In [1]:
```
"""
Description: This program replicates the practice given at the following URL: https://github.com/josephlee94/intuitive-deep-learning
The program will implement a neural network in order to predict house prices based on a given CSV dataset.

Name: Andrea Marcelli
"""
import pandas as pd

# Importing the spreadsheet with the data into a data frame through pandas
df = pd.read_csv('housepricedata.csv')
# Display the dataframe
df
```

Out[1]:

	LotArea	OverallQual	OverallCond	TotalBsmtSF	FullBath	HalfBath	BedroomAbvGr	TotRmsAbvGrd	Fireplaces	GarageArea	AboveMedianPrice
0	8450	7	5	856	2	1	3	8	0	548	1
1	9600	6	8	1262	2	0	3	6	1	460	1
2	11250	7	5	920	2	1	3	6	1	608	1
3	9550	7	5	756	1	0	3	7	1	642	0
4	14260	8	5	1145	2	1	4	9	1	836	1
...	...	...	...	...	...	...	...	...	...	...	...
1455	7917	6	5	953	2	1	3	7	1	460	1
1456	13175	6	6	1542	2	0	3	7	2	500	1
1457	9042	7	9	1152	2	0	4	9	2	252	1
1458	9717	5	6	1078	1	0	2	5	0	240	0
1459	9937	5	6	1256	1	1	3	6	0	276	0

1460 rows × 11 columns

In [2]:
```
# Converting the data frame into an array
dataset = df.values
# Display the array values
dataset
```

Out[2]:
```
array([[ 8450,     7,     5, ...,     0,   548,     1],
       [ 9600,     6,     8, ...,     1,   460,     1],
       [11250,     7,     5, ...,     1,   608,     1],
       ...,
       [ 9042,     7,     9, ...,     2,   252,     1],
       [ 9717,     5,     6, ...,     0,   240,     0],
       [ 9937,     5,     6, ...,     0,   276,     0]], dtype=int64)
```

In [3]:
```
# Splitting the dataset into input features and label to predict
X = dataset[:,0:10]
Y = dataset[:,10]

from sklearn import preprocessing

# Normalizing data to be inside the range between 0 and 1
min_max_scaler = preprocessing.MinMaxScaler()
X_scale = min_max_scaler.fit_transform(X)

X_scale
```

Out[3]:
```
array([[0.0334198 , 0.66666667, 0.5       , ..., 0.5       , 0.        ,
        0.3864598 ],
       [0.03879502, 0.55555556, 0.875     , ..., 0.33333333, 0.33333333,
        0.32440056],
       [0.04650728, 0.66666667, 0.5       , ..., 0.33333333, 0.33333333,
        0.42877292],
       ...,
       [0.03618687, 0.66666667, 1.        , ..., 0.58333333, 0.66666667,
        0.17771509],
       [0.03934189, 0.44444444, 0.625     , ..., 0.25      , 0.        ,
        0.16925247],
       [0.04037019, 0.44444444, 0.625     , ..., 0.33333333, 0.        ,
        0.19464034]])
```

In [5]:
```
from sklearn.model_selection import train_test_split

X_train, X_val_and_test, Y_train, Y_val_and_test = train_test_split(X_scale, Y, test_size=0.3)
X_val, X_test, Y_val, Y_test = train_test_split(X_val_and_test, Y_val_and_test, test_size=0.5)
print(X_train.shape, X_val.shape, X_test.shape, Y_train.shape, Y_val.shape, Y_test.shape)
```

```
(1022, 10) (219, 10) (219, 10) (1022,) (219,) (219,)
```

In [7]:
```
# Creating and Training the Neural Network
from keras.models import Sequential
from keras.layers import Dense

# Creating the first model with three layers, two hidden layers, and one output layer
model = Sequential([
    Dense(32, activation='relu', input_shape=(10,)),
    Dense(32, activation='relu'),
    Dense(1, activation='sigmoid'),
])

# Configuring the model by selecting algorithm to use, loss function, and metrics to track
model.compile(optimizer='sgd', loss='binary_crossentropy', metrics=['accuracy'])

# Storing the history of the data
hist = model.fit(X_train, Y_train, batch_size=32, epochs=100, validation_data=(X_val, Y_val))
```

```
Epoch 1/100
32/32 [==============================] - 1s 7ms/step - loss: 0.6907 - accuracy: 0.5078 - val_loss: 0.6891 - val_accuracy: 0.4886
Epoch 2/100
32/32 [==============================] - 0s 2ms/step - loss: 0.6856 - accuracy: 0.5205 - val_loss: 0.6849 - val_accuracy: 0.4840
Epoch 3/100
32/32 [==============================] - 0s 2ms/step - loss: 0.6809 - accuracy: 0.5147 - val_loss: 0.6809 - val_accuracy: 0.4840
Epoch 4/100
32/32 [==============================] - 0s 2ms/step - loss: 0.6766 - accuracy: 0.5166 - val_loss: 0.6771 - val_accuracy: 0.4840
Epoch 5/100
32/32 [==============================] - 0s 2ms/step - loss: 0.6727 - accuracy: 0.5176 - val_loss: 0.6735 - val_accuracy: 0.4886
Epoch 6/100
32/32 [==============================] - 0s 1ms/step - loss: 0.6690 - accuracy: 0.5215 - val_loss: 0.6699 - val_accuracy: 0.5023
Epoch 7/100
32/32 [==============================] - 0s 2ms/step - loss: 0.6653 - accuracy: 0.5372 - val_loss: 0.6664 - val_accuracy: 0.5114
Epoch 8/100
32/32 [==============================] - 0s 2ms/step - loss: 0.6614 - accuracy: 0.5450 - val_loss: 0.6627 - val_accuracy: 0.5160
Epoch 9/100
32/32 [==============================] - 0s 1ms/step - loss: 0.6574 - accuracy: 0.5665 - val_loss: 0.6587 - val_accuracy: 0.5434
Epoch 10/100
32/32 [==============================] - 0s 2ms/step - loss: 0.6534 - accuracy: 0.5783 - val_loss: 0.6544 - val_accuracy: 0.6027
Epoch 11/100
32/32 [==============================] - 0s 2ms/step - loss: 0.6491 - accuracy: 0.6282 - val_loss: 0.6501 - val_accuracy: 0.6210
Epoch 12/100
32/32 [==============================] - 0s 2ms/step - loss: 0.6445 - accuracy: 0.6791 - val_loss: 0.6457 - val_accuracy: 0.6484
Epoch 13/100
32/32 [==============================] - 0s 2ms/step - loss: 0.6398 - accuracy: 0.7094 - val_loss: 0.6410 - val_accuracy: 0.6621
Epoch 14/100
32/32 [==============================] - 0s 2ms/step - loss: 0.6348 - accuracy: 0.7211 - val_loss: 0.6358 - val_accuracy: 0.6895
Epoch 15/100
32/32 [==============================] - 0s 1ms/step - loss: 0.6296 - accuracy: 0.7485 - val_loss: 0.6304 - val_accuracy: 0.7169
Epoch 16/100
32/32 [==============================] - 0s 2ms/step - loss: 0.6241 - accuracy: 0.7671 - val_loss: 0.6247 - val_accuracy: 0.7397
Epoch 17/100
32/32 [==============================] - 0s 2ms/step - loss: 0.6182 - accuracy: 0.7838 - val_loss: 0.6187 - val_accuracy: 0.7397
Epoch 18/100
32/32 [==============================] - 0s 2ms/step - loss: 0.6122 - accuracy: 0.7926 - val_loss: 0.6124 - val_accuracy: 0.7489
Epoch 19/100
32/32 [==============================] - 0s 2ms/step - loss: 0.6056 - accuracy: 0.8004 - val_loss: 0.6057 - val_accuracy: 0.7626
Epoch 20/100
32/32 [==============================] - 0s 2ms/step - loss: 0.5987 - accuracy: 0.8053 - val_loss: 0.5987 - val_accuracy: 0.7626
Epoch 21/100
32/32 [==============================] - 0s 2ms/step - loss: 0.5918 - accuracy: 0.8053 - val_loss: 0.5914 - val_accuracy: 0.7854
Epoch 22/100
32/32 [==============================] - 0s 2ms/step - loss: 0.5842 - accuracy: 0.8160 - val_loss: 0.5840 - val_accuracy: 0.7854
Epoch 23/100
32/32 [==============================] - 0s 1ms/step - loss: 0.5761 - accuracy: 0.8180 - val_loss: 0.5757 - val_accuracy: 0.8037
Epoch 24/100
32/32 [==============================] - 0s 2ms/step - loss: 0.5681 - accuracy: 0.8209 - val_loss: 0.5676 - val_accuracy: 0.8082
Epoch 25/100
32/32 [==============================] - 0s 1ms/step - loss: 0.5596 - accuracy: 0.8278 - val_loss: 0.5591 - val_accuracy: 0.8128
Epoch 26/100
32/32 [==============================] - 0s 1ms/step - loss: 0.5509 - accuracy: 0.8307 - val_loss: 0.5501 - val_accuracy: 0.8311
Epoch 27/100
32/32 [==============================] - 0s 2ms/step - loss: 0.5421 - accuracy: 0.8297 - val_loss: 0.5410 - val_accuracy: 0.8311
Epoch 28/100
32/32 [==============================] - 0s 1ms/step - loss: 0.5332 - accuracy: 0.8366 - val_loss: 0.5318 - val_accuracy: 0.8311
Epoch 29/100
32/32 [==============================] - 0s 1ms/step - loss: 0.5241 - accuracy: 0.8356 - val_loss: 0.5227 - val_accuracy: 0.8311
Epoch 30/100
32/32 [==============================] - 0s 2ms/step - loss: 0.5146 - accuracy: 0.8425 - val_loss: 0.5142 - val_accuracy: 0.8311
Epoch 31/100
32/32 [==============================] - 0s 2ms/step - loss: 0.5056 - accuracy: 0.8395 - val_loss: 0.5039 - val_accuracy: 0.8493
Epoch 32/100
32/32 [==============================] - 0s 1ms/step - loss: 0.4964 - accuracy: 0.8454 - val_loss: 0.4945 - val_accuracy: 0.8539
Epoch 33/100
32/32 [==============================] - 0s 1ms/step - loss: 0.4871 - accuracy: 0.8474 - val_loss: 0.4848 - val_accuracy: 0.8721
Epoch 34/100
32/32 [==============================] - 0s 2ms/step - loss: 0.4781 - accuracy: 0.8513 - val_loss: 0.4762 - val_accuracy: 0.8721
Epoch 35/100
32/32 [==============================] - 0s 1ms/step - loss: 0.4693 - accuracy: 0.8513 - val_loss: 0.4663 - val_accuracy: 0.8721
Epoch 36/100
32/32 [==============================] - 0s 2ms/step - loss: 0.4604 - accuracy: 0.8562 - val_loss: 0.4573 - val_accuracy: 0.8721
Epoch 37/100
32/32 [==============================] - 0s 1ms/step - loss: 0.4519 - accuracy: 0.8532 - val_loss: 0.4482 - val_accuracy: 0.8676
Epoch 38/100
32/32 [==============================] - 0s 1ms/step - loss: 0.4436 - accuracy: 0.8542 - val_loss: 0.4391 - val_accuracy: 0.8767
Epoch 39/100
```

```
32/32 [==============================] - 0s 1ms/step - loss: 0.4356 - accuracy: 0.8571 - val_loss: 0.4305 - val_accuracy: 0.8950
Epoch 40/100
32/32 [==============================] - 0s 1ms/step - loss: 0.4280 - accuracy: 0.8620 - val_loss: 0.4229 - val_accuracy: 0.8767
Epoch 41/100
32/32 [==============================] - 0s 1ms/step - loss: 0.4202 - accuracy: 0.8611 - val_loss: 0.4145 - val_accuracy: 0.8950
Epoch 42/100
32/32 [==============================] - 0s 1ms/step - loss: 0.4130 - accuracy: 0.8591 - val_loss: 0.4062 - val_accuracy: 0.8950
Epoch 43/100
32/32 [==============================] - 0s 1ms/step - loss: 0.4060 - accuracy: 0.8679 - val_loss: 0.4005 - val_accuracy: 0.8813
Epoch 44/100
32/32 [==============================] - 0s 1ms/step - loss: 0.3995 - accuracy: 0.8659 - val_loss: 0.3917 - val_accuracy: 0.8950
Epoch 45/100
32/32 [==============================] - 0s 1ms/step - loss: 0.3931 - accuracy: 0.8659 - val_loss: 0.3851 - val_accuracy: 0.8950
Epoch 46/100
32/32 [==============================] - 0s 2ms/step - loss: 0.3871 - accuracy: 0.8689 - val_loss: 0.3790 - val_accuracy: 0.8904
Epoch 47/100
32/32 [==============================] - 0s 1ms/step - loss: 0.3816 - accuracy: 0.8699 - val_loss: 0.3725 - val_accuracy: 0.8904
Epoch 48/100
32/32 [==============================] - 0s 1ms/step - loss: 0.3757 - accuracy: 0.8669 - val_loss: 0.3666 - val_accuracy: 0.8904
Epoch 49/100
32/32 [==============================] - 0s 1ms/step - loss: 0.3709 - accuracy: 0.8699 - val_loss: 0.3609 - val_accuracy: 0.8904
Epoch 50/100
32/32 [==============================] - 0s 1ms/step - loss: 0.3658 - accuracy: 0.8699 - val_loss: 0.3554 - val_accuracy: 0.8904
Epoch 51/100
32/32 [==============================] - 0s 1ms/step - loss: 0.3616 - accuracy: 0.8689 - val_loss: 0.3491 - val_accuracy: 0.8950
Epoch 52/100
32/32 [==============================] - 0s 2ms/step - loss: 0.3574 - accuracy: 0.8669 - val_loss: 0.3435 - val_accuracy: 0.8950
Epoch 53/100
32/32 [==============================] - 0s 2ms/step - loss: 0.3537 - accuracy: 0.8659 - val_loss: 0.3405 - val_accuracy: 0.8904
Epoch 54/100
32/32 [==============================] - 0s 2ms/step - loss: 0.3488 - accuracy: 0.8689 - val_loss: 0.3380 - val_accuracy: 0.8904
Epoch 55/100
32/32 [==============================] - 0s 2ms/step - loss: 0.3459 - accuracy: 0.8669 - val_loss: 0.3308 - val_accuracy: 0.8950
Epoch 56/100
32/32 [==============================] - 0s 2ms/step - loss: 0.3418 - accuracy: 0.8728 - val_loss: 0.3272 - val_accuracy: 0.8950
Epoch 57/100
32/32 [==============================] - 0s 1ms/step - loss: 0.3388 - accuracy: 0.8689 - val_loss: 0.3234 - val_accuracy: 0.8950
Epoch 58/100
32/32 [==============================] - 0s 1ms/step - loss: 0.3353 - accuracy: 0.8708 - val_loss: 0.3187 - val_accuracy: 0.8950
Epoch 59/100
32/32 [==============================] - 0s 1ms/step - loss: 0.3326 - accuracy: 0.8718 - val_loss: 0.3181 - val_accuracy: 0.8904
Epoch 60/100
32/32 [==============================] - 0s 1ms/step - loss: 0.3304 - accuracy: 0.8748 - val_loss: 0.3130 - val_accuracy: 0.8950
Epoch 61/100
32/32 [==============================] - 0s 1ms/step - loss: 0.3273 - accuracy: 0.8757 - val_loss: 0.3096 - val_accuracy: 0.8950
Epoch 62/100
32/32 [==============================] - 0s 1ms/step - loss: 0.3250 - accuracy: 0.8669 - val_loss: 0.3049 - val_accuracy: 0.8995
Epoch 63/100
32/32 [==============================] - 0s 1ms/step - loss: 0.3224 - accuracy: 0.8718 - val_loss: 0.3013 - val_accuracy: 0.9041
Epoch 64/100
32/32 [==============================] - 0s 1ms/step - loss: 0.3206 - accuracy: 0.8748 - val_loss: 0.3015 - val_accuracy: 0.8995
Epoch 65/100
32/32 [==============================] - 0s 2ms/step - loss: 0.3183 - accuracy: 0.8728 - val_loss: 0.2992 - val_accuracy: 0.8995
Epoch 66/100
32/32 [==============================] - 0s 1ms/step - loss: 0.3162 - accuracy: 0.8748 - val_loss: 0.2942 - val_accuracy: 0.8995
Epoch 67/100
32/32 [==============================] - 0s 1ms/step - loss: 0.3142 - accuracy: 0.8748 - val_loss: 0.2974 - val_accuracy: 0.8904
Epoch 68/100
32/32 [==============================] - 0s 1ms/step - loss: 0.3122 - accuracy: 0.8787 - val_loss: 0.2912 - val_accuracy: 0.8995
Epoch 69/100
32/32 [==============================] - 0s 1ms/step - loss: 0.3105 - accuracy: 0.8767 - val_loss: 0.2896 - val_accuracy: 0.8995
Epoch 70/100
32/32 [==============================] - 0s 1ms/step - loss: 0.3086 - accuracy: 0.8738 - val_loss: 0.2884 - val_accuracy: 0.8950
Epoch 71/100
32/32 [==============================] - 0s 1ms/step - loss: 0.3069 - accuracy: 0.8787 - val_loss: 0.2841 - val_accuracy: 0.8995
Epoch 72/100
32/32 [==============================] - 0s 1ms/step - loss: 0.3051 - accuracy: 0.8796 - val_loss: 0.2822 - val_accuracy: 0.8995
Epoch 73/100
32/32 [==============================] - 0s 1ms/step - loss: 0.3038 - accuracy: 0.8728 - val_loss: 0.2802 - val_accuracy: 0.9041
Epoch 74/100
32/32 [==============================] - 0s 1ms/step - loss: 0.3016 - accuracy: 0.8806 - val_loss: 0.2817 - val_accuracy: 0.8950
Epoch 75/100
32/32 [==============================] - 0s 1ms/step - loss: 0.3009 - accuracy: 0.8777 - val_loss: 0.2791 - val_accuracy: 0.8950
Epoch 76/100
32/32 [==============================] - 0s 1ms/step - loss: 0.2992 - accuracy: 0.8787 - val_loss: 0.2797 - val_accuracy: 0.8950
```



```
32/32 [==============================] - 0s 2ms/step - loss: 0.2977 - accuracy: 0.8816 - val_loss: 0.2750 - val_accuracy: 0.8995
```

```
Epoch 78/100
32/32 [==============================] - 0s 1ms/step - loss: 0.2961 - accuracy: 0.8767 - val_loss: 0.2714 - val_accuracy: 0.9087
Epoch 79/100
32/32 [==============================] - 0s 1ms/step - loss: 0.2948 - accuracy: 0.8816 - val_loss: 0.2780 - val_accuracy: 0.8904
Epoch 80/100
32/32 [==============================] - 0s 2ms/step - loss: 0.2945 - accuracy: 0.8796 - val_loss: 0.2715 - val_accuracy: 0.8950
Epoch 81/100
32/32 [==============================] - 0s 1ms/step - loss: 0.2925 - accuracy: 0.8738 - val_loss: 0.2680 - val_accuracy: 0.9087
Epoch 82/100
32/32 [==============================] - 0s 2ms/step - loss: 0.2921 - accuracy: 0.8767 - val_loss: 0.2681 - val_accuracy: 0.9041
Epoch 83/100
32/32 [==============================] - 0s 1ms/step - loss: 0.2905 - accuracy: 0.8796 - val_loss: 0.2682 - val_accuracy: 0.8995
Epoch 84/100
32/32 [==============================] - 0s 2ms/step - loss: 0.2894 - accuracy: 0.8816 - val_loss: 0.2636 - val_accuracy: 0.9087
Epoch 85/100
32/32 [==============================] - 0s 2ms/step - loss: 0.2890 - accuracy: 0.8787 - val_loss: 0.2655 - val_accuracy: 0.8995
Epoch 86/100
32/32 [==============================] - 0s 1ms/step - loss: 0.2873 - accuracy: 0.8816 - val_loss: 0.2637 - val_accuracy: 0.8995
Epoch 87/100
32/32 [==============================] - 0s 1ms/step - loss: 0.2865 - accuracy: 0.8796 - val_loss: 0.2626 - val_accuracy: 0.8995
Epoch 88/100
32/32 [==============================] - 0s 1ms/step - loss: 0.2854 - accuracy: 0.8777 - val_loss: 0.2674 - val_accuracy: 0.8904
Epoch 89/100
32/32 [==============================] - 0s 1ms/step - loss: 0.2850 - accuracy: 0.8816 - val_loss: 0.2610 - val_accuracy: 0.8995
Epoch 90/100
32/32 [==============================] - 0s 1ms/step - loss: 0.2838 - accuracy: 0.8806 - val_loss: 0.2579 - val_accuracy: 0.9087
Epoch 91/100
32/32 [==============================] - 0s 1ms/step - loss: 0.2827 - accuracy: 0.8816 - val_loss: 0.2615 - val_accuracy: 0.8995
Epoch 92/100
32/32 [==============================] - 0s 2ms/step - loss: 0.2818 - accuracy: 0.8816 - val_loss: 0.2565 - val_accuracy: 0.9087
Epoch 93/100
32/32 [==============================] - 0s 1ms/step - loss: 0.2814 - accuracy: 0.8796 - val_loss: 0.2625 - val_accuracy: 0.8904
Epoch 94/100
32/32 [==============================] - 0s 2ms/step - loss: 0.2806 - accuracy: 0.8826 - val_loss: 0.2564 - val_accuracy: 0.8995
Epoch 95/100
32/32 [==============================] - 0s 1ms/step - loss: 0.2791 - accuracy: 0.8855 - val_loss: 0.2510 - val_accuracy: 0.9041
Epoch 96/100
32/32 [==============================] - 0s 1ms/step - loss: 0.2788 - accuracy: 0.8836 - val_loss: 0.2528 - val_accuracy: 0.9041
Epoch 97/100
32/32 [==============================] - 0s 1ms/step - loss: 0.2776 - accuracy: 0.8836 - val_loss: 0.2549 - val_accuracy: 0.8995
Epoch 98/100
32/32 [==============================] - 0s 2ms/step - loss: 0.2772 - accuracy: 0.8787 - val_loss: 0.2553 - val_accuracy: 0.8950
Epoch 99/100
32/32 [==============================] - 0s 2ms/step - loss: 0.2773 - accuracy: 0.8806 - val_loss: 0.2578 - val_accuracy: 0.8858
Epoch 100/100
32/32 [==============================] - 0s 2ms/step - loss: 0.2767 - accuracy: 0.8836 - val_loss: 0.2540 - val_accuracy: 0.8950
```

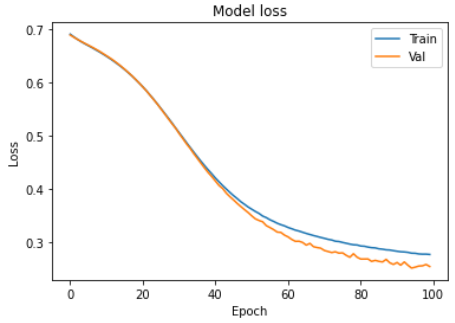
In [8]:
```
# Evalutating data
model.evaluate(X_test, Y_test)[1]
```

```
7/7 [==============================] - 0s 1ms/step - loss: 0.3133 - accuracy: 0.9041
```

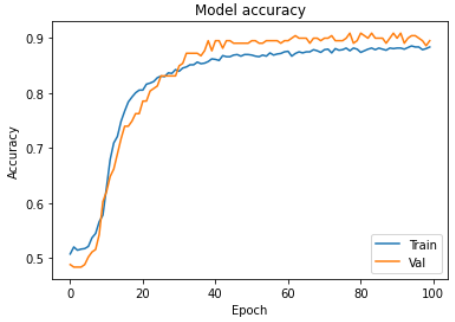
Out[8]:
```
0.9041095972061157
```

In [9]:
```
import matplotlib.pyplot as plt

# Creating a plot to visualize the training loss and validation loss
plt.plot(hist.history['loss'])
plt.plot(hist.history['val_loss'])
plt.title('Model loss')
plt.ylabel('Loss')
plt.xlabel('Epoch')
plt.legend(['Train', 'Val'], loc='upper right')
plt.show()
```



In [16]:
```
# Creating a plot to visualize training accuracy and the validation accuracy
plt.plot(hist.history['accuracy'])
plt.plot(hist.history['val_accuracy'])
plt.title('Model accuracy')
plt.ylabel('Accuracy')
plt.xlabel('Epoch')
plt.legend(['Train', 'Val'], loc='lower right')
plt.show()
```



In [19]:
```
# Creating a model that will overfit
model_2 = Sequential([
    Dense(1000, activation='relu', input_shape=(10,)),
    Dense(1000, activation='relu'),
    Dense(1000, activation='relu'),
    Dense(1000, activation='relu'),
    Dense(1, activation='sigmoid'),
])

model_2.compile(optimizer='adam',
                loss='binary_crossentropy',
                metrics=['accuracy'])
hist_2 = model_2.fit(X_train, Y_train, batch_size=32, epochs=100, validation_data=(X_val, Y_val))
```

```
Epoch 1/100
32/32 [==============================] - 2s 32ms/step - loss: 0.4619 - accuracy: 0.7759 - val_loss: 0.3142 - val_accuracy: 0.8584
Epoch 2/100
32/32 [==============================] - 1s 29ms/step - loss: 0.3326 - accuracy: 0.8571 - val_loss: 0.2837 - val_accuracy: 0.8813
Epoch 3/100
32/32 [==============================] - 1s 29ms/step - loss: 0.3113 - accuracy: 0.8718 - val_loss: 0.2740 - val_accuracy: 0.8995
Epoch 4/100
32/32 [==============================] - 1s 29ms/step - loss: 0.2996 - accuracy: 0.8796 - val_loss: 0.2461 - val_accuracy: 0.8995
Epoch 5/100
32/32 [==============================] - 1s 29ms/step - loss: 0.2777 - accuracy: 0.8933 - val_loss: 0.2324 - val_accuracy: 0.9178
Epoch 6/100
32/32 [==============================] - 1s 29ms/step - loss: 0.2471 - accuracy: 0.8953 - val_loss: 0.2527 - val_accuracy: 0.8813
Epoch 7/100
32/32 [==============================] - 1s 29ms/step - loss: 0.2724 - accuracy: 0.8816 - val_loss: 0.2654 - val_accuracy: 0.8813
Epoch 8/100
32/32 [==============================] - 1s 29ms/step - loss: 0.2606 - accuracy: 0.8914 - val_loss: 0.1972 - val_accuracy: 0.9224
Epoch 9/100
32/32 [==============================] - 1s 29ms/step - loss: 0.2379 - accuracy: 0.8973 - val_loss: 0.1911 - val_accuracy: 0.9452
Epoch 10/100
32/32 [==============================] - 1s 29ms/step - loss: 0.2317 - accuracy: 0.9031 - val_loss: 0.2177 - val_accuracy: 0.9041
Epoch 11/100
32/32 [==============================] - 1s 29ms/step - loss: 0.2225 - accuracy: 0.9041 - val_loss: 0.1814 - val_accuracy: 0.9269
Epoch 12/100
32/32 [==============================] - 1s 29ms/step - loss: 0.2252 - accuracy: 0.9012 - val_loss: 0.2287 - val_accuracy: 0.9178
Epoch 13/100
32/32 [==============================] - 1s 29ms/step - loss: 0.2460 - accuracy: 0.8914 - val_loss: 0.2279 - val_accuracy: 0.8950
Epoch 14/100
32/32 [==============================] - 1s 29ms/step - loss: 0.2378 - accuracy: 0.8992 - val_loss: 0.1968 - val_accuracy: 0.9224
Epoch 15/100
32/32 [==============================] - 1s 29ms/step - loss: 0.2242 - accuracy: 0.9100 - val_loss: 0.1965 - val_accuracy: 0.9269
Epoch 16/100
32/32 [==============================] - 1s 29ms/step - loss: 0.2123 - accuracy: 0.9139 - val_loss: 0.1939 - val_accuracy: 0.9178
Epoch 17/100
32/32 [==============================] - 1s 29ms/step - loss: 0.2021 - accuracy: 0.9129 - val_loss: 0.1979 - val_accuracy: 0.9224
Epoch 18/100
32/32 [==============================] - 1s 29ms/step - loss: 0.2358 - accuracy: 0.8924 - val_loss: 0.2589 - val_accuracy: 0.8995
Epoch 19/100
32/32 [==============================] - 1s 29ms/step - loss: 0.2147 - accuracy: 0.8982 - val_loss: 0.2200 - val_accuracy: 0.8995
Epoch 20/100
32/32 [==============================] - 1s 29ms/step - loss: 0.2139 - accuracy: 0.9119 - val_loss: 0.1765 - val_accuracy: 0.9361
Epoch 21/100
32/32 [==============================] - 1s 29ms/step - loss: 0.2073 - accuracy: 0.9159 - val_loss: 0.1816 - val_accuracy: 0.9269
Epoch 22/100
32/32 [==============================] - 1s 29ms/step - loss: 0.2062 - accuracy: 0.9159 - val_loss: 0.1845 - val_accuracy: 0.9315
Epoch 23/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1960 - accuracy: 0.9159 - val_loss: 0.1927 - val_accuracy: 0.9178
Epoch 24/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1979 - accuracy: 0.9188 - val_loss: 0.1787 - val_accuracy: 0.9224
Epoch 25/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1940 - accuracy: 0.9188 - val_loss: 0.1938 - val_accuracy: 0.9361
Epoch 26/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1886 - accuracy: 0.9217 - val_loss: 0.2246 - val_accuracy: 0.9041
Epoch 27/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1855 - accuracy: 0.9149 - val_loss: 0.2104 - val_accuracy: 0.9315
Epoch 28/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1910 - accuracy: 0.9188 - val_loss: 0.2183 - val_accuracy: 0.9041
Epoch 29/100
32/32 [==============================] - 1s 29ms/step - loss: 0.2163 - accuracy: 0.9129 - val_loss: 0.2115 - val_accuracy: 0.9132
Epoch 30/100
32/32 [==============================] - 1s 29ms/step - loss: 0.2051 - accuracy: 0.9178 - val_loss: 0.1830 - val_accuracy: 0.9406
Epoch 31/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1865 - accuracy: 0.9198 - val_loss: 0.1906 - val_accuracy: 0.9315
Epoch 32/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1846 - accuracy: 0.9178 - val_loss: 0.2195 - val_accuracy: 0.9224
Epoch 33/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1975 - accuracy: 0.9129 - val_loss: 0.2118 - val_accuracy: 0.9132
Epoch 34/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1770 - accuracy: 0.9178 - val_loss: 0.2061 - val_accuracy: 0.8995
Epoch 35/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1849 - accuracy: 0.9237 - val_loss: 0.1856 - val_accuracy: 0.9315
Epoch 36/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1652 - accuracy: 0.9315 - val_loss: 0.2140 - val_accuracy: 0.9178
Epoch 37/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1735 - accuracy: 0.9295 - val_loss: 0.2160 - val_accuracy: 0.9315
Epoch 38/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1863 - accuracy: 0.9159 - val_loss: 0.1967 - val_accuracy: 0.9224
Epoch 39/100
```

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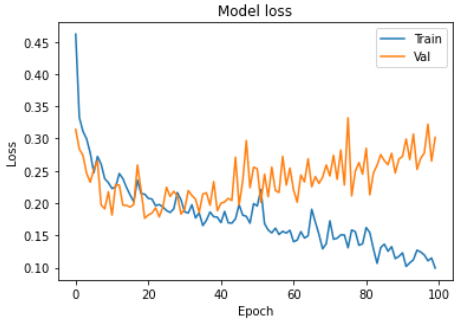
32/32 [==============================] - 1s 29ms/step - loss: 0.1790 - accuracy: 0.9286 - val_loss: 0.2333 - val_accuracy: 0.9041
Epoch 40/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1783 - accuracy: 0.9286 - val_loss: 0.1883 - val_accuracy: 0.9361
Epoch 41/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1697 - accuracy: 0.9295 - val_loss: 0.1999 - val_accuracy: 0.9315
Epoch 42/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1872 - accuracy: 0.9335 - val_loss: 0.2018 - val_accuracy: 0.9269
Epoch 43/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1695 - accuracy: 0.9247 - val_loss: 0.2073 - val_accuracy: 0.9087
Epoch 44/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1689 - accuracy: 0.9305 - val_loss: 0.2040 - val_accuracy: 0.9132
Epoch 45/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1755 - accuracy: 0.9315 - val_loss: 0.2712 - val_accuracy: 0.8904
Epoch 46/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1977 - accuracy: 0.9080 - val_loss: 0.1969 - val_accuracy: 0.9361
Epoch 47/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1813 - accuracy: 0.9168 - val_loss: 0.2345 - val_accuracy: 0.9132
Epoch 48/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1794 - accuracy: 0.9198 - val_loss: 0.2968 - val_accuracy: 0.8995
Epoch 49/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1690 - accuracy: 0.9207 - val_loss: 0.2239 - val_accuracy: 0.9315
Epoch 50/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1994 - accuracy: 0.9168 - val_loss: 0.2558 - val_accuracy: 0.8950
Epoch 51/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1956 - accuracy: 0.9198 - val_loss: 0.2533 - val_accuracy: 0.9178
Epoch 52/100
32/32 [==============================] - 1s 29ms/step - loss: 0.2211 - accuracy: 0.9070 - val_loss: 0.2013 - val_accuracy: 0.9269
Epoch 53/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1682 - accuracy: 0.9315 - val_loss: 0.2449 - val_accuracy: 0.9361
Epoch 54/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1584 - accuracy: 0.9295 - val_loss: 0.2099 - val_accuracy: 0.9178
Epoch 55/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1539 - accuracy: 0.9344 - val_loss: 0.2558 - val_accuracy: 0.9132
Epoch 56/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1612 - accuracy: 0.9384 - val_loss: 0.2194 - val_accuracy: 0.9041
Epoch 57/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1514 - accuracy: 0.9423 - val_loss: 0.2166 - val_accuracy: 0.9178
Epoch 58/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1563 - accuracy: 0.9384 - val_loss: 0.2725 - val_accuracy: 0.9224
Epoch 59/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1536 - accuracy: 0.9413 - val_loss: 0.2280 - val_accuracy: 0.9178
Epoch 60/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1579 - accuracy: 0.9354 - val_loss: 0.2542 - val_accuracy: 0.9087
Epoch 61/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1401 - accuracy: 0.9462 - val_loss: 0.2205 - val_accuracy: 0.9132
Epoch 62/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1427 - accuracy: 0.9393 - val_loss: 0.2014 - val_accuracy: 0.9269
Epoch 63/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1558 - accuracy: 0.9384 - val_loss: 0.2436 - val_accuracy: 0.9041
Epoch 64/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1459 - accuracy: 0.9432 - val_loss: 0.2329 - val_accuracy: 0.9361
Epoch 65/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1493 - accuracy: 0.9374 - val_loss: 0.2688 - val_accuracy: 0.8904
Epoch 66/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1905 - accuracy: 0.9237 - val_loss: 0.2254 - val_accuracy: 0.9087
Epoch 67/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1706 - accuracy: 0.9266 - val_loss: 0.2411 - val_accuracy: 0.9087
Epoch 68/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1515 - accuracy: 0.9432 - val_loss: 0.2305 - val_accuracy: 0.9041
Epoch 69/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1291 - accuracy: 0.9491 - val_loss: 0.2402 - val_accuracy: 0.9269
Epoch 70/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1372 - accuracy: 0.9442 - val_loss: 0.2591 - val_accuracy: 0.9315
Epoch 71/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1726 - accuracy: 0.9256 - val_loss: 0.2421 - val_accuracy: 0.9132
Epoch 72/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1440 - accuracy: 0.9442 - val_loss: 0.2742 - val_accuracy: 0.9178
Epoch 73/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1456 - accuracy: 0.9384 - val_loss: 0.2368 - val_accuracy: 0.9361
Epoch 74/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1508 - accuracy: 0.9413 - val_loss: 0.2822 - val_accuracy: 0.8904
Epoch 75/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1506 - accuracy: 0.9452 - val_loss: 0.2281 - val_accuracy: 0.9315
Epoch 76/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1307 - accuracy: 0.9462 - val_loss: 0.3322 - val_accuracy: 0.8950
```



```
32/32 [==============================] - 1s 29ms/step - loss: 0.1584 - accuracy: 0.9374 - val_loss: 0.2112 - val_accuracy: 0.9315
```

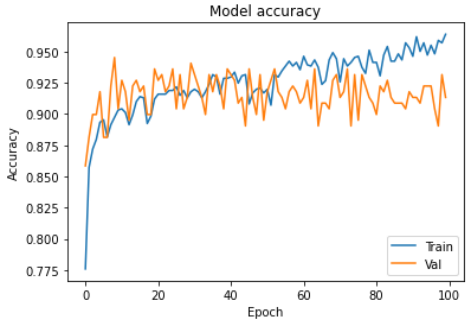
```
Epoch 78/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1557 - accuracy: 0.9325 - val_loss: 0.2494 - val_accuracy: 0.9224
Epoch 79/100
32/32 [==============================] - 1s 30ms/step - loss: 0.1346 - accuracy: 0.9511 - val_loss: 0.2629 - val_accuracy: 0.9132
Epoch 80/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1369 - accuracy: 0.9413 - val_loss: 0.2448 - val_accuracy: 0.9087
Epoch 81/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1621 - accuracy: 0.9413 - val_loss: 0.2850 - val_accuracy: 0.8995
Epoch 82/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1541 - accuracy: 0.9305 - val_loss: 0.2127 - val_accuracy: 0.9224
Epoch 83/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1289 - accuracy: 0.9472 - val_loss: 0.2470 - val_accuracy: 0.9178
Epoch 84/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1066 - accuracy: 0.9540 - val_loss: 0.2587 - val_accuracy: 0.9269
Epoch 85/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1311 - accuracy: 0.9423 - val_loss: 0.2751 - val_accuracy: 0.9132
Epoch 86/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1364 - accuracy: 0.9423 - val_loss: 0.2659 - val_accuracy: 0.9087
Epoch 87/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1254 - accuracy: 0.9481 - val_loss: 0.2596 - val_accuracy: 0.9087
Epoch 88/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1325 - accuracy: 0.9432 - val_loss: 0.2773 - val_accuracy: 0.9087
Epoch 89/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1140 - accuracy: 0.9569 - val_loss: 0.2468 - val_accuracy: 0.9041
Epoch 90/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1174 - accuracy: 0.9530 - val_loss: 0.2682 - val_accuracy: 0.9178
Epoch 91/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1229 - accuracy: 0.9462 - val_loss: 0.2725 - val_accuracy: 0.9132
Epoch 92/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1018 - accuracy: 0.9618 - val_loss: 0.2994 - val_accuracy: 0.9132
Epoch 93/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1074 - accuracy: 0.9501 - val_loss: 0.2676 - val_accuracy: 0.9087
Epoch 94/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1122 - accuracy: 0.9569 - val_loss: 0.3071 - val_accuracy: 0.9224
Epoch 95/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1271 - accuracy: 0.9472 - val_loss: 0.2522 - val_accuracy: 0.9224
Epoch 96/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1242 - accuracy: 0.9550 - val_loss: 0.2695 - val_accuracy: 0.9224
Epoch 97/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1197 - accuracy: 0.9481 - val_loss: 0.2776 - val_accuracy: 0.9041
Epoch 98/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1106 - accuracy: 0.9589 - val_loss: 0.3223 - val_accuracy: 0.8904
Epoch 99/100
32/32 [==============================] - 1s 29ms/step - loss: 0.1149 - accuracy: 0.9569 - val_loss: 0.2652 - val_accuracy: 0.9315
Epoch 100/100
32/32 [==============================] - 1s 29ms/step - loss: 0.0993 - accuracy: 0.9638 - val_loss: 0.3019 - val_accuracy: 0.9132
```

In [20]:
```
# Creating a plot to visualize the overfitting loss and validation loss
plt.plot(hist_2.history['loss'])
plt.plot(hist_2.history['val_loss'])
plt.title('Model loss')
plt.ylabel('Loss')
plt.xlabel('Epoch')
plt.legend(['Train', 'Val'], loc='upper right')
plt.show()
```



In [21]:
```
# Creating a plot to visualize the overfitting accuracy and validation accuracy
plt.plot(hist_2.history['val_accuracy'])
```

```
plt.title('Model accuracy')
plt.ylabel('Accuracy')
plt.xlabel('Epoch')
plt.legend(['Train', 'Val'], loc='lower right')
plt.show()
```



In [30]:
```
# Creating a third model with L2 regularization and dropout incorporated
from keras.layers import Dropout
from keras import regularizers

model_3 = Sequential([
    Dense(1000, activation='relu', kernel_regularizer=regularizers.l2(0.01), input_shape=(10,)),
    Dropout(0.3),
    Dense(1000, activation='relu', kernel_regularizer=regularizers.l2(0.01)),
    Dropout(0.3),
    Dense(1000, activation='relu', kernel_regularizer=regularizers.l2(0.01)),
    Dropout(0.3),
    Dense(1000, activation='relu', kernel_regularizer=regularizers.l2(0.01)),
    Dropout(0.3),
    Dense(1, activation='relu', kernel_regularizer=regularizers.l2(0.01)),
])
```

In [31]:
```
model_3.compile(optimizer='adam', loss='binary_crossentropy', metrics=['accuracy'])
hist_3 = model_3.fit(X_train, Y_train, batch_size=32, epochs=100, validation_data=(X_val, Y_val))
```

```
Epoch 1/100
32/32 [==============================] - 2s 39ms/step - loss: 18.9597 - accuracy: 0.7250 - val_loss: 9.9868 - val_accuracy: 0.8721
Epoch 2/100
32/32 [==============================] - 1s 33ms/step - loss: 7.0600 - accuracy: 0.8082 - val_loss: 5.0501 - val_accuracy: 0.8904
Epoch 3/100
32/32 [==============================] - 1s 33ms/step - loss: 4.4364 - accuracy: 0.8542 - val_loss: 3.7156 - val_accuracy: 0.8813
Epoch 4/100
32/32 [==============================] - 1s 34ms/step - loss: 3.4328 - accuracy: 0.8063 - val_loss: 2.9900 - val_accuracy: 0.8676
Epoch 5/100
32/32 [==============================] - 1s 33ms/step - loss: 2.9646 - accuracy: 0.8395 - val_loss: 2.4899 - val_accuracy: 0.8767
Epoch 6/100
32/32 [==============================] - 1s 33ms/step - loss: 2.4405 - accuracy: 0.8523 - val_loss: 2.1128 - val_accuracy: 0.9041
Epoch 7/100
32/32 [==============================] - 1s 34ms/step - loss: 2.1015 - accuracy: 0.8650 - val_loss: 1.9040 - val_accuracy: 0.9041
Epoch 8/100
32/32 [==============================] - 1s 34ms/step - loss: 1.9363 - accuracy: 0.8376 - val_loss: 1.7362 - val_accuracy: 0.8813
Epoch 9/100
32/32 [==============================] - 1s 34ms/step - loss: 1.6846 - accuracy: 0.8640 - val_loss: 1.4782 - val_accuracy: 0.9132
Epoch 10/100
32/32 [==============================] - 1s 33ms/step - loss: 1.5732 - accuracy: 0.8493 - val_loss: 1.4964 - val_accuracy: 0.8904
Epoch 11/100
32/32 [==============================] - 1s 33ms/step - loss: 1.9446 - accuracy: 0.7828 - val_loss: 4.0463 - val_accuracy: 0.5114
Epoch 12/100
32/32 [==============================] - 1s 33ms/step - loss: 1.7263 - accuracy: 0.7172 - val_loss: 1.4319 - val_accuracy: 0.8128
Epoch 13/100
32/32 [==============================] - 1s 33ms/step - loss: 1.4040 - accuracy: 0.8346 - val_loss: 1.3096 - val_accuracy: 0.8174
Epoch 14/100
32/32 [==============================] - 1s 33ms/step - loss: 1.2832 - accuracy: 0.8092 - val_loss: 1.1364 - val_accuracy: 0.9041
Epoch 15/100
32/32 [==============================] - 1s 33ms/step - loss: 1.2709 - accuracy: 0.8317 - val_loss: 1.1777 - val_accuracy: 0.8311
Epoch 16/100
32/32 [==============================] - 1s 34ms/step - loss: 1.1180 - accuracy: 0.8386 - val_loss: 1.0343 - val_accuracy: 0.8858
Epoch 17/100
32/32 [==============================] - 1s 34ms/step - loss: 1.0604 - accuracy: 0.8219 - val_loss: 0.9170 - val_accuracy: 0.8904
Epoch 18/100
32/32 [==============================] - 1s 34ms/step - loss: 1.0049 - accuracy: 0.8395 - val_loss: 0.8557 - val_accuracy: 0.8950
Epoch 19/100
32/32 [==============================] - 1s 33ms/step - loss: 1.0064 - accuracy: 0.7984 - val_loss: 0.8647 - val_accuracy: 0.8995
Epoch 20/100
32/32 [==============================] - 1s 33ms/step - loss: 0.9227 - accuracy: 0.8542 - val_loss: 0.7872 - val_accuracy: 0.8904
Epoch 21/100
32/32 [==============================] - 1s 33ms/step - loss: 0.8222 - accuracy: 0.8699 - val_loss: 0.7172 - val_accuracy: 0.9132
Epoch 22/100
32/32 [==============================] - 1s 33ms/step - loss: 0.8620 - accuracy: 0.8620 - val_loss: 0.7319 - val_accuracy: 0.8904
Epoch 23/100
32/32 [==============================] - 1s 33ms/step - loss: 0.8275 - accuracy: 0.8376 - val_loss: 0.7078 - val_accuracy: 0.8630
Epoch 24/100
32/32 [==============================] - 1s 33ms/step - loss: 0.7748 - accuracy: 0.8415 - val_loss: 0.6591 - val_accuracy: 0.8858
Epoch 25/100
32/32 [==============================] - 1s 33ms/step - loss: 0.7432 - accuracy: 0.8611 - val_loss: 0.5808 - val_accuracy: 0.9132
Epoch 26/100
32/32 [==============================] - 1s 33ms/step - loss: 0.6886 - accuracy: 0.8738 - val_loss: 0.6351 - val_accuracy: 0.8904
Epoch 27/100
32/32 [==============================] - 1s 33ms/step - loss: 0.6209 - accuracy: 0.8767 - val_loss: 0.5540 - val_accuracy: 0.8904
Epoch 28/100
32/32 [==============================] - 1s 33ms/step - loss: 0.6641 - accuracy: 0.8787 - val_loss: 0.5879 - val_accuracy: 0.8904
Epoch 29/100
32/32 [==============================] - 1s 33ms/step - loss: 0.6623 - accuracy: 0.8532 - val_loss: 0.5001 - val_accuracy: 0.9087
Epoch 30/100
32/32 [==============================] - 1s 34ms/step - loss: 0.5957 - accuracy: 0.8679 - val_loss: 0.4835 - val_accuracy: 0.9132
Epoch 31/100
32/32 [==============================] - 1s 33ms/step - loss: 0.5538 - accuracy: 0.8757 - val_loss: 0.5172 - val_accuracy: 0.8813
Epoch 32/100
32/32 [==============================] - 1s 33ms/step - loss: 0.5923 - accuracy: 0.8493 - val_loss: 0.4563 - val_accuracy: 0.9224
Epoch 33/100
32/32 [==============================] - 1s 33ms/step - loss: 0.6468 - accuracy: 0.8748 - val_loss: 0.4399 - val_accuracy: 0.9224
Epoch 34/100
32/32 [==============================] - 1s 34ms/step - loss: 0.5395 - accuracy: 0.8738 - val_loss: 0.4318 - val_accuracy: 0.9087
Epoch 35/100
32/32 [==============================] - 1s 33ms/step - loss: 0.5402 - accuracy: 0.8718 - val_loss: 0.4300 - val_accuracy: 0.9224
Epoch 36/100
32/32 [==============================] - 1s 33ms/step - loss: 0.5157 - accuracy: 0.8757 - val_loss: 0.4079 - val_accuracy: 0.9132
Epoch 37/100
32/32 [==============================] - 1s 33ms/step - loss: 0.5167 - accuracy: 0.8757 - val_loss: 0.3999 - val_accuracy: 0.9178
Epoch 38/100
32/32 [==============================] - 1s 33ms/step - loss: 0.5166 - accuracy: 0.8630 - val_loss: 0.3995 - val_accuracy: 0.9087
Epoch 39/100
```

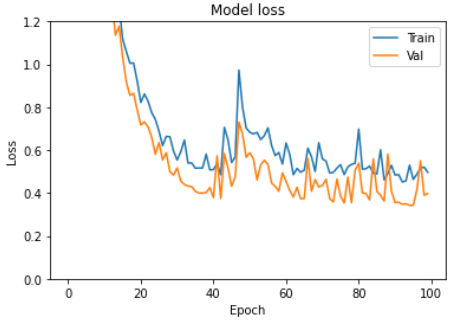
```
32/32 [==============================] - 1s 34ms/step - loss: 0.5811 - accuracy: 0.8738 - val_loss: 0.4018 - val_accuracy: 0.9178
Epoch 40/100
32/32 [==============================] - 1s 33ms/step - loss: 0.5078 - accuracy: 0.8513 - val_loss: 0.4254 - val_accuracy: 0.9041
Epoch 41/100
32/32 [==============================] - 1s 33ms/step - loss: 0.5092 - accuracy: 0.8738 - val_loss: 0.3787 - val_accuracy: 0.9269
Epoch 42/100
32/32 [==============================] - 1s 33ms/step - loss: 0.5386 - accuracy: 0.8806 - val_loss: 0.5729 - val_accuracy: 0.8813
Epoch 43/100
32/32 [==============================] - 1s 33ms/step - loss: 0.4851 - accuracy: 0.8718 - val_loss: 0.3747 - val_accuracy: 0.9224
Epoch 44/100
32/32 [==============================] - 1s 33ms/step - loss: 0.7065 - accuracy: 0.7652 - val_loss: 0.5831 - val_accuracy: 0.9041
Epoch 45/100
32/32 [==============================] - 1s 33ms/step - loss: 0.6481 - accuracy: 0.8180 - val_loss: 0.5180 - val_accuracy: 0.8721
Epoch 46/100
32/32 [==============================] - 1s 34ms/step - loss: 0.5424 - accuracy: 0.8464 - val_loss: 0.4316 - val_accuracy: 0.9087
Epoch 47/100
32/32 [==============================] - 1s 33ms/step - loss: 0.5684 - accuracy: 0.8689 - val_loss: 0.4758 - val_accuracy: 0.8995
Epoch 48/100
32/32 [==============================] - 1s 34ms/step - loss: 0.9734 - accuracy: 0.6536 - val_loss: 0.7309 - val_accuracy: 0.8813
Epoch 49/100
32/32 [==============================] - 1s 33ms/step - loss: 0.8007 - accuracy: 0.6898 - val_loss: 0.6757 - val_accuracy: 0.8630
Epoch 50/100
32/32 [==============================] - 1s 33ms/step - loss: 0.7031 - accuracy: 0.7926 - val_loss: 0.5668 - val_accuracy: 0.8813
Epoch 51/100
32/32 [==============================] - 1s 34ms/step - loss: 0.6835 - accuracy: 0.8200 - val_loss: 0.5880 - val_accuracy: 0.8311
Epoch 52/100
32/32 [==============================] - 1s 34ms/step - loss: 0.6754 - accuracy: 0.8337 - val_loss: 0.5598 - val_accuracy: 0.8813
Epoch 53/100
32/32 [==============================] - 1s 34ms/step - loss: 0.6828 - accuracy: 0.8425 - val_loss: 0.4608 - val_accuracy: 0.9132
Epoch 54/100
32/32 [==============================] - 1s 33ms/step - loss: 0.6490 - accuracy: 0.8014 - val_loss: 0.5311 - val_accuracy: 0.8676
Epoch 55/100
32/32 [==============================] - 1s 34ms/step - loss: 0.6673 - accuracy: 0.8444 - val_loss: 0.5530 - val_accuracy: 0.8813
Epoch 56/100
32/32 [==============================] - 1s 33ms/step - loss: 0.7042 - accuracy: 0.8591 - val_loss: 0.5332 - val_accuracy: 0.8858
Epoch 57/100
32/32 [==============================] - 1s 33ms/step - loss: 0.6224 - accuracy: 0.8591 - val_loss: 0.4470 - val_accuracy: 0.8995
Epoch 58/100
32/32 [==============================] - 1s 33ms/step - loss: 0.5742 - accuracy: 0.8454 - val_loss: 0.4305 - val_accuracy: 0.9041
Epoch 59/100
32/32 [==============================] - 1s 33ms/step - loss: 0.5888 - accuracy: 0.8640 - val_loss: 0.4085 - val_accuracy: 0.9041
Epoch 60/100
32/32 [==============================] - 1s 33ms/step - loss: 0.5349 - accuracy: 0.8386 - val_loss: 0.4937 - val_accuracy: 0.8904
Epoch 61/100
32/32 [==============================] - 1s 33ms/step - loss: 0.6328 - accuracy: 0.8787 - val_loss: 0.4540 - val_accuracy: 0.8995
Epoch 62/100
32/32 [==============================] - 1s 34ms/step - loss: 0.5800 - accuracy: 0.8659 - val_loss: 0.4121 - val_accuracy: 0.8995
Epoch 63/100
32/32 [==============================] - 1s 33ms/step - loss: 0.4852 - accuracy: 0.8571 - val_loss: 0.3815 - val_accuracy: 0.9178
Epoch 64/100
32/32 [==============================] - 1s 33ms/step - loss: 0.5146 - accuracy: 0.8708 - val_loss: 0.4265 - val_accuracy: 0.8904
Epoch 65/100
32/32 [==============================] - 1s 33ms/step - loss: 0.4968 - accuracy: 0.8571 - val_loss: 0.3734 - val_accuracy: 0.9041
Epoch 66/100
32/32 [==============================] - 1s 33ms/step - loss: 0.5069 - accuracy: 0.8738 - val_loss: 0.3752 - val_accuracy: 0.9041
Epoch 67/100
32/32 [==============================] - 1s 33ms/step - loss: 0.6091 - accuracy: 0.7886 - val_loss: 0.5608 - val_accuracy: 0.8402
Epoch 68/100
32/32 [==============================] - 1s 33ms/step - loss: 0.5683 - accuracy: 0.8219 - val_loss: 0.4079 - val_accuracy: 0.9132
Epoch 69/100
32/32 [==============================] - 1s 33ms/step - loss: 0.5001 - accuracy: 0.8796 - val_loss: 0.4633 - val_accuracy: 0.8950
Epoch 70/100
32/32 [==============================] - 1s 33ms/step - loss: 0.6346 - accuracy: 0.8611 - val_loss: 0.4278 - val_accuracy: 0.9087
Epoch 71/100
32/32 [==============================] - 1s 33ms/step - loss: 0.5593 - accuracy: 0.8865 - val_loss: 0.4357 - val_accuracy: 0.8904
Epoch 72/100
32/32 [==============================] - 1s 33ms/step - loss: 0.5483 - accuracy: 0.8650 - val_loss: 0.4637 - val_accuracy: 0.8721
Epoch 73/100
32/32 [==============================] - 1s 33ms/step - loss: 0.4934 - accuracy: 0.8356 - val_loss: 0.3737 - val_accuracy: 0.9087
Epoch 74/100
32/32 [==============================] - 1s 34ms/step - loss: 0.4961 - accuracy: 0.8708 - val_loss: 0.3585 - val_accuracy: 0.9132
Epoch 75/100
32/32 [==============================] - 1s 34ms/step - loss: 0.5167 - accuracy: 0.8581 - val_loss: 0.4648 - val_accuracy: 0.8676
Epoch 76/100
32/32 [==============================] - 1s 33ms/step - loss: 0.5320 - accuracy: 0.8513 - val_loss: 0.3857 - val_accuracy: 0.9224
```



```
32/32 [==============================] - 1s 33ms/step - loss: 0.4858 - accuracy: 0.8464 - val_loss: 0.3539 - val_accuracy: 0.9087
```

```
Epoch 78/100
32/32 [==============================] - 1s 34ms/step - loss: 0.5217 - accuracy: 0.8542 - val_loss: 0.4740 - val_accuracy: 0.8539
Epoch 79/100
32/32 [==============================] - 1s 34ms/step - loss: 0.5337 - accuracy: 0.8278 - val_loss: 0.3548 - val_accuracy: 0.9178
Epoch 80/100
32/32 [==============================] - 1s 33ms/step - loss: 0.5386 - accuracy: 0.8386 - val_loss: 0.5060 - val_accuracy: 0.8219
Epoch 81/100
32/32 [==============================] - 1s 33ms/step - loss: 0.6983 - accuracy: 0.7348 - val_loss: 0.5393 - val_accuracy: 0.7671
Epoch 82/100
32/32 [==============================] - 1s 34ms/step - loss: 0.5112 - accuracy: 0.8346 - val_loss: 0.4004 - val_accuracy: 0.8995
Epoch 83/100
32/32 [==============================] - 1s 33ms/step - loss: 0.5134 - accuracy: 0.8523 - val_loss: 0.3973 - val_accuracy: 0.8995
Epoch 84/100
32/32 [==============================] - 1s 34ms/step - loss: 0.5254 - accuracy: 0.8748 - val_loss: 0.3680 - val_accuracy: 0.9087
Epoch 85/100
32/32 [==============================] - 1s 33ms/step - loss: 0.4922 - accuracy: 0.8562 - val_loss: 0.5591 - val_accuracy: 0.8950
Epoch 86/100
32/32 [==============================] - 1s 34ms/step - loss: 0.4884 - accuracy: 0.8532 - val_loss: 0.4074 - val_accuracy: 0.8858
Epoch 87/100
32/32 [==============================] - 1s 33ms/step - loss: 0.6017 - accuracy: 0.7789 - val_loss: 0.3892 - val_accuracy: 0.8995
Epoch 88/100
32/32 [==============================] - 1s 33ms/step - loss: 0.4615 - accuracy: 0.8679 - val_loss: 0.3624 - val_accuracy: 0.9041
Epoch 89/100
32/32 [==============================] - 1s 35ms/step - loss: 0.4907 - accuracy: 0.8542 - val_loss: 0.5809 - val_accuracy: 0.8813
Epoch 90/100
32/32 [==============================] - 1s 34ms/step - loss: 0.5295 - accuracy: 0.8317 - val_loss: 0.4091 - val_accuracy: 0.8950
Epoch 91/100
32/32 [==============================] - 1s 33ms/step - loss: 0.4838 - accuracy: 0.8542 - val_loss: 0.3558 - val_accuracy: 0.9041
Epoch 92/100
32/32 [==============================] - 1s 33ms/step - loss: 0.4856 - accuracy: 0.8591 - val_loss: 0.3567 - val_accuracy: 0.9041
Epoch 93/100
32/32 [==============================] - 1s 34ms/step - loss: 0.4517 - accuracy: 0.8650 - val_loss: 0.3473 - val_accuracy: 0.9041
Epoch 94/100
32/32 [==============================] - 1s 34ms/step - loss: 0.4563 - accuracy: 0.8601 - val_loss: 0.3499 - val_accuracy: 0.9041
Epoch 95/100
32/32 [==============================] - 1s 33ms/step - loss: 0.5300 - accuracy: 0.8748 - val_loss: 0.3426 - val_accuracy: 0.9087
Epoch 96/100
32/32 [==============================] - 1s 34ms/step - loss: 0.4633 - accuracy: 0.8640 - val_loss: 0.3426 - val_accuracy: 0.9087
Epoch 97/100
32/32 [==============================] - 1s 34ms/step - loss: 0.4875 - accuracy: 0.8796 - val_loss: 0.4143 - val_accuracy: 0.8995
Epoch 98/100
32/32 [==============================] - 1s 34ms/step - loss: 0.5163 - accuracy: 0.8679 - val_loss: 0.5503 - val_accuracy: 0.8950
Epoch 99/100
32/32 [==============================] - 1s 34ms/step - loss: 0.5208 - accuracy: 0.8659 - val_loss: 0.3900 - val_accuracy: 0.9041
Epoch 100/100
32/32 [==============================] - 1s 34ms/step - loss: 0.4964 - accuracy: 0.8718 - val_loss: 0.3975 - val_accuracy: 0.8995
```

In [32]:
```
# Creating a plot to visualize the trained loss and validation loss of the third model
plt.plot(hist_3.history['loss'])
plt.plot(hist_3.history['val_loss'])
plt.title('Model loss')
plt.ylabel('Loss')
plt.xlabel('Epoch')
plt.legend(['Train', 'Val'], loc='upper right')
plt.ylim(top=1.2, bottom=0)
plt.show()
```




```
rained accuracy and validation accuracy of the third model
plt.plot(hist_3.history['accuracy'])
```

```
plt.plot(hist_3.history['val_accuracy'])
plt.title('Model accuracy')
plt.ylabel('Accuracy')
plt.xlabel('Epoch')
plt.legend(['Train', 'Val'], loc='lower right')
plt.show()
```