In [18]:

```python
from nltk.tokenize import word_tokenize
from nltk.tokenize import sent_tokenize
from nltk import pos_tag
from pprint import pprint

import numpy as np
import pandas as pd
import networkx as nx
import matplotlib.pyplot as plt
import pydot
import graphviz
import seaborn as sns;

from collections import Counter
from itertools import tee
from scipy import stats
from matplotlib.colors import ListedColormap
```

In [2]:

```python
with open('trainspec.txt', 'r') as specfile:
    spec=specfile.read().replace('\n', '')
sentences = sent_tokenize(spec)

def pairwise(iterable):
    a, b = tee(iterable)
    next(b, None)
    return zip(a, b)
```

In [3]:

```python
allTags = []
stopwords = [',','.']
dataDict = dict()
prevTag=''
currTag=''
Obs=[]
for sentence in sentences:
    wordTokens = word_tokenize(sentence)
    wordTokens = [w for w in wordTokens if w not in stopwords]
    posTags = pos_tag(wordTokens)
    for _curr_, _next_ in pairwise(posTags):
        if (_curr_[1],_next_[1]) in dataDict:
            dataDict[(_curr_[1],_next_[1])][0]+=1
        else:
            dataDict[(_curr_[1],_next_[1])]=[1]
        dataDict[(_curr_[1],_next_[1])].append((_curr_[0],_next_[0]))
        Obs.append((_curr_[1],_next_[1]))
    Obs.append((-1,-1))
    tags = [(w,t) for (w,t) in posTags]

    allTags = allTags + tags

noOfObservations = len(dataDict) # we have the observations in the dict value index 0 for every key
print(noOfObservations)

# computing probabilities for each pair to decide the feature term selection criteria
tags = [t for (w,t) in allTags]
distinctTags = Counter(tags).keys()
distinctTagsCount = Counter(tags).values()
dTags = list(zip(distinctTags, distinctTagsCount))

# get tag pairs with NN, NNS, NNP or NNPS in it
pairs=[k for k,v in dataDict.items()]
nounBasedPairs = [(x,y) for (x,y) in pairs if x in ['NN','NNS','NNP','NNPS'] or y in ['NN','NNS','NNP','NNPS']]
print(nounBasedPairs)

tokens=[v[0] for k,v in dataDict.items()]
print(tokens)
totalNoOfToken = sum(tokens)
```

```
64
[('DT', 'NN'), ('NN', 'VBZ'), ('NN', 'POS'), ('POS', 'NNS'), ('NNS', 'NNS'), ('NNS', 'DT'), ('IN', 'NN'), ('NN', 'NNS'), ('N
N', 'NN'), ('NN', 'DT'), ('NN', 'IN'), ('NN', 'MD'), ('JJ', 'NNS'), ('NNS', 'TO'), ('NNS', 'IN'), ('JJ', 'NN'), ('RB', 'NN'),
('VBZ', 'NNS'), ('NNS', 'VBG'), ('VBG', 'NNS'), ('IN', 'NNS'), ('NN', 'TO'), ('NNS', 'PRP'), ('NNS', 'VBP'), ('VBZ', 'NN'),
('IN', 'NNP'), ('NNP', 'DT'), ('DT', 'NNP'), ('NNP', 'VBZ'), ('NNP', 'NN'), ('NN', 'VBP'), ('POS', 'NN'), ('VB', 'NN'), ('VB
```

```
N', 'NN'), ('NN', 'WDT'), ('DT', 'NNS'), ('VBP', 'NN')]
[14, 105, 55, 38, 2, 1, 1, 7, 4, 7, 13, 6, 3, 24, 11, 4, 1, 6, 2, 5, 11, 5, 5, 3, 11, 6, 2, 4, 3, 10, 3, 1, 1, 2, 1, 2, 1, 2,
1, 2, 1, 1, 2, 1, 1, 2, 1, 2, 1, 1, 1, 1, 1, 2, 1, 1, 2, 2, 1, 2, 2, 1, 1, 1]
```

In [4]:

```
# calculate the probabilities for each tag pair
print(totalNoOfToken) #461

# update dictionary with probabilities
for v in dataDict.values():
    v[0]=v[0]/(totalNoOfToken)
probs = [vp[0] for vp in dataDict.values()]
aKeys=[k for k,v in dataDict.items()]
```

```
417
```

In [5]:

```
threshold = max(np.median(probs),stats.mode(probs)[0])
print(threshold)
```

```
0.004796163069544364
```

In [6]:

```
# for filtering features
# model-1
validSeq = [k for k,val in dataDict.items() if val[0]>=threshold]
# model-2
validSeq = [k for k,val in dataDict.items() if k in nounBasedPairs]

# create the observation data
Obsv=[aKeys.index(_o) if _o in aKeys else len(aKeys) for _o in Obs]
```

In [7]:

```python
# extracting probable feature terms
feature_start = 0
features = []
feature = []
for sentence in sentences:
    wordTokens = word_tokenize(sentence)
    wordTokens = [w for w in wordTokens if w not in stopwords]
    posTags = pos_tag(wordTokens)

    for _curr_, _next_ in pairwise(posTags):
        if (_curr_[1],_next_[1]) in validSeq:
            if feature_start == 0:
                feature_start = 1
                feature.append(_curr_[0])
                feature.append(_next_[0])
            else:
                feature.append(_next_[0])
        else:
            if feature_start == 1:
                feature_start = 0
                features.append(' '.join(feature))
                feature=[]
    if feature_start == 1:
        feature_start = 0
        features.append(' '.join(feature))
        feature=[]

# minimal clean up of features:
# - lower case feature names
# - removing duplicates

features = [f.lower() for f in features]
features = list(dict.fromkeys(features))
for f in features:
    subf = [_f for _f in features if _f != f]
    fsubset = [_f for _f in subf if f in _f]
    if len(fsubset)>0:
        features = subf

i = 0
for f in features:
    print("F"+str(i)+" - ",f.lower())
    i=i+1
# number of features
noOfStates = len(features)
```

```
print(noOfStates)
```

```
F0 -  the purchase 's payments details the supplier confirms
F1 -  the system asks
F2 -  for shipment details
F3 -  with credit cards
F4 -  a customer pays
F5 -  a credit card the system approves
F6 -  the payment by
F7 -  the credit card company
F8 -  the system completes
F9 -  an order the supplier can
F10 -  ordered products to
F11 -  the shipping documents via email
F12 -  the system finalizes
F13 -  a software order details the supplier ships
F14 -  ordered product via email
F15 -  different shipping options
F16 -  a customer buys
F17 -  small product the system supports
F18 -  air mail shipping
F19 -  the system displays
F20 -  registered customer buys
F21 -  the inventory
F22 -  with gift cards
F23 -  a gift card the system supports
F24 -  only land shipping
F25 -  the purchase status
F26 -  the system provides details on
F27 -  the product delivery status
F28 -  the product return page
F29 -  the customer returns
F30 -  the product page
F31 -  a supplier enters
F32 -  new products the system updates
F33 -  the catalog
F34 -  the system enables customers writing reviews on products
F35 -  a customer reviews
F36 -  a product the system sends
F37 -  the product review to
F38 -  relevant supplier
F39 -  a supplier receives
F40 -  new products he
F41 -  new products to
F42 -  available products list
F43 -  the shopping cart
```

F44 - ordering page
F45 - a customer purchases a product the system updates
F46 - the system validates purchase details the supplier confirms
F47 - the system clears
F48 - with paypal the system verifies
F49 - the paypal payment information
F50 - tracking options
F51 - a customer tracks
F52 - the product 's order status the system presents
F53 - the shipment details
F54 - the system can
F55 - handle product return
F56 - a customer returns
F57 - damaged product the system sends
F58 - negative review on
F59 - the product to
F60 - the system allows
F61 - a customer cancels
F62 - an order that
F63 - the system refunds
F64 - the goods return impact
F65 - maintain product reviews
F66 - registered customer reviews
F67 - a product the system stores the product review by product category
68

