

```
In [1]: # Import các thư viện cần thiết như: mlxtend, openpyxl, xlrd
```

```
In [2]: import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
%matplotlib inline

from mlxtend.frequent_patterns import apriori
from mlxtend.frequent_patterns import association_rules
```

```
In [3]: # Đọc dữ liệu
```

```
In [4]: df = pd.read_csv('groceries.csv',sep='/t',header=None, engine='python')
```

```
In [5]: # Xem thông tin
```

```
In [6]: df
```

Out[6]:

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 × 1 columns

In [7]: `# Làm sạch dữ liệu biến chuỗi thành mảng`

In [8]: `df = df[0].str.split(',', expand=True)`

In [9]: `df.head(10)`

Out[9]:

	0	1	2	3	4	5	6	7	8	9	...	22	23	24	25	26	27	2
0	citrus fruit	semi-finished bread	margarine	ready soups	None	None	None	None	None	None	...	None	None	None	None	None	None	Non
1	tropical fruit	yogurt	coffee	None	None	None	None	None	None	...	None	Non						
2	whole milk	None	None	None	None	None	None	None	None	...	None	Non						
3	pip fruit	yogurt	cream cheese	meat spreads	None	None	None	None	None	None	...	None	None	None	None	None	None	Non
4	other vegetables	whole milk	condensed milk	long life bakery product	None	None	None	None	None	None	...	None	None	None	None	None	None	Non
5	whole milk	butter	yogurt	rice	abrasive cleaner	None	None	None	None	None	...	None	None	None	None	None	None	Non
6	rolls/buns	None	None	None	None	None	None	None	None	...	None	Non						
7	other vegetables	UHT-milk	rolls/buns	bottled beer	liquor (appetizer)	None	None	None	None	None	...	None	None	None	None	None	None	Non
8	potted plants	None	None	None	None	None	None	None	None	...	None	Non						
9	whole milk	cereals	None	None	None	None	None	None	None	...	None	Non						

10 rows × 32 columns



In [10]: # Xem các thông tin của biến

In [11]: df.info()

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 9835 entries, 0 to 9834
Data columns (total 32 columns):
 #   Column  Non-Null Count  Dtype  
--- 
 0   0        9835 non-null   object  
 1   1        7676 non-null   object  
 2   2        6033 non-null   object  
 3   3        4734 non-null   object  
 4   4        3729 non-null   object  
 5   5        2874 non-null   object  
 6   6        2229 non-null   object  
 7   7        1684 non-null   object  
 8   8        1246 non-null   object  
 9   9        896 non-null    object  
 10  10       650 non-null   object  
 11  11       468 non-null   object  
 12  12       351 non-null   object  
 13  13       273 non-null   object  
 14  14       196 non-null   object  
 15  15       141 non-null   object  
 16  16       95 non-null    object  
 17  17       66 non-null    object  
 18  18       52 non-null    object  
 19  19       38 non-null    object  
 20  20       29 non-null    object  
 21  21       18 non-null    object  
 22  22       14 non-null    object  
 23  23       8 non-null     object  
 24  24       7 non-null     object  
 25  25       7 non-null     object  
 26  26       6 non-null     object  
 27  27       5 non-null     object  
 28  28       4 non-null     object  
 29  29       1 non-null     object  
 30  30       1 non-null     object  
 31  31       1 non-null     object  
dtypes: object(32)
memory usage: 2.4+ MB
```

```
In [12]: # Đọc dữ liệu
```

```
In [13]: import numpy as np  
basket = np.array(df)  
basket
```

```
Out[13]: array([['citrus fruit', 'semi-finished bread', 'margarine', ..., None,  
        None, None],  
        ['tropical fruit', 'yogurt', 'coffee', ..., None, None, None],  
        ['whole milk', None, None, ..., None, None, None],  
        ...,  
        ['chicken', 'citrus fruit', 'other vegetables', ..., None, None,  
        None],  
        ['semi-finished bread', 'bottled water', 'soda', ..., None, None,  
        None],  
        ['chicken', 'tropical fruit', 'other vegetables', ..., None, None,  
        None]], dtype=object)
```

```
In [14]: # Lọc dữ liệu None
```

```
In [15]: basket = [[x for x in row if str(x) != 'None']] for row in basket]  
basket
```

```
Out[15]: [['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'],
           ['citrus fruit',
            'tropical fruit',
            'whole milk',
            'butter',
            'curd',
            'yogurt',
            'flour',
            'bottled water',
            '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',
 'frozen dessert',
 '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',
 'canned beer',
 'newspapers',
 'shopping bags'],
['yogurt', 'beverages', 'bottled water', 'specialty bar'],
['hamburger meat',
 'other vegetables',
 'rolls/buns',
 'spices',
 'bottled water',
 'hygiene articles',
 'napkins'],
['root vegetables', 'other vegetables', 'whole milk', 'beverages', 'sugar'],
['pork',
 'berries',
 'other vegetables',
 'whole milk'],
```

```
'whipped/sour cream',
'artif. sweetener',
'soda',
'abrasive cleaner'],
['beef', 'grapes', 'detergent'],
['pastry', 'soda'],
['fruit/vegetable juice'],
['canned beer'],
['root vegetables', 'other vegetables', 'whole milk', 'dessert'],
['citrus fruit', 'zwieback', 'newspapers'],
['sausage',
'rolls/buns',
'soda',
'canned beer',
'specialty bar',
'shopping bags'],
['tropical fruit',
'root vegetables',
'whole milk',
'yogurt',
'domestic eggs',
'brown bread',
'pastry',
'sugar',
'cereals',
'coffee',
'soda',
'waffles',
'candy'],
['berries', 'yogurt'],
['canned beer'],
['butter milk',
'yogurt',
'cream cheese',
'spread cheese',
'rolls/buns',
'bottled water',
'soda',
'newspapers'],
['coffee'],
['pastry', 'bottled water'],
```

```
['rolls/buns'],
['misc. beverages'],
['root vegetables',
 'other vegetables',
 'butter',
 'curd',
 'whipped/sour cream',
 'UHT-milk',
 'hard cheese',
 'rolls/buns',
 'bottled water',
 'long life bakery product'],
['sausage', 'rolls/buns', 'cat food', 'newspapers'],
['canned beer'],
['ham', 'grapes', 'other vegetables', 'whole milk'],
['turkey',
 'tropical fruit',
 'other vegetables',
 'curd',
 'domestic eggs',
 'brown bread',
 'semi-finished bread',
 'margarine',
 'baking powder',
 'fruit/vegetable juice'],
['whole milk', 'yogurt', 'processed cheese', 'pickled vegetables', 'soda'],
['whole milk', 'curd', 'yogurt', 'pastry'],
['packaged fruit/vegetables', 'brown bread', 'canned beer'],
['rolls/buns',
 'oil',
 'bottled water',
 'chewing gum',
 'chocolate marshmallow',
 'hygiene articles',
 'napkins'],
['ham', 'beef', 'whipped/sour cream', 'ice cream', 'rolls/buns', 'cat food'],
['rolls/buns', 'pastry', 'sugar'],
['other vegetables',
 'whole milk',
 'frozen vegetables',
 'canned fish'],
```

```
'salty snack',
'seasonal products',
'detergent'],
['sausage', 'pastry'],
['sausage', 'beef', 'whole milk'],
['frankfurter', 'tropical fruit', 'rolls/buns', 'brown bread', 'sugar'],
['rolls/buns', 'pastry', 'soda'],
['whole milk'],
['curd cheese', 'coffee'],
['red/blush wine', 'newspapers'],
['sausage', 'whole milk', 'curd'],
['tropical fruit',
'pip fruit',
'berries',
'whole milk',
'frozen potato products',
'rolls/buns',
'pickled vegetables',
'chocolate'],
['red/blush wine'],
['whole milk',
'butter',
'margarine',
'specialty fat',
'specialty chocolate',
'candles',
'flower (seeds)'],
['frankfurter',
'citrus fruit',
'whole milk',
'domestic eggs',
'oil',
'sparkling wine',
'specialty chocolate',
'newspapers'],
['whole milk', 'meat spreads', 'soda'],
['frozen potato products'],
['other vegetables', 'whole milk', 'rolls/buns', 'sugar'],
['citrus fruit', 'whole milk', 'curd', 'butter milk', 'pastry'],
['flour', 'salt', 'bottled water', 'fruit/vegetable juice', 'bottled beer'],
['sugar', 'bottled water', 'soda', 'bottled beer'],
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```
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['chocolate'],
['root vegetables',
 'whole milk',
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 'domestic eggs',
 'rolls/buns',
 'oil',
 'margarine',
 'canned vegetables',
 'fruit/vegetable juice',
 'bathroom cleaner'],
['root vegetables', 'onions', 'hard cheese', 'frozen vegetables'],
['herbs',
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 'frozen vegetables',
 'salt',
 'oil',
 'white wine',
 'candles'],
['bottled water'],
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 'root vegetables',
 'onions',
 'yogurt',
 'rolls/buns',
 'brandy',
 'detergent'],
['coffee', 'newspapers'],
['pork', 'other vegetables', 'whipped/sour cream'],
['berries', 'yogurt'],
['soda'],
['berries'],
['fruit/vegetable juice', 'salty snack', 'candles'],
['citrus fruit', 'butter milk', 'yogurt', 'cream cheese'],
['pork',
 'hamburger meat',
 'citrus fruit',
 'berries',
 'onions',
 'whipped/sour cream',
```

```
'rice',
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['detergent'],
[['grapes', 'photo/film'],
['sausage',
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'fruit/vegetable juice',
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'red/blush wine',
'waffles',
'shopping bags'],
['chicken',
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'other vegetables',
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'pasta',
'oil',
'detergent'],
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['soda', 'misc. beverages'],
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'rolls/buns',
'pastry',
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'specialty bar',
'bathroom cleaner'],
[['frankfurter', 'rolls/buns', 'bottled water'],
['sausage',
'whole milk',
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'fruit/vegetable juice',
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'napkins',
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'brown bread',
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['processed cheese'],
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'pickled vegetables',
'bottled beer',
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['whole milk',
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'frozen vegetables',
'rolls/buns',
'margarine',
'bottled water',
'red/blush wine',
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```
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['citrus fruit', 'berries', 'UHT-milk', 'processed cheese'],
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['hamburger meat',
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 'sparkling wine'],
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 'frozen vegetables',
 'domestic eggs',
 'soda',
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['whole milk', 'cream cheese', 'soda'],
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 'coffee',
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 'shopping bags'],
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['packaged fruit/vegetables',
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 'canned beer'],
['pastry', 'soda'],
['other vegetables', 'red/blush wine'],
['misc. beverages'],
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 'sausage',
 'citrus fruit',
 'tropical fruit',
 'pip fruit',
 'whole milk',
 'hard cheese'],
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```
'cream cheese',
'domestic eggs',
'rice',
'sugar',
'canned fruit',
'misc. beverages',
'fruit/vegetable juice',
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['sparkling wine'],
['specialty bar'],
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['curd cheese'],
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['whole milk', 'yogurt', 'beverages', 'brown bread', 'shopping bags'],
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'ham',
'pip fruit',
'other vegetables',
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'frozen vegetables',
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```
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'baking powder'],
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'meat spreads',
'cake bar',
'chocolate',
'shopping bags'],
['sausage',
'pork',
'citrus fruit',
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'white bread',
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'bottled beer'],
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['popcorn'],
['whole milk', 'rolls/buns', 'sugar', 'bottled water', 'soda'],
['tropical fruit',
'other vegetables',
'packaged fruit/vegetables',
```

```
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'snack products'],
['beef', 'herbs', 'flour', 'cling film/bags', 'flower soil/fertilizer'],
['whole milk', 'butter', 'dessert', 'rolls/buns'],
['frankfurter', 'soda', 'chewing gum'],
['tropical fruit', 'specialty cheese', 'bottled water'],
['canned beer'],
['finished products',
'other vegetables',
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['hamburger meat', 'root vegetables', 'whole milk'],
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['whole milk', 'cream cheese', 'cereals', 'dog food'],
['whole milk', 'salt'],
['dessert', 'ice cream'],
['sausage', 'soft cheese', 'coffee'],
['other vegetables', 'bottled water', 'waffles', 'dishes', 'shopping bags'],
['ham', 'whole milk', 'rolls/buns'],
```

```
['other vegetables', 'ice cream'],
['other vegetables', 'bottled water'],
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['herbs', 'candy'],
['frankfurter',
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 'pip fruit',
 'root vegetables',
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 'yogurt',
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 'soft cheese',
 'sliced cheese',
 'cream cheese',
 'frozen meals',
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 'cereals',
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 'waffles'],
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 'zwieback',
 'cake bar',
 'specialty bar',
 'shopping bags'],
['frankfurter',
 'tropical fruit',
 'whole milk',
 'spread cheese',
 'margarine',
 'shopping bags'],
```

```
['other vegetables'],
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['specialty bar'],
['curd', 'salt', 'liquor (appetizer)', 'detergent', 'shopping bags'],
['frankfurter', 'rolls/buns'],
['soda'],
['beef'],
['berries'],
['root vegetables'],
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['dessert'],
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['brown bread'],
['canned beer'],
[['pork', 'beef', 'pip fruit', 'herbs', 'spices'],
['frankfurter', 'citrus fruit', 'UHT-milk', 'margarine', 'sugar'],
['sausage', 'bottled beer', 'liquor (appetizer)'],
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['specialty chocolate'],
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[['whole milk', 'bottled water', 'newspapers'],
['rolls/buns', 'chewing gum'],
[['pork', 'root vegetables', 'other vegetables', 'whole milk', 'dishes'],
['citrus fruit', 'pastry'],
['potted plants'],
['rolls/buns', 'pastry', 'soda'],
['butter'],
['yogurt'],
['bottled water'],
['soda'],
['make up remover'],
['hygiene articles'],
[['condensed milk', 'sugar', 'coffee', 'shopping bags'],
[['sausage', 'other vegetables', 'yogurt', 'soda', 'shopping bags'],
[['whole milk', 'beverages', 'UHT-milk', 'soda'],
[['sausage', 'pork', 'beef', 'whole milk', 'rolls/buns', 'margarine'],
[['beverages'],
[['beverages', 'specialty bar'],
[['bottled water', 'fruit/vegetable juice'],
[['newspapers']]
```

```
['cleaner', 'female sanitary products'],
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 'beverages',
 'hard cheese',
 'rolls/buns',
 'dish cleaner',
 'cookware'],
['misc. beverages', 'newspapers'],
['white wine'],
['sausage',
 'sliced cheese',
 'rolls/buns',
 'soda',
 'canned beer',
 'shopping bags'],
['meat', 'curd', 'bottled beer', 'cake bar'],
['frankfurter',
 'meat',
 'tropical fruit',
 'onions',
 'oil',
 'baking powder',
 'tea',
 'cling film/bags'],
['ice cream', 'rolls/buns', 'canned beer'],
['canned beer'],
['tropical fruit',
 'berries',
 'root vegetables',
 'other vegetables',
 'bottled water',
 'shopping bags'],
['meat',
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```
'citrus fruit',
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'butter milk',
'venerages',
'cream cheese',
'rolls/buns',
'brown bread',
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'bottled water'],
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'venerages',
'sliced cheese',
'rolls/buns',
'spices',
'house keeping products',
'flower (seeds)'],
['frankfurter',
'sausage',
'root vegetables',
'butter',
'curd',
'sliced cheese',
'rolls/buns',
'salty snack',
'long life bakery product'],
['meat', 'other vegetables', 'butter', 'rolls/buns'],
['root vegetables',
'venerages',
'Instant food products',
'pickled vegetables',
'detergent'],
['root vegetables',
'herbs',
'other vegetables',
'whole milk',
'sliced cheese',
'rolls/buns'],
```

```
['whole milk', 'whipped/sour cream', 'semi-finished bread', 'margarine'],
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 'dessert',
 'yogurt',
 'whipped/sour cream',
 'frozen dessert',
 'rolls/buns',
 'salt',
 'sugar',
 'cereals',
 'canned vegetables',
 'canned fish',
 'skin care',
 'hygiene articles',
 'napkins'],
['citrus fruit',
 'curd',
 'pastry',
 'margarine',
 'sugar',
 'candy',
 'newspapers'],
['other vegetables',
 'whole milk',
 'bottled water',
 'soda',
 'misc. beverages',
 'bottled beer',
 'red/blush wine',
 'napkins'],
['citrus fruit', 'whole milk', 'rolls/buns'],
['sausage', 'oil', 'hygiene articles', 'napkins'],
['frankfurter',
 'beef',
 'hamburger meat',
 'grapes',
 'root vegetables',
 'whole milk',
 'butter'],
```

```
'frozen dessert',
'potato products',
'bottled water',
'bottled beer'],
['hard cheese', 'rolls/buns', 'bottled water', 'newspapers'],
['cream cheese', 'rolls/buns', 'soda', 'chocolate'],
['turkey', 'beef', 'frozen vegetables', 'dishes', 'photo/film'],
['pork',
'other vegetables',
'whipped/sour cream',
'rolls/buns',
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'bottled beer'],
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'pork',
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'ice cream',
'rolls/buns',
'soda'],
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 'white bread',
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 'newspapers'],
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 ['rolls/buns', 'soda'],
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'bottled water',
'cling film/bags'],
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  'napkins'],
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'flour',
'rice',
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'salty snack',
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'dish cleaner',
'dental care'],
['berries',
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'sugar',
'soups',
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 'shopping bags'],
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'canned beer',
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'dessert',
'domestic eggs',
'rolls/buns',
'white bread',
'coffee',
'bottled water'],
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 'brown bread',
 'canned vegetables',
 'soda',
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 'rum'],
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['ice cream'],
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 'yogurt',
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 'specialty cheese',
 'pastry',
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['other vegetables', 'butter milk', 'frozen fish', 'salty snack'],
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['citrus fruit',
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 'yogurt',
 'sliced cheese',
 'rolls/buns',
 'white bread',
 'brown bread',
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['UHT-milk', 'salt', 'soda', 'specialty chocolate', 'shopping bags'],
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['artif. sweetener', 'soda', 'photo/film'],
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'processed cheese',
'rolls/buns',
'coffee',
'bottled beer'],
['pip fruit',
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'dessert',
'yogurt',
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'shopping bags'],
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['whole milk', 'newspapers'],
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['packaged fruit/vegetables',
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'oil',
'soda',
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'chocolate',
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'frozen vegetables',
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'baking powder',
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'cocoa drinks',
'salty snack',
'waffles',
'candy',
'napkins'],
['citrus fruit',
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'curd',
'yogurt',
'whipped/sour cream',
'cream cheese',
'pastry',
'vinegar',
'oil',
'coffee',
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'detergent',
'cleaner',
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'newspapers'],
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'curd',
'frozen meals',
'domestic eggs',
'cake bar',
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'cleaner',
'house keeping products',
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'yogurt',
'whipped/sour cream',
'hard cheese',
'frozen vegetables',
'frozen fish',
'domestic eggs',
'white bread',
'rice',
'specialty fat',
'dog food',
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'fruit/vegetable juice',
'long life bakery product',
'softener',
'napkins',
'cling film/bags'],
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['pork',
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'other vegetables',
'yogurt',
'semi-finished bread',
'flour',
'margarine',
'artif. sweetener',
```

```
'organic products',
'chocolate marshmallow'],
...]
```

```
In [17]: # Biến đổi sang dạng hot encoding
```

```
In [16]: from mlxtend.preprocessing import TransactionEncoder
te = TransactionEncoder()
te_arr = te.fit(basket).transform(basket).astype(int)
dt=pd.DataFrame(te_arr, columns=te.columns_)
dt
```

```
Out[16]:
```

	Instant food products	UHT-milk	abrasive cleaner	artif. sweetener	baby cosmetics	baby food	bags	baking powder	bathroom cleaner	beef	...	turkey	vinegar	waffles	whipped/sour cream
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
...
9830	0	0	0	0	0	0	0	0	0	1	...	0	0	0	1
9831	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9832	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9833	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9834	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0

9835 rows × 169 columns

```
In [21]: # APRIORI
```

```
In [19]: import time
Apriori_results = []
Apriori_execute_time = []
x=np.linspace(0.01,0.1,num=10)
x=np.round(x,2)
j=0
for i in (x):
    print("Minsup", i, ":")
    start_time = time.time()
    itemsets=apriori(dt.astype('bool'), min_support=i, use_colnames = True)
    end_time = time.time()
    Apriori_results.append(itemsets)
    Apriori_execute_time.append(end_time-start_time)
    print(Apriori_results[j])
    j=j+1
```

Minsup 0.01 :

	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, root vegetables, tropical fruit)
329	0.014540	(whole milk, root vegetables, yogurt)
330	0.010473	(whole milk, soda, yogurt)
331	0.015150	(whole milk, tropical fruit, yogurt)
332	0.010880	(whole milk, whipped/sour cream, yogurt)

[333 rows x 2 columns]

Minsup 0.02 :

	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, other vegetables, yogurt)

[122 rows x 2 columns]

Minsup 0.03 :

	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]

Minsup 0.04 :

	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 (other vegetables, yogurt)
36 0.056634 (rolls/buns, whole milk)
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)

Minsup 0.05 :

	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	(rolls/buns, whole milk)
30	0.056024	(whole milk, yogurt)

Minsup 0.06 :

	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)

Minsup 0.07 :

	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)
Minsup 0.08 :
    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)
Minsup 0.09 :
    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)
Minsup 0.1 :
    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)
```

In [22]: # FP-GROWTH

In [23]:

```
import time
from mlxtend.frequent_patterns import fpgrowth
fpgrowth_results = []
fpgrowth_execute_time = []
x=np.linspace(0.01,0.1,num=10)
x=np.round(x,2)
j=0
for i in (x):
    print("Minsup", i, ":")
    start_time = time.time()
    itemsets=fpgrowth(dt.astype('bool'), min_support=i, use_colnames = True)
    end_time = time.time()
    fpgrowth_results.append(itemsets)
    fpgrowth_execute_time.append(end_time-start_time)
    print(fpgrowth_results[j])
    j=j+1
```

Minsup 0.01 :

	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	(rolls/buns, frozen vegetables)
329	0.012405	(frozen vegetables, yogurt)
330	0.014235	(other vegetables, onions)
331	0.012100	(whole milk, onions)
332	0.010778	(whole milk, sliced cheese)

[333 rows x 2 columns]

Minsup 0.02 :

	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	(other vegetables, pork)
119	0.029995	(whole milk, domestic eggs)
120	0.022267	(other vegetables, domestic eggs)
121	0.020437	(whole milk, frozen vegetables)

[122 rows x 2 columns]

Minsup 0.03 :

	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]

Minsup 0.04 :

	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	(other vegetables, yogurt)
34	0.042298	(whole milk, tropical fruit)

```
35 0.074835      (whole milk, other vegetables)
36 0.042603      (rolls/buns, other vegetables)
37 0.056634      (rolls/buns, whole milk)
38 0.040061      (whole milk, soda)
39 0.047382      (other vegetables, root vegetables)
40 0.048907      (whole milk, root vegetables)
```

Minsup 0.05 :

	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	(rolls/buns, whole milk)

Minsup 0.06 :

	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)

Minsup 0.07 :

	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)
Minsup 0.08 :
    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)
Minsup 0.09 :
    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)
Minsup 0.1 :
    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)
```

```
In [24]: data = {'Execute time of Apriori': Apriori_execute_time, 'Execute time of FP-Growth': fpgrowth_execute_time}
table = pd.DataFrame(data, x)
```

```
table
```

```
Out[24]: Execute time of Apriori  Execute time of FP-Growth
```

	Execute time of Apriori	Execute time of FP-Growth
0.01	0.195044	0.116026
0.02	0.067015	0.159035
0.03	0.037008	0.070015
0.04	0.021005	0.061013
0.05	0.019004	0.058013
0.06	0.010002	0.128029
0.07	0.008002	0.045010
0.08	0.006001	0.039009
0.09	0.005001	0.036008
0.10	0.005001	0.035008

```
In [25]: # Vẽ biểu đồ thời gian thực thi
```

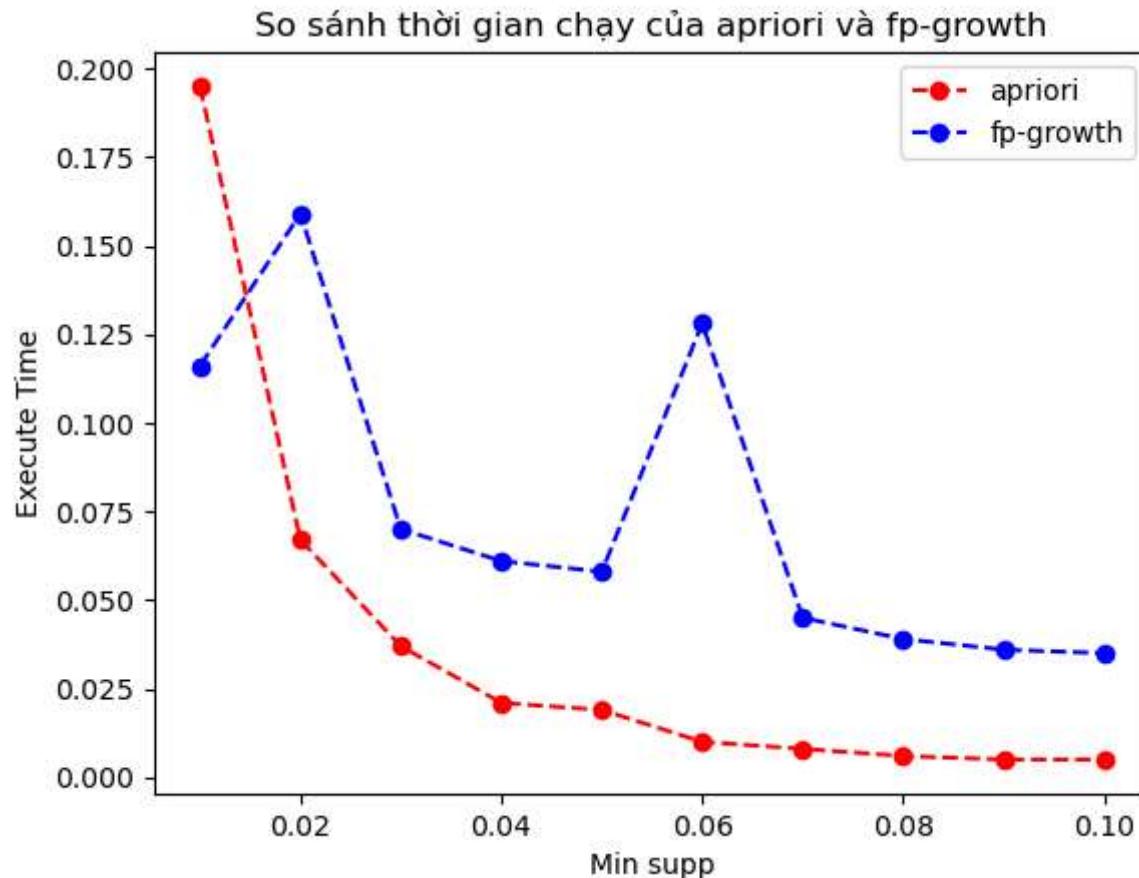
```
In [26]: label=['0.01','0.02','0.03','0.04','0.05','0.06','0.07','0.08','0.09','0.1']
```

```
In [27]: plt.figure(figsize=(15,7))
```

```
Out[27]: <Figure size 1500x700 with 0 Axes>
```

```
<Figure size 1500x700 with 0 Axes>
```

```
In [28]: plt.plot(x, Apriori_execute_time, color='r', marker='o', label='apriori', linestyle='dashed')
plt.plot(x, fpgrowth_execute_time, color='b', marker='o', label='fp-growth', linestyle='dashed')
plt.title('So sánh thời gian chạy của apriori và fp-growth')
plt.xlabel('Min supp')
plt.ylabel('Execute Time')
plt.legend()
plt.show()
```



Nhận xét

1. Thời gian chạy
 - A. Apriori: Chậm hơn FP-Growth
2. Mức độ tăng thời gian chạy
 - A. Apriori: Tăng nhanh hơn FP-Growth khi mức hỗ trợ tối thiểu (min supp) giảm.
 - B. FP-Growth: Tăng chậm hơn Apriori khi mức hỗ trợ tối thiểu (min supp) giảm.
3. Lý do:
 - A. Apriori: Phải quét toàn bộ tập dữ liệu nhiều lần để tìm kiếm các tập mục phổ biến.
 - B. FP-Growth: Sử dụng cấu trúc cây FP-Tree để lưu trữ dữ liệu hiệu quả hơn, giúp giảm số lần quét dữ liệu.

C. Vì khi min_sup càng lớn thì sẽ giúp ta loại bỏ những giá trị không thỏa yêu cầu nhanh hơn và tìm được tập phổ biến.

4. Kết luận:

A. FP-Growth là thuật toán khai thác tập phổ biến hiệu quả hơn Apriori về thời gian chạy.

B. Apriori có thể phù hợp với các tập dữ liệu nhỏ, trong khi FP-Growth phù hợp với các tập dữ liệu lớn.

In []: