Predicting the headline of a news

1. Business/Real-world Problem

1.1 Problem Statement

Build a model which can Predict the headline of a news.

1.2 Real-world/Business objectives and constraints.

- No strict Latency constraints.
- Interpretability is not much important.

1.3 Data source

We will scrap the data from https://inshorts.com/en/read (https://inshorts.com/en/read).

2. Include packages

In [0]:
```
import warnings
warnings.filterwarnings("ignore")
import pandas as pd
import matplotlib
matplotlib.use(u'nbAgg')
import matplotlib.pyplot as plt
import seaborn as sns
import numpy as np
import pickle
from sklearn import preprocessing
from sklearn.model_selection import RandomizedSearchCV
from sklearn.metrics import log_loss
from sklearn.metrics import confusion_matrix
from sklearn.model_selection import train_test_split
%matplotlib inline
from nltk.corpus import stopwords
from gensim.scripts.glove2word2vec import glove2word2vec
from tensorflow.keras.callbacks import EarlyStopping
from tensorflow.keras.layers import Dropout,MaxPooling1D,Conv1D,Dense,LSTM,Drop
from keras.preprocessing.text import Tokenizer
from keras.preprocessing.sequence import pad_sequences
from tensorflow.keras.models import Model
from attention import AttentionLayer
from keras import backend as K
from datetime import datetime
from tensorflow import keras
```

3. Scraping the data

In [0]:
```
"""
import requests
from bs4 import BeautifulSoup
import pandas as pd
from tqdm  import tqdm
# code for scraping the first page
d={'headlines':[],'news':[]}
r = requests.get("https://inshorts.com/en/read")
soup = BeautifulSoup(r.content, 'html.parser')
min_news_id = soup.findAll("script",{"type":"text/javascript"})[2].text
min_news_id = min_news_id[25:35]
soup=soup.findAll("div",{"class":"news-card z-depth-1"})
for data in soup:
    d['headlines'].append(data.find(itemprop="headline").getText())
    d['news'].append(data.find(itemprop="articleBody").getText())
# code for scraping more pages
for i in tqdm(range(2100)):
    try:
        params = {'news_offset': min_news_id}
        req = requests.post("https://inshorts.com/en/ajax/more_news",data=param
        json_data = req.json()
        min_news_id = json_data['min_news_id']
        soup = BeautifulSoup(json_data['html'], 'html.parser')
        soup=soup.findAll("div",{"class":"news-card z-depth-1"})
        for data in soup:
            d['headlines'].append(data.find(itemprop="headline").getText())
            d['news'].append(data.find(itemprop="articleBody").getText())
    except:
        pass
# storing the data into .csv file
df = pd.DataFrame(d)
df.to_csv("inshorts_news.csv", index=False)
"""
```

Out[2]:
```
'\nimport requests\nfrom bs4 import BeautifulSoup\nimport pandas as pd\nfrom t
qdm  import tqdm\n# code for scraping the first page\nd={\'headlines\':[],\'ne
ws\':[]}\nr = requests.get("https://inshorts.com/en/read")\nsoup = BeautifulSo
up(r.content, \'html.parser\')\nmin_news_id = soup.findAll("script",{"type":"t
ext/javascript"})[2].text\nmin_news_id = min_news_id[25:35]\nsoup=soup.findAll
("div",{"class":"news-card z-depth-1"})\nfor data in soup:\n    d[\'headline
s\'].append(data.find(itemprop="headline").getText())\n    d[\'news\'].append
(data.find(itemprop="articleBody").getText())\n# code for scraping more pages\
nfor i in tqdm(range(2100)):\n    try:\n        params = {\'news_offset\': min
_news_id}\n        req = requests.post("https://inshorts.com/en/ajax/more_new
s",data=params)\n        json_data = req.json()\n        min_news_id = json_da
ta[\'min_news_id\']\n        soup = BeautifulSoup(json_data[\'html\'], \'html.
parser\')\n        soup=soup.findAll("div",{"class":"news-card z-depth-1"})\n
for data in soup:\n            d[\'headlines\'].append(data.find(itemprop="hea
dline").getText())\n            d[\'news\'].append(data.find(itemprop="article
Body").getText())\n    except:\n        pass\n# storing the data into .csv fil
e\ndf = pd.DataFrame(d)\ndf.to_csv("inshorts_news.csv", index=False)\n'
```

4. Preprocessing the data and EDA

Mount the google drive

In [4]:
```
from google.colab import drive
drive.mount('/content/drive')
```

```
Go to this URL in a browser: https://accounts.google.com/o/oauth2/auth?client_id=947318989803-6bn6qk8qdgf4n4g3pfee6491hc0brc4i.apps.googleusercontent.com&redirect_uri=urn%3aietf%3awg%3aoauth%3a2.0%3aoob&response_type=code&scope=email%20https%3a%2f%2fwww.googleapis.com%2fauth%2fdocs.test%20https%3a%2f%2fwww.googleapis.com%2fauth%2fdrive%20https%3a%2f%2fwww.googleapis.com%2fauth%2fdrive.photos.readonly%20https%3a%2f%2fwww.googleapis.com%2fauth%2fpeopleapi.readonly

Enter your authorization code:
··········
Mounted at /content/drive
```

Loading dataset

In [0]:
```
df=pd.read_csv('/content/drive/My Drive/new1_inshorts_news.csv')
```

In [0]:
```
df
```

Out[5]:

	headlines	news
0	South Africa's Zozibini Tunzi crowned Miss Uni...	Zozibini Tunzi from South Africa has been crow...
1	21-yr-old rapper Juice Wrld dies after reporte...	America's 21-year-old rapper Jarad Anthony Hig...
2	Rajasthan Min demands ban on 'Panipat', says f...	Rajasthan Tourism Minister Vishvendra Singh on...
3	India's Vartika crashes out of Miss Universe, ...	India's 26-year-old Vartika Singh, who entered...
4	What was the answer that won Zozibini Tunzi th...	In Miss Universe 2019's final round, all three...
...	...	...
188317	Govt committee suggests cutting royalty on coal	According to reports, an inter-ministerial com...
188318	Police ask complainant to polish their shoes	A complainant from Muzaffarnagar in Uttar Prad...
188319	Asus debuts ZenFone 3 series starting at ₹16,750	Asus on Monday unveiled three new smartphones ...
188320	'GDP can rise by $1tn by 100% internet access'	India's GDP could be increased by an additiona...
188321	Commodity trader Noble Group CEO resigns	Hong Kong-based Asia's biggest commodity tradi...

188322 rows × 2 columns

In [0]:
```
df['news'][0]
```

Out[71]:
```
"Zozibini Tunzi from South Africa has been crowned Miss Universe 2019 at the finale which was held in Atlanta, Georgia, US on Monday. Puerto Rico's Madison Anderson was named the first runner-up while Sofía Aragón from Mexico stood third at the pageant. India was represented by 26-year-old Vartika Singh, who couldn't qualify for top 10.\n"
```

In [0]:
```
df['headlines'][0]
```

Out[72]:
```
"South Africa's Zozibini Tunzi crowned Miss Universe 2019"
```

In [0]:
```
df = df[df.notnull()]
```

In [0]:
```
df = df.dropna(how='any')
df
```

Out[74]:

	headlines	news
0	South Africa's Zozibini Tunzi crowned Miss Uni...	Zozibini Tunzi from South Africa has been crow...
1	21-yr-old rapper Juice Wrld dies after reporte...	America's 21-year-old rapper Jarad Anthony Hig...
2	Rajasthan Min demands ban on 'Panipat', says f...	Rajasthan Tourism Minister Vishvendra Singh on...
3	India's Vartika crashes out of Miss Universe, ...	India's 26-year-old Vartika Singh, who entered...
4	What was the answer that won Zozibini Tunzi th...	In Miss Universe 2019's final round, all three...
...	...	...
188317	Govt committee suggests cutting royalty on coal	According to reports, an inter-ministerial com...
188318	Police ask complainant to polish their shoes	A complainant from Muzaffarnagar in Uttar Prad...
188319	Asus debuts ZenFone 3 series starting at ₹16,750	Asus on Monday unveiled three new smartphones ...
188320	'GDP can rise by $1tn by 100% internet access'	India's GDP could be increased by an additiona...
188321	Commodity trader Noble Group CEO resigns	Hong Kong-based Asia's biggest commodity tradi...

188322 rows × 2 columns

In [0]:
```
!pip install ftfy
```

```
Collecting ftfy
  Downloading https://files.pythonhosted.org/packages/ec/d8/5e877ac5e827eaa41a7ea8c0dc1d3042e05d7e337604dc2aedb854e7b500/ftfy-5.7.tar.gz (https://files.pythonhosted.org/packages/ec/d8/5e877ac5e827eaa41a7ea8c0dc1d3042e05d7e337604dc2aedb854e7b500/ftfy-5.7.tar.gz) (58kB)
     |████████████████████████████████| 61kB 3.1MB/s eta 0:00:011
Requirement already satisfied: wcwidth in /usr/local/lib/python3.6/dist-packages (from ftfy) (0.1.8)
Building wheels for collected packages: ftfy
  Building wheel for ftfy (setup.py) ... done
  Created wheel for ftfy: filename=ftfy-5.7-cp36-none-any.whl size=44593 sha256=7eb700bf135915af321f56cca71e68a2e3bf500f5ae92435eff4a50cae487b53
  Stored in directory: /root/.cache/pip/wheels/8e/da/59/6c8925d571aacade638a0f515960c21c0887af1bfe31908fbf
Successfully built ftfy
Installing collected packages: ftfy
Successfully installed ftfy-5.7
```

Remove any bad unicode string using ftfy package

In [0]:
```
import ftfy
from tqdm import tqdm
headline = []
for i in tqdm(df.headlines):
    title = ftfy.fix_text(i)
    headline.append(title)
```

```
100%|██████████| 188322/188322 [00:07<00:00, 26052.43it/s]
```

In [0]:
```
df['headlines']=headline
```

In [0]:
```
h_len = []
for s in tqdm(df.headlines):
  w=s.split()
  h_len.append(len(w))
```

```
100%|██████████| 188322/188322 [00:00<00:00, 886061.72it/s]
```

In [0]:
```
max(h_len) # maximum length of headline is 18
```

Out[111]: 18

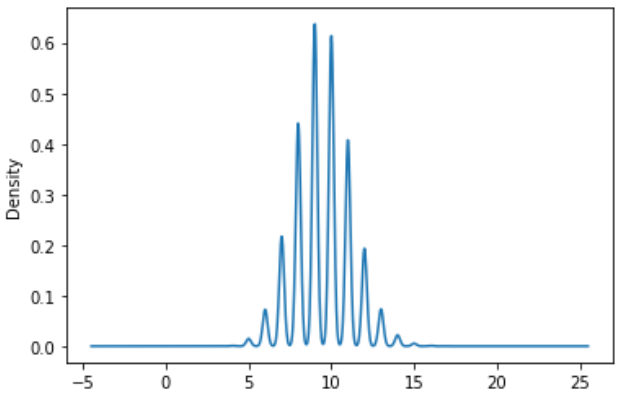
In [0]:
```
min(h_len) # minimum length of headline is 3
```

Out[15]: 3

In [0]:
```
sum(h_len)/188322 # Avg length of headline is 9
```

Out[16]: 9.480310319559052

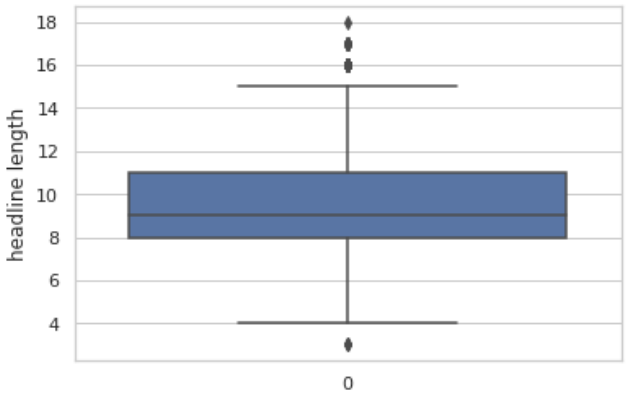
In [0]:
```
s = pd.Series(h_len)
ax = s.plot.kde()
```



Maximum headlines have length between 5-15.

In [0]:
```
import seaborn as sns
sns.set(style="whitegrid")
ax = sns.boxplot(data=h_len)
ax.set_ylabel('headline length')
```

Out[18]: Text(0, 0.5, 'headline length')



observation: 75% of headlines have length below 12 words.

In [0]:
```
import ftfy
from tqdm import tqdm_notebook
news = []
for i in tqdm_notebook(df.news):
    title = ftfy.fix_text(i)
    news.append(title)
```

```
HBox(children=(IntProgress(value=0, max=188322), HTML(value='')))
```

In [0]:
```
df['news']=news
```

In [0]:
```
n_len = []
for s in tqdm_notebook(df.news):
  w=s.split()
  n_len.append(len(w))
```

```
HBox(children=(IntProgress(value=0, max=188322), HTML(value='')))
```

In [0]:
```
max(n_len) # maximum length of news is 67
```

Out[22]:
```
67
```

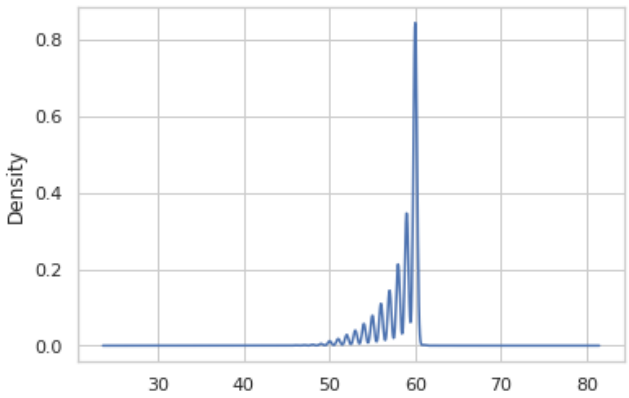
In [0]:
```
min(n_len) # minimum length of news is 38
```

Out[23]:
```
38
```

In [0]:
```
sum(n_len)/188322 # average length of news is 58
```

Out[24]:
```
58.26926222108941
```

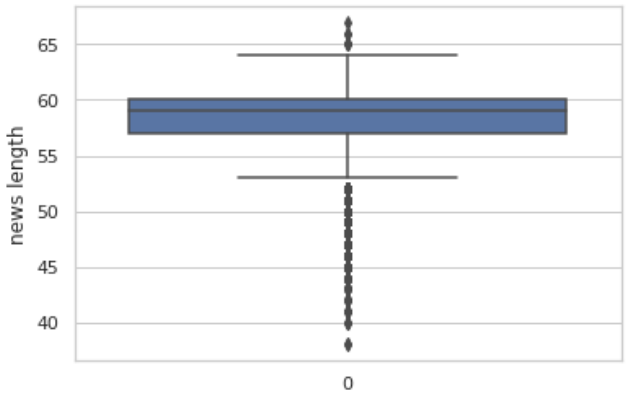
In [0]:
```
s = pd.Series(n_len)
ax = s.plot.kde()
```



observation: Nearly all news have length near 60.

In [0]:
```
import seaborn as sns
sns.set(style="whitegrid")
ax = sns.boxplot(data=n_len)
ax.set_ylabel('news length')
```

Out[26]: Text(0, 0.5, 'news length')



observation: 75% of news have length below 60 words.

5. Date preprocessing

In [0]:
```
stopwords= ['i', 'me', 'my', 'myself', 'we', 'our', 'ours', 'ourselves', 'you'
"you'll", "you'd", 'your', 'yours', 'yourself', 'yourselves', 'he'
'she', "she's", 'her', 'hers', 'herself', 'it', "it's", 'its',
'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this',
'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have','had','as',
'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or', 'because'
'at', 'by', 'for', 'with', 'about', 'against', 'between', 'into'
'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'on',
'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how',
'most', 'other', 'some', 'such', 'only', 'own', 'same', 'so', 'than'
's', 't', 'can', 'will', 'just', 'would']
```

Headlines

In [7]:
```
import re
def decontracted(phrase):
  # specific
  phrase = re.sub(r"won't", "will not", phrase)
  phrase = re.sub(r"can\'t", "can not", phrase)
  # general
  phrase = re.sub(r"n\'t", " not", phrase)
  phrase = re.sub(r"\'re", " are", phrase)
  phrase = re.sub(r"\'s", " is", phrase)
  phrase = re.sub(r"\'d", " would", phrase)
  phrase = re.sub(r"\'ll", " will", phrase)
  phrase = re.sub(r"\'t", " not", phrase)
  phrase = re.sub(r"\'ve", " have", phrase)
  phrase = re.sub(r"\'m", " am", phrase)
  return phrase


from tqdm import tqdm
preprocessed1 = []
# tqdm is for printing the status bar
for sentance in tqdm(df['headlines'].values):
  sent = decontracted(sentance)
  sent = sent.replace('\\r', ' ')
  sent = sent.replace('\\"', ' ')
  sent = sent.replace('\\n', ' ')
  sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
# https://gist.github.com/sebleier/554280
  sent = ' '.join(e for e in sent.split() if e.lower() not in stopwords)
  preprocessed1.append(sent.lower().strip())
df['headlines']=preprocessed1
```

```
100%|██████████| 188322/188322 [00:05<00:00, 36804.26it/s]
```

News

In [8]:
```
import re
def decontracted(phrase):
  # specific
  phrase = re.sub(r"won't", "will not", phrase)
  phrase = re.sub(r"can\'t", "can not", phrase)
  # general
  phrase = re.sub(r"n\'t", " not", phrase)
  phrase = re.sub(r"\'re", " are", phrase)
  phrase = re.sub(r"\'s", " is", phrase)
  phrase = re.sub(r"\'d", " would", phrase)
  phrase = re.sub(r"\'ll", " will", phrase)
  phrase = re.sub(r"\'t", " not", phrase)
  phrase = re.sub(r"\'ve", " have", phrase)
  phrase = re.sub(r"\'m", " am", phrase)
  return phrase

from tqdm import tqdm
preprocessed2 = []
# tqdm is for printing the status bar
for sentance in tqdm(df['news'].values):
  sent = decontracted(sentance)
  sent = sent.replace('\\r', ' ')
  sent = sent.replace('\\"', ' ')
  sent = sent.replace('\\n', ' ')
  sent = re.sub('[^A-Za-z0-9]+', ' ', sent)
# https://gist.github.com/sebleier/554280
  sent = ' '.join(e for e in sent.split() if e.lower() not in stopwords)
  preprocessed2.append(sent.lower().strip())
df['news']=preprocessed2
```

```
100%|██████████| 188322/188322 [00:19<00:00, 9823.59it/s]
```

Adding 'ssttaarrtt' and 'eenndd' token to the headlines.

In [0]:
```
df['headlines'] = df['headlines'].apply(lambda x : 'ssttaarrtt '+ x + ' eenndd'
```

In [9]:
```
df['headlines'][0]
```

Out[9]: 'ssttaarrtt south africa zozibini tunzi crowned miss universe 2019 eenndd'

In [10]:
```
df['headlines'][:1000]
```

Out[10]:
```
0      ssttaarrtt south africa zozibini tunzi crowned...
1      ssttaarrtt 21 yr old rapper juice wrld dies af...
2      ssttaarrtt rajasthan min demands ban panipat s...
3      ssttaarrtt india vartika crashes of miss unive...
4      ssttaarrtt answer that won zozibini tunzi miss...
                             ...
995    ssttaarrtt aminimoon fireball recently observe...
996    ssttaarrtt do not jijas bjp karyakartas sithar...
997    ssttaarrtt police seek 10 day custody of accus...
998    ssttaarrtt half burnt body of woman found fore...
999    ssttaarrtt aapke chachere bhai lagte hain kya ...
Name: headlines, Length: 1000, dtype: object
```

7. Splitting the dataset

In [0]:
```
from sklearn.model_selection import train_test_split
X_1, X_test, y_1, y_test = train_test_split(np.array(df['news']),np.array(df['h
# split the train data set into cross validation train and cross validation tes
X_tr, X_cv, y_tr, y_cv = train_test_split(X_1, y_1, test_size=0.15)
```

In [0]:
```
print(X_tr.shape)
print(X_cv.shape)
print(X_test.shape)
```

```
(159273,)
(28107,)
(942,)
```

In [0]:
```
X_tr
```

Out[16]:
```
array(['mobile chipmaker qualcomm tuesday unveiled snapdragon x20 lte modem of
fers download speed of 1 2 gbps 20 improvement over previous generation achiev
e speed qualcomm modem downloads 12 unique data streams of 100 mbps each uploa
d speed of x20 lte modem 150 mbps',
       'twitter co founder ceo jack dorsey friday apologised allowing advertis
ement promoting white supremacist group platform made mistake apologise automa
ted system allowed ad promoting hate policy retro fixed dorsey tweeted twitter
recently suspended number of accounts over hate speech',
       'actor dwayne johnson has said he not rule working bollywood added that
he has lot of respect bollywood referring actor varun dhawan dwayne stated he
big fan interacted him social media know he big star india maybe one day you c
ould see bollywood action movie',
       ...,
       'telangana minister kt rama rao has urged officials public representati
ves students of all state run institutions wear handloom clothes at least week
rao son of chief minister k chandrasekhar rao meeting mlas of all political pa
rties during winter session presenting them bag of handloom clothes requesting
them promote handloom sector',
       'president elect ram nath kovind take oath country 14th president talke
d his childhood saying his election post represent all kovinds toiling away ma
ke living he born uttar pradesh village his father sell off piece of his land
fund his education',
       'government may increase excise duty petrol diesel generate more revenu
e amid rising fuel prices reports said may make change at later stage crude oi
l prices soften leading downward revision cost of petrol diesel petrol diesel
prices tuesday stood at 74 13 67 07 respectively delhi'],
      dtype=object)
```

Tokenizing and padding the sequences

In [0]:
```
from keras.preprocessing.text import Tokenizer
from keras.preprocessing.sequence import pad_sequences
```

Tokenize news

In [0]:
```
t = Tokenizer()
t.fit_on_texts(X_tr)
vocab_size = len(t.word_index) + 1 # for index zero we have to add +1
# integer encode the documents
encoded_docs = t.texts_to_sequences(X_tr)
encoded_docs_test = t.texts_to_sequences(X_test)
encoded_docs_cv = t.texts_to_sequences(X_cv)
max_length = 70
padded_docs_train = pad_sequences(encoded_docs, maxlen=max_length, padding='pos
padded_docs_test = pad_sequences(encoded_docs_test, maxlen=max_length, padding=
padded_docs_cv = pad_sequences(encoded_docs_cv, maxlen=max_length, padding='pos
```

In [14]:
```
padded_docs_train[0]
```

Out[14]:
```
array([  248,   805,   108,    21,  5706,    46,    20, 25069, 16780,
        1081,    10,     3,  1251,  1222,  2011,    29,    81,    71,
       10524,   902,  3255,   611, 16781,  7073,     5,    11,    21,
         374,    29,  4325,    37,     3,     5,   227,  1690,   454,
         219,    26,  2305,    35, 30767,     0,     0,     0,     0,
           0,     0,     0,     0,     0,     0,     0,     0,     0,
           0,     0,     0,     0,     0,     0,     0,     0,     0,
           0,     0,     0,     0,     0,     0,     0],    dtype=int32)
```

In [15]:
```
t_word_index
```

Out[15]:
```
{'of': 1,
 'has': 2,
 'said': 3,
 'that': 4,
 'he': 5,
 'his': 6,
 'after': 7,
 'at': 8,
 'not': 9,
 'india': 10,
 'added': 11,
 'year': 12,
 'over': 13,
 'also': 14,
 'us': 15,
 'she': 16,
 'their': 17,
 'first': 18,
 'government': 19,
 'people': 20
```

Tokenize headlines

In [0]:
```
y_tokenizer = Tokenizer()
y_tokenizer.fit_on_texts(y_tr)
y_vocab_size = len(y_tokenizer.word_index) + 1
# integer encode the documents
y_encoded_docs = y_tokenizer.texts_to_sequences(y_tr)

y_encoded_docs_test = y_tokenizer.texts_to_sequences(y_test)
y_encoded_docs_cv = y_tokenizer.texts_to_sequences(y_cv)
y_max_length = 20
y_padded_docs_train = pad_sequences(y_encoded_docs, maxlen=y_max_length, paddin
y_padded_docs_test = pad_sequences(y_encoded_docs_test, maxlen=y_max_length, pa
y_padded_docs_cv = pad_sequences(y_encoded_docs_cv, maxlen=y_max_length, paddin
```

In [17]:
```
y_tokenizer.word_index
```

Out[17]:
```
{'ssttaarrtt': 1,
 'eenndd': 2,
 'of': 3,
 'india': 4,
 'not': 5,
 'after': 6,
 'at': 7,
 'over': 8,
 'us': 9,
 'pm': 10,
 '2': 11,
 'man': 12,
 'govt': 13,
 '1': 14,
 'world': 15,
 'bjp': 16,
 'delhi': 17,
 'old': 18,
 '3': 19,
 'new': 20
```

In [18]:
```
y_padded_docs_train[0]
```

Out[18]:
```
array([    1,  2246,   883, 12565,  1088,     4,  1366,    60,    83,
         284,     2,     0,     0,     0,     0,     0,     0,     0,
           0,     0], dtype=int32)
```

Loading the word vectors

Download glove word vectors

In [14]:
```
!wget --header="Host: storage.googleapis.com" --header="User-Agent: Mozilla/5.0
```

```
--2020-03-21 14:29:07--  https://storage.googleapis.com/kaggle-data-sets/213609/464671/bundle/archive.zip?GoogleAccessId=web-data@kaggle-161607.iam.gserviceaccount.com&Expires=1584850356&Signature=jQ0PXa83Tceu%2B%2FTH8%2FcUJgeRUW5kAje0OqkUK92vPwT9Ut9c%2BWQ5aE2XD44Vi%2FUejiBGZNUHBSLouHbFEh9VicPvPgHXiR%2FcECkjrqkkDiIuxHrW%2BGahIVZfyQYyQm6G508DVYQbHUjr5UBBiz1ziBcPYQIJ%2FadPB9oSlmiH80VE3eNMtD7aEWAiIBF4g34IU48QUZEIKqWDCXXriNIPALl%2FwcCxZR5BubOM4O9gCmG6xgxdFD3T99NZb%2Birm1WqnyZ2qanALgbDCGRyqMCJ5ogqzmKvY3ap%2BdzFB8ueZ6bJ5L7s%2FAbVRu0KuBLodOtNQJ5t78Mtgoh9lcjyA0kFNg%3D%3D&response-content-disposition=attachment%3B+filename%3Dglove42b300dtxt.zip (https://storage.googleapis.com/kaggle-data-sets/213609/464671/bundle/archive.zip?GoogleAccessId=web-data@kaggle-161607.iam.gserviceaccount.com&Expires=1584850356&Signature=jQ0PXa83Tceu%2B%2FTH8%2FcUJgeRUW5kAje0OqkUK92vPwT9Ut9c%2BWQ5aE2XD44Vi%2FUejiBGZNUHBSLouHbFEh9VicPvPgHXiR%2FcECkjrqkkDiIuxHrW%2BGahIVZfyQYyQm6G508DVYQbHUjr5UBBiz1ziBcPYQIJ%2FadPB9oSlmiH80VE3eNMtD7aEWAiIBF4g34IU48QUZEIKqWDCXXriNIPALl%2FwcCxZR5BubOM4O9gCmG6xgxdFD3T99NZb%2Birm1WqnyZ2qanALgbDCGRyqMCJ5ogqzmKvY3ap%2BdzFB8ueZ6bJ5L7s%2FAbVRu0KuBLodOtNQJ5t78Mtgoh9lcjyA0kFNg%3D%3D&response-content-disposition=attachment%3B+filename%3Dglove42b300dtxt.zip)
Resolving storage.googleapis.com (storage.googleapis.com)... 74.125.31.128, 2607:f8b0:400c:c15::80
Connecting to storage.googleapis.com (storage.googleapis.com)|74.125.31.128|:443... connected.
HTTP request sent, awaiting response... 200 OK
Length: 1928408067 (1.8G) [application/zip]
Saving to: ‘glove42b300dtxt.zip’

glove42b300dtxt.zip 100%[===================>]   1.80G   134MB/s    in 15s

2020-03-21 14:29:22 (124 MB/s) - ‘glove42b300dtxt.zip’ saved [1928408067/1928408067]
```

In [15]:
```
!unzip glove42b300dtxt.zip
```

```
Archive:  glove42b300dtxt.zip
  inflating: glove.42B.300d.txt
```

Creating dictionary which contain word as key and 300 vectors as value.

In [16]:
```
from numpy import asarray
from tqdm import tqdm_notebook
embeddings_index = dict()
f = open('glove.42B.300d.txt')
for line in tqdm_notebook(f):
  values = line.split()
  word = values[0]
  coefs = asarray(values[1:], dtype='float32')
  embeddings_index[word] = coefs
f.close()
```

```
HBox(children=(IntProgress(value=1, bar_style='info', max=1), HTML(value='')))
```

News word vector matrix (encoder input matrix)

In [17]:
```
from numpy import zeros
input_matrix = zeros((vocab_size, 300))
for word, i in tqdm_notebook(t.word_index.items()):
  embedding_vector = embeddings_index.get(word)
  if embedding_vector is not None:
    input_matrix[i] = embedding_vector
```

```
HBox(children=(IntProgress(value=0, max=104836), HTML(value='')))
```

Headlines word vector matrix (decoder input matrix)

In [18]:
```
from numpy import zeros
decoder_matrix = zeros((y_vocab_size, 300))
for word, i in tqdm_notebook(y_tokenizer.word_index.items()):
  embedding_vector = embeddings_index.get(word)
  if embedding_vector is not None:
    decoder_matrix[i] = embedding_vector
```

```
HBox(children=(IntProgress(value=0, max=44570), HTML(value='')))
```

News data contains total 104870 different words.

In [24]:
```
input_matrix.shape
```

Out[24]:
```
(104945, 300)
```

In [85]:
```
decoder_matrix.shape
```

Out[85]:
```
(44499, 300)
```

Modelling

Model 1

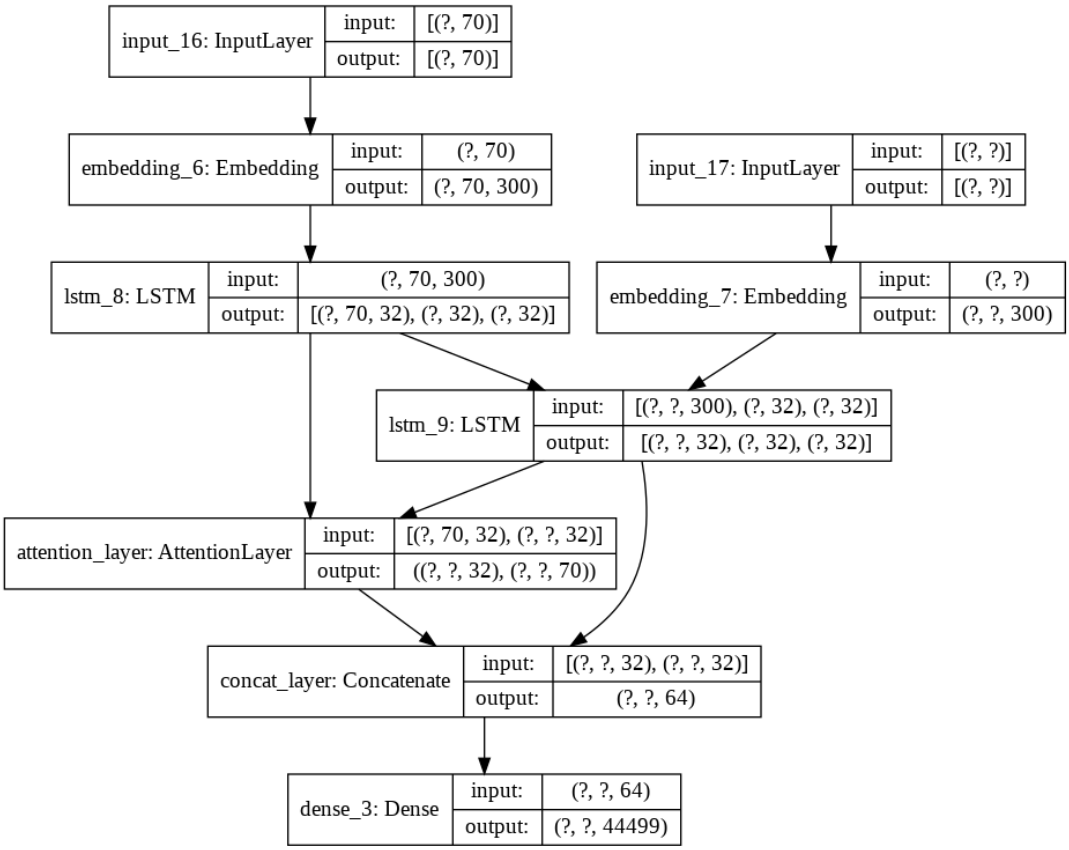
LSTM Encoder + Bahdanau Attention + LSTM decoder

In [86]:
```
# to plot the tensorboard

emb_dim = 300

encoder_input = Input(shape=(70,))
x1=Embedding(vocab_size, 300,weights=[input_matrix],trainable=False)(encoder_in
e_lstm_out, e_hidden_out, e_cell_out = LSTM(32,return_sequences=True,return_sta

decoder_input = Input(shape=(None,))

decoder_embedding_layer = Embedding(y_vocab_size, 300,weights=[decoder_matrix],
decoder_embedding = decoder_embedding_layer(decoder_input)

decoder_lstm = LSTM(32, return_sequences=True, return_state=True)
d_lstm_out,d_hidden_out,d_cell_out = decoder_lstm(decoder_embedding,initial_sta
#https://towardsdatascience.com/light-on-math-ml-attention-with-keras-dc8dbc1fa
attention_layer = AttentionLayer(name='attention_layer')
attention_out, attention_states = attention_layer([e_lstm_out, d_lstm_out])

# Concat attention input and decoder LSTM output
concat = Concatenate(axis=-1, name='concat_layer')([d_lstm_out, attention_out])

decoder_dense =  Dense(y_vocab_size, activation='softmax')
decoder_dense_outputs = decoder_dense(concat)

# Define the model
model = Model([encoder_input, decoder_input], decoder_dense_outputs)

model.summary()
```

```
Model: "model_9"
__________________________________________________________________________________
_____________________
Layer (type)                 Output Shape              Param #     Connected to
==================================================================================
====================
input_16 (InputLayer)        [(None, 70)]              0
__________________________________________________________________________________
_____________________
input_17 (InputLayer)        [(None, None)]            0
__________________________________________________________________________________
_____________________
embedding_6 (Embedding)      (None, 70, 300)           31483500    input_16
[0][0]
__________________________________________________________________________________
_____________________
embedding_7 (Embedding)      (None, None, 300)         13349700    input_17
[0][0]
__________________________________________________________________________________
_____________________
lstm_8 (LSTM)                [(None, 70, 32), (No 42624       embedding_6
[0][0]
__________________________________________________________________________________
_____________________
lstm_9 (LSTM)                [(None, None, 32), ( 42624       embedding_7
[0][0]
                                                              lstm_8[0][1]
                                                              lstm_8[0][2]
__________________________________________________________________________________
_____________________
attention_layer (AttentionLayer ((None, None, 32), ( 2080        lstm_8[0][0]
                                                              lstm_9[0][0]
__________________________________________________________________________________
_____________________
concat_layer (Concatenate)   (None, None, 64)          0           lstm_9[0][0]
                                                              attention_lay
er[0][0]
```

In [87]:
```
from tensorflow.keras.utils import plot_model
plot_model(model, to_file='model.png', show_shapes=True)
```

Out[87]:



ephocs=8 and batch_size=128

In [88]:
```
model.compile(optimizer='adam', loss='sparse_categorical_crossentropy')
t1=padded_docs_train
t2=y_padded_docs_train
t1_cv=padded_docs_cv
t2_cv=y_padded_docs_cv
history=model.fit([t1,t2[:,:-1]],
                  t2.reshape(t2.shape[0],t2.shape[1], 1)[:,1:]
                  ,epochs=8,batch_size=128, validation_data=([t1_cv,t2_cv[:,:-1
                  t2_cv.reshape(t2_cv.shape[0],t2_cv.shape[1], 1)[:,1:]),
                  callbacks=[tensorboard_callback])
```

```
Train on 159273 samples, validate on 28107 samples
Epoch 1/8
159273/159273 [==============================] - 261s 2ms/sample - loss: 4.062
5 - val_loss: 3.4938
Epoch 2/8
159273/159273 [==============================] - 254s 2ms/sample - loss: 3.346
1 - val_loss: 3.1206
Epoch 3/8
159273/159273 [==============================] - 253s 2ms/sample - loss: 3.055
6 - val_loss: 2.9285
Epoch 4/8
159273/159273 [==============================] - 253s 2ms/sample - loss: 2.875
3 - val_loss: 2.8056
Epoch 5/8
159273/159273 [==============================] - 253s 2ms/sample - loss: 2.747
5 - val_loss: 2.7235
Epoch 6/8
159273/159273 [==============================] - 256s 2ms/sample - loss: 2.651
9 - val_loss: 2.6653
Epoch 7/8
159273/159273 [==============================] - 258s 2ms/sample - loss: 2.577
3 - val_loss: 2.6208
Epoch 8/8
159273/159273 [==============================] - 255s 2ms/sample - loss: 2.517
3 - val_loss: 2.5878
```

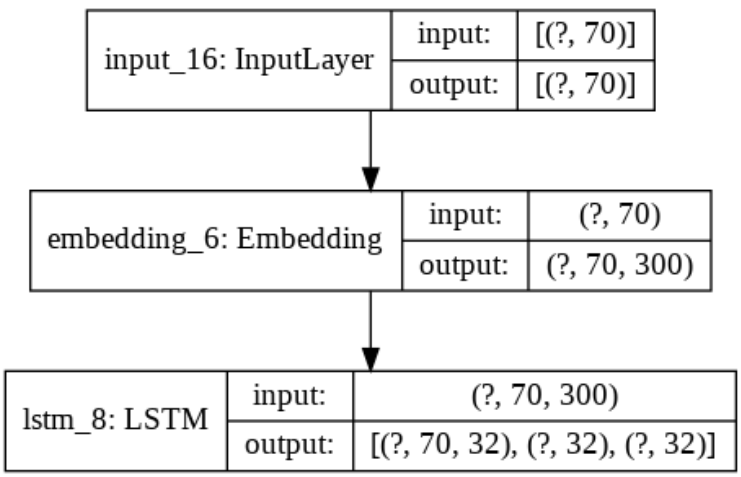
Inference

In [0]:
```
news_word_index=t.index_word
headlines_word_index=y_tokenizer.index_word
target_headlines_word_index=y_tokenizer.word_index
```

In [0]:
```
encoder_model = Model(inputs=encoder_input,outputs=[e_lstm_out, e_hidden_out, e
```

In [90]:
```
plot_model(encoder_model, to_file='model.png', show_shapes=True)
```

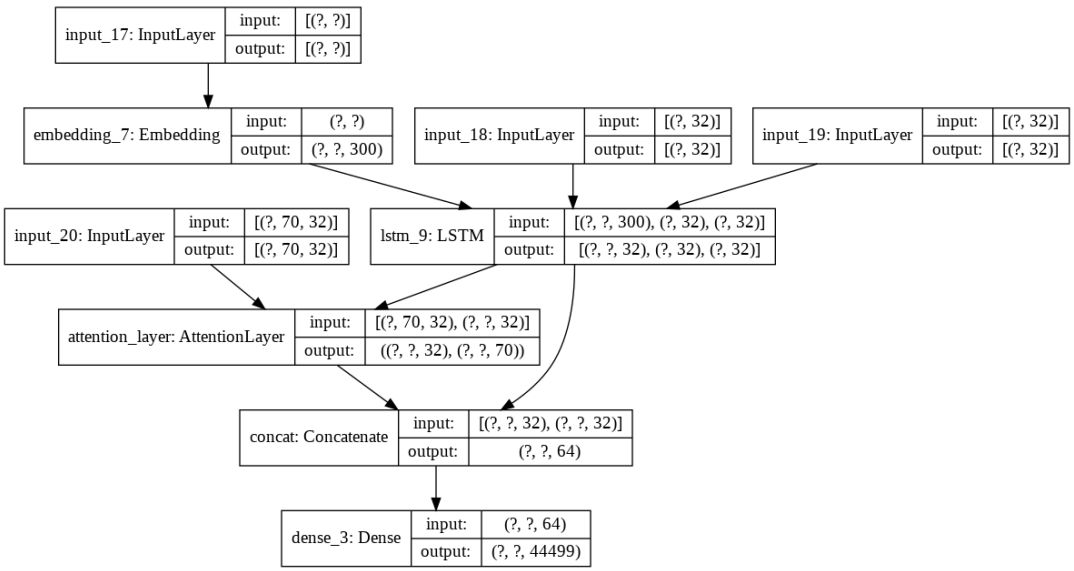
Out[90]:



In [0]:
```
decoder_input_h = Input(shape=(32,))
decoder_input_c = Input(shape=(32,))
decoder_hidden_state = Input(shape=(70,32))

dec_emb2= decoder_embedding_layer(decoder_input)
decoder_outputs2, state_h2, state_c2 = decoder_lstm(dec_emb2, initial_state=[de

attn_out_inf, attn_states_inf = attention_layer([decoder_hidden_state, decoder_
decoder_inf_concat = Concatenate(axis=-1, name='concat')([decoder_outputs2, att

decoder_outputs2 = decoder_dense(decoder_inf_concat)

decoder_model = Model(
    [decoder_input] + [decoder_hidden_state,decoder_input_h, decoder_input_c],
    [decoder_outputs2] + [state_h2, state_c2])
```

In [92]:
```
plot_model(decoder_model, to_file='model.png', show_shapes=True)
```

Out[92]:



In [0]:
```
# https://machinelearningmastery.com/encoder-decoder-attention-sequence-to-sequ
# https://towardsdatascience.com/light-on-math-ml-attention-with-keras-dc8dbc1f
def decode_sequence(input_seq):
    # Encode the input as state vectors.
    e_out, e_h, e_c = encoder_model.predict(input_seq)

    # Generate empty target sequence of length 1.
    seq = np.zeros((1,1))

    # Populate the first word of target sequence with the start word.
    seq[0, 0] = target_headlines_word_index['ssttaarrtt']

    stop_condition = False
    decoded_sentence = ''
    while not stop_condition:

        output, h, c = decoder_model.predict([seq] + [e_out, e_h, e_c])

        token_index = np.argmax(output[0, -1, :])
        if(token_index==0):
          token_index=2
        try:
          token = headlines_word_index[token_index]

          if(token!='eenndd'):
            decoded_sentence += ' '+token

        # Exit condition: either hit max length or find stop word.
          if (token == 'eenndd'  or len(decoded_sentence.split()) >= (20-1)):
            stop_condition = True
        except:
          pass
        # Update the target sequence (of length 1).
        seq = np.zeros((1,1))
        seq[0, 0] = token_index

        # Update internal states
        e_h, e_c = h, c

    return decoded_sentence
```

In [0]:
```
def headlines(input_seq):
    s=''
    for i in input_seq:
        if((i!=0 and i!=target_headlines_word_index['ssttaarrtt']) and i!=targe
            s=s+headlines_word_index[i]+' '
    return s

def news(input_seq):
    s=''

    for i in input_seq:
        if(i!=0):
            s=s+news_word_index[i]+' '
    return s
```

In [95]:
```
for i in range(5):
  print("News:",news(padded_docs_train[i]))
  print("Original headline:",headlines(y_padded_docs_train[i]))
  print("Predicted headline:",decode_sequence(padded_docs_train[i].reshape(1,70
  print("\n")
```

```
News: shah rukh khan while recalling time people apprehensive chak de india sa
id everyone thought worst film made no heroine girls unknown look awful beard
he added while talking film srk further said he does certain films because the
y appeal him organically
Original headline: everyone said chak de india worst film made srk
Predicted headline:  not want not want not want srk


News: transportation security administration has announced more comprehensive
involved physical screening of passengers at us airports new pat rule comes af
ter audit homeland security revealed that airport officers failed detect guns
weapons passengers us airports subjected pat searches they refuse pass through
imaging scanners
Original headline: pat downs at us airports get more invasive
Predicted headline:  us airlines cancels over 1 000 flights


News: 20 year old indonesian man allegedly forged his diploma overstated his g
rades gain admission into police academy has arrested discrepancy noticed poli
ce education officials started verifying applicants credentials suspect charge
d document forgery jailed six years police said
Original headline: man breaks law get into police academy gets arrested
Predicted headline:  man arrested raping man arrested


News: at least one person killed 14 others injured after communal clashes brok
e assam hailakandi friday officials said clashes broke people protested prayer
s held road front of mosque officials added district administration has also s
ought army help maintain peace area
Original headline: 1 dead 14 injured communal clashes assam hailakandi
Predicted headline:  4 killed 4 injured after clashes clashes j k


News: congress president rahul gandhi sunday took ride namma metro bengaluru d
uring his karnataka assembly elections campaign gandhi boarded metro at vidhan
a soudha station got off at mg road station he also visited bookstore karnatak
a elections scheduled may 12 counting of votes held may 15
Original headline: rahul rides bengaluru metro during karnataka poll campaign
Predicted headline:  delhi cm takes his first floor of karnataka cm
```

In [96]:
```
for i in range(5):
  print("News:",news(padded_docs_test[i]))
  print("Original headline:",headlines(y_padded_docs_test[i]))
  print("Predicted headline:",decode_sequence(padded_docs_test[i].reshape(1,70)
  print("\n")
```

```
News: former american swimmer michael phelps decorated olympian of all time ha
s said he extremely thankful that he not end his life while fighting depressio
n 23 time olympic gold medalist added that he suffered depression after every
olympic games his career phelps further said he not want live anymore after 20
12 olympics
Original headline: under depression after every olympics 23 time champion
Predicted headline:  phelps phelps he he he he aged year


News: proxy advisory firms come support of infosys co founder narayana murthy
stance making panaya probe report public infosys earlier declined murthy reque
st claimed that management has cleared of alleged wrongdoings advisory firms a
lso questioned company stock performance asked founders specific plan put info
sys back stability track
Original headline: advisory firms back murthy over making panaya probe public
Predicted headline:  infosys ceo resigns over 1 months after infosys


News: konkona sen sharma has named best actress film lipstick under burkha at
17th edition of new york indian film festival she also received best director
award directorial debut death gunj notably lipstick under burkha opening film
at film festival
Original headline: konkona named best actress lipstick under burkha
Predicted headline:  new film of new film of new film awards


News: mexico create new division of federal police preserve secure cultural he
ritage according officials division recruit officers knowledge of archaeology
art prevent thefts looting of cultural artefacts officials said according offi
cial figures 90 of stolen cultural objects archaeological pieces religious art
never recovered
Original headline: mexico create new police division preserve culture
Predicted headline:  new york city city city city


News: minor solar storm expected hit earth today could trigger northern lights
places like alaska sweden norway iceland solar storms measured scale of g5 g5
extreme capable of disrupting electrical grids current storm little no effect
earth us weather agency noaa reported
Original headline: minor solar flare expected hit earth today cause auroras
Predicted headline:  world largest warming hit earth
```

Model 1 BLEU score

In [97]:
```
h=[]
s=[]
for i in range(942):
  h1=[headlines(y_padded_docs_test[i]).split()]
  h.append(h1)
  s.append(decode_sequence(padded_docs_test[i].reshape(1,70)).split())

from nltk.translate.bleu_score import corpus_bleu
print('BLEU-1: %f' % corpus_bleu(h, s, weights=(1.0, 0, 0, 0)))
print('BLEU-2: %f' % corpus_bleu(h, s, weights=(0.5, 0.5, 0, 0)))
```

```
BLEU-1: 0.132946
BLEU-2: 0.053922
```

In [0]:

Model 2

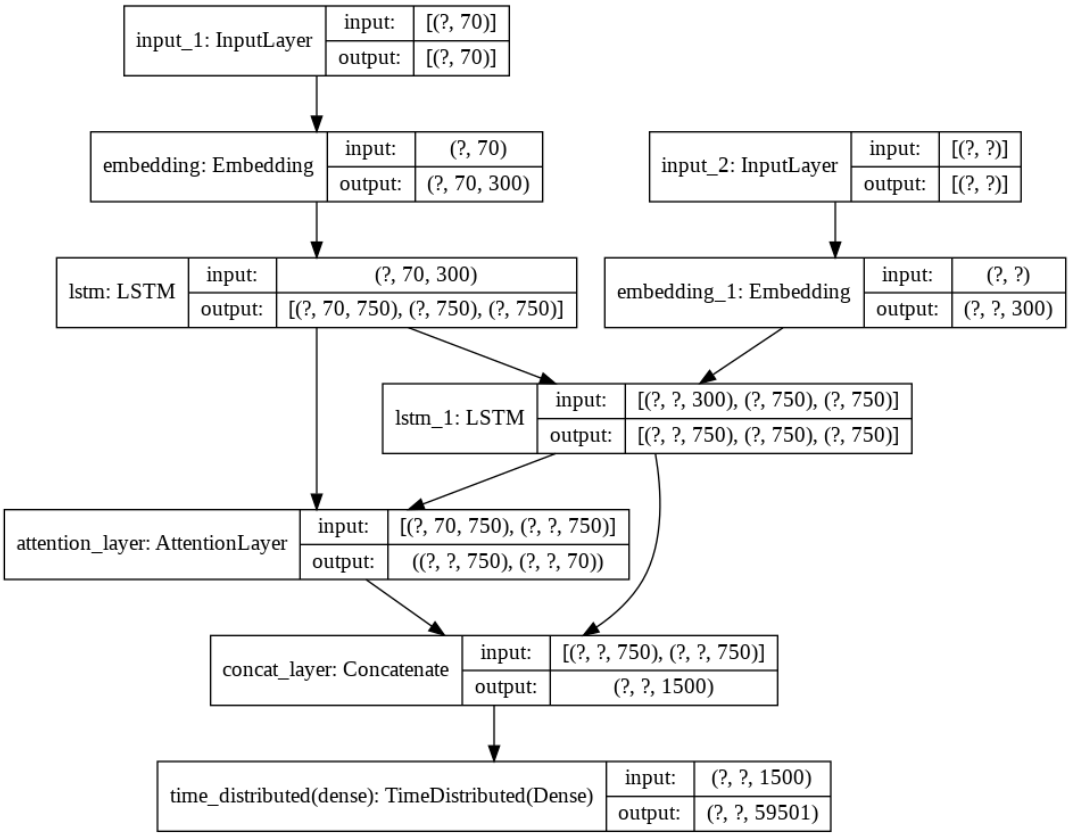
Model with stop words not removed from headlines.

In [0]:
```
from keras import backend as K
logdir = "log2/scalars/" + datetime.now().strftime("%Y%m%d-%H%M%S")
tensorboard_callback = keras.callbacks.TensorBoard(log_dir=logdir)

emb_dim = 300

encoder_input = Input(shape=(70,))
x1=Embedding(vocab_size, 300,weights=[input_matrix],trainable=False)(encoder_in
e_lstm_out, e_hidden_out, e_cell_out = LSTM(750,return_sequences=True,return_st

decoder_input = Input(shape=(None,))

decoder_embedding_layer = Embedding(y_vocab_size, 300,weights=[decoder_matrix],
decoder_embedding = decoder_embedding_layer(decoder_input)

decoder_lstm = LSTM(750, return_sequences=True, return_state=True)
d_lstm_out,d_hidden_out,d_cell_out = decoder_lstm(decoder_embedding,initial_sta
# https://towardsdatascience.com/light-on-math-ml-attention-with-keras-dc8dbc1f
attention_layer = AttentionLayer(name='attention_layer')
attention_out, attention_states = attention_layer([e_lstm_out, d_lstm_out])

# Concat attention input and decoder LSTM output
concat = Concatenate(axis=-1, name='concat_layer')([d_lstm_out, attention_out])

#dense layer
decoder_dense =  TimeDistributed(Dense(y_vocab_size, activation='softmax'))
decoder_dense_outputs = decoder_dense(concat)

# Define the model
model = Model([encoder_input, decoder_input], decoder_dense_outputs)

model.summary()
```

```
WARNING:tensorflow:From /tensorflow-1.15.0/python3.6/tensorflow_core/python/ke
ras/initializers.py:119: calling RandomUniform.__init__ (from tensorflow.pytho
n.ops.init_ops) with dtype is deprecated and will be removed in a future versi
on.
Instructions for updating:
Call initializer instance with the dtype argument instead of passing it to the
constructor
WARNING:tensorflow:From /tensorflow-1.15.0/python3.6/tensorflow_core/python/op
s/resource_variable_ops.py:1630: calling BaseResourceVariable.__init__ (from t
ensorflow.python.ops.resource_variable_ops) with constraint is deprecated and
will be removed in a future version.
Instructions for updating:
If using Keras pass *_constraint arguments to layers.
Model: "model"
__________________________________________________________________________________
_________________
Layer (type)                 Output Shape              Param #     Connected to
==================================================================================
==================
input_1 (InputLayer)         [(None, 70)]              0
__________________________________________________________________________________
_________________
input_2 (InputLayer)         [(None, None)]            0
__________________________________________________________________________________
_________________
embedding (Embedding)        (None, 70, 300)           31475400    input_1[0][0]
__________________________________________________________________________________
_________________
embedding_1 (Embedding)      (None, None, 300)         17850300    input_2[0][0]
__________________________________________________________________________________
_________________
lstm (LSTM)                  [(None, 70, 750), (N 3153000     embedding
[0][0]
__________________________________________________________________________________
```

In [0]:
```
from tensorflow.keras.utils import plot_model
plot_model(model, to_file='model.png', show_shapes=True)
```

Out[21]:

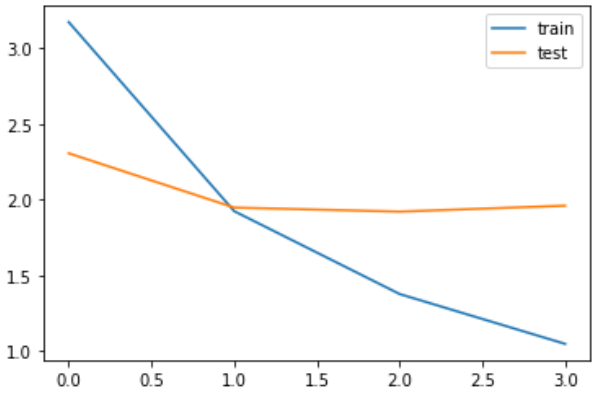


epochs=4 , batch size=32

In [0]:
```
model.compile(optimizer='adam', loss='sparse_categorical_crossentropy')
t1=padded_docs_train
t2=y_padded_docs_train
t1_cv=padded_docs_cv
t2_cv=y_padded_docs_cv
history=model.fit([t1,t2[:,:-1]],
                  t2.reshape(t2.shape[0],t2.shape[1], 1)[:,1:]
                  ,epochs=4,batch_size=32, validation_data=([t1_cv,t2_cv[:,:-1]
                  t2_cv.reshape(t2_cv.shape[0],t2_cv.shape[1], 1)[:,1:]),
                  callbacks=[tensorboard_callback])
```

```
WARNING:tensorflow:From /tensorflow-1.15.0/python3.6/tensorflow_core/python/op
s/math_grad.py:1424: where (from tensorflow.python.ops.array_ops) is deprecate
d and will be removed in a future version.
Instructions for updating:
Use tf.where in 2.0, which has the same broadcast rule as np.where
Train on 159273 samples, validate on 28107 samples
Epoch 1/4
159273/159273 [==============================] - 1107s 7ms/sample - loss: 3.17
43 - val_loss: 2.3073
Epoch 2/4
159273/159273 [==============================] - 1104s 7ms/sample - loss: 1.92
50 - val_loss: 1.9487
Epoch 3/4
159273/159273 [==============================] - 1103s 7ms/sample - loss: 1.37
74 - val_loss: 1.9219
Epoch 4/4
159273/159273 [==============================] - 1103s 7ms/sample - loss: 1.04
81 - val_loss: 1.9611
```

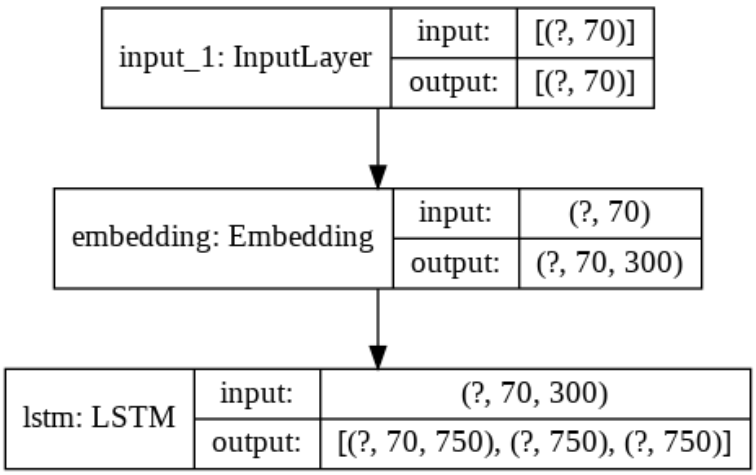
In [0]:
```
from matplotlib import pyplot
pyplot.plot(history.history['loss'], label='train')
pyplot.plot(history.history['val_loss'], label='test')
pyplot.legend()
pyplot.show()
```



In [0]:
```
encoder_model = Model(inputs=encoder_input,outputs=[e_lstm_out, e_hidden_out, e
```

In [0]:
```
plot_model(encoder_model, to_file='model.png', show_shapes=True)
```

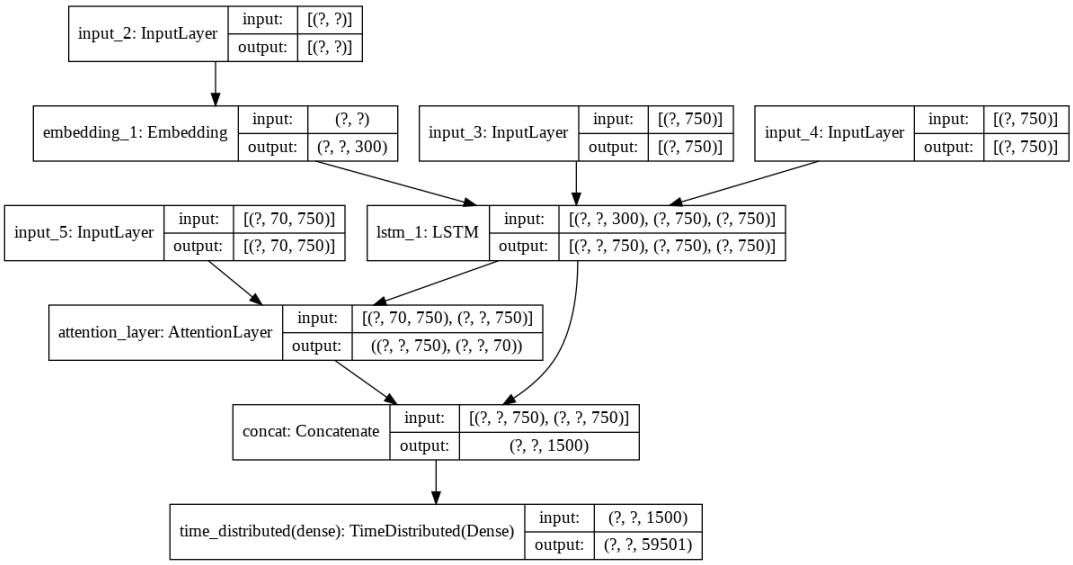
Out[102]:



In [0]:
```
decoder_input_h = Input(shape=(750,))
decoder_input_c = Input(shape=(750,))
decoder_hidden_state = Input(shape=(70,750))

dec_emb2= decoder_embedding_layer(decoder_input)
decoder_outputs2, state_h2, state_c2 = decoder_lstm(dec_emb2, initial_state=[de

attn_out_inf, attn_states_inf = attention_layer([decoder_hidden_state, decoder_
decoder_inf_concat = Concatenate(axis=-1, name='concat')([decoder_outputs2, att

decoder_outputs2 = decoder_dense(decoder_inf_concat)

decoder_model = Model(
    [decoder_input] + [decoder_hidden_state,decoder_input_h, decoder_input_c],
    [decoder_outputs2] + [state_h2, state_c2])
```

In [0]:
```
plot_model(decoder_model, to_file='model.png', show_shapes=True)
```

Out[103]:



In [0]:
```
# https://machinelearningmastery.com/encoder-decoder-attention-sequence-to-sequ
# https://towardsdatascience.com/light-on-math-ml-attention-with-keras-dc8dbc1f
def decode_sequence(input_seq):
    # Encode the input as state vectors.
    e_out, e_h, e_c = encoder_model.predict(input_seq)

    # Generate empty target sequence of length 1.
    seq = np.zeros((1,1))

    # Populate the first word of target sequence with the start word.
    seq[0, 0] = target_headlines_word_index['ssttaarrtt']

    stop_condition = False
    decoded_sentence = ''

    while not stop_condition:

        output, h, c = decoder_model.predict([seq] + [e_out, e_h, e_c])

        token_index = np.argmax(output[0, -1, :])
        if(token_index==0):
          token_index=2
        try:
          token = headlines_word_index[token_index]

          if(token!='eenndd'):
            decoded_sentence += ' '+token

        # Exit condition: either hit max length or find stop word.
          if (token == 'eenndd'  or len(decoded_sentence.split()) >= (20-1)):
            stop_condition = True
        except:
          pass
        # Update the target sequence (of length 1).
        seq = np.zeros((1,1))
        seq[0, 0] = token_index

        # Update internal states
        e_h, e_c = h, c

    return decoded_sentence
```

In [0]:
```
def headlines(input_seq):
    s=''
    for i in input_seq:
        if((i!=0 and i!=target_headlines_word_index['ssttaarrtt']) and i!=targe
            s=s+headlines_word_index[i]+' '
    return s

def news(input_seq):
    s=''

    for i in input_seq:
        if(i!=0):
            s=s+news_word_index[i]+' '
    return s
```

In [0]:
```
for i in range(5):
  print(i+1)
  print("News:",news(padded_docs_train[i]))
  print("Original headline:",headlines(y_padded_docs_train[i]))
  print("Predicted headline:",decode_sequence(padded_docs_train[i].reshape(1,70
  print("\n")
```

```
1
News: uber pilot new opt safety feature let users record audio through app dur
ing ongoing ride select cities brazil mexico starting december users able subm
it clip they wish report safety incident after ride riders drivers not able li
sten recorded audio
Original headline: uber to test feature to record audio during rides in brazil
mexico
Predicted headline:  uber to get safety feature after rides rides app tracks i
n brazil


2
News: separatist organisations jammu kashmir extended their strike till decemb
er 1 across kashmir valley however strike relaxed saturday monday they said ad
ditionally strike relaxed partially november 30 december 1 has unrest across v
alley following encounter of hizbul mujahideen commander burhan wani july
Original headline: separatists extend strike till dec 1 in kashmir
Predicted headline:  separatists in j k extended to their strike till december
1


3
News: talking his film super 30 hrithik roshan has revealed that his mother pi
nkie roshan watched film nine times theatres she never got chance meet anand s
ir his brother pranav personally he added super 30 based life of patna based m
athematician anand kumar also featured mrunal thakur pankaj tripathi
Original headline: my mother watched 'super 30' 9 times in theatres hrithik
Predicted headline:  my mother watched 'super 30' in theatres hrithik


4
News: indonesia based ride hailing payments unicorn gojek co founder nadiem ma
karim monday said he has resigned ceo position join indonesian president joko
widodo cabinet received big honour able join cabinet makarim told reporters ma
karim said his specific role announced president later week
Original headline: gojek co founder nadiem makarim quits as ceo to join indone
sia cabinet
Predicted headline:  gojek resigns as ceo of the position to join indonesia


5
News: centre has amended rules linked smoking public disallow hookahs smoking
zones of hotels restaurants airports aimed at fixing loophole rules that state
d smoking no services shall allowed smoking areas amended rule now states that
no service shall allowed smoking zones
Original headline: no more hookahs in smoking zones of restaurants govt orders
Predicted headline:  govt to ban smoking in smoking zones
```

In [0]:
```
for i in range(5):
  print(i+1)
  print("News:",news(padded_docs_test[i]))
  print("Original headline:",headlines(y_padded_docs_test[i]))
  print("Predicted headline:",decode_sequence(padded_docs_test[i].reshape(1,70)
  print("\n")
```

```
1
News: oyo bringing comfort design concept us 150 hotels across 60 cities 21 st
ates promising deliver value chic hospitality at affordable prices aims empowe
r independent hoteliers make reality guests oyo brings world class design capa
bilities pricing revenue management innovative technology talent real estate o
wners around world
Original headline: oyo commits to redefine the hospitality landscape in the us
Predicted headline:  oyo brings us cities with 60 cities in 60 cities


2
News: cheteshwar pujara has become third indian ninth overall batsman history
bat all five days of test achieving feat first test sri lanka at eden gardens
before pujara former indian cricketers ml jaisimha ravi shastri achieved feat
both of at eden gardens
Original headline: pujara third indian to bat on all 5 days of a test
Predicted headline:  pujara 3rd indian to hit centuries in all 5 days in all 5
days


3
News: parliamentary panel examine various security issues related payments ban
king sector has asked government officials representatives of banks appear bef
ore comes after many 32 lakh debit cards data compromised 641 customers across
19 banks duped of 1 3 crore using stolen debit card data
Original headline: parliamentary panel to examine security issues over payment
s
Predicted headline:  govt asks govt officials to appear before up on debit car
d data


4
News: actor amitabh bachchan took twitter share photo mark 48 years film indus
try today feb 15th 1969 officially joined film industry signed 1st film saat h
industani he wrote amitabh bachchan has won four national awards best actor 15
filmfare awards across categories his career far
Original headline: big b shares pic to mark 48 years in film industry
Predicted headline:  amitabh bachchan shares photo with 48 years in film indus
try


5
News: india registered their first ever 10 wicket win t20is their victory over
zimbabwe second t20 monday till date india s highest victory margin terms of b
owling 9 wicket wins over sri lanka uae visakhapatnam dhaka respectively notab
ly both wins come year itself
Original headline: india registers first 10 wicket win in t20is
Predicted headline:  india win 1st ever 10 wicket win in their first ever odi
win
```

Model 2 BLEU score

In [0]:
```
h=[]
s=[]
for i in range(942):
  h1=[headlines(y_padded_docs_test[i]).split()]
  h.append(h1)
  s.append(decode_sequence(padded_docs_test[i].reshape(1,70)).split())

from nltk.translate.bleu_score import corpus_bleu
print('BLEU-1: %f' % corpus_bleu(h, s, weights=(1.0, 0, 0, 0)))
print('BLEU-2: %f' % corpus_bleu(h, s, weights=(0.5, 0.5, 0, 0)))
```

```
BLEU-1: 0.365156
BLEU-2: 0.232804
```

Stop words removed from both headlines and news for all below models

Model 3

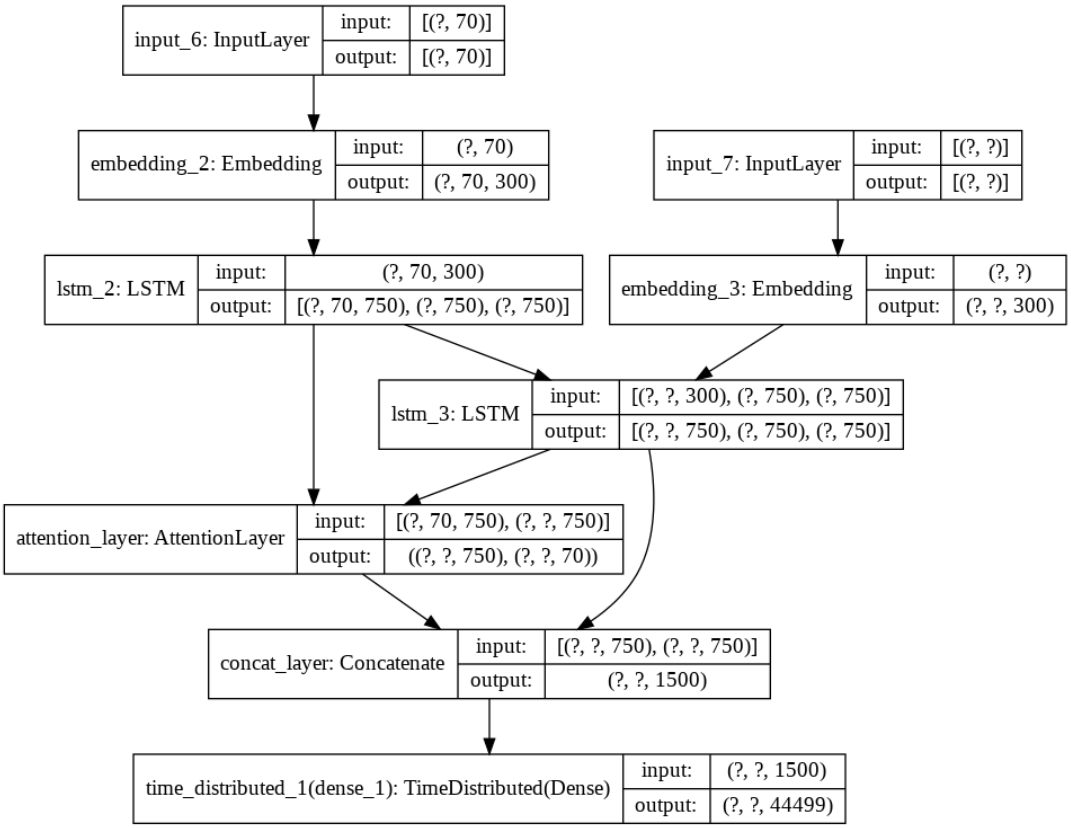
LSTM Encoder(750 units) + Bahdanau Attention + LSTM decoder(750 units)

In [54]:
```
from keras import backend as K
logdir = "log3/scalars/" + datetime.now().strftime("%Y%m%d-%H%M%S")
tensorboard_callback = keras.callbacks.TensorBoard(log_dir=logdir)

emb_dim = 300

encoder_input = Input(shape=(70,))
x1=Embedding(vocab_size, 300,weights=[input_matrix],trainable=False)(encoder_in
e_lstm_out, e_hidden_out, e_cell_out = LSTM(750,return_sequences=True,return_st

decoder_input = Input(shape=(None,))

decoder_embedding_layer = Embedding(y_vocab_size, 300,weights=[decoder_matrix],
decoder_embedding = decoder_embedding_layer(decoder_input)

decoder_lstm = LSTM(750, return_sequences=True, return_state=True)
d_lstm_out,d_hidden_out,d_cell_out = decoder_lstm(decoder_embedding,initial_sta
# https://towardsdatascience.com/light-on-math-ml-attention-with-keras-dc8dbc1f
attention_layer = AttentionLayer(name='attention_layer')
attention_out, attention_states = attention_layer([e_lstm_out, d_lstm_out])

# Concat attention input and decoder LSTM output
concat = Concatenate(axis=-1, name='concat_layer')([d_lstm_out, attention_out])

#dense layer
decoder_dense =  TimeDistributed(Dense(y_vocab_size, activation='softmax'))
decoder_dense_outputs = decoder_dense(concat)

# Define the model
model = Model([encoder_input, decoder_input], decoder_dense_outputs)

model.summary()
```

```
Model: "model_3"
__________________________________________________________________________________
_____________________
Layer (type)                 Output Shape              Param #     Connected to
==================================================================================
====================
input_6 (InputLayer)         [(None, 70)]              0
__________________________________________________________________________________
_____________________
input_7 (InputLayer)         [(None, None)]            0
__________________________________________________________________________________
_____________________
embedding_2 (Embedding)      (None, 70, 300)           31483500    input_6[0][0]
__________________________________________________________________________________
_____________________
embedding_3 (Embedding)      (None, None, 300)         13349700    input_7[0][0]
__________________________________________________________________________________
_____________________
lstm_2 (LSTM)                [(None, 70, 750), (N 3153000     embedding_2
[0][0]
__________________________________________________________________________________
_____________________
lstm_3 (LSTM)                [(None, None, 750),  3153000     embedding_3
[0][0]
                                                               lstm_2[0][1]
                                                               lstm_2[0][2]
__________________________________________________________________________________
_____________________
attention_layer (AttentionLayer ((None, None, 750),  1125750     lstm_2[0][0]
                                                               lstm_3[0][0]
__________________________________________________________________________________
_____________________
concat_layer (Concatenate)   (None, None, 1500)   0           lstm_3[0][0]
                                                               attention_lay
er[0][0]
```

In [55]:
```
from tensorflow.keras.utils import plot_model
plot_model(model, to_file='model.png', show_shapes=True)
```

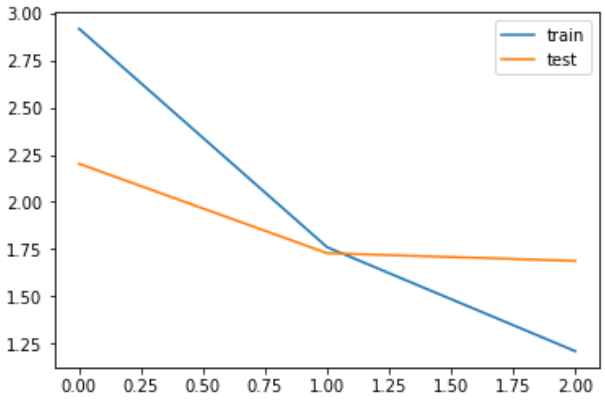
Out[55]:



In [56]:
```
model.compile(optimizer='adam', loss='sparse_categorical_crossentropy')
t1=padded_docs_train
t2=y_padded_docs_train
t1_cv=padded_docs_cv
t2_cv=y_padded_docs_cv
history=model.fit([t1,t2[:,:-1]],
                  t2.reshape(t2.shape[0],t2.shape[1], 1)[:,1:]
                  ,epochs=3,batch_size=32, validation_data=([t1_cv,t2_cv[:,:-1]
                  t2_cv.reshape(t2_cv.shape[0],t2_cv.shape[1], 1)[:,1:]),
                  callbacks=[tensorboard_callback])
```

```
Train on 159273 samples, validate on 28107 samples
Epoch 1/3
159273/159273 [==============================] - 1010s 6ms/sample - loss: 2.91
85 - val_loss: 2.2024
Epoch 2/3
159273/159273 [==============================] - 1005s 6ms/sample - loss: 1.76
03 - val_loss: 1.7284
Epoch 3/3
159273/159273 [==============================] - 1000s 6ms/sample - loss: 1.20
92 - val_loss: 1.6875
```

In [57]:
```
from matplotlib import pyplot
pyplot.plot(history.history['loss'], label='train')
pyplot.plot(history.history['val_loss'], label='test')
pyplot.legend()
pyplot.show()
```

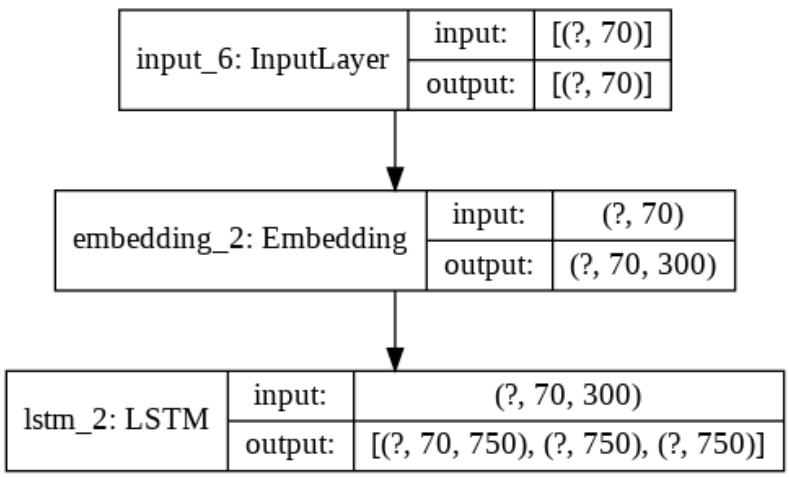


Inference

In [0]:
```
encoder_model = Model(inputs=encoder_input,outputs=[e_lstm_out, e_hidden_out, e
```

In [59]:
```
plot_model(encoder_model, to_file='model.png', show_shapes=True)
```

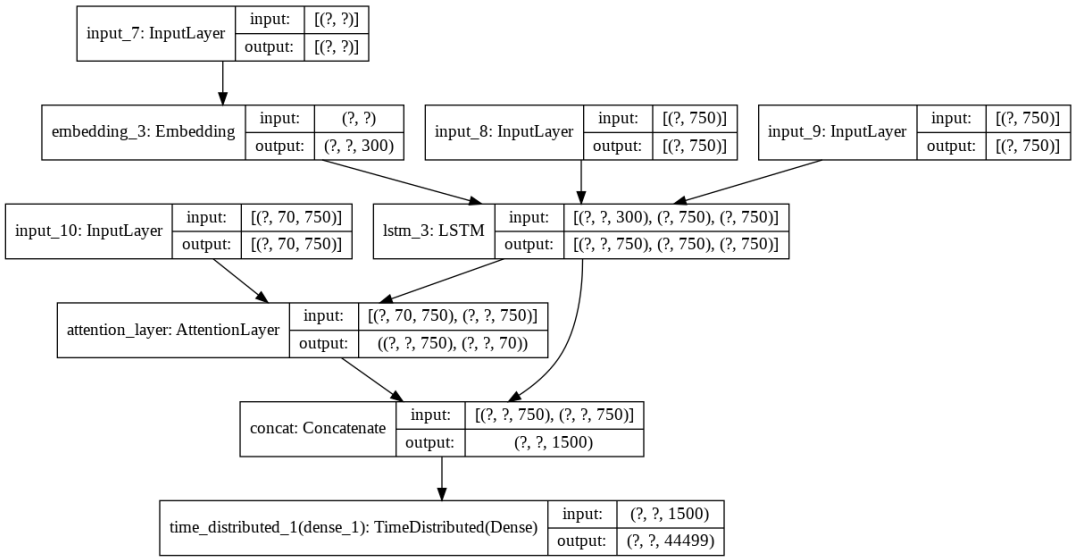
Out[59]:



In [0]:
```
decoder_input_h = Input(shape=(750,))
decoder_input_c = Input(shape=(750,))
decoder_hidden_state = Input(shape=(70,750))

dec_emb2= decoder_embedding_layer(decoder_input)
decoder_outputs2, state_h2, state_c2 = decoder_lstm(dec_emb2, initial_state=[de

attn_out_inf, attn_states_inf = attention_layer([decoder_hidden_state, decoder_
decoder_inf_concat = Concatenate(axis=-1, name='concat')([decoder_outputs2, att

decoder_outputs2 = decoder_dense(decoder_inf_concat)

decoder_model = Model(
    [decoder_input] + [decoder_hidden_state,decoder_input_h, decoder_input_c],
    [decoder_outputs2] + [state_h2, state_c2])
```

In [61]:
```
plot_model(decoder_model, to_file='model.png', show_shapes=True)
```

Out[61]:



In [0]:
```
# https://machinelearningmastery.com/encoder-decoder-attention-sequence-to-sequ
# https://towardsdatascience.com/light-on-math-ml-attention-with-keras-dc8dbc1f
def decode_sequence(input_seq):
    # Encode the input as state vectors.
    e_out, e_h, e_c = encoder_model.predict(input_seq)

    # Generate empty target sequence of length 1.
    seq = np.zeros((1,1))

    # Populate the first word of target sequence with the start word.
    seq[0, 0] = target_headlines_word_index['ssttaarrtt']

    stop_condition = False
    decoded_sentence = ''

    while not stop_condition:

        output, h, c = decoder_model.predict([seq] + [e_out, e_h, e_c])

        token_index = np.argmax(output[0, -1, :])
        if(token_index==0):
          token_index=2
        try:
          token = headlines_word_index[token_index]

          if(token!='eenndd'):
            decoded_sentence += ' '+token

        # Exit condition: either hit max length or find stop word.
          if (token == 'eenndd'  or len(decoded_sentence.split()) >= (20-1)):
            stop_condition = True
        except:
          pass
        # Update the target sequence (of length 1).
        seq = np.zeros((1,1))
        seq[0, 0] = token_index

        # Update internal states
        e_h, e_c = h, c

    return decoded_sentence
```

In [0]:
```
def headlines(input_seq):
    s=''
    for i in input_seq:
        if((i!=0 and i!=target_headlines_word_index['ssttaarrtt']) and i!=targe
            s=s+headlines_word_index[i]+' '
    return s

def news(input_seq):
    s=''

    for i in input_seq:
        if(i!=0):
            s=s+news_word_index[i]+' '
    return s
```

In [64]:
```
for i in range(5):
  print(i+1)
  print("News:",news(padded_docs_train[i]))
  print("Original headline:",headlines(y_padded_docs_train[i]))
  print("Predicted headline:",decode_sequence(padded_docs_train[i].reshape(1,70
  print("\n")
```

```
1
News: shah rukh khan while recalling time people apprehensive chak de india sa
id everyone thought worst film made no heroine girls unknown look awful beard
he added while talking film srk further said he does certain films because the
y appeal him organically
Original headline: everyone said chak de india worst film made srk
Predicted headline:  people thought worst film made no biopic srk


2
News: transportation security administration has announced more comprehensive
involved physical screening of passengers at us airports new pat rule comes af
ter audit homeland security revealed that airport officers failed detect guns
weapons passengers us airports subjected pat searches they refuse pass through
imaging scanners
Original headline: pat downs at us airports get more invasive
Predicted headline:  us airports get more invasive invasive


3
News: 20 year old indonesian man allegedly forged his diploma overstated his g
rades gain admission into police academy has arrested discrepancy noticed poli
ce education officials started verifying applicants credentials suspect charge
d document forgery jailed six years police said
Original headline: man breaks law get into police academy gets arrested
Predicted headline:  20 yr old man forges his tuition after failing admission


4
News: at least one person killed 14 others injured after communal clashes brok
e assam hailakandi friday officials said clashes broke people protested prayer
s held road front of mosque officials added district administration has also s
ought army help maintain peace area
Original headline: 1 dead 14 injured communal clashes assam hailakandi
Predicted headline:  1 killed 14 injured communal clashes assam hailakandi


5
News: congress president rahul gandhi sunday took ride namma metro bengaluru d
uring his karnataka assembly elections campaign gandhi boarded metro at vidhan
a soudha station got off at mg road station he also visited bookstore karnatak
a elections scheduled may 12 counting of votes held may 15
Original headline: rahul rides bengaluru metro during karnataka poll campaign
Predicted headline:  rahul takes ride metro bengaluru during k notaka polls
```

In [65]:
```
for i in range(5):
  print(i+1)
  print("News:",news(padded_docs_test[i]))
  print("Original headline:",headlines(y_padded_docs_test[i]))
  print("Predicted headline:",decode_sequence(padded_docs_test[i].reshape(1,70)
  print("\n")
```

```
1
News: former american swimmer michael phelps decorated olympian of all time ha
s said he extremely thankful that he not end his life while fighting depressio
n 23 time olympic gold medalist added that he suffered depression after every
olympic games his career phelps further said he not want live anymore after 20
12 olympics
Original headline: under depression after every olympics 23 time champion
Predicted headline:  extremely grateful phelps phelps


2
News: proxy advisory firms come support of infosys co founder narayana murthy
stance making panaya probe report public infosys earlier declined murthy reque
st claimed that management has cleared of alleged wrongdoings advisory firms a
lso questioned company stock performance asked founders specific plan put info
sys back stability track
Original headline: advisory firms back murthy over making panaya probe public
Predicted headline:  infosys murthy supports murthy infosys chairman


3
News: konkona sen sharma has named best actress film lipstick under burkha at
17th edition of new york indian film festival she also received best director
award directorial debut death gunj notably lipstick under burkha opening film
at film festival
Original headline: konkona named best actress lipstick under burkha
Predicted headline:  konkona named best actress film lipstick under burkha


4
News: mexico create new division of federal police preserve secure cultural he
ritage according officials division recruit officers knowledge of archaeology
art prevent thefts looting of cultural artefacts officials said according offi
cial figures 90 of stolen cultural objects archaeological pieces religious art
never recovered
Original headline: mexico create new police division preserve culture
Predicted headline:  mexico create new area area area


5
News: minor solar storm expected hit earth today could trigger northern lights
places like alaska sweden norway iceland solar storms measured scale of g5 g5
extreme capable of disrupting electrical grids current storm little no effect
earth us weather agency noaa reported
Original headline: minor solar flare expected hit earth today cause auroras
Predicted headline:  solar storm hit earth may hit earth study
```

Model 3 BLEU score

In [66]:
```
h=[]
s=[]
for i in range(942):
  h1=[headlines(y_padded_docs_test[i]).split()]
  h.append(h1)
  s.append(decode_sequence(padded_docs_test[i].reshape(1,70)).split())

from nltk.translate.bleu_score import corpus_bleu
print('BLEU-1: %f' % corpus_bleu(h, s, weights=(1.0, 0, 0, 0)))
print('BLEU-2: %f' % corpus_bleu(h, s, weights=(0.5, 0.5, 0, 0)))
```

```
BLEU-1: 0.401676
BLEU-2: 0.263726
```

Model 4

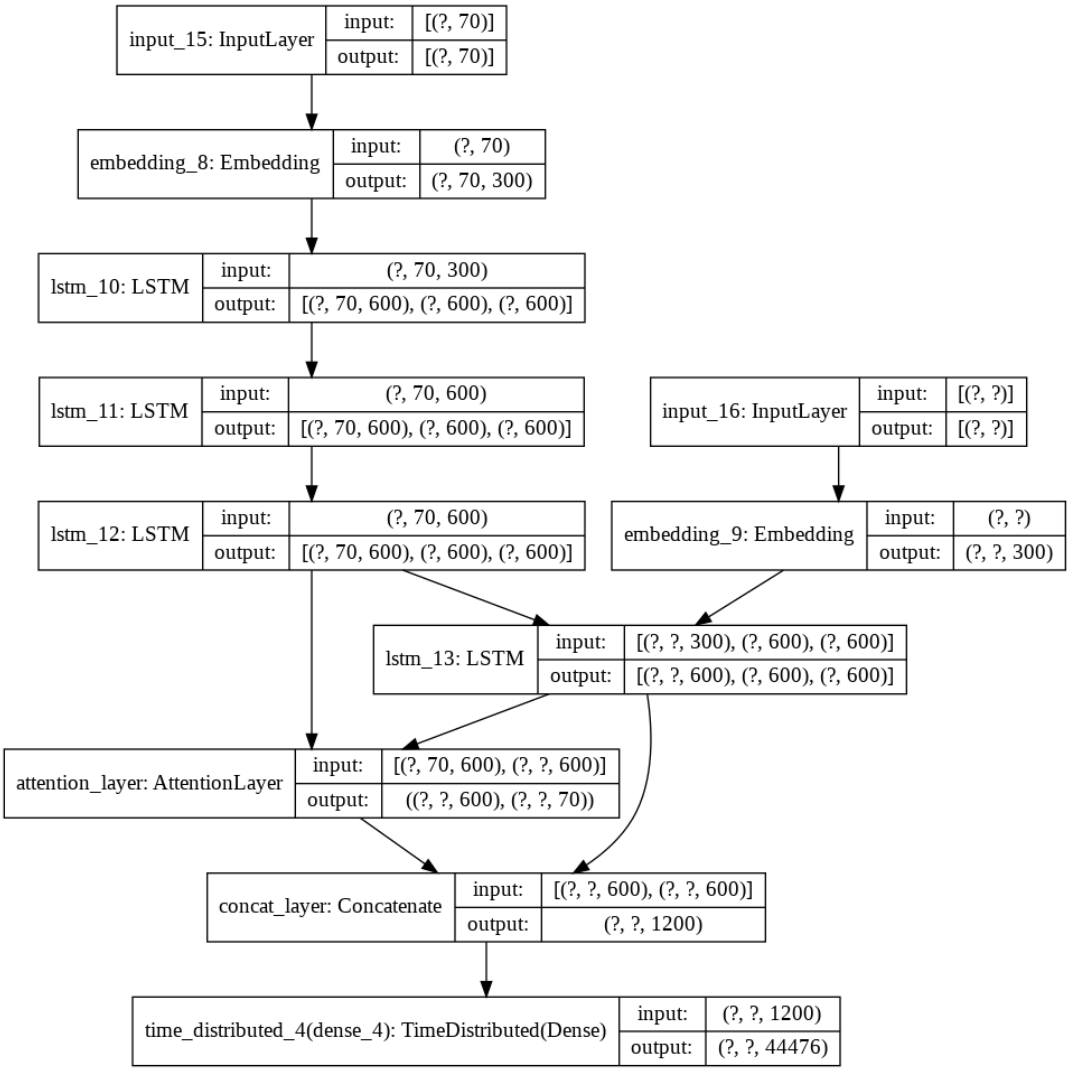
3-LSTM encoder + Bahdanau attention + Decoder

In [0]:
```
from keras import backend as K
logdir = "log4/scalars/" + datetime.now().strftime("%Y%m%d-%H%M%S")
tensorboard_callback = keras.callbacks.TensorBoard(log_dir=logdir)

emb_dim = 300

encoder_input = Input(shape=(70,))
x1=Embedding(vocab_size, 300,weights=[input_matrix],trainable=False)(encoder_in
encoder_lstm1 = LSTM(600,return_sequences=True,return_state=True)

e_lstm_out, e_hidden_out, e_cell_out = encoder_lstm1(x1)

encoder_lstm2 = LSTM(600,return_sequences=True,return_state=True)
encoder_output2, state_h2, state_c2 = encoder_lstm2(e_lstm_out)

encoder_lstm3=LSTM(600, return_state=True, return_sequences=True)
encoder_outputs, state_h, state_c= encoder_lstm3(encoder_output2)

decoder_input = Input(shape=(None,))

decoder_embedding_layer = Embedding(y_vocab_size, 300,weights=[decoder_matrix],
decoder_embedding = decoder_embedding_layer(decoder_input)

decoder_lstm = LSTM(600, return_sequences=True, return_state=True)
d_lstm_out,d_hidden_out,d_cell_out = decoder_lstm(decoder_embedding,initial_sta

# https://towardsdatascience.com/light-on-math-ml-attention-with-keras-dc8dbc1f
attention_layer = AttentionLayer(name='attention_layer')
attention_out, attention_states = attention_layer([encoder_outputs, d_lstm_out]

# Concat attention input and decoder LSTM output
concat = Concatenate(axis=-1, name='concat_layer')([d_lstm_out, attention_out])

#dense layer
decoder_dense =  TimeDistributed(Dense(y_vocab_size, activation='softmax'))
decoder_dense_outputs = decoder_dense(concat)

# Define the model
model = Model([encoder_input, decoder_input], decoder_dense_outputs)

model.summary()
```

```
Model: "model_8"
__________________________________________________________________________________
_________________
Layer (type)                 Output Shape              Param #     Connected to
==================================================================================
==================
input_15 (InputLayer)        [(None, 70)]              0
__________________________________________________________________________________
_________________
embedding_8 (Embedding)      (None, 70, 300)           31467900    input_15
[0][0]
__________________________________________________________________________________
_________________
lstm_10 (LSTM)               [(None, 70, 600), (N 2162400     embedding_8
[0][0]
__________________________________________________________________________________
_________________
input_16 (InputLayer)        [(None, None)]            0
__________________________________________________________________________________
_________________
lstm_11 (LSTM)               [(None, 70, 600), (N 2882400     lstm_10[0][0]
__________________________________________________________________________________
_________________
embedding_9 (Embedding)      (None, None, 300)         13342800    input_16
[0][0]
```

In [0]:
```
from tensorflow.keras.utils import plot_model
plot_model(model, to_file='model.png', show_shapes=True)
```

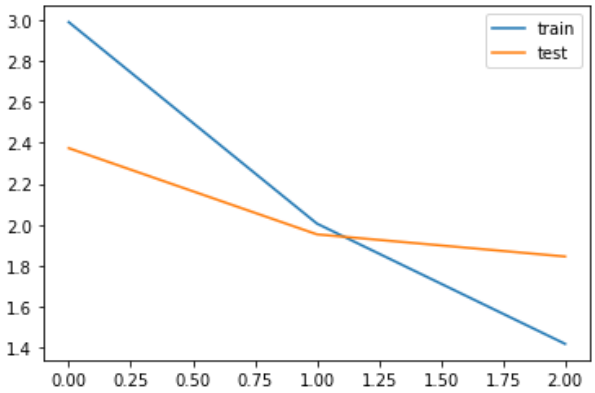
Out[152]:



In [0]:
```
model.compile(optimizer='adam', loss='sparse_categorical_crossentropy')
t1=padded_docs_train
t2=y_padded_docs_train
t1_cv=padded_docs_cv
t2_cv=y_padded_docs_cv
history=model.fit([t1,t2[:,:-1]],
                  t2.reshape(t2.shape[0],t2.shape[1], 1)[:,1:]
                  ,epochs=3,batch_size=32, validation_data=([t1_cv,t2_cv[:,:-1]
                  t2_cv.reshape(t2_cv.shape[0],t2_cv.shape[1], 1)[:,1:]),
                  callbacks=[tensorboard_callback])
```

```
Train on 159273 samples, validate on 28107 samples
Epoch 1/3
159273/159273 [==============================] - 1917s 12ms/sample - loss: 2.9
904 - val_loss: 2.3741
Epoch 2/3
159273/159273 [==============================] - 1911s 12ms/sample - loss: 2.0
052 - val_loss: 1.9526
Epoch 3/3
159273/159273 [==============================] - 1907s 12ms/sample - loss: 1.4
171 - val_loss: 1.8441
```

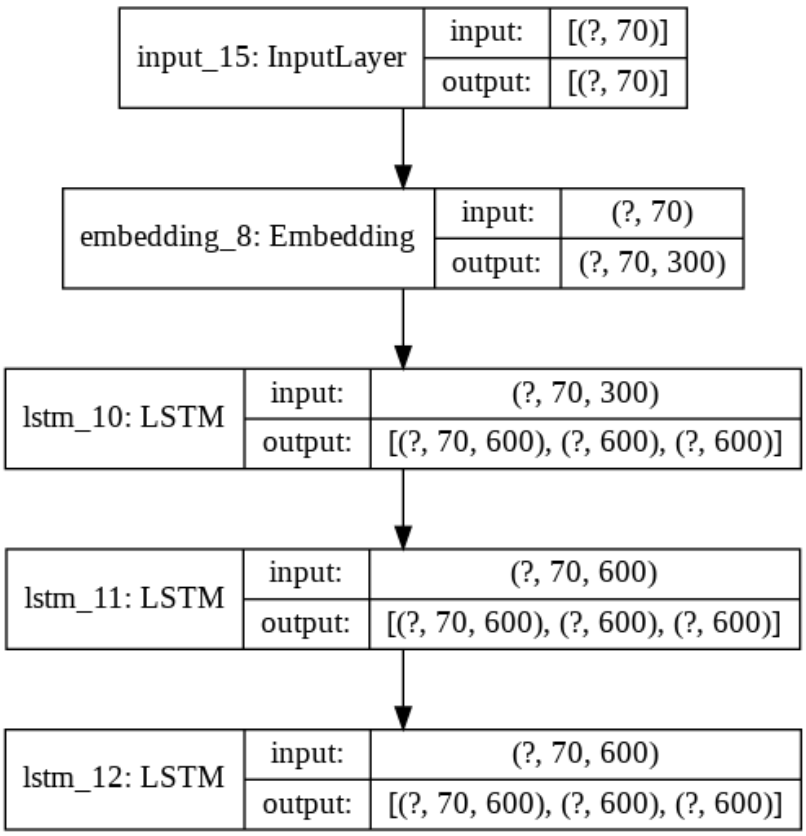
In [0]:
```
from matplotlib import pyplot
pyplot.plot(history.history['loss'], label='train')
pyplot.plot(history.history['val_loss'], label='test')
pyplot.legend()
pyplot.show()
```



In [0]:
```
encoder_model = Model(inputs=encoder_input_outputs=[encoder_outputs, state_h, s
```

In [0]:
```
plot_model(encoder_model, to_file='model.png', show_shapes=True)
```

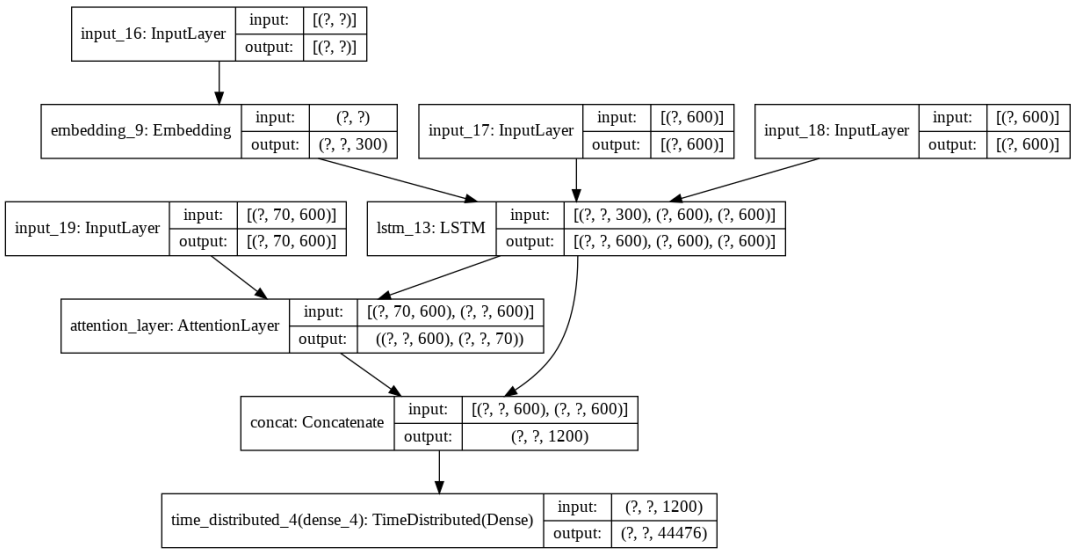
Out[158]:



In [0]:
```
decoder_input_h = Input(shape=(600,))
decoder_input_c = Input(shape=(600,))
decoder_hidden_state = Input(shape=(70,600))

dec_emb2= decoder_embedding_layer(decoder_input)
decoder_outputs2, state_h2, state_c2 = decoder_lstm(dec_emb2, initial_state=[de

attn_out_inf, attn_states_inf = attention_layer([decoder_hidden_state, decoder_
decoder_inf_concat = Concatenate(axis=-1, name='concat')([decoder_outputs2, att

decoder_outputs2 = decoder_dense(decoder_inf_concat)

decoder_model = Model(
    [decoder_input] + [decoder_hidden_state,decoder_input_h, decoder_input_c],
    [decoder_outputs2] + [state_h2, state_c2])
```

In [0]:
```
plot_model(decoder_model, to_file='model.png', show_shapes=True)
```

Out[160]:



In [0]:
```
# https://machinelearningmastery.com/encoder-decoder-attention-sequence-to-sequ
# https://towardsdatascience.com/light-on-math-ml-attention-with-keras-dc8dbc1f
def decode_sequence(input_seq):
    # Encode the input as state vectors.
    e_out, e_h, e_c = encoder_model.predict(input_seq)

    # Generate empty target sequence of length 1.
    seq = np.zeros((1,1))

    # Populate the first word of target sequence with the start word.
    seq[0, 0] = target_headlines_word_index['ssttaarrtt']

    stop_condition = False
    decoded_sentence = ''

    while not stop_condition:

        output, h, c = decoder_model.predict([seq] + [e_out, e_h, e_c])

        token_index = np.argmax(output[0, -1, :])
        if(token_index==0):
          token_index=2
        try:
          token = headlines_word_index[token_index]

          if(token!='eenndd'):
            decoded_sentence += ' '+token

        # Exit condition: either hit max length or find stop word.
          if (token == 'eenndd'  or len(decoded_sentence.split()) >= (20-1)):
            stop_condition = True
        except:
          pass
        # Update the target sequence (of length 1).
        seq = np.zeros((1,1))
        seq[0, 0] = token_index

        # Update internal states
        e_h, e_c = h, c

    return decoded_sentence
```

In [0]:
```
def headlines(input_seq):
    s=''
    for i in input_seq:
        if((i!=0 and i!=target_headlines_word_index['ssttaarrtt']) and i!=targe
            s=s+headlines_word_index[i]+' '
    return s

def news(input_seq):
    s=''

    for i in input_seq:
        if(i!=0):
            s=s+news_word_index[i]+' '
    return s
```

In [41]:
```
for i in range(5):
  print(i+1)
  print("News:",news(padded_docs_train[i]))
  print("Original headline:",headlines(y_padded_docs_train[i]))
  print("Predicted headline:",decode_sequence(padded_docs_train[i].reshape(1,70
  print("\n")
```

```
1
News: shah rukh khan while recalling time people apprehensive chak de india sa
id everyone thought worst film made no heroine girls unknown look awful beard
he added while talking film srk further said he does certain films because the
y appeal him organically
Original headline: everyone said chak de india worst film made srk
Predicted headline:  everyone thought worst film made no role srk


2
News: transportation security administration has announced more comprehensive
involved physical screening of passengers at us airports new pat rule comes af
ter audit homeland security revealed that airport officers failed detect guns
weapons passengers us airports subjected pat searches they refuse pass through
imaging scanners
Original headline: pat downs at us airports get more invasive
Predicted headline:  us airport security checks at airports


3
News: 20 year old indonesian man allegedly forged his diploma overstated his g
rades gain admission into police academy has arrested discrepancy noticed poli
ce education officials started verifying applicants credentials suspect charge
d document forgery jailed six years police said
Original headline: man breaks law get into police academy gets arrested
Predicted headline:  indonesian man forges exam degree into police academy aca
demy


4
News: at least one person killed 14 others injured after communal clashes brok
e assam hailakandi friday officials said clashes broke people protested prayer
s held road front of mosque officials added district administration has also s
ought army help maintain peace area
Original headline: 1 dead 14 injured communal clashes assam hailakandi
Predicted headline:  1 killed 14 injured communal clashes assam


5
News: congress president rahul gandhi sunday took ride namma metro bengaluru d
uring his karnataka assembly elections campaign gandhi boarded metro at vidhan
a soudha station got off at mg road station he also visited bookstore karnatak
a elections scheduled may 12 counting of votes held may 15
Original headline: rahul rides bengaluru metro during karnataka poll campaign
Predicted headline:  rahul takes ride metro metro bengaluru metro
```

In [51]:
```
for i in range(5):
  print(int(i+1)
  print("News:",news(padded_docs_test[i]))
  print("Original headline:",headlines(y_padded_docs_test[i]))
  print("Predicted headline:",decode_sequence(padded_docs_test[i].reshape(1,70)
  print("\n")
```

```
1
News: proxy advisory firms come support of infosys co founder narayana murthy
stance making panaya probe report public infosys earlier declined murthy reque
st claimed that management has cleared of alleged wrongdoings advisory firms a
lso questioned company stock performance asked founders specific plan put info
sys back stability track
Original headline: advisory firms back murthy over making panaya probe public
Predicted headline:  infosys board firmly support murthy report


2
News: mexico create new division of federal police preserve secure cultural he
ritage according officials division recruit officers knowledge of archaeology
art prevent thefts looting of cultural artefacts officials said according offi
cial figures 90 of stolen cultural objects archaeological pieces religious art
never recovered
Original headline: mexico create new police division preserve culture
Predicted headline:  mexico create new division police protect heritage herita
ge


3
News: karnataka congress mp bk hariprasad thursday claimed pulwama attack 40 c
rpf jawans martyred result of match fixing pakistan pm narendra modi his comme
nt came after union minister ravi shankar prasad criticised congress demanding
evidence of iaf strike hariprasad said attack not happened without knowledge o
f government
Original headline: pulwama attack match fixing pak pm modi cong mp
Predicted headline:  pulwama attack avenged 40 crpf martyrs cong mp


4
News: china three state owned wireless carriers debuted 5g mobile phone servic
es thursday making world largest 5g mobile phone network china mobile ltd coun
try largest carrier unveiled network 50 cities including beijing shanghai shen
zhen rivals china telecom corporation ltd china unicom hong kong ltd also intr
oduced their 5g services
Original headline: china debuts world largest 5g mobile phone network
Predicted headline:  china baidu 5g mobile phone services china


5
News: at meeting of bjp parliamentarians pm narendra modi thursday rebuked par
ty mps ignoring his text messages report quoting party sources has claimed ask
ing them follow his mobile app pm modi said he sent messages wishing good morn
ing mps seen acknowledged few of them
Original headline: pm modi slams bjp mps ignoring his texts reports
Predicted headline:  pm modi reprimands party mps skipping text messages
```

Model 4 BLEU score

In [53]:
```
h=[]
s=[]
for i in range(942):
  h1=[headlines(y_padded_docs_test[i]).split()]
  h.append(h1)
  s.append(decode_sequence(padded_docs_test[i].reshape(1,70)).split())

from nltk.translate.bleu_score import corpus_bleu
print('BLEU-1: %f' % corpus_bleu(h, s, weights=(1.0, 0, 0, 0)))
print('BLEU-2: %f' % corpus_bleu(h, s, weights=(0.5, 0.5, 0, 0)))
```

```
BLEU-1: 0.323565
BLEU-2: 0.198645
```

Model 5

Encoder(Bidirectional(lstm)) + Bahdanau Attention + Decoder(lstm)

Best model

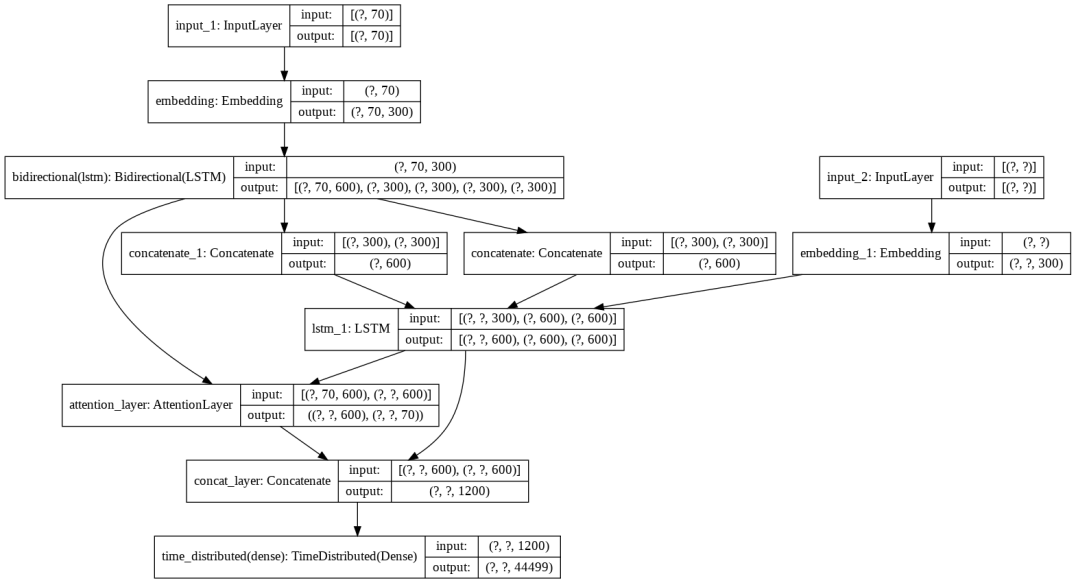
In [25]:

```
from keras import backend as K

emb_dim = 300

encoder_input = Input(shape=(70,))
x1=Embedding(vocab_size, 300,weights=[input_matrix],trainable=False)(encoder_in

encoder = Bidirectional(LSTM(units= 300, input_shape=(70,300),return_state=True
                             return_sequences=True, dropout=0.5,recurrent_dropo
encoder_out,f_h_out,f_cell_out,b_h_out,b_cell_out =encoder(x1)
state_h = Concatenate()([f_h_out, b_h_out])
state_c = Concatenate()([f_cell_out, b_cell_out])
#encoder_states = [state_h, state_c]


decoder_input = Input(shape=(None,))

decoder_embedding_layer = Embedding(y_vocab_size, 300,weights=[decoder_matrix],
decoder_embedding = decoder_embedding_layer(decoder_input)

decoder_lstm = LSTM(600, return_sequences=True, return_state=True,dropout=0.4)
d_lstm_out,d_hidden_out,d_cell_out = decoder_lstm(decoder_embedding,initial_sta
#https://towardsdatascience.com/light-on-math-ml-attention-with-keras-dc8dbc1fa
attention_layer = AttentionLayer(name='attention_layer')
attention_out, attention_states = attention_layer([encoder_out, d_lstm_out])

# Concat attention input and decoder LSTM output
concat = Concatenate(axis=-1, name='concat_layer')([d_lstm_out, attention_out])

#dense layer
decoder_dense =  TimeDistributed(Dense(y_vocab_size, activation='softmax'))
decoder_outputs = decoder_dense(concat)

# Define the model
model = Model([encoder_input, decoder_input], decoder_outputs)

model.summary()
```

```
WARNING:tensorflow:From /tensorflow-1.15.0/python3.6/tensorflow_core/python/ke
ras/initializers.py:119: calling RandomUniform.__init__ (from tensorflow.pytho
n.ops.init_ops) with dtype is deprecated and will be removed in a future versi
on.
Instructions for updating:
Call initializer instance with the dtype argument instead of passing it to the
constructor
WARNING:tensorflow:From /tensorflow-1.15.0/python3.6/tensorflow_core/python/op
s/resource_variable_ops.py:1630: calling BaseResourceVariable.__init__ (from t
ensorflow.python.ops.resource_variable_ops) with constraint is deprecated and
will be removed in a future version.
Instructions for updating:
If using Keras pass *_constraint arguments to layers.
WARNING:tensorflow:From /tensorflow-1.15.0/python3.6/tensorflow_core/python/op
s/init_ops.py:97: calling GlorotUniform.__init__ (from tensorflow.python.ops.i
nit_ops) with dtype is deprecated and will be removed in a future version.
Instructions for updating:
Call initializer instance with the dtype argument instead of passing it to the
constructor
WARNING:tensorflow:From /tensorflow-1.15.0/python3.6/tensorflow_core/python/op
s/init_ops.py:97: calling Orthogonal.__init__ (from tensorflow.python.ops.init
_ops) with dtype is deprecated and will be removed in a future version.
Instructions for updating:
Call initializer instance with the dtype argument instead of passing it to the
constructor
WARNING:tensorflow:From /tensorflow-1.15.0/python3.6/tensorflow_core/python/op
s/init_ops.py:97: calling Zeros.__init__ (from tensorflow.python.ops.init_ops)
with dtype is deprecated and will be removed in a future version.
Instructions for updating:
Call initializer instance with the dtype argument instead of passing it to the
```