In [8]:

```python
# HMM implementation. Preparing row stochatic inputs
O = np.array([Obsv])

T = len(O[0]) # of observations

M = len(np.unique(O))
A = np.empty((noOfStates, noOfStates))  #Rows are present state
B = np.empty((noOfStates, M)) #likelihood of intial state , +1 for spaces
N = np.shape(B)[0]

# Initial probabilities
for i in range(0,noOfStates):
    A[i]=np.random.dirichlet(np.ones(noOfStates),size=1)
    B[i]=np.random.dirichlet(np.ones(M),size=1)

pi = np.random.rand(N) # likelihood of intial state
pi = pi/pi.sum()

print("O=",O)
print("A=",A)
print("B=",B)
print("pi=",pi)
print(N)
print(M)
print(T)
```

```
O= [[ 0  1  2  3  1  4  5  6  7  1  2  3  1 64  1  2  8  9 10 64  1  2 11 12
   9 10 64  0  1  2  8  0  1 13 14  1  2 15 16  1 17 18 19  1 13 13 64 20
   1  2 11 19  1 14  1 21 22 23 24 25 26 27  1 64  1  2  3  1 10 28  9 64
  20  1  2  3  1 13 10  7  1  2  3 24 29 17  9 64  1  2  3  1 10 64  1  2
  30 29 10 64 31  0  1  2  3 32 33 29 14  1  2 15 33 29 13 64  1  2  3 24
  25 64 20 24 29  2  3  1 14  1  2  3  1 64  1  2 11 12  9 10 64  0  1  2
   8  0  1 13 14  1  2 15 34 13 64  1 21 22 23  1 13 64  1  2 35 28  0  1
  13 13 64  1  2  3  1 13 13 64  0  1  2  3  1 14  1  2  3  1 64  1  2  3
   1 13 64 20  1  2 30 25  7  1  2  3  1 64  1  2 35 36 37 28 38 64 20  1
   2  3  1 14  1  2  3  1 13 39 27 24 29 64 20  1  2 30 25 40 41  3 24 25
  26 27  1 64  1  2  3  1 64 20  1  2  3 24 25 42 43  1 21 22 23  1 64  1
   2  3  1 13 64  1  2  3 24 29 64  0  1 10  7  1 14  1  2  3  1 64 20  1
   2  3  1 13 10  7  1  2  3 24 29 17  9 64  1  2  3  1 13 13 64 20  1  2
  44 10  7  1  2  3  1 64  1  2  3  1 13 64  1  2 11 12 45 64  0  1  2  8
  45 46 47 48  3 47 49 13 64  1 50 51 37 64 20  1  2  3  1  4 52 13 14  1
   2  3  1 10 64  1 21 22 53 13 64  0  1  2  3 54 55 14  1  2  3 24 29 17
   0  1 39 27  1 64  1  2 11 19  1 64  0  1  2  3  1 56 57 15 58 59 60  1
   2  3  1 64  1  2 11 19  1 64 20  1  2  3  1 56 57 61 59 60  1  2  3  1
  17 18 19 62 42 63 64  1 21 22 53 10 64  0 24 29  2  3  1 14  1 10  7  1
```

```
  13 17  9 13 64]]
A= [[0.00925737 0.0157135  0.01155965 ... 0.01911543 0.01105932 0.01363339]
 [0.01146125 0.00200518 0.00046816 ... 0.00087919 0.00610001 0.02737441]
 [0.00157685 0.0237731  0.00649767 ... 0.01459875 0.03941655 0.00757395]
 ...
 [0.00348105 0.01696801 0.02758954 ... 0.01449423 0.03398814 0.00405553]
 [0.00057237 0.04030563 0.00349301 ... 0.0003622  0.01077557 0.01076404]
 [0.00686401 0.0009596  0.0047426  ... 0.00241215 0.01540818 0.09525096]]
B= [[0.01607036 0.02288629 0.00992536 ... 0.00081371 0.00217585 0.0192101 ]
 [0.03425502 0.04880609 0.00478903 ... 0.00944575 0.01653368 0.00580427]
 [0.01104561 0.01147382 0.01187659 ... 0.03554252 0.05814849 0.0028147 ]
 ...
 [0.00066892 0.02053466 0.00716279 ... 0.01631853 0.01791003 0.01781489]
 [0.01673019 0.01958323 0.00285217 ... 0.01012448 0.00217617 0.0096102 ]
 [0.02091443 0.00834902 0.00103462 ... 0.003035   0.03159479 0.01363756]]
pi= [0.00457244 0.00104814 0.01763841 0.02688425 0.01151385 0.01843476
 0.0104688  0.01173413 0.01113263 0.00231603 0.01834459 0.00270597
 0.02191767 0.02974635 0.00998642 0.02325485 0.01855986 0.02293765
 0.00018414 0.03063989 0.01878638 0.02020092 0.00995439 0.02188039
 0.02087078 0.01487332 0.00720473 0.01105576 0.01820549 0.00531718
 0.00136362 0.02706269 0.01106469 0.01810888 0.02489079 0.00750481
 0.01385645 0.00507634 0.01648572 0.02635581 0.00532748 0.00468113
 0.00852884 0.02023206 0.0141969  0.02011382 0.02361248 0.00793986
 0.02172303 0.01253861 0.0199065  0.02184673 0.01415928 0.02935441
 0.00470489 0.01987812 0.01746558 0.0248635  0.00862136 0.00264976
 0.02635323 0.0148739  0.01374221 0.01327388 0.00138126 0.0084415
 0.02388966 0.00156009]
68
65
461
```

In [9]:

```python
# Reused the implementation from https://github.com/rbnsnsd2/hidden_markov_model (uses Mark Stamp's pseudo code)
def init_matrices(O, N):

    T = len(O[0])
    M = len(np.unique(O))
    A = np.random.rand(N,N)
    A = A/A.sum(axis=1)[:,None]
    B = np.random.rand(N,M)
    B = B/B.sum(axis=1)[:,None]
    pi = np.random.rand(N)
    pi = pi/pi.sum()
    c = np.zeros((T))
    alpha = np.zeros((T,N))
    beta = np.zeros((T,N))
    gamma = np.zeros((T,N))
    digam = np.zeros((T,N,N))
    return A, B, pi, alpha, beta, gamma, digam, M, T, c

maxIters = 100
iters = 0
oldLogProb = -10**100

c = np.zeros((T))
alpha = np.zeros((T,N))
beta = np.zeros((T,N))
gamma = np.zeros((T,N))
digam = np.zeros((T,N,N))

def apass(A,B,pi,alpha,N,T,c):
    c[0] = 0
    for i in range(N):
        alpha[0,i] = pi[i]*B[i,O[0,0]]
        c[0] = c[0] + alpha[0,i]

    c[0] = 1/c[0]
    for i in range(N):
        alpha[0,i] = c[0]*alpha[0,i]

    for t in range(1,T):
        c[t] = 0

        for i in range(N):
            alpha[t,i] = 0
            for j in range(N):
                alpha[t,i] = alpha[t,i] + alpha[t-1,j]*A[j,i]
```

```
                alpha[t,i] = alpha[t,i]*B[i,O[0,t]]
                c[t] = c[t] + alpha[t,i]

            c[t] = 1/c[t] #Scale alpha[t,i]
            for i in range(N):
                alpha[t,i] = c[t]*alpha[t,i]
        return alpha, c

    def bpass(A,B,pi,beta,N,T,c):
        for i in range(N):
            beta[T-1,i] = c[T-1]

        for t in range(T-2,-1,-1):
            for i in range(N):
                beta[t,i] = 0
                for j in range(N):
                    beta[t,i] = beta[t,i] + A[i,j]*B[j,O[0,t+1]]*beta[t+1,j]
                beta[t,i] = c[t]*beta[t,i]

        return beta, c

    def digamma(A,B,pi,alpha,beta,gamma,digam,N,T):
        for t in range(T-1):
            for i in range(N):
                gamma[t,i] = 0
                for j in range(N):
                    digam[t,i,j] = alpha[t,i]*A[i,j]*B[j,O[0,t+1]]*beta[t+1,j]
                    gamma[t,i] = gamma[t,i] + digam[t,i,j]
        for i in range(N):
            gamma[T-1,i] = alpha[T-1,i]

        return gamma, digam

    def re_est(A,B,pi,gamma,digam):
        for i in range(N):
            pi[i] = gamma[0,i]

        for i in range(N):
            for j in range(N):
                numer = 0
                denom = 0
                for t in range(T-1):
                    numer = numer + digam[t,i,j]
                    denom = denom + gamma[t,i]
                A[i,j] = numer/denom

```

```
    for i in range(N):
        for j in range(M):
            numer = 0
            denom = 0
            for t in range(T):
                if O[0,t] == j: numer = numer + gamma[t,i]
                denom = denom + gamma[t,i]
            B[i,j] = numer/denom
    return A, B, pi

def logprob(c):
    return -np.sum(np.log(c))

def markov(O,N):
    iters = 0
    logProb = 0
    delta = 1
    A, B, pi, alpha, beta, gamma, digam, M, T, c = init_matrices(O,N)
    while iters <= maxIters and logProb >= oldLogProb and delta >= 0.000001:
        alpha, c = apass(A,B,pi,alpha,N,T,c)
        beta, c = bpass(A,B,pi,beta,N,T,c)
        gamma, digam = digamma(A,B,pi,alpha,beta,gamma,digam,N,T)
        A, B, pi = re_est(A,B,pi,gamma,digam)
        delta1 = logProb
        logProb = logprob(c)
        delta = np.absolute(delta1 - logProb)
        iters = iters + 1
    print("Interations: ", iters)
    return A,B,pi,alpha,beta,gamma,digam

def fitObservations(o,maxIter,N, M, a, b, p):
    T = len(o[0])

    for t in range(0,T):
        if o[0,t] > M:
            return 'Invalid data'

    oldLogProb=-np.log(0)
    currIter=0

    A = a
    B = b
    c = np.zeros((T))
    pi = p

    alpha = np.zeros((T,N))
```

```
    beta = np.zeros((T,N))
    gamma = np.zeros((T,N))
    digam = np.zeros((T,N,N))

    for i in range(0,maxIters):
        currIter = i
        alpha, c = apass(A,B,pi,alpha,N,T,c)
        beta, c = bpass(A,B,pi,beta,N,T,c)
        gamma, digam = digamma(A,B,pi,alpha,beta,gamma,digam,N,T)

        A, B, pi = re_est(A,B,pi,gamma,digam)
        logProb = logprob(c)
        if logProb <= oldLogProb:
            break
        oldLogProb = logProb;
    return currIter, A, B, pi;

def p_obs_lambda(alpha):
    return np.sum(alpha[T-1,:])

def p_state(gamma):
    return np.argmax(gamma,axis=1)
```

In [10]:

```python
#A, B, pi, alpha, beta, gamma, digam = markov(O,N)
itr,A,B,pi = fitObservations(O,5,N, M, A, B, pi)
print("A = {}\nB = {}".format(A,B))
print("pi = {}".format(pi))
```

```
C:\Users\anjal\Anaconda3\lib\site-packages\ipykernel_launcher.py:129: RuntimeWarning: divide by zero encountered in log

A = [[0.00950147 0.02598282 0.00940017 ... 0.01835193 0.01047832 0.00846778]
 [0.01205526 0.00246956 0.00031428 ... 0.00085705 0.00513453 0.01552943]
 [0.00163962 0.0431368  0.00515679 ... 0.01592979 0.03866244 0.00523629]
 ...
 [0.00361631 0.02664977 0.02055353 ... 0.01382082 0.0297443  0.00270454]
 [0.00056378 0.05854308 0.00234576 ... 0.00035906 0.00932415 0.00631269]
 [0.00829058 0.00185371 0.003989   ... 0.00264859 0.01740119 0.06868638]]
B = [[3.54066918e-02 3.36160421e-01 5.70245790e-02 ... 1.32609321e-04
  2.67519105e-04 1.56153691e-01]
 [4.73211516e-02 4.95249262e-01 1.85628611e-02 ... 9.34756446e-04
  1.01209823e-03 2.73601614e-02]
 [2.42253420e-02 1.98164497e-01 1.00231949e-01 ... 9.15868043e-03
  8.48777573e-03 3.06229990e-02]
 ...
 [1.45101291e-03 2.98436252e-01 4.65363392e-02 ... 2.85138868e-03
  2.14330220e-03 1.41713458e-01]
 [4.33454951e-02 3.24710943e-01 2.08411745e-02 ... 1.99363740e-03
  3.17377346e-04 9.63589443e-02]
 [5.43983564e-02 1.72380383e-01 9.69344689e-03 ... 5.57396895e-04
  4.86172758e-03 1.41162339e-01]]
pi = [5.61976566e-03 2.75864871e-03 1.29792556e-02 3.82777597e-04
 1.33278052e-02 1.26506949e-02 9.66982068e-03 2.54642217e-04
 1.34664944e-04 1.21584042e-03 1.16240043e-02 3.73652838e-03
 1.15403435e-02 3.80946812e-02 1.18126022e-04 1.32461108e-02
 1.03087866e-02 1.59328166e-02 4.96072866e-07 2.00118531e-02
 8.81731849e-03 1.45225891e-02 6.93756169e-03 8.12503201e-03
 1.43733503e-02 4.35278632e-03 7.17012824e-04 8.46933765e-03
 1.75349760e-02 1.10275014e-02 1.94906419e-03 2.53707565e-02
 1.07184367e-02 7.34742069e-02 1.08955548e-02 1.64972288e-04
 1.59415823e-02 1.31456017e-03 6.98270794e-03 9.36274318e-03
 1.05840159e-02 4.78463894e-04 2.27995478e-02 8.53547796e-03
 1.98953976e-02 5.06169445e-02 8.86366981e-02 2.80508592e-02
 5.32916552e-02 3.98246436e-03 1.02133673e-02 2.09901775e-02
 7.41285113e-02 3.59400218e-04 5.74587420e-04 2.90110660e-05
 3.68453862e-02 9.29155391e-02 3.34568884e-04 6.52146713e-04
 2.83797553e-03 1.24521939e-03 1.06782616e-03 2.54020686e-03
 3.77330549e-05 4.62209073e-04 3.10374161e-02 2.19748031e-03]
```

In [76]:

```
print(np.max(pi))
print(np.sort(pi))
```

```
0.0929155391214
[4.96072866e-07 2.90110660e-05 3.77330549e-05 1.18126022e-04
 1.34664944e-04 1.64972288e-04 2.54642217e-04 3.34568884e-04
 3.59400218e-04 3.82777597e-04 4.62209073e-04 4.78463894e-04
 5.74587420e-04 6.52146713e-04 7.17012824e-04 1.06782616e-03
 1.21584042e-03 1.24521939e-03 1.31456017e-03 1.94906419e-03
 2.19748031e-03 2.54020686e-03 2.75864871e-03 2.83797553e-03
 3.73652838e-03 3.98246436e-03 4.35278632e-03 5.61976566e-03
 6.93756169e-03 6.98270794e-03 8.12503201e-03 8.46933765e-03
 8.53547796e-03 8.81731849e-03 9.36274318e-03 9.66982068e-03
 1.02133673e-02 1.03087866e-02 1.05840159e-02 1.07184367e-02
 1.08955548e-02 1.10275014e-02 1.15403435e-02 1.16240043e-02
 1.26506949e-02 1.29792556e-02 1.32461108e-02 1.33278052e-02
 1.43733503e-02 1.45225891e-02 1.59328166e-02 1.59415823e-02
 1.75349760e-02 1.98953976e-02 2.00118531e-02 2.09901775e-02
 2.27995478e-02 2.53707565e-02 2.80508592e-02 3.10374161e-02
 3.68453862e-02 3.80946812e-02 5.06169445e-02 5.32916552e-02
 7.34742069e-02 7.41285113e-02 8.86366981e-02 9.29155391e-02]
```

In [68]:

```
states = ["F"+str(i) for i in range(0,noOfStates)]

finalTransitionMatrix = pd.DataFrame(columns=states, index=states)
for i in range(0,noOfStates):
    finalTransitionMatrix.loc[states[i]] = A[i]

finalTransitionMatrix.to_excel("output.xlsx")
```

In [69]:

```python
# Create graph and visualize
# create graph object
G = nx.MultiDiGraph()

# nodes correspond to states
G.add_nodes_from(states)

# edges represent transition probabilities
for i in range(0,noOfStates):
    for j in range(0,noOfStates):
        tmp_origin, tmp_destination = "F"+str(i), "F"+str(j)
        G.add_edge(tmp_origin, tmp_destination, weight=A[i][j], label=A[i][j])
pprint(G.edges(data=True))

# create edge labels for jupyter plot but is not necessary
edge_labels = {(n1,n2):d['label'] for n1,n2,d in G.edges(data=True)}
#nx.draw_networkx_edge_labels(G , pos, edge_labels=edge_labels)
nx.drawing.nx_pydot.write_dot(G, 'fm_markov.dot')
```


```
48, 'label': 0.001600773404547848}), ('F4', 'F46', {'weight': 0.007172497388885861, 'label': 0.007172497388885861}), ('F
4', 'F47', {'weight': 0.0012922606593647435, 'label': 0.0012922606593647435}), ('F4', 'F48', {'weight': 0.009163102154278
367, 'label': 0.009163102154278367}), ('F4', 'F49', {'weight': 0.02134546932040302, 'label': 0.02134546932040302}), ('F
4', 'F50', {'weight': 0.0020771178042849605, 'label': 0.0020771178042849605}), ('F4', 'F51', {'weight': 0.002853541868413
3285, 'label': 0.0028535418684133285}), ('F4', 'F52', {'weight': 0.006661580671481208, 'label': 0.006661580671481208}),
('F4', 'F53', {'weight': 0.023193723710736736, 'label': 0.023193723710736736}), ('F4', 'F54', {'weight': 0.00296233383314
7275, 'label': 0.002962333833147275}), ('F4', 'F55', {'weight': 0.013281389680561478, 'label': 0.013281389680561478}),
('F4', 'F56', {'weight': 0.0013341327070220154, 'label': 0.0013341327070220154}), ('F4', 'F57', {'weight': 0.014528738958
238275, 'label': 0.014528738958238275}), ('F4', 'F58', {'weight': 0.010920480249861126, 'label': 0.010920480249861126}),
('F4', 'F59', {'weight': 0.0006529477074332631, 'label': 0.0006529477074332631}), ('F4', 'F60', {'weight': 0.001824842625
7109639, 'label': 0.0018248426257109639}), ('F4', 'F61', {'weight': 0.004823575884552484, 'label': 0.00482357588455248
4}), ('F4', 'F62', {'weight': 0.0042819375785237675, 'label': 0.0042819375785237675}), ('F4', 'F63', {'weight': 0.0398344
988269488, 'label': 0.0398344988269488}), ('F4', 'F64', {'weight': 0.01978745249952135, 'label': 0.01978745249952135}),
('F4', 'F65', {'weight': 0.01935871058433816, 'label': 0.01935871058433816}), ('F4', 'F66', {'weight': 0.0084192667654886
81, 'label': 0.008419266765488681}), ('F4', 'F67', {'weight': 0.01842478133604653, 'label': 0.01842478133604653}), ('F5',
'F0', {'weight': 0.015721224889385474, 'label': 0.015721224889385474}), ('F5', 'F1', {'weight': 0.04267427702687161, 'lab
el': 0.04267427702687161}), ('F5', 'F2', {'weight': 0.001835054526684013, 'label': 0.001835054526684013}), ('F5', 'F3',
{'weight': 0.028614471350579113, 'label': 0.028614471350579113}), ('F5', 'F4', {'weight': 2.189310329160908e-05, 'label':
2.189310329160908e-05}), ('F5', 'F5', {'weight': 0.016072690389322145, 'label': 0.016072690389322145}), ('F5', 'F6', {'we
ight': 0.01248304886779744, 'label': 0.01248304886779744}), ('F5', 'F7', {'weight': 0.007447607734021711, 'label': 0.0074
```

In [70]:

```python
dataProcessing = A.flatten()
mu = np.mean(dataProcessing)
sigma = np.std(dataProcessing)

# Confidence 95% Interval Construction
LeftInter = -(1.96*sigma)+(mu)
RightInter = (1.96*sigma)+(mu)

print(LeftInter)
print(RightInter)

# Confidence for 90% 1.645
LeftInter1 = -(1.645*sigma)+(mu)
RightInter1 = (1.645*sigma)+(mu)

print(LeftInter1)
print(RightInter1)
```

```
-0.015055742178278195
0.04446750688416055
-0.010272623950046512
0.03968438865592887
```

In [72]:

```
normalizedArr = []
narr = []
for x in dataProcessing:
    val=(x-mu)/(sigma)
    narr.append(val)
    if val>=LeftInter1 and val<=RightInter1:
        normalizedArr.append(0)
    elif val<LeftInter1:
        normalizedArr.append(-1)
    else:
        normalizedArr.append(1)

A_norm = np.asarray(normalizedArr, dtype=np.float32)
A_norm = A_norm.reshape(68,68)
for i in range(0,noOfStates):
    finalTransitionMatrix.loc[states[i]] = A_norm[i]

n_arr = np.asarray(narr, dtype=np.float32)
n_arr = n_arr.reshape(68,68)
for i in range(0,noOfStates):
    finalTransitionMatrix.loc[states[i]] = n_arr[i]

finalTransitionMatrix.to_excel("normalized_output.xlsx")
```

In [84]:

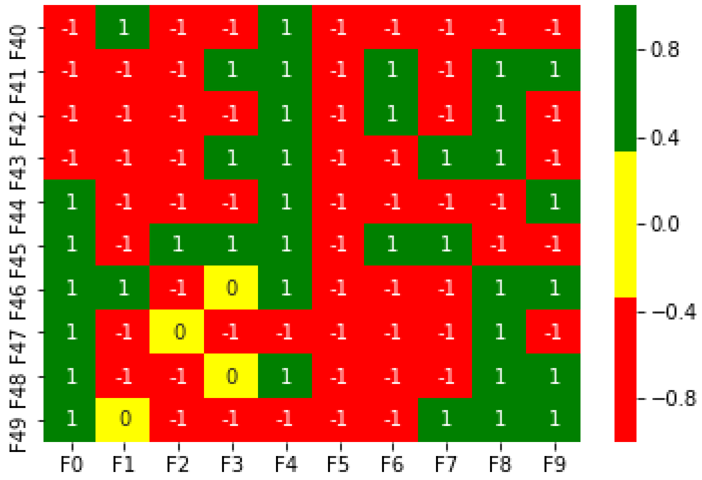
```
data=A_norm[0:68,0:68]
df = pd.DataFrame(data, columns=states[0:68],index=states[0:68])
plt.figure(figsize=(18, 18))
sns.heatmap(df, cmap=ListedColormap(['red', 'yellow', 'green']), annot=True)
```

Out[84]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x198631c2048>
```

In [85]:
```
data=A_norm[0:10,40:50]
df = pd.DataFrame(data, columns=states[0:10],index=states[40:50])
sns.heatmap(df, cmap=ListedColormap(['red', 'yellow', 'green']), annot=True)
```

Out[85]: <matplotlib.axes._subplots.AxesSubplot at 0x1985f576e80>



In [ ]:
```

```