In this assignment, we will implement a simple rule-based POS tagger

First let's download the universal dependency treebank from the following url
https://lindat.mff.cuni.cz/repository/xmlui/handle/11234/1-4611

Create a folder named `data` . Copy the downloaded `ud-treebanks-v2.9.tgz` file into the current directory and untar it

let us import some libraries

In [1]:
```
import codecs
import random

from sklearn.metrics import classification_report
from sklearn.metrics import confusion_matrix, ConfusionMatrixDisplay, accuracy_scc

import matplotlib.pyplot as plt
```

Now let's write some utility functions

Utility Code

Code to read data from CoNLL format

In [2]:
```
def conllReader(filename, word_field=1, label_field=3):
    sentences = []
    sentence = []
    label_list = []

    with codecs.open(filename, 'r', errors='ignore', encoding='utf8') as f_in:
        for line in f_in:
            line = line.strip()
            if line:
                if line.startswith('#'):
                    continue
                word = line.split('\t')[word_field]
                label = line.split('\t')[label_field]
                tokens = [word, label]
                sentence.append( tokens )

                if label not in label_list:
                    label_list.append( label )
            else:
                if len(sentence) > 0:
                    sentences.append( sentence )
                sentence = []
        f_in.close()

    return sentences, label_list
```

In [3]:
```
train_split, label_list = conllReader('data/ud-treebanks-v2.9/UD_Hindi-HDTB/hi_hdt
label_list.sort()
print('Read {0} number of train sentences'.format( len(train_split) ))
print('\nFirst sentence looks like')
print(train_split[0])
```

```
print('\n Labels used are')
print(label_list)
```

```
Read 13304 number of train sentences

First sentence looks like
[['यह', 'DET'], ['एशिया', 'PROPN'], ['की', 'ADP'], ['सबसे', 'ADV'], ['बड़ी', 'ADJ'],
['मस्जिदों', 'NOUN'], ['में', 'ADP'], ['से', 'ADP'], ['एक', 'NUM'], ['है', 'AUX'], ['।',
'PUNCT']]

 Labels used are
['ADJ', 'ADP', 'ADV', 'AUX', 'CCONJ', 'DET', 'INTJ', 'NOUN', 'NUM', 'PART', 'PRO
N', 'PROPN', 'PUNCT', 'SCONJ', 'VERB', 'X']
```

In [4]:

```
def getMax(dictionary):
    max_key = list(dictionary.keys())[0]
    max_value = dictionary[max_key]
    for key in dictionary:
        if max_value > dictionary[key]:
            max_value = dictionary[key]
            max_key = key

    return key
```

Now we have the data loading part written, let's write a simple Most-Frequent POS tagger

Most Frequent POS Tagger

Let's load the train and test sets

In [5]:

```
train_split, label_list = conllReader('data/ud-treebanks-v2.9/UD_Hindi-HDTB/hi_hdt
test_split, _ = conllReader('data/ud-treebanks-v2.9/UD_Hindi-HDTB/hi_hdtb-ud-test.

print('Read {0} number of train sentences'.format( len(train_split) ))
print('Read {0} number of test sentences'.format( len(test_split) ))
```

```
Read 13304 number of train sentences
Read 1684 number of test sentences
```

For every word in train split, let's get the POS statistics

In [6]:

```
word_pos_frequency = {}

for every_sentence in train_split:
    for every_token in every_sentence:
        word, label = every_token
        if word in word_pos_frequency:
            if label in word_pos_frequency[word]:
                word_pos_frequency[word][label] += 1
            else:
                word_pos_frequency[word][label] = 1
        else:
            word_pos_frequency[word] = {}
            word_pos_frequency[word][label] = 1

print('Total number of words in train split is {0}'.format( len(word_pos_frequency
first_word = next(iter(word_pos_frequency))
print( 'Word is {0}'.format(first_word) )
print( word_pos_frequency[first_word] )
```

```
Total number of words in train split is 16879
Word is यह
{'DET': 658, 'PRON': 573, 'NOUN': 1}
```

Evaluate on test split

In [7]:

```
ground_truth = []
prediction = []

for every_sentence in train_split:
    ground_truth_sentence = []
    prediction_sentence = []

    for every_token in every_sentence:
        word, label = every_token
        ground_truth_sentence.append( label )

        if word in word_pos_frequency:
            prediction_sentence.append( getMax( word_pos_frequency[word] ) )
        else:
            prediction_sentence.append( random.choice( label_list ) )

    ground_truth.append( ground_truth_sentence )
    prediction.append( prediction_sentence )
```

In [8]:

```
flatten_gold_truth = [j for sub in ground_truth for j in sub]
flatten_predictions = [j for sub in prediction for j in sub]
label_list.sort()
print(classification_report(flatten_gold_truth, flatten_predictions, target_names=
```

```
              precision    recall  f1-score   support

         ADJ     0.4962    0.6667    0.5690     16459
         ADP     0.8807    0.2457    0.3843     59221
         ADV     0.2227    0.3552    0.2737      2703
         AUX     0.0936    0.1350    0.1106     20821
       CCONJ     1.0000    0.2372    0.3834      5110
         DET     0.1115    0.1210    0.1161      6081
        INTJ     1.0000    1.0000    1.0000         3
        NOUN     0.6175    0.6462    0.6315     62191
         NUM     0.8006    0.3329    0.4703      5332
        PART     0.3651    0.5358    0.4343      5610
        PRON     0.5566    0.7281    0.6309     11857
       PROPN     0.3714    0.6528    0.4735     34289
       PUNCT     1.0000    1.0000    1.0000     18668
       SCONJ     1.0000    0.1202    0.2147      5389
        VERB     0.6276    0.6397    0.6336     27188
           X     0.0451    0.6444    0.0843       135

    accuracy                         0.5125    281057
   macro avg     0.5743    0.5038    0.4631    281057
weighted avg     0.6185    0.5125    0.5082    281057
```

In [9]:

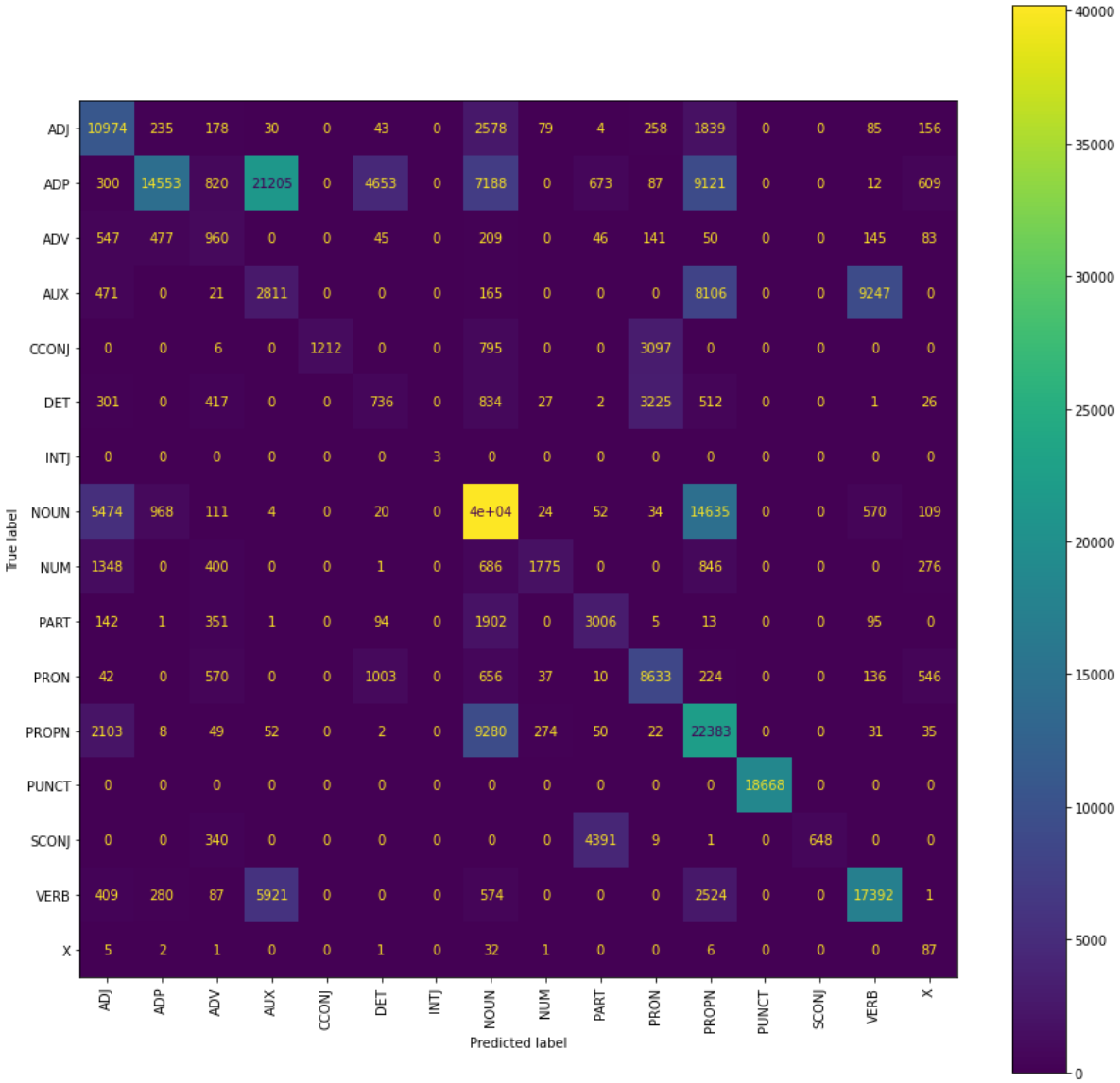
```
cm = confusion_matrix(flatten_gold_truth, flatten_predictions)

cmd = ConfusionMatrixDisplay(cm, display_labels=label_list)

fig, ax = plt.subplots()
fig.set_figheight(15)
fig.set_figwidth(15)
```

```
cmd.plot(xticks_rotation='vertical', ax =ax)
```

Out[9]: <sklearn.metrics._plot.confusion_matrix.ConfusionMatrixDisplay at 0x123278bfd90>



In [10]:

```
#For tasks requiring phrase-level annotation
# from seqeval.metrics import accuracy_score
# from seqeval.metrics import classification_report
# from seqeval.metrics import f1_score
# from seqeval.scheme import IOB1
# print('F1 Score is')
# print( f1_score(ground_truth, prediction) )

# print('Classification report')
# print( classification_report(ground_truth, prediction, scheme=IOB1) )
```

Implement Rule-based System here

In [10]:

```
INDIC_NLP_RESOURCES=r"C:\Users\akash\IIITL_NLP_Lab\Lab01\indic_nlp_resources"
```

In [11]:

```
import sys
from indicnlp import common
```

```
common.set_resources_path(INDIC_NLP_RESOURCES)
```

In [12]:

```
from indicnlp import loader
loader.load()
```

In [13]:

```
from indicnlp.normalize.indic_normalize import IndicNormalizerFactory

factory=IndicNormalizerFactory()
normalizer=factory.get_normalizer("hi")
```

Rules for Hindi language

In [25]:

```
hindi_num = '०१२३४५६७८९0123456789' # digits in hindi and english from 0-9
hindi_num_text = ['शून्य','एक', 'डेढ़', 'दो', 'दोनों', 'तीन', 'चार', 'चारों', 'पाँच', 'पांच'
                  'हज़ार', 'लाख', 'लाखों', 'करोड़', 'अरब'] # most common hindi numbe

def chk_num(word):
    for chr in word:
        if chr in hindi_num:
            return True
    if word in hindi_num_text:
        return True
    return False


def chk_det(word):
    common_det_list = ['उसका', 'उसकी', 'उसके', 'मेरा', 'मेरी', 'आपका', 'आपकी', 'य
                'कुछ', 'कई', 'ऐसे', 'ऐसी', 'ऐसा', 'इस', 'उस', 'इन', 'इनकी']
    if word in common_det_list:
        return True
    else:
        return False


def chk_adp(word):
    if ((word == 'का') or (word == 'के') or (word == 'को') or (word == 'से') or (wo
        (word == 'लिए')):
        return True
    else:
        return False

def chk_sconj(word):
    if (word == 'तो') or (word == 'कि') or (word == 'यदि') or (word == 'क्योंकि') or
        return True
    else:
        return False

def chk_aux(word):
    if word == 'है' or word == 'हैं':
        return True
    else:
        return False

def chk_cconj(word):
    if (word == 'लेकिन') or (word == 'और') or (word == 'व') or (word == 'या'):
        return True
    else:
        return False
```

```
def chk_part(word):
    part_ls = ['नहीं', 'भी', 'ही', 'न', 'केवल', 'भर']
    if word in part_ls:
        return True
    else:
        return False

INTJs = ['हे', 'अरे', 'ऐ', 'ओह', 'शाबाश', 'वाह']

advs = ['अच्छा', 'कल', 'ऊपर', 'थोडा', 'ध्यानपूर्वक', 'भली', 'भाँति', 'धीरे', 'तेज', 'बाद',
        'सबसे', 'पहले', 'जरूर' , 'अक्सर' , 'शायद' , 'इसलिए', 'कभी', 'बिल्कुल', 'तक'
        'अभी', 'रोज ', 'आगे', 'पीछे', 'नीचे', 'दाएँ', 'बाएँ', 'उतना', 'जितना', 'अधिक',
       'खुलकर', 'फिर', 'जैसे', 'बेहद', 'बहुत', 'यूँ', 'काफी', 'वहीं']

# def chk_adj_with_pos(word, ps, pps):

#     lst_c = word[len(word)-1]
#     hcf1 = hex(ord(word[0]))
#     hcf2 = 0x20
#     hcl1 = hex(ord(lst_c))
#     hcl2 = 0x20

#     if len(word) > 1:
#         sec_lst_c = word[len(word)-2]
#         hcl2 = hex(ord(sec_lst_c))
#         hcf2 = hex(ord(word[1]))
#     if pps != 'ADJ':
#         if ps == 'NOUN':
#             if ((hcf1 == '0x926' and hcf2 == '0x941') or (hcf1 == '0x92c' and hc
#             (hcf1 == '0x92c' and hcf2 == '0x947')): # checking prefixes for adj
#                 return True

#             elif ((hcl2 == '0x93f' and hcl1 == '0x915') or (hcl2 == '0x93f' and
#             (hcl2 == '0x93f' and hcl1 == '0x92e') or (hcl2 == '0x940'  and (hcl1
#             (hcl2 == '0x93f' and (hcl1 != '0x926' or hcl1 != '0x90f' or hcl1 !=
#                  (hcl1 == '0x940') or (hcl1 == '0x93e') or (hcl2 == '0x924' and
#                  or (hcl1 == '0x942')): # checking suffixes for adj
#                 return True

#         return False

################################################################################
```

In [26]:

```
ground_truth = []
prediction = []
prev_pos = ''
prev_wrd = ' '

for every_sentence in train_split:
    ground_truth_sentence = []
    prediction_sentence = []

    for every_token in every_sentence:
        word, label = every_token
        word_norm = normalizer.normalize(word)
        ground_truth_sentence.append( label )

        if word_norm in INTJs:
            prediction_sentence.append('INTJ')

        elif chk_num(word_norm):
            prediction_sentence.append('NUM')
```

```
        elif chk_part(word_norm):
            prediction_sentence.append('PART')

        elif chk_sconj(word_norm):
            prediction_sentence.append('SCONJ')

        elif chk_aux(word_norm):
            prediction_sentence.append('AUX')

        elif chk_cconj(word_norm):
            prediction_sentence.append('CCONJ')

        elif chk_adp(word_norm):
            prediction_sentence.append('ADP')

        elif chk_det(word_norm):
            prediction_sentence.append('DET')

        elif word_norm in advs and prev_pos == 'ADP':
            prediction_sentence.append('ADV')

        else:
            if word_norm in word_pos_frequency:
                prediction_sentence.append( getMax( word_pos_frequency[word_norm]
            else:
                prediction_sentence.append( random.choice( label_list ) )

        curr = prediction_sentence.pop()
        if (curr == 'VERB' or curr == 'ADJ') and (prev_pos != 'ADV') and (prev_wrd
            rem = prediction_sentence.pop()
            prediction_sentence.append('ADV')
        prediction_sentence.append(curr)

#         curr = prediction_sentence.pop() # Check for Adjectives
#         if chk_adj_with_pos(prev_wrd, curr, prev_pos) and (len(prediction_senten
#             rem = prediction_sentence.pop()
#             prediction_sentence.append('ADJ')
#         prediction_sentence.append(curr)
#         prev_wrd = word_norm

        prev_pos = prediction_sentence[len(prediction_sentence)-1]
        prev_wrd = word_norm

    ground_truth.append( ground_truth_sentence )
    prediction.append( prediction_sentence )
```

In [27]:

```
flatten_ground_truth = [j for sub in ground_truth for j in sub]
flatten_predictions = [j for sub in prediction for j in sub]

# print(accuracy_score(flatten_ground_truth, flatten_predictions))
print(classification_report(flatten_ground_truth, flatten_predictions, digits=4))
```

	precision	recall	f1-score	support
ADJ	0.5390	0.6595	0.5932	16459
ADP	0.9492	0.9258	0.9374	59221
ADV	0.3187	0.6323	0.4238	2703
AUX	0.6524	0.5351	0.5879	20821
CCONJ	0.9621	0.9681	0.9651	5110
DET	0.6469	0.7604	0.6991	6081
INTJ	1.0000	1.0000	1.0000	3
NOUN	0.7462	0.6423	0.6904	62191
NUM	0.7728	0.9653	0.8584	5332
PART	0.8797	0.8709	0.8753	5610
PRON	0.9082	0.6444	0.7539	11857
PROPN	0.5042	0.6324	0.5611	34289
PUNCT	0.9998	0.9972	0.9985	18668
SCONJ	0.9466	0.9898	0.9677	5389
VERB	0.6802	0.6356	0.6571	27188
X	0.0533	0.6296	0.0982	135
accuracy			0.7426	281057
macro avg	0.7225	0.7805	0.7292	281057
weighted avg	0.7620	0.7426	0.7478	281057

In [28]:

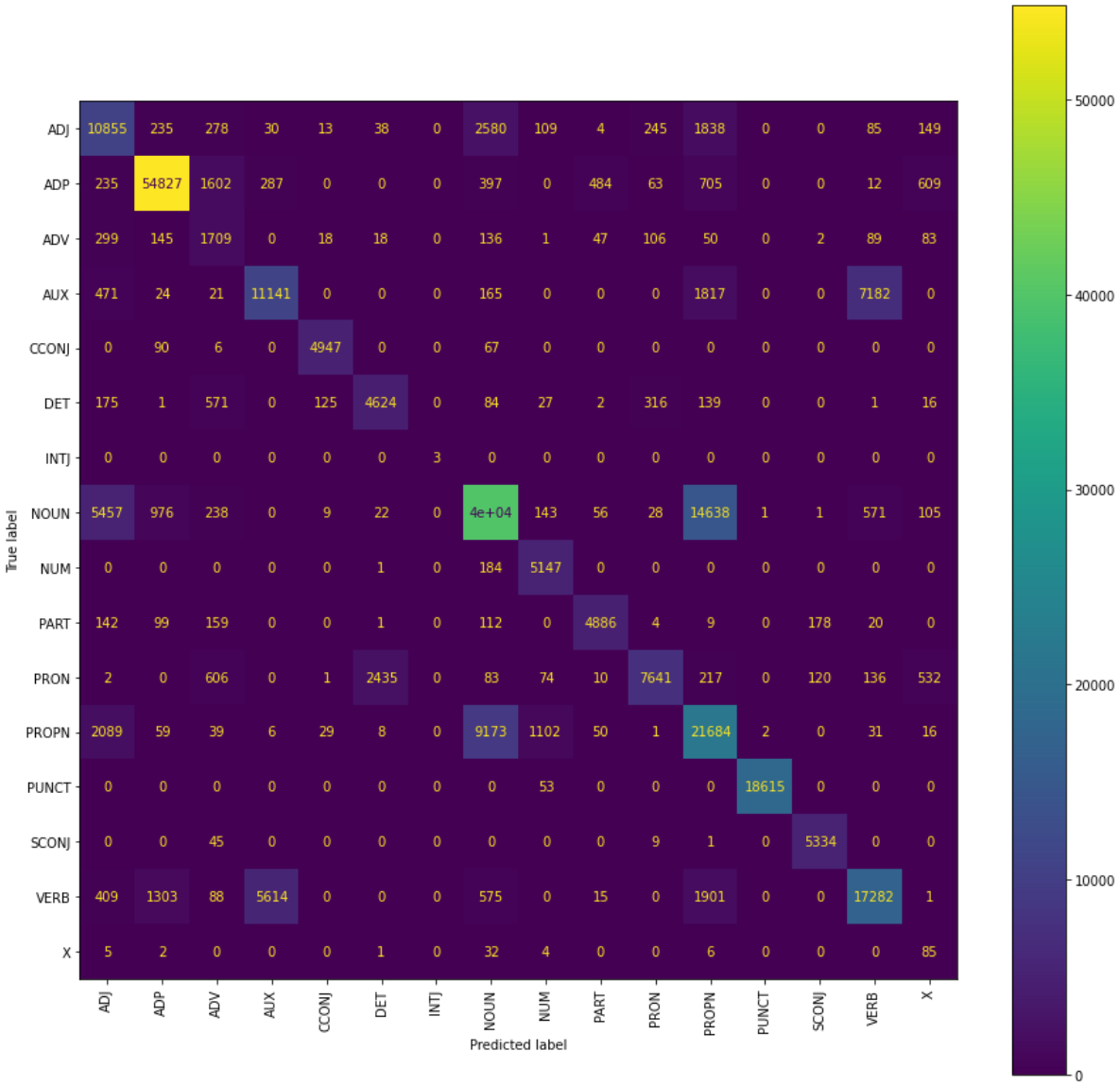
```
cm = confusion_matrix(flatten_ground_truth, flatten_predictions)
cmd = ConfusionMatrixDisplay(cm, display_labels=label_list)

fig, ax = plt.subplots()
fig.set_figheight(15)
fig.set_figwidth(15)

cmd.plot(xticks_rotation='vertical', ax =ax)
```

Out[28]:

```
<sklearn.metrics._plot.confusion_matrix.ConfusionMatrixDisplay at 0x1233aa8d280>
```



On Test Split

In [29]:

```
ground_truth = []
prediction = []
prev_pos = ''
prev_wrd = ' '

for every_sentence in test_split:
    ground_truth_sentence = []
    prediction_sentence = []

    for every_token in every_sentence:
        word, label = every_token
        word_norm = normalizer.normalize(word)
        ground_truth_sentence.append( label )

        if word_norm in INTJs:
            prediction_sentence.append('INTJ')

        elif chk_num(word_norm):
            prediction_sentence.append('NUM')

        elif chk_part(word_norm):
            prediction_sentence.append('PART')

        elif chk_sconj(word_norm):
```

```
            prediction_sentence.append('SCONJ')

        elif chk_aux(word_norm):
            prediction_sentence.append('AUX')

        elif chk_cconj(word_norm):
            prediction_sentence.append('CCONJ')

        elif chk_adp(word_norm):
            prediction_sentence.append('ADP')

        elif chk_det(word_norm):
            prediction_sentence.append('DET')

        elif word_norm in advs and prev_pos == 'ADP':
            prediction_sentence.append('ADV')

        else:
            if word_norm in word_pos_frequency:
                prediction_sentence.append( getMax( word_pos_frequency[word_norm]
            else:
                prediction_sentence.append( random.choice( label_list ) )

        curr = prediction_sentence.pop()
        if (curr == 'VERB' or curr == 'ADJ') and (prev_pos != 'ADV') and (prev_wrd
            rem = prediction_sentence.pop()
            prediction_sentence.append('ADV')
        prediction_sentence.append(curr)

        prev_pos = prediction_sentence[len(prediction_sentence)-1]
        prev_wrd = word_norm

    ground_truth.append( ground_truth_sentence )
    prediction.append( prediction_sentence )
```

In [30]:

```
flatten_ground_truth = [j for sub in ground_truth for j in sub]
flatten_predictions = [j for sub in prediction for j in sub]

print(accuracy_score(flatten_ground_truth, flatten_predictions))
print(classification_report(flatten_ground_truth, flatten_predictions, target_name
```

```
0.7076488851255998
C:\Users\akash\anaconda3\envs\nlplab\lib\site-packages\sklearn\metrics\_classifica
tion.py:1248: UndefinedMetricWarning: Recall and F-score are ill-defined and being
set to 0.0 in labels with no true samples. Use `zero_division` parameter to contro
l this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
```

```
                precision    recall  f1-score   support

           ADJ     0.5016    0.6182    0.5538      2043
           ADP     0.9358    0.9259    0.9308      7544
           ADV     0.2431    0.6086    0.3474       304
           AUX     0.6338    0.5447    0.5859      2596
         CCONJ     0.8452    0.9717    0.9040       635
           DET     0.6128    0.7436    0.6719       745
          INTJ     0.0000    0.0000    0.0000         0
          NOUN     0.7270    0.5922    0.6527      8036
           NUM     0.6923    0.9481    0.8002       693
          PART     0.7736    0.8479    0.8090       677
          PRON     0.8292    0.6655    0.7384      1372
         PROPN     0.4411    0.4847    0.4619      4438
         PUNCT     0.9638    1.0000    0.9815      2420
         SCONJ     0.8491    0.9878    0.9132       655
          VERB     0.6504    0.5918    0.6197      3263
             X     0.0074    0.2222    0.0142         9

      accuracy                         0.7076     35430
     macro avg     0.6066    0.6720    0.6241     35430
  weighted avg     0.7268    0.7076    0.7130     35430
```

```
C:\Users\akash\anaconda3\envs\nlplab\lib\site-packages\sklearn\metrics\_classification.py:1248: UndefinedMetricWarning: Recall and F-score are ill-defined and being set to 0.0 in labels with no true samples. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
C:\Users\akash\anaconda3\envs\nlplab\lib\site-packages\sklearn\metrics\_classification.py:1248: UndefinedMetricWarning: Recall and F-score are ill-defined and being set to 0.0 in labels with no true samples. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
```

In [31]:

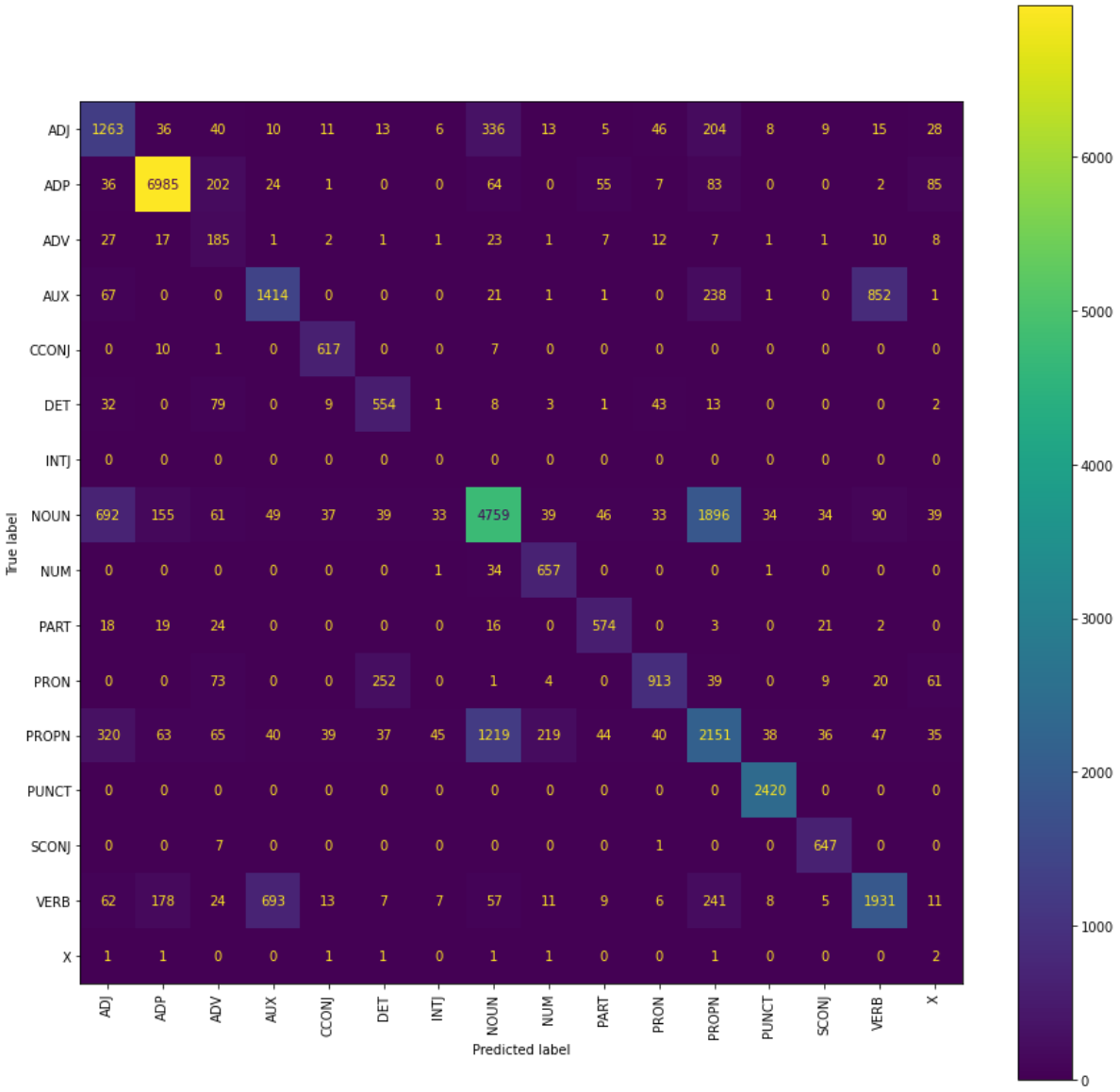
```
cm = confusion_matrix(flatten_ground_truth, flatten_predictions)
cmd = ConfusionMatrixDisplay(cm, display_labels=label_list)

fig, ax = plt.subplots()
fig.set_figheight(15)
fig.set_figwidth(15)

cmd.plot(xticks_rotation='vertical', ax =ax)
```

Out[31]:

```
<sklearn.metrics._plot.confusion_matrix.ConfusionMatrixDisplay at 0x1233ae62730>
```


ADJ 1263 36 40 10 11 13 6 336 13 5 46 204 8 9 15 28
ADP 36 6985 202 24 1 0 0 64 0 55 7 83 0 0 2 85
ADV 27 17 185 1 2 1 1 23 1 7 12 7 1 1 10 8
AUX 67 0 0 1414 0 0 0 21 1 1 0 238 1 0 852 1
CCONJ 0 10 1 0 617 0 0 7 0 0 0 0 0 0 0 0
DET 32 0 79 0 9 554 1 8 3 1 43 13 0 0 0 2
INTJ 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
NOUN 692 155 61 49 37 39 33 4759 39 46 33 1896 34 34 90 39
NUM 0 0 0 0 0 0 1 34 657 0 0 0 1 0 0 0
PART 18 19 24 0 0 0 0 16 0 574 0 3 0 21 2 0
PRON 0 0 73 0 0 252 0 1 4 0 913 39 0 9 20 61
PROPN 320 63 65 40 39 37 45 1219 219 44 40 2151 38 36 47 35
PUNCT 0 0 0 0 0 0 0 0 0 0 0 0 2420 0 0 0
SCONJ 0 0 7 0 0 0 0 0 0 0 1 0 0 647 0 0
VERB 62 178 24 693 13 7 7 57 11 9 6 241 8 5 1931 11
X 1 1 0 0 1 1 0 1 1 0 0 1 0 0 0 2
True label
ADJ ADP ADV AUX CCONJ DET INTJ NOUN NUM PART PRON PROPN PUNCT SCONJ VERB X
Predicted label
6000 5000 4000 3000 2000 1000 0

In [ ]: