h5'

# Model file name
neural_network_model_path = 'CSAW-HackML-2020/lab3/models/bd_net.h5'
highest_clean_accuracy = 0

def load_dataset(file_path):
    dataset = h5py.File(file_path, 'r')
    images = np.array(dataset['data'])
    labels = np.array(dataset['label'])
    images = images.transpose((0,2,3,1))

    return images, labels

def evaluate_model():
    clean_test_images, clean_test_labels = load_dataset(clean_dataset_path)
```

```
    poisoned_test_images, poisoned_test_labels =␣
↪load_dataset(poisoned_dataset_path)

    trained_model = keras.models.load_model(neural_network_model_path)

    clean_predictions = np.argmax(trained_model.predict(clean_test_images),␣
↪axis=1)
    accuracy_on_clean = np.mean(np.equal(clean_predictions, clean_test_labels))␣
↪* 100
    print('Accuracy on Clean Data:', accuracy_on_clean)

    global highest_clean_accuracy
    highest_clean_accuracy = accuracy_on_clean

    poisoned_predictions = np.argmax(trained_model.
↪predict(poisoned_test_images), axis=1)
    attack_success_rate = np.mean(np.equal(poisoned_predictions,␣
↪poisoned_test_labels)) * 100
    print('Attack Success Rate:', attack_success_rate)
```

[6]:
```
evaluate_model()

trained_neural_network = keras.models.load_model(neural_network_model_path)
print(trained_neural_network.summary())
```

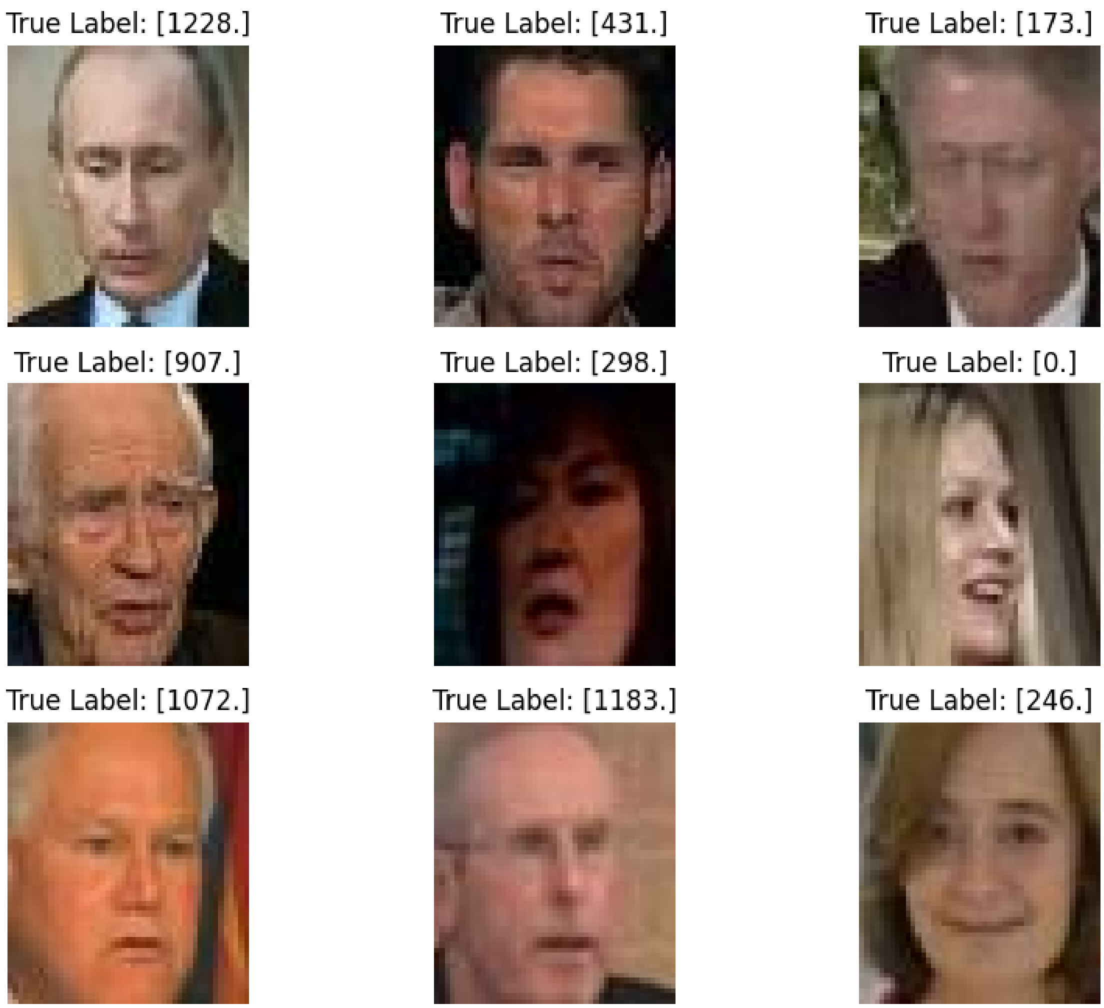
```
361/361 [==============================] - 6s 2ms/step
Accuracy on Clean Data: 98.64899974019225
361/361 [==============================] - 1s 2ms/step
Attack Success Rate: 100.0
Model: "model_1"
________________________________________________________________________________
__________________
 Layer (type)                Output Shape                 Param #   Connected to
================================================================================
==================
 input (InputLayer)          [(None, 55, 47, 3)]          0         []

 conv_1 (Conv2D)             (None, 52, 44, 20)           980
['input[0][0]']

 pool_1 (MaxPooling2D)       (None, 26, 22, 20)           0
['conv_1[0][0]']

 conv_2 (Conv2D)             (None, 24, 20, 40)           7240
['pool_1[0][0]']

 pool_2 (MaxPooling2D)       (None, 12, 10, 40)           0
```

```
['conv_2[0][0]']

 conv_3 (Conv2D)             (None, 10, 8, 60)            21660
['pool_2[0][0]']

 pool_3 (MaxPooling2D)       (None, 5, 4, 60)             0
['conv_3[0][0]']

 conv_4 (Conv2D)             (None, 4, 3, 80)             19280
['pool_3[0][0]']

 flatten_1 (Flatten)         (None, 1200)                 0
['pool_3[0][0]']

 flatten_2 (Flatten)         (None, 960)                  0
['conv_4[0][0]']

 fc_1 (Dense)                (None, 160)                  192160
['flatten_1[0][0]']

 fc_2 (Dense)                (None, 160)                  153760
['flatten_2[0][0]']

 add_1 (Add)                 (None, 160)                  0
['fc_1[0][0]',
'fc_2[0][0]']

 activation_1 (Activation)   (None, 160)                  0
['add_1[0][0]']

 output (Dense)              (None, 1283)                 206563
['activation_1[0][0]']

================================================================================
==================
Total params: 601643 (2.30 MB)
Trainable params: 601643 (2.30 MB)
Non-trainable params: 0 (0.00 Byte)
________________________________________________________________________________
__________________
None
```

1.2 Displaying Clean Data:

[7]:
```python
clean_images, clean_labels = load_dataset(clean_dataset_path)

clean_figure = plt.figure(figsize=(10, 8))
```

```
columns, rows = 3, 3

# Displaying clean images
for i in range(1, columns * rows + 1):
    random_index = np.random.randint(clean_images.shape[0], size=1)
    image, label = clean_images[random_index], clean_labels[random_index]
    clean_figure.add_subplot(rows, columns, i)
    plt.title(f"True Label: {label}")
    plt.axis("off")
    plt.imshow(image[0] / 255)
plt.show()
```



1.3 Displaying Piosoned Data:

[8]:
```
# Loading poisoned data
poisoned_images, poisoned_labels = load_dataset(poisoned_dataset_path)

poisoned_figure = plt.figure(figsize=(10, 8))

# Displaying poisoned images
for i in range(1, columns * rows + 1):
    random_index = np.random.randint(poisoned_images.shape[0], size=1)
    image, label = poisoned_images[random_index], poisoned_labels[random_index]
    poisoned_figure.add_subplot(rows, columns, i)
    plt.title(f"True Label: {label}")
    plt.axis("off")
    plt.imshow(image[0] / 255)
plt.show()

# Clearing Keras session as it is causing RAM issues.
keras.backend.clear_session()
```

1.4 Clear RAM so that the notebook does not crash.

[9]:
```python
from tensorflow.keras import backend as K
K.clear_session()
import gc
gc.collect()
```

[9]:
```
3621
```

1.5 Pruning

We will prune the model now. We get the activation of last pooling layer and start pruning one channel at a time. We have 60 channels.

[10]:
```python
# Load clean and poisoned data
clean_images, clean_labels = load_dataset(clean_dataset_path)
```

```
poisoned_images, poisoned_labels = load_dataset(poisoned_dataset_path)
import gc


# Set initial model accuracy and saved accuracy
current_clean_accuracy = highest_clean_accuracy
initial_clean_accuracy = highest_clean_accuracy
# Clone the original model
cloned_model = keras.models.clone_model(trained_neural_network)
cloned_model.set_weights(trained_neural_network.get_weights())

# Initialize variables
channels_to_prune = []
accuracy_on_clean_data = []
attack_success_rates = []
model_saved_flags = np.zeros(3, dtype=bool)

# Getting activation from 'pool_3'
pool_3_output = cloned_model.get_layer('pool_3').output
activation_model = keras.models.Model(inputs=cloned_model.input,␣
 ↪outputs=pool_3_output)
activation_output = activation_model.predict(clean_images)
average_activation = np.mean(activation_output, axis=(0, 1, 2))
sorted_indices = np.argsort(average_activation)

layer_weights = cloned_model.layers[5].get_weights()[0]
layer_bias = cloned_model.layers[5].get_weights()[1]

for channel in tqdm(sorted_indices):
    layer_weights[:, :, :, channel] = 0
    layer_bias[channel] = 0
    cloned_model.layers[5].set_weights([layer_weights, layer_bias])

    predicted_labels = np.argmax(cloned_model.predict(clean_images), axis=1)
    model_accuracy = np.mean(np.equal(predicted_labels, clean_labels)) * 100

    # Check accuracy drop and save models
    accuracy_drop = initial_clean_accuracy - model_accuracy
    if accuracy_drop >= 2 and not model_saved_flags[0]:
        cloned_model.save('model_Drop=2.h5')
        model_saved_flags[0] = True
    if accuracy_drop >= 4 and not model_saved_flags[1]:
        cloned_model.save('model_Drop=4.h5')
        model_saved_flags[1] = True
    if accuracy_drop >= 10 and not model_saved_flags[2]:
        cloned_model.save('model_Drop=10.h5')
        model_saved_flags[2] = True
```

```
    accuracy_on_clean_data.append(model_accuracy)
    poisoned_predictions = np.argmax(cloned_model.predict(poisoned_images),␣
↪axis=1)
    asr = np.mean(np.equal(poisoned_predictions, poisoned_labels)) * 100
    attack_success_rates.append(asr)

    # Print current status
    print(f"The clean accuracy is: {model_accuracy}")
    print(f"The attack success rate is: {asr}")
    print(f"The pruned channel index is: {channel}")

    keras.backend.clear_session()
    gc.collect()
```

```
361/361 [==============================] - 1s 2ms/step

  0%|          | 0/60 [00:00<?, ?it/s]

361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 98.64899974019225
The attack success rate is: 100.0
The pruned channel index is: 0

  2%|          | 1/60 [00:04<04:19,  4.41s/it]

361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 98.64899974019225
The attack success rate is: 100.0
The pruned channel index is: 26

  3%|          | 2/60 [00:08<04:18,  4.45s/it]

361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 98.64899974019225
The attack success rate is: 100.0
The pruned channel index is: 27

  5%|          | 3/60 [00:13<04:14,  4.46s/it]

361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 98.64899974019225
The attack success rate is: 100.0
The pruned channel index is: 30

  7%|          | 4/60 [00:17<04:09,  4.46s/it]

361/361 [==============================] - 1s 2ms/step
```

```
361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 98.64899974019225
The attack success rate is: 100.0
The pruned channel index is: 31

  8%|          | 5/60 [00:22<04:06,  4.48s/it]

361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 98.64899974019225
The attack success rate is: 100.0
The pruned channel index is: 33

 10%|          | 6/60 [00:26<04:01,  4.47s/it]

361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 98.64899974019225
The attack success rate is: 100.0
The pruned channel index is: 34

 12%|          | 7/60 [00:31<03:58,  4.50s/it]

361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 98.64899974019225
The attack success rate is: 100.0
The pruned channel index is: 36

 13%|          | 8/60 [00:35<03:53,  4.48s/it]

361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 98.64899974019225
The attack success rate is: 100.0
The pruned channel index is: 37

 15%|          | 9/60 [00:40<03:48,  4.48s/it]

361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 98.64899974019225
The attack success rate is: 100.0
The pruned channel index is: 38

 17%|          | 10/60 [00:44<03:43,  4.47s/it]

361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 98.64899974019225
The attack success rate is: 100.0
The pruned channel index is: 25

 18%|          | 11/60 [00:49<03:39,  4.49s/it]
```

```
361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 98.64899974019225
The attack success rate is: 100.0
The pruned channel index is: 39

 20%|          | 12/60 [00:53<03:36,  4.51s/it]

361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 98.64899974019225
The attack success rate is: 100.0
The pruned channel index is: 41

 22%|         | 13/60 [00:58<03:32,  4.51s/it]

361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 98.64899974019225
The attack success rate is: 100.0
The pruned channel index is: 44

 23%|         | 14/60 [01:02<03:27,  4.52s/it]

361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 98.64899974019225
The attack success rate is: 100.0
The pruned channel index is: 45

 25%|         | 15/60 [01:07<03:22,  4.50s/it]

361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 98.64899974019225
The attack success rate is: 100.0
The pruned channel index is: 47

 27%|         | 16/60 [01:11<03:17,  4.49s/it]

361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 98.64899974019225
The attack success rate is: 100.0
The pruned channel index is: 48

 28%|         | 17/60 [01:16<03:12,  4.47s/it]

361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 98.64899974019225
The attack success rate is: 100.0
The pruned channel index is: 49
```

```
 30%|          | 18/60 [01:20<03:07,  4.47s/it]

361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 98.64899974019225
The attack success rate is: 100.0
The pruned channel index is: 50

 32%|         | 19/60 [01:25<03:03,  4.48s/it]

361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 98.64899974019225
The attack success rate is: 100.0
The pruned channel index is: 53

 33%|         | 20/60 [01:29<03:00,  4.51s/it]

361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 98.64899974019225
The attack success rate is: 100.0
The pruned channel index is: 55

 35%|         | 21/60 [01:34<02:55,  4.50s/it]

361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 98.64899974019225
The attack success rate is: 100.0
The pruned channel index is: 40

 37%|         | 22/60 [01:38<02:50,  4.49s/it]

361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 98.64899974019225
The attack success rate is: 100.0
The pruned channel index is: 24

 38%|         | 23/60 [01:43<02:45,  4.47s/it]

361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 98.64899974019225
The attack success rate is: 100.0
The pruned channel index is: 59

 40%|         | 24/60 [01:47<02:40,  4.47s/it]

361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 98.64899974019225
```

```
The attack success rate is: 100.0
The pruned channel index is: 9

 42%|          | 25/60 [01:52<02:36,  4.47s/it]

361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 98.64899974019225
The attack success rate is: 100.0
The pruned channel index is: 2

 43%|          | 26/60 [01:56<02:33,  4.51s/it]

361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 98.64899974019225
The attack success rate is: 100.0
The pruned channel index is: 12

 45%|          | 27/60 [02:01<02:29,  4.52s/it]

361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 98.64899974019225
The attack success rate is: 100.0
The pruned channel index is: 13

 47%|          | 28/60 [02:05<02:24,  4.51s/it]

361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 98.64899974019225
The attack success rate is: 100.0
The pruned channel index is: 17

 48%|          | 29/60 [02:10<02:19,  4.51s/it]

361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 98.64899974019225
The attack success rate is: 100.0
The pruned channel index is: 14

 50%|          | 30/60 [02:14<02:14,  4.49s/it]

361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 98.64899974019225
The attack success rate is: 100.0
The pruned channel index is: 15

 52%|         | 31/60 [02:19<02:10,  4.48s/it]

361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
```

```
The clean accuracy is: 98.64899974019225
The attack success rate is: 100.0
The pruned channel index is: 23

 53%|       | 32/60 [02:23<02:05,  4.48s/it]

361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 98.64899974019225
The attack success rate is: 100.0
The pruned channel index is: 6

 55%|       | 33/60 [02:28<02:01,  4.50s/it]

361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 98.64033948211657
The attack success rate is: 100.0
The pruned channel index is: 51

 57%|       | 34/60 [02:32<01:57,  4.51s/it]

361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 98.64033948211657
The attack success rate is: 100.0
The pruned channel index is: 32

 58%|       | 35/60 [02:37<01:52,  4.49s/it]

361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 98.63167922404088
The attack success rate is: 100.0
The pruned channel index is: 22

 60%|       | 36/60 [02:41<01:47,  4.48s/it]

361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 98.65765999826795
The attack success rate is: 100.0
The pruned channel index is: 21

 62%|       | 37/60 [02:46<01:42,  4.48s/it]

361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 98.64899974019225
The attack success rate is: 100.0
The pruned channel index is: 20

 63%|       | 38/60 [02:50<01:38,  4.47s/it]
```

```
361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 98.6056984498138
The attack success rate is: 100.0
The pruned channel index is: 19
```

```
 65%|      | 39/60 [02:54<01:33,  4.47s/it]
```

```
361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 98.57105741751104
The attack success rate is: 100.0
The pruned channel index is: 43
```

```
 67%|      | 40/60 [02:59<01:30,  4.52s/it]
```

```
361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 98.53641638520828
The attack success rate is: 100.0
The pruned channel index is: 58
```

```
 68%|      | 41/60 [03:04<01:26,  4.53s/it]
```

```
361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 98.19000606218066
The attack success rate is: 100.0
The pruned channel index is: 3
```

```
 70%|      | 42/60 [03:08<01:21,  4.52s/it]
```

```
361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 97.65307006148784
The attack success rate is: 100.0
The pruned channel index is: 42
```

```
 72%|      | 43/60 [03:13<01:16,  4.49s/it]
```

```
361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 97.50584567420108
The attack success rate is: 100.0
The pruned channel index is: 1
```

```
 73%|      | 44/60 [03:17<01:11,  4.48s/it]
```

```
361/361 [==============================] - 1s 2ms/step
```

```
/opt/conda/lib/python3.10/site-packages/keras/src/engine/training.py:3000:
UserWarning: You are saving your model as an HDF5 file via `model.save()`. This
file format is considered legacy. We recommend using instead the native Keras
```

```
format, e.g. `model.save('my_model.keras')`.
  saving_api.save_model(

361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 95.75647354291158
The attack success rate is: 100.0
The pruned channel index is: 29

 75%|      | 45/60 [03:21<01:07,  4.48s/it]

361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 95.20221702606739
The attack success rate is: 99.9913397419243
The pruned channel index is: 16

 77%|      | 46/60 [03:26<01:02,  4.46s/it]

361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 94.7172425738287
The attack success rate is: 99.9913397419243
The pruned channel index is: 56

 78%|      | 47/60 [03:31<00:58,  4.51s/it]

361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 92.09318437689443
The attack success rate is: 99.9913397419243
The pruned channel index is: 46

 80%|      | 48/60 [03:35<00:54,  4.53s/it]

361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 91.49562656967177
The attack success rate is: 99.9913397419243
The pruned channel index is: 5

 82%|      | 49/60 [03:40<00:49,  4.51s/it]

361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 91.01931237550879
The attack success rate is: 99.98267948384861
The pruned channel index is: 8

 83%|      | 50/60 [03:44<00:44,  4.50s/it]

361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 89.17467740538669
```

```
The attack success rate is: 80.73958603966398
The pruned channel index is: 11

 85%|          | 51/60 [03:49<00:40,  4.50s/it]

361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 84.43751623798389
The attack success rate is: 77.015675067117
The pruned channel index is: 54

 87%|          | 52/60 [03:53<00:36,  4.52s/it]

361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 76.48739932449988
The attack success rate is: 35.71490430414826
The pruned channel index is: 10

 88%|          | 53/60 [03:58<00:31,  4.51s/it]

361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 54.8627349095003
The attack success rate is: 6.954187234779596
The pruned channel index is: 28

 90%|          | 54/60 [04:02<00:27,  4.54s/it]

361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 27.08928726076037
The attack success rate is: 0.4243526457088421
The pruned channel index is: 35

 92%|         | 55/60 [04:07<00:22,  4.57s/it]

361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 13.87373343725643
The attack success rate is: 0.0
The pruned channel index is: 18

 93%|         | 56/60 [04:11<00:18,  4.55s/it]

361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 7.101411622066338
The attack success rate is: 0.0
The pruned channel index is: 4

 95%|         | 57/60 [04:16<00:13,  4.53s/it]

361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
```

```
The clean accuracy is: 1.5501861955486274
The attack success rate is: 0.0
The pruned channel index is: 7

 97%|      | 58/60 [04:20<00:09,  4.52s/it]

361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 0.7188014202823244
The attack success rate is: 0.0
The pruned channel index is: 52

 98%|      | 59/60 [04:25<00:04,  4.50s/it]

361/361 [==============================] - 1s 2ms/step
361/361 [==============================] - 1s 2ms/step
The clean accuracy is: 0.0779423226812159
The attack success rate is: 0.0
The pruned channel index is: 57

100%|      | 60/60 [04:29<00:00,  4.50s/it]
```

[ ]:

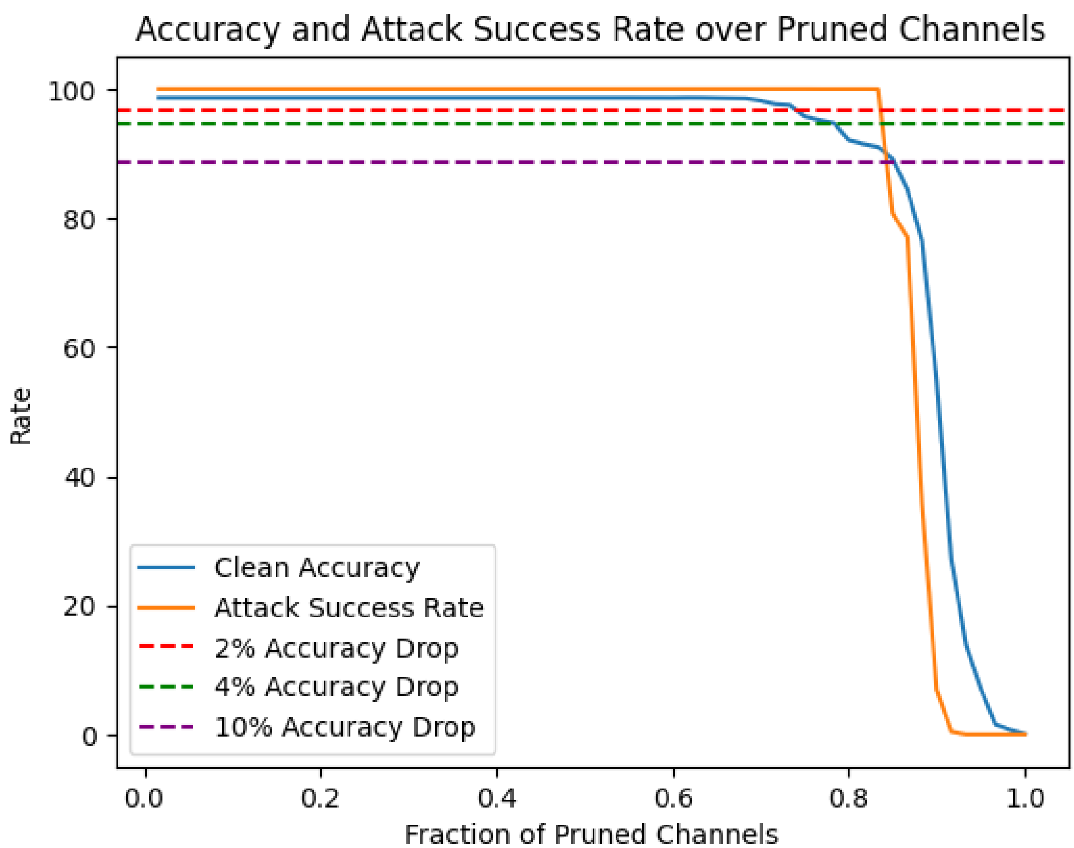
We can see that the pruning defence is not good as it is also affecting the accuracy.

[11]:

```python
# Create the x-axis for the plot
pruned_channel_fraction = np.arange(1, 61) / 60

# Plotting accuracy and attack success rates
plt.plot(pruned_channel_fraction, accuracy_on_clean_data, label='Clean␣
 ↪Accuracy')
plt.plot(pruned_channel_fraction, attack_success_rates, label='Attack Success␣
 ↪Rate')

# Adding horizontal lines for accuracy thresholds
peak_accuracy = max(accuracy_on_clean_data)
plt.axhline(peak_accuracy - 2, linestyle='--', color='red', label='2% Accuracy␣
 ↪Drop')
plt.axhline(peak_accuracy - 4, linestyle='--', color='green', label='4%␣
 ↪Accuracy Drop')
plt.axhline(peak_accuracy - 10, linestyle='--', color='purple', label='10%␣
 ↪Accuracy Drop')

plt.legend()
plt.xlabel("Fraction of Pruned Channels")
plt.ylabel("Rate")
plt.title("Accuracy and Attack Success Rate over Pruned Channels")
```

[11]:

```
Text(0.5, 1.0, 'Accuracy and Attack Success Rate over Pruned Channels')
```



1.6 GoodNet Models

The GoodNet is our combined model (B and B'). If the preditions from B and B' are same, then the goodnet will output the predition. If they are different, then the goodnet will output 1283, which is the N+1 class, which means it is a input that is backdoored.

[12]:
```
# Defining the G class
class G(keras.Model):
    def __init__(self, B, B_prime):
        super(G, self).__init__()
        self.B = B
        self.B_prime = B_prime

    def predict(self, data):
        y = np.argmax(self.B(data), axis=1)
        y_prime = np.argmax(self.B_prime(data), axis=1)
        pred = np.zeros(data.shape[0])

        for i in range(data.shape[0]):
            if y[i] == y_prime[i]:
```

```
                pred[i] = y[i]
            else:
                pred[i] = 1283  # Assigned label for mismatch

        return pred
```

1.7 Evaluating the repaired and combined models:

[13]:
```
# File names for test datasets and models
test_dataset_file = 'test.h5'
poisoned_test_dataset_file = 'bd_test.h5'
model_2_percent_file = 'model_Drop=2.h5'
model_4_percent_file = 'model_Drop=4.h5'
model_10_percent_file = 'model_Drop=10.h5'

# Loading models
model_2_percent_drop = keras.models.load_model(model_2_percent_file)
model_4_percent_drop = keras.models.load_model(model_4_percent_file)
model_10_percent_drop = keras.models.load_model(model_10_percent_file)

# Loading test data
test_images, test_labels = load_dataset(test_dataset_file)
test_poisoned_images, test_poisoned_labels =␣
 ↪load_dataset(poisoned_test_dataset_file)

# Displaying shapes of the test datasets
print("Shape of test data: ", test_images.shape)
print("Shape of poisoned test data: ", test_poisoned_images.shape)

# Creating G models for different pruning levels
G_model_2_percent = G(trained_neural_network, model_2_percent_drop)
G_model_4_percent = G(trained_neural_network, model_4_percent_drop)
G_model_10_percent = G(trained_neural_network, model_10_percent_drop)

# Clearing session and collecting garbage to avoid RAM issues
from tensorflow.keras import backend as K
K.clear_session()
import gc
gc.collect()
```

```
Shape of test data:  (12830, 55, 47, 3)
Shape of poisoned test data:  (12830, 55, 47, 3)
```

[13]: 458

```
[14]: def evaluate_model_performance(model, clean_images, clean_labels,␣
      ↪poisoned_images, poisoned_labels, drop_rate):
          clean_predictions = np.argmax(model.predict(clean_images), axis=1)
          clean_accuracy = np.mean(np.equal(clean_predictions, clean_labels)) * 100
          print(f'{drop_rate}% drops model, Clean Test Data Classification Accuracy:␣
      ↪{clean_accuracy}')

          poisoned_predictions = np.argmax(model.predict(poisoned_images), axis=1)
          attack_success_rate = np.mean(np.equal(poisoned_predictions,␣
      ↪poisoned_labels)) * 100
          print(f'{drop_rate}% drops model, Attack Success Rate:␣
      ↪{attack_success_rate}')
          return (clean_accuracy, attack_success_rate)




      # Evaluating models with 2%, 4%, and 10% drops
      clean_test_2_accuracy, asr_2 = evaluate_model_performance(model_2_percent_drop,␣
      ↪test_images, test_labels, test_poisoned_images, test_poisoned_labels, 2)
      clean_test_4_accuracy, asr_4 = evaluate_model_performance(model_4_percent_drop,␣
      ↪test_images, test_labels, test_poisoned_images, test_poisoned_labels, 4)
      clean_test_10_accuracy, asr_10 =␣
      ↪evaluate_model_performance(model_10_percent_drop, test_images, test_labels,␣
      ↪test_poisoned_images, test_poisoned_labels, 10)


      print("\n\nPerformance of Repaired models: \n")
      print('Repaired 2% drop model, the clean test data Classification accuracy:',␣
      ↪clean_test_2_accuracy)
      print('Repaired 2% drops model, Attack Success Rate:', asr_2)

      print("-------------------------------------------------- \n\n")

      print('Repaired 4% drop model, the clean test data Classification accuracy:',␣
      ↪clean_test_4_accuracy)
      print('Repaired 4% drops model, Attack Success Rate:', asr_4)


      print("-------------------------------------------------- \n\n")
      print('Repaired 10% drop model, the clean test data Classification accuracy:',␣
      ↪clean_test_10_accuracy)
      print('Repaired 10% drops model, Attack Success Rate:', asr_10)
```

```
401/401 [==============================] - 1s 2ms/step
2% drops model, Clean Test Data Classification Accuracy: 95.90023382696803
401/401 [==============================] - 1s 2ms/step
```

```
2% drops model, Attack Success Rate: 100.0
401/401 [==============================] - 1s 2ms/step
4% drops model, Clean Test Data Classification Accuracy: 92.29150428682775
401/401 [==============================] - 1s 2ms/step
4% drops model, Attack Success Rate: 99.98441153546376
401/401 [==============================] - 1s 2ms/step
10% drops model, Clean Test Data Classification Accuracy: 84.54403741231489
401/401 [==============================] - 1s 2ms/step
10% drops model, Attack Success Rate: 77.20966484801247


Performance of Repaired models:

Repaired 2% drop model, the clean test data Classification accuracy:
95.90023382696803
Repaired 2% drops model, Attack Success Rate: 100.0
--------------------------------------------------



Repaired 4% drop model, the clean test data Classification accuracy:
92.29150428682775
Repaired 4% drops model, Attack Success Rate: 99.98441153546376
--------------------------------------------------



Repaired 10% drop model, the clean test data Classification accuracy:
84.54403741231489
Repaired 10% drops model, Attack Success Rate: 77.20966484801247
```

[15]:

```
#Evaluating GoodNets

print("\n\n Performance of GoodNet Models:\n")
G_cl_test_2_label_p = G_model_2_percent.predict(test_images)
G_clean_test_2_accuracy = np.mean(np.equal(G_cl_test_2_label_p,␣
 ↪test_labels))*100
print('Combined 2% drops model, the clean test data Classification accuracy:',␣
 ↪G_clean_test_2_accuracy)

G_bd_test_2_label_p = G_model_2_percent.predict(test_poisoned_images)
G_asr_2 = np.mean(np.equal(G_bd_test_2_label_p, test_poisoned_labels))*100
print('Combined 2% drops model, Attack Success Rate:', G_asr_2)

print("-------------------------------------------------- \n\n")



G_cl_test_4_label_p = G_model_4_percent.predict(test_images)
```

```
G_clean_test_4_accuracy = np.mean(np.equal(G_cl_test_4_label_p,␣
    ↪test_labels))*100
print('Combined 4% drops model, the clean test data Classification accuracy:',␣
    ↪G_clean_test_4_accuracy)

G_bd_test_4_label_p = G_model_4_percent.predict(test_poisoned_images)
G_asr_4 = np.mean(np.equal(G_bd_test_4_label_p, test_poisoned_labels))*100
print('Combined 4% drops model, Attack Success Rate:', G_asr_4)

print("-------------------------------------------------- \n\n")



G_cl_test_10_label_p = G_model_10_percent.predict(test_images)
G_clean_test_10_accuracy = np.mean(np.equal(G_cl_test_10_label_p,␣
    ↪test_labels))*100
print('Combined 10% drops model, the clean test data Classification accuracy:',␣
    ↪G_clean_test_10_accuracy)

G_bd_test_10_label_p = G_model_10_percent.predict(test_poisoned_images)
G_asr_10 = np.mean(np.equal(G_bd_test_10_label_p, test_poisoned_labels))*100
print('Combined 10% drops model, Attack Success Rate:', G_asr_10)
```

```
 Performance of GoodNet Models:

Combined 2% drops model, the clean test data Classification accuracy:
95.74434918160561
Combined 2% drops model, Attack Success Rate: 100.0
--------------------------------------------------


Combined 4% drops model, the clean test data Classification accuracy:
92.1278254091972
Combined 4% drops model, Attack Success Rate: 99.98441153546376
--------------------------------------------------


Combined 10% drops model, the clean test data Classification accuracy:
84.3335931410756
Combined 10% drops model, Attack Success Rate: 77.20966484801247
```

[16]:
```
import matplotlib.pyplot as plt
import pandas as pd
import seaborn as sns
import numpy as np
```

```
def plot_performance(accuracy, attack_rates, model_labels, plot_title):
    # Using a seaborn style for the plot
    sns.set(style="whitegrid")

    # Creating DataFrame
    performance_data = {
        "Test Accuracy": accuracy,
        "Attack Success Rate": attack_rates,
        "Model": model_labels
    }
    df = pd.DataFrame(performance_data)
    df.set_index('Model', inplace=True)
    return df

    # Plotting
#     opacity = 0.7
#     bar_width = 0.35
#     plt.xlabel('Model')
#     plt.ylabel('Rate')
#     plt.xticks(range(len(accuracy)), model_labels)
#     colors = ['skyblue', 'lightcoral']
#     bar1 = plt.bar(np.arange(len(accuracy)) + bar_width, accuracy, bar_width,␣
↪alpha=opacity, color=colors[0], label='Accuracy')
#     bar2 = plt.bar(range(len(attack_rates)), attack_rates, bar_width,␣
↪alpha=opacity, color=colors[1], label='Attack Rate')


#     for rect in bar1 + bar2:
#         height = rect.get_height()
#         plt.text(rect.get_x() + rect.get_width() / 2.0, height, f'{height:.
↪02f}', ha='center', va='bottom')

#     plt.legend()
#     plt.title(plot_title)
#     plt.tight_layout()
#     plt.show()
```

[18]:

```
print("Repaired Models:")

original_test_acc = [clean_test_2_accuracy, clean_test_4_accuracy,␣
↪clean_test_10_accuracy]
original_attack_rate = [asr_2, asr_4, asr_10]
df_1 = plot_performance(original_test_acc, original_attack_rate, ["2%", "4%",␣
↪"10%"], 'Performance of Repaired Model')
```

```
df_1
```

```
Repaired Models:
```

[18]:

Model	Test Accuracy	Attack Success Rate
2%	95.900234	100.000000
4%	92.291504	99.984412
10%	84.544037	77.209665

[19]:

```
print("Combined Models:")
# GoodNet model performance
g_test_acc = [G_clean_test_2_accuracy, G_clean_test_4_accuracy,␣
 ↪G_clean_test_10_accuracy]
g_attack_rate = [G_asr_2, G_asr_4, G_asr_10]
df_2 = plot_performance(g_test_acc, g_attack_rate, ["G_2%", "G_4%", "G_10%"],␣
 ↪'Performance of GoodNet Model')




df_2
```

```
Combined Models:
```

[19]:

Model	Test Accuracy	Attack Success Rate
G_2%	95.744349	100.000000
G_4%	92.127825	99.984412
G_10%	84.333593	77.209665

[ ]: