21522351_Week2_Cau6

March 28, 2024

21522351 - Nguyễn Ngọc Hà My

6. (Lập trình) Cho mẫu dữ liệu Groceries Dataset2 về các giao dịch trong một tháng của một cửa hàng outlet, gồm 9835 giao dịch và 169 items. Với min_sup từ 0.01 đến 0.1, hãy:

a) Tìm tất cả các tập phổ biến trong từng trường hợp bằng giải thuật Apriori và ghi nhận thời gian xử lý của thuật toán. Gợi ý: sinh viên có thể sử dụng module OneHotTransactions hoặc TransactionEncoder của thư viện mlxtend để chuyển dữ liệu về dạng one-hot encoding trước khi đưa vào thuật toán.

```python
import pandas as pd
import seaborn as sns
import numpy as np
import matplotlib.pyplot as plt
%matplotlib inline
from mlxtend.frequent_patterns import apriori
from mlxtend.frequent_patterns import association_rules
from mlxtend.frequent_patterns import fpgrowth
from mlxtend.preprocessing import TransactionEncoder
```

```python
#Ghép các cột trong file groceries thành một cột cách nhau bởi dấu "," và không
 ↪có tên cột
df = pd.read_csv("groceries.csv",header=None, sep='\t')
```

```python
df.head
```

```
<bound method NDFrame.head of
0
0      citrus fruit,semi-finished bread,margarine,rea…
1                           tropical fruit,yogurt,coffee
2                                             whole milk
3            pip fruit,yogurt,cream cheese,meat spreads
4      other vegetables,whole milk,condensed milk,lon…
…                                                      …
9830   sausage,chicken,beef,hamburger meat,citrus fru…
9831                                    cooking chocolate
9832   chicken,citrus fruit,other vegetables,butter,y…
9833   semi-finished bread,bottled water,soda,bottled…
9834   chicken,tropical fruit,other vegetables,vinega…
```

```
[9835 rows x 1 columns]>
```

```python
#Tách các dữ liệu trong một cột thành nhiều cột dựa vào dấu ",". Và tên cột sẽ
 ↪bắt đầu bằng số 0
df = df[0].str.split(',', expand=True)
```

```python
df
```

	0	1	2
0	citrus fruit	semi-finished bread	margarine
1	tropical fruit	yogurt	coffee
2	whole milk	None	None
3	pip fruit	yogurt	cream cheese
4	other vegetables	whole milk	condensed milk
...	...	...	...
9830	sausage	chicken	beef
9831	cooking chocolate	None	None
9832	chicken	citrus fruit	other vegetables
9833	semi-finished bread	bottled water	soda
9834	chicken	tropical fruit	other vegetables

	3	4	5
0	ready soups	None	None
1	None	None	None
2	None	None	None
3	meat spreads	None	None
4	long life bakery product	None	None
...	...	...	...
9830	hamburger meat	citrus fruit	grapes
9831	None	None	None
9832	butter	yogurt	frozen dessert
9833	bottled beer	None	None
9834	vinegar	shopping bags	None

	6	7	8	9	...	22
0	None	None	None	None	...	None
1	None	None	None	None	...	None
2	None	None	None	None	...	None
3	None	None	None	None	...	None
4	None	None	None	None	...	None
...	...	...	...	...	...	...
9830	root vegetables	whole milk	butter	whipped/sour cream	...	None
9831	None	None	None	None	...	None
9832	domestic eggs	rolls/buns	rum	cling film/bags	...	None
9833	None	None	None	None	...	None
9834	None	None	None	None	...	None

```
        23     24     25     26     27     28     29     30     31
0      None   None   None   None   None   None   None   None   None
1      None   None   None   None   None   None   None   None   None
2      None   None   None   None   None   None   None   None   None
3      None   None   None   None   None   None   None   None   None
4      None   None   None   None   None   None   None   None   None
...     ...    ...    ...    ...    ...    ...    ...
9830   None   None   None   None   None   None   None   None   None
9831   None   None   None   None   None   None   None   None   None
9832   None   None   None   None   None   None   None   None   None
9833   None   None   None   None   None   None   None   None   None
9834   None   None   None   None   None   None   None   None   None

[9835 rows x 32 columns]
```

Sử dụng module TransactionEncoder của thư viện mlxtend để chuyển dữ liệu về dạng one-hot encoding trước khi đưa vào thuật toán.

Chuyển đổi dữ liệu df thành mảng

```python
data = []
for i in range(0, 9835):
    data.append([str(df.values[i,j]) for j in range(0, 32)])
trans = np.array(data)
```

```python
#Loại bỏ các giá trị None
data =[[x for x in row if str(x)!='None']for row in data]
data
```

```
[['citrus fruit', 'semi-finished bread', 'margarine', 'ready soups'],
 ['tropical fruit', 'yogurt', 'coffee'],
 ['whole milk'],
 ['pip fruit', 'yogurt', 'cream cheese', 'meat spreads'],
 ['other vegetables',
  'whole milk',
  'condensed milk',
  'long life bakery product'],
 ['whole milk', 'butter', 'yogurt', 'rice', 'abrasive cleaner'],
 ['rolls/buns'],
 ['other vegetables',
  'UHT-milk',
  'rolls/buns',
  'bottled beer',
  'liquor (appetizer)'],
 ['potted plants'],
 ['whole milk', 'cereals'],
 ['tropical fruit',
```

```
 'other vegetables',
 'white bread',
 'bottled water',
 'chocolate'],
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 'butter',
 'curd',
 'yogurt',
 'flour',
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 'dishes'],
['beef'],
['frankfurter', 'rolls/buns', 'soda'],
['chicken', 'tropical fruit'],
['butter', 'sugar', 'fruit/vegetable juice', 'newspapers'],
['fruit/vegetable juice'],
['packaged fruit/vegetables'],
['chocolate'],
['specialty bar'],
['other vegetables'],
['butter milk', 'pastry'],
['whole milk'],
['tropical fruit',
 'cream cheese',
 'processed cheese',
 'detergent',
 'newspapers'],
['tropical fruit',
 'root vegetables',
 'other vegetables',
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 'rolls/buns',
 'flour',
 'sweet spreads',
 'salty snack',
 'waffles',
 'candy',
 'bathroom cleaner'],
['bottled water', 'canned beer'],
['yogurt'],
['sausage', 'rolls/buns', 'soda', 'chocolate'],
['other vegetables'],
['brown bread',
 'soda',
 'fruit/vegetable juice',
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```
 'canned beer',
 'newspapers',
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['yogurt', 'beverages', 'bottled water', 'specialty bar'],
['hamburger meat',
 'other vegetables',
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 'spices',
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 'napkins'],
['root vegetables', 'other vegetables', 'whole milk', 'beverages', 'sugar'],
['pork',
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['fruit/vegetable juice'],
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['canned beer'],
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```
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```
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['frozen meals', 'misc. beverages'],
['whipped/sour cream'],
['beef', 'root vegetables', 'bottled beer', 'chocolate', 'shopping bags'],
['chicken',
 'pork',
 'other vegetables',
 'whole milk',
 'whipped/sour cream',
 'UHT-milk',
 'domestic eggs',
 'rolls/buns',
 'bottled water',
 'soda',
 'fruit/vegetable juice',
 'bottled beer'],
['chicken',
 'pork',
 'hamburger meat',
 'pip fruit',
 'nuts/prunes',
 'root vegetables',
 'other vegetables',
 'whole milk',
 'spread cheese',
 'frozen potato products',
 'brown bread',
 'Instant food products',
 'soda',
 'fruit/vegetable juice',
 'shopping bags'],
['beef',
 'tropical fruit',
 'root vegetables',
 'herbs',
 'other vegetables',
 'whole milk',
 'yogurt',
 'hard cheese',
```

```
 'rolls/buns',
 'brown bread',
 'bottled water',
 'bottled beer',
 'salty snack',
 'shopping bags'],
['packaged fruit/vegetables', 'pickled vegetables'],
['sugar'],
['frankfurter',
 'sausage',
 'beef',
 'root vegetables',
 'packaged fruit/vegetables',
 'whole milk',
 'dessert',
 'yogurt',
 'sliced cheese',
 'ice cream',
 'rolls/buns',
 'soda'],
['berries', 'frozen vegetables', 'pet care', 'instant coffee'],
['bottled water', 'soda', 'chewing gum', 'napkins'],
['sausage',
 'chicken',
 'citrus fruit',
 'berries',
 'root vegetables',
 'curd',
 'beverages',
 'abrasive cleaner'],
['whole milk',
 'UHT-milk',
 'domestic eggs',
 'soda',
 'fruit/vegetable juice',
 'dishes',
 'newspapers'],
['ice cream', 'rolls/buns'],
['frankfurter', 'citrus fruit', 'tropical fruit', 'rolls/buns'],
['root vegetables',
 'whole milk',
 'white bread',
 'brown bread',
 'sweet spreads',
 'dog food',
 'brandy',
 'shopping bags'],
```

```
['sausage', 'rolls/buns', 'specialty chocolate'],
['sausage',
 'ham',
 'citrus fruit',
 'tropical fruit',
 'berries',
 'packaged fruit/vegetables',
 'whole milk',
 'whipped/sour cream',
 'sliced cheese',
 'pastry',
 'sugar',
 'baking powder'],
['beef', 'root vegetables', 'whole milk', 'cream cheese'],
['fruit/vegetable juice'],
['sugar', 'hygiene articles'],
['berries', 'whipped/sour cream'],
['yogurt', 'beverages', 'coffee'],
['pork', 'beef'],
['bottled beer', 'shopping bags'],
['curd', 'butter milk', 'yogurt', 'sliced cheese', 'coffee'],
['beef', 'Instant food products', 'canned beer'],
['pork',
 'berries',
 'whipped/sour cream',
 'beverages',
 'flour',
 'oil',
 'soda',
 'chocolate',
 'newspapers'],
['white bread'],
['grapes',
 'whole milk',
 'processed cheese',
 'rolls/buns',
 'white bread',
 'fruit/vegetable juice'],
['potato products', 'flower (seeds)'],
['root vegetables',
 'onions',
 'yogurt',
 'rolls/buns',
 'coffee',
 'bottled water',
 'dishes'],
['chicken',
```

```
 'hamburger meat',
 'UHT-milk',
 'soda',
 'canned beer',
 'bathroom cleaner',
 'newspapers'],
['chicken', 'other vegetables', 'salt'],
['fish', 'cream cheese', 'coffee'],
['canned beer'],
['other vegetables',
 'whole milk',
 'frozen meals',
 'rolls/buns',
 'brown bread',
 'napkins'],
['chicken',
 'pork',
 'whole milk',
 'frozen vegetables',
 'brown bread',
 'vinegar',
 'bottled beer',
 'red/blush wine',
 'newspapers'],
['other vegetables', 'misc. beverages'],
['tropical fruit', 'whole milk'],
['whole milk', 'cake bar', 'newspapers'],
['beef', 'hamburger meat', 'berries', 'pastry', 'hygiene articles'],
['sausage', 'grapes', 'rolls/buns', 'soda', 'salty snack'],
['whole milk', 'rolls/buns', 'chocolate'],
['rolls/buns', 'soda'],
['citrus fruit', 'tropical fruit', 'pip fruit', 'other vegetables'],
['whole milk',
 'sliced cheese',
 'domestic eggs',
 'artif. sweetener',
 'bottled water',
 'soda',
 'shopping bags'],
['pastry', 'soda', 'bottled beer'],
['tropical fruit',
 'other vegetables',
 'whole milk',
 'yogurt',
 'soft cheese',
 'hard cheese',
 'spread cheese',
```

```
 'curd cheese',
 'frozen vegetables',
 'ice cream',
 'pastry',
 'coffee',
 'fruit/vegetable juice',
 'hygiene articles'],
['sliced cheese', 'pastry', 'newspapers'],
['soda'],
['ham',
 'citrus fruit',
 'whole milk',
 'dessert',
 'frozen meals',
 'coffee',
 'popcorn',
 'shopping bags'],
['salty snack'],
['whole milk',
 'curd',
 'cream cheese',
 'flour',
 'coffee',
 'bottled water',
 'misc. beverages',
 'newspapers'],
['root vegetables', 'whipped/sour cream'],
['soda', 'canned beer', 'shopping bags'],
['curd',
 'roll products',
 'margarine',
 'bottled water',
 'canned beer',
 'white wine',
 'dish cleaner'],
['bottled water', 'soda', 'fruit/vegetable juice', 'bottled beer', 'napkins'],
['packaged fruit/vegetables', 'potted plants'],
['tropical fruit',
 'root vegetables',
 'frozen vegetables',
 'ice cream',
 'bottled water',
 'cling film/bags'],
['ham',
 'beef',
 'grapes',
 'yogurt',
```

```
 'whipped/sour cream',
 'domestic eggs',
 'white bread',
 'pastry',
 'bottled water',
 'fruit/vegetable juice',
 'white wine',
 'salty snack',
 'chocolate',
 'newspapers',
 'shopping bags'],
['pork',
 'citrus fruit',
 'UHT-milk',
 'brown bread',
 'soda',
 'bottled beer',
 'canned beer',
 'long life bakery product'],
['beverages', 'rolls/buns', 'soda', 'misc. beverages', 'liqueur', 'cake bar'],
['sausage', 'rolls/buns', 'soda'],
['sausage',
 'citrus fruit',
 'whole milk',
 'yogurt',
 'rolls/buns',
 'bottled water',
 'soda',
 'napkins'],
['root vegetables',
 'whole milk',
 'butter',
 'yogurt',
 'cream cheese',
 'frozen fish',
 'shopping bags'],
['whole milk', 'cream cheese'],
['frankfurter',
 'turkey',
 'root vegetables',
 'other vegetables',
 'yogurt',
 'rolls/buns',
 'pastry',
 'ready soups'],
['soda', 'shopping bags'],
['soda', 'bottled beer'],
```

```
['frankfurter', 'popcorn'],
['berries',
 'whole milk',
 'whipped/sour cream',
 'pickled vegetables',
 'detergent',
 'newspapers'],
['canned beer'],
['frankfurter', 'pork', 'white bread', 'canned vegetables', 'soda'],
['frankfurter',
 'hamburger meat',
 'whole milk',
 'butter',
 'curd',
 'flour',
 'rice',
 'oil',
 'sugar',
 'mustard',
 'salty snack',
 'chocolate',
 'chocolate marshmallow',
 'dish cleaner',
 'dental care'],
['berries',
 'root vegetables',
 'whole milk',
 'beverages',
 'sugar',
 'soups',
 'coffee',
 'shopping bags'],
['frankfurter', 'rolls/buns'],
['newspapers'],
['frozen fish', 'newspapers'],
['tropical fruit', 'newspapers'],
['beef',
 'grapes',
 'berries',
 'whole milk',
 'yogurt',
 'rolls/buns',
 'newspapers',
 'potted plants'],
['rolls/buns',
 'coffee',
 'instant coffee',
```

```
 'salty snack',
 'specialty chocolate'],
['specialty chocolate', 'potted plants'],
['sparkling wine', 'dish cleaner'],
['citrus fruit', 'napkins', 'shopping bags'],
['onions', 'herbs', 'bottled beer'],
['whole milk', 'pastry', 'detergent', 'candles'],
['photo/film'],
['hamburger meat'],
['other vegetables', 'whole milk', 'white bread', 'chewing gum'],
['whole milk', 'rolls/buns', 'shopping bags'],
['pork',
 'tropical fruit',
 'grapes',
 'hard cheese',
 'soda',
 'napkins',
 'shopping bags'],
['tropical fruit',
 'grapes',
 'berries',
 'other vegetables',
 'whole milk',
 'butter',
 'dessert',
 'yogurt',
 'whipped/sour cream',
 'ice cream',
 'pastry',
 'salt',
 'baking powder',
 'bottled water',
 'misc. beverages',
 'fruit/vegetable juice',
 'canned beer',
 'specialty chocolate',
 'potted plants'],
['chicken',
 'pork',
 'citrus fruit',
 'other vegetables',
 'whipped/sour cream',
 'white bread',
 'chewing gum',
 'potted plants'],
['other vegetables', 'chewing gum'],
['sausage', 'bottled water', 'red/blush wine'],
```

```
['whole milk', 'whipped/sour cream', 'baking powder'],
['rolls/buns', 'coffee'],
['hygiene articles'],
['ice cream', 'newspapers'],
['curd',
 'whipped/sour cream',
 'domestic eggs',
 'flour',
 'misc. beverages',
 'newspapers'],
['whole milk', 'frozen meals', 'newspapers'],
['onions',
 'whole milk',
 'dessert',
 'domestic eggs',
 'rolls/buns',
 'white bread',
 'coffee',
 'bottled water'],
['finished products',
 'organic sausage',
 'sliced cheese',
 'white bread',
 'fruit/vegetable juice'],
['salt', 'dog food', 'long life bakery product'],
['tropical fruit',
 'root vegetables',
 'other vegetables',
 'domestic eggs',
 'white bread',
 'brown bread',
 'canned vegetables',
 'soda',
 'fruit/vegetable juice',
 'rum'],
['other vegetables', 'whole milk', 'yogurt'],
['chocolate'],
['ice cream'],
['tropical fruit', 'oil', 'cat food'],
['frankfurter',
 'citrus fruit',
 'whole milk',
 'yogurt',
 'sliced cheese',
 'specialty cheese',
 'pastry',
 'fruit/vegetable juice'],
```

```
['butter', 'pasta', 'canned fish', 'softener', 'flower (seeds)'],
['other vegetables', 'butter milk', 'frozen fish', 'salty snack'],
['tropical fruit', 'pastry', 'canned beer', 'chocolate'],
['citrus fruit',
 'root vegetables',
 'packaged fruit/vegetables',
 'yogurt',
 'sliced cheese',
 'rolls/buns',
 'white bread',
 'brown bread',
 'zwieback'],
['UHT-milk', 'salt', 'soda', 'specialty chocolate', 'shopping bags'],
['beef'],
['curd', 'yogurt', 'spread cheese', 'sugar', 'canned vegetables'],
['citrus fruit',
 'other vegetables',
 'whole milk',
 'dessert',
 'yogurt',
 'frozen vegetables',
 'fruit/vegetable juice',
 'bottled beer',
 'salty snack'],
['yogurt', 'brown bread', 'bottled beer', 'white wine'],
['bottled beer', 'liquor', 'red/blush wine'],
['grapes'],
['pork', 'other vegetables', 'soda'],
['sausage',
 'citrus fruit',
 'berries',
 'other vegetables',
 'whole milk',
 'yogurt',
 'whipped/sour cream',
 'cream cheese',
 'frozen vegetables',
 'domestic eggs',
 'pastry',
 'margarine',
 'soups',
 'canned fish',
 'chocolate',
 'candy',
 'napkins'],
['frankfurter',
 'chicken',
```

```
 'pork',
 'tropical fruit',
 'root vegetables',
 'other vegetables',
 'yogurt',
 'UHT-milk',
 'mayonnaise',
 'brown bread',
 'pastry',
 'flour',
 'mustard',
 'coffee',
 'cocoa drinks',
 'fruit/vegetable juice',
 'salty snack',
 'long life bakery product',
 'chocolate',
 'seasonal products'],
['artif. sweetener', 'soda', 'photo/film'],
['frankfurter',
 'onions',
 'butter',
 'processed cheese',
 'rolls/buns',
 'coffee',
 'bottled beer'],
['pip fruit',
 'root vegetables',
 'dessert',
 'yogurt',
 'domestic eggs',
 'shopping bags'],
['frankfurter', 'whole milk', 'coffee', 'detergent'],
['whole milk', 'newspapers'],
['domestic eggs', 'hygiene articles', 'photo/film', 'flower soil/fertilizer'],
['packaged fruit/vegetables',
 'dessert',
 'mayonnaise',
 'oil',
 'soda',
 'waffles',
 'chocolate',
 'flower (seeds)',
 'shopping bags'],
['chicken',
 'other vegetables',
 'whipped/sour cream',
```

```
 'frozen vegetables',
 'bottled water',
 'long life bakery product'],
['pork',
 'whole milk',
 'curd',
 'yogurt',
 'whipped/sour cream',
 'cream cheese',
 'domestic eggs',
 'white bread',
 'sugar',
 'baking powder',
 'coffee',
 'cocoa drinks',
 'salty snack',
 'waffles',
 'candy',
 'napkins'],
['citrus fruit',
 'other vegetables',
 'whole milk',
 'curd',
 'yogurt',
 'whipped/sour cream',
 'cream cheese',
 'pastry',
 'vinegar',
 'oil',
 'coffee',
 'long life bakery product',
 'detergent',
 'cleaner',
 'napkins',
 'newspapers'],
['light bulbs'],
['cream cheese', 'margarine', 'tea'],
['sausage',
 'curd',
 'frozen meals',
 'domestic eggs',
 'cake bar',
 'seasonal products',
 'detergent',
 'cleaner',
 'house keeping products',
 'potted plants',
```

```
  'shopping bags'],
 ['citrus fruit', 'onions'],
 ['other vegetables', 'whipped/sour cream', 'roll products'],
 ['chicken',
  'tropical fruit',
  'pip fruit',
  'root vegetables',
  'other vegetables',
  'whole milk',
  'butter',
  'yogurt',
  'whipped/sour cream',
  'hard cheese',
  'frozen vegetables',
  'frozen fish',
  'domestic eggs',
  'white bread',
  'rice',
  'specialty fat',
  'dog food',
  'bottled water',
  'fruit/vegetable juice',
  'long life bakery product',
  'softener',
  'napkins',
  'cling film/bags'],
 ['ice cream'],
 ['pork', 'beef', 'ice cream', 'rolls/buns', 'newspapers'],
 ['pork',
  'tropical fruit',
  'other vegetables',
  'yogurt',
  'semi-finished bread',
  'flour',
  'margarine',
  'artif. sweetener',
  'organic products',
  'chocolate marshmallow'],
 …]
```

```python
#Chuyển dữ liệu về dạng One hot encoding bằng TransactionctionEncoder và đổi
↪kiểu dữ liệu Boolean về Integer
te = TransactionEncoder()
te_array = te.fit(data).transform(data).astype("bool")
te_array
```

```
[ ]: array([[False, False, False, …, False, False, False],
            [False, False, False, …, False,  True, False],
            [False, False, False, …,  True, False, False],
            …,
            [False, False, False, …, False,  True, False],
            [False, False, False, …, False, False, False],
            [False, False, False, …, False, False, False]])
```

```
[ ]: #Kiểm tra thông tin các cột của te
     te.columns_
```

```
[ ]: ['Instant food products',
      'UHT-milk',
      'abrasive cleaner',
      'artif. sweetener',
      'baby cosmetics',
      'baby food',
      'bags',
      'baking powder',
      'bathroom cleaner',
      'beef',
      'berries',
      'beverages',
      'bottled beer',
      'bottled water',
      'brandy',
      'brown bread',
      'butter',
      'butter milk',
      'cake bar',
      'candles',
      'candy',
      'canned beer',
      'canned fish',
      'canned fruit',
      'canned vegetables',
      'cat food',
      'cereals',
      'chewing gum',
      'chicken',
      'chocolate',
      'chocolate marshmallow',
      'citrus fruit',
      'cleaner',
      'cling film/bags',
      'cocoa drinks',
      'coffee',
```

```
'condensed milk',
'cooking chocolate',
'cookware',
'cream',
'cream cheese',
'curd',
'curd cheese',
'decalcifier',
'dental care',
'dessert',
'detergent',
'dish cleaner',
'dishes',
'dog food',
'domestic eggs',
'female sanitary products',
'finished products',
'fish',
'flour',
'flower (seeds)',
'flower soil/fertilizer',
'frankfurter',
'frozen chicken',
'frozen dessert',
'frozen fish',
'frozen fruits',
'frozen meals',
'frozen potato products',
'frozen vegetables',
'fruit/vegetable juice',
'grapes',
'hair spray',
'ham',
'hamburger meat',
'hard cheese',
'herbs',
'honey',
'house keeping products',
'hygiene articles',
'ice cream',
'instant coffee',
'jam',
'ketchup',
'kitchen towels',
'kitchen utensil',
'light bulbs',
'liqueur',
```

```
'liquor',
'liquor (appetizer)',
'liver loaf',
'long life bakery product',
'make up remover',
'male cosmetics',
'margarine',
'mayonnaise',
'meat',
'meat spreads',
'misc. beverages',
'mustard',
'napkins',
'newspapers',
'nut snack',
'nuts/prunes',
'oil',
'onions',
'organic products',
'organic sausage',
'other vegetables',
'packaged fruit/vegetables',
'pasta',
'pastry',
'pet care',
'photo/film',
'pickled vegetables',
'pip fruit',
'popcorn',
'pork',
'potato products',
'potted plants',
'preservation products',
'processed cheese',
'prosecco',
'pudding powder',
'ready soups',
'red/blush wine',
'rice',
'roll products',
'rolls/buns',
'root vegetables',
'rubbing alcohol',
'rum',
'salad dressing',
'salt',
'salty snack',
```

```
    'sauces',
    'sausage',
    'seasonal products',
    'semi-finished bread',
    'shopping bags',
    'skin care',
    'sliced cheese',
    'snack products',
    'soap',
    'soda',
    'soft cheese',
    'softener',
    'sound storage medium',
    'soups',
    'sparkling wine',
    'specialty bar',
    'specialty cheese',
    'specialty chocolate',
    'specialty fat',
    'specialty vegetables',
    'spices',
    'spread cheese',
    'sugar',
    'sweet spreads',
    'syrup',
    'tea',
    'tidbits',
    'toilet cleaner',
    'tropical fruit',
    'turkey',
    'vinegar',
    'waffles',
    'whipped/sour cream',
    'whisky',
    'white bread',
    'white wine',
    'whole milk',
    'yogurt',
    'zwieback']
```

```python
#Chuyển te_array từ mảng thành DataFrame
import pandas as pd
dt=pd.DataFrame(te_array, columns=te.columns_)
```

```python
dt
```

```
[ ]:        Instant food products   UHT-milk   abrasive cleaner   artif. sweetener  \
      0                    False      False              False              False
      1                    False      False              False              False
      2                    False      False              False              False
      3                    False      False              False              False
      4                    False      False              False              False
      …                      …          …                  …                  …
      9830                 False      False              False              False
      9831                 False      False              False              False
      9832                 False      False              False              False
      9833                 False      False              False              False
      9834                 False      False              False              False

            baby cosmetics  baby food   bags  baking powder  bathroom cleaner  \
      0               False      False  False          False             False
      1               False      False  False          False             False
      2               False      False  False          False             False
      3               False      False  False          False             False
      4               False      False  False          False             False
      …                 …          …      …              …                 …
      9830            False      False  False          False             False
      9831            False      False  False          False             False
      9832            False      False  False          False             False
      9833            False      False  False          False             False
      9834            False      False  False          False             False

             beef  …  turkey  vinegar  waffles  whipped/sour cream  whisky  \
      0     False  …   False    False    False               False   False
      1     False  …   False    False    False               False   False
      2     False  …   False    False    False               False   False
      3     False  …   False    False    False               False   False
      4     False  …   False    False    False               False   False
      …       …  …     …        …        …                   …       …
      9830   True  …   False    False    False                True   False
      9831  False  …   False    False    False               False   False
      9832  False  …   False    False    False               False   False
      9833  False  …   False    False    False               False   False
      9834  False  …   False     True    False               False   False

            white bread  white wine  whole milk  yogurt  zwieback
      0           False       False       False   False     False
      1           False       False       False    True     False
      2           False       False        True   False     False
      3           False       False       False    True     False
      4           False       False        True   False     False
      …             …           …           …       …         …
      9830        False       False        True   False     False
```

```
9831      False       False       False   False     False
9832      False       False       False   True      False
9833      False       False       False   False     False
9834      False       False       False   False     False

[9835 rows x 169 columns]
```

a) Tìm tất cả các tập phổ biến trong từng trường hợp bằng giải thuật Apriori và ghi nhận thời gian xử lý của thuật toán. Import thư viện để tính thời gian

```python
from datetime import datetime, timedelta
import time
```

```python
#Tạo hai mảng để lưu giá trị thời gian chạy của thuật toán Apriori và FP-Growth
Time_Ap = []
Time_FP = []
```

```python
#Tìm tập phổ biến bằng thuật toán Apriori với min_sup = 0.01.
start_Ap_l2 = time.time()
itemsets = apriori(dt, min_support=0.01, use_colnames = True)
end_Ap_l2 = time.time()
print(timedelta(seconds=round(end_Ap_l2-start_Ap_l2,5)))
Time_Ap.append(end_Ap_l2-start_Ap_l2)
itemsets
```

```
0:00:00.245100
```

```
        support                                     itemsets
0      0.033452                                    (UHT-milk)
1      0.017692                                (baking powder)
2      0.052466                                         (beef)
3      0.033249                                      (berries)
4      0.026029                                    (beverages)
..          …                                             …
328    0.011998       (whole milk, tropical fruit, root vegetables)
329    0.014540            (whole milk, yogurt, root vegetables)
330    0.010473                      (whole milk, yogurt, soda)
331    0.015150            (whole milk, yogurt, tropical fruit)
332    0.010880      (whole milk, whipped/sour cream, yogurt)

[333 rows x 2 columns]
```

```python
#Tìm tập phổ biến bằng thuật toán Apriori với min_sup = 0.02.
start_Ap_l2 = time.time()
itemsets = apriori(dt, min_support=0.02, use_colnames = True)
end_Ap_l2 = time.time()
print(timedelta(seconds=round(end_Ap_l2-start_Ap_l2,5)))
Time_Ap.append(end_Ap_l2-start_Ap_l2)
```

```
itemsets
```

0:00:00.109320

```
[ ]:          support                                      itemsets
    0      0.033452                                       (UHT-milk)
    1      0.052466                                           (beef)
    2      0.033249                                        (berries)
    3      0.026029                                      (beverages)
    4      0.080529                                    (bottled beer)
    ..          …                                             …
    117    0.032232             (whole milk, whipped/sour cream)
    118    0.020742                     (whipped/sour cream, yogurt)
    119    0.056024                           (whole milk, yogurt)
    120    0.023183  (whole milk, other vegetables, root vegetables)
    121    0.022267           (whole milk, yogurt, other vegetables)

    [122 rows x 2 columns]
```

```
[ ]:  #Tìm tập phổ biến bằng thuật toán Apriori với min_sup = 0.03.
      start_Ap_l3 = time.time()
      itemsets = apriori(dt, min_support=0.03, use_colnames = True)
      end_Ap_l3 = time.time()
      print(timedelta(seconds=round(end_Ap_l3-start_Ap_l3,3)))
      Time_Ap.append(end_Ap_l3-start_Ap_l3)
      itemsets
```

0:00:00.064000

```
[ ]:          support                         itemsets
    0      0.033452                        (UHT-milk)
    1      0.052466                            (beef)
    2      0.033249                         (berries)
    3      0.080529                    (bottled beer)
    4      0.110524                   (bottled water)
    ..          …                              …
    58     0.048907       (whole milk, root vegetables)
    59     0.040061               (whole milk, soda)
    60     0.042298       (whole milk, tropical fruit)
    61     0.032232  (whole milk, whipped/sour cream)
    62     0.056024             (whole milk, yogurt)

    [63 rows x 2 columns]
```

```
[ ]:  #Tìm tập phổ biến bằng thuật toán Apriori với min_sup = 0.04.
      start_Ap_l4 = time.time()
      itemsets = apriori(dt, min_support=0.04, use_colnames = True)
      end_Ap_l4 = time.time()
```

```
print(timedelta(seconds=round(end_Ap_l4-start_Ap_l4,4)))
Time_Ap.append(end_Ap_l4-start_Ap_l4)
itemsets
```

0:00:00.029400

[ ]:   support   itemsets
     0   0.052466   (beef)
     1   0.080529   (bottled beer)
     2   0.110524   (bottled water)
     3   0.064870   (brown bread)
     4   0.055414   (butter)
     5   0.077682   (canned beer)
     6   0.042908   (chicken)
     7   0.049619   (chocolate)
     8   0.082766   (citrus fruit)
     9   0.058058   (coffee)
     10   0.053279   (curd)
     11   0.063447   (domestic eggs)
     12   0.058973   (frankfurter)
     13   0.048094   (frozen vegetables)
     14   0.072293   (fruit/vegetable juice)
     15   0.058566   (margarine)
     16   0.052364   (napkins)
     17   0.079817   (newspapers)
     18   0.193493   (other vegetables)
     19   0.088968   (pastry)
     20   0.075648   (pip fruit)
     21   0.057651   (pork)
     22   0.183935   (rolls/buns)
     23   0.108998   (root vegetables)
     24   0.093950   (sausage)
     25   0.098526   (shopping bags)
     26   0.174377   (soda)
     27   0.104931   (tropical fruit)
     28   0.071683   (whipped/sour cream)
     29   0.042095   (white bread)
     30   0.255516   (whole milk)
     31   0.139502   (yogurt)
     32   0.042603   (rolls/buns, other vegetables)
     33   0.047382   (other vegetables, root vegetables)
     34   0.074835   (whole milk, other vegetables)
     35   0.043416   (yogurt, other vegetables)
     36   0.056634   (whole milk, rolls/buns)
     37   0.048907   (whole milk, root vegetables)
     38   0.040061   (whole milk, soda)
     39   0.042298   (whole milk, tropical fruit)

```
40  0.056024                        (whole milk, yogurt)
```

```
[ ]: #Tìm tập phổ biến bằng thuật toán Apriori với min_sup = 0.05.
     start_Ap_l5 = time.time()
     itemsets = apriori(dt, min_support=0.05, use_colnames = True)
     end_Ap_l5 = time.time()
     print(timedelta(seconds=round(end_Ap_l5-start_Ap_l5,5)))
     Time_Ap.append(end_Ap_l5-start_Ap_l5)
     itemsets
```

```
0:00:00.027290
```

```
[ ]:      support                          itemsets
     0    0.052466                          (beef)
     1    0.080529                     (bottled beer)
     2    0.110524                    (bottled water)
     3    0.064870                      (brown bread)
     4    0.055414                         (butter)
     5    0.077682                      (canned beer)
     6    0.082766                     (citrus fruit)
     7    0.058058                         (coffee)
     8    0.053279                           (curd)
     9    0.063447                    (domestic eggs)
     10   0.058973                      (frankfurter)
     11   0.072293              (fruit/vegetable juice)
     12   0.058566                       (margarine)
     13   0.052364                         (napkins)
     14   0.079817                      (newspapers)
     15   0.193493                 (other vegetables)
     16   0.088968                          (pastry)
     17   0.075648                       (pip fruit)
     18   0.057651                           (pork)
     19   0.183935                      (rolls/buns)
     20   0.108998                  (root vegetables)
     21   0.093950                        (sausage)
     22   0.098526                   (shopping bags)
     23   0.174377                           (soda)
     24   0.104931                   (tropical fruit)
     25   0.071683               (whipped/sour cream)
     26   0.255516                      (whole milk)
     27   0.139502                         (yogurt)
     28   0.074835  (whole milk, other vegetables)
     29   0.056634          (whole milk, rolls/buns)
     30   0.056024             (whole milk, yogurt)
```

```
[ ]: #Tìm tập phổ biến bằng thuật toán Apriori với min_sup = 0.06.
     start_Ap_l6 = time.time()
     itemsets = apriori(dt, min_support=0.06, use_colnames = True)
```

```
end_Ap_l6 = time.time()
print(timedelta(seconds=round(end_Ap_l6-start_Ap_l6,5)))
Time_Ap.append(end_Ap_l6-start_Ap_l6)
itemsets
```

0:00:00.021780

[ ]:
	support	itemsets
0	0.080529	(bottled beer)
1	0.110524	(bottled water)
2	0.064870	(brown bread)
3	0.077682	(canned beer)
4	0.082766	(citrus fruit)
5	0.063447	(domestic eggs)
6	0.072293	(fruit/vegetable juice)
7	0.079817	(newspapers)
8	0.193493	(other vegetables)
9	0.088968	(pastry)
10	0.075648	(pip fruit)
11	0.183935	(rolls/buns)
12	0.108998	(root vegetables)
13	0.093950	(sausage)
14	0.098526	(shopping bags)
15	0.174377	(soda)
16	0.104931	(tropical fruit)
17	0.071683	(whipped/sour cream)
18	0.255516	(whole milk)
19	0.139502	(yogurt)
20	0.074835	(whole milk, other vegetables)

[ ]:
```
#Tìm tập phổ biến bằng thuật toán Apriori với min_sup = 0.07.
start_Ap_l7 = time.time()
itemsets = apriori(dt, min_support=0.07, use_colnames = True)
end_Ap_l7 = time.time()
print(timedelta(seconds=round(end_Ap_l7-start_Ap_l7,5)))
Time_Ap.append(end_Ap_l7-start_Ap_l7)
itemsets
```

0:00:00.014500

[ ]:
	support	itemsets
0	0.080529	(bottled beer)
1	0.110524	(bottled water)
2	0.077682	(canned beer)
3	0.082766	(citrus fruit)
4	0.072293	(fruit/vegetable juice)
5	0.079817	(newspapers)
6	0.193493	(other vegetables)

```
7   0.088968                        (pastry)
8   0.075648                     (pip fruit)
9   0.183935                    (rolls/buns)
10  0.108998              (root vegetables)
11  0.093950                       (sausage)
12  0.098526                 (shopping bags)
13  0.174377                          (soda)
14  0.104931                (tropical fruit)
15  0.071683             (whipped/sour cream)
16  0.255516                    (whole milk)
17  0.139502                        (yogurt)
18  0.074835  (whole milk, other vegetables)
```

```python
#Tìm tập phổ biến bằng thuật toán Apriori với min_sup = 0.08.
start_Ap_l8 = time.time()
itemsets = apriori(dt, min_support=0.08, use_colnames = True)
end_Ap_l8 = time.time()
print(timedelta(seconds=round(end_Ap_l8-start_Ap_l8,5)))
Time_Ap.append(end_Ap_l8-start_Ap_l8)
itemsets
```

```
0:00:00.009570
```

```
      support            itemsets
0   0.080529       (bottled beer)
1   0.110524      (bottled water)
2   0.082766        (citrus fruit)
3   0.193493    (other vegetables)
4   0.088968             (pastry)
5   0.183935          (rolls/buns)
6   0.108998     (root vegetables)
7   0.093950             (sausage)
8   0.098526       (shopping bags)
9   0.174377                (soda)
10  0.104931      (tropical fruit)
11  0.255516          (whole milk)
12  0.139502              (yogurt)
```

```python
#Tìm tập phổ biến bằng thuật toán Apriori với min_sup = 0.09.
start_Ap_l9 = time.time()
itemsets = apriori(dt, min_support=0.09, use_colnames = True)
end_Ap_l9 = time.time()
print(timedelta(seconds=round(end_Ap_l9-start_Ap_l9,5)))
Time_Ap.append(end_Ap_l9-start_Ap_l9)
itemsets
```

```
0:00:00.008470
```

```
[ ]:       support           itemsets
       0  0.110524       (bottled water)
       1  0.193493   (other vegetables)
       2  0.183935         (rolls/buns)
       3  0.108998    (root vegetables)
       4  0.093950            (sausage)
       5  0.098526      (shopping bags)
       6  0.174377               (soda)
       7  0.104931      (tropical fruit)
       8  0.255516         (whole milk)
       9  0.139502             (yogurt)
```

```
[ ]: #Tìm tập phổ biến bằng thuật toán Apriori với min_sup = 0.1.
     start_Ap_l10 = time.time()
     itemsets = apriori(dt, min_support=0.1, use_colnames = True)
     end_Ap_l10 = time.time()
     print(timedelta(seconds=round(end_Ap_l10-start_Ap_l10,5)))
     Time_Ap.append(end_Ap_l10-start_Ap_l10)
     itemsets
```

```
0:00:00.007570
```

```
[ ]:       support           itemsets
       0  0.110524       (bottled water)
       1  0.193493   (other vegetables)
       2  0.183935         (rolls/buns)
       3  0.108998    (root vegetables)
       4  0.174377               (soda)
       5  0.104931      (tropical fruit)
       6  0.255516         (whole milk)
       7  0.139502             (yogurt)
```

b) Tìm tất cả các tập phổ biến trong từng trường hợp bằng giải thuật FP-Growth và ghi nhận thời gian xử lý của thuật toán.

```
[ ]: #Tìm tập phổ biến bằng thuật toán FP-Growth với min_sup = 0.01.
     start_FP_l1 = time.time()
     itemsets = fpgrowth(dt, min_support=0.01, use_colnames = True)
     end_FP_l1 = time.time()
     print(timedelta(seconds=round(end_FP_l1-start_FP_l1,5)))
     Time_FP.append(end_FP_l1-start_FP_l1)
     itemsets
```

```
0:00:00.167230
```

```
[ ]:       support                     itemsets
       0  0.082766              (citrus fruit)
       1  0.058566                 (margarine)
       2  0.017692        (semi-finished bread)
```

```
3    0.139502                               (yogurt)
4    0.104931                    (tropical fruit)
..        …                                     …
328  0.010168   (frozen vegetables, rolls/buns)
329  0.012405        (frozen vegetables, yogurt)
330  0.014235         (onions, other vegetables)
331  0.012100              (whole milk, onions)
332  0.010778      (sliced cheese, whole milk)

[333 rows x 2 columns]
```

```python
#Tìm tập phổ biến bằng thuật toán FP-Growth với min_sup = 0.02.
start_FP_l2 = time.time()
itemsets = fpgrowth(dt, min_support=0.02, use_colnames = True)
end_FP_l2 = time.time()
print(timedelta(seconds=round(end_FP_l2-start_FP_l2,5)))
Time_FP.append(end_FP_l2-start_FP_l2)
itemsets
```

```
0:00:00.149980
```

```
        support                        itemsets
0      0.082766                    (citrus fruit)
1      0.058566                       (margarine)
2      0.139502                         (yogurt)
3      0.104931                   (tropical fruit)
4      0.058058                         (coffee)
..        …                                     …
117    0.022166                  (whole milk, pork)
118    0.021657           (pork, other vegetables)
119    0.029995          (whole milk, domestic eggs)
120    0.022267  (domestic eggs, other vegetables)
121    0.020437     (whole milk, frozen vegetables)

[122 rows x 2 columns]
```

```python
#Tìm tập phổ biến bằng thuật toán FP-Growth với min_sup = 0.03.
start_FP_l3 = time.time()
itemsets = fpgrowth(dt, min_support=0.03, use_colnames = True)
end_FP_l3 = time.time()
print(timedelta(seconds=round(end_FP_l3-start_FP_l3,5)))
Time_FP.append(end_FP_l3-start_FP_l3)
itemsets
```

```
0:00:00.096210
```

```
        support                        itemsets
0      0.082766                    (citrus fruit)
```

```
1   0.058566                            (margarine)
2   0.139502                              (yogurt)
3   0.104931                       (tropical fruit)
4   0.058058                               (coffee)
..       …                                       …
58  0.033249                   (whole milk, pastry)
59  0.047382   (other vegetables, root vegetables)
60  0.048907           (whole milk, root vegetables)
61  0.030605                    (rolls/buns, sausage)
62  0.032232        (whole milk, whipped/sour cream)

[63 rows x 2 columns]
```

```python
#Tìm tập phổ biến bằng thuật toán FP-Growth với min_sup = 0.04.
start_FP_l4 = time.time()
itemsets = fpgrowth(dt, min_support=0.04, use_colnames = True)
end_FP_l4 = time.time()
print(timedelta(seconds=round(end_FP_l4-start_FP_l4,5)))
Time_FP.append(end_FP_l4-start_FP_l4)
itemsets
```

```
0:00:00.082610
```

```
     support                      itemsets
0   0.082766                 (citrus fruit)
1   0.058566                    (margarine)
2   0.139502                       (yogurt)
3   0.104931                (tropical fruit)
4   0.058058                        (coffee)
5   0.255516                    (whole milk)
6   0.075648                     (pip fruit)
7   0.193493              (other vegetables)
8   0.055414                        (butter)
9   0.183935                    (rolls/buns)
10  0.080529                   (bottled beer)
11  0.110524                  (bottled water)
12  0.049619                     (chocolate)
13  0.042095                   (white bread)
14  0.053279                          (curd)
15  0.052466                          (beef)
16  0.174377                          (soda)
17  0.058973                    (frankfurter)
18  0.042908                       (chicken)
19  0.079817                    (newspapers)
20  0.072293          (fruit/vegetable juice)
21  0.088968                        (pastry)
22  0.108998                (root vegetables)
23  0.077682                   (canned beer)
```

```
24  0.093950                              (sausage)
25  0.098526                         (shopping bags)
26  0.064870                           (brown bread)
27  0.052364                              (napkins)
28  0.071683                    (whipped/sour cream)
29  0.057651                                 (pork)
30  0.063447                        (domestic eggs)
31  0.048094                    (frozen vegetables)
32  0.056024                   (whole milk, yogurt)
33  0.043416           (yogurt, other vegetables)
34  0.042298           (whole milk, tropical fruit)
35  0.074835           (whole milk, other vegetables)
36  0.042603           (rolls/buns, other vegetables)
37  0.056634                (whole milk, rolls/buns)
38  0.040061                     (whole milk, soda)
39  0.047382  (other vegetables, root vegetables)
40  0.048907          (whole milk, root vegetables)
```

```python
#Tìm tập phổ biến bằng thuật toán FP-Growth với min_sup = 0.05.
start_FP_l5 = time.time()
itemsets = fpgrowth(dt, min_support=0.05, use_colnames = True)
end_FP_l5 = time.time()
print(timedelta(seconds=round(end_FP_l5-start_FP_l5,5)))
Time_FP.append(end_FP_l5-start_FP_l5)
itemsets
```

```
0:00:00.071610
```

```
        support                   itemsets
0    0.082766              (citrus fruit)
1    0.058566                 (margarine)
2    0.139502                    (yogurt)
3    0.104931             (tropical fruit)
4    0.058058                    (coffee)
5    0.255516                (whole milk)
6    0.075648                  (pip fruit)
7    0.193493          (other vegetables)
8    0.055414                    (butter)
9    0.183935                (rolls/buns)
10   0.080529              (bottled beer)
11   0.110524             (bottled water)
12   0.053279                      (curd)
13   0.052466                      (beef)
14   0.174377                      (soda)
15   0.058973               (frankfurter)
16   0.079817                (newspapers)
17   0.072293       (fruit/vegetable juice)
18   0.088968                    (pastry)
```

```
19  0.108998                    (root vegetables)
20  0.077682                        (canned beer)
21  0.093950                           (sausage)
22  0.098526                      (shopping bags)
23  0.064870                        (brown bread)
24  0.052364                            (napkins)
25  0.071683                 (whipped/sour cream)
26  0.057651                               (pork)
27  0.063447                      (domestic eggs)
28  0.056024               (whole milk, yogurt)
29  0.074835     (whole milk, other vegetables)
30  0.056634            (whole milk, rolls/buns)
```

```python
#Tìm tập phổ biến bằng thuật toán FP-Growth với min_sup = 0.06.
start_FP_l6 = time.time()
itemsets = fpgrowth(dt, min_support=0.06, use_colnames = True)
end_FP_l6 = time.time()
print(timedelta(seconds=round(end_FP_l6-start_FP_l6,5)))
Time_FP.append(end_FP_l6-start_FP_l6)
itemsets
```

```
0:00:00.061790
```

```
     support                     itemsets
0   0.082766                 (citrus fruit)
1   0.139502                       (yogurt)
2   0.104931                (tropical fruit)
3   0.255516                   (whole milk)
4   0.075648                     (pip fruit)
5   0.193493              (other vegetables)
6   0.183935                    (rolls/buns)
7   0.080529                  (bottled beer)
8   0.110524                 (bottled water)
9   0.174377                         (soda)
10  0.079817                   (newspapers)
11  0.072293           (fruit/vegetable juice)
12  0.088968                       (pastry)
13  0.108998                (root vegetables)
14  0.077682                  (canned beer)
15  0.093950                     (sausage)
16  0.098526                (shopping bags)
17  0.064870                  (brown bread)
18  0.071683           (whipped/sour cream)
19  0.063447                (domestic eggs)
20  0.074835     (whole milk, other vegetables)
```

```
#Tìm tập phổ biến bằng thuật toán FP-Growth với min_sup = 0.07.
start_FP_l8 = time.time()
itemsets = fpgrowth(dt, min_support=0.07, use_colnames = True)
end_FP_l8 = time.time()
print(timedelta(seconds=round(end_FP_l8-start_FP_l8,5)))
Time_FP.append(end_FP_l8-start_FP_l8)
itemsets
```

0:00:00.046940

```
     support                        itemsets
0   0.082766                    (citrus fruit)
1   0.139502                         (yogurt)
2   0.104931                  (tropical fruit)
3   0.255516                      (whole milk)
4   0.075648                       (pip fruit)
5   0.193493                (other vegetables)
6   0.183935                      (rolls/buns)
7   0.080529                     (bottled beer)
8   0.110524                    (bottled water)
9   0.174377                           (soda)
10  0.079817                      (newspapers)
11  0.072293           (fruit/vegetable juice)
12  0.088968                          (pastry)
13  0.108998                  (root vegetables)
14  0.077682                     (canned beer)
15  0.093950                         (sausage)
16  0.098526                   (shopping bags)
17  0.071683             (whipped/sour cream)
18  0.074835  (whole milk, other vegetables)
```

```
#Tìm tập phổ biến bằng thuật toán FP-Growth với min_sup = 0.08.
start_FP_l8 = time.time()
itemsets = fpgrowth(dt, min_support=0.08, use_colnames = True)
end_FP_l8 = time.time()
print(timedelta(seconds=round(end_FP_l8-start_FP_l8,5)))
Time_FP.append(end_FP_l8-start_FP_l8)
itemsets
```

0:00:00.043300

```
    support            itemsets
0  0.082766       (citrus fruit)
1  0.139502            (yogurt)
2  0.104931     (tropical fruit)
3  0.255516         (whole milk)
4  0.193493  (other vegetables)
5  0.183935         (rolls/buns)
```

```
6   0.080529        (bottled beer)
7   0.110524       (bottled water)
8   0.174377                (soda)
9   0.088968              (pastry)
10  0.108998     (root vegetables)
11  0.093950             (sausage)
12  0.098526       (shopping bags)
```

[ ]: *#Tìm tập phổ biến bằng thuật toán FP-Growth với min_sup = 0.09.*
     start_FP_l9 = time.time()
     itemsets = fpgrowth(dt, min_support=0.09, use_colnames = **True**)
     end_FP_l9 = time.time()
     print(timedelta(seconds=round(end_FP_l9-start_FP_l9,5)))
     Time_FP.append(end_FP_l9-start_FP_l9)
     itemsets

     0:00:00.043170

[ ]:   support   itemsets
     0 0.139502   (yogurt)
     1 0.104931   (tropical fruit)
     2 0.255516   (whole milk)
     3 0.193493   (other vegetables)
     4 0.183935   (rolls/buns)
     5 0.110524   (bottled water)
     6 0.174377   (soda)
     7 0.108998   (root vegetables)
     8 0.093950   (sausage)
     9 0.098526   (shopping bags)

[ ]: *#Tìm tập phổ biến bằng thuật toán FP-Growth với min_sup = 0.1.*
     start_FP_l10 = time.time()
     itemsets = fpgrowth(dt, min_support=0.1, use_colnames = **True**)
     end_FP_l10 = time.time()
     print(timedelta(seconds=round(end_FP_l10-start_FP_l10,5)))
     Time_FP.append(end_FP_l10-start_FP_l10)
     itemsets

     0:00:00.052620

[ ]:   support   itemsets
     0 0.139502   (yogurt)
     1 0.104931   (tropical fruit)
     2 0.255516   (whole milk)
     3 0.193493   (other vegetables)
     4 0.183935   (rolls/buns)
     5 0.110524   (bottled water)
     6 0.174377   (soda)
```

```
7   0.108998    (root vegetables)
```

Thời gian của từng thuật toán đưa vào mảng

```
[ ]: print("Thời gian chạy Apriori")
     Time_Ap
```

Thời gian chạy Apriori

```
[ ]: [0.2451021671295166,
      0.10932183265686035,
      0.06429028511047363,
      0.029379844665527344,
      0.027292490005493164,
      0.02178192138671875,
      0.014495372772216797,
      0.00957059860229492,
      0.008466720581054688,
      0.007573843002319336]
```

```
[ ]: print("Thời gian chạy FP-Growth")
     Time_FP
```

Thời gian chạy FP-Growth

```
[ ]: [0.1672346591949463,
      0.14997577667236328,
      0.09621429443359375,
      0.082611083984375,
      0.0716085433959961,
      0.06178760528564453,
      0.046942710876464844,
      0.04329824447631836,
      0.04317355155944824,
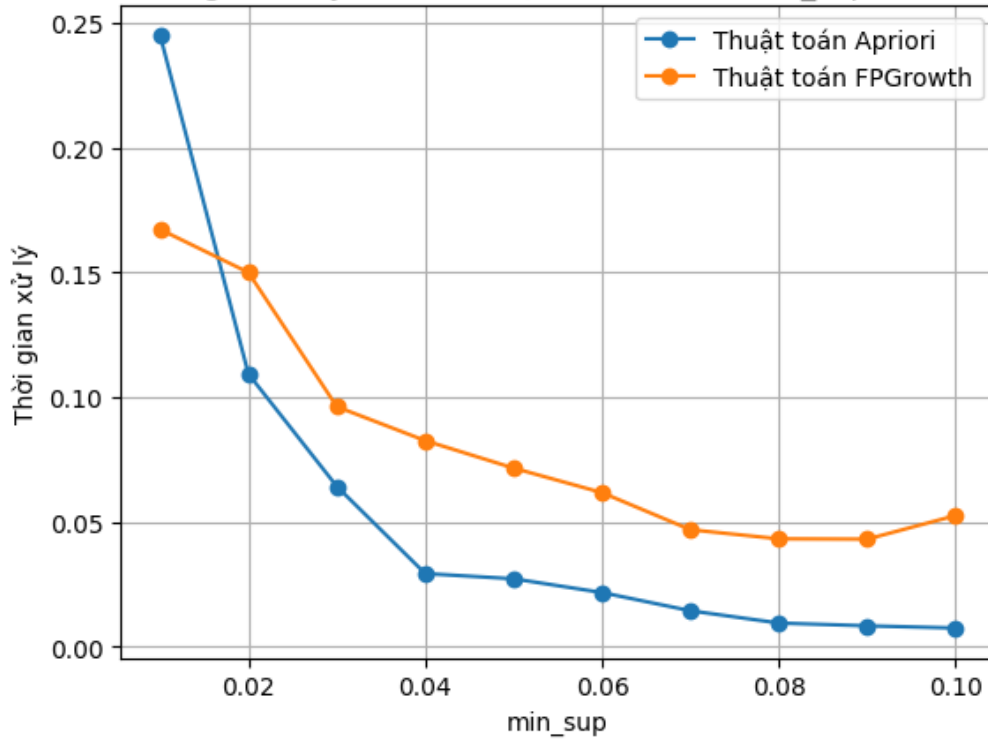      0.052622079849243164]
```

c) Vẽ biểu đồ so sánh thời gian xử lý của hai thuật toán trên với nhau.

Vẽ biểu đồ

```
[ ]: min_sup_values = [0.01, 0.02, 0.03, 0.04, 0.05, 0.06, 0.07, 0.08, 0.09, 0.1]
     # Vẽ biểu đồ
     plt.plot(min_sup_values, Time_Ap, label='Thuật toán Apriori', marker='o')
     plt.plot(min_sup_values, Time_FP, label='Thuật toán FPGrowth', marker='o')
     plt.xlabel('min_sup')
     plt.ylabel('Thời gian xử lý')
     plt.title('So sánh thời gian xử lý của hai thuật toán với các min_sup từ 0.01␣
      ↪đến 0.1')
     plt.legend()
     plt.grid(True)
```

```
plt.show()
```


So sánh thời gian xử lý của hai thuật toán với các min_sup từ 0.01 đến 0.1

Nhận xét: Qua quan sát, ban đầu, với giá trị min_sup được đặt là 0.01, thì thường thấy rằng thuật toán FP-Growth hoạt động nhanh hơn so với Apriori. Tuy nhiên, khi giá trị min_sup tăng lên, đáng chú ý là thuật toán Apriori lại hiệu quả hơn FP-Growth. Ngược lại, khi min_sup giảm, thì thuật toán FP-Growth thường chạy nhanh hơn.

Giải thích Khi min_sup nhỏ, nghĩa là chúng ta đang tìm kiếm các luật hiếm xuất hiện trong tập dữ liệu lớn. FP-Growth thường hiệu quả hơn trong trường hợp này vì nó sử dụng một cấu trúc cây dữ liệu được tối ưu hóa để tìm kiếm và phát hiện các mẫu hiếm. Trong khi đó, Apriori phải thực hiện nhiều quét dữ liệu và kiểm tra các tập phổ biến, điều này làm tăng độ phức tạp tính toán.