Text generation using Cornell movie dialogs corpus

In [1]:
```
import numpy as np # linear algebra
import pandas as pd # data processing, CSV file I/O (e.g. pd.read_csv)
import re
from wordcloud import WordCloud
import matplotlib.pyplot as plt
import plotly.express as px
from collections import Counter
from sklearn.model_selection import train_test_split
import tensorflow as tf
from tqdm import tqdm
import spacy
import nltk
import markovify
```

1. Data preparation

1.1 Install the convokit and download the corpus

In [50]:
```
!pip install convokit
from convokit import Corpus, download
corpus = Corpus(filename=download("movie-corpus"))
```

```
Downloading movie-corpus to /root/.convokit/downloads/movie-corpus
Downloading movie-corpus from http://zissou.infosci.cornell.edu/convokit/datasets/movie-corpus/movie-corpus.zip (40.9MB)... Done
```

1.11 Utterances dataframe

In [20]:
```
df=corpus.get_utterances_dataframe()
df
```

Out[20]:

id	timestamp	text	speaker	reply_to	conversation_id	meta.movie_id	meta.parsed	vectors
L1045	None	They do not!	u0	L1044	L1044	m0	[{'rt': 1, 'toks': [{'tok': 'They', 'tag': 'PR...	[]
L1044	None	They do to!	u2	None	L1044	m0	[{'rt': 1, 'toks': [{'tok': 'They', 'tag': 'PR...	[]
L985	None	I hope so.	u0	L984	L984	m0	[{'rt': 1, 'toks': [{'tok': 'I', 'tag': 'PRP',...	[]
L984	None	She okay?	u2	None	L984	m0	[{'rt': 1, 'toks': [{'tok': 'She', 'tag': 'PRP...	[]
L925	None	Let's go.	u0	L924	L924	m0	[{'rt': 0, 'toks': [{'tok': 'Let', 'tag': 'VB'...	[]
...	...	...	...	...	...	...	...	...
L666371	None	Lord Chelmsford seems to want me to stay back ...	u9030	L666370	L666369	m616	[{'rt': 2, 'toks': [{'tok': 'Lord', 'tag': 'NN...	[]
L666370	None	I'm to take the Sikali with the main column to...	u9034	L666369	L666369	m616	[{'rt': 1, 'toks': [{'tok': 'I', 'tag': 'PRP',...	[]
L666369	None	Your orders, Mr Vereker?	u9030	None	L666369	m616	[{'rt': 1, 'toks': [{'tok': 'Your', 'tag': 'PR...	[]
L666257	None	Good ones, yes, Mr Vereker. Gentlemen who can ...	u9030	L666256	L666256	m616	[{'rt': 1, 'toks': [{'tok': 'Good', 'tag': 'JJ...	[]
L666256	None	Colonel Durnford... William Vereker. I hear yo...	u9034	None	L666256	m616	[{'rt': 1, 'toks': [{'tok': 'Colonel', 'tag': ...	[]

304713 rows × 8 columns

1.12 Speakers dataframe

In [21]:
```
corpus.get_speakers_dataframe()
```

Out[21]:

id	vectors	meta.character_name	meta.movie_idx	meta.movie_name	meta.gender	meta.credit_pos
u0	[]	BIANCA	m0	10 things i hate about you	f	4
u2	[]	CAMERON	m0	10 things i hate about you	m	3
u3	[]	CHASTITY	m0	10 things i hate about you	?	?
u4	[]	JOEY	m0	10 things i hate about you	m	6
u5	[]	KAT	m0	10 things i hate about you	f	2
...	...	...	...	...	...	...
u9029	[]	CREALOCK	m616	zulu dawn	?	?
u9033	[]	STUART SMITH	m616	zulu dawn	?	?
u9028	[]	COGHILL	m616	zulu dawn	?	?
u9031	[]	MELVILL	m616	zulu dawn	?	?
u9034	[]	VEREKER	m616	zulu dawn	?	?

9035 rows × 6 columns

1.13 conversations dataframe

In [22]:
```
corpus.get_conversations_dataframe()
```

Out[22]:

	vectors	meta.movie_idx	meta.movie_name	meta.release_year	meta.rating	meta.votes	meta.genre
id							
L1044	[]	m0	10 things i hate about you	1999	6.90	62847	['comedy', 'romance']
L984	[]	m0	10 things i hate about you	1999	6.90	62847	['comedy', 'romance']
L924	[]	m0	10 things i hate about you	1999	6.90	62847	['comedy', 'romance']
L870	[]	m0	10 things i hate about you	1999	6.90	62847	['comedy', 'romance']
L866	[]	m0	10 things i hate about you	1999	6.90	62847	['comedy', 'romance']
...	...	...	...	...	...	...	...
L666324	[]	m616	zulu dawn	1979	6.40	1911	['action', 'adventure', 'drama', 'history', 'w...
L666262	[]	m616	zulu dawn	1979	6.40	1911	['action', 'adventure', 'drama', 'history', 'w...
L666520	[]	m616	zulu dawn	1979	6.40	1911	['action', 'adventure', 'drama', 'history', 'w...
L666369	[]	m616	zulu dawn	1979	6.40	1911	['action', 'adventure', 'drama', 'history', 'w...
L666256	[]	m616	zulu dawn	1979	6.40	1911	['action', 'adventure', 'drama', 'history', 'w...

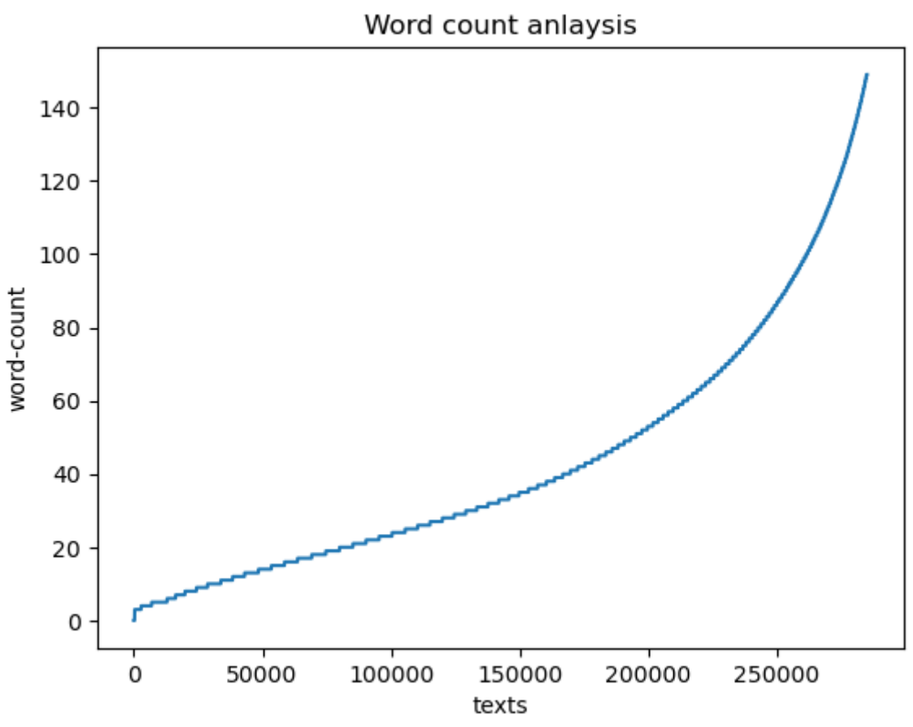
83097 rows × 7 columns

2. Exploratory data analysis (EDA)

2.1 Text length analysis

In [23]:
```
'''Plot of texts vs word count'''
a=(df['text'].apply(lambda x:len(x)))
textLength=sorted(list(a))
textLength=[i for i in textLength if i <150]
ind=[i for i in range(len(textLength))]
cdf=pd.DataFrame.from_dict({'text_count':ind,'textLength':textLength})
plt.plot(ind,textLength)
plt.xlabel('texts')
plt.ylabel('word-count')
plt.title('Word count anlaysis')
```

Out[23]:
```
Text(0.5, 1.0, 'Word count anlaysis')
```



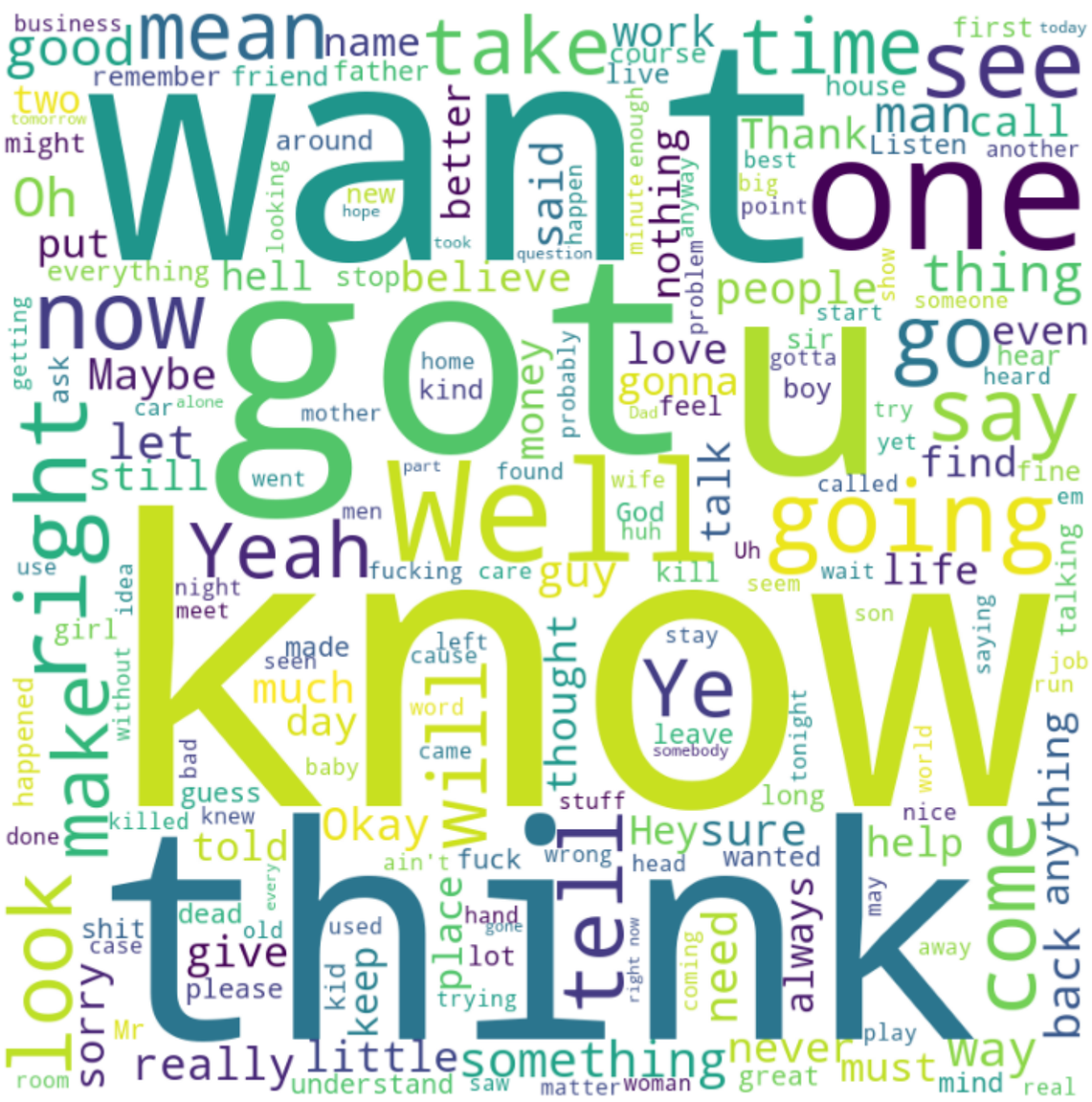
From the line plot of the text length,

- Nearly 50% of texts are formed by text with word counts<30 words.
- Nearly 80% of texts are formed by text with word counts<60 words

We have a considerably large number of lengthy texts available in our corpus.

2.2 Word cloud analysis

In [24]:
```
'''Word cloud'''
text=list(df['text'])
cloudWords = " ".join(text)
wordCloud=WordCloud(width=800,height=800,background_color="white",min_font_size=10).generate(cloudWords)
plt.figure(figsize=(7,7),facecolor=None)
plt.imshow(wordCloud)
plt.axis("off")
plt.tight_layout(pad=0)
```



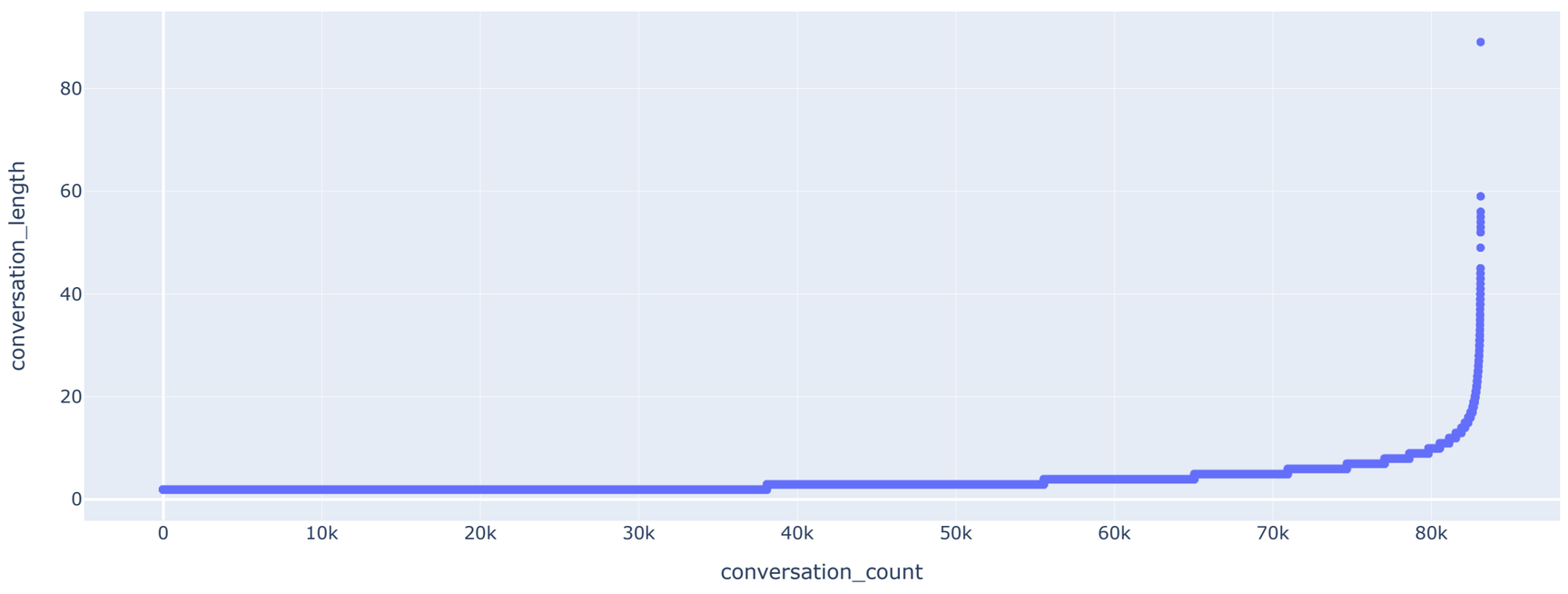
From the word cloud,

- The words know,think and want are most occuring words in the corpus
- The words well,got,one and going are next most occuring words in the corpus.

Most of the words are typical words that are used in normal conversations.

2.3 Conversation length analysis

In [25]:
```
'''Plot of conversation length'''
conv_length=Counter(list(df['conversation_id']))
ind=[i for i in range(len(conv_length.keys()))]
converstation_length=sorted(conv_length.values())
cdf=pd.DataFrame.from_dict({'conversation_count':ind,'conversation_length':converstation_length})

fig=px.scatter(cdf,x='conversation_count',y='conversation_length',
          title='conversation_length Anlysis')
fig.update_yaxes(matches=None)
fig.show()
```



From the linechart of the conversations length,

- Nearly half of the conversations in the corpus have length 2.
- Nearly 7% of the conversation has a length of 4.
- Almost 90% of conversations have length less than 8.

Most of the conversation in the corpus have short duration only very few are of long duration

3. Data preprocessing

In [51]:
```
'''Create 2 columns from utterances_dataframe using text data for input and
label also a reference array to find BLEU score'''

df=corpus.get_utterances_dataframe()
df=df[['conversation_id','text']]
df=df[:100000]
ref=list(df.text.apply(lambda x:x.split()))
```

In [4]:
```
'''Create new columns for decoder_ouput,decoder_input and append start and
end tokens to decoder data'''


df['encoder_input']=df.groupby(['conversation_id'])['text'].shift(1)
df=df.dropna()
df=df[['encoder_input','text']]


df.rename(columns={'text':'decoder_input'},inplace=True)
df['decoder_output']=df['decoder_input']

df['decoder_input']='<start> '+df['decoder_input']
df['decoder_output']=df['decoder_output']+' <end>'
df['decoder_input'].iloc[0]=df['decoder_input'].iloc[0]+' <end>'
df
```

Out[4]:

	encoder_input	decoder_input	decoder_output
id			
L1044	They do not!	<start> They do to! <end>	They do to! <end>
L984	I hope so.	<start> She okay?	She okay? <end>
L924	Let's go.	<start> Wow	Wow <end>
L871	Okay -- you're gonna need to learn how to lie.	<start> No	No <end>
L870	No	<start> I'm kidding. You know how sometimes y...	I'm kidding. You know how sometimes you just ...
...	...	...	...
L536608	Then you must spend your life answering questi...	<start> I don't like to leave questions unansw...	I don't like to leave questions unanswered. <end>
L536607	I don't like to leave questions unanswered.	<start> Why?	Why? <end>
L536606	Why?	<start> I understand how you feel. We just wan...	I understand how you feel. We just want to ret...
L536548	Capability, yes. But where can warp drive take...	<start> You have warp capability?	You have warp capability? <end>
L536542	If I were in your shoes, I'd feel the same way...	<start> Your directive apparently doesn't incl...	Your directive apparently doesn't include spyi...

72570 rows × 3 columns

In [5]:
```
import gc
train=df
del df
gc.collect()
```

Out[5]:
```
23
```

In [6]:
```
'''Build tokenizer with encoder_input and decoder_input train set'''
encoder_input_tokenizer=tf.keras.preprocessing.text.Tokenizer(filters='!"#$()*+/:;=@[\\]^_`{|}~\t\n',
                                          lower=False,
                                          )
encoder_input_tokenizer.fit_on_texts(train['encoder_input'].values)
decoder_input_tokenizer=tf.keras.preprocessing.text.Tokenizer(filters='!"#$%()*+/:;=@[\\]^_`{|}~\t\n',
                                          lower=False,
                                          )
decoder_input_tokenizer.fit_on_texts(train['decoder_input'].values)
```

In [7]:
```
'''vocab lengths of encoder_input and decoder_input tokens '''
encoder_inlen=len(encoder_input_tokenizer.word_index.keys())
decoder_inlen=len(decoder_input_tokenizer.word_index.keys())
len(encoder_input_tokenizer.word_index.keys()),len(decoder_input_tokenizer.word_index.keys())
```

Out[7]:
```
(58466, 57979)
```

In [18]:
```
'''<start> and <end> words integer equilent token'''
decoder_input_tokenizer.word_index['<end>'],decoder_input_tokenizer.word_index['<start>'],
```

Out[18]:
```
(24640, 1)
```

In [8]:
```
'''Tokenize and pad the input and output text'''
max_input_len=105
max_sentencelen=22
enocoder_input_tokenized_train=encoder_input_tokenizer.texts_to_sequences(train['encoder_input'].values)
decoder_input_tokenized_train=decoder_input_tokenizer.texts_to_sequences(train['decoder_input'].values)
decoder_output_tokenized_train=decoder_input_tokenizer.texts_to_sequences(train['decoder_output'].values)

enocoder_input_padded_train=tf.keras.preprocessing.sequence.pad_sequences(enocoder_input_tokenized_train,
                                                                          maxlen=max_input_len
                                                                          ,truncating='post',
                                                                          padding='post',)
decoder_input_padded_train=tf.keras.preprocessing.sequence.pad_sequences(decoder_input_tokenized_train,
                                                                         maxlen=max_sentencelen
                                                                         ,truncating='post',
                                                                         padding='post')
decoder_output_padded_train=tf.keras.preprocessing.sequence.pad_sequences(decoder_output_tokenized_train,
                                                                          maxlen=max_sentencelen
                                                                          ,truncating='post',
                                                                          padding='post')
```

In [30]:
```
joblib.dump(encoder_input_tokenizer,'encoder_input_tokenizer.pkl')
joblib.dump(decoder_input_tokenizer,'decoder_input_tokenizer.pkl')
import gc
del enocoder_input_tokenized_train,decoder_input_tokenized_train,corpus
gc.collect()
```

Out[30]:
```
['decoder_input_tokenizer.pkl']
```

4. Modelling

4.1 Recurrent Neural Network

In [13]:

```
'''Encoder block'''
class Encoder(tf.keras.Model):
    '''Initialize with vocabulary counts of input for embed layer,counts of embedding layer output,
length of input sequence and number of lstm units for lstm'''
    def __init__(self,encoder_vocab_size,embedding_size,lstm_units,input_sequence_length):
        super().__init__()
        self.vocab_size=encoder_vocab_size
        self.embedding_size=embedding_size
        self.input_length=input_sequence_length
        self.lstm_units=lstm_units

        self.embedding=tf.keras.layers.Embedding(input_dim=self.vocab_size,
                                                 output_dim=self.embedding_size,
                                                 input_length=self.input_length,
                                                 mask_zero=True,
                                                 name='encoder_embedding_layer')
        self.lstm=tf.keras.layers.LSTM(self.lstm_units,return_state=True,
                                       return_sequences=True,
                                       name='encoder_lstm_layer')
        '''Call the encoder with input sequence and, lstm states wich are initilized using iniitilize_
        states function  and return final lstm output,states.'''
    def call(self,input_sequence,states):

        embedded_output=self.embedding(input_sequence)
        lstm_output,lstm_stateh,lstm_statec=self.lstm(embedded_output,states)
        return lstm_output,lstm_stateh,lstm_statec
        '''Initilize lstm initial states with batch_size and lstm_units counts'''
    def initialize_states(self,batch_size):
        initial_stateh=tf.zeros(shape=(batch_size,self.lstm_units))
        initial_statec=tf.zeros(shape=(batch_size,self.lstm_units))

        return initial_stateh,initial_statec


'''Decoder block'''
class Decoder(tf.keras.Model):
    '''Initialize with vocabulary counts of input for embed layer,counts of embedding layer output,
    length of input sequence and number of lstm units for lstm'''
    def __init__(self,decoder_vocab_size,embedding_size,lstm_units,input_length):
        super().__init__()
        self.vocab_size=decoder_vocab_size
        self.embedding_size=embedding_size
        self.input_length=input_length
        self.lstm_units=lstm_units

        self.embedding=tf.keras.layers.Embedding(input_dim=self.vocab_size,
                                                 output_dim=self.embedding_size,
                                                 input_length=self.input_length,
                                                 mask_zero=True,
                                                 name='decoder_embedding_layer')
        self.lstm=tf.keras.layers.LSTM(self.lstm_units,return_state=True,
                                       return_sequences=True,
                                       name='decoder_lstm_layer')
        '''Call the decoder with input sequence and, lstm states which is the final lstm states
        of encoder lstm'''
    def call(self,input_sequence,states):
        embedded_output=self.embedding(input_sequence)
        lstm_output,lstm_stateh,lstm_statec=self.lstm(embedded_output,states)
        return lstm_output,lstm_stateh,lstm_statec
```

In [14]:

```
'''Full model'''
class Encoder_Decoder(tf.keras.Model):
    def __init__(self,*params):
        super().__init__()
        '''Initilaize required parameters and blocks '''
        self.encoder_input_len=params[0]
        self.decoder_input_len=params[1]
        self.encoder_inlen=params[2]
        self.decoder_inlen=params[3]
        self.batch_size=params[4]

        self.encoder=Encoder(encoder_vocab_size=encoder_inlen+1,embedding_size=100
                             ,lstm_units=212,
                            input_sequence_length=self.encoder_input_len)
        self.decoder=Decoder(decoder_vocab_size=decoder_inlen+1,embedding_size=300
                             ,lstm_units=212,
                            input_length=self.encoder_input_len)
        self.states=self.encoder.initialize_states(self.batch_size)
        self.dense=tf.keras.layers.Dense(self.decoder_inlen+1,activation='softmax')

    def call(self,data):
        '''Call the blocks'''
        inputs,output=data[0],data[1]
        encoder_output,encoder_stateh,encoder_statec=self.encoder(inputs,self.states)
        decoder_output=self.decoder(output,[encoder_stateh,encoder_statec])
        dense_output=self.dense(decoder_output[0])

        return dense_output
```

In [10]:

```
'''Loss function'''
loss_object = tf.keras.losses.SparseCategoricalCrossentropy(
    from_logits=True, reduction='none')
def loss_function(real, pred):

    """ Custom loss function that will not consider the loss for padded zeros.
    why are we using this, can't we use simple sparse categorical crossentropy?
    Yes, you can use simple sparse categorical crossentropy as loss like we did in task-1. But in this loss function we are ignoring the loss
    for the padded zeros. i.e when the input is zero then we donot need to worry what the output is. This padded zeros are added from our end
    during preprocessing to make equal length for all the sentences.

    """
    mask = tf.math.logical_not(tf.math.equal(real, 0))
    loss_ = loss_object(real, pred)
    mask = tf.cast(mask, dtype=loss_.dtype)
    loss_ *= mask
    gc.collect()
    return tf.reduce_mean(loss_)
```

In [17]:

```
'''Compile and fit the model'''
batch_size=118
tf.keras.backend.clear_session()
model=Encoder_Decoder(max_sentencelen,max_sentencelen,encoder_inlen,decoder_inlen,batch_size)
model.compile(optimizer=tf.keras.optimizers.Adam(),loss=loss_function)


model.fit(x=[enocoder_input_padded_train,decoder_input_padded_train]
          ,y=decoder_output_padded_train,
          batch_size=batch_size,
          epochs=70,
          validation_data=([enocoder_input_padded_train,decoder_input_padded_train]
          ,decoder_output_padded_train))
```

```
Epoch 1/70

/opt/conda/lib/python3.7/site-packages/keras/backend.py:5586: UserWarning: "`sparse_categorical_crossentropy` received `from_logits=True`, but the `output` argume
nt was produced by a Softmax activation and thus does not represent logits. Was this intended?
  output, from_logits, "Softmax", "sparse_categorical_crossentropy"
```

```
615/615 [==============================] - 127s 188ms/step - loss: 3.1222 - val_loss: 2.7554
Epoch 2/70
615/615 [==============================] - 75s 122ms/step - loss: 2.6834 - val_loss: 2.5391
Epoch 3/70
615/615 [==============================] - 66s 108ms/step - loss: 2.5241 - val_loss: 2.4156
Epoch 4/70
615/615 [==============================] - 67s 109ms/step - loss: 2.4174 - val_loss: 2.3202
Epoch 5/70
615/615 [==============================] - 63s 102ms/step - loss: 2.3313 - val_loss: 2.2381
Epoch 6/70
615/615 [==============================] - 65s 106ms/step - loss: 2.2544 - val_loss: 2.1616
Epoch 7/70
615/615 [==============================] - 64s 104ms/step - loss: 2.1822 - val_loss: 2.0879
Epoch 8/70
615/615 [==============================] - 62s 100ms/step - loss: 2.1117 - val_loss: 2.0168
Epoch 9/70
615/615 [==============================] - 60s 98ms/step - loss: 2.0423 - val_loss: 1.9436
Epoch 10/70
615/615 [==============================] - 61s 99ms/step - loss: 1.9726 - val_loss: 1.8732
Epoch 11/70
615/615 [==============================] - 61s 99ms/step - loss: 1.9032 - val_loss: 1.8037
Epoch 12/70
615/615 [==============================] - 61s 99ms/step - loss: 1.8344 - val_loss: 1.7339
Epoch 13/70
615/615 [==============================] - 64s 104ms/step - loss: 1.7668 - val_loss: 1.6665
Epoch 14/70
615/615 [==============================] - 64s 104ms/step - loss: 1.7011 - val_loss: 1.6035
Epoch 15/70
615/615 [==============================] - 61s 98ms/step - loss: 1.6390 - val_loss: 1.5432
Epoch 16/70
615/615 [==============================] - 61s 98ms/step - loss: 1.5802 - val_loss: 1.4884
Epoch 17/70
615/615 [==============================] - 60s 98ms/step - loss: 1.5254 - val_loss: 1.4359
Epoch 18/70
615/615 [==============================] - 60s 98ms/step - loss: 1.4739 - val_loss: 1.3869
Epoch 19/70
615/615 [==============================] - 61s 98ms/step - loss: 1.4252 - val_loss: 1.3408
Epoch 20/70
615/615 [==============================] - 60s 98ms/step - loss: 1.3794 - val_loss: 1.2981
Epoch 21/70
615/615 [==============================] - 61s 100ms/step - loss: 1.3360 - val_loss: 1.2567
Epoch 22/70
615/615 [==============================] - 64s 104ms/step - loss: 1.2948 - val_loss: 1.2179
Epoch 23/70
615/615 [==============================] - 61s 99ms/step - loss: 1.2556 - val_loss: 1.1817
Epoch 24/70
615/615 [==============================] - 61s 99ms/step - loss: 1.2188 - val_loss: 1.1463
Epoch 25/70
615/615 [==============================] - 60s 98ms/step - loss: 1.1837 - val_loss: 1.1134
Epoch 26/70
615/615 [==============================] - 60s 98ms/step - loss: 1.1505 - val_loss: 1.0818
Epoch 27/70
615/615 [==============================] - 60s 98ms/step - loss: 1.1186 - val_loss: 1.0525
Epoch 28/70
615/615 [==============================] - 63s 102ms/step - loss: 1.0880 - val_loss: 1.0224
Epoch 29/70
615/615 [==============================] - 63s 102ms/step - loss: 1.0586 - val_loss: 0.9949
Epoch 30/70
615/615 [==============================] - 63s 103ms/step - loss: 1.0309 - val_loss: 0.9705
Epoch 31/70
615/615 [==============================] - 60s 98ms/step - loss: 1.0044 - val_loss: 0.9452
Epoch 32/70
615/615 [==============================] - 63s 103ms/step - loss: 0.9791 - val_loss: 0.9196
Epoch 33/70
615/615 [==============================] - 60s 98ms/step - loss: 0.9543 - val_loss: 0.8962
Epoch 34/70
615/615 [==============================] - 63s 103ms/step - loss: 0.9308 - val_loss: 0.8742
Epoch 35/70
615/615 [==============================] - 60s 98ms/step - loss: 0.9075 - val_loss: 0.8523
Epoch 36/70
615/615 [==============================] - 64s 104ms/step - loss: 0.8858 - val_loss: 0.8331
Epoch 37/70
615/615 [==============================] - 63s 103ms/step - loss: 0.8651 - val_loss: 0.8128
Epoch 38/70
615/615 [==============================] - 60s 97ms/step - loss: 0.8452 - val_loss: 0.7949
Epoch 39/70
615/615 [==============================] - 61s 99ms/step - loss: 0.8255 - val_loss: 0.7756
Epoch 40/70
615/615 [==============================] - 61s 98ms/step - loss: 0.8068 - val_loss: 0.7578
Epoch 41/70
615/615 [==============================] - 63s 103ms/step - loss: 0.7888 - val_loss: 0.7412
Epoch 42/70
615/615 [==============================] - 63s 103ms/step - loss: 0.7715 - val_loss: 0.7252
Epoch 43/70
615/615 [==============================] - 63s 103ms/step - loss: 0.7548 - val_loss: 0.7092
Epoch 44/70
615/615 [==============================] - 64s 104ms/step - loss: 0.7389 - val_loss: 0.6942
Epoch 45/70
615/615 [==============================] - 60s 98ms/step - loss: 0.7234 - val_loss: 0.6791
Epoch 46/70
```

```
615/615 [==============================] - 61s 99ms/step - loss: 0.7085 - val_loss: 0.6655
Epoch 47/70
615/615 [==============================] - 61s 99ms/step - loss: 0.6931 - val_loss: 0.6509
Epoch 48/70
615/615 [==============================] - 60s 98ms/step - loss: 0.6792 - val_loss: 0.6376
Epoch 49/70
615/615 [==============================] - 61s 99ms/step - loss: 0.6661 - val_loss: 0.6262
Epoch 50/70
615/615 [==============================] - 60s 97ms/step - loss: 0.6534 - val_loss: 0.6132
Epoch 51/70
615/615 [==============================] - 60s 98ms/step - loss: 0.6403 - val_loss: 0.6002
Epoch 52/70
615/615 [==============================] - 63s 102ms/step - loss: 0.6275 - val_loss: 0.5899
Epoch 53/70
615/615 [==============================] - 63s 103ms/step - loss: 0.6162 - val_loss: 0.5785
Epoch 54/70
615/615 [==============================] - 60s 98ms/step - loss: 0.6044 - val_loss: 0.5673
Epoch 55/70
615/615 [==============================] - 63s 102ms/step - loss: 0.5930 - val_loss: 0.5558
Epoch 56/70
615/615 [==============================] - 63s 103ms/step - loss: 0.5817 - val_loss: 0.5467
Epoch 57/70
615/615 [==============================] - 63s 103ms/step - loss: 0.5714 - val_loss: 0.5359
Epoch 58/70
615/615 [==============================] - 63s 103ms/step - loss: 0.5614 - val_loss: 0.5271
Epoch 59/70
615/615 [==============================] - 61s 99ms/step - loss: 0.5522 - val_loss: 0.5172
Epoch 60/70
615/615 [==============================] - 63s 103ms/step - loss: 0.5419 - val_loss: 0.5083
Epoch 61/70
615/615 [==============================] - 60s 97ms/step - loss: 0.5321 - val_loss: 0.5005
Epoch 62/70
615/615 [==============================] - 60s 97ms/step - loss: 0.5234 - val_loss: 0.4919
Epoch 63/70
615/615 [==============================] - 60s 98ms/step - loss: 0.5150 - val_loss: 0.4832
Epoch 64/70
615/615 [==============================] - 63s 103ms/step - loss: 0.5066 - val_loss: 0.4757
Epoch 65/70
615/615 [==============================] - 60s 98ms/step - loss: 0.4980 - val_loss: 0.4664
Epoch 66/70
615/615 [==============================] - 60s 97ms/step - loss: 0.4894 - val_loss: 0.4601
Epoch 67/70
615/615 [==============================] - 64s 103ms/step - loss: 0.4823 - val_loss: 0.4530
Epoch 68/70
615/615 [==============================] - 60s 98ms/step - loss: 0.4748 - val_loss: 0.4460
Epoch 69/70
615/615 [==============================] - 60s 98ms/step - loss: 0.4671 - val_loss: 0.4379
Epoch 70/70
615/615 [==============================] - 64s 103ms/step - loss: 0.4599 - val_loss: 0.4318
```

Out[17]:

```
<keras.callbacks.History at 0x7f2d3fe62f10>
```

In [24]:
```
'''Function to predict the output
input_sentence=input dataset
samples=array takes sample indexes if op is custom,if random it uses first index to
create random numbers,if round it uses first index to create first text of a series
text generations.
iter=int-number of iterations for round
op='string',if random produces seris of texts for given iter,if custom then
generates reply for given text,if random generaes random texts of given length
'''
def predict(input_sentence,samples,iter=5,op='round'):
    inputs=input_sentence['encoder_input'].values
    'genrates initial inputs'
    if op=='random':
        random_numbers=np.random.choice(len(inputs),samples[0],replace=False)
        inputs=[inputs[i] for i in random_numbers]
        iter=len(inputs)
    elif op=='custom':
        inputs=[inputs[i] for i in samples]
        iter=len(inputs)
    else:
        inputs=[inputs[i] for i in samples]


targetArray=[]
target=inputs[0]
speaker=['A: ','B: ']
'''for each input/iteration in case round'''
for j in range(iter):

    if op=='round':
        inp=target
        print(speaker[j%2],inp)
    else:
        inp=inputs[j]
        print('A: ',inp)
    j=j+1
    '''tokenize,pad and initilize initial state for input'''
    sequence=encoder_input_tokenizer.texts_to_sequences([inp])
    sequence=tf.keras.preprocessing.sequence.pad_sequences(sequence,maxlen=max_input_len,
                                             padding='post',
                                            truncating='post'
                                                  )

    states=model.layers[0].initialize_states(1)
    encoder_output,lstm_h,lstm_C=model.layers[0](sequence,states)
        decoder_input=np.zeros((1,1))
        decoder_input[0,0]=decoder_input_tokenizer.word_index['<start>']
        decoder_states=[lstm_h,lstm_C]
        target=''
        '''Generate output  for max output length times'''
        for i in range(max_sentencelen):
            decoder_output,state_h,state_c=model.layers[1](decoder_input,decoder_states)
            dense_out=model.layers[2](decoder_output)
            decoder_states=[state_h,state_c]
            decoder_input[0,0]=np.argmax(dense_out)
            if decoder_input_tokenizer.index_word[decoder_input[0,0]]=='<end>':
                targetArray.append(target)
                break
            else:
                target=target+" "+decoder_input_tokenizer.index_word[decoder_input[0,0]]
        if op!='round':
            print('B :',target)
    return targetArray,inputs
```

In [32]:
```
'''Generate series of texts by passing 1 text'''
predicted,inputs=predict(train,[20],op='round',iter=8)
```

```
A:  Who knows?  All I've ever heard her say is that she'd dip before dating a guy that smokes.
B:   So that's the kind of girl who works off the door before he talked to his wife, give me feel better.
A:   No, it isn't.
B:   I'm sorry, Daddy.
A:   I don't know. I just want to help you. I don't want to be alone.
B:   Why?
A:   I don't believe that.
B:   Was I? No more times just in the mirror I might give you a hundred million people in a dream of those
```

In [43]:
```
test_index=[15,50,135,93]
'''Function to calculate BLEU score'''
from nltk.translate.bleu_score import sentence_bleu
def get_bleu(ref,hyp_array):
    bleu_array=[]
    for hyp in hyp_array:
        bleu_array.append(sentence_bleu(ref,hyp.split()))
    return sum(bleu_array)/len(bleu_array)
```

In [61]:
```
'''Generate reply for some selected input and calcualate BLEU score'''
predicted,inputs=predict(train,test_index,op='custom')
print('\nBLEU score for random texts predicted is:',get_bleu(ref,predicted))
```

```
A:  You never wanted to go out with 'me, did you?
B:  I was?
A:  Would you mind getting me a drink, Cameron?
B:  Great
A:  The hell is that?  What kind of 'guy just picks up a girl and carries her away while you're talking to her?
B:  Extremely unfortunate maneuver
A:  Can we go now?
B:  You are so good for me to prove you already told them about the last two of these old days.

BLEU score for random texts predicted is: 0.8137550729550667
```

4.1 Recurrent Neural Network with attention mechanism

In [11]:

```
class Encoder(tf.keras.Model):
    '''Initialize with vocabulary counts of input for embed layer,counts of embedding layer output,
length of input sequence and number of lstm units for lstm'''
    def __init__(self,encoder_vocab_size,embedding_size,lstm_units,input_sequence_length):
        super().__init__()
        self.vocab_size=encoder_vocab_size
        self.embedding_size=embedding_size
        self.input_length=input_sequence_length
        self.lstm_units=lstm_units

        self.embedding=tf.keras.layers.Embedding(input_dim=self.vocab_size,
                                                 output_dim=self.embedding_size,
                                                 input_length=self.input_length,
                                                 mask_zero=True,
                                                 name='encoder_embedding_layer')
        self.lstm=tf.keras.layers.LSTM(self.lstm_units,return_state=True,
                                       return_sequences=True,
                                       name='encoder_lstm')

        '''Call the encoder with input sequence and, lstm states wich are initilized using iniitilize_
        states function  and return final lstm output,states.'''
    def call(self,input_sequence,states):
        embedded_output=self.embedding(input_sequence)
        lstm_output,lstm_stateh,lstm_statec=self.lstm(embedded_output,initial_state=states)

        return lstm_output,lstm_stateh,lstm_statec
        '''Initilize lstm initial states with batch_size and lstm_units counts'''
    def initialize_states(self,batch_size):
        initial_stateh=tf.zeros(shape=(batch_size,self.lstm_units))
        initial_statec=tf.zeros(shape=(batch_size,self.lstm_units))

        return initial_stateh,initial_statec


'''Attention layer'''
class Attention(tf.keras.layers.Layer):
    def __init__(self,att_units):
        super().__init__()
        '''Initialize layers and weights for dot,general and concat atention methods'''
        self.attention_units=att_units
        self.Wt=tf.keras.layers.Dense(units=self.attention_units,use_bias=False,kernel_initializer='HeUniform')
        self.Ws=tf.keras.layers.Dense(units=self.attention_units,use_bias=False,kernel_initializer='HeUniform')
        self.Va=tf.keras.layers.Dense(units=1,use_bias=False,kernel_initializer='HeUniform')

    def call(self,decoder_hidden_state,encoder_output):
        '''attention implementation'''
        decoder_hidden_state=tf.expand_dims(decoder_hidden_state,axis=1)
        Wt_ht=self.Wt(encoder_output)
        Ws_hs=self.Ws(decoder_hidden_state)
        attention=self.Va(tf.tanh(Wt_ht+Ws_hs))
        attention_weight=tf.nn.softmax(attention,axis=1)
        context_vector=attention_weight*encoder_output
        context_vector=tf.reduce_sum(context_vector,axis=1)

        return context_vector,attention_weight



''' Decoder block'''

class One_step_decoder(tf.keras.Model):
    '''initilize embedding,lstm and attention layers with required parameters'''
    def __init__(self,decoder_vocab_size,decoder_embedding_dim,input_length,
                 lstm_units,att_units):
        super().__init__()
        self.embedding=tf.keras.layers.Embedding(input_dim=decoder_vocab_size,
                                                 output_dim=decoder_embedding_dim,
                                                 input_length=input_length,
                                                 mask_zero=True)
        self.lstm=tf.keras.layers.LSTM(units=lstm_units,
                                       return_state=True,
                                       return_sequences=True)
        self.dense=tf.keras.layers.Dense(units=decoder_vocab_size,kernel_initializer='HeUniform')
        self.attention=Attention(att_units)

    def call(self,input_to_decoder,encoder_output,state_h,state_c):

        embedding_output=self.embedding(input_to_decoder)
        '''get the context_vector and attentio_weights using hidden_state of previous timestep of
        decoder, and encoder_output using attention layer'''
        context_vector,attention_weights=self.attention(state_h,encoder_output)
        '''get lstm ouput,hidden_state and cell state with lstm layer'''
        lstm_input=tf.concat([embedding_output,tf.expand_dims(context_vector,axis=1)],axis=-1)
        lstm_output,lstm_h,lstm_c=self.lstm(lstm_input,initial_state=[state_h,state_c])
        '''return dense output,lstm states,attention_weights and context_vector'''
        output=self.dense(lstm_output)
        output=tf.reduce_sum(output,axis=1)

        return output,lstm_h,lstm_c,attention_weights,context_vector
```

```
class Decoder(tf.keras.Model):
    def __init__(self,decoder_vocab_size,decoder_embedding_dim,input_length,lstm_units,
                 att_units):
        super().__init__()
        '''Initilaize the onestep decoder'''
        self.one_step_decoder=One_step_decoder(decoder_vocab_size,decoder_embedding_dim,input_length,
                    lstm_units,att_units)
    def call(self, input_to_decoder,encoder_output,decoder_hidden_state,decoder_cell_state ):
        '''For each timestep/sequence in the input predict the output and store it in a tensor and return
        as output'''

        all_outputs=tf.TensorArray(tf.float32,size=input_to_decoder.shape[1],name='output_array')

        for time_stamp in range(input_to_decoder.shape[1]):
            output,decoder_hidden_state,decoder_cell_state,attention_weights,context_vector=self.one_step_decoder(input_to_decoder[:,time_stamp:time_stamp+1],encoder
_output,decoder_hidden_state,decoder_cell_state)
            all_outputs=all_outputs.write(time_stamp,output)
        all_outputs=tf.transpose(all_outputs.stack(),(1,0,2))

        return all_outputs

'''Complete model implementation'''
class encoder_decoder(tf.keras.Model):
  def __init__(self,*params):
    super().__init__()
    '''Inititalize required parameters and all the layers'''
    self.encoder_input_len=params[0]
    self.decoder_input_len=params[1]
    self.encoder_inlen=params[2]
    self.decoder_inlen=params[3]
    self.batch_size=params[4]
    self.att_units=params[5]


    self.encoder=Encoder(encoder_vocab_size=encoder_inlen+1,embedding_size=100,lstm_units=212,input_sequence_length=self.encoder_input_len)
    self.decoder=Decoder(decoder_vocab_size=decoder_inlen+1,decoder_embedding_dim=300,input_length=self.decoder_input_len,
                         lstm_units=212,att_units=self.att_units)
    self.initial_state=self.encoder.initialize_states(self.batch_size)

  def call(self,data):
    '''Call the full block '''
    input,output=data[0],data[1]
    encoder_output,state_h,state_c=self.encoder(input,self.initial_state)
    decoder_output=self.decoder(output,encoder_output,state_h,state_c)
    gc.collect()
    return decoder_output
  def on_epoch_end(self, epoch, logs=None):
    gc.collect()
    tf.keras.backend.clear_session()
```

In [12]:

```
'''callback'''
earlyStop=tf.keras.callbacks.EarlyStopping(
    monitor='val_loss',
    verbose=1,
    patience=1
)
```

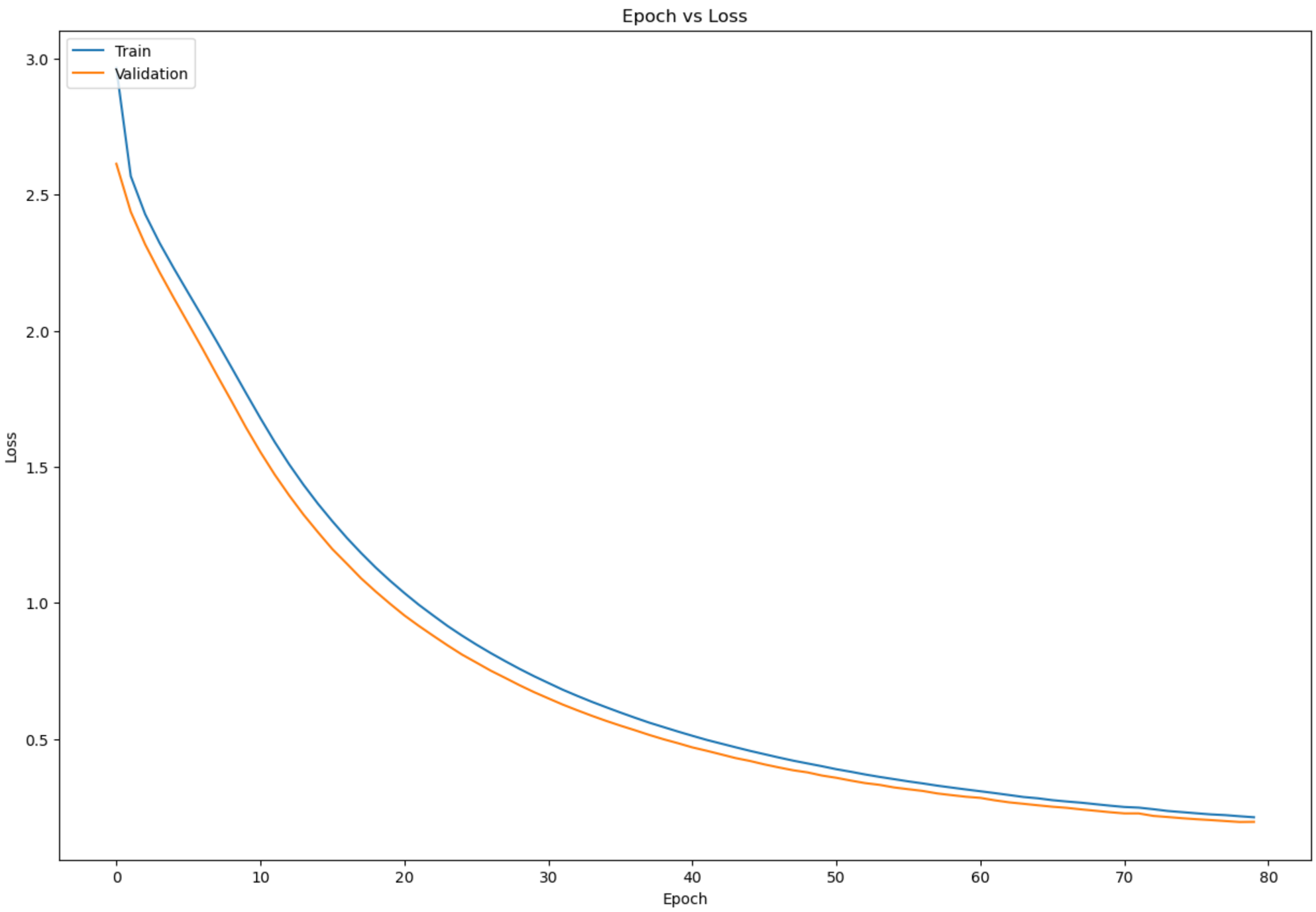
In [13]:

```
'''Compile and fit the model'''

batch_size=118
tf.keras.backend.clear_session()
model=encoder_decoder(max_sentencelen,max_sentencelen,encoder_inlen,decoder_inlen,batch_size,212)
model.compile(optimizer=tf.keras.optimizers.Adam(),loss=loss_function)


history=model.fit(x=[enocoder_input_padded_train,decoder_input_padded_train]
          ,y=decoder_output_padded_train,
          batch_size=batch_size,
          epochs=150,
          validation_data=([enocoder_input_padded_train,decoder_input_padded_train]
          ,decoder_output_padded_train),callbacks=[earlyStop]
          )
```

```
Epoch 1/150
615/615 [==============================] - 302s 373ms/step - loss: 2.9653 - val_loss: 2.6137
Epoch 2/150
615/615 [==============================] - 151s 245ms/step - loss: 2.5683 - val_loss: 2.4371
Epoch 3/150
615/615 [==============================] - 153s 248ms/step - loss: 2.4282 - val_loss: 2.3173
Epoch 4/150
615/615 [==============================] - 151s 246ms/step - loss: 2.3228 - val_loss: 2.2152
Epoch 5/150
615/615 [==============================] - 143s 232ms/step - loss: 2.2287 - val_loss: 2.1193
Epoch 6/150
615/615 [==============================] - 142s 231ms/step - loss: 2.1384 - val_loss: 2.0260
Epoch 7/150
615/615 [==============================] - 143s 232ms/step - loss: 2.0487 - val_loss: 1.9322
Epoch 8/150
615/615 [==============================] - 150s 244ms/step - loss: 1.9578 - val_loss: 1.8356
Epoch 9/150
615/615 [==============================] - 143s 232ms/step - loss: 1.8649 - val_loss: 1.7410
Epoch 10/150
615/615 [==============================] - 149s 242ms/step - loss: 1.7712 - val_loss: 1.6446
Epoch 11/150
615/615 [==============================] - 148s 241ms/step - loss: 1.6791 - val_loss: 1.5545
Epoch 12/150
615/615 [==============================] - 143s 232ms/step - loss: 1.5909 - val_loss: 1.4710
Epoch 13/150
615/615 [==============================] - 149s 243ms/step - loss: 1.5090 - val_loss: 1.3949
Epoch 14/150
615/615 [==============================] - 143s 232ms/step - loss: 1.4337 - val_loss: 1.3240
Epoch 15/150
615/615 [==============================] - 148s 241ms/step - loss: 1.3642 - val_loss: 1.2596
Epoch 16/150
615/615 [==============================] - 144s 234ms/step - loss: 1.3000 - val_loss: 1.1975
Epoch 17/150
615/615 [==============================] - 148s 241ms/step - loss: 1.2392 - val_loss: 1.1443
Epoch 18/150
615/615 [==============================] - 142s 232ms/step - loss: 1.1830 - val_loss: 1.0900
Epoch 19/150
615/615 [==============================] - 148s 240ms/step - loss: 1.1303 - val_loss: 1.0421
Epoch 20/150
615/615 [==============================] - 148s 240ms/step - loss: 1.0817 - val_loss: 0.9970
Epoch 21/150
615/615 [==============================] - 149s 242ms/step - loss: 1.0362 - val_loss: 0.9540
Epoch 22/150
615/615 [==============================] - 148s 241ms/step - loss: 0.9932 - val_loss: 0.9156
Epoch 23/150
615/615 [==============================] - 148s 241ms/step - loss: 0.9537 - val_loss: 0.8793
Epoch 24/150
615/615 [==============================] - 147s 240ms/step - loss: 0.9151 - val_loss: 0.8438
Epoch 25/150
615/615 [==============================] - 148s 241ms/step - loss: 0.8798 - val_loss: 0.8101
Epoch 26/150
615/615 [==============================] - 141s 230ms/step - loss: 0.8467 - val_loss: 0.7806
Epoch 27/150
615/615 [==============================] - 148s 241ms/step - loss: 0.8154 - val_loss: 0.7508
Epoch 28/150
615/615 [==============================] - 142s 230ms/step - loss: 0.7859 - val_loss: 0.7243
Epoch 29/150
615/615 [==============================] - 148s 240ms/step - loss: 0.7574 - val_loss: 0.6973
Epoch 30/150
615/615 [==============================] - 148s 240ms/step - loss: 0.7306 - val_loss: 0.6721
Epoch 31/150
615/615 [==============================] - 142s 231ms/step - loss: 0.7056 - val_loss: 0.6490
Epoch 32/150
615/615 [==============================] - 148s 240ms/step - loss: 0.6808 - val_loss: 0.6262
Epoch 33/150
615/615 [==============================] - 148s 240ms/step - loss: 0.6583 - val_loss: 0.6054
Epoch 34/150
615/615 [==============================] - 142s 231ms/step - loss: 0.6368 - val_loss: 0.5854
Epoch 35/150
615/615 [==============================] - 148s 241ms/step - loss: 0.6167 - val_loss: 0.5665
Epoch 36/150
615/615 [==============================] - 148s 241ms/step - loss: 0.5970 - val_loss: 0.5488
Epoch 37/150
615/615 [==============================] - 142s 231ms/step - loss: 0.5781 - val_loss: 0.5321
Epoch 38/150
615/615 [==============================] - 142s 230ms/step - loss: 0.5598 - val_loss: 0.5147
Epoch 39/150
615/615 [==============================] - 148s 240ms/step - loss: 0.5435 - val_loss: 0.4987
Epoch 40/150
615/615 [==============================] - 148s 240ms/step - loss: 0.5271 - val_loss: 0.4842
Epoch 41/150
615/615 [==============================] - 142s 231ms/step - loss: 0.5115 - val_loss: 0.4688
Epoch 42/150
615/615 [==============================] - 141s 230ms/step - loss: 0.4963 - val_loss: 0.4563
Epoch 43/150
615/615 [==============================] - 148s 240ms/step - loss: 0.4828 - val_loss: 0.4431
Epoch 44/150
615/615 [==============================] - 147s 239ms/step - loss: 0.4693 - val_loss: 0.4296
Epoch 45/150
615/615 [==============================] - 147s 239ms/step - loss: 0.4561 - val_loss: 0.4190
```

```
Epoch 46/150
615/615 [==============================] - 148s 240ms/step - loss: 0.4439 - val_loss: 0.4064
Epoch 47/150
615/615 [==============================] - 142s 230ms/step - loss: 0.4317 - val_loss: 0.3952
Epoch 48/150
615/615 [==============================] - 142s 231ms/step - loss: 0.4201 - val_loss: 0.3848
Epoch 49/150
615/615 [==============================] - 148s 240ms/step - loss: 0.4098 - val_loss: 0.3770
Epoch 50/150
615/615 [==============================] - 142s 231ms/step - loss: 0.3996 - val_loss: 0.3654
Epoch 51/150
615/615 [==============================] - 142s 230ms/step - loss: 0.3886 - val_loss: 0.3571
Epoch 52/150
615/615 [==============================] - 142s 231ms/step - loss: 0.3794 - val_loss: 0.3469
Epoch 53/150
615/615 [==============================] - 142s 231ms/step - loss: 0.3694 - val_loss: 0.3376
Epoch 54/150
615/615 [==============================] - 148s 240ms/step - loss: 0.3604 - val_loss: 0.3311
Epoch 55/150
615/615 [==============================] - 148s 240ms/step - loss: 0.3522 - val_loss: 0.3217
Epoch 56/150
615/615 [==============================] - 148s 240ms/step - loss: 0.3439 - val_loss: 0.3151
Epoch 57/150
615/615 [==============================] - 147s 239ms/step - loss: 0.3364 - val_loss: 0.3088
Epoch 58/150
615/615 [==============================] - 148s 240ms/step - loss: 0.3283 - val_loss: 0.2996
Epoch 59/150
615/615 [==============================] - 141s 230ms/step - loss: 0.3212 - val_loss: 0.2934
Epoch 60/150
615/615 [==============================] - 148s 240ms/step - loss: 0.3142 - val_loss: 0.2874
Epoch 61/150
615/615 [==============================] - 148s 241ms/step - loss: 0.3076 - val_loss: 0.2833
Epoch 62/150
615/615 [==============================] - 148s 241ms/step - loss: 0.3008 - val_loss: 0.2743
Epoch 63/150
615/615 [==============================] - 148s 241ms/step - loss: 0.2937 - val_loss: 0.2669
Epoch 64/150
615/615 [==============================] - 148s 241ms/step - loss: 0.2865 - val_loss: 0.2615
Epoch 65/150
615/615 [==============================] - 148s 241ms/step - loss: 0.2817 - val_loss: 0.2560
Epoch 66/150
615/615 [==============================] - 142s 232ms/step - loss: 0.2749 - val_loss: 0.2508
Epoch 67/150
615/615 [==============================] - 142s 232ms/step - loss: 0.2700 - val_loss: 0.2467
Epoch 68/150
615/615 [==============================] - 142s 231ms/step - loss: 0.2656 - val_loss: 0.2410
Epoch 69/150
615/615 [==============================] - 142s 231ms/step - loss: 0.2601 - val_loss: 0.2359
Epoch 70/150
615/615 [==============================] - 142s 231ms/step - loss: 0.2547 - val_loss: 0.2307
Epoch 71/150
615/615 [==============================] - 148s 241ms/step - loss: 0.2498 - val_loss: 0.2263
Epoch 72/150
615/615 [==============================] - 142s 232ms/step - loss: 0.2474 - val_loss: 0.2262
Epoch 73/150
615/615 [==============================] - 148s 241ms/step - loss: 0.2417 - val_loss: 0.2171
Epoch 74/150
615/615 [==============================] - 142s 231ms/step - loss: 0.2352 - val_loss: 0.2130
Epoch 75/150
615/615 [==============================] - 148s 241ms/step - loss: 0.2310 - val_loss: 0.2086
Epoch 76/150
615/615 [==============================] - 142s 231ms/step - loss: 0.2267 - val_loss: 0.2049
Epoch 77/150
615/615 [==============================] - 148s 240ms/step - loss: 0.2226 - val_loss: 0.2018
Epoch 78/150
615/615 [==============================] - 142s 232ms/step - loss: 0.2199 - val_loss: 0.1981
Epoch 79/150
615/615 [==============================] - 148s 241ms/step - loss: 0.2158 - val_loss: 0.1947
Epoch 80/150
615/615 [==============================] - 142s 231ms/step - loss: 0.2120 - val_loss: 0.1953
Epoch 80: early stopping
```

In [22]:
```
'''Plot Epoch vs Loss'''
import matplotlib.pyplot as plt
plt.figure(figsize=(15,10))
plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
plt.title('Epoch vs Loss')
plt.xlabel('Epoch')
plt.ylabel('Loss')
plt.legend(['Train','Validation'],loc='upper left')
plt.show()
```



In [ ]:
```
import joblib
joblib.dump(model,'model.pkl')
```

In [36]:

```
'''Function to predict the output
input_sentence=input dataset
samples=array takes sample indexes if op is custom,if random it uses first index to
create random numbers,if round it uses first index to create first text of a series
text generations.
iter=int-number of iterations for round
op='string',if random produces seris of texts for given iter,if custom then
generates reply for given text,if random generaes random texts of given length
'''
def predict(input_sentence,samples,iter=5,op='random'):
    inputs=input_sentence['encoder_input'].values
    'genrates initial inputs'
    if op=='random':
        random_numbers=np.random.choice(len(inputs),samples[0],replace=False)
        inputs=[inputs[i] for i in random_numbers]
        iter=len(inputs)
    elif op=='custom':
        inputs=[inputs[i] for i in samples]
        iter=len(inputs)
    else:
        inputs=[inputs[i] for i in samples]

    targetArray=[]
    target=inputs[0]
    speaker=['A: ','B: ']
    '''for each input/iteration in case round'''
    for j in range(iter):

        if op=='round':
            inp=target
            print(speaker[j%2],inp)
        else:
            inp=inputs[j]
            print('A: ',inp)
        j=j+1
        '''tokenize,pad and initilize initial state for input'''
        sequence=encoder_input_tokenizer.texts_to_sequences([inp])
        sequence=tf.keras.preprocessing.sequence.pad_sequences(sequence,maxlen=max_input_len,
                                                    padding='post',
                                                   truncating='post'
                                                         )

        states=model.layers[0].initialize_states(1)
        encoder_output,lstm_h,lstm_C=model.layers[0](sequence,states)
        decoder_input=np.zeros((1,1))
        decoder_input[0,0]=decoder_input_tokenizer.word_index['<start>']
        target=''
        '''Generate output  for max output length times'''
        for i in range(max_sentencelen):
            decoder_output,lstm_h,lstm_C,attention_weights,context_vector =model.layers[1].one_step_decoder(decoder_input,encoder_output,lstm_h,lstm_C)
            decoder_input[0,0]=np.argmax(decoder_output)
            if decoder_input_tokenizer.index_word[decoder_input[0,0]]=='<end>':
                targetArray.append(target)
                break
            else:
                target=target+" "+decoder_input_tokenizer.index_word[decoder_input[0,0]]
        if op!='round':
            print('B :',target)
    return targetArray,inputs
```

In [42]:

```
'''Generate series of texts by passing 1 text'''
predicted,inputs=predict(train,[5804],op='round',iter=17)
```

```
A:  Wait a minute.  How do you feel this morning?
B:   Excuse me
A:   No, he was just a private conversation. What do you want to do about it?
B:   We've done nothing yet. This is a very difficult decision, Henry.
A:   Yes.
B:   Do you like the idea of all?
A:   No.
B:   You don't want to get hurt, do you? Okay. Be place where your mother is coming up like this.
A:   Sure, I understand. I just want to be with you.
B:   You don't have to get yourself and open that case.
A:   See, that's it I don't know anything about you.
B:   The game's over. You scared me.
A:   Now you make it your office.
B:   I'll find him.
A:   What are you going to do?
B:   I don't know. Maybe he could help commit me on the map.
A:   We haven't been able to get him in the same day.
```

In [65]:
```
'''Generate reply for some selected input and calcualate BLEU score'''
predicted,inputs=predict(train,test_index,custom=True,round=False)
print('\nBLEU score for random texts predicted is:',get_bleu(ref,predicted))
```

```
A:  You never wanted to go out with 'me, did you?
B:  I was?
A:  Would you mind getting me a drink, Cameron?
B:  Great
A:  The hell is that?  What kind of 'guy just picks up a girl and carries her away while you're talking to her?
B:  Extremely unfortunate maneuver
A:  Can we go now?
B:  Yes.

BLEU score for random texts predicted is: 0.9602241038134286
```

4.3 GPT finetuned

In [5]:
```
'''load and preprocess the dataframe'''
df=corpus.get_utterances_dataframe()
df=df[['conversation_id','text']]
df=df[:100000]

user_ids=[]
count=Counter(list(df['conversation_id']))
count_keys=count.keys()
for i in tqdm(count_keys):
    for j in range(count[i]):
        if j%2==0:
            user_ids.append('A: ')
        else:
            user_ids.append('B: ')

df['text']=df.text.apply(lambda x:re.sub("[\<\(\[].*?[\)\>\]]",'',x))
df['text']=df['text'].apply(lambda x:x+' <EOL>')
df['text']=user_ids+df['text']


combined_data='\n'.join(list(df['text']))
with open('train.txt','w') as train:
    train.write(combined_data)
```

```
100%|██████████| 27430/27430 [00:00<00:00, 715906.53it/s]
```

In [ ]:
```
!pip install gpt_2_simple
```

In [7]:

```
'''download GPT model with 124M params and finetune the dataset'''
import gpt_2_simple as gpt2
import tensorflow as tf
gpt2.download_gpt2(model_name='124M')
sess = gpt2.start_tf_sess()
gpt2.finetune(sess,dataset='/kaggle/working/train.txt'
              ,model_name='124M'
              ,steps=200
              ,print_every=200
              ,sample_every=100,
               restore_from='fresh'

              )
```

```
Fetching checkpoint: 1.05Mit [00:00, 363Mit/s]
Fetching encoder.json: 1.05Mit [00:01, 627kit/s]
Fetching hparams.json: 1.05Mit [00:00, 384Mit/s]
Fetching model.ckpt.data-00000-of-00001: 498Mit [01:17, 6.44Mit/s]
Fetching model.ckpt.index: 1.05Mit [00:00, 479Mit/s]
Fetching model.ckpt.meta: 1.05Mit [00:01, 966kit/s]
Fetching vocab.bpe: 1.05Mit [00:01, 937kit/s]

Loading checkpoint models/124M/model.ckpt
Loading dataset...

100%|██████████| 1/1 [00:10<00:00, 10.04s/it]

dataset has 2144413 tokens
Training...
======== SAMPLE 1 ========
:
A: You sure... It works. <EOL>
B: So what? <EOL>
A: Yeah... I'm... <EOL>
B: Did you ever say, "Okay, we can't get it again until you make us a promise" again? <EOL>
A: Oh, it's a great idea. If you can get the people to forgive this, we can make some peace. <EOL>
A: If it's good for you, I'll try to make it better. We're coming with lots of work this week.  You look a little nervous right now. <EOL>
B: What do you mean I don't feel any differently? <EOL>
A: You were supposed to try and get the other guys to forgive these cases. <EOL>
B: I thought you said you were going to try and get things done. <EOL>
A: You've been a couple of days without seeing me on Sunday as well... <EOL>
B: Why? Are you having a lot of problems? <EOL>
A: It's fine... I'm sure you've all figured out your problems. <EOL>
B: You still haven't gotten the paperwork? <EOL>
A: We've been in contact with the Attorney's Office... <EOL>
B: You'd have to be smart as hell to have such a situation? <EOL>
A: It's nothing. Don't try to help our cause... We've been involved since this one. <EOL>
B: Why? <EOL>
A: We should be going to the county auditor's. <EOL>
B: Yes, it would, and I wouldn't be surprised if you went to court for it again. <EOL>
A: This is our own fault, isn't it? Don't you know what I'm saying? We're not getting anything out of it - you're wrong? <EOL>
B: Well, it's just another time to ask these people to forgive me for taking part in things so obviously I'm just going to try to help them. I guess it's good for me to have things in their control. <EOL>
A: Oh, sure. You never called me. <EOL>
B: I'll try not to mess this up. <EOL>
A: It would be very easy. <EOL>
B: Can we talk for a minute? <EOL>
A: And I think this is going to be a very good reason for you to go forward with this. <EOL>
A: Just try to keep the other parties clear. <EOL>
B: What happened to it? <EOL>
A: Yes. <EOL>
B: You asked what the attorney's doing. <EOL>
A: I can't do what you're doing. <EOL>
A: I just can't do it. I want you to know I still have my lawyers and I'm doing everything I can to help you. <EOL>
B: How do I feel? <EOL>
A: I'm telling you, I think everyone is on a mission. No one should have to give up everything that they have, even if this is good for them. They're going to hav
e to make certain decisions now. <EOL>
B: How long? <EOL>
A: I think I can do all I can to get things working again. <EOL>
B: I've read that. <EOL>
A: I've got a message from Governor Ritz.  I just want you to keep this a secret. <EOL>
A: We just need to get to the police station.  I want you to call at your own expense.  We have to go right back to jail. I need to talk to the lawyer. I'm sure h
e's going to be very helpful. <EOL>
B: It's very important to me.  We're trying to get back to court and getting it right. <EOL>
A: You've said you think it's a good idea to help keep this secret. <EOL>
B: I don't know. <EOL>
A: I just want to go home. I want you to go home and get some rest today. I just want you to go home, too. We've had some problems this week. <EOL>
B: You really don't want us back? <EOL>
A: When I first came to court, I wanted to show somebody that when we work together we can deal with the people we call. You were going to get this done in

[200 | 271.79] loss=2.36 avg=2.36
Saving checkpoint/run1/model-200
```

In [8]:
```
'''generate texts for some inputs'''
test_index=['L695','L580','L584','L413318']
input_data=[]
target_array=[]
for i in test_index:
    inp=df[df.index==i].values[0][1]
    input_data.append(inp.split(': ')[1].rstrip(' <EOL>'))
    print('A:'+inp.split(':')[1].rstrip(' <EOL>'))
    inputs=gpt2.generate(sess,prefix=inp,temperature=0.7,
                         return_as_list=True,
                 include_prefix=False,nsamples=1, batch_size=1,
                 seed=42
                )
    inputs=inputs[0].split('\n')
    out=inputs[1]
    target_array.append(out.split(': ')[1].rstrip(' <EOL>'))
    print('B:'+out.split(':')[1].rstrip(' <EOL>'))
```

```
A: You never wanted to go out with 'me, did you?
B: You don't know me either.
A: Would you mind getting me a drink, Cameron?
B: Not really, but I like the idea of it. You know, like a little granola bar.
A: The hell is that?  What kind of 'guy just picks up a girl and carries her away while you're talking to her?
B: Not really, man.
A: Can we go now?
B: Not really, but I like the idea of it.
```

In [15]:
```
'''Generate reply for some selected input and calcualate BLEU score'''
print('\nBLEU score for random texts predicted is:',get_bleu(ref,target_array))
```

```
BLEU score for random texts predicted is: 0.7126467352147094
```

4.4 Markov chain using Markovify

In [6]:
```
'''load and preprocess the dataframe'''
df=corpus.get_utterances_dataframe()
df=df[['conversation_id','text']]
df=df[:100000]
df['text']=df.text.apply(lambda x:re.sub("[\<\(\[].*?[\)\>\]]",'',x))
combined_data=''.join(list(df['text']))
```

In [47]:
```
'''fit the model and generate the text'''
generator=markovify.Text(combined_data,state_size=3,retain_original=False)
name=['A:','B:']
target=[]
for i in range(8):
    sentence=generator.make_sentence(tries=50)
    target.append(sentence)
    print(str(name[i%2]),sentence)
```

```
A: Other than her, there's no one out there.Go for it.
B: I don't know.
A: About the business Childs ran?He said he worked there --Yeah.
B: I didn't...If I look weak now, it's over.My friends have a country house we can use liquid nitrogen to keep the newspapers away from him.But it's a great stor
y.
A: You were sent here and you know it!
B: I need your help.
A: I vetted the source, Marty.
B: It won't be long before they commit them.
```

In [48]:
```
'''Generate reply for some selected input and calcualate BLEU score'''
print('\nBLEU score for random texts predicted is:',get_bleu(ref,target))
```

```
BLEU score for random texts predicted is: 0.8719586172718907
```

5. Results

In [49]:
```
from prettytable import PrettyTable
table=PrettyTable()
table.field_names=(["Model","BLEU"])
table.add_row(["GPT fine_tuned","0.7126"])
table.add_row(["RNN/base_line","0.8137"])
table.add_row(["Markov chain","0.8719"])
table.add_row(["RNN with attention","0.9602"])

print(table)
```

```
+--------------------+--------+
|       Model        |  BLEU  |
+--------------------+--------+
|   GPT fine_tuned   | 0.7126 |
|   RNN/base_line    | 0.8137 |
|    Markov chain    | 0.8719 |
| RNN with attention | 0.9602 |
+--------------------+--------+
```

Observation & conclusion/best model

From the generated conversation for the best model,

- Model fails to generate coherent and meaningful conversation.
- It lacks logical progression,there are grammatical and syntax errors.
- Though it lacks many things ,from the generated sample we can loosely conclude that the conversation is about the two people talking about a case/work that's need to be handled in the future.
- Increasing training data/increasing input and output length may improve the issue.

6. References

- https://www.analyticsvidhya.com/blog/2018/03/text-generation-using-python-nlp/ (https://www.analyticsvidhya.com/blog/2018/03/text-generation-using-python-nlp/)
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- https://hyunjoonlee70.github.io/Blog_Post_3/ (https://hyunjoonlee70.github.io/Blog_Post_3/)
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- https://stackoverflow.com/questions/56415280/fine-tune-gpt-2-text-prediction-for-conversational-ai (https://stackoverflow.com/questions/56415280/fine-tune-gpt-2-text-prediction-for-conversational-ai)
- https://github.com/tensorflow/tensorflow/issues/31312 (https://github.com/tensorflow/tensorflow/issues/31312)

Final pipeline

In [34]:
```
'''We can add the model inside of function,but for each call we need to load
the model and that's an unnecessary overhead'''
# models=joblib.load('model.pkl')

def predict(inputs,iter=1,models=model):
    'load model and tokenizers'
    encoder_input_tokenizer=joblib.load('encoder_input_tokenizer.pkl')
    decoder_input_tokenizer=joblib.load('decoder_input_tokenizer.pkl')
    max_sentencelen=22
    max_input_len=105
    targetArray=[]
    target=inputs
    speaker=['A: ','B: ']

    '''for each iteration'''
    for j in range(iter):

        inputs=target
        print(speaker[j%2],inputs)
        j=j+1
        '''tokenize,pad and initilize initial state for input'''

    sequence=encoder_input_tokenizer.texts_to_sequences([inputs])
    sequence=tf.keras.preprocessing.sequence.pad_sequences(sequence,maxlen=max_input_len,
                                                padding='post',
                                               truncating='post'
                                                     )

    states=models.layers[0].initialize_states(1)
    encoder_output,lstm_h,lstm_C=models.layers[0](sequence,states)
    decoder_input=np.zeros((1,1))
    decoder_input[0,0]=decoder_input_tokenizer.word_index['<start>']
    target=''
    '''Generate output  for max output length times'''
    for i in range(max_sentencelen):
        decoder_output,lstm_h,lstm_C,attention_weights,context_vector =models.layers[1].one_step_decoder(decoder_input,encoder_output,lstm_h,lstm_C)
        decoder_input[0,0]=np.argmax(decoder_output)
        if decoder_input_tokenizer.index_word[decoder_input[0,0]]=='<end>':
            targetArray.append(target)
            break
        else:
            target=target+" "+decoder_input_tokenizer.index_word[decoder_input[0,0]]
print('A :',target)
```

In [32]:
```
predict('Who killed bahubali?',iter=1,models=model)
```

```
A:  Who killed bahubali?
B :  We got a long time ago.
```

In [35]:
```
predict('Hi',iter=10,models=model)
```

```
A:  Hi
B:   I was in the laundromat. I saw your car. Thought I'd say hi.
A:   Are you following me?
B:   I'm going to get to work.
A:   Can I call the cops?
B:   Yep.
A:   That's the whole thing. You know if you are a man who aren't gonna call me, right? And by Harry's your boys
B:   That boss is a mile on either way?
A:   Go home, and I won't thank you right now or it's just an option.
B:   How about what? A Phenomenon. A miracle. A new era of family, that was always one of the sting of that stuff
A :  I was the first ones to let you have a chance.
```

In [29]:
```
predict('Say something',iter=10,models=model)
```

```
A:  Say something
B:   This the time, boss. For the way, I got sick and tired it is.
A:   But you didn't think about a lot of garbage? I'd like you to know me and if you could choose many of
B:   Well, I saw you from my old friend of a while so many years ago... I just think somethin's happened.
A:   What for?
B:   You never gave me a lift if you didn't get a towel?
A:   See I'm tellin' me why you're not
B:   Nothing to get me outta ya rehearsal.
A:   Uh-uh. What are you doing?
B:   No, we won't.
B :  You go on the beach with your office and stuff.
```