In [26]:
```
from tensorflow.keras.utils import plot_model
plot_model(model, to_file='model.png', show_shapes=True)
```

Out[26]:



In [0]:
```
from tensorflow.keras import metrics
model.compile(optimizer='adam', loss='sparse_categorical_crossentropy' )
```

In [29]:
```
t1=padded_docs_train
t2=y_padded_docs_train
t1_cv=padded_docs_cv
t2_cv=y_padded_docs_cv
history=model.fit([t1,t2[:,:-1]],
                  t2.reshape(t2.shape[0],t2.shape[1], 1)[:,1:]
                  ,epochs=5,batch_size=32, validation_data=([t1_cv,t2_cv[:,:-1]
                  t2_cv.reshape(t2_cv.shape[0],t2_cv.shape[1], 1)[:,1:]),

                  )
```

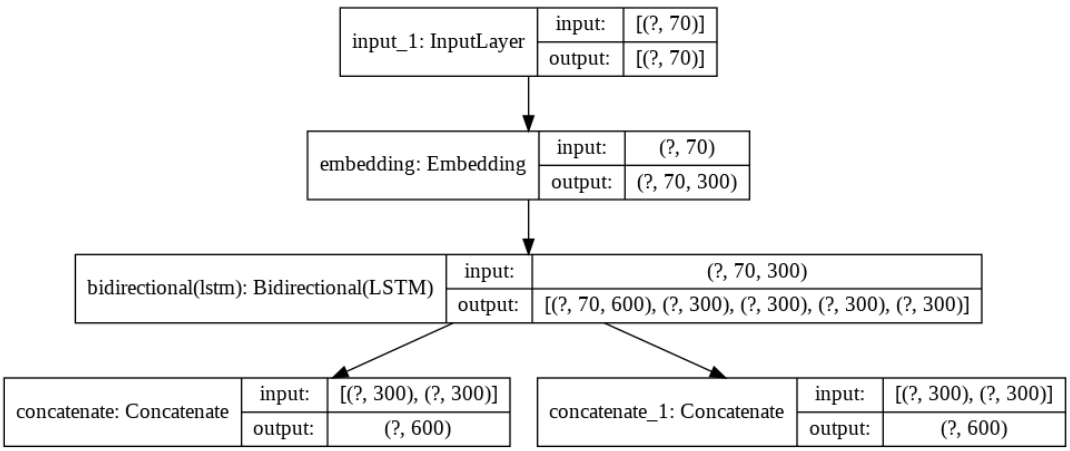
```
Train on 159273 samples, validate on 28107 samples
Epoch 1/5
159273/159273 [==============================] - 1296s 8ms/sample - loss: 2.96
17 - val_loss: 2.2864
Epoch 2/5
159273/159273 [==============================] - 1289s 8ms/sample - loss: 2.09
59 - val_loss: 1.8806
Epoch 3/5
159273/159273 [==============================] - 1285s 8ms/sample - loss: 1.69
00 - val_loss: 1.7747
Epoch 4/5
159273/159273 [==============================] - 1286s 8ms/sample - loss: 1.47
01 - val_loss: 1.7733
Epoch 5/5
159273/159273 [==============================] - 1279s 8ms/sample - loss: 1.32
52 - val_loss: 1.7558
```

In [0]:
```
news_word_index=t.index_word
headlines_word_index=y_tokenizer.index_word
target_headlines_word_index=y_tokenizer.word_index
```

In [0]:
```
encoder_model = Model(inputs=encoder_input_outputs=[encoder_out, state_h, state
```

In [32]:
```
plot_model(encoder_model, to_file='model.png', show_shapes=True)
```

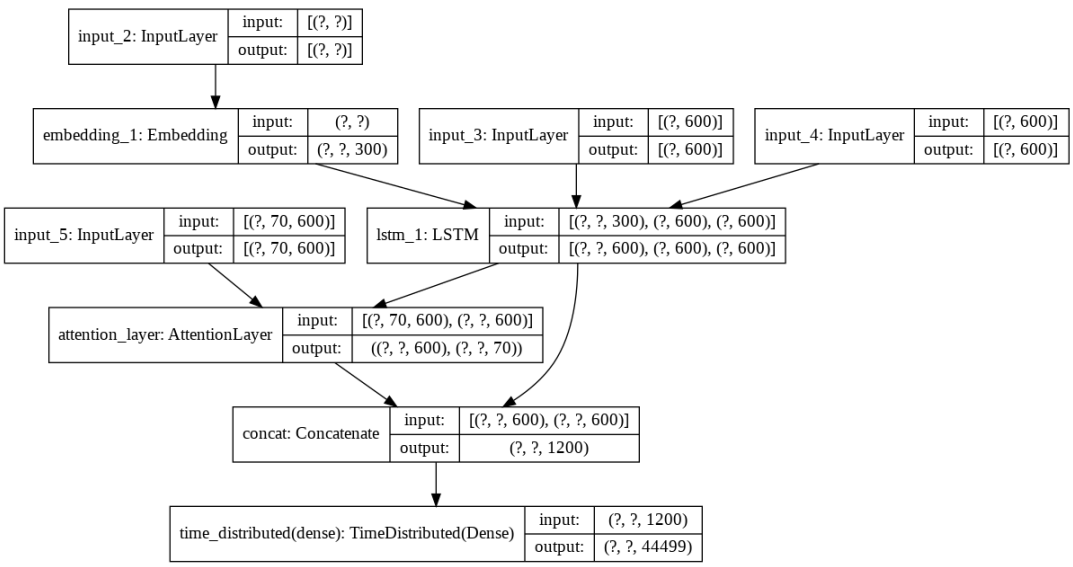
Out[32]:



In [0]:
```
decoder_input_h = Input(shape=(600,))
decoder_input_c = Input(shape=(600,))
decoder_hidden_state = Input(shape=(70,600))

dec_emb2= decoder_embedding_layer(decoder_input)
decoder_outputs2, state_h2, state_c2 = decoder_lstm(dec_emb2, initial_state=[de

attn_out_inf, attn_states_inf = attention_layer([decoder_hidden_state, decoder_
decoder_inf_concat = Concatenate(axis=-1, name='concat')([decoder_outputs2, att

decoder_outputs2 = decoder_dense(decoder_inf_concat)

decoder_model = Model(
    [decoder_input] + [decoder_hidden_state,decoder_input_h, decoder_input_c],
    [decoder_outputs2] + [state_h2, state_c2])
```

In [34]:
```
plot_model(decoder_model, to_file='model.png', show_shapes=True)
```

Out[34]:



In [0]:
```
#https://machinelearningmastery.com/encoder-decoder-attention-sequence-to-seque
#https://towardsdatascience.com/light-on-math-ml-attention-with-keras-dc8dbc1fa
def decode_sequence(input_seq):
    # Encode the input as state vectors.
    e_out, e_h, e_c = encoder_model.predict(input_seq)

    # Generate empty target sequence of length 1.
    seq = np.zeros((1,1))

    # Populate the first word of target sequence with the start word.
    seq[0, 0] = target_headlines_word_index['ssttaarrtt']

    stop_condition = False
    decoded_sentence = ''

    while not stop_condition:

        output, h, c = decoder_model.predict([seq] + [e_out, e_h, e_c])

        token_index = np.argmax(output[0, -1, :])
        try:
          token = headlines_word_index[token_index]

          if(token!='eenndd'):
            decoded_sentence += ' '+token

        # Exit condition: either hit max length or find stop word.
          if (token == 'eenndd'  or len(decoded_sentence.split()) >= (20-1)):
            stop_condition = True
        except:
          pass
        # Update the target sequence (of length 1).
        seq = np.zeros((1,1))
        seq[0, 0] = token_index

        # Update internal states
        e_h, e_c = h, c

    return decoded_sentence
```

In [0]:
```
def headlines(input_seq):
    s=''
    for i in input_seq:
        if((i!=0 and i!=target_headlines_word_index['ssttaarrtt']) and i!=targe
            s=s+headlines_word_index[i]+' '
    return s

def news(input_seq):
    s=''

    for i in input_seq:
        if(i!=0):
            s=s+news_word_index[i]+' '
    return s
```

In [37]:
```
for i in range(5):
  print(i+1)
  print("News:",news(padded_docs_train[i]))
  print("Original headline:",headlines(y_padded_docs_train[i]))
  print("Predicted headline:",decode_sequence(padded_docs_train[i].reshape(1,70
  print("\n")
```

```
1
News: shah rukh khan while recalling time people apprehensive chak de india sa
id everyone thought worst film made no heroine girls unknown look awful beard
he added while talking film srk further said he does certain films because the
y appeal him organically
Original headline: everyone said chak de india worst film made srk
Predicted headline:  everyone thought worst film made no role srk


2
News: transportation security administration has announced more comprehensive
involved physical screening of passengers at us airports new pat rule comes af
ter audit homeland security revealed that airport officers failed detect guns
weapons passengers us airports subjected pat searches they refuse pass through
imaging scanners
Original headline: pat downs at us airports get more invasive
Predicted headline:  us airport security checks at airports


3
News: 20 year old indonesian man allegedly forged his diploma overstated his g
rades gain admission into police academy has arrested discrepancy noticed poli
ce education officials started verifying applicants credentials suspect charge
d document forgery jailed six years police said
Original headline: man breaks law get into police academy gets arrested
Predicted headline:  indonesian man forges exam degree into police academy aca
demy


4
News: at least one person killed 14 others injured after communal clashes brok
e assam hailakandi friday officials said clashes broke people protested prayer
s held road front of mosque officials added district administration has also s
ought army help maintain peace area
Original headline: 1 dead 14 injured communal clashes assam hailakandi
Predicted headline:  1 killed 14 injured communal clashes assam


5
News: congress president rahul gandhi sunday took ride namma metro bengaluru d
uring his karnataka assembly elections campaign gandhi boarded metro at vidhan
a soudha station got off at mg road station he also visited bookstore karnatak
a elections scheduled may 12 counting of votes held may 15
Original headline: rahul rides bengaluru metro during karnataka poll campaign
Predicted headline:  rahul takes ride metro metro bengaluru metro
```

In [44]:
```
for i in range(5):
  print(i+1)
  print("News:",news(padded_docs_test[i]))
  print("Original headline:",headlines(y_padded_docs_test[i]))
  print("Predicted headline:",decode_sequence(padded_docs_test[i].reshape(1,70)
  print("\n")
```

```
1
News: former american swimmer michael phelps decorated olympian of all time ha
s said he extremely thankful that he not end his life while fighting depressio
n 23 time olympic gold medalist added that he suffered depression after every
olympic games his career phelps further said he not want live anymore after 20
12 olympics
Original headline: under depression after every olympics 23 time champion
Predicted headline:  very grateful life meaningless phelps phelps


2
News: proxy advisory firms come support of infosys co founder narayana murthy
stance making panaya probe report public infosys earlier declined murthy reque
st claimed that management has cleared of alleged wrongdoings advisory firms a
lso questioned company stock performance asked founders specific plan put info
sys back stability track
Original headline: advisory firms back murthy over making panaya probe public
Predicted headline:  infosys board firmly support murthy report


3
News: konkona sen sharma has named best actress film lipstick under burkha at
17th edition of new york indian film festival she also received best director
award directorial debut death gunj notably lipstick under burkha opening film
at film festival
Original headline: konkona named best actress lipstick under burkha
Predicted headline:  konkona sharma named best actress lipstick under burkha a
t nyfw


4
News: mexico create new division of federal police preserve secure cultural he
ritage according officials division recruit officers knowledge of archaeology
art prevent thefts looting of cultural artefacts officials said according offi
cial figures 90 of stolen cultural objects archaeological pieces religious art
never recovered
Original headline: mexico create new police division preserve culture
Predicted headline:  mexico create new division police protect heritage herita
ge


5
News: minor solar storm expected hit earth today could trigger northern lights
places like alaska sweden norway iceland solar storms measured scale of g5 g5
extreme capable of disrupting electrical grids current storm little no effect
earth us weather agency noaa reported
Original headline: minor solar flare expected hit earth today cause auroras
Predicted headline:  solar storm hit earth today germany
```

Model 5 BLEU score

In [43]:
```
h=[]
s=[]
for i in range(942):
  h1=[headlines(y_padded_docs_test[i]).split()]
  h.append(h1)
  s.append(decode_sequence(padded_docs_test[i].reshape(1,70)).split())

from nltk.translate.bleu_score import corpus_bleu
print('BLEU-1: %f' % corpus_bleu(h, s, weights=(1.0, 0, 0, 0)))
print('BLEU-2: %f' % corpus_bleu(h, s, weights=(0.5, 0.5, 0, 0)))
```

```
BLEU-1: 0.416519
BLEU-2: 0.277199
```

In [0]:
```
```

Model 6

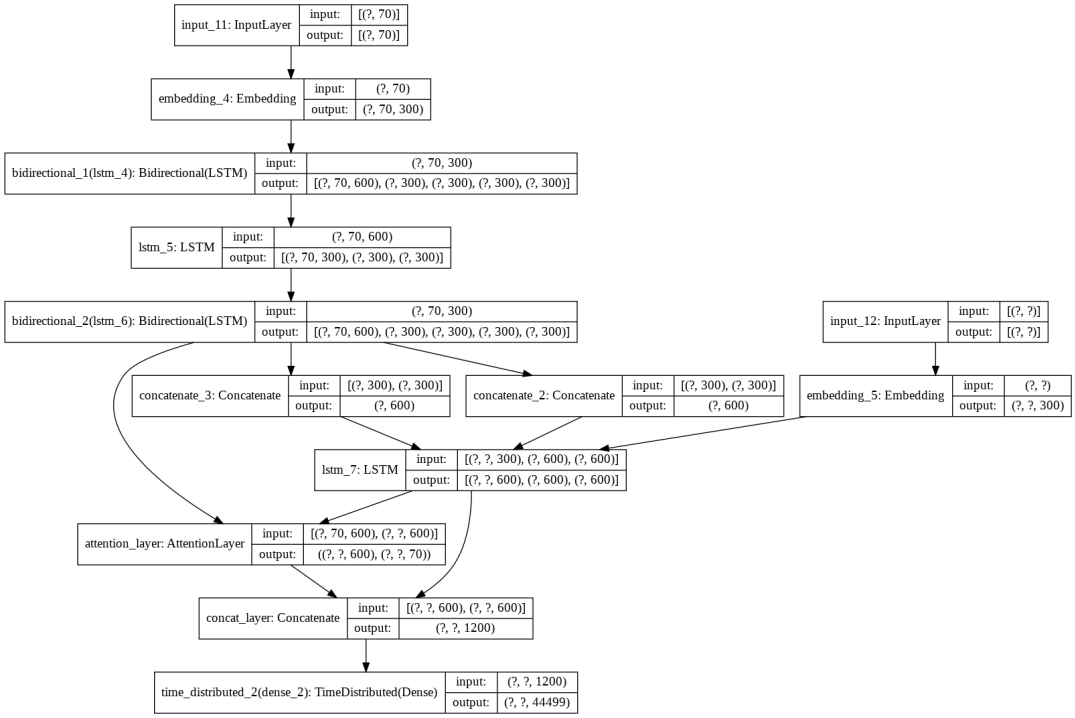
Encoder(Bidir(Lstm) + lstm + Bidir(Lstm)) + Bahdanau attention + Decoder(Lstm)

In [67]:
```
from keras import backend as K

emb_dim = 300

encoder_input = Input(shape=(70,))
x1=Embedding(vocab_size, 300,weights=[input_matrix],trainable=False)(encoder_in


encoder = Bidirectional(LSTM(units= 300,return_state=True,
                             return_sequences=True, dropout=0.5,recurrent_dropo
encoder_out,f_h_out,f_cell_out,b_h_out,b_cell_out =encoder(x1)
#B = multiply([f_out, b_out])
#state_h = Concatenate()([f_h_out, b_h_out])
#state_c = Concatenate()([f_cell_out, b_cell_out])
#encoder_states = [state_h, state_c]
l1  = LSTM(300, return_state=True,return_sequences=True,dropout=0.4,recurrent_d
a,b,c = l1(encoder_out)

encoder1 = Bidirectional(LSTM(units= 300,return_state=True,
                             return_sequences=True, dropout=0.5,recurrent_dropo

encoder_out1,f_h_out1,f_cell_out1,b_h_out1,b_cell_out1 =encoder1(a)
state_h1 = Concatenate()([f_h_out1, b_h_out1])
state_c1 = Concatenate()([f_cell_out1, b_cell_out1])

decoder_input = Input(shape=(None,))

decoder_embedding_layer = Embedding(y_vocab_size, 300,weights=[decoder_matrix],
decoder_embedding = decoder_embedding_layer(decoder_input)

decoder_lstm = LSTM(600, return_sequences=True, return_state=True,dropout=0.4,r
d_lstm_out,d_hidden_out,d_cell_out = decoder_lstm(decoder_embedding,initial_sta
#https://towardsdatascience.com/light-on-math-ml-attention-with-keras-dc8dbc1fa
attention_layer = AttentionLayer(name='attention_layer')
attention_out, attention_states = attention_layer([encoder_out1, d_lstm_out])

# Concat attention input and decoder LSTM output
concat = Concatenate(axis=-1, name='concat_layer')([d_lstm_out, attention_out])

#dense layer
decoder_dense =  TimeDistributed(Dense(y_vocab_size, activation='softmax'))
decoder_outputs = decoder_dense(concat)

# Define the model
model = Model([encoder_input, decoder_input], decoder_outputs)

model.summary()
```

```
Model: "model_6"
__________________________________________________________________________________
_________________
Layer (type)                    Output Shape         Param #     Connected to
==================================================================================
==================
input_11 (InputLayer)           [(None, 70)]         0
__________________________________________________________________________________
_________________
embedding_4 (Embedding)         (None, 70, 300)      31483500    input_11
[0][0]
__________________________________________________________________________________
_________________
bidirectional_1 (Bidirectional) [(None, 70, 600), (N 1442400     embedding_4
[0][0]
__________________________________________________________________________________
_________________
lstm_5 (LSTM)                   [(None, 70, 300), (N 1081200     bidirectional
_1[0][0]
__________________________________________________________________________________
```

In [68]:
```
from tensorflow.keras.utils import plot_model
plot_model(model, to_file='model.png', show_shapes=True)
```

Out[68]:

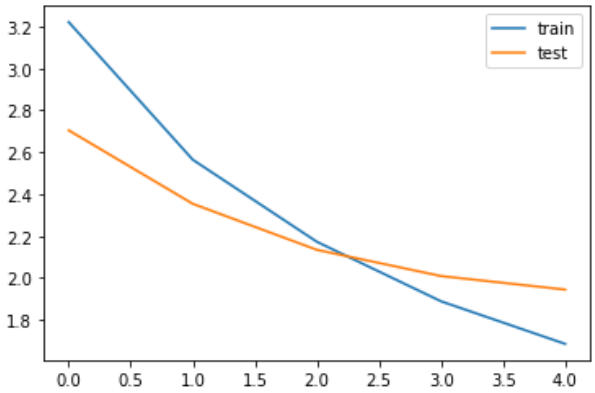


In [0]:
```
model.compile(optimizer='adam', loss='sparse_categorical_crossentropy')
```

In [70]:
```
history=model.fit([t1,t2[:,:-1]],
                  t2.reshape(t2.shape[0],t2.shape[1], 1)[:,1:]
                  ,epochs=5,batch_size=32, validation_data=([t1_cv,t2_cv[:,:-1]
                  t2_cv.reshape(t2_cv.shape[0],t2_cv.shape[1], 1)[:,1:]))
```

```
Train on 159273 samples, validate on 28107 samples
Epoch 1/5
159273/159273 [==============================] - 3177s 20ms/sample - loss: 3.2
218 - val_loss: 2.7048
Epoch 2/5
159273/159273 [==============================] - 3204s 20ms/sample - loss: 2.5
643 - val_loss: 2.3538
Epoch 3/5
159273/159273 [==============================] - 3178s 20ms/sample - loss: 2.1
724 - val_loss: 2.1339
Epoch 4/5
159273/159273 [==============================] - 3160s 20ms/sample - loss: 1.8
883 - val_loss: 2.0087
Epoch 5/5
159273/159273 [==============================] - 3161s 20ms/sample - loss: 1.6
848 - val_loss: 1.9442
```

In [72]:
```
from matplotlib import pyplot
pyplot.plot(history.history['loss'], label='train')
pyplot.plot(history.history['val_loss'], label='test')
pyplot.legend()
pyplot.show()
```

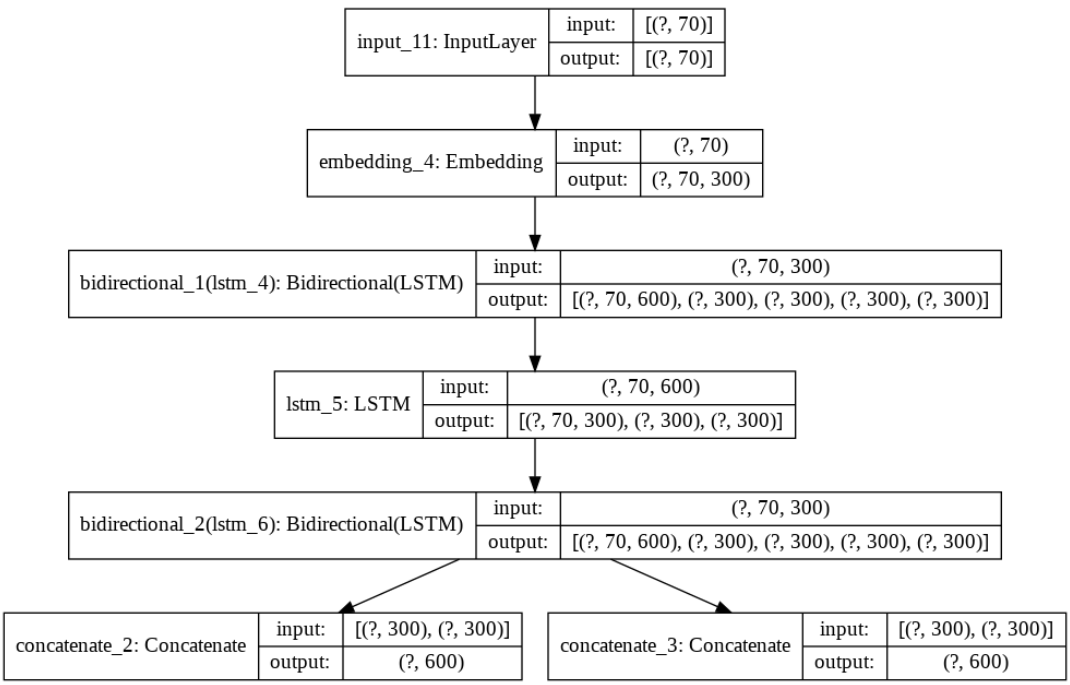


In [0]:
```
news_word_index=t.index_word
headlines_word_index=y_tokenizer.index_word
target_headlines_word_index=y_tokenizer.word_index
```

In [0]:
```
encoder_model = Model(inputs=encoder_input,outputs=[encoder_out1, state_h1, sta
```

In [75]:
```
plot_model(encoder_model, to_file='model.png', show_shapes=True)
```

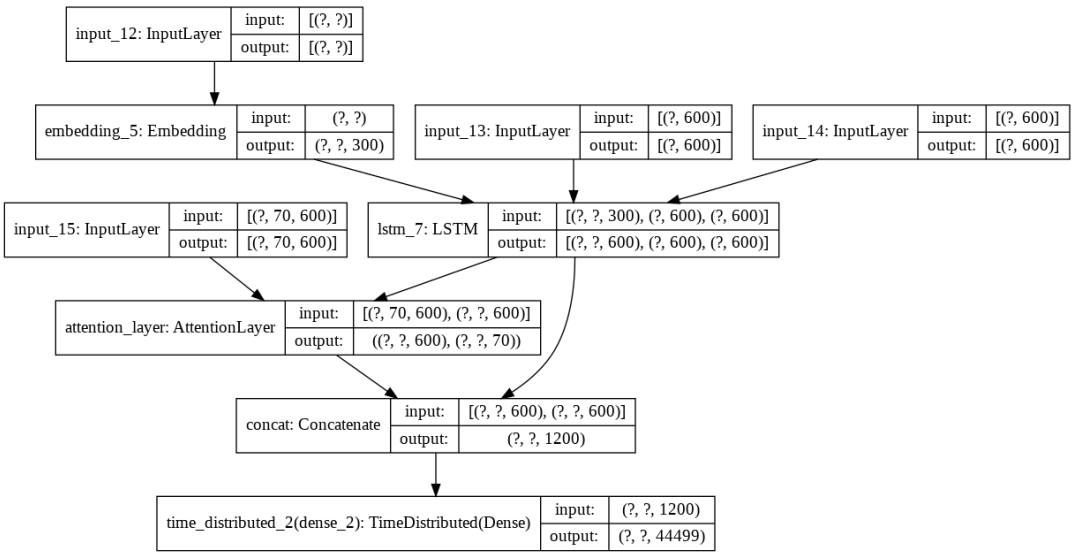
Out[75]:



In [0]:
```
decoder_input_h = Input(shape=(600,))
decoder_input_c = Input(shape=(600,))
decoder_hidden_state = Input(shape=(70,600))

dec_emb2= decoder_embedding_layer(decoder_input)
decoder_outputs2, state_h2, state_c2 = decoder_lstm(dec_emb2, initial_state=[de

attn_out_inf, attn_states_inf = attention_layer([decoder_hidden_state, decoder_
decoder_inf_concat = Concatenate(axis=-1, name='concat')([decoder_outputs2, att

decoder_outputs2 = decoder_dense(decoder_inf_concat)

decoder_model = Model(
    [decoder_input] + [decoder_hidden_state,decoder_input_h, decoder_input_c],
    [decoder_outputs2] + [state_h2, state_c2])
```

In [77]:
```
plot_model(decoder_model, to_file='model.png', show_shapes=True)
```

Out[77]:



In [0]:
```
#https://machinelearningmastery.com/encoder-decoder-attention-sequence-to-seque
#https://towardsdatascience.com/light-on-math-ml-attention-with-keras-dc8dbc1fa
def decode_sequence(input_seq):
    # Encode the input as state vectors.
    e_out, e_h, e_c = encoder_model.predict(input_seq)

    # Generate empty target sequence of length 1.
    seq = np.zeros((1,1))

    # Populate the first word of target sequence with the start word.
    seq[0, 0] = target_headlines_word_index['ssttaarrtt']

    stop_condition = False
    decoded_sentence = ''

    while not stop_condition:

        output, h, c = decoder_model.predict([seq] + [e_out, e_h, e_c])

        token_index = np.argmax(output[0, -1, :])
        if(token_index==0):
          token_index=2
        try:
          token = headlines_word_index[token_index]

          if(token!='eenndd'):
            decoded_sentence += ' '+token

        # Exit condition: either hit max length or find stop word.
          if (token == 'eenndd'  or len(decoded_sentence.split()) >= (20-1)):
            stop_condition = True
        except:
          pass
        # Update the target sequence (of length 1).
        seq = np.zeros((1,1))
        seq[0, 0] = token_index

        # Update internal states
        e_h, e_c = h, c

    return decoded_sentence
```

In [0]:
```
def headlines(input_seq):
    s=''
    for i in input_seq:
        if((i!=0 and i!=target_headlines_word_index['ssttaarrtt']) and i!=targe
            s=s+headlines_word_index[i]+' '
    return s

def news(input_seq):
    s=''

    for i in input_seq:
        if(i!=0):
            s=s+news_word_index[i]+' '
    return s
```

In [80]:
```
for i in range(5):
  print(i+1)
  print("News:",news(padded_docs_train[i]))
  print("Original headline:",headlines(y_padded_docs_train[i]))
  print("Predicted headline:",decode_sequence(padded_docs_train[i].reshape(1,70
  print("\n")
```

```
1
News: shah rukh khan while recalling time people apprehensive chak de india sa
id everyone thought worst film made no heroine girls unknown look awful beard
he added while talking film srk further said he does certain films because the
y appeal him organically
Original headline: everyone said chak de india worst film made srk
Predicted headline:  everyone worst film made no filmfare srk


2
News: transportation security administration has announced more comprehensive
involved physical screening of passengers at us airports new pat rule comes af
ter audit homeland security revealed that airport officers failed detect guns
weapons passengers us airports subjected pat searches they refuse pass through
imaging scanners
Original headline: pat downs at us airports get more invasive
Predicted headline:  us airports get new rules check check security


3
News: 20 year old indonesian man allegedly forged his diploma overstated his g
rades gain admission into police academy has arrested discrepancy noticed poli
ce education officials started verifying applicants credentials suspect charge
d document forgery jailed six years police said
Original headline: man breaks law get into police academy gets arrested
Predicted headline:  thai man fakes his class 10 yr old student


4
News: at least one person killed 14 others injured after communal clashes brok
e assam hailakandi friday officials said clashes broke people protested prayer
s held road front of mosque officials added district administration has also s
ought army help maintain peace area
Original headline: 1 dead 14 injured communal clashes assam hailakandi
Predicted headline:  1 dead 14 injured communal clashes assam hailakandi


5
News: congress president rahul gandhi sunday took ride namma metro bengaluru d
uring his karnataka assembly elections campaign gandhi boarded metro at vidhan
a soudha station got off at mg road station he also visited bookstore karnatak
a elections scheduled may 12 counting of votes held may 15
Original headline: rahul rides bengaluru metro during karnataka poll campaign
Predicted headline:  rahul rides bicycle ride k notaka election campaign
```

In [81]:
```
for i in range(5):
  print(i+1)
  print("News:",news(padded_docs_test[i]))
  print("Original headline:",headlines(y_padded_docs_test[i]))
  print("Predicted headline:",decode_sequence(padded_docs_test[i].reshape(1,70)
  print("\n")
```

```
1
News: former american swimmer michael phelps decorated olympian of all time ha
s said he extremely thankful that he not end his life while fighting depressio
n 23 time olympic gold medalist added that he suffered depression after every
olympic games his career phelps further said he not want live anymore after 20
12 olympics
Original headline: under depression after every olympics 23 time champion
Predicted headline:  very happy that not end life phelps phelps


2
News: proxy advisory firms come support of infosys co founder narayana murthy
stance making panaya probe report public infosys earlier declined murthy reque
st claimed that management has cleared of alleged wrongdoings advisory firms a
lso questioned company stock performance asked founders specific plan put info
sys back stability track
Original headline: advisory firms back murthy over making panaya probe public
Predicted headline:  infosys nilekani opposes infosys founders panaya probe


3
News: konkona sen sharma has named best actress film lipstick under burkha at
17th edition of new york indian film festival she also received best director
award directorial debut death gunj notably lipstick under burkha opening film
at film festival
Original headline: konkona named best actress lipstick under burkha
Predicted headline:  konkona patel named best actress lipstick under burkha at
cannes


4
News: mexico create new division of federal police preserve secure cultural he
ritage according officials division recruit officers knowledge of archaeology
art prevent thefts looting of cultural artefacts officials said according offi
cial figures 90 of stolen cultural objects archaeological pieces religious art
never recovered
Original headline: mexico create new police division preserve culture
Predicted headline:  mexico police use new new barracks


5
News: minor solar storm expected hit earth today could trigger northern lights
places like alaska sweden norway iceland solar storms measured scale of g5 g5
extreme capable of disrupting electrical grids current storm little no effect
earth us weather agency noaa reported
Original headline: minor solar flare expected hit earth today cause auroras
Predicted headline:  solar storms could vanish seabed greenland
```

Model 6 BLEU score

In [84]:
```
h=[]
s=[]
for i in range(942):
  h1=[headlines(y_padded_docs_test[i]).split()]
  h.append(h1)
  s.append(decode_sequence(padded_docs_test[i].reshape(1,70)).split())

from nltk.translate.bleu_score import corpus_bleu
print('BLEU-1: %f' % corpus_bleu(h, s, weights=(1.0, 0, 0, 0)))
print('BLEU-2: %f' % corpus_bleu(h, s, weights=(0.5, 0.5, 0, 0)))
```

```
BLEU-1: 0.323708
BLEU-2: 0.197235
```

Conclusion

In [10]:
```
from prettytable import PrettyTable
x = PrettyTable()


x.field_names = ['Model no',"Architecture", "BLEU-1","BLEU-2"]
x.add_row(['1','Encoder(1-Lstm) + attention + Decoder(1-Lstm)','0.132946','0.05
x.add_row(['2','Encoder(1-Lstm) + attention + Decoder(1-Lstm) stop words \n not
x.add_row(['3','Encoder(1-Lstm) + attention + Decoder(1-Lstm)','0.401676','0.26
x.add_row(['4','Encoder(3-Lstm) + attention + Decoder(1-Lstm)','0.323565','0.19
x.add_row(['5','Encoder(Bidir(Lstm) + Attention + Decoder(1-Lstm)','0.416519','
x.add_row(['6','Encoder(Bidir(Lstm) + lstm + Bidir(Lstm)) + attention + Decoder

print(x)
```

```
+----------+-------------------------------------------------------------------
-------+----------+----------+
| Model no |                                Architecture
|  BLEU-1  |  BLEU-2  |
+----------+-------------------------------------------------------------------
-------+----------+----------+
|    1     |              Encoder(1-Lstm) + attention + Decoder(1-Lstm)
| 0.132946 | 0.053922 |
|    2     |        Encoder(1-Lstm) + attention + Decoder(1-Lstm) stop words
| 0.365156 | 0.232804 |
|          |                            not removed from headlines
|          |          |
|    3     |              Encoder(1-Lstm) + attention + Decoder(1-Lstm)
| 0.401676 | 0.263726 |
|    4     |              Encoder(3-Lstm) + attention + Decoder(1-Lstm)
| 0.323565 | 0.198645 |
|    5     |            Encoder(Bidir(Lstm) + Attention + Decoder(1-Lstm)
| 0.416519 | 0.277199 |
|    6     | Encoder(Bidir(Lstm) + lstm + Bidir(Lstm)) + attention + Decoder
(1-Lstm) | 0.323708 | 0.197235 |
+----------+-------------------------------------------------------------------
-------+----------+----------+
```

Observation: Model 5 is the bestwith BLEU-1 = 0.416519 and BLEU-2 = 0.277199

Future scope

- We have trained the network on 1.5 lakhs datapoints, increasing the no of datapoints can help improve accuracy.
- Better hyperparameter tuning and architecture.
- using Beam search decoding
- pointer generator network
- pre-trained BERT model

Refrences

- https://machinelearningmastery.com/encoder-decoder-attention-sequence-to-sequence-prediction-keras/ (https://machinelearningmastery.com/encoder-decoder-attention-sequence-to-sequence-prediction-keras/)
- https://towardsdatascience.com/light-on-math-ml-attention-with-keras-dc8dbc1fad39 (https://towardsdatascience.com/light-on-math-ml-attention-with-keras-dc8dbc1fad39)
- https://www.appliedaicourse.com/ (https://www.appliedaicourse.com/)
- https://arxiv.org/abs/1512.01712 (https://arxiv.org/abs/1512.01712)
- https://arxiv.org/abs/1409.0473 (https://arxiv.org/abs/1409.0473)

In [0]:

In [0]: