In [13]:
```
#Import libraries
import pandas as pd
import tensorflow as tf
from sklearn.model_selection import train_test_split, GridSearchCV
from tensorflow import keras
from keras import optimizers
from keras.models import Sequential
from keras.layers import Dense
from keras.wrappers.scikit_learn import KerasClassifier
import numpy as np
from sklearn.metrics import classification_report,accuracy_score, precision_sc
ore, recall_score, confusion_matrix
import seaborn as sns
import matplotlib.pyplot as plt
```

In [41]:
```
#Data Preparation
data = pd.read_csv('dataframe.csv')
X = data.drop('feature_0', axis=1)  # Features
X=X.drop('Unnamed: 0',axis=1)
y = data['feature_0']  # Target

# Split the dataset into training and testing sets
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, rando
m_state=42)

print(X.shape)
print(y.shape)
print("Training set shape:", X_train.shape)
print("Testing set shape:", y_train.shape)
print(data.head())
```

```
(610, 70)
(610,)
Training set shape: (488, 70)
Testing set shape: (488,)
   Unnamed: 0  feature_0  feature_1  feature_2  feature_3  feature_4  \
0           0          1        0.0        0.0        1.0        0.0
1           1          0        0.0        0.0        1.0        0.0
2           2          1        0.0        0.0        1.0        0.0
3           3          1        0.0        0.0        1.0        0.0
4           4          0        0.0        0.0        1.0        0.0

   feature_5  feature_6  feature_7  feature_8  ...  feature_61  feature_62  \
0        0.0        1.0        0.0        1.0  ...         1.0         0.0
1        0.0        1.0        0.0        1.0  ...         1.0         0.0
2        0.0        1.0        0.0        1.0  ...         1.0         0.0
3        0.0        1.0        0.0        1.0  ...         1.0         0.0
4        0.0        1.0        0.0        1.0  ...         1.0         0.0

   feature_63  feature_64  feature_65  feature_66  feature_67  feature_68  \
0         1.0         0.0         0.0         0.0         0.0         0.0
1         1.0         0.0         0.0         0.0         0.0         0.0
2         1.0         0.0         0.0         0.0         0.0         0.0
3         1.0         0.0         0.0         0.0         0.0         0.0
4         1.0         0.0         0.0         0.0         0.0         0.0

   feature_69  feature_70
0         0.0         1.0
1         0.0         1.0
2         0.0         1.0
3         0.0         1.0
4         0.0         1.0

[5 rows x 72 columns]
```

In [42]:
```
#Optimization technique (GridSearchCV and KerasClassifier)
#Utilized the below GridSearchCV to find optimal layer values and lr
#used additional technicque from https://www.youtube.com/watch?v=lV0weESA0Sc&ab_channel=DigitalSreeni to assist this method
def create_model(learning_rate, neurons_per_layer):
    model = Sequential()
    model.add(Dense(neurons_per_layer, activation='relu', input_shape=(X_train.shape[1],)))
    model.add(Dense(neurons_per_layer/2, activation='relu'))
    model.add(Dense(1, activation='sigmoid'))  # Output layer
    model.compile(optimizer=optimizers.Adam(lr=learning_rate), loss='binary_crossentropy', metrics=['accuracy'])
    return model

model = KerasClassifier(build_fn=create_model, epochs=10, batch_size=64, verbose=0)

param_grid = {
    'learning_rate': [0.0001, 0.001, 0.01],
    'neurons_per_layer': [32, 64, 128],
}
grid = GridSearchCV(estimator=model, param_grid=param_grid, cv=3, scoring='accuracy')
grid_result = grid.fit(X_train, y_train)

# Summarize results
print("Best: %f using %s" % (grid_result.best_score_, grid_result.best_params_))
```

```
C:\Users\Soorya Suresh\Anaconda\lib\site-packages\tensorflow\python\keras\eng
ine\sequential.py:450: UserWarning: `model.predict_classes()` is deprecated a
nd will be removed after 2021-01-01. Please use instead:* `np.argmax(model.pr
edict(x), axis=-1)`,   if your model does multi-class classification   (e.g.
if it uses a `softmax` last-layer activation).* `(model.predict(x) > 0.5).ast
ype("int32")`,   if your model does binary classification   (e.g. if it uses
a `sigmoid` last-layer activation).
  warnings.warn('`model.predict_classes()` is deprecated and '

WARNING:tensorflow:5 out of the last 13 calls to <function Model.make_predict
_function.<locals>.predict_function at 0x000001D930CC8310> triggered tf.funct
ion retracing. Tracing is expensive and the excessive number of tracings coul
d be due to (1) creating @tf.function repeatedly in a loop, (2) passing tenso
rs with different shapes, (3) passing Python objects instead of tensors. For
(1), please define your @tf.function outside of the loop. For (2), @tf.functi
on has experimental_relax_shapes=True option that relaxes argument shapes tha
t can avoid unnecessary retracing. For (3), please refer to https://www.tenso
rflow.org/guide/function#controlling_retracing and https://www.tensorflow.or
g/api_docs/python/tf/function for  more details.

C:\Users\Soorya Suresh\Anaconda\lib\site-packages\tensorflow\python\keras\eng
ine\sequential.py:450: UserWarning: `model.predict_classes()` is deprecated a
nd will be removed after 2021-01-01. Please use instead:* `np.argmax(model.pr
edict(x), axis=-1)`,   if your model does multi-class classification   (e.g.
if it uses a `softmax` last-layer activation).* `(model.predict(x) > 0.5).ast
ype("int32")`,   if your model does binary classification   (e.g. if it uses
a `sigmoid` last-layer activation).
  warnings.warn('`model.predict_classes()` is deprecated and '

Best: 0.536822 using {'learning_rate': 0.01, 'neurons_per_layer': 64}
```

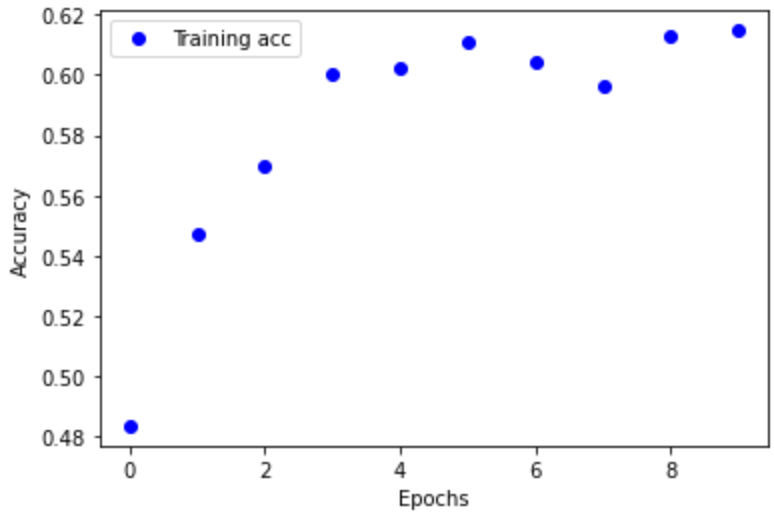
In [43]:

```
#Neural Network Model
model = Sequential([
    Dense(64, activation='relu', input_shape=(X_train.shape[1],)),
    Dense(32, activation='relu'),
    Dense(1, activation='sigmoid')#sigmoid in output layer for binary classifi
cation
])
```

In [44]:
```
#Training the Recommendation System
learning_rate=0.01
model.compile(optimizer=optimizers.Adam(lr=learning_rate), loss='binary_crosse
ntropy', metrics=['accuracy'])
history = model.fit(X_train, y_train, epochs=10, batch_size=64)
model.summary()
```

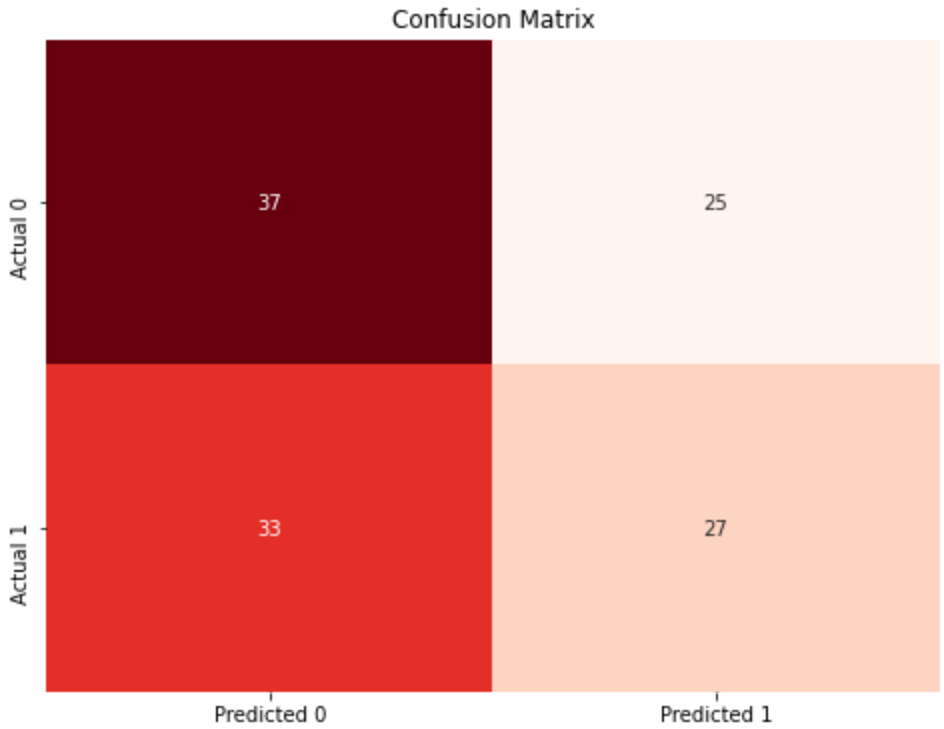
```
Epoch 1/10
8/8 [==============================] - 1s 2ms/step - loss: 0.7189 - accuracy:
0.4948
Epoch 2/10
8/8 [==============================] - 0s 2ms/step - loss: 0.6954 - accuracy:
0.5327
Epoch 3/10
8/8 [==============================] - 0s 3ms/step - loss: 0.6796 - accuracy:
0.5599
Epoch 4/10
8/8 [==============================] - 0s 2ms/step - loss: 0.6755 - accuracy:
0.5840
Epoch 5/10
8/8 [==============================] - 0s 2ms/step - loss: 0.6525 - accuracy:
0.6279
Epoch 6/10
8/8 [==============================] - 0s 3ms/step - loss: 0.6700 - accuracy:
0.5937
Epoch 7/10
8/8 [==============================] - 0s 3ms/step - loss: 0.6622 - accuracy:
0.6068
Epoch 8/10
8/8 [==============================] - 0s 3ms/step - loss: 0.6594 - accuracy:
0.5887
Epoch 9/10
8/8 [==============================] - 0s 3ms/step - loss: 0.6550 - accuracy:
0.6306
Epoch 10/10
8/8 [==============================] - 0s 2ms/step - loss: 0.6468 - accuracy:
0.6318
Model: "sequential_245"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
dense_735 (Dense)            (None, 64)                4544
_________________________________________________________________
dense_736 (Dense)            (None, 32)                2080
_________________________________________________________________
dense_737 (Dense)            (None, 1)                 33
=================================================================
Total params: 6,657
Trainable params: 6,657
Non-trainable params: 0
_________________________________________________________________
```

In [45]:
```
%matplotlib inline

acc = history.history['accuracy']

epochs = range(len(acc))

plt.plot(epochs, acc, 'bo', label='Training acc')
plt.xlabel('Epochs')
plt.ylabel('Accuracy')
plt.legend()
plt.show()
```



In [46]:
```
#Evaluation
y_pred=model.predict_classes(X_test)
print(classification_report(y_test,y_pred))
cm = confusion_matrix(y_test, y_pred)

plt.figure(figsize=(8, 6))
sns.heatmap(cm, annot=True, fmt='d', cmap='Reds', cbar=False,
            xticklabels=['Predicted 0', 'Predicted 1'],
            yticklabels=['Actual 0', 'Actual 1'])
plt.title('Confusion Matrix')
plt.show()

accuracy = accuracy_score(y_test, y_pred)
print(f"Accuracy: {accuracy * 100:.2f}%")
```

```
C:\Users\Soorya Suresh\Anaconda\lib\site-packages\tensorflow\python\keras\eng
ine\sequential.py:450: UserWarning: `model.predict_classes()` is deprecated a
nd will be removed after 2021-01-01. Please use instead:* `np.argmax(model.pr
edict(x), axis=-1)`,   if your model does multi-class classification   (e.g.
if it uses a `softmax` last-layer activation).* `(model.predict(x) > 0.5).ast
ype("int32")`,   if your model does binary classification   (e.g. if it uses
a `sigmoid` last-layer activation).
  warnings.warn('`model.predict_classes()` is deprecated and '

WARNING:tensorflow:5 out of the last 13 calls to <function Model.make_predict
_function.<locals>.predict_function at 0x000001D92E496C10> triggered tf.funct
ion retracing. Tracing is expensive and the excessive number of tracings coul
d be due to (1) creating @tf.function repeatedly in a loop, (2) passing tenso
rs with different shapes, (3) passing Python objects instead of tensors. For
(1), please define your @tf.function outside of the loop. For (2), @tf.functi
on has experimental_relax_shapes=True option that relaxes argument shapes tha
t can avoid unnecessary retracing. For (3), please refer to https://www.tenso
rflow.org/guide/function#controlling_retracing and https://www.tensorflow.or
g/api_docs/python/tf/function for  more details.
              precision    recall  f1-score   support

           0       0.53      0.60      0.56        62
           1       0.52      0.45      0.48        60

    accuracy                           0.52       122
   macro avg       0.52      0.52      0.52       122
weighted avg       0.52      0.52      0.52       122
```




```
Accuracy: 52.46%
```

In [67]:
```
#Random Data Comparison

random_dataset = np.random.randint(0, 2, size=(610,71))
new_data = pd.DataFrame(random_dataset)

X1 = new_data.drop(new_data.columns[0], axis=1)
y1 = new_data[0]

X_train1, X_test1, y_train1, y_test1 = train_test_split(X1, y1, test_size=0.2,
random_state=42)
print(X1.shape)
print(y1.shape)
print(new_data.shape)
print("Training set shape:", X_train1.shape)
print("Testing set shape:", y_train1.shape)
print(new_data.head())
```

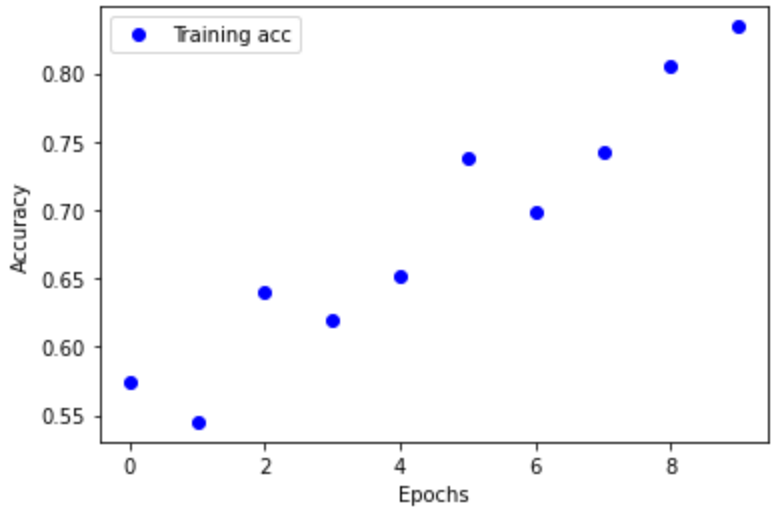
```
(610, 70)
(610,)
(610, 71)
Training set shape: (488, 70)
Testing set shape: (488,)
   0   1   2   3   4   5   6   7   8   9   ...  61  62  63  64  65  66  67  \
0   0   1   1   0   0   1   1   1   1   1  ...   0   0   1   1   0   1   1
1   1   0   0   1   0   1   1   0   0   0  ...   1   1   1   1   0   0   0
2   1   0   0   1   0   1   0   0   1   0  ...   0   1   1   1   0   1   0
3   0   1   1   0   1   0   0   1   0   1  ...   0   0   1   1   0   0   0
4   0   1   0   0   0   1   1   0   1   0  ...   0   0   0   1   0   0   0

   68  69  70
0   0   1   1
1   0   1   1
2   1   0   1
3   0   1   1
4   0   1   1

[5 rows x 71 columns]
```

In [68]:
```
model_new = Sequential([
    Dense(64, activation='relu', input_shape=(X_train1.shape[1],)),
    Dense(32, activation='relu'),
    Dense(1, activation='sigmoid')
])
```

In [69]:
```
learning_rate=0.01
model_new.compile(optimizer=optimizers.Adam(lr=learning_rate), loss='binary_cr
ossentropy', metrics=['accuracy'])
history1 = model_new.fit(X_train1, y_train1, epochs=10, batch_size=64)
model_new.summary()
```

```
Epoch 1/10
8/8 [==============================] - 1s 1ms/step - loss: 0.7037 - accuracy:
0.5850
Epoch 2/10
8/8 [==============================] - 0s 2ms/step - loss: 0.6897 - accuracy:
0.5199
Epoch 3/10
8/8 [==============================] - 0s 3ms/step - loss: 0.6350 - accuracy:
0.6642
Epoch 4/10
8/8 [==============================] - 0s 2ms/step - loss: 0.6357 - accuracy:
0.6286
Epoch 5/10
8/8 [==============================] - 0s 2ms/step - loss: 0.6016 - accuracy:
0.6715
Epoch 6/10
8/8 [==============================] - 0s 2ms/step - loss: 0.5740 - accuracy:
0.7412
Epoch 7/10
8/8 [==============================] - 0s 2ms/step - loss: 0.5476 - accuracy:
0.7228
Epoch 8/10
8/8 [==============================] - 0s 2ms/step - loss: 0.5276 - accuracy:
0.7551
Epoch 9/10
8/8 [==============================] - 0s 2ms/step - loss: 0.4999 - accuracy:
0.7847
Epoch 10/10
8/8 [==============================] - 0s 2ms/step - loss: 0.4275 - accuracy:
0.8277
Model: "sequential_250"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
dense_750 (Dense)            (None, 64)                4544
_________________________________________________________________
dense_751 (Dense)            (None, 32)                2080
_________________________________________________________________
dense_752 (Dense)            (None, 1)                 33
=================================================================
Total params: 6,657
Trainable params: 6,657
Non-trainable params: 0
_________________________________________________________________
```

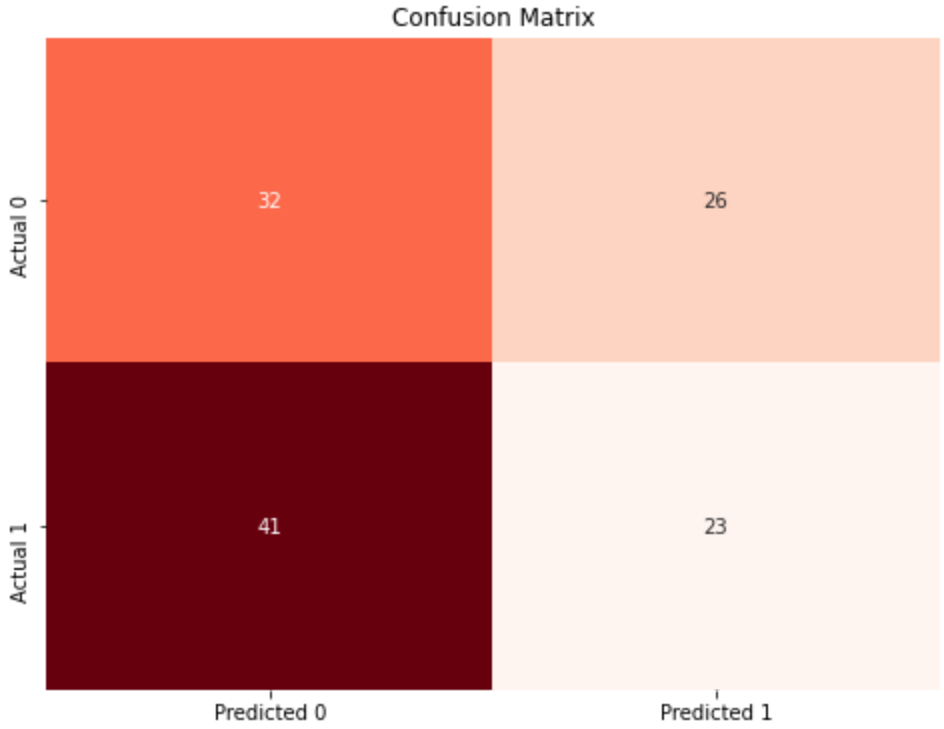
In [70]:
```
%matplotlib inline

acc = history1.history['accuracy']

epochs = range(len(acc))

plt.plot(epochs, acc, 'bo', label='Training acc')
plt.xlabel('Epochs')
plt.ylabel('Accuracy')
plt.legend()
plt.show()
```



In [71]:
```
y_pred_new=model_new.predict_classes(X_test1)
print(classification_report(y_test1,y_pred_new))
cm = confusion_matrix(y_test1, y_pred_new)

plt.figure(figsize=(8, 6))
sns.heatmap(cm, annot=True, fmt='d', cmap='Reds', cbar=False,
            xticklabels=['Predicted 0', 'Predicted 1'],
            yticklabels=['Actual 0', 'Actual 1'])
plt.title('Confusion Matrix')
plt.show()

accuracy = accuracy_score(y_test1, y_pred_new)
print(f"Accuracy: {accuracy * 100:.2f}%")
model_new.summary()
```

	precision	recall	f1-score	support
0	0.44	0.55	0.49	58
1	0.47	0.36	0.41	64
accuracy			0.45	122
macro avg	0.45	0.46	0.45	122
weighted avg	0.45	0.45	0.45	122

```
C:\Users\Soorya Suresh\Anaconda\lib\site-packages\tensorflow\python\keras\eng
ine\sequential.py:450: UserWarning: `model.predict_classes()` is deprecated a
nd will be removed after 2021-01-01. Please use instead:* `np.argmax(model.pr
edict(x), axis=-1)`,   if your model does multi-class classification   (e.g.
if it uses a `softmax` last-layer activation).* `(model.predict(x) > 0.5).ast
ype("int32")`,   if your model does binary classification   (e.g. if it uses
a `sigmoid` last-layer activation).
  warnings.warn('`model.predict_classes()` is deprecated and '
```




```
Accuracy: 45.08%
Model: "sequential_250"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
dense_750 (Dense)            (None, 64)                4544
_________________________________________________________________
dense_751 (Dense)            (None, 32)                2080
_________________________________________________________________
dense_752 (Dense)            (None, 1)                 33
=================================================================
Total params: 6,657
Trainable params: 6,657
Non-trainable params: 0
_________________________________________________________________
```

From comparing the performance metrics obtained from training the real data vs. random data is that the random data returned lower accuracy scores. This is probably because the real data must have patterns and more of a trend compared to a randomly generated data. Refer to the report for more analysis.