In [38]:

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import LabelEncoder
from keras.models import Model, Sequential
from keras.layers import LSTM, Activation, Dense, Dropout, Input, Embedding
from keras.optimizers import Adam
from keras.preprocessing.text import Tokenizer
from keras.preprocessing import sequence
from keras.utils import pad_sequences
from keras.utils import to_categorical
from keras.callbacks import EarlyStopping
%matplotlib inline
```

In [5]:

```
df = pd.read_csv('/content/spam.csv',encoding='latin-1')
df.head()
```

Out[5]:

	v1	v2	Unnamed: 2	Unnamed: 3	Unnamed: 4
0	ham	Go until jurong point, crazy.. Available only ...	NaN	NaN	NaN
1	ham	Ok lar... Joking wif u oni...	NaN	NaN	NaN
2	spam	Free entry in 2 a wkly comp to win FA Cup fina...	NaN	NaN	NaN
3	ham	U dun say so early hor... U c already then say...	NaN	NaN	NaN
4	ham	Nah I don't think he goes to usf, he lives aro...	NaN	NaN	NaN

In [6]:

```
df.drop(['Unnamed: 2', 'Unnamed: 3', 'Unnamed: 4'],axis=1,inplace=True)
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 5572 entries, 0 to 5571
Data columns (total 2 columns):
 #   Column  Non-Null Count  Dtype 
---  ------  --------------  ----- 
 0   v1      5572 non-null   object
 1   v2      5572 non-null   object
dtypes: object(2)
memory usage: 87.2+ KB
```

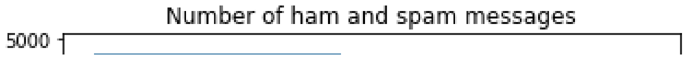
In [7]:

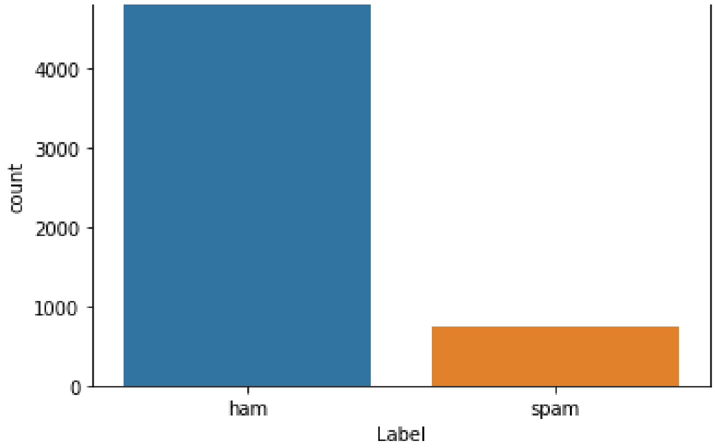
```
sns.countplot(df.v1)
plt.xlabel('Label')
plt.title('Number of ham and spam messages')
```

```
/usr/local/lib/python3.7/dist-packages/seaborn/_decorators.py:43: FutureWarning: Pass the
following variable as a keyword arg: x. From version 0.12, the only valid positional argu
ment will be `data`, and passing other arguments without an explicit keyword will result
in an error or misinterpretation.
  FutureWarning
```

Out[7]:

```
Text(0.5, 1.0, 'Number of ham and spam messages')
```





In [8]:

```
X = df.v2
Y = df.v1
le = LabelEncoder()
Y = le.fit_transform(Y)
Y = Y.reshape(-1,1)
```

In [17]:

```
X_train,X_test,Y_train,Y_test = train_test_split(X,Y,test_size=0.15)
```

In [30]:

```
max_words = 1000
max_len = 150
tok = Tokenizer(num_words=max_words)
tok.fit_on_texts(X_train)
sequences = tok.texts_to_sequences(X_train)
sequences_matrix = pad_sequences(sequences,maxlen=max_len)
```

In [35]:

```
tok.index_word
```

Out[35]:

```
{1: 'i',
 2: 'to',
 3: 'you',
 4: 'a',
 5: 'the',
 6: 'u',
 7: 'and',
 8: 'in',
 9: 'is',
 10: 'me',
 11: 'my',
 12: 'for',
 13: 'your',
 14: 'it',
 15: 'of',
 16: 'call',
 17: 'have',
 18: 'on',
 19: '2',
 20: 'that',
 21: 'now',
 22: 'are',
 23: 'so',
 24: 'but',
 25: 'not',
 26: 'can',
 27: 'do',
 28: 'at',
 29: 'or',
 30: 'get',
 31: 'with',
 32: 'if',
 33: 'ur',
 34: "i'm",
 35: 'be',
 36: 'will',
 37: 'no',
 38: 'just',
 39: 'we',
 40: 'this',
 41: 'gt',
 42: 'lt',
 43: '4',
 44: 'up',
 45: 'ok',
 46: 'free',
 47: 'when',
 48: 'out',
 49: 'go',
 50: 'how',
 51: 'from',
 52: 'what',
 53: 'all',
 54: 'know',
 55: 'then',
 56: 'got',
 57: 'like',
 58: 'good',
 59: 'come',
 60: 'was',
 61: 'its',
 62: 'am',
 63: 'only',
 64: 'time',
 65: 'day',
 66: 'he',
 67: 'love',
 68: 'send',
 69: 'there',
 70: 'as',
 71: 'text',
 72: 'want',
 73: 'one',
 74: 'going',
 75: 'need',
 76: 'by',
 77: "i'll",
 78: 'about',
 79: 'r',
 80: 'txt',
 81: 'stop',
 82: 'still',
 83: 'home',
 84: 'see',
 85: 'sorry',
 86: 'lor',
 87: 'she',
 88: 'mobile',
 89: 'k',
 90: 'reply',
 91: 'dont',
 92: 'today',
 93: 'back',
 94: 'n',
 95: 'da',
 96: 'any',
 97: 'take',
 98: 'our',
 99: 'later',
 100: 'new',
 101: 'they',
 102: 'tell',
 103: "don't",
 104: 'think',
 105: 'pls',
 106: 'hi',
 107: 'ì',
 108: 'please',
 109: 'been',
 110: 'some',
 111: 'phone',
 112: 'her',
 113: 'hope',
 114: 'much',
 115: 'well',
 116: 'did',
 117: 'too',
 118: 'him',
 119: 'hey',
 120: '1',
 121: 'here',
 122: 'd',
 123: 'make',
 124: 'has',
 125: 'week',
 126: 'night',
 127: 'who',
 128: 'oh',
 129: 'msg',
 130: 'where',
 131: 'an',
 132: 'claim',
 133: 'great',
 134: 'more',
 135: 'dear',
 136: 'happy',
 137: 'yes',
 138: 'way',
 139: 'c',
 140: 'wat',
 141: 'had',
 142: 'www',
 143: 'work',
 144: 'already',
 145: 'number',
 146: 'give',
 147: 'say',
 148: "it's",
 149: 'should',
 150: 'tomorrow',
 151: 'right',
 152: 'e',
 153: 'cash',
 154: 'amp',
 155: 'doing',
 156: 'meet',
 157: 'message',
 158: 'after',
 159: 'im',
 160: 'life',
 161: 'prize',
 162: 'said',
 163: '3',
 164: 'really',
 165: 'ask',
 166: 'them',
 167: 'babe',
 168: 'last',
 169: 'very',
 170: 'why',
 171: 'morning',
 172: 'find',
 173: 'win',
174: 'yeah',
175: 'b',
176: 't',
177: 'also',
178: 'sure',
179: 'cos',
180: 'let',
181: 'lol',
182: 'uk',
183: 'pick',
184: 'miss',
185: 'urgent',
186: 'thanks',
187: 'anything',
188: 'care',
189: 'sent',
190: 'nokia',
191: 'again',
192: 'something',
193: '150p',
194: 'com',
195: 'cant',
196: 'min',
197: "i've",
198: 'won',
199: 'keep',
200: 'would',
201: 's',
202: 'went',
203: 'contact',
204: 'nice',
205: 'his',
206: 'buy',
207: 'wait',
208: 'place',
209: 'every',
210: 'money',
211: 'over',
212: 'us',
213: 'were',
214: 'even',
215: 'which',
216: 'co',
217: 'someone',
218: 'gonna',
219: 'soon',
220: 'down',
221: 'ya',
222: 'sms',
223: 'first',
224: '5',
225: 'chat',
226: 'thing',
227: "that's",
228: 'late',
229: 'could',
230: 'before',
231: 'leave',
232: 'sleep',
233: 'help',
234: 'dun',
235: 'feel',
236: 'special',
237: 'next',
238: 'wan',
239: 'customer',
240: "can't",
241: 'things',
242: 'service',
243: 'gud',
244: 'off',
245: 'always',
246: '18',
247: 'around',
248: 'many',
249: 'friends',
250: 'v',
251: 'thk',
252: 'per',
253: 'getting',
254: 'tonight',
255: 'may',
256: 'hello',
257: 'told',
258: 'wish',
259: 'friend',
260: 'ìï',
261: 'year',
262: 'try',
263: 'other',
264: 'fine',
265: 'tone',
266: 'use',
267: '16',
268: 'people',
269: '50',
270: 'yet',
271: 'x',
272: 'lunch',
273: "you're",
274: 'same',
275: 'guaranteed',
276: 'stuff',
277: '6',
278: 'talk',
279: 'waiting',
280: 'name',
281: 'haha',
282: 'mins',
283: 'finish',
284: 'few',
285: 'days',
286: 'best',
287: 'holiday',
288: 'live',
289: 'class',
290: 'man',
291: "didn't",
292: 'job',
293: 'trying',
294: 'enjoy',
295: 'heart',
296: 'meeting',
297: 'being',
298: 'yup',
299: 'coming',
300: 'thought',
301: 'having',
302: 'ill',
303: 'long',
304: 'draw',
305: 'yo',
306: 'cool',
307: 'account',
308: 'line',
309: 'person',
310: 'better',
311: 'bit',
312: 'y',
313: 'never',
314: 'done',
315: 'car',
316: 'problem',
317: 'play',
 318: 'nothing',
 319: 'another',
 320: 'smile',
 321: 'cs',
 322: '7',
 323: 'wk',
 324: 'big',
 325: 'house',
 326: 'mind',
 327: 'real',
 328: 'end',
 329: 'receive',
 330: 'camera',
 331: 'thats',
 332: 'eat',
 333: 'word',
 334: 'dat',
 335: 'check',
 336: 'chance',
 337: 'ready',
 338: 'latest',
 339: 'lar',
 340: 'dinner',
 341: '150ppm',
 342: 'awarded',
 343: 'box',
 344: 'shows',
 345: '1st',
 346: 'boy',
 347: 'sir',
 348: 'world',
 349: 'bt',
 350: 'into',
 351: 'than',
 352: 'start',
 353: 'guess',
 354: 'sweet',
 355: 'room',
 356: 'half',
 357: 'ah',
 358: 'girl',
 359: 'bad',
 360: 'jus',
 361: 'maybe',
 362: 'den',
 363: 'å£1',
 364: 'guys',
 365: 'wanna',
 366: 'look',
 367: 'watching',
 368: 'landline',
 369: 'month',
 370: 'code',
 371: 'might',
 372: 'once',
 373: 'plan',
 374: 'god',
 375: 'sat',
 376: 'called',
 377: 'rate',
 378: 'pa',
 379: 'xxx',
 380: 'shall',
 381: 'because',
 382: 'video',
 383: 'ever',
 384: 'aight',
 385: 'remember',
 386: 'kiss',
 387: '9',
 388: 'liao',
 389: 'lot',
 390: 'dunno',
 391: 'collect',
 392: 'actually',
 393: 'early',
 394: 'tv',
 395: 'po',
 396: 'little',
 397: 'fun',
 398: "he's",
 399: 'å£1000',
 400: 'speak',
 401: 'minutes',
 402: 'put',
 403: 'enough',
 404: 'left',
 405: 'forgot',
 406: 'part',
 407: 'bed',
 408: 'll',
 409: 'does',
 410: 'watch',
 411: 'cost',
 412: 'missing',
 413: 'evening',
 414: "how's",
 415: 'everything',
 416: 'probably',
 417: 'tmr',
 418: 'offer',
 419: 'office',
 420: 'working',
 421: 'without',
 422: 'made',
 423: 'ringtone',
 424: 'wife',
 425: 'dis',
 426: '10',
 427: 'apply',
 428: 'easy',
 429: 'since',
 430: 'award',
 431: 'reach',
 432: 'princess',
 433: '8',
 434: 'baby',
 435: 'thank',
 436: 'shit',
 437: 'birthday',
 438: 'details',
 439: 'tones',
 440: 'wif',
 441: 'wot',
 442: 'wont',
 443: 'okay',
 444: 'fuck',
 445: 'didnt',
 446: 'texts',
 447: 'looking',
 448: 'm',
 449: 'dad',
 450: 'hear',
 451: 'thanx',
 452: 'mail',
 453: 'important',
 454: 'orange',
 455: 'between',
 456: 'quite',
 457: 'while',
 458: 'wanted',
 459: 'entry',
 460: 'bus',
 461: 'must',
 462: "there's",
 463: 'those',
 464: '000',
 465: 'weekend',
 466: 'until',
 467: 'plus',
 468: 'says',
 469: 'true',
 470: 'bring',
 471: 'food',
 472: 'wake',
 473: 'network',
 474: 'stay',
 475: 'anyway',
 476: 'shopping',
 477: 'most',
 478: 'selected',
 479: 'update',
 480: 'sexy',
 481: 'alright',
 482: 'pain',
 483: 'else',
 484: 'leh',
 485: 'worry',
 486: 'though',
 487: 'school',
 488: 'yours',
 489: '2nd',
 490: 'price',
 491: 'collection',
 492: 'pay',
 493: 'means',
 494: 'asked',
 495: '500',
 496: 'xmas',
 497: 'bored',
 498: 'weekly',
 499: 'show',
 500: 'decimal',
 501: 'lei',
 502: 'yesterday',
 503: 'came',
 504: 'hour',
 505: 'gift',
 506: 'havent',
 507: 'away',
 508: 'music',
 509: 'able',
 510: 'hav',
 511: 'luv',
 512: 'valid',
 513: 'join',
 514: '10p',
 515: 'abt',
 516: 'hurt',
 517: 'movie',
 518: 'coz',
 519: 'hot',
 520: "we're",
 521: 'nite',
 522: 'dreams',
 523: 'messages',
 524: 'date',
 525: 'missed',
 526: 'attempt',
 527: 'g',
 528: 'mob',
 529: '8007',
 530: 'afternoon',
 531: 'town',
 532: 'family',
 533: 'huh',
534: 'making',
535: 'game',
536: 'address',
537: 'till',
538: 'two',
539: 'sch',
540: 'guy',
541: 'online',
542: 'sleeping',
543: 'both',
544: 'plz',
545: 'news',
546: 'tot',
547: 'points',
548: 'wants',
549: 'oso',
550: 'run',
551: 'pic',
552: 'haf',
553: 'de',
554: "what's",
555: 'sad',
556: 'id',
557: 'years',
558: "haven't",
559: 'noe',
560: 'å£500',
561: 'set',
562: 'wen',
563: 'together',
564: 'aft',
565: 'words',
566: 'mean',
567: 'vouchers',
568: 'these',
569: 'shop',
570: 'club',
571: 'gr8',
572: 'dude',
573: 'old',
574: 'private',
575: 'calls',
576: 'double',
577: "won't",
578: 'pics',
579: 'times',
580: 'yourself',
581: 'either',
582: 'lose',
583: 'final',
584: 'til',
585: 'wid',
586: 'busy',
587: 'national',
588: 're',
589: 'post',
590: 'goes',
591: 'change',
592: 'calling',
593: 'story',
594: 'pounds',
595: 'driving',
596: 'friendship',
597: 'colour',
598: 'unsubscribe',
599: 'å£100',
600: 'goin',
601: 'trip',
602: 'ard',
603: "''",
604: 'http',
605: 'å£2000',
606: 'juz',
607: 'walk',
608: 'started',
609: 'available',
610: '86688',
611: 'found',
612: 'face',
613: 'email',
614: 'gd',
615: 'congrats',
616: 'games',
617: 'hair',
618: 'bonus',
619: 'feeling',
620: 'top',
621: 'drop',
622: 'rite',
623: 'saying',
624: 'tried',
625: 'delivery',
626: 'chikku',
627: 'drink',
628: 'brother',
629: 'question',
630: 'answer',
631: 'charge',
632: 'beautiful',
633: 'msgs',
634: 'taking',
635: 'sae',
636: 'took',
637: 'saw',
638: 'close',
639: 'statement',
640: 'expires',
641: 'head',
642: 'happen',
643: 'simple',
644: 'å£5000',
645: 'wil',
646: 'cause',
647: 'leaving',
648: 'fast',
649: 'far',
650: 'makes',
651: 'full',
652: '11',
653: 'believe',
654: "she's",
655: 'mum',
656: 'book',
657: 'takes',
658: 'kind',
659: 'choose',
660: 'okie',
661: 'order',
662: 'finished',
663: 'services',
664: 'whats',
665: 'thinking',
666: 'tomo',
667: 'await',
668: "c's",
669: 'company',
670: 'identifier',
671: 'visit',
672: 'todays',
673: 'sun',
674: "we'll",
675: 'happened',
676: 'w',
677: 'don',
678: 'test',
679: 'sounds',
680: 'awesome',
681: 'lots',
682: 'auction',
683: 'card',
684: 'second',
685: 'secret',
686: 'hard',
687: 'hit',
688: 'hours',
689: 'break',
690: '12hrs',
691: 'pub',
692: 'mine',
693: 'poly',
694: 'wit',
695: "doesn't",
696: 'smiling',
697: 'worth',
698: 'everyone',
699: 'voucher',
700: 'net',
701: 'neva',
702: 'open',
703: 'content',
704: 'needs',
705: 'winner',
706: 'minute',
707: 'ring',
708: 'used',
709: 'read',
710: 'lucky',
711: 'å£3',
712: 'sister',
713: 'blue',
714: 'comes',
715: 'loving',
716: 'welcome',
717: 'lets',
718: 'player',
719: 'goodmorning',
720: 'prob',
721: 'outside',
722: '750',
723: 'wrong',
724: 'land',
725: 'o',
726: 'tel',
727: 'bout',
728: 'sis',
729: 'pretty',
730: 'info',
731: 'pm',
732: 'tho',
733: 'gone',
734: '100',
735: 'hows',
736: 'hmm',
737: 'knw',
738: 'nt',
739: 'lesson',
740: 'operator',
741: 'angry',
742: 'course',
743: 'project',
744: 'finally',
745: 'whatever',
746: 'row',
747: 'search',
748: 'mobileupd8',
749: 'seeing',
750: "you'll",
751: 'luck',
752: 'cut',
753: 'ha',
754: 'fucking',
755: 'ltd',
756: 'frm',
757: 'college',
758: 'meant',
759: 'opt',
760: 'darlin',
761: 'fone',
762: '08000930705',
763: 'boytoy',
764: 'drive',
765: 'alone',
766: 'each',
767: 'anytime',
768: 'decided',
769: 'case',
770: 'balance',
771: 'lovely',
772: "you've",
773: 'carlos',
774: 'parents',
775: 'savamob',
776: 'sea',
777: 'saturday',
778: 'girls',
779: 'anyone',
780: 'oredi',
781: '30',
782: 'download',
783: 'etc',
784: 'hand',
785: 'ac',
786: 'telling',
787: 'mah',
788: 'frnd',
789: '2003',
790: '800',
791: 'ni8',
792: 'invited',
793: 'suite342',
794: '2lands',
795: 'th',
796: 'pobox',
797: 'light',
798: 'bslvyl',
799: 'friday',
800: 'tc',
801: 'their',
802: 'b4',
803: 'mates',
804: 'side',
805: 'mate',
806: 'treat',
807: 'bank',
808: 'reveal',
809: 'thinks',
810: '\x89û',
811: 'mrng',
812: 'camcorder',
813: 'sunday',
814: 'smth',
815: 'ass',
816: 'reading',
817: 'st',
818: 'earlier',
819: 'father',
820: 'john',
821: 'knew',
822: 'felt',
823: 'least',
824: 'weeks',
825: 'press',
826: 'offers',
827: 'smoke',
828: 'lost',
829: 'dating',
830: 'snow',
831: 'hold',
832: 'forget',
833: 'wonderful',
834: 'frnds',
835: 'wkly',
836: '87066',
837: 'enter',
838: 'touch',
839: 'type',
840: 'seen',
841: 'fr',
842: "i'd",
843: 'pass',
844: 'chennai',
845: 'å£250',
846: 'crazy',
847: 'comp',
848: 'phones',
849: 'extra',
850: 'reason',
851: 'laptop',
852: 'f',
853: 'un',
854: 'redeemed',
855: '04',
856: 'mom',
857: 'numbers',
858: 'å£350',
859: 'sex',
860: 'understand',
861: 'unlimited',
862: 'support',
863: 'motorola',
864: '08000839402',
865: 'fri',
866: 'yar',
867: '20',
868: 'caller',
869: '03',
870: 'muz',
871: 'wow',
872: 'xx',
873: 'ipod',
874: 'whole',
875: 'hungry',
876: 'rental',
877: 'comin',
878: 'currently',
879: 'met',
880: 'gas',
881: 'semester',
882: 'hee',
883: 'quiz',
884: "wasn't",
885: 'std',
886: 'charged',
887: 'crave',
888: 'log',
889: 'rs',
890: 'yr',
891: 'point',
892: 'eve',
893: 'jay',
 894: 'mayb',
 895: 'complimentary',
 896: 'listen',
 897: 'mr',
 898: 'surprise',
 899: "'",
 900: 'congratulations',
 901: 'bath',
 902: 'nope',
 903: 'gal',
 904: 'red',
 905: 'correct',
 906: 'area',
 907: 'otherwise',
 908: 'cum',
 909: 'ago',
 910: 'checking',
 911: 'couple',
 912: 'slowly',
 913: 'ten',
 914: 'freemsg',
 915: 'laugh',
 916: 'mobiles',
 917: 'information',
 918: 'small',
 919: 'party',
 920: 'loads',
 921: 'somewhere',
 922: 'å£10',
 923: 'ge',
 924: 'slow',
 925: 'march',
 926: 'india',
 927: 'admirer',
 928: 'film',
 929: 'loved',
 930: 'within',
 931: 'immediately',
 932: 'die',
 933: 'eg',
 934: 'almost',
 935: 'discount',
 936: 'whenever',
 937: 'spend',
 938: 'hmv',
 939: 'kate',
 940: 'mu',
 941: 'leaves',
 942: 'across',
 943: 'darren',
 944: 'credit',
 945: 'different',
 946: 'rest',
 947: 'dream',
 948: 'reward',
 949: 'christmas',
 950: 'monday',
 951: "isn't",
 952: '0800',
 953: 'gym',
 954: 'asking',
 955: 'confirm',
 956: 'plans',
 957: 'difficult',
 958: 'rply',
 959: 'drugs',
 960: 'ends',
 961: 'usf',
 962: 'valued',
 963: 'link',
 964: 'exam',
 965: 'park',
 966: 'store',
 967: 'empty',
 968: 'eh',
 969: 'supposed',
 970: 'through',
 971: 'askd',
 972: 'police',
 973: 'via',
 974: 'uncle',
 975: 'feels',
 976: 'dnt',
 977: 'computer',
 978: 'gotta',
 979: 'wana',
 980: 'hospital',
 981: 'picking',
 982: 'heard',
 983: 'completely',
 984: 'sort',
 985: 'reached',
 986: 'nobody',
 987: 'lovable',
 988: 'short',
 989: 'tonite',
 990: 'rakhesh',
 991: 'em',
 992: 'weed',
 993: 'clean',
 994: 'poor',
 995: 'hmmm',
 996: '4u',
 997: 'mon',
 998: 'sony',
 999: 'call2optout',
 1000: 'studying',
 ...}
```

In [37]:

```
TOT_SIZE = len(tok.word_index)+1
```

In [40]:

```
lstm_model = Sequential()
lstm_model.add(Embedding(TOT_SIZE, 32, input_length=max_len))
lstm_model.add(LSTM(100))
lstm_model.add(Dropout(0.4))
lstm_model.add(Dense(20, activation="relu"))
lstm_model.add(Dropout(0.3))
lstm_model.add(Dense(1, activation = "sigmoid"))
lstm_model.compile(loss = "binary_crossentropy", optimizer = "adam", metrics = ["accurac
y"])
```

In [41]:

```
lstm_model.summary()
```

```
Model: "sequential_1"
_________________________________________________________________
 Layer (type)                Output Shape              Param #   
=================================================================
 embedding_1 (Embedding)     (None, 150, 32)           262496    
                                                                 
 lstm_1 (LSTM)               (None, 100)               53200     
                                                                 
 dropout_2 (Dropout)         (None, 100)               0         
                                                                 
 dense_2 (Dense)             (None, 20)                2020      
                                                                 
 dropout_3 (Dropout)         (None, 20)                0         
                                                                 
 dense_3 (Dense)             (None, 1)                 21        
```

```
=================================================================
Total params: 317,737
Trainable params: 317,737
Non-trainable params: 0
_________________________________________________________________
```

In [44]:

```
lstm_model.fit(sequences_matrix,Y_train,batch_size=128,epochs=10,
          validation_split=0.2,
          workers = 10,
          callbacks=[EarlyStopping(monitor='val_loss',min_delta=0.0001)])
```

```
Epoch 1/10
30/30 [==============================] - 10s 329ms/step - loss: 0.0851 - accuracy: 0.9805
- val_loss: 0.0558 - val_accuracy: 0.9852
Epoch 2/10
30/30 [==============================] - 10s 326ms/step - loss: 0.0497 - accuracy: 0.9871
- val_loss: 0.0464 - val_accuracy: 0.9873
```

Out[44]:

```
<keras.callbacks.History at 0x7f6696448550>
```

In [45]:

```
lstm_model.save('LSTM.h5')
```

In [47]:

```
test_sequences = tok.texts_to_sequences(X_test)
test_sequences_matrix = pad_sequences(test_sequences,maxlen=max_len)
```

In [49]:

```
acc = lstm_model.evaluate(test_sequences_matrix,Y_test)
```

```
27/27 [==============================] - 1s 32ms/step - loss: 0.0442 - accuracy: 0.9856
```

In [51]:

```
print('Test set\n  Loss: {:0.3f}\n  Accuracy: {:0.3f}'.format(acc[0],acc[1]))
```

```
Test set
  Loss: 0.044
  Accuracy: 0.986
```