In [1]:

```
import os
os.environ["TF_CPP_MIN_LOG_LEVEL"] = "2"
```

In [2]:

```
import tensorflow as tf
from tensorflow import keras
from tensorflow.keras import layers
import matplotlib.pyplot as plt
import seaborn as sns
import csv

import pandas as pd
import numpy as np
from sklearn.model_selection import train_test_split
from sklearn.metrics import mean_squared_error
from sklearn.preprocessing import StandardScaler
from threading import Timer
from timeit import default_timer as timer
from IPython.display import clear_output
```

In [3]:

```
start = timer()
prep_dataset1 = pd.read_csv('../datasets/dataset_test_02_07.csv', delimiter="
# prep_dataset2 = pd.read_csv('datasets/com_concept_drift/sdn_train_unormalize
# prep_dataset3 = pd.read_csv('datasets/com_concept_drift/sdn_train_unormalize
# prep_test = pd.read_csv('datasets/com_concept_drift/sdn_test_unormalized.csv

# prep_dataset1 = prep_dataset1[prep_dataset1.delay>0]
# prep_dataset2 = prep_dataset2[prep_dataset2.delay>0]
# prep_dataset3 = prep_dataset3[prep_dataset3.delay>0]
# prep_test = prep_test[prep_test.delay>0]
df = prep_dataset1.iloc[:,1:4]
train_size = int(len(df) * 0.7)
test_size = len(df) - train_size
train, test = df.iloc[0:train_size], df.iloc[train_size:len(df)]
```

In [4]:

```
df
```

Out[4]:

	temperature	label	delay
0	19.3024	1	126.251634
1	19.1652	1	126.251634
2	19175.0000	1	126.251634
3	19.1456	1	126.251634
4	19.1652	1	126.251634
...	...	...	...
4895	19.5768	0	420.416429
4896	19.5866	0	420.416429
4897	19567.0000	0	420.416429
4898	19.5572	0	420.416429
4899	19.5572	0	420.416429

4900 rows × 3 columns

In [5]:

```
train
```

Out[5]:

	temperature	label	delay
0	19.3024	1	126.251634
1	19.1652	1	126.251634
2	19175.0000	1	126.251634
3	19.1456	1	126.251634
4	19.1652	1	126.251634
...	...	...	...
3425	22.6344	1	140.133064
3426	22.6442	1	140.133064
3427	22.7128	1	140.133064
3428	22.7324	1	140.133064
3429	22.7618	1	140.133064

3430 rows × 3 columns

In [6]:

```
test
```

Out[6]:

	temperature	label	delay
3430	22752.0000	1	140.125256
3431	22.7324	1	140.125256
3432	22752.0000	1	140.125256
3433	22.7912	1	140.125256
3434	22.7716	1	140.125256
...	...	...	...
4895	19.5768	0	420.416429
4896	19.5866	0	420.416429
4897	19567.0000	0	420.416429
4898	19.5572	0	420.416429
4899	19.5572	0	420.416429

1470 rows × 3 columns

Normalizing

In [7]:

```
def normalizing(df):
    f_columns = ['temperature']
    scaler1 = StandardScaler().fit(df)
    scaler2 = StandardScaler().fit(df)

    scaler1= scaler1.fit(df[f_columns].to_numpy())
    scaler2 = scaler2.fit(df[['delay']])

    df.loc[:,f_columns] = scaler1.transform(df[f_columns].to_numpy())
    df['delay'] = scaler2.transform(df[['delay']])
    return df


def unormalizing(df,Y_test,y_pred ):

    scaler = StandardScaler().fit(df)
    scaler = scaler.fit(df[['delay']])
    y_test_inv = scaler.inverse_transform(Y_test.reshape(1,-1))
    y_pred_inv = scaler.inverse_transform(y_pred)

    return y_test_inv, y_pred_inv
```

In [8]:

```
def saveFile(dataset, name='dataset'):
    print('saving: ',name, '......')
    f = open(name,'w')
    try:
        writer = csv.writer(f)
        writer.writerow(dataset.columns)
        for i in np.arange(int(dataset.shape[0])):
            writer.writerow(dataset.iloc[i,])
    finally:
        f.close()


def preprocessing(dataset, order):
    print(dataset)
    saveFile(dataset, 'datasets/mininet/sdn_train_mininet_unormalized_'+str(o
    norm = normalizing(dataset)
    saveFile(norm, 'datasets/mininet/sdn_train_mininet_normalized_'+str(order

    return norm
```

In [9]:

```
def create_dataset(X, y, time_steps=1):
    Xs, ys = [], []
    for i in range(len(X) - time_steps):
        clear_output(wait=True)
        print('modeling to keras ',round((i/(len(X) - time_steps))*100,2), ('
        s = round(timer() - start)
        if(s>60):
            s /=60
            print(' ', s, ' seconds')
        v = X.iloc[i: (i+time_steps), 1:3].to_numpy()
        Xs.append(v)
        ys.append(y.iloc[i+time_steps])
    return np.array(Xs), np.array(ys)
```

In [10]:

```
preprocessing(train, 'train')
preprocessing(test,'test')
```

```
      temperature  label       delay
0         19.3024      1  126.251634
1         19.1652      1  126.251634
2      19175.0000      1  126.251634
3         19.1456      1  126.251634
4         19.1652      1  126.251634
...           ...    ...         ...
3425      22.6344      1  140.133064
3426      22.6442      1  140.133064
3427      22.7128      1  140.133064
3428      22.7324      1  140.133064
3429      22.7618      1  140.133064

[3430 rows x 3 columns]
saving:  datasets/mininet/sdn_train_mininet_unormalized_train.c
sv ......

C:\Users\silva\anaconda3\lib\site-packages\pandas\core\indexin
g.py:1736: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFra
me.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.or
g/pandas-docs/stable/user_guide/indexing.html#returning-a-view-
versus-a-copy (https://pandas.pydata.org/pandas-docs/stable/use
r_guide/indexing.html#returning-a-view-versus-a-copy)
  isetter(loc, value[:, i].tolist())
<ipython-input-7-90b713e14068>:10: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFra
me.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.or
g/pandas-docs/stable/user_guide/indexing.html#returning-a-view-
versus-a-copy (https://pandas.pydata.org/pandas-docs/stable/use
r_guide/indexing.html#returning-a-view-versus-a-copy)
  df['delay'] = scaler2.transform(df[['delay']])

saving:  datasets/mininet/sdn_train_mininet_normalized_trai
n.csv ......
      temperature  label       delay
3430   22752.0000      1  140.125256
3431      22.7324      1  140.125256
3432   22752.0000      1  140.125256
3433      22.7912      1  140.125256
3434      22.7716      1  140.125256
```

```
...           ...    ...          ...
4895      19.5768      0  420.416429
4896      19.5866      0  420.416429
4897   19567.0000      0  420.416429
4898      19.5572      0  420.416429
4899      19.5572      0  420.416429

[1470 rows x 3 columns]
saving:  datasets/mininet/sdn_train_mininet_unormalized_tes
t.csv ......

C:\Users\silva\anaconda3\lib\site-packages\pandas\core\indexin
g.py:1736: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFra
me.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.or
g/pandas-docs/stable/user_guide/indexing.html#returning-a-view-
versus-a-copy (https://pandas.pydata.org/pandas-docs/stable/use
r_guide/indexing.html#returning-a-view-versus-a-copy)
  isetter(loc, value[:, i].tolist())
<ipython-input-7-90b713e14068>:10: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFra
me.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.or
g/pandas-docs/stable/user_guide/indexing.html#returning-a-view-
versus-a-copy (https://pandas.pydata.org/pandas-docs/stable/use
r_guide/indexing.html#returning-a-view-versus-a-copy)
  df['delay'] = scaler2.transform(df[['delay']])

saving:  datasets/mininet/sdn_train_mininet_normalized_test.csv
......
```

Out[10]:

	temperature	label	delay
3430	2.706406	1	-0.765642
3431	-0.399553	1	-0.765642
3432	2.706406	1	-0.765642
3433	-0.399545	1	-0.765642
3434	-0.399548	1	-0.765642
...	...	...	...
4895	-0.399984	0	0.697763
4896	-0.399983	0	0.697763

	temperature	label	delay
4897	2.271175	0	0.697763
4898	-0.399987	0	0.697763
4899	-0.399987	0	0.697763

In [11]:

```
def LSTMconf(X_train):
    print('Init config LSTM')
    model = keras.Sequential()
    model.add(
        keras.layers.Bidirectional(
            keras.layers.LSTM(
                 activation="relu",
                units=512,
                input_shape=(X_train.shape[1],X_train.shape[2])
            )
        ))
    model.add(keras.layers.Dense(units=512, activation="relu"))
    model.add(keras.layers.Dense(units=512, activation="relu"))
    model.add(keras.layers.Dense(units=512, activation="relu"))
    model.add(keras.layers.Dense(units=512, activation="relu"))
    model.add(keras.layers.Dropout(rate=0.2))
    model.add(keras.layers.Dense(units=1))

    loss ="mse"
    optim = tf.keras.optimizers.Adam(
    learning_rate=0.0001)
    metrics=["accuracy"]

    model.compile(loss=loss, optimizer=optim,
#              metrics=metrics
             )
    return model
```

In [12]:

```
def LSTMfit(model,X_train,Y_train):
    print('Init Train')
    start = timer()
    history = model.fit(
        X_train, Y_train,
        epochs=256,
        batch_size= 128,
        validation_split=0.1,
        shuffle=False,
    #     callbacks=[tensorboard_callback]
    )
    return history
```

In [13]:

```
train = pd.read_csv('datasets/mininet/sdn_train_mininet_normalized_train.csv'
test = pd.read_csv('datasets/mininet/sdn_train_mininet_normalized_test.csv', 
X_train,Y_train = create_dataset(train, train.delay)
model = LSTMconf(X_train)
history = LSTMfit(model,X_train, Y_train)

# r = Timer(1.0, preprocessing, (prep_dataset.iloc[cont:cont+window,:]))
# r.start()
# print(X_train)
```

```
25/25 [==============================] - 1s 57ms/step - los
s: 0.0175 - val_loss: 0.0198
Epoch 251/256
25/25 [==============================] - 2s 62ms/step - los
s: 0.0128 - val_loss: 0.0366
Epoch 252/256
25/25 [==============================] - 1s 54ms/step - los
s: 0.0158 - val_loss: 0.0209
Epoch 253/256
25/25 [==============================] - 1s 50ms/step - los
s: 0.0116 - val_loss: 0.0340
Epoch 254/256
25/25 [==============================] - 1s 51ms/step - los
s: 0.0130 - val_loss: 0.0309
Epoch 255/256
25/25 [==============================] - 1s 56ms/step - los
s: 0.0113 - val_loss: 0.0210
Epoch 256/256
25/25 [==============================] - 1s 60ms/step - los
s: 0.0091 - val_loss: 0.0309
```

In [14]:

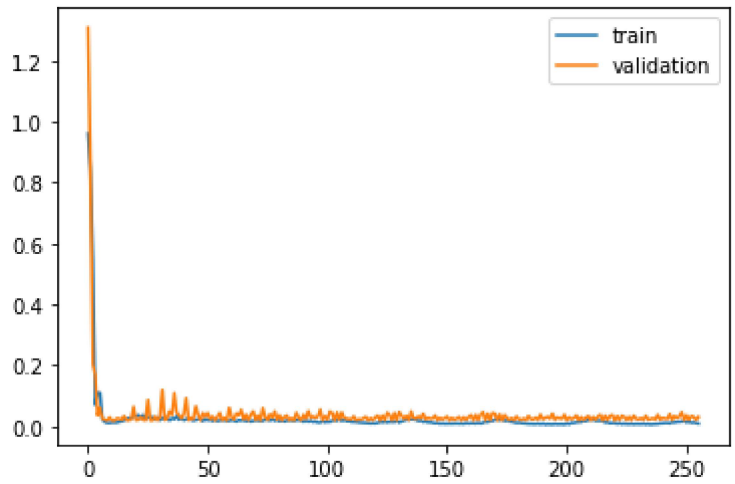
```
print('Saving Model')
model.save('models/lstm_mininet')
```

```
Saving Model
INFO:tensorflow:Assets written to: models/lstm_mininet\assets
```

loss training

In [15]:

```
fig1 = plt.figure()
ax1 = fig1.add_subplot(1,1,1)
ax1.plot(history.history['loss'], label='train')
ax1.plot(history.history['val_loss'], label='validation')
ax1.legend();
```



In [16]:

```
test_un = pd.read_csv('datasets/mininet/sdn_train_mininet_unormalized_test.csv
test = pd.read_csv('datasets/mininet/sdn_train_mininet_normalized_test.csv', 
X_test,Y_test = create_dataset(test, test.delay)
```

```
modeling to keras  99.93 %  6.8  seconds
```

In [17]:

```
test_un
```

Out[17]:

	temperature	label	delay
0	22752.0000	1.0	140.125256
1	22.7324	1.0	140.125256
2	22752.0000	1.0	140.125256
3	22.7912	1.0	140.125256
4	22.7716	1.0	140.125256
...	...	...	...
1465	19.5768	0.0	420.416429
1466	19.5866	0.0	420.416429
1467	19567.0000	0.0	420.416429
1468	19.5572	0.0	420.416429
1469	19.5572	0.0	420.416429

1470 rows × 3 columns

predicting

In [18]:

```
y_pred = model.predict(X_test)
```

unormalizing

In [19]:

```
y_test_inv, y_pred_inv = unormalizing(test_un, Y_test, y_pred)
```

In [20]:

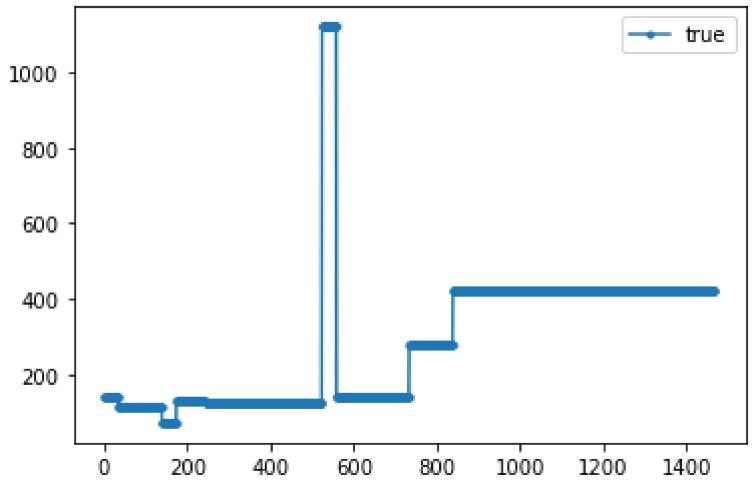
```
y_test_inv
```

Out[20]:

```
array([[140.1252563 , 140.1252563 , 140.1252563 , ..., 420.4164
2904,
        420.41642904, 420.41642904]])
```

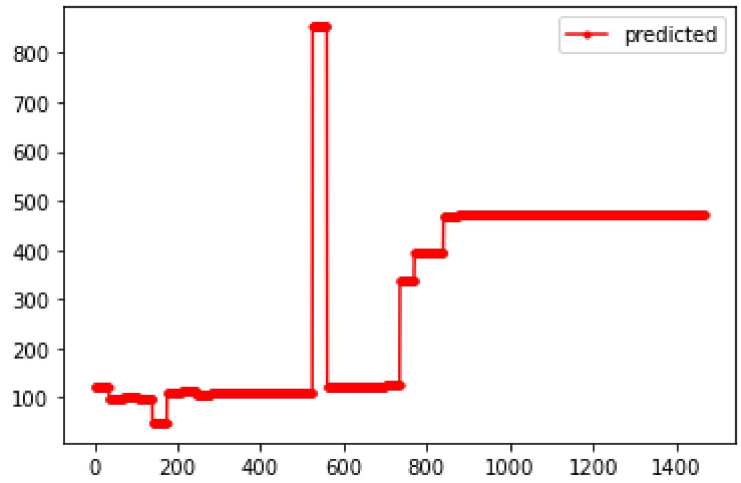
In [21]:

```
fig2 = plt.figure()
a2 = fig2.add_subplot(1,1,1)
a2.plot(y_test_inv.flatten(), marker='.', label='true')
a2.legend();
```



In [22]:

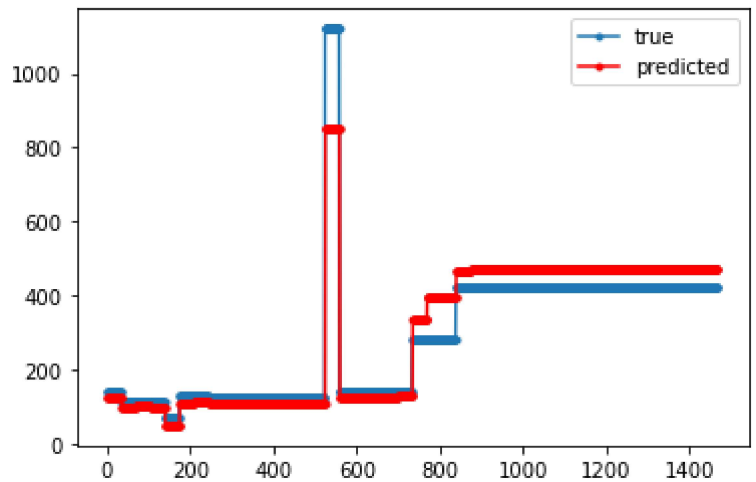
```
fig3 = plt.figure()
a3 = fig3.add_subplot(1,1,1)
a3.plot(y_pred_inv.flatten(),'r',marker='.', label='predicted')
a3.legend();
```



In [23]:

```
fig4 = plt.figure()
a4 = fig4.add_subplot(1,1,1)

a4.plot(y_test_inv.flatten(), marker='.', label='true')
a4.plot(y_pred_inv.flatten(),'r',marker='.', label='predicted')
a4.legend();
```



In [24]:

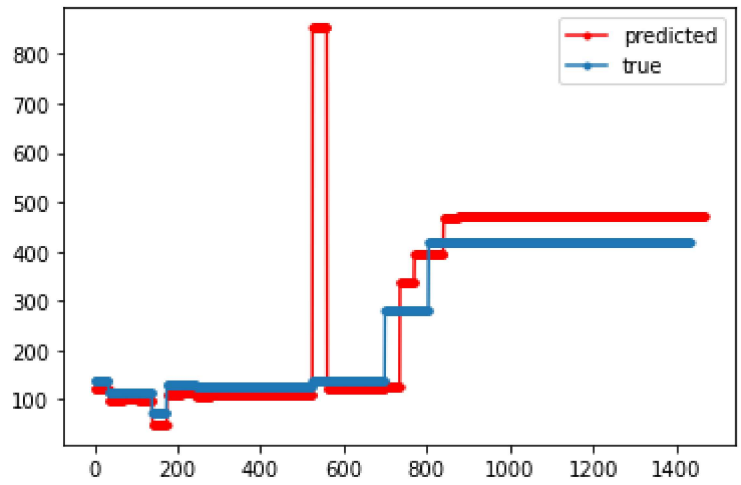
```
l1 = []
l2 = []
for i in np.arange(y_pred_inv.shape[0]):
    clear_output(wait=True)
    print('progress ',round((i/y_pred_inv.shape[0])*100,2), ('%'))
    if(y_pred_inv[i,0]<=1000):
        l1.append(y_pred_inv[i,0])
    if(y_test_inv[0,i]<=1000):
        l2.append(y_test_inv[0,i])

y_pred_inv2 = np.array(l1)
y_test_inv2 = np.array(l2)
```

```
progress  99.93 %
```

In [25]:

```
plt.plot(y_pred_inv2.flatten(),'r',marker='.', label='predicted')
plt.plot(y_test_inv2.flatten(), marker='.', label='true')
plt.legend();
```



In [26]:

```
from sklearn.metrics import mean_squared_error
from sklearn.metrics import median_absolute_error
from sklearn.metrics import mean_absolute_error
from sklearn.metrics import mean_squared_log_error
```

In [27]:

```
size = np.min([y_pred_inv2.shape[0],y_test_inv2.shape[0] ])
rmse =  mean_squared_error(y_test_inv2[0:size], y_pred_inv2[0:size], squared=
mae =  mean_absolute_error(y_test_inv2[0:size], y_pred_inv2[0:size])
median_mae = median_absolute_error(y_test_inv2[0:size], y_pred_inv2[0:size])


print(rmse)
print(mae)
print(median_mae)
```

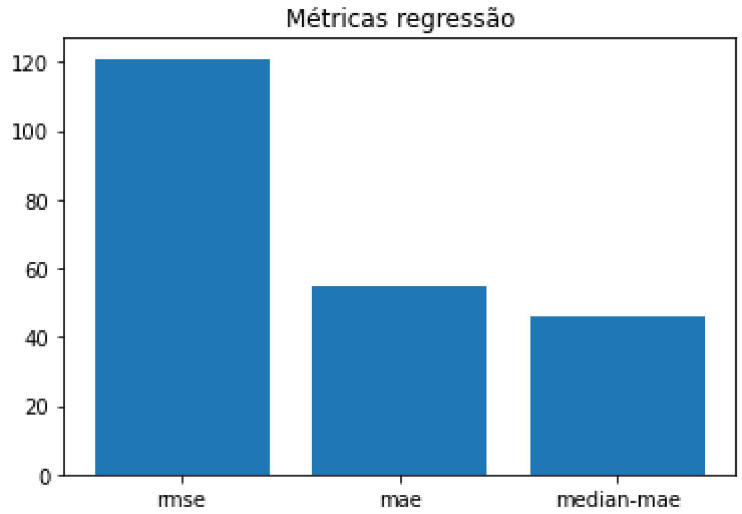
```
120.9622638637501
54.740776156281825
45.79392862319946
```

In [28]:

```
objects = ('rmse', 'mae', 'median-mae')
y_pos = np.arange(3)
performance = [rmse,mae,median_mae]

plt.bar(y_pos, performance, align='center')
plt.xticks(y_pos, objects)
#plt.ylabel('Usage')
plt.title('Métricas regressão')

plt.show()
```



In [29]:

```
from sklearn.metrics import explained_variance_score
```

In [30]:

```
explained_variance_score(y_test_inv2[0:size], y_pred_inv2[0:size])
```

Out[30]:

```
0.3224903034115163
```

In [31]:

```
y_test_inv2[0:size]
```

Out[31]:

```
array([140.1252563 , 140.1252563 , 140.1252563 , ..., 420.41642
904,
       420.41642904, 420.41642904])
```

In [ ]:

In [ ]:

In [ ]: