In [2]:
```
!pip install numpy pandas matplotlib seaborn scikit-p learn
```

```
Requirement already satisfied: numpy in c:\users\sudha\anaconda3\lib\site-packages
(1.26.4)
Requirement already satisfied: pandas in c:\users\sudha\anaconda3\lib\site-packages
(2.2.2)
Requirement already satisfied: matplotlib in c:\users\sudha\anaconda3\lib\site-packag
es (3.9.2)
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Requirement already satisfied: scikit-learn in c:\users\sudha\anaconda3\lib\site-pack
ages (1.5.1)
Requirement already satisfied: python-dateutil>=2.8.2 in c:\users\sudha\anaconda3\lib
\site-packages (from pandas) (2.9.0.post0)
Requirement already satisfied: pytz>=2020.1 in c:\users\sudha\anaconda3\lib\site-pack
ages (from pandas) (2024.1)
Requirement already satisfied: tzdata>=2022.7 in c:\users\sudha\anaconda3\lib\site-pa
ckages (from pandas) (2023.3)
Requirement already satisfied: contourpy>=1.0.1 in c:\users\sudha\anaconda3\lib\site-
packages (from matplotlib) (1.2.0)
Requirement already satisfied: cycler>=0.10 in c:\users\sudha\anaconda3\lib\site-pack
ages (from matplotlib) (0.11.0)
Requirement already satisfied: fonttools>=4.22.0 in c:\users\sudha\anaconda3\lib\site
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-packages (from matplotlib) (1.4.4)
Requirement already satisfied: packaging>=20.0 in c:\users\sudha\anaconda3\lib\site-p
ackages (from matplotlib) (24.1)
Requirement already satisfied: pillow>=8 in c:\users\sudha\anaconda3\lib\site-package
s (from matplotlib) (10.4.0)
Requirement already satisfied: pyparsing>=2.3.1 in c:\users\sudha\anaconda3\lib\site-
packages (from matplotlib) (3.1.2)
Requirement already satisfied: scipy>=1.6.0 in c:\users\sudha\anaconda3\lib\site-pack
ages (from scikit-learn) (1.13.1)
Requirement already satisfied: joblib>=1.2.0 in c:\users\sudha\anaconda3\lib\site-pac
kages (from scikit-learn) (1.4.2)
Requirement already satisfied: threadpoolctl>=3.1.0 in c:\users\sudha\anaconda3\lib\s
ite-packages (from scikit-learn) (3.5.0)
Requirement already satisfied: six>=1.5 in c:\users\sudha\anaconda3\lib\site-packages
(from python-dateutil>=2.8.2->pandas) (1.16.0)
```

In [4]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LinearRegression
from sklearn.ensemble import RandomForestRegressor
from sklearn.metrics import mean_squared_error, r2_score
```

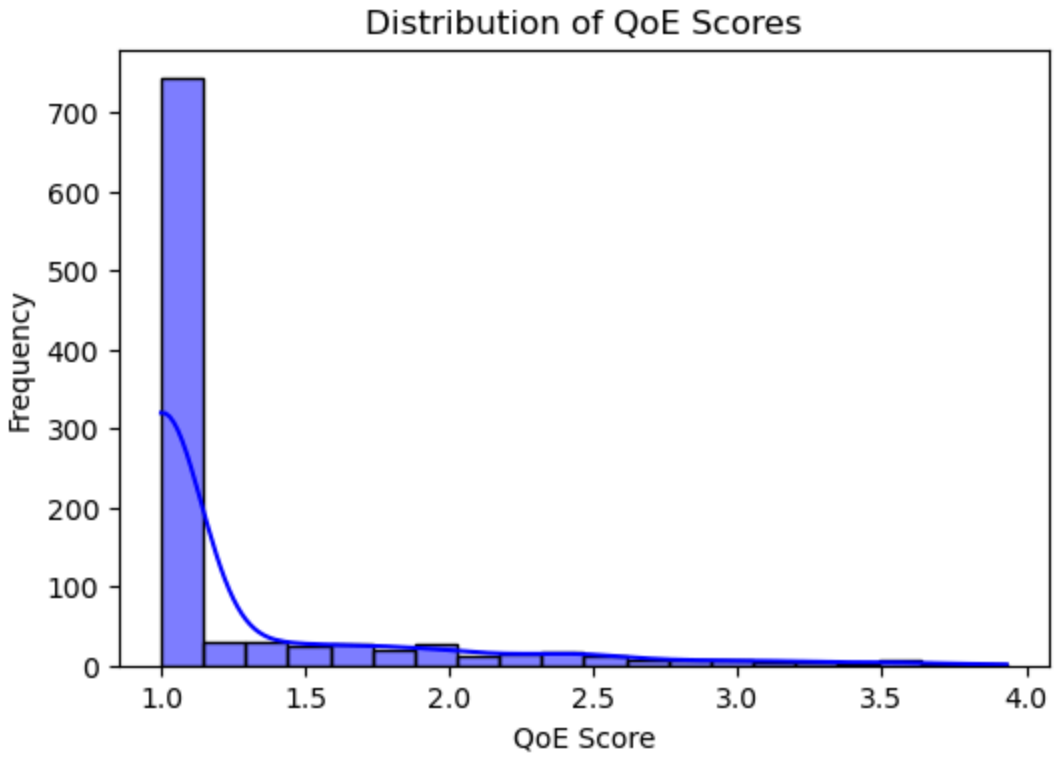
In [6]:
```
np.random.seed(42)
data = {
    'Latency (ms)': np.random.randint(20, 300, 1000),
    'Packet Loss (%)': np.random.uniform(0, 5, 1000),
    'Jitter (ms)': np.random.randint(5, 100, 1000),
    'Bandwidth (Mbps)': np.random.uniform(5, 100, 1000),
}
data['QoE Score'] = 5 - (data['Latency (ms)'] / 80 + data['Packet Loss (%)'] / 2 + dat
```

```
data['QoE Score'] = np.clip(data['QoE Score'], 1, 5)
df = pd.DataFrame(data)
```

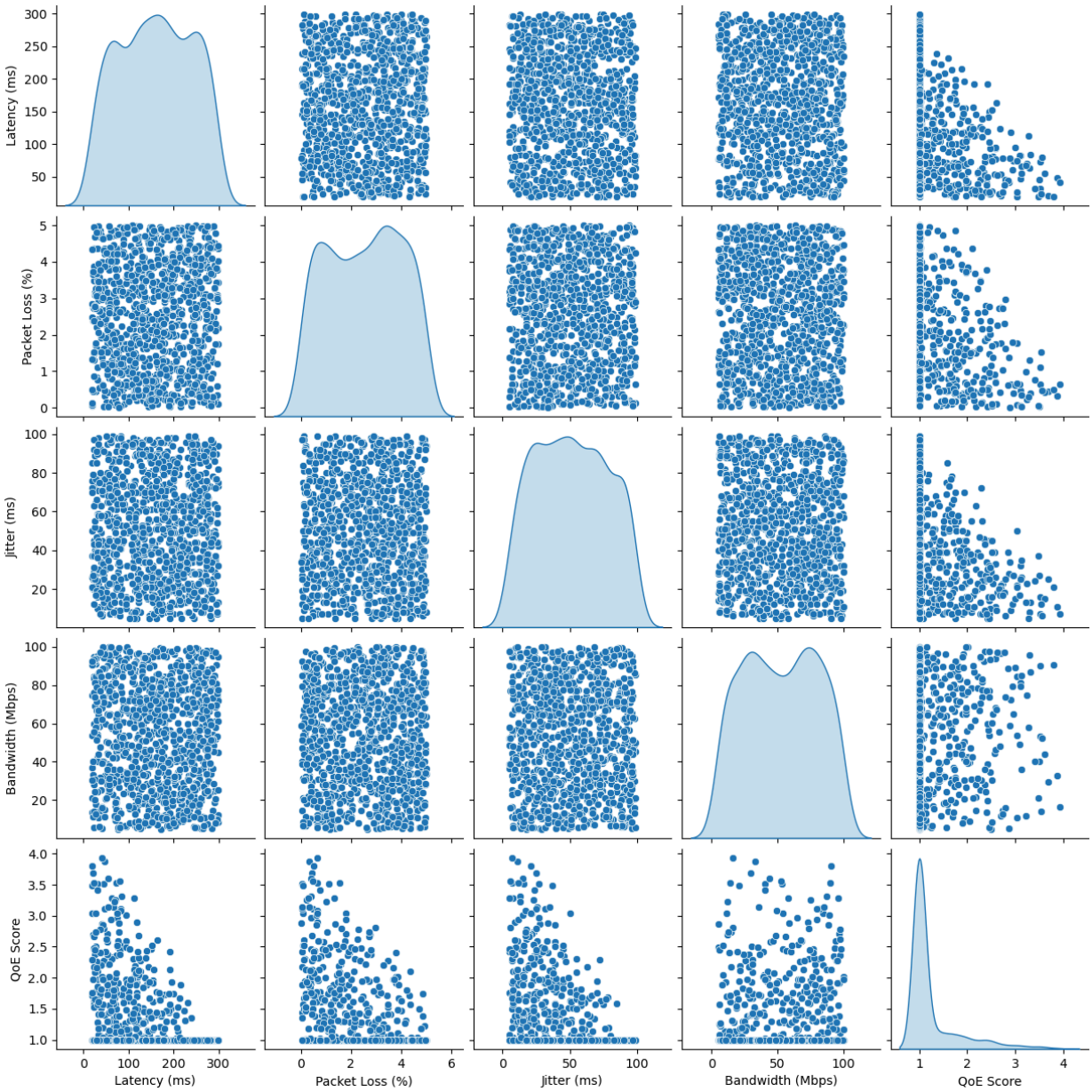
In [8]:
```
print("First 5 rows of dataset:")
print(df.head())
print("\nSummary Statistics:")
print(df.describe())
```

```
First 5 rows of dataset:
   Latency (ms)  Packet Loss (%)  Jitter (ms)  Bandwidth (Mbps)  QoE Score
0           122         4.472761           42         54.416140   1.000000
1           290         3.999276           50         18.573216   1.000000
2           126         2.126068            8         78.657884   2.095300
3            91         0.112347           64         30.783891   1.672993
4           208         1.343387           61         52.186065   1.000000

Summary Statistics:
       Latency (ms)  Packet Loss (%)  Jitter (ms)  Bandwidth (Mbps)  \
count   1000.000000      1000.000000  1000.000000       1000.000000
mean     159.911000         2.529291    51.287000         52.266419
std       79.781452         1.466028    26.553036         27.456459
min       20.000000         0.016091     5.000000          5.001105
25%       91.750000         1.201573    28.000000         28.640983
50%      162.500000         2.594944    51.000000         52.522429
75%      231.250000         3.793849    73.000000         76.081555
max      299.000000         4.997069    99.000000         99.894798

         QoE Score
count  1000.000000
mean      1.258111
std       0.544678
min       1.000000
25%       1.000000
50%       1.000000
75%       1.179662
max       3.931992
```

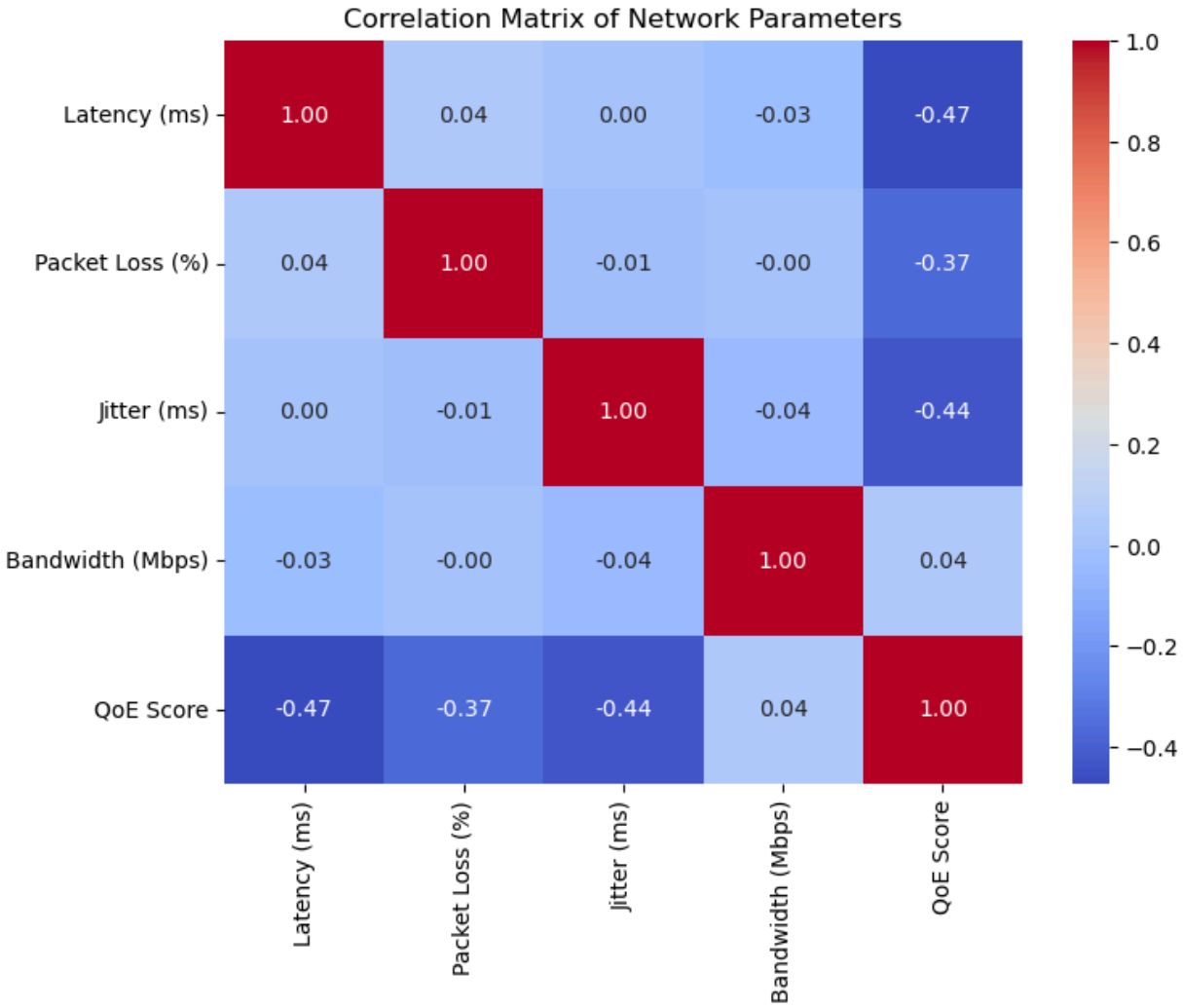
In [10]:
```
plt.figure(figsize=(6,4))
sns.histplot(df['QoE Score'], bins=20, kde=True, color='blue')
plt.title("Distribution of QoE Scores")
plt.xlabel("QoE Score")
plt.ylabel("Frequency")
plt.show()
```



In [12]:
```
sns.pairplot(df, diag_kind='kde')
plt.show()
```



In [14]:
```
plt.figure(figsize=(8,6))
sns.heatmap(df.corr(), annot=True, cmap='coolwarm', fmt=".2f")
plt.title("Correlation Matrix of Network Parameters")
plt.show()
```



In [16]:
```
X = df[['Latency (ms)', 'Packet Loss (%)', 'Jitter (ms)', 'Bandwidth (Mbps)']]
y = df['QoE Score']
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=
```

In [18]:
```
lr_model = LinearRegression()
lr_model.fit(X_train, y_train)
y_pred_lr = lr_model.predict(X_test)
mse_lr = mean_squared_error(y_test, y_pred_lr)
r2_lr = r2_score(y_test, y_pred_lr)
print(f"Linear Regression - MSE: {mse_lr:.2f}, R2 Score: {r2_lr:.2f}")
```

```
Linear Regression - MSE: 0.12, R2 Score: 0.55
```

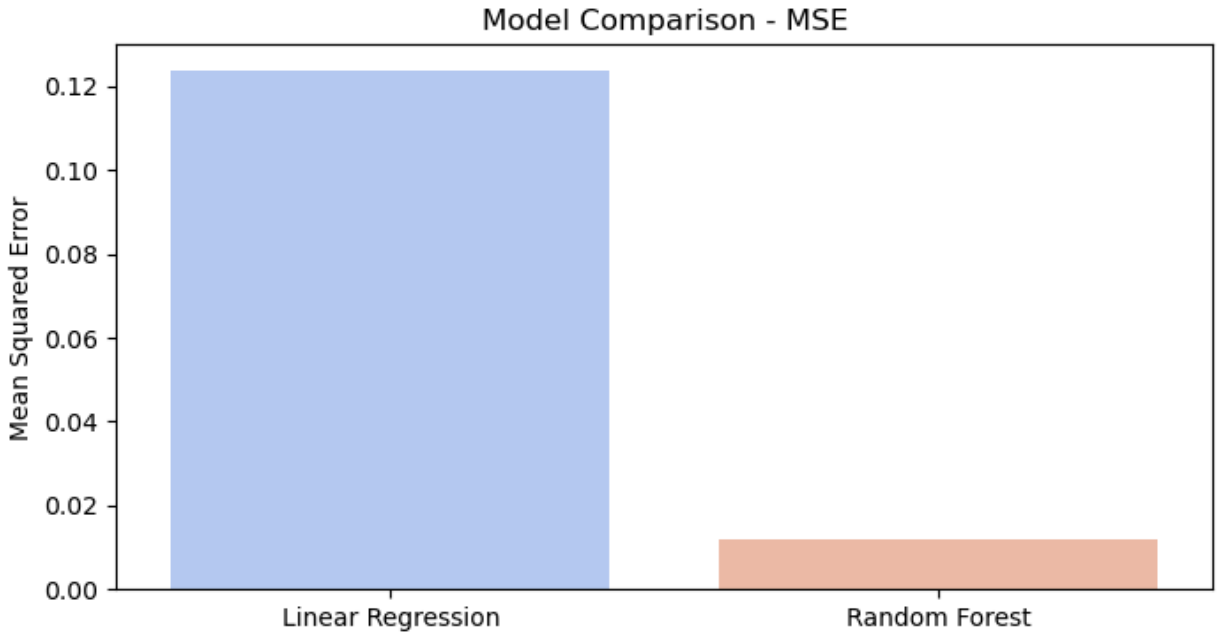
In [20]:
```
rf_model = RandomForestRegressor(n_estimators=100, random_state=42)
rf_model.fit(X_train, y_train)
y_pred_rf = rf_model.predict(X_test)
mse_rf = mean_squared_error(y_test, y_pred_rf)
r2_rf = r2_score(y_test, y_pred_rf)
print(f"Random Forest - MSE: {mse_rf:.2f}, R2 Score: {r2_rf:.2f}")
```

```
Random Forest - MSE: 0.01, R2 Score: 0.96
```

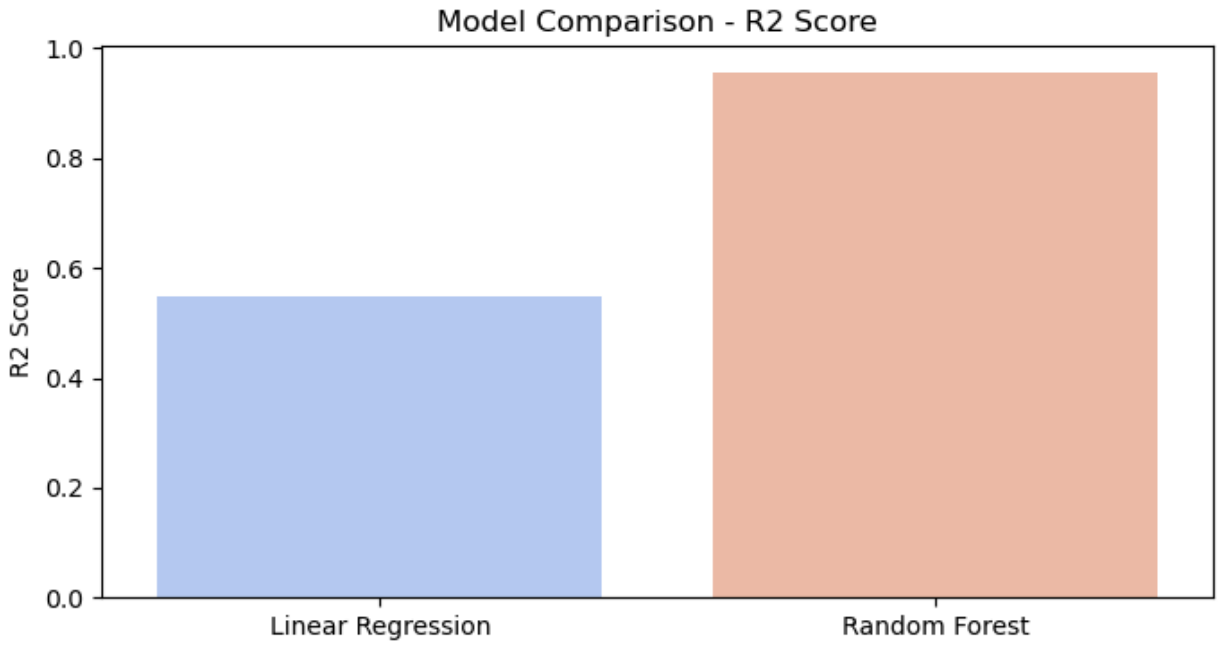
In [22]:
```
models = ["Linear Regression", "Random Forest"]
mse_values = [mse_lr, mse_rf]
r2_values = [r2_lr, r2_rf]
```

```
plt.figure(figsize=(8,4))
sns.barplot(x=models, y=mse_values, palette='coolwarm')
plt.title("Model Comparison - MSE")
plt.ylabel("Mean Squared Error")
plt.show()

plt.figure(figsize=(8,4))
sns.barplot(x=models, y=r2_values, palette='coolwarm')
plt.title("Model Comparison - R2 Score")
plt.ylabel("R2 Score")
plt.show()
```

```
C:\Users\sudha\AppData\Local\Temp\ipykernel_1164\1199408385.py:6: FutureWarning:

Passing `palette` without assigning `hue` is deprecated and will be removed in v0.14.
0. Assign the `x` variable to `hue` and set `legend=False` for the same effect.

  sns.barplot(x=models, y=mse_values, palette='coolwarm')
```

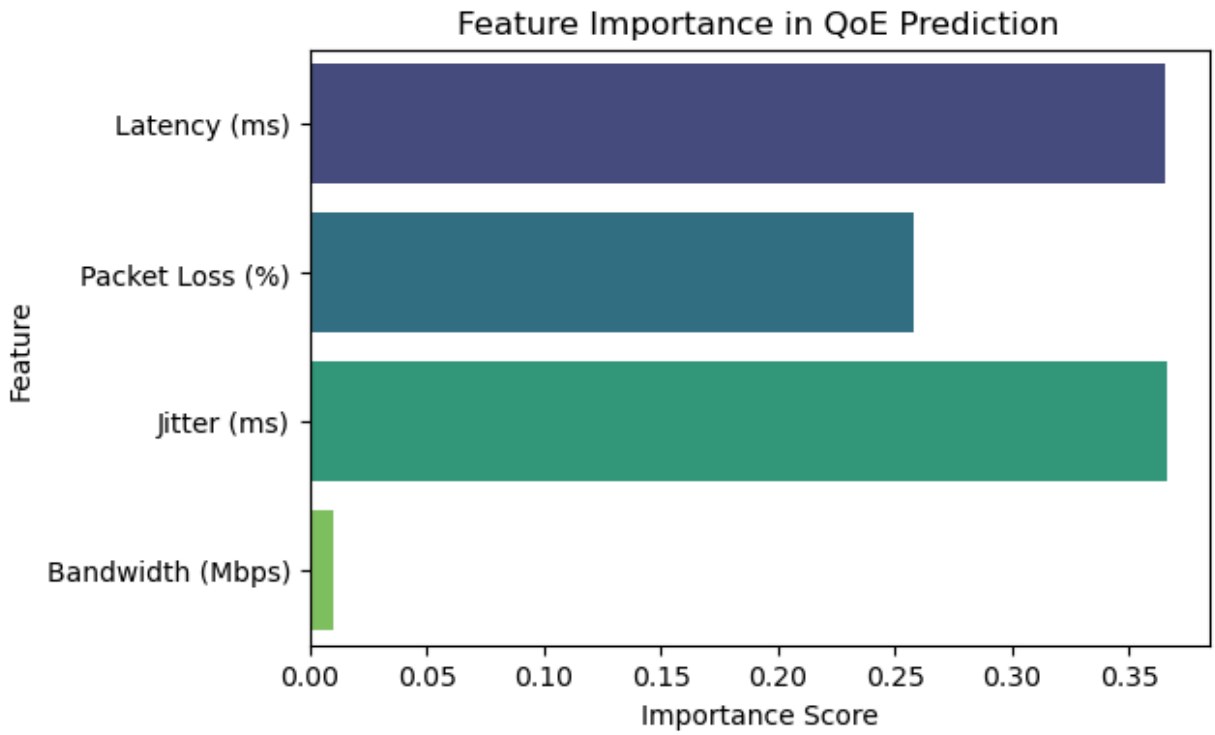



```
C:\Users\sudha\AppData\Local\Temp\ipykernel_1164\1199408385.py:12: FutureWarning:

Passing `palette` without assigning `hue` is deprecated and will be removed in v0.14.
0. Assign the `x` variable to `hue` and set `legend=False` for the same effect.

  sns.barplot(x=models, y=r2_values, palette='coolwarm')
```



In [24]:
```
importance = rf_model.feature_importances_
features = X.columns
plt.figure(figsize=(6,4))
sns.barplot(x=importance, y=features, palette='viridis')
plt.title("Feature Importance in QoE Prediction")
plt.xlabel("Importance Score")
plt.ylabel("Feature")
plt.show()
```

```
C:\Users\sudha\AppData\Local\Temp\ipykernel_1164\3597949485.py:4: FutureWarning:

Passing `palette` without assigning `hue` is deprecated and will be removed in v0.14.
0. Assign the `y` variable to `hue` and set `legend=False` for the same effect.

  sns.barplot(x=importance, y=features, palette='viridis')
```



In [26]:
```
optimized_conditions = pd.DataFrame({
    'Latency (ms)': np.linspace(20, 100, 10),
    'Packet Loss (%)': np.linspace(0, 2, 10),
    'Jitter (ms)': np.linspace(5, 30, 10),
    'Bandwidth (Mbps)': np.linspace(10, 100, 10)
})
optimized_conditions['Predicted QoE'] = rf_model.predict(optimized_conditions)
best_conditions = optimized_conditions.loc[optimized_conditions['Predicted QoE'].idxma
print("Optimal Network Conditions for Best QoE:")
print(best_conditions)
```

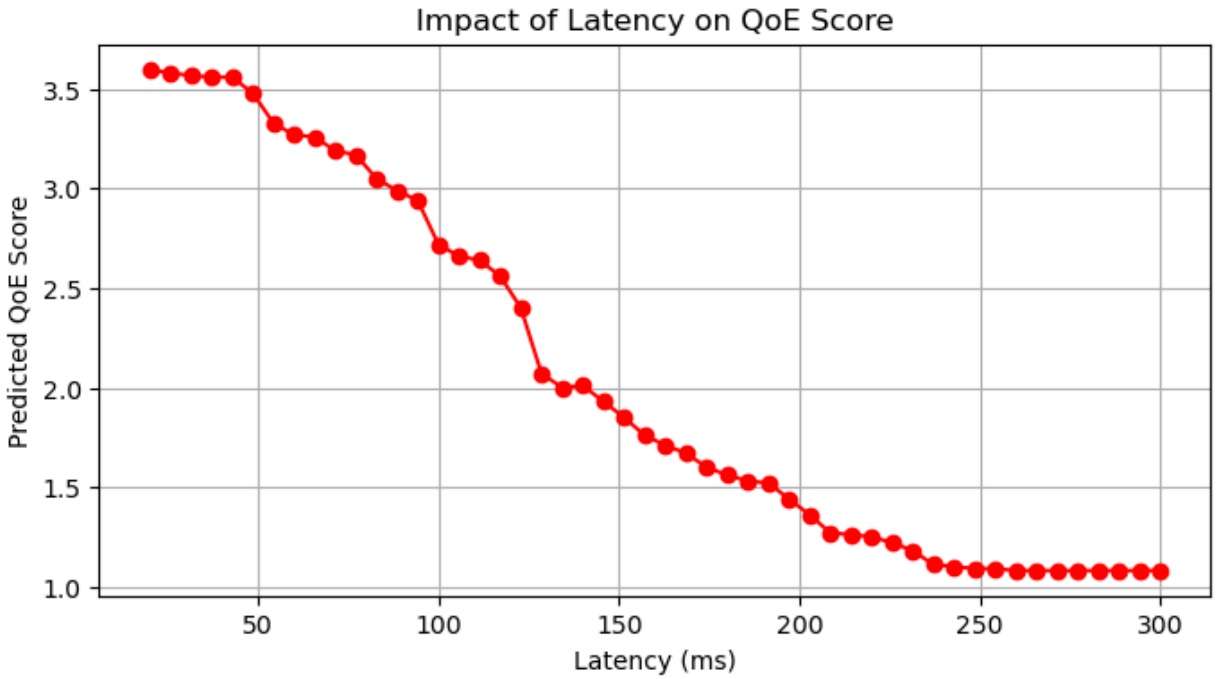
```
Optimal Network Conditions for Best QoE:
Latency (ms)        28.888889
Packet Loss (%)      0.222222
Jitter (ms)          7.777778
Bandwidth (Mbps)    20.000000
Predicted QoE        3.776261
Name: 1, dtype: float64
```

In [28]:
```
def predict_qoe(latency, packet_loss, jitter, bandwidth):
    input_data = pd.DataFrame([[latency, packet_loss, jitter, bandwidth]],
                              columns=['Latency (ms)', 'Packet Loss (%)', 'Jitter (ms)
    qoe_score = rf_model.predict(input_data)[0]
    return round(qoe_score, 2)

latency = 50
packet_loss = 1
jitter = 10
bandwidth = 25
predicted_qoe = predict_qoe(latency, packet_loss, jitter, bandwidth)
print(f"Predicted QoE Score: {predicted_qoe}/5")
```

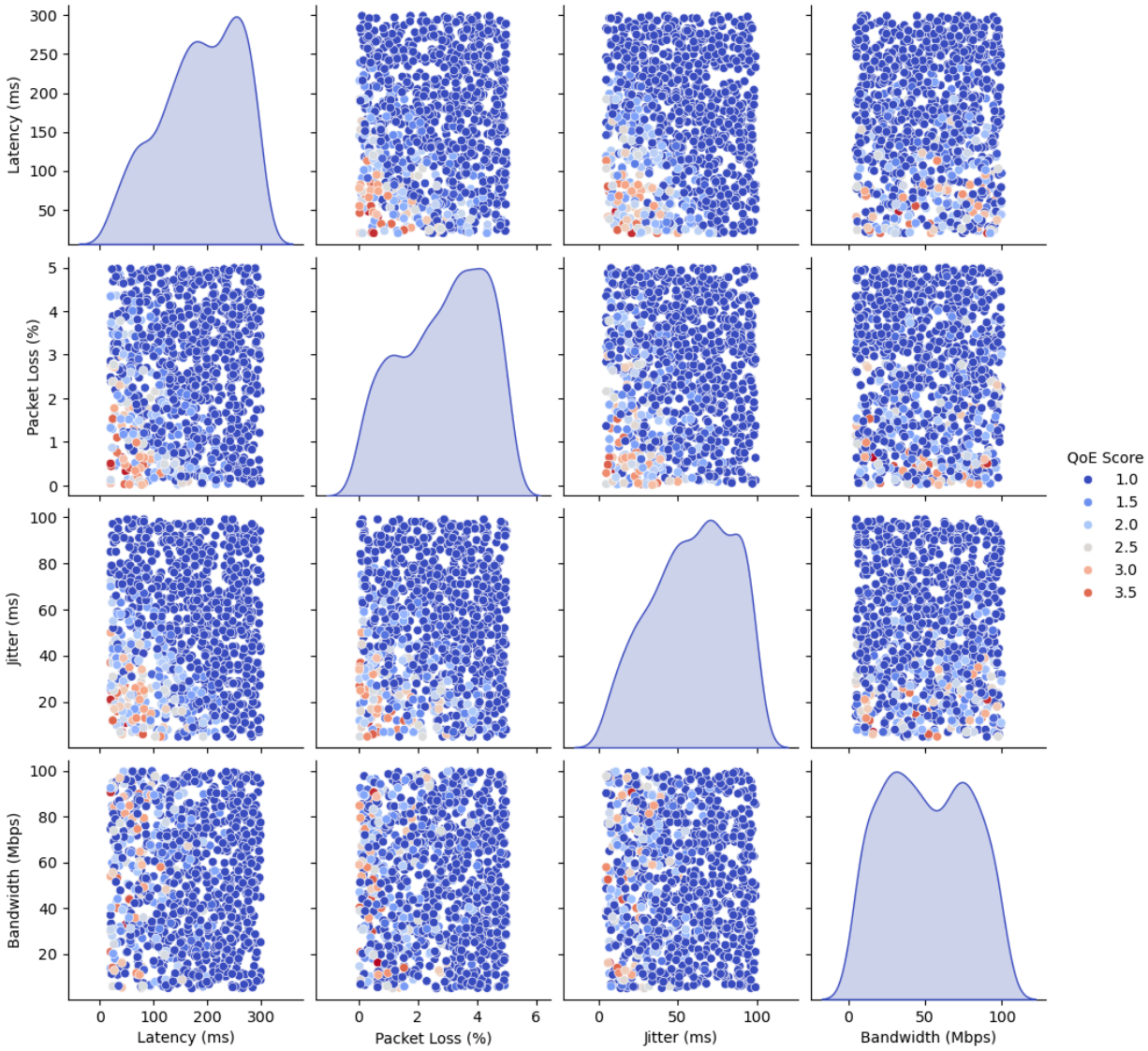
```
Predicted QoE Score: 3.47/5
```

In [30]:
```
latencies = np.linspace(20, 300, 50)
predicted_qoe_values = [predict_qoe(lat, 1, 10, 50) for lat in latencies]
```

```
plt.figure(figsize=(8,4))
plt.plot(latencies, predicted_qoe_values, marker='o', linestyle='-', color='red')
plt.title("Impact of Latency on QoE Score")
plt.xlabel("Latency (ms)")
plt.ylabel("Predicted QoE Score")
plt.grid()
plt.show()
```

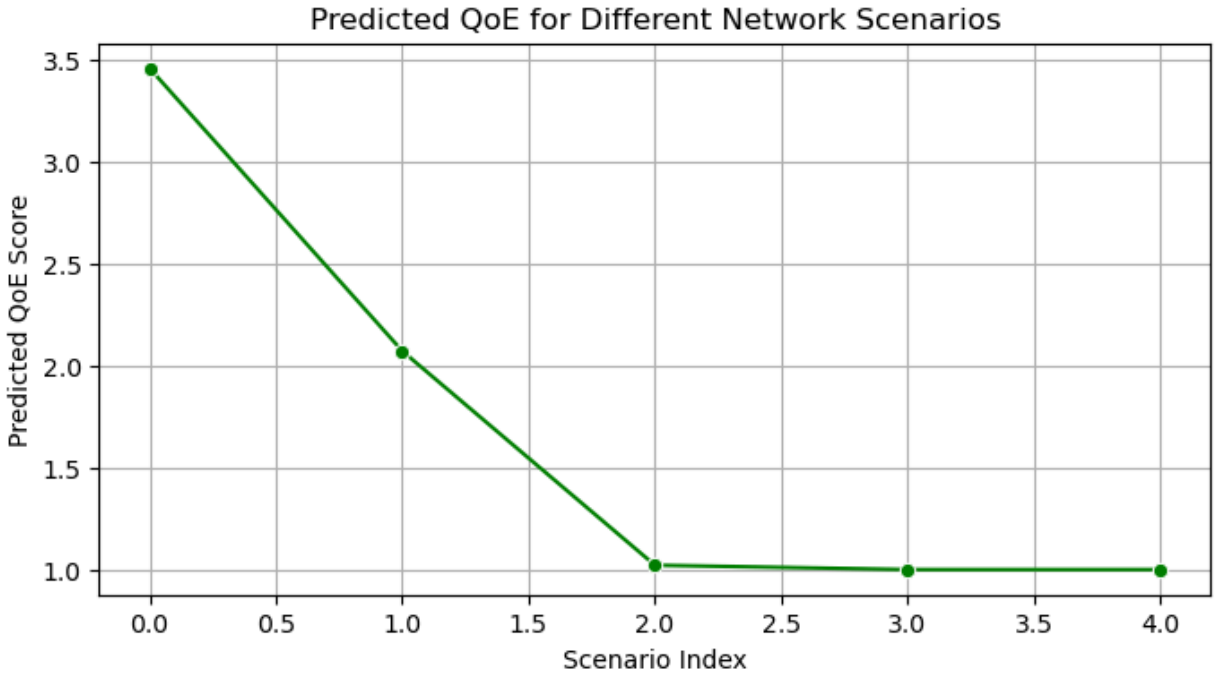


In [32]:
```
sns.pairplot(df, hue="QoE Score", palette="coolwarm")
plt.show()
```



In [34]:
```
scenarios = pd.DataFrame({
    'Latency (ms)': [50, 100, 150, 200, 250],
    'Packet Loss (%)': [1, 2, 3, 4, 5],
    'Jitter (ms)': [10, 20, 30, 40, 50],
    'Bandwidth (Mbps)': [10, 20, 30, 40, 50]
})
scenarios['Predicted QoE'] = rf_model.predict(scenarios)
print("Predicted QoE Scores for Various Scenarios:")
print(scenarios)

plt.figure(figsize=(8,4))
sns.lineplot(x=scenarios.index, y=scenarios['Predicted QoE'], marker='o', color='greer
plt.title("Predicted QoE for Different Network Scenarios")
plt.xlabel("Scenario Index")
plt.ylabel("Predicted QoE Score")
plt.grid()
plt.show()
```

```
Predicted QoE Scores for Various Scenarios:
   Latency (ms)  Packet Loss (%)  Jitter (ms)  Bandwidth (Mbps)  Predicted QoE
0            50                1           10                10       3.457042
1           100                2           20                20       2.071310
2           150                3           30                30       1.021342
3           200                4           40                40       1.000000
4           250                5           50                50       1.000000
```



In [2]:
```
!pip install tensorflow
```

```
Collecting tensorflow
  Downloading tensorflow-2.19.0-cp312-cp312-win_amd64.whl.metadata (4.1 kB)
Collecting absl-py>=1.0.0 (from tensorflow)
  Downloading absl_py-2.2.0-py3-none-any.whl.metadata (2.4 kB)
Collecting astunparse>=1.6.0 (from tensorflow)
  Downloading astunparse-1.6.3-py2.py3-none-any.whl.metadata (4.4 kB)
Collecting flatbuffers>=24.3.25 (from tensorflow)
  Downloading flatbuffers-25.2.10-py2.py3-none-any.whl.metadata (875 bytes)
Collecting gast!=0.5.0,!=0.5.1,!=0.5.2,>=0.2.1 (from tensorflow)
  Downloading gast-0.6.0-py3-none-any.whl.metadata (1.3 kB)
Collecting google-pasta>=0.1.1 (from tensorflow)
  Downloading google_pasta-0.2.0-py3-none-any.whl.metadata (814 bytes)
Collecting libclang>=13.0.0 (from tensorflow)
  Downloading libclang-18.1.1-py2.py3-none-win_amd64.whl.metadata (5.3 kB)
Collecting opt-einsum>=2.3.2 (from tensorflow)
  Downloading opt_einsum-3.4.0-py3-none-any.whl.metadata (6.3 kB)
Requirement already satisfied: packaging in c:\users\sudha\anaconda3\lib\site-package
s (from tensorflow) (24.1)
Requirement already satisfied: protobuf!=4.21.0,!=4.21.1,!=4.21.2,!=4.21.3,!=4.21.4,!
=4.21.5,<6.0.0dev,>=3.20.3 in c:\users\sudha\anaconda3\lib\site-packages (from tensor
flow) (4.25.3)
Requirement already satisfied: requests<3,>=2.21.0 in c:\users\sudha\anaconda3\lib\si
te-packages (from tensorflow) (2.32.3)
Requirement already satisfied: setuptools in c:\users\sudha\anaconda3\lib\site-packag
es (from tensorflow) (75.1.0)
Requirement already satisfied: six>=1.12.0 in c:\users\sudha\anaconda3\lib\site-packa
ges (from tensorflow) (1.16.0)
Collecting termcolor>=1.1.0 (from tensorflow)
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Requirement already satisfied: typing-extensions>=3.6.6 in c:\users\sudha\anaconda3\l
ib\site-packages (from tensorflow) (4.11.0)
Requirement already satisfied: wrapt>=1.11.0 in c:\users\sudha\anaconda3\lib\site-pac
kages (from tensorflow) (1.14.1)
Collecting grpcio<2.0,>=1.24.3 (from tensorflow)
  Downloading grpcio-1.71.0-cp312-cp312-win_amd64.whl.metadata (4.0 kB)
Collecting tensorboard~=2.19.0 (from tensorflow)
  Downloading tensorboard-2.19.0-py3-none-any.whl.metadata (1.8 kB)
Collecting keras>=3.5.0 (from tensorflow)
  Downloading keras-3.9.0-py3-none-any.whl.metadata (6.1 kB)
Requirement already satisfied: numpy<2.2.0,>=1.26.0 in c:\users\sudha\anaconda3\lib\s
ite-packages (from tensorflow) (1.26.4)
Requirement already satisfied: h5py>=3.11.0 in c:\users\sudha\anaconda3\lib\site-pack
ages (from tensorflow) (3.11.0)
Collecting ml-dtypes<1.0.0,>=0.5.1 (from tensorflow)
  Downloading ml_dtypes-0.5.1-cp312-cp312-win_amd64.whl.metadata (22 kB)
Requirement already satisfied: wheel<1.0,>=0.23.0 in c:\users\sudha\anaconda3\lib\sit
e-packages (from astunparse>=1.6.0->tensorflow) (0.44.0)
Requirement already satisfied: rich in c:\users\sudha\anaconda3\lib\site-packages (fr
om keras>=3.5.0->tensorflow) (13.7.1)
Collecting namex (from keras>=3.5.0->tensorflow)
  Downloading namex-0.0.8-py3-none-any.whl.metadata (246 bytes)
Collecting optree (from keras>=3.5.0->tensorflow)
  Downloading optree-0.14.1-cp312-cp312-win_amd64.whl.metadata (50 kB)
Requirement already satisfied: charset-normalizer<4,>=2 in c:\users\sudha\anaconda3\l
ib\site-packages (from requests<3,>=2.21.0->tensorflow) (3.3.2)
Requirement already satisfied: idna<4,>=2.5 in c:\users\sudha\anaconda3\lib\site-pack
ages (from requests<3,>=2.21.0->tensorflow) (3.7)
Requirement already satisfied: urllib3<3,>=1.21.1 in c:\users\sudha\anaconda3\lib\sit
e-packages (from requests<3,>=2.21.0->tensorflow) (2.2.3)
Requirement already satisfied: certifi>=2017.4.17 in c:\users\sudha\anaconda3\lib\sit
```

```
e-packages (from requests<3,>=2.21.0->tensorflow) (2025.1.31)
Requirement already satisfied: markdown>=2.6.8 in c:\users\sudha\anaconda3\lib\site-p
ackages (from tensorboard~=2.19.0->tensorflow) (3.4.1)
Collecting tensorboard-data-server<0.8.0,>=0.7.0 (from tensorboard~=2.19.0->tensorflo
w)
  Downloading tensorboard_data_server-0.7.2-py3-none-any.whl.metadata (1.1 kB)
Requirement already satisfied: werkzeug>=1.0.1 in c:\users\sudha\anaconda3\lib\site-p
ackages (from tensorboard~=2.19.0->tensorflow) (3.0.3)
Requirement already satisfied: MarkupSafe>=2.1.1 in c:\users\sudha\anaconda3\lib\site
-packages (from werkzeug>=1.0.1->tensorboard~=2.19.0->tensorflow) (2.1.3)
Requirement already satisfied: markdown-it-py>=2.2.0 in c:\users\sudha\anaconda3\lib
\site-packages (from rich->keras>=3.5.0->tensorflow) (2.2.0)
Requirement already satisfied: pygments<3.0.0,>=2.13.0 in c:\users\sudha\anaconda3\li
b\site-packages (from rich->keras>=3.5.0->tensorflow) (2.15.1)
Requirement already satisfied: mdurl~=0.1 in c:\users\sudha\anaconda3\lib\site-packag
es (from markdown-it-py>=2.2.0->rich->keras>=3.5.0->tensorflow) (0.1.0)
Downloading tensorflow-2.19.0-cp312-cp312-win_amd64.whl (376.0 MB)
   ---------------------------------------- 0.0/376.0 MB ? eta -:--:--
   ---------------------------------------- 0.8/376.0 MB 5.6 MB/s eta 0:01:08
   ---------------------------------------- 1.3/376.0 MB 3.9 MB/s eta 0:01:36
   ---------------------------------------- 1.8/376.0 MB 3.6 MB/s eta 0:01:45
   ---------------------------------------- 2.6/376.0 MB 3.1 MB/s eta 0:01:59
    --------------------------------------- 6.8/376.0 MB 6.8 MB/s eta 0:00:55
   - -------------------------------------- 11.0/376.0 MB 9.2 MB/s eta 0:00:40
   - -------------------------------------- 13.9/376.0 MB 9.9 MB/s eta 0:00:37
   - -------------------------------------- 16.3/376.0 MB 10.1 MB/s eta 0:00:36
   -- ------------------------------------- 19.9/376.0 MB 11.0 MB/s eta 0:00:33
   -- ------------------------------------- 23.3/376.0 MB 11.7 MB/s eta 0:00:31
   -- ------------------------------------- 27.0/376.0 MB 12.2 MB/s eta 0:00:29
   --- ------------------------------------ 29.4/376.0 MB 12.3 MB/s eta 0:00:29
   --- ------------------------------------ 30.7/376.0 MB 11.7 MB/s eta 0:00:30
   --- ------------------------------------ 31.2/376.0 MB 11.2 MB/s eta 0:00:31
   --- ------------------------------------ 32.0/376.0 MB 10.6 MB/s eta 0:00:33
   --- ------------------------------------ 32.5/376.0 MB 10.1 MB/s eta 0:00:35
   --- ------------------------------------ 34.6/376.0 MB 10.0 MB/s eta 0:00:35
   --- ------------------------------------ 37.0/376.0 MB 10.1 MB/s eta 0:00:34
   ---- ----------------------------------- 40.4/376.0 MB 10.4 MB/s eta 0:00:33
   ---- ----------------------------------- 43.5/376.0 MB 10.6 MB/s eta 0:00:32
   ---- ----------------------------------- 46.7/376.0 MB 10.9 MB/s eta 0:00:31
   ----- ---------------------------------- 49.5/376.0 MB 11.0 MB/s eta 0:00:30
   ----- ---------------------------------- 51.1/376.0 MB 10.9 MB/s eta 0:00:30
   ----- ---------------------------------- 54.0/376.0 MB 11.0 MB/s eta 0:00:30
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Downloading namex-0.0.8-py3-none-any.whl (5.8 kB)
Downloading optree-0.14.1-cp312-cp312-win_amd64.whl (306 kB)
Installing collected packages: namex, libclang, flatbuffers, termcolor, tensorboard-d
ata-server, optree, opt-einsum, ml-dtypes, grpcio, google-pasta, gast, astunparse, ab
sl-py, tensorboard, keras, tensorflow
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Successfully installed absl-py-2.2.0 astunparse-1.6.3 flatbuffers-25.2.10 gast-0.6.0
google-pasta-0.2.0 grpcio-1.71.0 keras-3.9.0 libclang-18.1.1 ml-dtypes-0.5.1 namex-0.
0.8 opt-einsum-3.4.0 optree-0.14.1 tensorboard-2.19.0 tensorboard-data-server-0.7.2 t
ensorflow-2.19.0 termcolor-2.5.0
```

In [6]:
```python
import numpy as np
import pandas as pd

# Simulate Network Data
np.random.seed(42)
data = {
    'Latency (ms)': np.random.randint(20, 300, 1000),
    'Packet Loss (%)': np.random.uniform(0, 5, 1000),
    'Jitter (ms)': np.random.randint(5, 100, 1000),
    'Bandwidth (Mbps)': np.random.uniform(5, 100, 1000),
}
data['QoE Score'] = 5 - (data['Latency (ms)'] / 80 + data['Packet Loss (%)'] / 2 + dat
data['QoE Score'] = np.clip(data['QoE Score'], 1, 5)

# Create DataFrame
df = pd.DataFrame(data)
```

In [8]:
```python
import tensorflow as tf
from tensorflow import keras
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense, Input

# Ensure X_train is defined before running this step
if 'X_train' not in globals():
    from sklearn.model_selection import train_test_split
    X = df[['Latency (ms)', 'Packet Loss (%)', 'Jitter (ms)', 'Bandwidth (Mbps)']]
    y = df['QoE Score']
    X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_st

# Define a deep learning model
deep_model = Sequential([
    Input(shape=(4,)),  # Correct way to specify input shape
    Dense(64, activation='relu'),
    Dense(32, activation='relu'),
    Dense(16, activation='relu'),
    Dense(1)  # Output layer (QoE Score)
])

# Compile the model
deep_model.compile(optimizer='adam', loss='mse', metrics=['mae'])

# Train the model
deep_model.fit(X_train, y_train, epochs=100, batch_size=16, verbose=1, validation_data

# Evaluate the model
dl_loss, dl_mae = deep_model.evaluate(X_test, y_test)
print(f"Deep Learning Model - Loss: {dl_loss:.2f}, MAE: {dl_mae:.2f}")
```

```
Epoch 1/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 2s 8ms/step - loss: 304.2001 - mae: 12.3210 - val_loss: 4.
2631 - val_mae: 1.6657
Epoch 2/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 2.5193 - mae: 1.2723 - val_loss: 1.005
0 - val_mae: 0.7468
Epoch 3/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.8398 - mae: 0.6800 - val_loss: 0.622
1 - val_mae: 0.5805
Epoch 4/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.5708 - mae: 0.5357 - val_loss: 0.503
7 - val_mae: 0.4990
Epoch 5/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.4505 - mae: 0.4451 - val_loss: 0.472
6 - val_mae: 0.4951
Epoch 6/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.4911 - mae: 0.4673 - val_loss: 0.451
1 - val_mae: 0.4767
Epoch 7/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.5117 - mae: 0.4697 - val_loss: 0.438
1 - val_mae: 0.4597
Epoch 8/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.5193 - mae: 0.4671 - val_loss: 0.437
3 - val_mae: 0.4378
Epoch 9/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.4233 - mae: 0.4174 - val_loss: 0.416
3 - val_mae: 0.4506
Epoch 10/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.4170 - mae: 0.3947 - val_loss: 0.425
6 - val_mae: 0.4702
Epoch 11/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.4422 - mae: 0.4318 - val_loss: 0.404
6 - val_mae: 0.4366
Epoch 12/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.4606 - mae: 0.4314 - val_loss: 0.387
2 - val_mae: 0.4328
Epoch 13/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.4831 - mae: 0.4285 - val_loss: 0.400
1 - val_mae: 0.4618
Epoch 14/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.4310 - mae: 0.4026 - val_loss: 0.392
8 - val_mae: 0.4563
Epoch 15/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.3279 - mae: 0.3809 - val_loss: 0.380
6 - val_mae: 0.4362
Epoch 16/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.3976 - mae: 0.4015 - val_loss: 0.370
0 - val_mae: 0.4225
Epoch 17/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.4108 - mae: 0.4146 - val_loss: 0.388
5 - val_mae: 0.4526
Epoch 18/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.3989 - mae: 0.4020 - val_loss: 0.377
5 - val_mae: 0.3993
Epoch 19/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.4455 - mae: 0.4149 - val_loss: 0.366
0 - val_mae: 0.4182
Epoch 20/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.3940 - mae: 0.4139 - val_loss: 0.353
7 - val_mae: 0.3917
```

```
Epoch 21/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.3614 - mae: 0.3704 - val_loss: 0.355
2 - val_mae: 0.4242
Epoch 22/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - loss: 0.3502 - mae: 0.3869 - val_loss: 0.355
3 - val_mae: 0.3919
Epoch 23/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.3268 - mae: 0.3583 - val_loss: 0.331
7 - val_mae: 0.3935
Epoch 24/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.3561 - mae: 0.3988 - val_loss: 0.323
0 - val_mae: 0.3690
Epoch 25/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.2943 - mae: 0.3313 - val_loss: 0.337
3 - val_mae: 0.3979
Epoch 26/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.3187 - mae: 0.3489 - val_loss: 0.333
8 - val_mae: 0.4273
Epoch 27/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.2742 - mae: 0.3414 - val_loss: 0.308
2 - val_mae: 0.3578
Epoch 28/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.3228 - mae: 0.3330 - val_loss: 0.299
6 - val_mae: 0.3702
Epoch 29/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.3642 - mae: 0.4041 - val_loss: 0.289
9 - val_mae: 0.3331
Epoch 30/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.2993 - mae: 0.3506 - val_loss: 0.325
2 - val_mae: 0.4135
Epoch 31/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.3575 - mae: 0.3647 - val_loss: 0.286
8 - val_mae: 0.3486
Epoch 32/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - loss: 0.2161 - mae: 0.2835 - val_loss: 0.264
6 - val_mae: 0.3201
Epoch 33/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.2969 - mae: 0.3333 - val_loss: 0.304
4 - val_mae: 0.4240
Epoch 34/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.3064 - mae: 0.3456 - val_loss: 0.262
9 - val_mae: 0.3269
Epoch 35/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.3397 - mae: 0.3290 - val_loss: 0.295
8 - val_mae: 0.3912
Epoch 36/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - loss: 0.2547 - mae: 0.3155 - val_loss: 0.243
6 - val_mae: 0.3056
Epoch 37/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - loss: 0.2935 - mae: 0.3245 - val_loss: 0.241
3 - val_mae: 0.3022
Epoch 38/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.2536 - mae: 0.2982 - val_loss: 0.231
6 - val_mae: 0.2981
Epoch 39/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.2147 - mae: 0.2588 - val_loss: 0.223
2 - val_mae: 0.3010
Epoch 40/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - loss: 0.2477 - mae: 0.3094 - val_loss: 0.224
6 - val_mae: 0.2922
```

```
Epoch 41/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.2134 - mae: 0.2669 - val_loss: 0.214
1 - val_mae: 0.3211
Epoch 42/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - loss: 0.2150 - mae: 0.2951 - val_loss: 0.210
5 - val_mae: 0.2843
Epoch 43/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.2589 - mae: 0.3075 - val_loss: 0.224
3 - val_mae: 0.3530
Epoch 44/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.2007 - mae: 0.2975 - val_loss: 0.203
2 - val_mae: 0.3273
Epoch 45/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.1784 - mae: 0.2598 - val_loss: 0.190
7 - val_mae: 0.2780
Epoch 46/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.1896 - mae: 0.2866 - val_loss: 0.198
3 - val_mae: 0.3178
Epoch 47/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.2290 - mae: 0.3428 - val_loss: 0.183
9 - val_mae: 0.2811
Epoch 48/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.1778 - mae: 0.2618 - val_loss: 0.181
5 - val_mae: 0.2768
Epoch 49/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.1710 - mae: 0.2521 - val_loss: 0.179
5 - val_mae: 0.2797
Epoch 50/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.2041 - mae: 0.2888 - val_loss: 0.200
9 - val_mae: 0.3521
Epoch 51/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.1939 - mae: 0.2929 - val_loss: 0.154
6 - val_mae: 0.2533
Epoch 52/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.1773 - mae: 0.2517 - val_loss: 0.152
6 - val_mae: 0.2599
Epoch 53/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.1998 - mae: 0.2623 - val_loss: 0.149
9 - val_mae: 0.2474
Epoch 54/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.1572 - mae: 0.2616 - val_loss: 0.261
5 - val_mae: 0.4347
Epoch 55/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - loss: 0.1919 - mae: 0.3201 - val_loss: 0.145
0 - val_mae: 0.2532
Epoch 56/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - loss: 0.1298 - mae: 0.2366 - val_loss: 0.136
7 - val_mae: 0.2366
Epoch 57/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - loss: 0.1641 - mae: 0.2479 - val_loss: 0.171
6 - val_mae: 0.2918
Epoch 58/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.1698 - mae: 0.2667 - val_loss: 0.140
7 - val_mae: 0.2426
Epoch 59/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.1494 - mae: 0.2398 - val_loss: 0.131
4 - val_mae: 0.2416
Epoch 60/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.1176 - mae: 0.2243 - val_loss: 0.147
5 - val_mae: 0.3089
```

```
Epoch 61/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.1578 - mae: 0.2962 - val_loss: 0.135
3 - val_mae: 0.2516
Epoch 62/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.1302 - mae: 0.2515 - val_loss: 0.139
3 - val_mae: 0.2613
Epoch 63/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.1391 - mae: 0.2595 - val_loss: 0.140
6 - val_mae: 0.2710
Epoch 64/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.1953 - mae: 0.3268 - val_loss: 0.114
8 - val_mae: 0.2265
Epoch 65/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.1459 - mae: 0.2490 - val_loss: 0.140
3 - val_mae: 0.2635
Epoch 66/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.1399 - mae: 0.2539 - val_loss: 0.123
2 - val_mae: 0.2694
Epoch 67/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.1488 - mae: 0.2712 - val_loss: 0.122
4 - val_mae: 0.2605
Epoch 68/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.1728 - mae: 0.3027 - val_loss: 0.109
3 - val_mae: 0.2324
Epoch 69/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.1764 - mae: 0.3157 - val_loss: 0.145
7 - val_mae: 0.2896
Epoch 70/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.1598 - mae: 0.2907 - val_loss: 0.110
4 - val_mae: 0.2440
Epoch 71/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.1310 - mae: 0.2464 - val_loss: 0.115
3 - val_mae: 0.2588
Epoch 72/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.1218 - mae: 0.2493 - val_loss: 0.096
2 - val_mae: 0.2338
Epoch 73/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - loss: 0.1411 - mae: 0.2717 - val_loss: 0.094
8 - val_mae: 0.2312
Epoch 74/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.1205 - mae: 0.2538 - val_loss: 0.151
5 - val_mae: 0.2946
Epoch 75/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.1244 - mae: 0.2691 - val_loss: 0.254
1 - val_mae: 0.3370
Epoch 76/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.1811 - mae: 0.3147 - val_loss: 0.102
4 - val_mae: 0.2427
Epoch 77/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.1078 - mae: 0.2332 - val_loss: 0.088
6 - val_mae: 0.2197
Epoch 78/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.1196 - mae: 0.2552 - val_loss: 0.097
2 - val_mae: 0.2271
Epoch 79/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.1097 - mae: 0.2291 - val_loss: 0.110
3 - val_mae: 0.2568
Epoch 80/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.1095 - mae: 0.2490 - val_loss: 0.105
2 - val_mae: 0.2444
```

```
Epoch 81/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - loss: 0.1212 - mae: 0.2555 - val_loss: 0.111
3 - val_mae: 0.2726
Epoch 82/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 6ms/step - loss: 0.1509 - mae: 0.3061 - val_loss: 0.128
9 - val_mae: 0.2901
Epoch 83/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 6ms/step - loss: 0.1571 - mae: 0.3031 - val_loss: 0.121
0 - val_mae: 0.2765
Epoch 84/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.1423 - mae: 0.2811 - val_loss: 0.108
1 - val_mae: 0.2698
Epoch 85/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.1135 - mae: 0.2500 - val_loss: 0.119
1 - val_mae: 0.2803
Epoch 86/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - loss: 0.1293 - mae: 0.2641 - val_loss: 0.261
0 - val_mae: 0.4219
Epoch 87/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.1813 - mae: 0.3282 - val_loss: 0.094
6 - val_mae: 0.2428
Epoch 88/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.1150 - mae: 0.2569 - val_loss: 0.132
6 - val_mae: 0.2805
Epoch 89/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - loss: 0.1352 - mae: 0.2773 - val_loss: 0.120
1 - val_mae: 0.2662
Epoch 90/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.1342 - mae: 0.2810 - val_loss: 0.191
9 - val_mae: 0.3536
Epoch 91/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.1495 - mae: 0.2907 - val_loss: 0.074
5 - val_mae: 0.2046
Epoch 92/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.1202 - mae: 0.2583 - val_loss: 0.081
9 - val_mae: 0.2171
Epoch 93/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.1094 - mae: 0.2401 - val_loss: 0.161
5 - val_mae: 0.3259
Epoch 94/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.1420 - mae: 0.2954 - val_loss: 0.266
8 - val_mae: 0.4322
Epoch 95/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.1617 - mae: 0.3131 - val_loss: 0.118
6 - val_mae: 0.2805
Epoch 96/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.1083 - mae: 0.2476 - val_loss: 0.084
5 - val_mae: 0.2255
Epoch 97/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - loss: 0.1018 - mae: 0.2403 - val_loss: 0.112
2 - val_mae: 0.2754
Epoch 98/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.1346 - mae: 0.2884 - val_loss: 0.098
6 - val_mae: 0.2389
Epoch 99/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.1237 - mae: 0.2614 - val_loss: 0.154
4 - val_mae: 0.3158
Epoch 100/100
50/50 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - loss: 0.1068 - mae: 0.2453 - val_loss: 0.071
7 - val_mae: 0.2083
```

```
7/7 ━━━━━━━━━━━━━━━━━━━━ 0s 6ms/step - loss: 0.0733 - mae: 0.2088
Deep Learning Model - Loss: 0.07, MAE: 0.21
```

In [10]:
```
# Predict QoE for test data
y_pred_dl = deep_model.predict(X_test)

# Convert predictions to DataFrame
predictions_df = pd.DataFrame({'Actual QoE': y_test.values, 'Predicted QoE': y_pred_dl

# Display first few rows
print(predictions_df.head())

# Plot actual vs predicted QoE scores
plt.figure(figsize=(8, 4))
plt.scatter(y_test, y_pred_dl, color='blue', alpha=0.5)
plt.plot([1, 5], [1, 5], '--', color='red')  # Ideal line
plt.xlabel("Actual QoE Score")
plt.ylabel("Predicted QoE Score")
plt.title("Actual vs Predicted QoE Scores (Deep Learning Model)")
plt.grid()
plt.show()
```

```
7/7 ━━━━━━━━━━━━━━━━━━━━ 0s 14ms/step
   Actual QoE  Predicted QoE
0    1.000000       0.957789
1    1.000000       1.234877
2    1.000000       1.274469
3    2.801309       1.980495
4    1.000000       1.127310
---------------------------------------------------------------------------
NameError                                 Traceback (most recent call last)
Cell In[10], line 11
      8 print(predictions_df.head())
     10 # Plot actual vs predicted QoE scores
---> 11 plt.figure(figsize=(8, 4))
     12 plt.scatter(y_test, y_pred_dl, color='blue', alpha=0.5)
     13 plt.plot([1, 5], [1, 5], '--', color='red')  # Ideal line

NameError: name 'plt' is not defined
```

In [14]:
```
# Predict QoE for test data
y_pred_dl = deep_model.predict(X_test)

# Convert predictions to DataFrame
predictions_df = pd.DataFrame({'Actual QoE': y_test.values, 'Predicted QoE': y_pred_dl

# Display first few rows
print(predictions_df.head())

# Plot actual vs predicted QoE scores
plt.figure(figsize=(8, 4))
plt.scatter(y_test, y_pred_dl, color='blue', alpha=0.5)
plt.plot([1, 5], [1, 5], '--', color='red')  # Ideal line
plt.xlabel("Actual QoE Score")
plt.ylabel("Predicted QoE Score")
plt.title("Actual vs Predicted QoE Scores (Deep Learning Model)")
plt.grid()
plt.show()
```

```
7/7 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step
```

```
   Actual QoE  Predicted QoE
0    1.000000       0.957789
1    1.000000       1.234877
2    1.000000       1.274469
3    2.801309       1.980495
4    1.000000       1.127310
```

```
---------------------------------------------------------------------------
NameError                                 Traceback (most recent call last)
Cell In[14], line 11
      8 print(predictions_df.head())
     10 # Plot actual vs predicted QoE scores
---> 11 plt.figure(figsize=(8, 4))
     12 plt.scatter(y_test, y_pred_dl, color='blue', alpha=0.5)
     13 plt.plot([1, 5], [1, 5], '--', color='red')  # Ideal line

NameError: name 'plt' is not defined
```

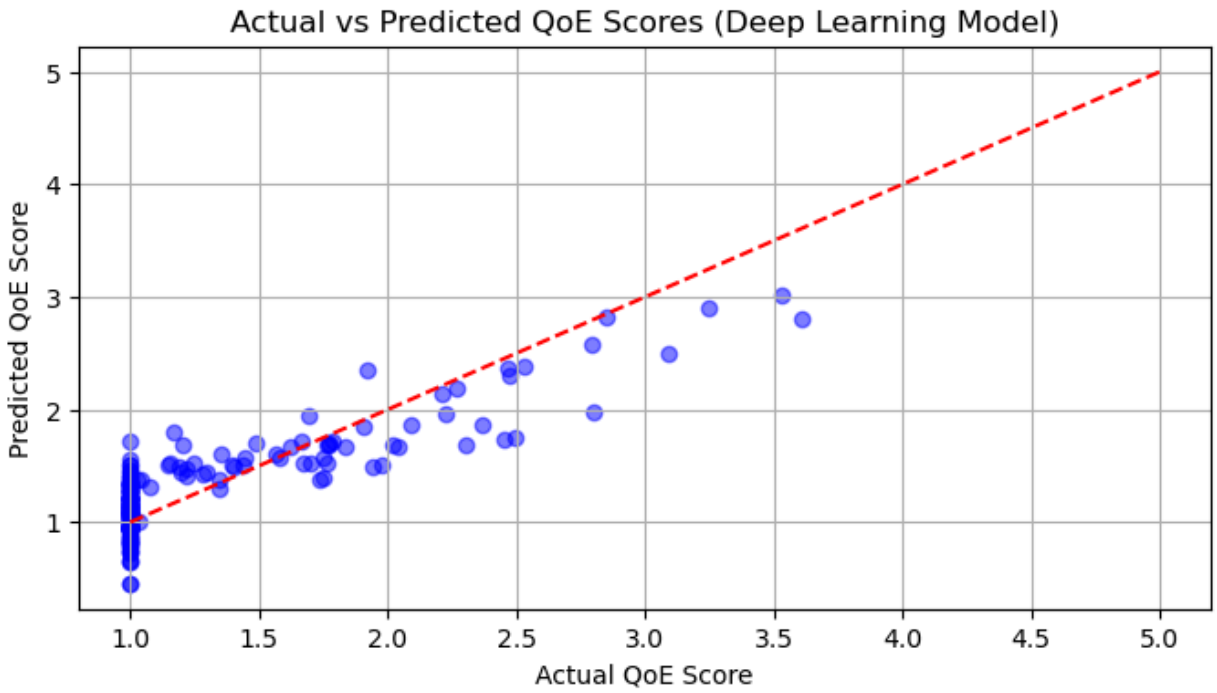
In [16]:
```
import matplotlib.pyplot as plt
```

In [18]:
```
import matplotlib.pyplot as plt
```

In [20]:
```
import matplotlib.pyplot as plt  # Ensure this is imported before using plt

# Predict QoE for test data
y_pred_dl = deep_model.predict(X_test)

# Convert predictions to DataFrame
predictions_df = pd.DataFrame({'Actual QoE': y_test.values, 'Predicted QoE': y_pred_dl

# Display first few rows
print(predictions_df.head())

# Plot actual vs predicted QoE scores
plt.figure(figsize=(8, 4))
plt.scatter(y_test, y_pred_dl, color='blue', alpha=0.5)
plt.plot([1, 5], [1, 5], '--', color='red')  # Ideal line
plt.xlabel("Actual QoE Score")
plt.ylabel("Predicted QoE Score")
plt.title("Actual vs Predicted QoE Scores (Deep Learning Model)")
plt.grid()
plt.show()
```

```
7/7 ━━━━━━━━━━━━━━━━━━━━ 0s 7ms/step
```

```
   Actual QoE  Predicted QoE
0    1.000000       0.957789
1    1.000000       1.234877
2    1.000000       1.274469
3    2.801309       1.980495
4    1.000000       1.127310
```



In [24]:
```
import matplotlib.pyplot as plt  # Ensure matplotlib is imported

# Compare all models
models = ["Linear Regression", "Random Forest", "Deep Learning"]
mse_values = [mse_lr, mse_rf, mse_dl]
r2_values = [r2_lr, r2_rf, r2_dl]

# Plot MSE Comparison
plt.figure(figsize=(8, 4))
plt.bar(models, mse_values, color=['blue', 'green', 'red'])
plt.xlabel("Models")
plt.ylabel("Mean Squared Error (MSE)")
plt.title("Model Comparison - MSE")
plt.show()

# Plot R2 Score Comparison
plt.figure(figsize=(8, 4))
plt.bar(models, r2_values, color=['blue', 'green', 'red'])
plt.xlabel("Models")
plt.ylabel("R2 Score")
plt.title("Model Comparison - R2 Score")
plt.show()
```

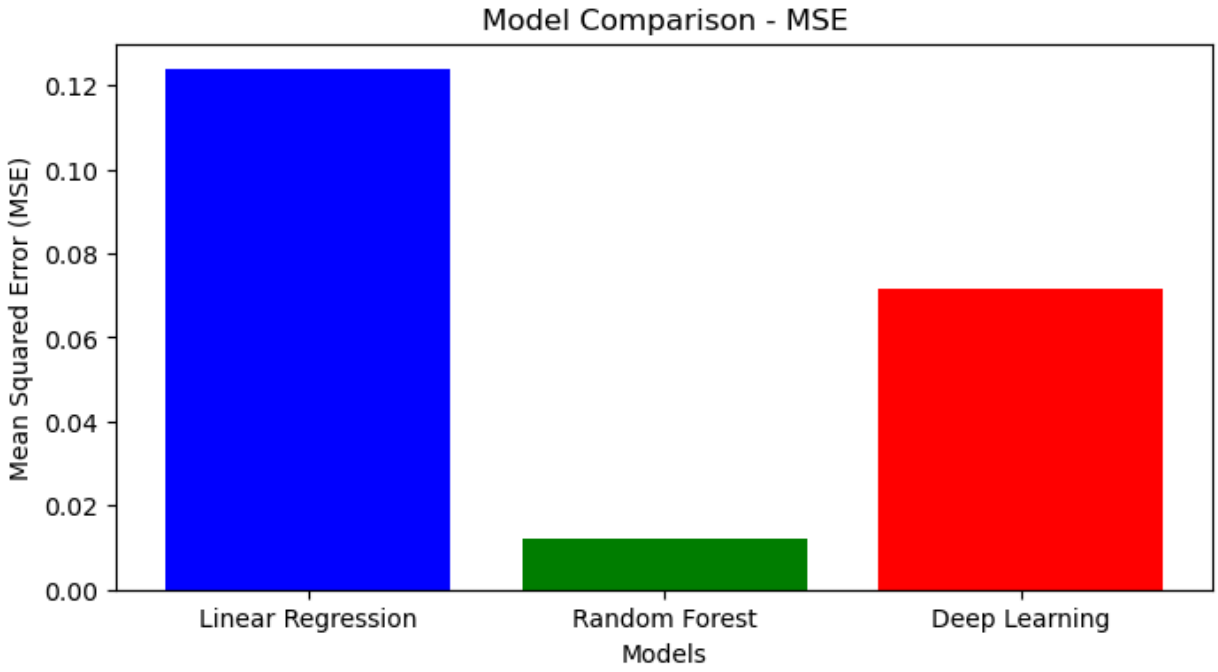
```
---------------------------------------------------------------------------
NameError                                 Traceback (most recent call last)
Cell In[24], line 5
      3 # Compare all models
      4 models = ["Linear Regression", "Random Forest", "Deep Learning"]
----> 5 mse_values = [mse_lr, mse_rf, mse_dl]
      6 r2_values = [r2_lr, r2_rf, r2_dl]
      8 # Plot MSE Comparison

NameError: name 'mse_lr' is not defined
```

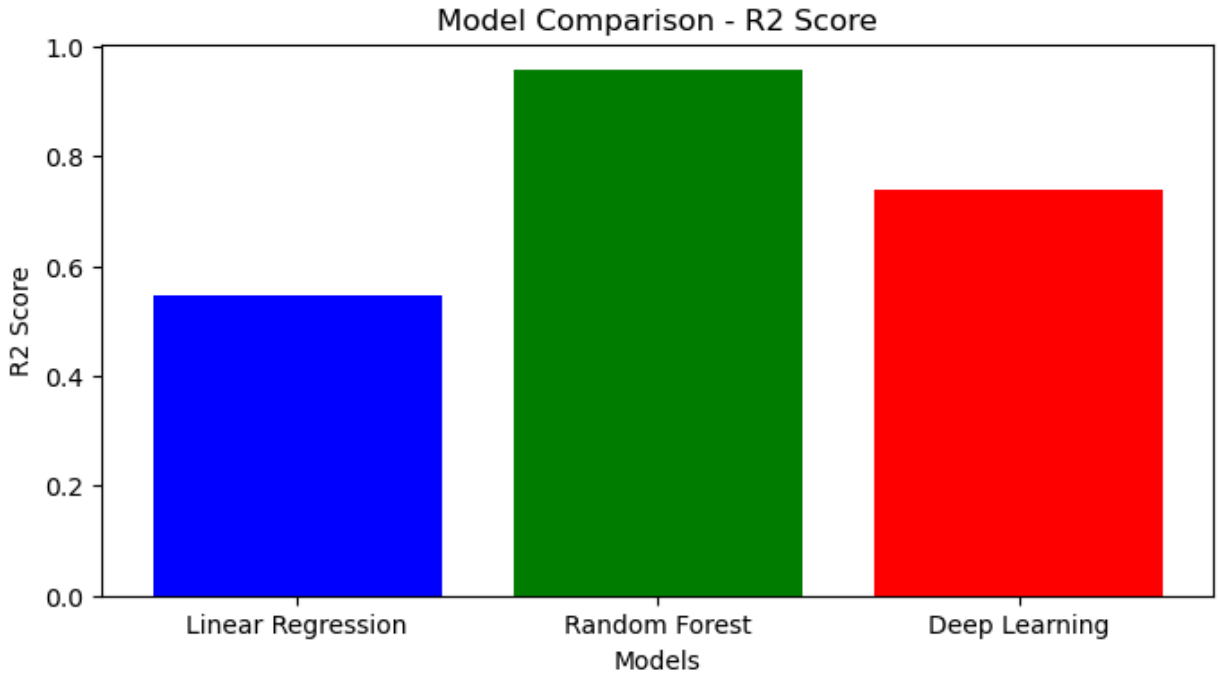
In [30]:
```
from sklearn.linear_model import LinearRegression  # Import Linear Regression model
from sklearn.ensemble import RandomForestRegressor  # Import Random Forest
```

```
from sklearn.metrics import mean_squared_error, r2_score  # Import evaluation metrics
from sklearn.model_selection import train_test_split  # Import data splitting functior
```

In [32]:

```
import matplotlib.pyplot as plt  # Ensure matplotlib is imported

# Ensure required libraries are imported
from sklearn.linear_model import LinearRegression
from sklearn.ensemble import RandomForestRegressor
from sklearn.metrics import mean_squared_error, r2_score
from sklearn.model_selection import train_test_split

# Recreate input-output data if not already defined
X = df[['Latency (ms)', 'Packet Loss (%)', 'Jitter (ms)', 'Bandwidth (Mbps)']]
y = df['QoE Score']
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=

# Train Linear Regression Model
lr_model = LinearRegression()
lr_model.fit(X_train, y_train)
y_pred_lr = lr_model.predict(X_test)
mse_lr = mean_squared_error(y_test, y_pred_lr)
r2_lr = r2_score(y_test, y_pred_lr)

# Train Random Forest Model
rf_model = RandomForestRegressor(n_estimators=100, random_state=42)
rf_model.fit(X_train, y_train)
y_pred_rf = rf_model.predict(X_test)
mse_rf = mean_squared_error(y_test, y_pred_rf)
r2_rf = r2_score(y_test, y_pred_rf)

# Train Deep Learning Model if not already done
if 'mse_dl' not in globals():
    y_pred_dl = deep_model.predict(X_test)
    mse_dl = mean_squared_error(y_test, y_pred_dl)
    r2_dl = r2_score(y_test, y_pred_dl)

# Compare all models
models = ["Linear Regression", "Random Forest", "Deep Learning"]
mse_values = [mse_lr, mse_rf, mse_dl]
r2_values = [r2_lr, r2_rf, r2_dl]

# Plot MSE Comparison
plt.figure(figsize=(8, 4))
plt.bar(models, mse_values, color=['blue', 'green', 'red'])
plt.xlabel("Models")
plt.ylabel("Mean Squared Error (MSE)")
plt.title("Model Comparison - MSE")
plt.show()

# Plot R2 Score Comparison
plt.figure(figsize=(8, 4))
plt.bar(models, r2_values, color=['blue', 'green', 'red'])
plt.xlabel("Models")
plt.ylabel("R2 Score")
plt.title("Model Comparison - R2 Score")
plt.show()
```



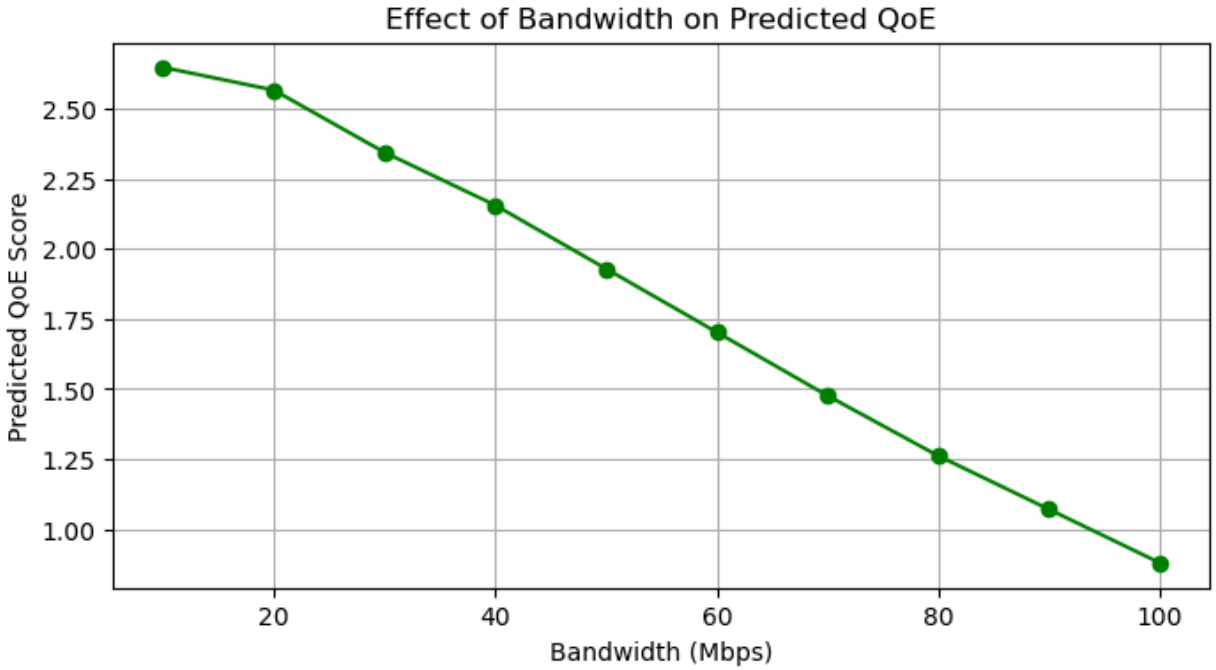


In [34]:
```
def predict_qoe_deep(latency, packet_loss, jitter, bandwidth):
    input_data = pd.DataFrame([[latency, packet_loss, jitter, bandwidth]],
                              columns=['Latency (ms)', 'Packet Loss (%)', 'Jitter (ms)
    qoe_score = deep_model.predict(input_data)[0][0]
    return round(qoe_score, 2)

# Test the function with sample network parameters
latency = 50
packet_loss = 1.5
jitter = 15
bandwidth = 50
predicted_qoe_dl = predict_qoe_deep(latency, packet_loss, jitter, bandwidth)
print(f"Predicted QoE Score (Deep Learning): {predicted_qoe_dl}/5")
```

```
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 69ms/step
Predicted QoE Score (Deep Learning): 2.4700000286102295/5
```

In [36]:
```
# Generate multiple network conditions
network_conditions = pd.DataFrame({
    'Latency (ms)': np.linspace(20, 200, 10),
    'Packet Loss (%)': np.linspace(0, 3, 10),
    'Jitter (ms)': np.linspace(5, 50, 10),
    'Bandwidth (Mbps)': np.linspace(10, 100, 10)
})

# Predict QoE scores using deep learning model
network_conditions['Predicted QoE'] = deep_model.predict(network_conditions)

# Find best condition
optimal_condition = network_conditions.loc[network_conditions['Predicted QoE'].idxmax(
print("Optimal Network Parameters for Best QoE:")
print(optimal_condition)

# Visualizing the effect of bandwidth on QoE
plt.figure(figsize=(8, 4))
plt.plot(network_conditions['Bandwidth (Mbps)'], network_conditions['Predicted QoE'],
plt.title("Effect of Bandwidth on Predicted QoE")
plt.xlabel("Bandwidth (Mbps)")
plt.ylabel("Predicted QoE Score")
plt.grid()
plt.show()
```

```
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 63ms/step
Optimal Network Parameters for Best QoE:
Latency (ms)        20.000
Packet Loss (%)      0.000
Jitter (ms)          5.000
Bandwidth (Mbps)    10.000
Predicted QoE        2.648
Name: 0, dtype: float64
```



In [38]:
```
# Function to suggest network parameter adjustments
def optimize_network(latency, packet_loss, jitter, bandwidth):
    current_qoe = predict_qoe_deep(latency, packet_loss, jitter, bandwidth)
```

```
    if current_qoe < 3:
        if latency > 100: latency -= 20
        if packet_loss > 2: packet_loss -= 0.5
        if jitter > 20: jitter -= 5
        if bandwidth < 50: bandwidth += 10

    optimized_qoe = predict_qoe_deep(latency, packet_loss, jitter, bandwidth)

    return {
        "Original QoE": current_qoe,
        "Optimized QoE": optimized_qoe,
        "Suggested Latency": latency,
        "Suggested Packet Loss": packet_loss,
        "Suggested Jitter": jitter,
        "Suggested Bandwidth": bandwidth
    }

# Example usage
network_status = optimize_network(120, 3, 25, 30)
print("Network Optimization Result:", network_status)
```

```
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 171ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 49ms/step
Network Optimization Result: {'Original QoE': 1.44, 'Optimized QoE': 1.69, 'Suggested
Latency': 100, 'Suggested Packet Loss': 2.5, 'Suggested Jitter': 20, 'Suggested Bandw
idth': 40}
```

In [40]:

```
# Generate summary table for different network conditions
results = []
for latency in [50, 100, 150, 200]:
    for loss in [1, 2, 3]:
        for jitter in [10, 20, 30]:
            for bandwidth in [20, 50, 80]:
                qoe = predict_qoe_deep(latency, loss, jitter, bandwidth)
                results.append([latency, loss, jitter, bandwidth, qoe])

# Convert to DataFrame
summary_df = pd.DataFrame(results, columns=['Latency (ms)', 'Packet Loss (%)', 'Jitter

# Display summary
print("Summary of QoE Predictions under Different Conditions:")
print(summary_df)

# Save as CSV for documentation
summary_df.to_csv("QoE_Prediction_Report.csv", index=False)

# Visualize QoE distribution
plt.figure(figsize=(8, 4))
sns.histplot(summary_df['Predicted QoE'], bins=20, kde=True, color='purple')
plt.title("Distribution of Predicted QoE Scores")
plt.xlabel("Predicted QoE Score")
plt.ylabel("Frequency")
plt.show()
```

```
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 52ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 49ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 43ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 45ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 47ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 43ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 50ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 43ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 46ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 51ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 42ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 44ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 41ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 46ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 46ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 46ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 46ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 44ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 46ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 43ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 42ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 47ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 46ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 51ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 54ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 61ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 68ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 62ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 53ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 59ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 67ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 71ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 51ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 50ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 48ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 57ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 86ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 51ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 49ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 52ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 62ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 53ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 50ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 55ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 46ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 54ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 56ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 51ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 46ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 52ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 54ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 50ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 56ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 58ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 52ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 66ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 55ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 52ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 48ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 48ms/step
```

```
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 53ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 54ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 54ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 51ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 49ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 48ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 52ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 49ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 48ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 53ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 51ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 44ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 57ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 51ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 55ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 51ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 51ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 66ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 90ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 46ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 44ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 53ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 50ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 48ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 53ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 52ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 70ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 60ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 54ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 55ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 61ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 58ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 63ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 61ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 63ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 56ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 48ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 52ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 80ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 57ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 54ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 59ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 63ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 55ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 60ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 51ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 59ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 52ms/step
Summary of QoE Predictions under Different Conditions:
     Latency (ms)  Packet Loss (%)  Jitter (ms)  Bandwidth (Mbps)  \
0              50                1           10                20
1              50                1           10                50
2              50                1           10                80
3              50                1           20                20
4              50                1           20                50
..            ...              ...          ...               ...
103           200                3           20                50
104           200                3           20                80
105           200                3           30                20
106           200                3           30                50
```

```
107           200                3           30                80

     Predicted QoE
0             2.27
1             2.81
2             2.95
3             2.17
4             2.55
..             ...
103           1.21
104           1.36
105           1.16
106           1.12
107           1.30

[108 rows x 5 columns]
```

```
---------------------------------------------------------------------------
NameError                                 Traceback (most recent call last)
Cell In[40], line 22
     20 # Visualize QoE distribution
     21 plt.figure(figsize=(8, 4))
---> 22 sns.histplot(summary_df['Predicted QoE'], bins=20, kde=True, color='purple')
     23 plt.title("Distribution of Predicted QoE Scores")
     24 plt.xlabel("Predicted QoE Score")

NameError: name 'sns' is not defined
```

```
<Figure size 800x400 with 0 Axes>
```

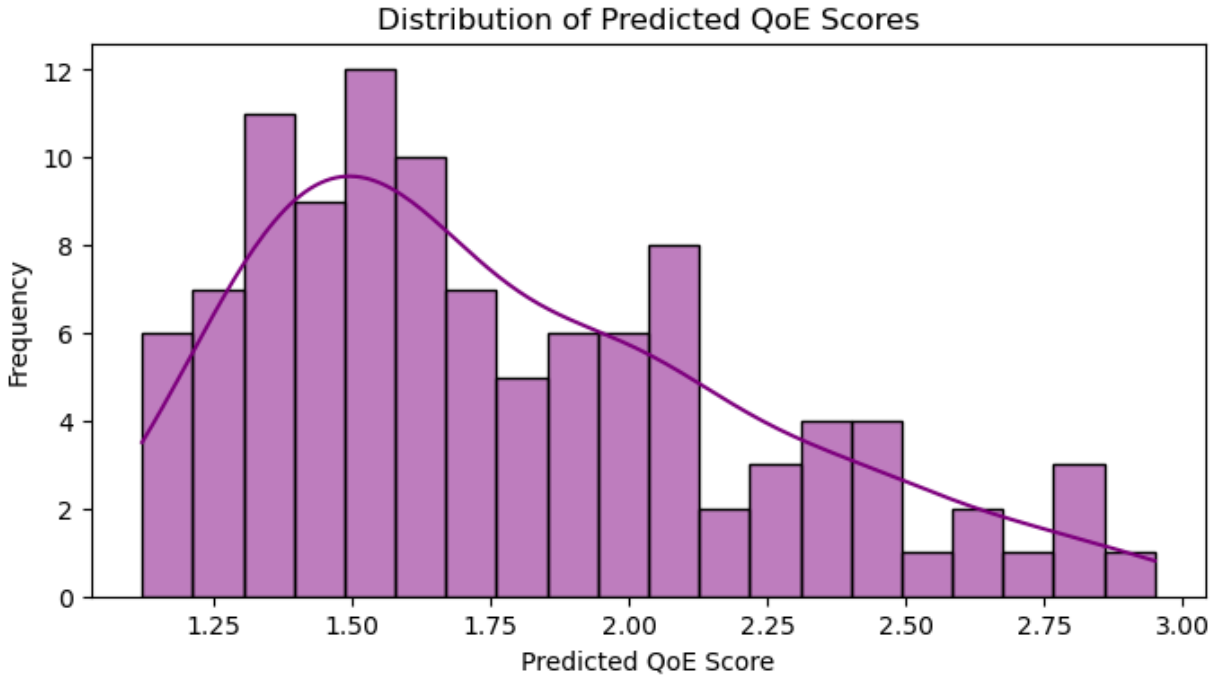
In [42]:
```
import seaborn as sns  # Import Seaborn for visualization
```

In [44]:
```
# Generate summary table for different network conditions
results = []
for latency in [50, 100, 150, 200]:
    for loss in [1, 2, 3]:
        for jitter in [10, 20, 30]:
            for bandwidth in [20, 50, 80]:
                qoe = predict_qoe_deep(latency, loss, jitter, bandwidth)
                results.append([latency, loss, jitter, bandwidth, qoe])

# Convert to DataFrame
summary_df = pd.DataFrame(results, columns=['Latency (ms)', 'Packet Loss (%)', 'Jitter

# Display summary
print("Summary of QoE Predictions under Different Conditions:")
print(summary_df)

# Save as CSV for documentation
summary_df.to_csv("QoE_Prediction_Report.csv", index=False)

# Visualize QoE distribution
plt.figure(figsize=(8, 4))
sns.histplot(summary_df['Predicted QoE'], bins=20, kde=True, color='purple')
plt.title("Distribution of Predicted QoE Scores")
plt.xlabel("Predicted QoE Score")
plt.ylabel("Frequency")
plt.show()
```

```
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 71ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 50ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 45ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 45ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 45ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 50ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 53ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 42ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 45ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 45ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 46ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 45ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 43ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 47ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 43ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 50ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 52ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 47ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 58ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 54ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 55ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 53ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 54ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 51ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 48ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 47ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 44ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 45ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 43ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 43ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 42ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 46ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 53ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 45ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 46ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 48ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 48ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 53ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 46ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 49ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 51ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 45ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 44ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 54ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 45ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 42ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 51ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 48ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 51ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 58ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 50ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 52ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 54ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 57ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 52ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 50ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 45ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 49ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 57ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 50ms/step
```

```
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 53ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 50ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 48ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 50ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 44ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 53ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 80ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 52ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 49ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 47ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 46ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 47ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 53ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 47ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 48ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 45ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 38ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 47ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 46ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 47ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 46ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 48ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 43ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 50ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 57ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 53ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 49ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 51ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 59ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 54ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 49ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 55ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 52ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 50ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 61ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 50ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 55ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 52ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 53ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 59ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 42ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 48ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 58ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 47ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 41ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 49ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 42ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 46ms/step
Summary of QoE Predictions under Different Conditions:
     Latency (ms)  Packet Loss (%)  Jitter (ms)  Bandwidth (Mbps)  \
0              50                1           10                20
1              50                1           10                50
2              50                1           10                80
3              50                1           20                20
4              50                1           20                50
..            ...              ...          ...               ...
103           200                3           20                50
104           200                3           20                80
105           200                3           30                20
106           200                3           30                50
```

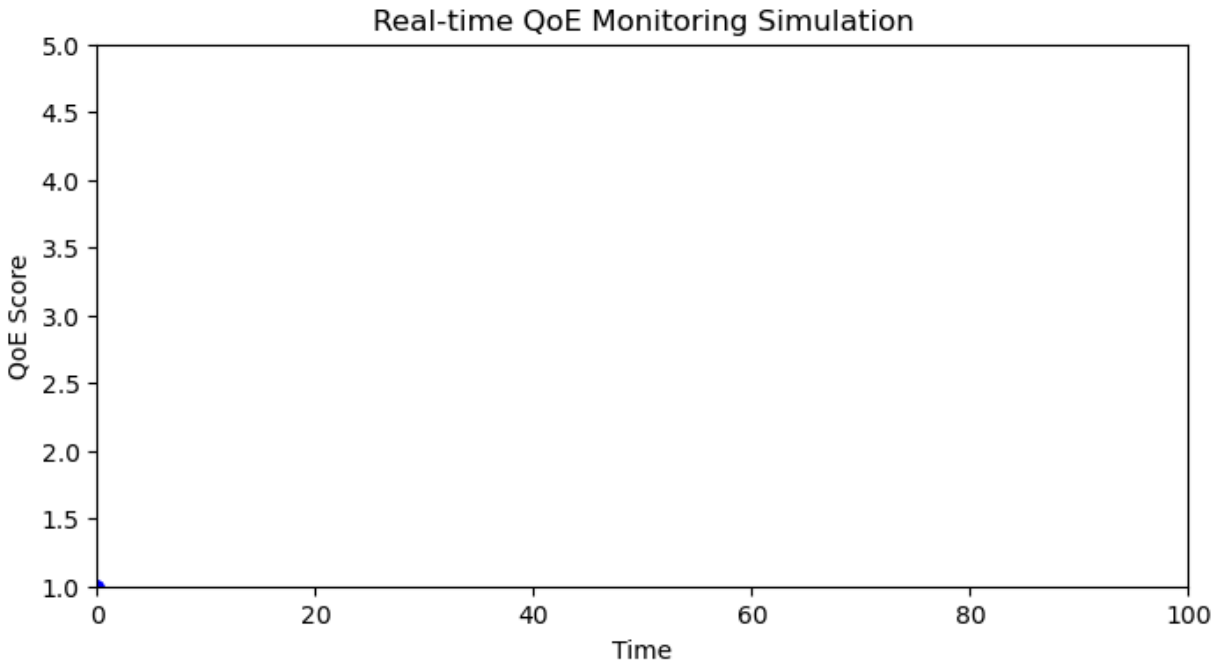
```
107           200                3           30                80

     Predicted QoE
0             2.27
1             2.81
2             2.95
3             2.17
4             2.55
..             ...
103           1.21
104           1.36
105           1.16
106           1.12
107           1.30

[108 rows x 5 columns]
```



In [46]:

```python
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
import random
from matplotlib.animation import FuncAnimation

# Initialize figure
fig, ax = plt.subplots(figsize=(8, 4))
x_data, y_data = [], []
line, = ax.plot([], [], 'bo-', markersize=5)

# Set labels
ax.set_xlim(0, 100)
ax.set_ylim(1, 5)
ax.set_xlabel("Time")
ax.set_ylabel("QoE Score")
ax.set_title("Real-time QoE Monitoring Simulation")

# Function to simulate real-time data
def update(frame):
```

```
    global x_data, y_data

    latency = random.randint(20, 300)  # Simulating Latency (ms)
    jitter = random.randint(5, 100)  # Simulating Jitter (ms)
    packet_loss = random.uniform(0, 5)  # Simulating Packet Loss (%)
    bandwidth = random.uniform(5, 100)  # Simulating Bandwidth (Mbps)

    # Calculate QoE dynamically
    qoe_score = 5 - (latency / 80 + packet_loss / 2 + jitter / 30)
    qoe_score = np.clip(qoe_score, 1, 5)  # Ensure QoE stays between 1-5

    x_data.append(frame)
    y_data.append(qoe_score)

    # Keep only last 100 points
    if len(x_data) > 100:
        x_data.pop(0)
        y_data.pop(0)

    line.set_data(x_data, y_data)
    return line,

# Run animation
ani = FuncAnimation(fig, update, frames=range(100), interval=500, blit=True)
plt.show()
```



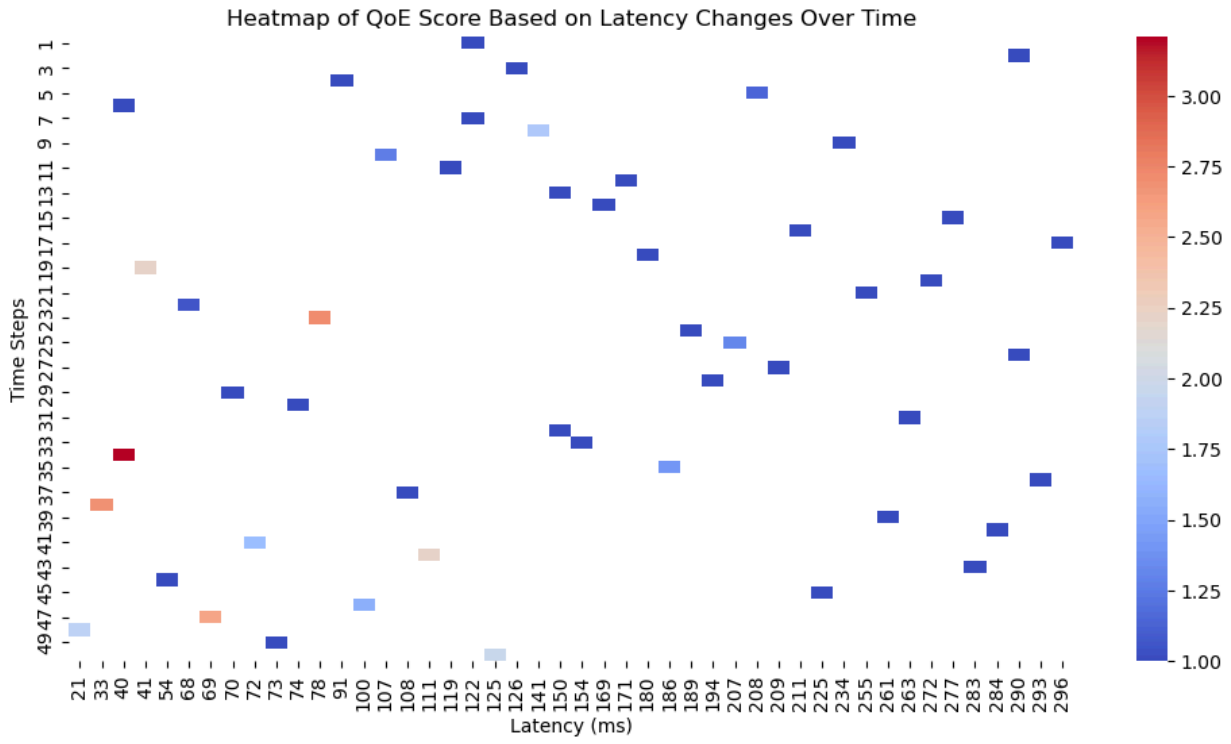
In [48]:

```
def simulate_qoe():
    latency = float(input("Enter Latency (ms): "))
    packet_loss = float(input("Enter Packet Loss (%): "))
    jitter = float(input("Enter Jitter (ms): "))
    bandwidth = float(input("Enter Bandwidth (Mbps): "))

    # Predict QoE using the trained Random Forest model
    input_data = pd.DataFrame([[latency, packet_loss, jitter, bandwidth]],
                              columns=['Latency (ms)', 'Packet Loss (%)', 'Jitter (ms)
    predicted_qoe = rf_model.predict(input_data)[0]

    print(f"Predicted QoE Score: {round(predicted_qoe, 2)} / 5")
```

```
# Run user input simulation
simulate_qoe()
```

```
Predicted QoE Score: 1.16 / 5
```

In [52]:
```
import seaborn as sns
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt

# Generate simulated data
np.random.seed(42)
time_steps = np.arange(1, 51)  # Simulating 50 time steps
latency = np.random.randint(20, 300, 50)
packet_loss = np.random.uniform(0, 5, 50)
jitter = np.random.randint(5, 100, 50)
bandwidth = np.random.uniform(5, 100, 50)

# Compute QoE Scores
qoe_scores = 5 - (latency / 80 + packet_loss / 2 + jitter / 30)
qoe_scores = np.clip(qoe_scores, 1, 5)  # Ensure QoE stays between 1-5

# Create a DataFrame
df_sim = pd.DataFrame({'Time': time_steps, 'Latency': latency, 'QoE Score': qoe_scores

# Use pivot_table instead of pivot to handle duplicate "Latency" values at the same ti
df_pivot = df_sim.pivot_table(index="Time", columns="Latency", values="QoE Score", agg

# Plot Heatmap
plt.figure(figsize=(12, 6))
sns.heatmap(df_pivot, cmap="coolwarm", annot=False)
plt.title("Heatmap of QoE Score Based on Latency Changes Over Time")
plt.xlabel("Latency (ms)")
plt.ylabel("Time Steps")
plt.show()
```



In [54]:
```
import time

def real_time_qoe_prediction():
    print("Starting Real-Time QoE Simulation...\n")

    for i in range(10):  # Simulate for 10 time steps
        latency = np.random.randint(20, 300)
        jitter = np.random.randint(5, 100)
        packet_loss = np.random.uniform(0, 5)
        bandwidth = np.random.uniform(5, 100)

        # Predict QoE using deep learning model
        input_data = np.array([[latency, packet_loss, jitter, bandwidth]])
        predicted_qoe = deep_model.predict(input_data)[0][0]

        print(f"Time Step {i+1}: Latency={latency}ms, Jitter={jitter}ms, Packet Loss={
        time.sleep(1)  # Simulating real-time delay

# Run real-time QoE prediction
real_time_qoe_prediction()
```

```
Starting Real-Time QoE Simulation...

1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 53ms/step
Time Step 1: Latency=131ms, Jitter=64ms, Packet Loss=1.30%, Bandwidth=99.64 Mbps → Predicted QoE: 1.24
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 45ms/step
Time Step 2: Latency=273ms, Jitter=16ms, Packet Loss=2.79%, Bandwidth=88.85 Mbps → Predicted QoE: 1.08
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 43ms/step
Time Step 3: Latency=28ms, Jitter=23ms, Packet Loss=3.63%, Bandwidth=90.23 Mbps → Predicted QoE: 2.29
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 39ms/step
Time Step 4: Latency=171ms, Jitter=58ms, Packet Loss=3.90%, Bandwidth=65.99 Mbps → Predicted QoE: 1.17
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 53ms/step
Time Step 5: Latency=94ms, Jitter=76ms, Packet Loss=3.93%, Bandwidth=68.55 Mbps → Predicted QoE: 1.14
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 47ms/step
Time Step 6: Latency=273ms, Jitter=93ms, Packet Loss=3.32%, Bandwidth=5.48 Mbps → Predicted QoE: 0.93
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 44ms/step
Time Step 7: Latency=213ms, Jitter=58ms, Packet Loss=2.24%, Bandwidth=99.47 Mbps → Predicted QoE: 0.98
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 44ms/step
Time Step 8: Latency=180ms, Jitter=72ms, Packet Loss=1.19%, Bandwidth=35.91 Mbps → Predicted QoE: 1.38
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 44ms/step
Time Step 9: Latency=154ms, Jitter=71ms, Packet Loss=3.29%, Bandwidth=58.99 Mbps → Predicted QoE: 1.11
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 49ms/step
Time Step 10: Latency=41ms, Jitter=34ms, Packet Loss=4.87%, Bandwidth=42.34 Mbps → Predicted QoE: 0.80
```

In [4]:

```python
import numpy as np  # Import NumPy
import pandas as pd  # Import Pandas (since you're using DataFrame)
```

In [6]:

```python
import numpy as np
import pandas as pd

# Simulating realistic network traffic conditions
time_steps = np.arange(1000)  # Simulating over 1000 time steps
data = {
    'Time': time_steps,
    'Latency (ms)': np.random.normal(100, 50, 1000),  # Mean=100, Std=50
    'Packet Loss (%)': np.random.normal(1.5, 1, 1000),
    'Jitter (ms)': np.random.normal(20, 10, 1000),
    'Bandwidth (Mbps)': np.random.normal(50, 20, 1000)
}

df = pd.DataFrame(data)

# Generate QoE Score using a weighted formula
df['QoE Score'] = 5 - (df['Latency (ms)'] / 80 + df['Packet Loss (%)'] / 2 + df['Jitte
df['QoE Score'] = np.clip(df['QoE Score'], 1, 5)  # Ensure QoE stays between 1 and 5

# Display first few rows
df.head()
```

Out[6]:

	Time	Latency (ms)	Packet Loss (%)	Jitter (ms)	Bandwidth (Mbps)	QoE Score
0	0	108.460495	1.188576	33.306166	67.552600	1.939750
1	1	19.659397	1.686803	31.860837	55.707161	2.848828
2	2	91.255006	1.748453	17.421558	51.544013	2.404367
3	3	54.207655	2.555885	20.366863	66.699487	2.365566
4	4	104.315674	2.146345	15.259815	38.300453	2.114221