In [ ]:
```
import os
print(os.getcwd())
```

In [ ]:
```
pip install symbolicai
```

In [ ]:
```
pip install torch_geometric
```

In [ ]:
```
pip install pyreason
```

In [ ]:
```
pip install networkx
```

In [ ]:
```
pip install python-igraph
```

In [6]:
```
import pandas as pd
import numpy as np
import warnings
warnings.filterwarnings('ignore') # To ignore all warnings
warnings.filterwarnings('ignore', category=UserWarning) # To ignore specific

np.random.seed(42)  # for reproducibility

n_entities = 10000
n_transactions = 50000

# Create synthetic entity IDs
entities = [f"User_{i}" for i in range(n_entities)]

# Randomly generate transactions
df_large = pd.DataFrame({
    'sender': np.random.choice(entities, n_transactions),
    'receiver': np.random.choice(entities, n_transactions),
    'amount': np.round(np.random.exponential(scale=1000, size=n_transactions
    'timestamp': pd.to_datetime('2025-01-01') + pd.to_timedelta(np.random.ra
})

# Remove self-transfers
df_large = df_large[df_large['sender'] != df_large['receiver']].reset_index(

print(df_large.head())
print(f"Total transactions: {len(df_large)}")

df_large['day'] = df_large['timestamp'].dt.date
daily_graphs = {day: df_large[df_large['day'] == day] for day in df_large['d

display(daily_graphs)
```

```
      sender   receiver   amount  timestamp
0  User_7270  User_6042   160.58 2025-03-01
1   User_860  User_8812    37.13 2025-06-20
2  User_5390  User_8962   588.82 2025-03-18
3  User_5191  User_6731   264.47 2025-02-23
4  User_5734  User_4793  2737.87 2025-02-28
Total transactions: 49991
```

```
{datetime.date(2025, 3, 1):           sender   receiver   amount  timestamp
day
 0      User_7270  User_6042   160.58 2025-03-01  2025-03-01
 48     User_5486  User_4736   983.93 2025-03-01  2025-03-01
 208    User_2511  User_8954   288.77 2025-03-01  2025-03-01
 217    User_2911  User_5232  2771.88 2025-03-01  2025-03-01
 501    User_6806  User_2989  2643.06 2025-03-01  2025-03-01
 ...          ...        ...      ...        ...         ...
 49651  User_8884   User_513  2818.36 2025-03-01  2025-03-01
 49721   User_347  User_3818   506.51 2025-03-01  2025-03-01
 49778  User_3555  User_2778   681.02 2025-03-01  2025-03-01
 49859   User_237   User_816   235.22 2025-03-01  2025-03-01
 49969  User_5496   User_217   243.24 2025-03-01  2025-03-01

 [290 rows x 5 columns],
 datetime.date(2025, 6, 20):           sender   receiver   amount  timestam
p         day
 1       User_860  User_8812    37.13 2025-06-20  2025-06-20
 141    User_9914  User_2112   673.42 2025-06-20  2025-06-20
 165    User_7994  User_8083   501.83 2025-06-20  2025-06-20
 302    User_1069  User_3743  2629.34 2025-06-20  2025-06-20
 663    User_8415  User_5842   894.77 2025-06-20  2025-06-20
 ...          ...        ...      ...        ...         ...
 49515  User_1565  User_5374   162.31 2025-06-20  2025-06-20
 49540   User_527  User_8668   325.70 2025-06-20  2025-06-20
 49603  User_5034  User_2423  1046.75 2025-06-20  2025-06-20
 49810  User_8135  User_6657  1150.40 2025-06-20  2025-06-20
 49852  User_5026  User_8878  1519.07 2025-06-20  2025-06-20

 [271 rows x 5 columns],
 datetime.date(2025, 3, 18):           sender   receiver   amount  timestam
p         day
 2      User_5390  User_8962   588.82 2025-03-18  2025-03-18
 144    User_9789  User_1580   835.85 2025-03-18  2025-03-18
 242    User_7400  User_3608   301.74 2025-03-18  2025-03-18
 511    User_1365  User_8762  1615.60 2025-03-18  2025-03-18
 1401   User_1218  User_8138   846.63 2025-03-18  2025-03-18
 ...          ...        ...      ...        ...         ...
 49099  User_1344  User_5443   577.43 2025-03-18  2025-03-18
 49102  User_9324  User_2700   315.70 2025-03-18  2025-03-18
 49180  User_3558  User_9319  1054.93 2025-03-18  2025-03-18
 49376  User_1350  User_5111  2279.61 2025-03-18  2025-03-18
 49914  User_7205  User_4641   233.98 2025-03-18  2025-03-18

 [280 rows x 5 columns],
 datetime.date(2025, 2, 23):           sender   receiver   amount  timestam
p         day
 3      User_5191  User_6731   264.47 2025-02-23  2025-02-23
 473    User_6748  User_5725  1338.94 2025-02-23  2025-02-23
 485    User_7543  User_6328   547.90 2025-02-23  2025-02-23
 665    User_4158  User_7742   847.02 2025-02-23  2025-02-23
 970    User_2243  User_4955  1874.51 2025-02-23  2025-02-23
 ...          ...        ...      ...        ...         ...
 48843  User_7759  User_5475  1703.88 2025-02-23  2025-02-23
 49119  User_7156  User_5774  2001.43 2025-02-23  2025-02-23
 49478  User_6035  User_7884   186.40 2025-02-23  2025-02-23
 49907  User_9831  User_5342   518.64 2025-02-23  2025-02-23
 49956  User_1892  User_9845    22.36 2025-02-23  2025-02-23

 [300 rows x 5 columns],
 datetime.date(2025, 2, 28):           sender   receiver   amount  timestam
p         day
 4      User_5734  User_4793  2737.87 2025-02-28  2025-02-28
 162    User_3748  User_1551   391.69 2025-02-28  2025-02-28
```

```
 192    User_3510  User_9537  1351.79 2025-02-28  2025-02-28
 248    User_6295  User_9196  1215.92 2025-02-28  2025-02-28
 650    User_5713  User_1733  1006.87 2025-02-28  2025-02-28
 ...          ...        ...      ...        ...         ...
 49525  User_4298  User_4670   666.64 2025-02-28  2025-02-28
 49580  User_1187  User_4158  1036.88 2025-02-28  2025-02-28
 49807  User_3016  User_3051    79.49 2025-02-28  2025-02-28
 49918  User_9754  User_5351   848.41 2025-02-28  2025-02-28
 49984  User_3488  User_6650  3820.41 2025-02-28  2025-02-28

 [252 rows x 5 columns],
 datetime.date(2025, 2, 13):           sender   receiver   amount  timestam
p         day
 5      User_6265  User_9806  1675.03 2025-02-13  2025-02-13
 87     User_2568   User_783  2031.37 2025-02-13  2025-02-13
 159    User_5575  User_6920  3796.77 2025-02-13  2025-02-13
 234    User_6287  User_2614  1814.93 2025-02-13  2025-02-13
 417     User_580  User_7672   872.35 2025-02-13  2025-02-13
 ...          ...        ...      ...        ...         ...
 49140  User_7034  User_4642   385.60 2025-02-13  2025-02-13
 49329  User_7549  User_4518     1.72 2025-02-13  2025-02-13
 49475  User_3681  User_3813  1641.58 2025-02-13  2025-02-13
 49739  User_9591  User_3959  3365.63 2025-02-13  2025-02-13
 49983  User_6090  User_9497   194.90 2025-02-13  2025-02-13

 [289 rows x 5 columns],
 datetime.date(2025, 2, 17):           sender   receiver   amount  timestam
p         day
 6       User_466    User_64  3127.46 2025-02-17  2025-02-17
 21     User_8666  User_3663    62.97 2025-02-17  2025-02-17
 262    User_4433  User_4459   108.80 2025-02-17  2025-02-17
 470    User_8945  User_7433  1030.75 2025-02-17  2025-02-17
 474    User_9817  User_1149  1273.13 2025-02-17  2025-02-17
 ...          ...        ...      ...        ...         ...
 49164  User_5171   User_313   624.10 2025-02-17  2025-02-17
 49274  User_3655   User_349  3485.56 2025-02-17  2025-02-17
 49473  User_7002  User_1609   975.26 2025-02-17  2025-02-17
 49504  User_5292  User_6473   416.63 2025-02-17  2025-02-17
 49625  User_3843  User_9846    49.01 2025-02-17  2025-02-17

 [289 rows x 5 columns],
 datetime.date(2025, 2, 22):           sender   receiver   amount  timestam
p         day
 7      User_4426  User_3698  2132.55 2025-02-22  2025-02-22
 128    User_7408  User_1974   701.94 2025-02-22  2025-02-22
 418    User_7004  User_2077   853.42 2025-02-22  2025-02-22
 421    User_4249  User_3086    92.69 2025-02-22  2025-02-22
 1040   User_7973  User_1830  1779.11 2025-02-22  2025-02-22
 ...          ...        ...      ...        ...         ...
 48470  User_5054  User_9184   893.00 2025-02-22  2025-02-22
 48652  User_2319  User_2785   596.22 2025-02-22  2025-02-22
 48896   User_676  User_7589  1384.21 2025-02-22  2025-02-22
 49013  User_1277  User_6858  1053.52 2025-02-22  2025-02-22
 49964  User_6473  User_9357  2343.89 2025-02-22  2025-02-22

 [294 rows x 5 columns],
 datetime.date(2025, 6, 12):           sender   receiver   amount  timestam
p         day
 8      User_5578   User_201  1301.79 2025-06-12  2025-06-12
 69     User_7869  User_3921  1685.33 2025-06-12  2025-06-12
 106    User_2731  User_2662   726.43 2025-06-12  2025-06-12
 462    User_5536  User_5298    44.68 2025-06-12  2025-06-12
 720    User_8017  User_5214  1403.70 2025-06-12  2025-06-12
 ...          ...        ...      ...        ...         ...
```

```
 49541  User_1411  User_3961  1292.71 2025-06-12  2025-06-12
 49828  User_3604  User_9474   405.90 2025-06-12  2025-06-12
 49883  User_9816  User_6995   239.39 2025-06-12  2025-06-12
 49926  User_7406  User_8753    36.89 2025-06-12  2025-06-12
 49937  User_1225  User_8769    38.68 2025-06-12  2025-06-12

 [288 rows x 5 columns],
 datetime.date(2025, 3, 10):           sender   receiver   amount  timestam
p         day
 9      User_8322  User_4237   910.41 2025-03-10  2025-03-10
 55     User_7555  User_4188  1796.14 2025-03-10  2025-03-10
 151    User_5592  User_4805    18.40 2025-03-10  2025-03-10
 161    User_4413  User_1970  1294.14 2025-03-10  2025-03-10
 222    User_1959   User_749   138.43 2025-03-10  2025-03-10
 ...          ...        ...      ...        ...         ...
 49212  User_3754  User_4295   834.65 2025-03-10  2025-03-10
 49231  User_4200  User_5130  1818.33 2025-03-10  2025-03-10
 49908  User_7130  User_2838   450.46 2025-03-10  2025-03-10
 49936  User_8328  User_6147   361.14 2025-03-10  2025-03-10
 49974  User_2250  User_3158  1816.48 2025-03-10  2025-03-10

 [274 rows x 5 columns],
 datetime.date(2025, 6, 6):           sender   receiver   amount  timestamp
day
 10     User_1685  User_3169    67.70 2025-06-06  2025-06-06
 261    User_4973   User_560  1200.00 2025-06-06  2025-06-06
 591    User_9086  User_6816   706.15 2025-06-06  2025-06-06
 658    User_7409    User_99   664.74 2025-06-06  2025-06-06
 701     User_770  User_9225   959.33 2025-06-06  2025-06-06
 ...          ...        ...      ...        ...         ...
 49202  User_2506  User_6164   108.95 2025-06-06  2025-06-06
 49384   User_783  User_9902   856.70 2025-06-06  2025-06-06
 49875   User_713  User_4823   279.46 2025-06-06  2025-06-06
 49915  User_6007  User_6652   187.82 2025-06-06  2025-06-06
 49925  User_5666   User_758  1613.44 2025-06-06  2025-06-06

 [279 rows x 5 columns],
 datetime.date(2025, 3, 28):           sender   receiver   amount  timestam
p         day
 11      User_769  User_2864   308.98 2025-03-28  2025-03-28
 163     User_663  User_3851   720.90 2025-03-28  2025-03-28
 336     User_784  User_1092    51.06 2025-03-28  2025-03-28
 480     User_825  User_2658   884.40 2025-03-28  2025-03-28
 831     User_232  User_4044   599.70 2025-03-28  2025-03-28
 ...          ...        ...      ...        ...         ...
 49098  User_6216  User_9258  2190.65 2025-03-28  2025-03-28
 49261  User_3576  User_1382   986.12 2025-03-28  2025-03-28
 49407  User_1232  User_6142   562.43 2025-03-28  2025-03-28
 49632  User_2133  User_9293  1712.21 2025-03-28  2025-03-28
 49709   User_545  User_5429   917.54 2025-03-28  2025-03-28

 [241 rows x 5 columns],
 datetime.date(2025, 2, 21):           sender   receiver   amount  timestam
p         day
 12     User_6949  User_6360  1240.43 2025-02-21  2025-02-21
 320    User_8319  User_5019   903.83 2025-02-21  2025-02-21
 624    User_1353  User_9980  1334.28 2025-02-21  2025-02-21
 1034   User_6456  User_1314   132.72 2025-02-21  2025-02-21
 1805   User_8125   User_921   146.44 2025-02-21  2025-02-21
 ...          ...        ...      ...        ...         ...
 49162  User_8091  User_2353   288.77 2025-02-21  2025-02-21
 49640  User_1351  User_5284   626.09 2025-02-21  2025-02-21
 49699  User_9106  User_7307   345.53 2025-02-21  2025-02-21
 49832   User_177  User_3846   731.37 2025-02-21  2025-02-21
```

```
 49850  User_4287  User_8970  1639.07 2025-02-21  2025-02-21

 [226 rows x 5 columns],
 datetime.date(2025, 2, 6):          sender   receiver   amount  timestamp
day
 13     User_2433  User_5412   512.80 2025-02-06  2025-02-06
 331    User_1686  User_3004  2398.83 2025-02-06  2025-02-06
 344     User_537  User_9700  2204.49 2025-02-06  2025-02-06
 386    User_7079  User_5976  2698.73 2025-02-06  2025-02-06
 508    User_5917  User_7632   455.08 2025-02-06  2025-02-06
 ...          ...        ...      ...        ...         ...
 49608  User_3661  User_7463  1552.63 2025-02-06  2025-02-06
 49677  User_3012  User_6995   376.57 2025-02-06  2025-02-06
 49695  User_9790  User_4616   344.86 2025-02-06  2025-02-06
 49701  User_7464  User_1167   173.89 2025-02-06  2025-02-06
 49893  User_2461  User_2837   515.83 2025-02-06  2025-02-06

 [277 rows x 5 columns],
 datetime.date(2025, 5, 2):          sender   receiver   amount  timestamp
day
 14     User_5311  User_7675   393.58 2025-05-02  2025-05-02
 58     User_3843   User_260   763.43 2025-05-02  2025-05-02
 72     User_6863  User_3277  1885.21 2025-05-02  2025-05-02
 196    User_4389  User_6064   348.78 2025-05-02  2025-05-02
 340    User_7206  User_7327    91.66 2025-05-02  2025-05-02
 ...          ...        ...      ...        ...         ...
 49087  User_1799   User_904   498.35 2025-05-02  2025-05-02
 49126  User_6797  User_1954   469.24 2025-05-02  2025-05-02
 49218  User_6097  User_4852   560.15 2025-05-02  2025-05-02
 49523  User_9805  User_6614  1166.11 2025-05-02  2025-05-02
 49799  User_4378   User_779  2011.78 2025-05-02  2025-05-02

 [304 rows x 5 columns],
 datetime.date(2025, 2, 3):          sender   receiver   amount  timestamp
day
 15     User_5051  User_9349   109.78 2025-02-03  2025-02-03
 256    User_2557  User_3676  1982.22 2025-02-03  2025-02-03
 479    User_3267   User_999   297.07 2025-02-03  2025-02-03
 514    User_7186  User_5226  1099.76 2025-02-03  2025-02-03
 756    User_6031  User_8133   454.20 2025-02-03  2025-02-03
 ...          ...        ...      ...        ...         ...
 49035  User_8543  User_4713  1321.88 2025-02-03  2025-02-03
 49053  User_8888  User_5542  2900.74 2025-02-03  2025-02-03
 49466  User_8910  User_5469  1879.93 2025-02-03  2025-02-03
 49932   User_698  User_4617   570.28 2025-02-03  2025-02-03
 49933  User_7568  User_2581  1169.24 2025-02-03  2025-02-03

 [299 rows x 5 columns],
 datetime.date(2025, 1, 17):           sender   receiver   amount  timestam
p         day
 16     User_6420  User_2309    72.77 2025-01-17  2025-01-17
 60     User_9692  User_1951   189.81 2025-01-17  2025-01-17
 326    User_1895  User_6616  1166.52 2025-01-17  2025-01-17
 338    User_7560  User_9513   267.14 2025-01-17  2025-01-17
 556    User_1191   User_252  2329.38 2025-01-17  2025-01-17
 ...          ...        ...      ...        ...         ...
 48848  User_4175   User_741   550.55 2025-01-17  2025-01-17
 48868  User_5942  User_6525   694.83 2025-01-17  2025-01-17
 49598  User_7424  User_3127  2231.84 2025-01-17  2025-01-17
 49616  User_2454  User_4777   495.25 2025-01-17  2025-01-17
 49783  User_7552   User_591  1513.22 2025-01-17  2025-01-17

 [273 rows x 5 columns],
 datetime.date(2025, 2, 18):           sender   receiver  amount  timestamp
```

```
day
 17     User_1184  User_6427  235.71 2025-02-18  2025-02-18
 266    User_5699  User_6320  144.44 2025-02-18  2025-02-18
 435    User_4452  User_5694  709.06 2025-02-18  2025-02-18
 518    User_4171  User_2670  409.91 2025-02-18  2025-02-18
 534    User_1062  User_7313  502.97 2025-02-18  2025-02-18
 ...          ...        ...     ...        ...         ...
 49001  User_6031  User_3764  859.62 2025-02-18  2025-02-18
 49211  User_7404   User_678  425.60 2025-02-18  2025-02-18
 49719  User_1740  User_5131  164.15 2025-02-18  2025-02-18
 49747   User_523  User_1501  730.04 2025-02-18  2025-02-18
 49940  User_3326  User_4629  653.81 2025-02-18  2025-02-18

 [288 rows x 5 columns],
 datetime.date(2025, 1, 13):           sender   receiver   amount  timestam
p         day
 18     User_4555   User_101  1799.24 2025-01-13  2025-01-13
 177    User_3696  User_9125   491.77 2025-01-13  2025-01-13
 682    User_7140  User_5772  1092.79 2025-01-13  2025-01-13
 978    User_7863   User_479    93.65 2025-01-13  2025-01-13
 1226    User_481  User_7741  1309.10 2025-01-13  2025-01-13
 ...          ...        ...      ...        ...         ...
 48718  User_7764  User_2057    12.21 2025-01-13  2025-01-13
 48722  User_7841  User_4660  1007.74 2025-01-13  2025-01-13
 49235  User_9066  User_5074  1112.88 2025-01-13  2025-01-13
 49390  User_3256  User_5391  2445.78 2025-01-13  2025-01-13
 49766  User_8159  User_7235   752.92 2025-01-13  2025-01-13

 [279 rows x 5 columns],
 datetime.date(2025, 5, 13):           sender   receiver   amount  timestam
p         day
 19     User_3385   User_376  1087.72 2025-05-13  2025-05-13
 468    User_5726  User_7101  1624.80 2025-05-13  2025-05-13
 515     User_395  User_5258   180.22 2025-05-13  2025-05-13
 639    User_6042  User_8195   508.93 2025-05-13  2025-05-13
 727    User_9550  User_8098  1263.96 2025-05-13  2025-05-13
 ...          ...        ...      ...        ...         ...
 49417  User_5045  User_6999   922.02 2025-05-13  2025-05-13
 49445  User_9204  User_7827  2618.84 2025-05-13  2025-05-13
 49691  User_5381  User_7803   913.65 2025-05-13  2025-05-13
 49728  User_8734  User_2413   341.07 2025-05-13  2025-05-13
 49779  User_8484  User_4550   174.45 2025-05-13  2025-05-13

 [294 rows x 5 columns],
 datetime.date(2025, 4, 5):           sender   receiver   amount  timestamp
day
 20     User_6396  User_8397   416.95 2025-04-05  2025-04-05
 25     User_2047  User_5593  1438.01 2025-04-05  2025-04-05
 93     User_5618   User_237    18.61 2025-04-05  2025-04-05
 158    User_8901  User_1461   536.39 2025-04-05  2025-04-05
 477    User_8808    User_19  2492.58 2025-04-05  2025-04-05
 ...          ...        ...      ...        ...         ...
 49006  User_3638   User_752  5209.35 2025-04-05  2025-04-05
 49385  User_7066  User_3132   444.16 2025-04-05  2025-04-05
 49718   User_571  User_6511   610.00 2025-04-05  2025-04-05
 49872  User_3424  User_4961   350.68 2025-04-05  2025-04-05
 49957  User_1388  User_5786   543.47 2025-04-05  2025-04-05

 [263 rows x 5 columns],
 datetime.date(2025, 3, 21):           sender   receiver   amount  timestam
p         day
 22     User_9274  User_9826   208.71 2025-03-21  2025-03-21
 122    User_7721  User_5434  1975.05 2025-03-21  2025-03-21
 543    User_5334    User_45  1943.23 2025-03-21  2025-03-21
```

```
 674     User_384  User_8371  1107.81 2025-03-21  2025-03-21
 677    User_2000  User_6269  4111.27 2025-03-21  2025-03-21
 ...          ...        ...      ...        ...         ...
 48986  User_4880  User_9520   219.10 2025-03-21  2025-03-21
 49080   User_466  User_8797   687.28 2025-03-21  2025-03-21
 49446  User_3024  User_7808   101.61 2025-03-21  2025-03-21
 49534  User_4070   User_135   765.42 2025-03-21  2025-03-21
 49752  User_2108  User_5639  1649.88 2025-03-21  2025-03-21

 [267 rows x 5 columns],
 datetime.date(2025, 5, 29):           sender   receiver   amount  timestam
p         day
 23     User_2558  User_6294   597.63 2025-05-29  2025-05-29
 607    User_4910  User_5416  1654.83 2025-05-29  2025-05-29
 636    User_4964  User_1724   766.31 2025-05-29  2025-05-29
 879    User_2048  User_1501  1698.00 2025-05-29  2025-05-29
 1000    User_827  User_4667  1039.03 2025-05-29  2025-05-29
 ...          ...        ...      ...        ...         ...
 48619  User_5550  User_6009  1427.23 2025-05-29  2025-05-29
 48690  User_3718  User_3719   444.85 2025-05-29  2025-05-29
 49242  User_8393  User_5774  3040.26 2025-05-29  2025-05-29
 49521  User_1654  User_4001   898.39 2025-05-29  2025-05-29
 49574  User_6819  User_1033  2603.18 2025-05-29  2025-05-29

 [246 rows x 5 columns],
 datetime.date(2025, 6, 1):           sender   receiver   amount  timestamp
day
 24     User_7849  User_1060   166.31 2025-06-01  2025-06-01
 53     User_1585   User_505   284.69 2025-06-01  2025-06-01
 132    User_1757  User_1395  1994.47 2025-06-01  2025-06-01
 255    User_8445  User_8776    69.06 2025-06-01  2025-06-01
 339    User_7343  User_1497   338.02 2025-06-01  2025-06-01
 ...          ...        ...      ...        ...         ...
 49553  User_6079  User_9612  1800.96 2025-06-01  2025-06-01
 49584  User_3727  User_4336   240.87 2025-06-01  2025-06-01
 49643  User_1429  User_3270  1190.69 2025-06-01  2025-06-01
 49673  User_4590  User_1274   327.73 2025-06-01  2025-06-01
 49841  User_1300  User_4607    72.43 2025-06-01  2025-06-01

 [257 rows x 5 columns],
 datetime.date(2025, 6, 15):           sender   receiver   amount  timestam
p         day
 26     User_2747  User_5563  1554.17 2025-06-15  2025-06-15
 363    User_4146  User_2169   108.88 2025-06-15  2025-06-15
 475     User_417  User_3003   339.54 2025-06-15  2025-06-15
 498    User_5104  User_7370   137.37 2025-06-15  2025-06-15
 589    User_6619  User_8413  1246.56 2025-06-15  2025-06-15
 ...          ...        ...      ...        ...         ...
 48086  User_7574  User_1922  1473.13 2025-06-15  2025-06-15
 48789  User_2702  User_3690  1350.82 2025-06-15  2025-06-15
 49299  User_7344  User_3629  1498.66 2025-06-15  2025-06-15
 49499  User_9183  User_9088   838.06 2025-06-15  2025-06-15
 49768  User_8343  User_3926  5197.34 2025-06-15  2025-06-15

 [264 rows x 5 columns],
 datetime.date(2025, 1, 4):           sender   receiver   amount  timestamp
day
 27     User_9167  User_5124   147.19 2025-01-04  2025-01-04
 65      User_995  User_5668  1389.26 2025-01-04  2025-01-04
 660    User_5124  User_9051   283.82 2025-01-04  2025-01-04
 729    User_4637  User_4755    66.26 2025-01-04  2025-01-04
 800    User_5126  User_2179   503.98 2025-01-04  2025-01-04
 ...          ...        ...      ...        ...         ...
 49519  User_7367  User_3795   897.03 2025-01-04  2025-01-04
```

```
 49535  User_2276  User_2599   400.37 2025-01-04  2025-01-04
 49676  User_3850  User_2056   195.32 2025-01-04  2025-01-04
 49808  User_1186  User_7431   429.49 2025-01-04  2025-01-04
 49966  User_7489  User_4464   472.90 2025-01-04  2025-01-04

 [263 rows x 5 columns],
 datetime.date(2025, 1, 6):           sender   receiver   amount  timestamp
day
 28     User_9998  User_9081  1297.81 2025-01-06  2025-01-06
 279    User_8050  User_8124  2109.86 2025-01-06  2025-01-06
 448    User_5878  User_7216  2312.84 2025-01-06  2025-01-06
 516    User_7400   User_279  3206.44 2025-01-06  2025-01-06
 578    User_2923   User_750   959.77 2025-01-06  2025-01-06
 ...          ...        ...      ...        ...         ...
 49516  User_9110  User_8294  1187.06 2025-01-06  2025-01-06
 49554  User_3138    User_70  1190.57 2025-01-06  2025-01-06
 49564    User_66  User_4766   366.55 2025-01-06  2025-01-06
 49742  User_1329  User_2706  3625.12 2025-01-06  2025-01-06
 49924  User_9901  User_9665   515.36 2025-01-06  2025-01-06

 [272 rows x 5 columns],
 datetime.date(2025, 6, 11):           sender   receiver   amount  timestam
p         day
 29      User_189  User_1562   717.93 2025-06-11  2025-06-11
 134    User_6374  User_1530  1987.79 2025-06-11  2025-06-11
 137    User_3242  User_5864   190.24 2025-06-11  2025-06-11
 453    User_6833  User_7476  1004.87 2025-06-11  2025-06-11
 571    User_1324  User_3139   317.16 2025-06-11  2025-06-11
 ...          ...        ...      ...        ...         ...
 49594  User_5127  User_3794    62.93 2025-06-11  2025-06-11
 49685  User_3112  User_9731   202.40 2025-06-11  2025-06-11
 49689  User_9503  User_6453  1346.38 2025-06-11  2025-06-11
 49753  User_1204  User_3935   977.05 2025-06-11  2025-06-11
 49784    User_36  User_6373  2445.95 2025-06-11  2025-06-11

 [295 rows x 5 columns],
 datetime.date(2025, 6, 23):           sender   receiver   amount  timestam
p         day
 30     User_2734  User_3195  3280.26 2025-06-23  2025-06-23
 81     User_8684   User_270   227.99 2025-06-23  2025-06-23
 202    User_7125  User_7915   805.49 2025-06-23  2025-06-23
 238    User_5423  User_8243  1097.17 2025-06-23  2025-06-23
 383    User_7027  User_6209  2123.86 2025-06-23  2025-06-23
 ...          ...        ...      ...        ...         ...
 49796  User_7183  User_6434   182.20 2025-06-23  2025-06-23
 49823  User_5808  User_3079   310.24 2025-06-23  2025-06-23
 49840  User_7395  User_7718  1605.62 2025-06-23  2025-06-23
 49910  User_3057  User_7653  1428.63 2025-06-23  2025-06-23
 49922  User_6783  User_5846  1499.20 2025-06-23  2025-06-23

 [274 rows x 5 columns],
 datetime.date(2025, 5, 31):           sender   receiver   amount  timestam
p         day
 31     User_3005   User_810  1549.13 2025-05-31  2025-05-31
 89     User_2027  User_7138   851.90 2025-05-31  2025-05-31
 176    User_1636  User_6868   610.00 2025-05-31  2025-05-31
 545    User_4330   User_980  1705.34 2025-05-31  2025-05-31
 615    User_3486  User_1388   553.46 2025-05-31  2025-05-31
 ...          ...        ...      ...        ...         ...
 49139  User_7287  User_9999   457.07 2025-05-31  2025-05-31
 49196   User_627  User_4357   558.97 2025-05-31  2025-05-31
 49320  User_9732  User_7607    12.15 2025-05-31  2025-05-31
 49713  User_6395  User_8928  1522.67 2025-05-31  2025-05-31
 49818  User_8203  User_1995   418.37 2025-05-31  2025-05-31
```

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 [272 rows x 5 columns],
 datetime.date(2025, 6, 26):           sender   receiver   amount  timestam
p         day
 32     User_4658  User_9250   880.20 2025-06-26  2025-06-26
 188    User_5791   User_389   600.14 2025-06-26  2025-06-26
 373    User_2491  User_3879  1342.01 2025-06-26  2025-06-26
 504    User_3766  User_9070    24.08 2025-06-26  2025-06-26
 644    User_7891  User_6103   768.63 2025-06-26  2025-06-26
 ...          ...        ...      ...        ...         ...
 49337  User_3219  User_9701   305.73 2025-06-26  2025-06-26
 49437   User_847  User_7800  1147.21 2025-06-26  2025-06-26
 49526  User_4332  User_2839   383.31 2025-06-26  2025-06-26
 49530  User_4305  User_5509  2147.67 2025-06-26  2025-06-26
 49674  User_1852  User_8244   175.17 2025-06-26  2025-06-26

 [296 rows x 5 columns],
 datetime.date(2025, 5, 26):           sender   receiver   amount  timestam
p         day
 33     User_1899  User_9452   925.38 2025-05-26  2025-05-26
 84     User_2062   User_365   454.09 2025-05-26  2025-05-26
 218    User_1734  User_3861   172.22 2025-05-26  2025-05-26
 325    User_5442  User_9987  2218.26 2025-05-26  2025-05-26
 776     User_523  User_1543   732.04 2025-05-26  2025-05-26
 ...          ...        ...      ...        ...         ...
 49230  User_1490  User_9976   502.96 2025-05-26  2025-05-26
 49428  User_4749  User_6049   166.86 2025-05-26  2025-05-26
 49671  User_3226  User_6293  3560.71 2025-05-26  2025-05-26
 49680  User_7501  User_4303   352.07 2025-05-26  2025-05-26
 49855  User_2214  User_6263  1925.77 2025-05-26  2025-05-26

 [297 rows x 5 columns],
 datetime.date(2025, 2, 7):           sender   receiver   amount  timestamp
day
 34     User_7734  User_8703   197.13 2025-02-07  2025-02-07
 272    User_9719  User_2526    80.59 2025-02-07  2025-02-07
 332    User_3009  User_7764   444.50 2025-02-07  2025-02-07
 351    User_7992   User_686   221.44 2025-02-07  2025-02-07
 513     User_698  User_5739  2368.91 2025-02-07  2025-02-07
 ...          ...        ...      ...        ...         ...
 49581   User_376  User_2552   929.19 2025-02-07  2025-02-07
 49588   User_724  User_4618  4041.64 2025-02-07  2025-02-07
 49707  User_9381   User_159   341.33 2025-02-07  2025-02-07
 49790  User_7793  User_5859  1777.18 2025-02-07  2025-02-07
 49817   User_710  User_6816   776.89 2025-02-07  2025-02-07

 [312 rows x 5 columns],
 datetime.date(2025, 4, 11):           sender   receiver   amount  timestam
p         day
 35     User_1267  User_4412  2240.81 2025-04-11  2025-04-11
 98     User_6184  User_1666  1068.83 2025-04-11  2025-04-11
 125    User_7858  User_7570   810.58 2025-04-11  2025-04-11
 207    User_4282   User_421   703.52 2025-04-11  2025-04-11
 221    User_2976  User_8314  1349.86 2025-04-11  2025-04-11
 ...          ...        ...      ...        ...         ...
 49179  User_9987  User_3654     0.96 2025-04-11  2025-04-11
 49186  User_6222  User_5110  2056.98 2025-04-11  2025-04-11
 49312  User_5015  User_3364  1340.18 2025-04-11  2025-04-11
 49593  User_2475  User_7293  1868.42 2025-04-11  2025-04-11
 49843  User_7478  User_6577  1895.28 2025-04-11  2025-04-11

 [276 rows x 5 columns],
 datetime.date(2025, 2, 1):           sender   receiver   amount  timestamp
day
```

```
 36     User_1528  User_4398   819.27 2025-02-01  2025-02-01
 164    User_1998   User_101  1169.29 2025-02-01  2025-02-01
 296    User_4642  User_3419   303.13 2025-02-01  2025-02-01
 391    User_1693  User_1748   347.38 2025-02-01  2025-02-01
 743    User_4164  User_7273   385.07 2025-02-01  2025-02-01
 ...          ...        ...      ...        ...         ...
 49125  User_6846  User_1842   984.71 2025-02-01  2025-02-01
 49217  User_5678  User_5811  1130.43 2025-02-01  2025-02-01
 49697  User_8085  User_1013  2318.02 2025-02-01  2025-02-01
 49771  User_8612  User_2081  2994.36 2025-02-01  2025-02-01
 49902  User_8014  User_7967  1231.63 2025-02-01  2025-02-01

 [259 rows x 5 columns],
 datetime.date(2025, 4, 23):           sender   receiver   amount  timestam
p         day
 37     User_3556  User_9317   853.54 2025-04-23  2025-04-23
 70     User_6439  User_2969   291.13 2025-04-23  2025-04-23
 233     User_262  User_8436   367.75 2025-04-23  2025-04-23
 365     User_574  User_1464  1719.27 2025-04-23  2025-04-23
 463    User_3913   User_797   121.26 2025-04-23  2025-04-23
 ...          ...        ...      ...        ...         ...
 48976  User_8984  User_5972   262.03 2025-04-23  2025-04-23
 49259  User_4468  User_5540   747.89 2025-04-23  2025-04-23
 49383  User_8960  User_6301   948.17 2025-04-23  2025-04-23
 49862  User_3889  User_8357   424.95 2025-04-23  2025-04-23
 49884  User_2408  User_4277  2762.75 2025-04-23  2025-04-23

 [296 rows x 5 columns],
 datetime.date(2025, 3, 4):           sender   receiver   amount  timestamp
day
 38     User_3890  User_5431   856.65 2025-03-04  2025-03-04
 186    User_5172  User_9470  2615.21 2025-03-04  2025-03-04
 282    User_6893  User_8325  1310.56 2025-03-04  2025-03-04
 293    User_7996  User_4082   242.65 2025-03-04  2025-03-04
 327    User_2733  User_2785  3473.00 2025-03-04  2025-03-04
 ...          ...        ...      ...        ...         ...
 49163  User_6744  User_4551   683.45 2025-03-04  2025-03-04
 49283  User_3567  User_2078    28.90 2025-03-04  2025-03-04
 49297  User_1192  User_4914   155.72 2025-03-04  2025-03-04
 49315  User_8019   User_974   451.89 2025-03-04  2025-03-04
 49959  User_1457  User_6162   462.19 2025-03-04  2025-03-04

 [285 rows x 5 columns],
 datetime.date(2025, 5, 30):           sender   receiver   amount  timestam
p         day
 39     User_8838  User_4177   323.29 2025-05-30  2025-05-30
 237    User_2049  User_9574  3362.78 2025-05-30  2025-05-30
 375    User_5691  User_1489   347.37 2025-05-30  2025-05-30
 523    User_4946  User_5269  1167.70 2025-05-30  2025-05-30
 722    User_9550  User_4608   955.22 2025-05-30  2025-05-30
 ...          ...        ...      ...        ...         ...
 48795  User_4963  User_2527  1202.96 2025-05-30  2025-05-30
 48880  User_1039  User_6140  1447.60 2025-05-30  2025-05-30
 48922  User_5403  User_8170  1741.33 2025-05-30  2025-05-30
 49365   User_666  User_6647   827.76 2025-05-30  2025-05-30
 49958  User_7165  User_7577   117.34 2025-05-30  2025-05-30

 [322 rows x 5 columns],
 datetime.date(2025, 5, 5):           sender   receiver   amount  timestamp
day
 40     User_5393   User_657  1671.80 2025-05-05  2025-05-05
 355    User_8173    User_73  4135.29 2025-05-05  2025-05-05
 553    User_7056   User_257   680.25 2025-05-05  2025-05-05
 788    User_4432  User_4320  1633.44 2025-05-05  2025-05-05
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 873    User_6469  User_5150  2406.47 2025-05-05  2025-05-05
 ...          ...        ...      ...        ...         ...
 49559  User_1318   User_591  1308.83 2025-05-05  2025-05-05
 49648  User_3199  User_5109   526.82 2025-05-05  2025-05-05
 49704    User_56  User_9157  1059.60 2025-05-05  2025-05-05
 49928  User_2508  User_4161   527.55 2025-05-05  2025-05-05
 49967  User_1172  User_1670   814.33 2025-05-05  2025-05-05

 [254 rows x 5 columns],
 datetime.date(2025, 4, 19):           sender   receiver   amount  timestam
p         day
 41     User_8792  User_6336  1982.96 2025-04-19  2025-04-19
 1156   User_4831  User_3606  3423.70 2025-04-19  2025-04-19
 1725   User_5895  User_8271  2042.75 2025-04-19  2025-04-19
 1753   User_6262   User_760   797.04 2025-04-19  2025-04-19
 2091   User_2494   User_558  1329.06 2025-04-19  2025-04-19
 ...          ...        ...      ...        ...         ...
 48490  User_7937  User_8777  1464.03 2025-04-19  2025-04-19
 48855  User_7313  User_2083  4676.66 2025-04-19  2025-04-19
 49626  User_6267  User_3913  3408.59 2025-04-19  2025-04-19
 49795  User_9114  User_9129   487.94 2025-04-19  2025-04-19
 49934  User_6450  User_2412  1360.69 2025-04-19  2025-04-19

 [283 rows x 5 columns],
 datetime.date(2025, 5, 4):           sender   receiver   amount  timestamp
day
 42     User_8433    User_52   339.52 2025-05-04  2025-05-04
 115    User_6910  User_8335    69.85 2025-05-04  2025-05-04
 319    User_3394   User_170   651.46 2025-05-04  2025-05-04
 428    User_2141   User_262   381.13 2025-05-04  2025-05-04
 494    User_1122  User_7143  2212.46 2025-05-04  2025-05-04
 ...          ...        ...      ...        ...         ...
 49443  User_4332  User_7222   347.69 2025-05-04  2025-05-04
 49712  User_9605  User_4009   228.49 2025-05-04  2025-05-04
 49838  User_9788    User_32   126.47 2025-05-04  2025-05-04
 49968  User_1711  User_9325   679.51 2025-05-04  2025-05-04
 49976  User_4383  User_2329  3248.38 2025-05-04  2025-05-04

 [272 rows x 5 columns],
 datetime.date(2025, 2, 4):           sender   receiver   amount  timestamp
day
 43     User_7513  User_5110   582.98 2025-02-04  2025-02-04
 100    User_6278  User_1656   119.31 2025-02-04  2025-02-04
 766    User_6777  User_7744    51.11 2025-02-04  2025-02-04
 1308   User_2983  User_5477   353.68 2025-02-04  2025-02-04
 1426   User_2162  User_8229   851.59 2025-02-04  2025-02-04
 ...          ...        ...      ...        ...         ...
 49486  User_5444  User_4197    40.61 2025-02-04  2025-02-04
 49505  User_9759  User_2465   514.82 2025-02-04  2025-02-04
 49529  User_8485  User_9766   643.20 2025-02-04  2025-02-04
 49579  User_8273  User_9107  1188.89 2025-02-04  2025-02-04
 49724  User_4592  User_4870   758.86 2025-02-04  2025-02-04

 [294 rows x 5 columns],
 datetime.date(2025, 5, 19):           sender   receiver   amount  timestam
p         day
 44     User_2612  User_1108   197.42 2025-05-19  2025-05-19
 364    User_3769  User_8924    53.37 2025-05-19  2025-05-19
 761    User_1887  User_7020   304.17 2025-05-19  2025-05-19
 1383   User_1913  User_1779   594.10 2025-05-19  2025-05-19
 1516   User_3155  User_7018   918.47 2025-05-19  2025-05-19
 ...          ...        ...      ...        ...         ...
 49879  User_2016  User_7321    83.06 2025-05-19  2025-05-19
 49912  User_9159  User_9797   101.50 2025-05-19  2025-05-19
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 49916  User_9211  User_2533  2135.30 2025-05-19  2025-05-19
 49941  User_2228  User_1597   588.55 2025-05-19  2025-05-19
 49944  User_3099    User_21   373.25 2025-05-19  2025-05-19

 [286 rows x 5 columns],
 datetime.date(2025, 1, 20):           sender   receiver   amount  timestam
p         day
 45     User_7041   User_986   272.52 2025-01-20  2025-01-20
 195    User_8958  User_3793   237.77 2025-01-20  2025-01-20
 309    User_3170   User_587   297.49 2025-01-20  2025-01-20
 559    User_2681  User_6296   307.03 2025-01-20  2025-01-20
 586    User_9435  User_8698   163.84 2025-01-20  2025-01-20
 ...          ...        ...      ...        ...         ...
 48352  User_6062  User_1448     3.46 2025-01-20  2025-01-20
 48581  User_8021  User_8564    56.26 2025-01-20  2025-01-20
 48612  User_8592   User_727    27.48 2025-01-20  2025-01-20
 49039  User_7561   User_436  5731.96 2025-01-20  2025-01-20
 49544   User_389  User_6674  2309.48 2025-01-20  2025-01-20

 [280 rows x 5 columns],
 datetime.date(2025, 3, 15):           sender   receiver   amount  timestam
p         day
 46     User_9555  User_6026   409.45 2025-03-15  2025-03-15
 57     User_1021  User_3001   157.18 2025-03-15  2025-03-15
 184    User_6528  User_2109   153.15 2025-03-15  2025-03-15
 402    User_1150  User_1190   559.18 2025-03-15  2025-03-15
 596    User_1214   User_620   225.22 2025-03-15  2025-03-15
 ...          ...        ...      ...        ...         ...
 48633  User_7458  User_3841   422.14 2025-03-15  2025-03-15
 48673  User_1666  User_6951  1044.72 2025-03-15  2025-03-15
 48891  User_1582  User_6802   438.05 2025-03-15  2025-03-15
 49508  User_5325  User_9504    35.04 2025-03-15  2025-03-15
 49896  User_7342  User_2859    74.69 2025-03-15  2025-03-15

 [291 rows x 5 columns],
 datetime.date(2025, 1, 28):           sender   receiver   amount  timestam
p         day
 47     User_6235  User_8047  2322.68 2025-01-28  2025-01-28
 247    User_4499  User_3492   339.80 2025-01-28  2025-01-28
 444    User_9540  User_2391   140.01 2025-01-28  2025-01-28
 451     User_851   User_847   149.24 2025-01-28  2025-01-28
 757    User_7687  User_3801   184.04 2025-01-28  2025-01-28
 ...          ...        ...      ...        ...         ...
 48771  User_9218  User_9260   523.47 2025-01-28  2025-01-28
 48882  User_7566  User_1627  1159.60 2025-01-28  2025-01-28
 49144  User_9444  User_5493  1898.05 2025-01-28  2025-01-28
 49234  User_4854  User_7134   597.54 2025-01-28  2025-01-28
 49612   User_755  User_1880   448.33 2025-01-28  2025-01-28

 [272 rows x 5 columns],
 datetime.date(2025, 6, 24):           sender   receiver   amount  timestam
p         day
 49     User_7099  User_8402   886.61 2025-06-24  2025-06-24
 88     User_5463  User_4483   716.69 2025-06-24  2025-06-24
 245    User_2255  User_7254  2350.73 2025-06-24  2025-06-24
 257    User_5592  User_1534  2074.18 2025-06-24  2025-06-24
 634    User_7483  User_7657  3250.66 2025-06-24  2025-06-24
 ...          ...        ...      ...        ...         ...
 49294  User_1917  User_8365   704.37 2025-06-24  2025-06-24
 49447  User_3070   User_553  1044.94 2025-06-24  2025-06-24
 49592  User_5381  User_2869   832.60 2025-06-24  2025-06-24
 49623  User_7736  User_9556  1445.35 2025-06-24  2025-06-24
 49930  User_2593  User_7145  3307.77 2025-06-24  2025-06-24
```

```
 [269 rows x 5 columns],
 datetime.date(2025, 6, 16):           sender   receiver   amount  timestam
p         day
 50     User_9670  User_4959  2932.90 2025-06-16  2025-06-16
 75      User_878  User_1488   445.86 2025-06-16  2025-06-16
 172    User_1291  User_4934  2586.56 2025-06-16  2025-06-16
 455    User_9760  User_8736   413.63 2025-06-16  2025-06-16
 833    User_6371  User_2221   308.31 2025-06-16  2025-06-16
 ...          ...        ...      ...        ...         ...
 48691  User_6914  User_4521   117.48 2025-06-16  2025-06-16
 48988  User_4050  User_4274  3376.94 2025-06-16  2025-06-16
 49199  User_3758     User_9  1344.12 2025-06-16  2025-06-16
 49206   User_473  User_5721  1105.53 2025-06-16  2025-06-16
 49209  User_5683  User_9741   249.32 2025-06-16  2025-06-16

 [262 rows x 5 columns],
 datetime.date(2025, 3, 12):           sender   receiver   amount  timestam
p         day
 51     User_8226  User_9106    16.18 2025-03-12  2025-03-12
 146    User_3627  User_2425   138.13 2025-03-12  2025-03-12
 382    User_9183  User_7444  1441.76 2025-03-12  2025-03-12
 387    User_7987   User_200  4140.41 2025-03-12  2025-03-12
 413    User_7404  User_2396   816.31 2025-03-12  2025-03-12
 ...          ...        ...      ...        ...         ...
 49246  User_9581  User_2498   300.28 2025-03-12  2025-03-12
 49441  User_7079  User_5897   147.47 2025-03-12  2025-03-12
 49520  User_4119  User_2798   156.44 2025-03-12  2025-03-12
 49667  User_1731  User_8454  1376.01 2025-03-12  2025-03-12
 49890  User_3241  User_6317   424.44 2025-03-12  2025-03-12

 [270 rows x 5 columns],
 datetime.date(2025, 5, 11):           sender   receiver   amount  timestam
p         day
 52     User_3152  User_7439   132.77 2025-05-11  2025-05-11
 127    User_2790  User_8544  3150.21 2025-05-11  2025-05-11
 148    User_5450  User_7219   455.43 2025-05-11  2025-05-11
 572    User_9347  User_1693   584.88 2025-05-11  2025-05-11
 689    User_2048  User_5856    16.45 2025-05-11  2025-05-11
 ...          ...        ...      ...        ...         ...
 48813  User_9729   User_395   902.18 2025-05-11  2025-05-11
 48983  User_8903  User_3176  3017.52 2025-05-11  2025-05-11
 49170  User_6522   User_261  1254.63 2025-05-11  2025-05-11
 49327  User_7787  User_9556  1352.19 2025-05-11  2025-05-11
 49760   User_711  User_7408   249.39 2025-05-11  2025-05-11

 [289 rows x 5 columns],
 datetime.date(2025, 5, 15):           sender   receiver   amount  timestam
p         day
 54     User_3943  User_3298   362.29 2025-05-15  2025-05-15
 329    User_7455  User_8995   294.20 2025-05-15  2025-05-15
 407    User_1081  User_9706   390.07 2025-05-15  2025-05-15
 569    User_7494  User_8753   330.52 2025-05-15  2025-05-15
 648    User_7714  User_6553     4.55 2025-05-15  2025-05-15
 ...          ...        ...      ...        ...         ...
 48592  User_8128  User_8060   160.26 2025-05-15  2025-05-15
 48632  User_5615  User_4468  1793.71 2025-05-15  2025-05-15
 49048  User_3536  User_8833   147.72 2025-05-15  2025-05-15
 49115  User_1933  User_3399   292.70 2025-05-15  2025-05-15
 49971  User_7487  User_1373   692.02 2025-05-15  2025-05-15

 [274 rows x 5 columns],
 datetime.date(2025, 2, 20):           sender   receiver   amount  timestam
p         day
 56     User_3073  User_4425  1469.28 2025-02-20  2025-02-20
```

```
 310     User_699  User_7183  1293.88 2025-02-20  2025-02-20
 371    User_4777  User_2649  1112.35 2025-02-20  2025-02-20
 1556   User_7725  User_7552   639.95 2025-02-20  2025-02-20
 1615    User_634  User_9385   263.09 2025-02-20  2025-02-20
 ...          ...        ...      ...        ...         ...
 48928  User_6614  User_2126   315.19 2025-02-20  2025-02-20
 49044   User_231  User_7820   967.75 2025-02-20  2025-02-20
 49619  User_5804  User_5866   561.57 2025-02-20  2025-02-20
 49744  User_3322  User_7990   191.39 2025-02-20  2025-02-20
 49820  User_6842   User_595   729.60 2025-02-20  2025-02-20

 [267 rows x 5 columns],
 datetime.date(2025, 1, 21):           sender   receiver   amount  timestam
p         day
 59     User_7989  User_8901   115.54 2025-01-21  2025-01-21
 92     User_5258  User_5485   818.94 2025-01-21  2025-01-21
 111    User_3840   User_662  1284.92 2025-01-21  2025-01-21
 265    User_8352  User_2552   555.92 2025-01-21  2025-01-21
 273    User_6015   User_721   135.09 2025-01-21  2025-01-21
 ...          ...        ...      ...        ...         ...
 48735  User_6572   User_717  3478.63 2025-01-21  2025-01-21
 49251  User_8556  User_5222   497.17 2025-01-21  2025-01-21
 49702  User_5736  User_9572  1952.63 2025-01-21  2025-01-21
 49954  User_8375  User_7200  1845.65 2025-01-21  2025-01-21
 49979  User_9260  User_4681  1043.60 2025-01-21  2025-01-21

 [267 rows x 5 columns],
 datetime.date(2025, 3, 19):           sender   receiver   amount  timestam
p         day
 61     User_6873  User_2370   277.32 2025-03-19  2025-03-19
 424    User_7253    User_22   624.50 2025-03-19  2025-03-19
 443    User_9207  User_9233   425.80 2025-03-19  2025-03-19
 483    User_9708  User_1690   971.14 2025-03-19  2025-03-19
 554    User_1542  User_4043    32.79 2025-03-19  2025-03-19
 ...          ...        ...      ...        ...         ...
 49339  User_2710  User_5785   635.82 2025-03-19  2025-03-19
 49359  User_5370  User_9060   594.12 2025-03-19  2025-03-19
 49455   User_735  User_6109  1305.05 2025-03-19  2025-03-19
 49546  User_3638  User_6554    30.79 2025-03-19  2025-03-19
 49868   User_767  User_4121  1401.80 2025-03-19  2025-03-19

 [315 rows x 5 columns],
 datetime.date(2025, 2, 25):           sender   receiver   amount  timestam
p         day
 62     User_5675  User_6153  2356.99 2025-02-25  2025-02-25
 227    User_1802  User_5576  1199.36 2025-02-25  2025-02-25
 244    User_9874  User_4043   505.96 2025-02-25  2025-02-25
 747    User_6269  User_7071  1429.32 2025-02-25  2025-02-25
 927    User_2898  User_7415   731.77 2025-02-25  2025-02-25
 ...          ...        ...      ...        ...         ...
 49477  User_2809  User_5695  3813.31 2025-02-25  2025-02-25
 49576   User_368  User_2742   268.75 2025-02-25  2025-02-25
 49646  User_5817  User_3130  4377.36 2025-02-25  2025-02-25
 49706  User_7226  User_2054    80.60 2025-02-25  2025-02-25
 49987  User_8762   User_533   670.46 2025-02-25  2025-02-25

 [293 rows x 5 columns],
 datetime.date(2025, 4, 4):           sender   receiver   amount  timestamp
day
 63      User_161  User_8279   455.27 2025-04-04  2025-04-04
 431    User_6484  User_8751  3464.95 2025-04-04  2025-04-04
 454    User_2427  User_4671  1230.56 2025-04-04  2025-04-04
 499    User_2143  User_3106   911.91 2025-04-04  2025-04-04
 1117   User_5207  User_3325  2058.91 2025-04-04  2025-04-04
```

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 ...          ...        ...      ...        ...         ...
 49198   User_566  User_5945  1179.39 2025-04-04  2025-04-04
 49303  User_1553  User_3582   348.72 2025-04-04  2025-04-04
 49476  User_7190  User_1973   877.51 2025-04-04  2025-04-04
 49565  User_6546  User_2072  4448.15 2025-04-04  2025-04-04
 49873  User_4548  User_7956   467.54 2025-04-04  2025-04-04

 [283 rows x 5 columns],
 datetime.date(2025, 4, 1):           sender   receiver   amount  timestamp
day
 64     User_4297  User_6483  2474.77 2025-04-01  2025-04-01
 117    User_6938  User_6609  1169.98 2025-04-01  2025-04-01
 254    User_4199     User_5   640.47 2025-04-01  2025-04-01
 693    User_5565  User_7271   284.15 2025-04-01  2025-04-01
 994    User_8554  User_4974  2576.10 2025-04-01  2025-04-01
 ...          ...        ...      ...        ...         ...
 49241  User_6458  User_1819   173.61 2025-04-01  2025-04-01
 49248  User_1617  User_6812  1788.80 2025-04-01  2025-04-01
 49252  User_3371  User_1080  2911.24 2025-04-01  2025-04-01
 49665  User_6190   User_978  1017.36 2025-04-01  2025-04-01
 49848  User_6643  User_6517   538.46 2025-04-01  2025-04-01

 [275 rows x 5 columns],
 datetime.date(2025, 6, 3):           sender   receiver   amount  timestamp
day
 66     User_7629  User_2734  1383.92 2025-06-03  2025-06-03
 105    User_8996  User_7559   330.51 2025-06-03  2025-06-03
 280    User_3446  User_5599  1101.16 2025-06-03  2025-06-03
 1136   User_4177  User_3847   168.34 2025-06-03  2025-06-03
 1443   User_4286  User_2443     9.52 2025-06-03  2025-06-03
 ...          ...        ...      ...        ...         ...
 49638  User_7882  User_9527  2286.37 2025-06-03  2025-06-03
 49745  User_2898  User_2787  2129.28 2025-06-03  2025-06-03
 49824  User_4950  User_1386  2679.67 2025-06-03  2025-06-03
 49866  User_2454   User_671  2024.73 2025-06-03  2025-06-03
 49978  User_3669  User_1026  2252.61 2025-06-03  2025-06-03

 [255 rows x 5 columns],
 datetime.date(2025, 1, 1):           sender   receiver   amount  timestamp
day
 67     User_9467  User_2256  1627.05 2025-01-01  2025-01-01
 124    User_1484  User_3396   412.40 2025-01-01  2025-01-01
 369    User_7509  User_4681   536.45 2025-01-01  2025-01-01
 427    User_5188  User_8154   235.65 2025-01-01  2025-01-01
 568    User_8702   User_270   756.81 2025-01-01  2025-01-01
 ...          ...        ...      ...        ...         ...
 49123  User_3261  User_3529    52.76 2025-01-01  2025-01-01
 49129  User_4768  User_1676  1024.49 2025-01-01  2025-01-01
 49278  User_1080  User_7518  2525.48 2025-01-01  2025-01-01
 49281  User_3250  User_5962   670.85 2025-01-01  2025-01-01
 49797  User_6420  User_6822   416.82 2025-01-01  2025-01-01

 [218 rows x 5 columns],
 datetime.date(2025, 3, 9):           sender   receiver   amount  timestamp
day
 68     User_1016  User_1072   100.89 2025-03-09  2025-03-09
 283    User_1693  User_4813   356.85 2025-03-09  2025-03-09
 335    User_1409  User_8459  1454.78 2025-03-09  2025-03-09
 564    User_9580  User_5874  3339.24 2025-03-09  2025-03-09
 738    User_3472  User_7062   581.82 2025-03-09  2025-03-09
 ...          ...        ...      ...        ...         ...
 49210  User_3602  User_5784   280.98 2025-03-09  2025-03-09
 49291  User_8546  User_9182   317.13 2025-03-09  2025-03-09
 49517  User_4619  User_7932   434.64 2025-03-09  2025-03-09
```

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 49538  User_8577  User_7901   965.42 2025-03-09  2025-03-09
 49573  User_2010   User_939   280.70 2025-03-09  2025-03-09

 [303 rows x 5 columns],
 datetime.date(2025, 5, 17):           sender   receiver   amount  timestam
p         day
 71     User_7892  User_5942  4130.89 2025-05-17  2025-05-17
 225    User_2385  User_6388  1247.44 2025-05-17  2025-05-17
 600     User_928  User_5244   698.00 2025-05-17  2025-05-17
 890     User_260  User_9929   950.19 2025-05-17  2025-05-17
 1131   User_4242  User_3067  1089.76 2025-05-17  2025-05-17
 ...          ...        ...      ...        ...         ...
 49075  User_9170  User_8028   520.28 2025-05-17  2025-05-17
 49204  User_8920  User_1867  1132.40 2025-05-17  2025-05-17
 49791  User_6677  User_5450   383.99 2025-05-17  2025-05-17
 49825  User_3282  User_9887    54.62 2025-05-17  2025-05-17
 49950  User_6978  User_9728   677.38 2025-05-17  2025-05-17

 [283 rows x 5 columns],
 datetime.date(2025, 3, 24):           sender   receiver   amount  timestam
p         day
 73     User_7916  User_3969  5697.46 2025-03-24  2025-03-24
 445    User_4611  User_5365   260.99 2025-03-24  2025-03-24
 661    User_1015  User_5784   763.05 2025-03-24  2025-03-24
 1353   User_4494  User_4850  1322.52 2025-03-24  2025-03-24
 1377   User_3845  User_3110   125.56 2025-03-24  2025-03-24
 ...          ...        ...      ...        ...         ...
 48463  User_5036  User_2302   704.37 2025-03-24  2025-03-24
 49205  User_3328  User_9981   793.49 2025-03-24  2025-03-24
 49373  User_9442  User_8648   455.26 2025-03-24  2025-03-24
 49765   User_331  User_3571   106.53 2025-03-24  2025-03-24
 49882  User_9463  User_7296   293.74 2025-03-24  2025-03-24

 [271 rows x 5 columns],
 datetime.date(2025, 4, 20):           sender   receiver   amount  timestam
p         day
 74     User_8529  User_7920  2766.47 2025-04-20  2025-04-20
 367    User_6293  User_8648  1480.86 2025-04-20  2025-04-20
 482    User_5745  User_4425  1060.93 2025-04-20  2025-04-20
 1168   User_2051  User_8010  1094.36 2025-04-20  2025-04-20
 1279   User_7124  User_3325  1630.81 2025-04-20  2025-04-20
 ...          ...        ...      ...        ...         ...
 49639  User_8343  User_1111   963.57 2025-04-20  2025-04-20
 49696   User_944  User_9032  2127.55 2025-04-20  2025-04-20
 49759  User_3334  User_7169   257.41 2025-04-20  2025-04-20
 49767  User_3834  User_2351   325.64 2025-04-20  2025-04-20
 49985  User_3212  User_1881   359.72 2025-04-20  2025-04-20

 [285 rows x 5 columns],
 datetime.date(2025, 3, 2):           sender   receiver   amount  timestamp
day
 76     User_9268  User_9850  2841.98 2025-03-02  2025-03-02
 486    User_7587  User_8526  1524.67 2025-03-02  2025-03-02
 495    User_4079  User_8980   559.53 2025-03-02  2025-03-02
 1021   User_3030  User_4000  2456.16 2025-03-02  2025-03-02
 1190   User_2969  User_5854   500.39 2025-03-02  2025-03-02
 ...          ...        ...      ...        ...         ...
 49181  User_8298  User_7849   165.13 2025-03-02  2025-03-02
 49213  User_4370  User_1725  2419.16 2025-03-02  2025-03-02
 49642  User_5524  User_1345   351.86 2025-03-02  2025-03-02
 49860   User_732  User_1386    72.36 2025-03-02  2025-03-02
 49877  User_1578  User_2063   903.75 2025-03-02  2025-03-02

 [267 rows x 5 columns],
```

```
 datetime.date(2025, 5, 16):          sender   receiver   amount  timestam
p         day
 77     User_4887  User_7959   400.82 2025-05-16  2025-05-16
 206    User_9339  User_6987   233.49 2025-05-16  2025-05-16
 488    User_7164  User_2510  1462.60 2025-05-16  2025-05-16
 708    User_6544  User_4340   631.08 2025-05-16  2025-05-16
 789    User_1276  User_5512   818.55 2025-05-16  2025-05-16
 ...          ...        ...      ...        ...         ...
 48754  User_9180  User_8484   199.66 2025-05-16  2025-05-16
 49276  User_5541  User_5445   323.66 2025-05-16  2025-05-16
 49597  User_5997  User_6028    63.61 2025-05-16  2025-05-16
 49835  User_7774  User_5453  1282.57 2025-05-16  2025-05-16
 49919  User_9033  User_8386   300.18 2025-05-16  2025-05-16

 [264 rows x 5 columns],
 datetime.date(2025, 4, 3):          sender   receiver   amount  timestamp
day
 78     User_4859  User_9323  1076.67 2025-04-03  2025-04-03
 224    User_6694  User_8777  1225.86 2025-04-03  2025-04-03
 291    User_9151  User_4261   557.34 2025-04-03  2025-04-03
 333    User_7806  User_8846   307.68 2025-04-03  2025-04-03
 503    User_3440  User_4303   148.69 2025-04-03  2025-04-03
 ...          ...        ...      ...        ...         ...
 49351    User_49  User_8570   877.21 2025-04-03  2025-04-03
 49462    User_95  User_8941  1834.90 2025-04-03  2025-04-03
 49548   User_840  User_8200   344.48 2025-04-03  2025-04-03
 49714  User_5498  User_8537  3175.78 2025-04-03  2025-04-03
 49876    User_85   User_179   949.80 2025-04-03  2025-04-03

 [248 rows x 5 columns],
 datetime.date(2025, 5, 6):          sender   receiver   amount  timestamp
day
 79     User_6331  User_2187  1707.33 2025-05-06  2025-05-06
 253    User_9637   User_758   284.11 2025-05-06  2025-05-06
 433    User_7421  User_9894   556.73 2025-05-06  2025-05-06
 913    User_8162  User_8037   416.68 2025-05-06  2025-05-06
 982    User_2891  User_7097   471.52 2025-05-06  2025-05-06
 ...          ...        ...      ...        ...         ...
 48637   User_125  User_2189   298.40 2025-05-06  2025-05-06
 48830  User_7353  User_1406  1400.10 2025-05-06  2025-05-06
 49156  User_9119  User_7587  5910.81 2025-05-06  2025-05-06
 49509  User_9317   User_751  2080.70 2025-05-06  2025-05-06
 49870  User_2424  User_2446   258.95 2025-05-06  2025-05-06

 [248 rows x 5 columns],
 datetime.date(2025, 6, 9):          sender   receiver   amount  timestamp
day
 80     User_8571  User_5210   481.22 2025-06-09  2025-06-09
 368    User_6457  User_2139  1423.12 2025-06-09  2025-06-09
 792     User_638  User_3856  3014.51 2025-06-09  2025-06-09
 1395   User_1933  User_3167    78.82 2025-06-09  2025-06-09
 1448    User_556  User_1137   494.17 2025-06-09  2025-06-09
 ...          ...        ...      ...        ...         ...
 49150  User_5822  User_8704   323.72 2025-06-09  2025-06-09
 49175  User_7551  User_6911   540.21 2025-06-09  2025-06-09
 49343  User_3602   User_737   548.10 2025-06-09  2025-06-09
 49754  User_4039  User_3691   295.79 2025-06-09  2025-06-09
 49927  User_9256   User_535   632.32 2025-06-09  2025-06-09

 [285 rows x 5 columns],
 datetime.date(2025, 5, 18):          sender   receiver   amount  timestam
p         day
 82     User_7208  User_7377  2252.72 2025-05-18  2025-05-18
 425    User_2744  User_8517   105.15 2025-05-18  2025-05-18
```

```
 617    User_9588  User_9284   623.88 2025-05-18  2025-05-18
 857    User_1063  User_9425   828.71 2025-05-18  2025-05-18
 945    User_2192  User_7491   258.99 2025-05-18  2025-05-18
 ...          ...        ...      ...        ...         ...
 48962  User_3372  User_3681  2626.43 2025-05-18  2025-05-18
 48999   User_590  User_4773   346.42 2025-05-18  2025-05-18
 49463  User_9103  User_1989  1546.86 2025-05-18  2025-05-18
 49533  User_3073  User_6437    53.39 2025-05-18  2025-05-18
 49773  User_7657  User_5999  1679.63 2025-05-18  2025-05-18

 [272 rows x 5 columns],
 datetime.date(2025, 1, 19):           sender   receiver   amount  timestam
p         day
 83     User_5276  User_9788   109.01 2025-01-19  2025-01-19
 104    User_2454  User_3523   495.29 2025-01-19  2025-01-19
 205    User_8800  User_7593    76.24 2025-01-19  2025-01-19
 219    User_1843  User_6706    73.84 2025-01-19  2025-01-19
 603    User_2105  User_9752  1219.94 2025-01-19  2025-01-19
 ...          ...        ...      ...        ...         ...
 48869  User_8412   User_820    96.08 2025-01-19  2025-01-19
 49052  User_4314  User_5289   985.42 2025-01-19  2025-01-19
 49349  User_3245  User_9062  2266.28 2025-01-19  2025-01-19
 49814  User_9709  User_6964  1414.68 2025-01-19  2025-01-19
 49833  User_4513  User_3081   549.90 2025-01-19  2025-01-19

 [307 rows x 5 columns],
 datetime.date(2025, 3, 31):           sender   receiver   amount  timestam
p         day
 85       User_64  User_8194   777.77 2025-03-31  2025-03-31
 541    User_9348  User_2522  1130.57 2025-03-31  2025-03-31
 555    User_5293  User_6951   607.63 2025-03-31  2025-03-31
 684    User_4809  User_2981   705.63 2025-03-31  2025-03-31
 862    User_7489  User_2860   405.29 2025-03-31  2025-03-31
 ...          ...        ...      ...        ...         ...
 48992  User_5126  User_2016   233.70 2025-03-31  2025-03-31
 49649  User_1359  User_2185   388.03 2025-03-31  2025-03-31
 49659  User_1473  User_8541   158.27 2025-03-31  2025-03-31
 49727  User_3590  User_4364  3217.87 2025-03-31  2025-03-31
 49741  User_7826  User_3951   345.51 2025-03-31  2025-03-31

 [292 rows x 5 columns],
 datetime.date(2025, 1, 30):           sender   receiver   amount  timestam
p         day
 86     User_8006  User_3051  1633.47 2025-01-30  2025-01-30
 232    User_4061  User_7953   239.00 2025-01-30  2025-01-30
 401    User_2838  User_7741   845.66 2025-01-30  2025-01-30
 492    User_2967  User_1604   298.61 2025-01-30  2025-01-30
 630    User_9337  User_2087  3289.43 2025-01-30  2025-01-30
 ...          ...        ...      ...        ...         ...
 49336  User_1403  User_7669  1606.36 2025-01-30  2025-01-30
 49645  User_4857  User_7363   831.85 2025-01-30  2025-01-30
 49663  User_7946  User_3623  1498.88 2025-01-30  2025-01-30
 49793  User_6717  User_6588  1831.10 2025-01-30  2025-01-30
 49839  User_8028  User_7669   675.84 2025-01-30  2025-01-30

 [280 rows x 5 columns],
 datetime.date(2025, 3, 3):           sender   receiver   amount  timestamp
day
 90     User_2695  User_9224  1922.95 2025-03-03  2025-03-03
 249    User_6197  User_6754  2037.19 2025-03-03  2025-03-03
 828    User_9795  User_4724  1645.58 2025-03-03  2025-03-03
 832    User_9361  User_7358   338.77 2025-03-03  2025-03-03
 1003   User_4451  User_6798   486.93 2025-03-03  2025-03-03
 ...          ...        ...      ...        ...         ...
```

```
 49104  User_7864  User_1711   141.79 2025-03-03  2025-03-03
 49157  User_1778  User_9369   837.93 2025-03-03  2025-03-03
 49377  User_2275  User_5031  2378.49 2025-03-03  2025-03-03
 49403  User_6026  User_7849  1207.66 2025-03-03  2025-03-03
 49522  User_3458  User_1787  2068.14 2025-03-03  2025-03-03

 [259 rows x 5 columns],
 datetime.date(2025, 1, 9):          sender   receiver   amount  timestamp
day
 91     User_9687  User_7159   629.26 2025-01-09  2025-01-09
 235    User_8815  User_9090   884.06 2025-01-09  2025-01-09
 252    User_5539  User_8723   363.56 2025-01-09  2025-01-09
 260    User_2961  User_2414   182.37 2025-01-09  2025-01-09
 769    User_5124  User_1551  2650.87 2025-01-09  2025-01-09
 ...          ...        ...      ...        ...         ...
 49511  User_5900   User_164  2513.95 2025-01-09  2025-01-09
 49611  User_4927  User_2520  1904.80 2025-01-09  2025-01-09
 49737  User_1725  User_4160   747.62 2025-01-09  2025-01-09
 49900  User_2745  User_7956   233.56 2025-01-09  2025-01-09
 49990  User_4906  User_2664    33.61 2025-01-09  2025-01-09

 [275 rows x 5 columns],
 datetime.date(2025, 4, 6):          sender   receiver   amount  timestamp
day
 94     User_6736  User_7058  3018.36 2025-04-06  2025-04-06
 284    User_3436  User_9239  1407.02 2025-04-06  2025-04-06
 397    User_9561    User_68  1304.59 2025-04-06  2025-04-06
 405    User_9204  User_3892   372.71 2025-04-06  2025-04-06
 409    User_7805  User_1076  1748.82 2025-04-06  2025-04-06
 ...          ...        ...      ...        ...         ...
 49502  User_4055  User_7334    91.63 2025-04-06  2025-04-06
 49637  User_9089  User_5055   325.97 2025-04-06  2025-04-06
 49669  User_2177  User_4347   415.96 2025-04-06  2025-04-06
 49849  User_9980  User_4447   395.75 2025-04-06  2025-04-06
 49923  User_3197  User_4536   398.88 2025-04-06  2025-04-06

 [273 rows x 5 columns],
 datetime.date(2025, 2, 10):           sender   receiver   amount  timestam
p         day
 95      User_391  User_1462   836.51 2025-02-10  2025-02-10
 189    User_9925  User_1648  3582.49 2025-02-10  2025-02-10
 542    User_7330  User_5693   417.06 2025-02-10  2025-02-10
 627    User_7575  User_2833  1282.89 2025-02-10  2025-02-10
 854    User_9352  User_6423  3662.63 2025-02-10  2025-02-10
 ...          ...        ...      ...        ...         ...
 48975  User_4193  User_7926  1122.54 2025-02-10  2025-02-10
 49120  User_4974  User_7737  1186.39 2025-02-10  2025-02-10
 49286  User_1440  User_1678   120.37 2025-02-10  2025-02-10
 49380  User_1917  User_8552  2022.41 2025-02-10  2025-02-10
 49489  User_7956  User_3117    71.38 2025-02-10  2025-02-10

 [274 rows x 5 columns],
 datetime.date(2025, 1, 16):           sender   receiver   amount  timestam
p         day
 96     User_5892  User_9063  1300.39 2025-01-16  2025-01-16
 160    User_5530  User_1999  2289.09 2025-01-16  2025-01-16
 193     User_202  User_6015  1230.36 2025-01-16  2025-01-16
 434    User_9949  User_2488   903.69 2025-01-16  2025-01-16
 467    User_4107  User_3258  1129.84 2025-01-16  2025-01-16
 ...          ...        ...      ...        ...         ...
 48420  User_8381  User_5004  3314.82 2025-01-16  2025-01-16
 48658  User_7911  User_2867  1820.98 2025-01-16  2025-01-16
 48905  User_3873  User_5545   890.03 2025-01-16  2025-01-16
 49340  User_9794  User_3816   702.90 2025-01-16  2025-01-16
```

```
 49811  User_4834  User_6897  1134.75 2025-01-16  2025-01-16

 [280 rows x 5 columns],
 datetime.date(2025, 1, 10):          sender   receiver   amount  timestam
p         day
 97     User_3561  User_9413   284.90 2025-01-10  2025-01-10
 240    User_3108  User_2274  1245.95 2025-01-10  2025-01-10
 484     User_412  User_7474   306.41 2025-01-10  2025-01-10
 491    User_2504  User_1871    30.98 2025-01-10  2025-01-10
 496    User_1571   User_641   788.78 2025-01-10  2025-01-10
 ...          ...        ...      ...        ...         ...
 49232  User_1481  User_4453  2606.28 2025-01-10  2025-01-10
 49454  User_7320  User_7554    67.33 2025-01-10  2025-01-10
 49469  User_7015  User_7597   827.65 2025-01-10  2025-01-10
 49905  User_5961  User_3449  1219.57 2025-01-10  2025-01-10
 49951   User_545  User_4586    36.09 2025-01-10  2025-01-10

 [290 rows x 5 columns],
 datetime.date(2025, 3, 25):          sender   receiver   amount  timestam
p         day
 99     User_3099  User_6296   616.23 2025-03-25  2025-03-25
 270    User_4911  User_1077   578.64 2025-03-25  2025-03-25
 529    User_7192  User_7772  1088.55 2025-03-25  2025-03-25
 669    User_4784  User_5820   311.91 2025-03-25  2025-03-25
 904    User_9310  User_1883   248.87 2025-03-25  2025-03-25
 ...          ...        ...      ...        ...         ...
 47551  User_1307  User_9117    32.47 2025-03-25  2025-03-25
 47787  User_3022  User_4079  2328.21 2025-03-25  2025-03-25
 47979  User_6805  User_3625  1220.29 2025-03-25  2025-03-25
 48393   User_300  User_3345   172.42 2025-03-25  2025-03-25
 48959  User_2668  User_2251   522.51 2025-03-25  2025-03-25

 [262 rows x 5 columns],
 datetime.date(2025, 6, 19):          sender   receiver   amount  timestam
p         day
 101    User_8392  User_1131  1772.94 2025-06-19  2025-06-19
 140    User_6668  User_1144   308.75 2025-06-19  2025-06-19
 350    User_2950  User_4670   549.87 2025-06-19  2025-06-19
 806    User_5870  User_8440   213.36 2025-06-19  2025-06-19
 837    User_6891  User_4904    40.18 2025-06-19  2025-06-19
 ...          ...        ...      ...        ...         ...
 49197  User_3267  User_3921  2204.94 2025-06-19  2025-06-19
 49239  User_7080  User_9572  1419.81 2025-06-19  2025-06-19
 49284  User_5120  User_8080   241.02 2025-06-19  2025-06-19
 49490  User_3808  User_5028  2082.86 2025-06-19  2025-06-19
 49785  User_1444  User_4374   761.35 2025-06-19  2025-06-19

 [296 rows x 5 columns],
 datetime.date(2025, 3, 16):          sender   receiver   amount  timestam
p         day
 102    User_3104   User_810  1828.46 2025-03-16  2025-03-16
 150    User_9721  User_2627  1383.62 2025-03-16  2025-03-16
 381     User_876  User_2674  3803.30 2025-03-16  2025-03-16
 547    User_6801  User_3294   603.99 2025-03-16  2025-03-16
 850    User_6767  User_9966   142.99 2025-03-16  2025-03-16
 ...          ...        ...      ...        ...         ...
 49448  User_1074  User_6423  1630.39 2025-03-16  2025-03-16
 49494  User_2713  User_1168   560.47 2025-03-16  2025-03-16
 49512  User_3323  User_8093  1235.74 2025-03-16  2025-03-16
 49655  User_3049  User_8380  1791.27 2025-03-16  2025-03-16
 49863  User_2824   User_452  2108.71 2025-03-16  2025-03-16

 [269 rows x 5 columns],
 datetime.date(2025, 1, 2):          sender   receiver   amount  timestamp
```

```
day
 103    User_7215    User_55    65.83 2025-01-02  2025-01-02
 356    User_4495  User_4901  3059.69 2025-01-02  2025-01-02
 763     User_666  User_9107  1043.95 2025-01-02  2025-01-02
 874    User_9333  User_8964    32.62 2025-01-02  2025-01-02
 1132   User_3695  User_3351   350.29 2025-01-02  2025-01-02
 ...          ...        ...      ...        ...         ...
 49496  User_6118  User_9553  1167.56 2025-01-02  2025-01-02
 49547  User_3792  User_3786  2127.12 2025-01-02  2025-01-02
 49595  User_6049  User_3791   257.16 2025-01-02  2025-01-02
 49769  User_8899  User_8508   543.58 2025-01-02  2025-01-02
 49946  User_9760  User_9304  3881.70 2025-01-02  2025-01-02

 [315 rows x 5 columns],
 datetime.date(2025, 2, 27):           sender   receiver   amount  timestam
p         day
 107    User_8154  User_3279   670.99 2025-02-27  2025-02-27
 119     User_206  User_8431   500.25 2025-02-27  2025-02-27
 169    User_5232    User_91   183.09 2025-02-27  2025-02-27
 201     User_197  User_8396   450.19 2025-02-27  2025-02-27
 343    User_2806  User_9946    81.82 2025-02-27  2025-02-27
 ...          ...        ...      ...        ...         ...
 49148  User_5335  User_5599  1227.70 2025-02-27  2025-02-27
 49266  User_6789  User_9876  3226.58 2025-02-27  2025-02-27
 49636  User_2203  User_5081   847.92 2025-02-27  2025-02-27
 49679  User_7192   User_830    55.39 2025-02-27  2025-02-27
 49726  User_6074  User_7322  1082.87 2025-02-27  2025-02-27

 [295 rows x 5 columns],
 datetime.date(2025, 5, 10):           sender   receiver   amount  timestam
p         day
 108    User_9762  User_1533  1068.36 2025-05-10  2025-05-10
 285    User_8754  User_7764   956.01 2025-05-10  2025-05-10
 323    User_6709  User_2108  1051.18 2025-05-10  2025-05-10
 561    User_1540  User_6846  2137.37 2025-05-10  2025-05-10
 866    User_8837  User_2471  1115.61 2025-05-10  2025-05-10
 ...          ...        ...      ...        ...         ...
 49381  User_9313  User_4777   839.16 2025-05-10  2025-05-10
 49413  User_7645  User_2233  1608.22 2025-05-10  2025-05-10
 49480  User_8696  User_4275    73.30 2025-05-10  2025-05-10
 49615   User_904  User_4743  2273.14 2025-05-10  2025-05-10
 49906  User_7591   User_475   662.53 2025-05-10  2025-05-10

 [272 rows x 5 columns],
 datetime.date(2025, 1, 18):           sender   receiver   amount  timestam
p         day
 109    User_5056  User_4011   284.34 2025-01-18  2025-01-18
 197    User_2327  User_9165  2177.87 2025-01-18  2025-01-18
 450    User_6303  User_6823   167.35 2025-01-18  2025-01-18
 618    User_8053  User_7639    69.46 2025-01-18  2025-01-18
 1045   User_6490  User_7490   711.08 2025-01-18  2025-01-18
 ...          ...        ...      ...        ...         ...
 49137  User_7109  User_9150   441.96 2025-01-18  2025-01-18
 49419  User_6006  User_7618  2241.91 2025-01-18  2025-01-18
 49735    User_50  User_8690  1154.24 2025-01-18  2025-01-18
 49895  User_8307  User_6020   955.92 2025-01-18  2025-01-18
 49903   User_626  User_9538  4666.61 2025-01-18  2025-01-18

 [276 rows x 5 columns],
 datetime.date(2025, 6, 7):           sender   receiver   amount  timestamp
day
 110    User_8110   User_933   250.64 2025-06-07  2025-06-07
 352    User_4780  User_9166   227.17 2025-06-07  2025-06-07
 394    User_8311  User_4957  1318.41 2025-06-07  2025-06-07
```

```
 865    User_5966  User_7790    69.25 2025-06-07  2025-06-07
 1001   User_3531  User_4618   162.69 2025-06-07  2025-06-07
 ...          ...        ...      ...        ...         ...
 49021    User_61   User_546   284.92 2025-06-07  2025-06-07
 49172  User_7274  User_6222   735.22 2025-06-07  2025-06-07
 49894  User_7985  User_5009    79.78 2025-06-07  2025-06-07
 49980  User_8475  User_5148   334.02 2025-06-07  2025-06-07
 49981  User_9024  User_7167   737.21 2025-06-07  2025-06-07

 [284 rows x 5 columns],
 datetime.date(2025, 5, 21):           sender   receiver   amount  timestam
p         day
 112    User_1028  User_3845  3738.29 2025-05-21  2025-05-21
 286    User_5895  User_7309    27.87 2025-05-21  2025-05-21
 300    User_9435   User_761  3810.63 2025-05-21  2025-05-21
 408     User_512  User_6043   724.30 2025-05-21  2025-05-21
 429    User_6617  User_1585  3594.84 2025-05-21  2025-05-21
 ...          ...        ...      ...        ...         ...
 49458  User_5048  User_8464   104.13 2025-05-21  2025-05-21
 49560  User_5684  User_7651    34.68 2025-05-21  2025-05-21
 49602  User_2291  User_3677   713.82 2025-05-21  2025-05-21
 49748  User_8846  User_3386  1421.84 2025-05-21  2025-05-21
 49886  User_6971  User_5011   509.91 2025-05-21  2025-05-21

 [250 rows x 5 columns],
 datetime.date(2025, 6, 4):           sender   receiver   amount  timestamp
day
 113    User_7385  User_3023  2925.17 2025-06-04  2025-06-04
 565    User_1365  User_9369   667.75 2025-06-04  2025-06-04
 631    User_6819  User_3110   169.45 2025-06-04  2025-06-04
 802    User_1646  User_9090   433.06 2025-06-04  2025-06-04
 812    User_6882  User_1197   287.77 2025-06-04  2025-06-04
 ...          ...        ...      ...        ...         ...
 49345  User_4096  User_8332  1294.84 2025-06-04  2025-06-04
 49435  User_3619  User_1512   336.70 2025-06-04  2025-06-04
 49566  User_2253  User_9971  1653.08 2025-06-04  2025-06-04
 49802  User_4302  User_4081   226.80 2025-06-04  2025-06-04
 49836   User_241  User_4351  1033.54 2025-06-04  2025-06-04

 [253 rows x 5 columns],
 datetime.date(2025, 3, 7):           sender   receiver   amount  timestamp
day
 114     User_502  User_5967  1570.15 2025-03-07  2025-03-07
 521     User_717  User_7668   997.46 2025-03-07  2025-03-07
 1228   User_7617  User_9174   561.29 2025-03-07  2025-03-07
 1696   User_4648  User_8876   484.85 2025-03-07  2025-03-07
 2216   User_5330  User_8766     3.86 2025-03-07  2025-03-07
 ...          ...        ...      ...        ...         ...
 49214  User_3878  User_2510   293.24 2025-03-07  2025-03-07
 49306  User_4072  User_6694   276.64 2025-03-07  2025-03-07
 49436  User_5065  User_4034   323.74 2025-03-07  2025-03-07
 49664  User_4502  User_6578   612.85 2025-03-07  2025-03-07
 49668  User_4901  User_4801  4337.32 2025-03-07  2025-03-07

 [296 rows x 5 columns],
 datetime.date(2025, 1, 29):           sender   receiver   amount  timestam
p         day
 116    User_9062  User_7907   271.51 2025-01-29  2025-01-29
 194    User_4218  User_8521  1027.18 2025-01-29  2025-01-29
 268    User_4493  User_2860   597.35 2025-01-29  2025-01-29
 539    User_6541   User_577   247.23 2025-01-29  2025-01-29
 544    User_8924  User_5724   285.65 2025-01-29  2025-01-29
 ...          ...        ...      ...        ...         ...
 48318  User_3397  User_3263   331.79 2025-01-29  2025-01-29
```

```
 48326  User_4225  User_1727   592.57 2025-01-29  2025-01-29
 48542  User_6910  User_8780  1513.27 2025-01-29  2025-01-29
 49105  User_1479   User_627   120.07 2025-01-29  2025-01-29
 49528  User_3069  User_4151  2732.64 2025-01-29  2025-01-29

 [261 rows x 5 columns],
 datetime.date(2025, 5, 3):           sender   receiver   amount  timestamp
day
 118    User_4488  User_6280   350.65 2025-05-03  2025-05-03
 142    User_3157   User_295   673.28 2025-05-03  2025-05-03
 353    User_2368  User_8697  1590.66 2025-05-03  2025-05-03
 550    User_7241  User_8817   422.86 2025-05-03  2025-05-03
 647    User_1581   User_216  1360.29 2025-05-03  2025-05-03
 ...          ...        ...      ...        ...         ...
 48569  User_2996  User_1702  1269.11 2025-05-03  2025-05-03
 48721  User_8190  User_6440  1135.44 2025-05-03  2025-05-03
 48757  User_2428  User_8784  1187.36 2025-05-03  2025-05-03
 48897  User_9605  User_5640   814.75 2025-05-03  2025-05-03
 49036  User_2302  User_8290  2750.45 2025-05-03  2025-05-03

 [284 rows x 5 columns],
 datetime.date(2025, 6, 8):           sender   receiver   amount  timestamp
day
 120    User_5134  User_2004  3072.25 2025-06-08  2025-06-08
 154    User_6776  User_7618  1662.91 2025-06-08  2025-06-08
 274    User_1218  User_9436  1298.70 2025-06-08  2025-06-08
 404    User_1931  User_3192  1081.89 2025-06-08  2025-06-08
 447    User_8527  User_5761   537.47 2025-06-08  2025-06-08
 ...          ...        ...      ...        ...         ...
 49355  User_3588  User_3748  1642.44 2025-06-08  2025-06-08
 49361   User_187  User_3486  4971.13 2025-06-08  2025-06-08
 49536  User_9683  User_5512  1847.24 2025-06-08  2025-06-08
 49583   User_683  User_2051   719.38 2025-06-08  2025-06-08
 49948  User_8793  User_1928   198.49 2025-06-08  2025-06-08

 [254 rows x 5 columns],
 datetime.date(2025, 6, 25):           sender   receiver   amount  timestam
p         day
 121    User_5977  User_6592    90.26 2025-06-25  2025-06-25
 334     User_154  User_7644  3396.34 2025-06-25  2025-06-25
 562    User_6172  User_8916   274.58 2025-06-25  2025-06-25
 771    User_4777  User_9056   408.24 2025-06-25  2025-06-25
 1160   User_2599  User_4661    59.83 2025-06-25  2025-06-25
 ...          ...        ...      ...        ...         ...
 48762  User_7347  User_8381    31.22 2025-06-25  2025-06-25
 48909  User_5606   User_435  1815.20 2025-06-25  2025-06-25
 48985  User_2577  User_8144   544.74 2025-06-25  2025-06-25
 49609  User_2564  User_5535    17.22 2025-06-25  2025-06-25
 49935  User_9136  User_4181   304.53 2025-06-25  2025-06-25

 [291 rows x 5 columns],
 datetime.date(2025, 3, 23):           sender   receiver   amount  timestam
p         day
 123    User_7035  User_4246    51.61 2025-03-23  2025-03-23
 263    User_2869  User_9605   529.51 2025-03-23  2025-03-23
 946    User_1248  User_3538  4638.28 2025-03-23  2025-03-23
 960    User_5408  User_6801   416.52 2025-03-23  2025-03-23
 1315    User_920  User_2912   121.01 2025-03-23  2025-03-23
 ...          ...        ...      ...        ...         ...
 49003  User_8283  User_8431   278.01 2025-03-23  2025-03-23
 49335   User_496   User_698   171.11 2025-03-23  2025-03-23
 49371   User_617  User_5499   690.57 2025-03-23  2025-03-23
 49694  User_7726  User_3614   158.97 2025-03-23  2025-03-23
 49730  User_6613   User_835  1864.38 2025-03-23  2025-03-23
```

```
 [257 rows x 5 columns],
 datetime.date(2025, 1, 3):          sender   receiver   amount  timestamp
day
 126     User_863  User_8994   440.65 2025-01-03  2025-01-03
 136    User_1678  User_3151  1158.56 2025-01-03  2025-01-03
 173    User_3581  User_8696   459.73 2025-01-03  2025-01-03
 567    User_9872  User_2841  2618.38 2025-01-03  2025-01-03
 594    User_6530  User_3093   156.30 2025-01-03  2025-01-03
 ...          ...        ...      ...        ...         ...
 49510  User_6201  User_8762  1913.13 2025-01-03  2025-01-03
 49561  User_4903  User_1496   980.31 2025-01-03  2025-01-03
 49757  User_8456  User_4693  2645.10 2025-01-03  2025-01-03
 49844  User_3395   User_411   230.63 2025-01-03  2025-01-03
 49961  User_3303  User_5107   409.04 2025-01-03  2025-01-03

 [283 rows x 5 columns],
 datetime.date(2025, 3, 17):          sender   receiver   amount  timestam
p         day
 129    User_8755  User_9325  1323.65 2025-03-17  2025-03-17
 243    User_3170   User_603   165.02 2025-03-17  2025-03-17
 449    User_9087  User_1950   623.44 2025-03-17  2025-03-17
 581    User_8905  User_8014  1364.93 2025-03-17  2025-03-17
 1245   User_4197  User_3727   940.91 2025-03-17  2025-03-17
 ...          ...        ...      ...        ...         ...
 48736  User_8357  User_7463  1063.04 2025-03-17  2025-03-17
 48879  User_4731  User_3447   265.65 2025-03-17  2025-03-17
 49400  User_7740  User_8560   992.24 2025-03-17  2025-03-17
 49692  User_2104  User_1395   618.66 2025-03-17  2025-03-17
 49781  User_8360  User_1914  1845.87 2025-03-17  2025-03-17

 [259 rows x 5 columns],
 datetime.date(2025, 4, 9):          sender   receiver   amount  timestamp
day
 130    User_5116  User_4561  1210.88 2025-04-09  2025-04-09
 461    User_8002    User_65   680.35 2025-04-09  2025-04-09
 532    User_3636  User_7545  2186.77 2025-04-09  2025-04-09
 1400   User_9179  User_1933   735.38 2025-04-09  2025-04-09
 1461    User_294  User_2024   248.13 2025-04-09  2025-04-09
 ...          ...        ...      ...        ...         ...
 49268  User_4618  User_2489  1361.50 2025-04-09  2025-04-09
 49309  User_1392  User_2297   242.63 2025-04-09  2025-04-09
 49483  User_4060  User_5109  1053.20 2025-04-09  2025-04-09
 49853  User_9964  User_8127   364.23 2025-04-09  2025-04-09
 49982  User_4677  User_6286   590.92 2025-04-09  2025-04-09

 [281 rows x 5 columns],
 datetime.date(2025, 2, 9):          sender   receiver   amount  timestamp
day
 131    User_6019  User_1063  1802.37 2025-02-09  2025-02-09
 456    User_4000  User_4153  2465.47 2025-02-09  2025-02-09
 466    User_4380  User_9559  1087.81 2025-02-09  2025-02-09
 540    User_4729  User_5516   403.13 2025-02-09  2025-02-09
 570    User_4312  User_5509  1570.07 2025-02-09  2025-02-09
 ...          ...        ...      ...        ...         ...
 49722   User_844   User_469  1239.00 2025-02-09  2025-02-09
 49764  User_9637  User_9354   250.44 2025-02-09  2025-02-09
 49770  User_7210   User_582  1010.16 2025-02-09  2025-02-09
 49847  User_6673  User_9630    47.28 2025-02-09  2025-02-09
 49858  User_6149  User_9779  1290.83 2025-02-09  2025-02-09

 [277 rows x 5 columns],
 datetime.date(2025, 6, 27):          sender   receiver   amount  timestam
p         day
```

```
 133    User_7574  User_9740   627.95 2025-06-27  2025-06-27
 178     User_698  User_9447   399.66 2025-06-27  2025-06-27
 400    User_5949  User_7369   427.54 2025-06-27  2025-06-27
 1179   User_1622  User_9468   311.61 2025-06-27  2025-06-27
 1419   User_8987  User_2415   112.09 2025-06-27  2025-06-27
 ...          ...        ...      ...        ...         ...
 49250  User_5654  User_3189  3413.54 2025-06-27  2025-06-27
 49379  User_2206  User_4341    26.49 2025-06-27  2025-06-27
 49710  User_2980  User_5207  2179.55 2025-06-27  2025-06-27
 49716  User_3203   User_755   627.11 2025-06-27  2025-06-27
 49751  User_3189   User_812  1133.97 2025-06-27  2025-06-27

 [316 rows x 5 columns],
 datetime.date(2025, 4, 30):           sender   receiver   amount  timestam
p         day
 135    User_6892    User_52  1059.73 2025-04-30  2025-04-30
 229    User_8120  User_2703    28.38 2025-04-30  2025-04-30
 622    User_8120  User_9461   560.12 2025-04-30  2025-04-30
 675     User_404   User_725  1229.68 2025-04-30  2025-04-30
 972    User_4612  User_6940  2008.09 2025-04-30  2025-04-30
 ...          ...        ...      ...        ...         ...
 49393  User_9171  User_8947  1489.46 2025-04-30  2025-04-30
 49725  User_5969  User_5845   575.68 2025-04-30  2025-04-30
 49762  User_5710  User_8181   209.75 2025-04-30  2025-04-30
 49830  User_7139  User_6371  6358.86 2025-04-30  2025-04-30
 49913  User_5936  User_2105   449.68 2025-04-30  2025-04-30

 [280 rows x 5 columns],
 datetime.date(2025, 1, 27):           sender   receiver   amount  timestam
p         day
 138    User_4636  User_5670   281.17 2025-01-27  2025-01-27
 239    User_4548  User_4918   584.55 2025-01-27  2025-01-27
 921    User_9064    User_27  1350.76 2025-01-27  2025-01-27
 985      User_94  User_8667  1496.72 2025-01-27  2025-01-27
 1101     User_54  User_6965    93.80 2025-01-27  2025-01-27
 ...          ...        ...      ...        ...         ...
 49550  User_5712  User_1650   756.36 2025-01-27  2025-01-27
 49653    User_99   User_318   950.38 2025-01-27  2025-01-27
 49682  User_1455  User_2637   561.75 2025-01-27  2025-01-27
 49777  User_5827  User_6370  2428.32 2025-01-27  2025-01-27
 49800  User_1662   User_256  1447.93 2025-01-27  2025-01-27

 [270 rows x 5 columns],
 datetime.date(2025, 1, 26):           sender   receiver   amount  timestam
p         day
 139    User_1059  User_2786  1163.68 2025-01-26  2025-01-26
 147    User_9555  User_8147   479.84 2025-01-26  2025-01-26
 298    User_8208  User_4017   191.62 2025-01-26  2025-01-26
 312    User_9331  User_5580   401.89 2025-01-26  2025-01-26
 395     User_830  User_3904  1208.63 2025-01-26  2025-01-26
 ...          ...        ...      ...        ...         ...
 49112  User_9263  User_8654  2116.33 2025-01-26  2025-01-26
 49273  User_1329  User_5744   263.53 2025-01-26  2025-01-26
 49333  User_4093  User_3621   587.21 2025-01-26  2025-01-26
 49431  User_6601   User_625   293.83 2025-01-26  2025-01-26
 49786  User_6022  User_4011   752.13 2025-01-26  2025-01-26

 [291 rows x 5 columns],
 datetime.date(2025, 4, 26):           sender   receiver   amount  timestam
p         day
 143    User_5915  User_4742   266.62 2025-04-26  2025-04-26
 275    User_4496  User_5801    16.00 2025-04-26  2025-04-26
 519    User_4360  User_5857  3854.00 2025-04-26  2025-04-26
 614    User_5645  User_7800   169.50 2025-04-26  2025-04-26
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 737    User_6327  User_6742  1257.80 2025-04-26  2025-04-26
 ...          ...        ...      ...        ...         ...
 49032  User_1711  User_1402  2778.39 2025-04-26  2025-04-26
 49045  User_9148  User_3174    56.32 2025-04-26  2025-04-26
 49208  User_9434  User_7771   204.87 2025-04-26  2025-04-26
 49253  User_6559  User_8580   664.30 2025-04-26  2025-04-26
 49881  User_3714  User_8503  1049.50 2025-04-26  2025-04-26

 [284 rows x 5 columns],
 datetime.date(2025, 2, 11):           sender   receiver   amount  timestam
p         day
 145    User_2693  User_6278   829.55 2025-02-11  2025-02-11
 611    User_6190  User_1027   813.06 2025-02-11  2025-02-11
 1394   User_4675  User_8322  1048.40 2025-02-11  2025-02-11
 1917   User_5752  User_3384  1015.57 2025-02-11  2025-02-11
 1959   User_2349  User_3998    19.31 2025-02-11  2025-02-11
 ...          ...        ...      ...        ...         ...
 49167  User_6593  User_4892   510.80 2025-02-11  2025-02-11
 49174  User_7155   User_895  2111.97 2025-02-11  2025-02-11
 49219   User_675   User_339    77.23 2025-02-11  2025-02-11
 49331   User_447  User_9825   800.53 2025-02-11  2025-02-11
 49736  User_5538  User_5809  1034.32 2025-02-11  2025-02-11

 [280 rows x 5 columns],
 datetime.date(2025, 4, 18):           sender   receiver   amount  timestam
p         day
 149    User_1663  User_7011   825.74 2025-04-18  2025-04-18
 241    User_7158  User_2161   228.87 2025-04-18  2025-04-18
 346    User_1841  User_2135   480.27 2025-04-18  2025-04-18
 929      User_77  User_3714  1455.69 2025-04-18  2025-04-18
 2312    User_448  User_6371   188.50 2025-04-18  2025-04-18
 ...          ...        ...      ...        ...         ...
 49249  User_5154  User_5898  3132.27 2025-04-18  2025-04-18
 49442  User_7977  User_7010   890.57 2025-04-18  2025-04-18
 49451  User_1915  User_5947  1781.58 2025-04-18  2025-04-18
 49641   User_171  User_1405   324.48 2025-04-18  2025-04-18
 49942  User_4948  User_3858  1633.02 2025-04-18  2025-04-18

 [266 rows x 5 columns],
 datetime.date(2025, 4, 8):           sender   receiver   amount  timestamp
day
 152    User_7392  User_6146   142.21 2025-04-08  2025-04-08
 414    User_3343   User_123  1895.01 2025-04-08  2025-04-08
 438    User_2849  User_9857  1678.74 2025-04-08  2025-04-08
 460    User_5387  User_9353  1130.33 2025-04-08  2025-04-08
 637    User_4835  User_9125  1443.48 2025-04-08  2025-04-08
 ...          ...        ...      ...        ...         ...
 49654  User_3442  User_4644    24.26 2025-04-08  2025-04-08
 49705  User_6671  User_8439  1394.34 2025-04-08  2025-04-08
 49763  User_9926  User_2905   268.15 2025-04-08  2025-04-08
 49774  User_7733  User_6613  2767.48 2025-04-08  2025-04-08
 49911  User_5867  User_7028  1957.66 2025-04-08  2025-04-08

 [288 rows x 5 columns],
 datetime.date(2025, 3, 30):           sender   receiver   amount  timestam
p         day
 153    User_1306  User_9785   359.53 2025-03-30  2025-03-30
 678    User_9860    User_81   334.39 2025-03-30  2025-03-30
 744    User_7941  User_6396   929.26 2025-03-30  2025-03-30
 940    User_5142  User_5967  1295.64 2025-03-30  2025-03-30
 1239   User_7970  User_1106   553.26 2025-03-30  2025-03-30
 ...          ...        ...      ...        ...         ...
 48763  User_2115  User_7372   885.22 2025-03-30  2025-03-30
 49040  User_1882   User_921   589.91 2025-03-30  2025-03-30
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 49262  User_3975  User_2050  2643.45 2025-03-30  2025-03-30
 49354  User_7210  User_6434  4234.44 2025-03-30  2025-03-30
 49887  User_2851   User_806  1501.60 2025-03-30  2025-03-30

 [278 rows x 5 columns],
 datetime.date(2025, 5, 24):           sender   receiver   amount  timestam
p         day
 155    User_5864  User_8701   654.92 2025-05-24  2025-05-24
 203    User_1930   User_362   930.23 2025-05-24  2025-05-24
 213    User_6546   User_482  1956.50 2025-05-24  2025-05-24
 357    User_9163   User_580   231.71 2025-05-24  2025-05-24
 376    User_3051  User_1664   890.89 2025-05-24  2025-05-24
 ...          ...        ...      ...        ...         ...
 49409  User_9050   User_287   842.50 2025-05-24  2025-05-24
 49464  User_4388  User_6481  1540.06 2025-05-24  2025-05-24
 49470  User_7374  User_4978   270.02 2025-05-24  2025-05-24
 49723  User_2665   User_630  1188.27 2025-05-24  2025-05-24
 49962  User_9645  User_8417   454.15 2025-05-24  2025-05-24

 [289 rows x 5 columns],
 datetime.date(2025, 4, 15):           sender   receiver   amount  timestam
p         day
 156    User_9474  User_7935   715.16 2025-04-15  2025-04-15
 199    User_2931  User_2237   164.83 2025-04-15  2025-04-15
 464    User_1066  User_5290   217.28 2025-04-15  2025-04-15
 526    User_4980  User_3066   810.71 2025-04-15  2025-04-15
 546    User_8010  User_5547   624.74 2025-04-15  2025-04-15
 ...          ...        ...      ...        ...         ...
 49088  User_1015  User_5040   973.86 2025-04-15  2025-04-15
 49438   User_791  User_7141  1227.33 2025-04-15  2025-04-15
 49506  User_3817  User_7093  1122.11 2025-04-15  2025-04-15
 49549  User_9569  User_3535   571.13 2025-04-15  2025-04-15
 49678  User_2716  User_3569   568.61 2025-04-15  2025-04-15

 [252 rows x 5 columns],
 datetime.date(2025, 5, 28):           sender   receiver   amount  timestam
p         day
 157    User_7526  User_1891   526.29 2025-05-28  2025-05-28
 423    User_3506  User_1744  1762.19 2025-05-28  2025-05-28
 691     User_716  User_8239   333.26 2025-05-28  2025-05-28
 726    User_7648  User_6055    58.97 2025-05-28  2025-05-28
 1141   User_4841  User_8644  1134.89 2025-05-28  2025-05-28
 ...          ...        ...      ...        ...         ...
 49154  User_4668  User_7823   708.70 2025-05-28  2025-05-28
 49256  User_2237  User_5784   254.18 2025-05-28  2025-05-28
 49264  User_5674  User_9320    38.72 2025-05-28  2025-05-28
 49318  User_3306  User_4353   359.55 2025-05-28  2025-05-28
 49780  User_9432  User_8596  1781.00 2025-05-28  2025-05-28

 [274 rows x 5 columns],
 datetime.date(2025, 4, 25):           sender   receiver   amount  timestam
p         day
 166    User_1495  User_1460   743.33 2025-04-25  2025-04-25
 175    User_7280  User_4782  1744.37 2025-04-25  2025-04-25
 396    User_5177   User_448  2774.90 2025-04-25  2025-04-25
 962    User_9446  User_4313   243.47 2025-04-25  2025-04-25
 1064   User_4243  User_1565   505.56 2025-04-25  2025-04-25
 ...          ...        ...      ...        ...         ...
 49401  User_9318  User_8049  1978.08 2025-04-25  2025-04-25
 49450   User_468  User_7854  1040.16 2025-04-25  2025-04-25
 49472  User_7658  User_8633   705.52 2025-04-25  2025-04-25
 49487  User_4931  User_6087   410.66 2025-04-25  2025-04-25
 49708  User_4044  User_6064   989.99 2025-04-25  2025-04-25
```

```
 [266 rows x 5 columns],
 datetime.date(2025, 1, 23):           sender   receiver   amount  timestam
p         day
 167    User_3304  User_8925   157.49 2025-01-23  2025-01-23
 267    User_6944  User_5418    32.71 2025-01-23  2025-01-23
 796    User_2125  User_4399   563.61 2025-01-23  2025-01-23
 963     User_922  User_6828  3279.89 2025-01-23  2025-01-23
 1174   User_5475  User_7033  4843.63 2025-01-23  2025-01-23
 ...          ...        ...      ...        ...         ...
 49570   User_955  User_7246    35.91 2025-01-23  2025-01-23
 49586  User_8457  User_5630  2185.97 2025-01-23  2025-01-23
 49644  User_8008  User_8199   527.65 2025-01-23  2025-01-23
 49656  User_8619  User_6931    74.53 2025-01-23  2025-01-23
 49715  User_3388  User_3328  1051.45 2025-01-23  2025-01-23

 [288 rows x 5 columns],
 datetime.date(2025, 2, 14):           sender   receiver   amount  timestam
p         day
 168    User_3763   User_532    98.25 2025-02-14  2025-02-14
 297    User_7679  User_2017  1656.42 2025-02-14  2025-02-14
 361    User_5919  User_3952   495.79 2025-02-14  2025-02-14
 502    User_7357  User_4918   646.93 2025-02-14  2025-02-14
 651    User_7026  User_4712   386.46 2025-02-14  2025-02-14
 ...          ...        ...      ...        ...         ...
 49107  User_3066  User_1455   465.83 2025-02-14  2025-02-14
 49397  User_8125  User_3832   272.74 2025-02-14  2025-02-14
 49456  User_8133  User_8293   534.36 2025-02-14  2025-02-14
 49693  User_2053  User_7669   359.87 2025-02-14  2025-02-14
 49813  User_7989  User_1684  3156.67 2025-02-14  2025-02-14

 [283 rows x 5 columns],
 datetime.date(2025, 5, 12):           sender   receiver   amount  timestam
p         day
 170    User_1853  User_1819  1409.18 2025-05-12  2025-05-12
 419    User_8130  User_9307   346.93 2025-05-12  2025-05-12
 437    User_6665   User_213    64.90 2025-05-12  2025-05-12
 510     User_728  User_6980    49.14 2025-05-12  2025-05-12
 525    User_8335  User_2052   971.66 2025-05-12  2025-05-12
 ...          ...        ...      ...        ...         ...
 48798  User_2582  User_6151   907.42 2025-05-12  2025-05-12
 48810  User_6294  User_1114  1328.53 2025-05-12  2025-05-12
 49657   User_586  User_9531   137.81 2025-05-12  2025-05-12
 49690  User_8752  User_3878   535.79 2025-05-12  2025-05-12
 49931  User_1472  User_5836   687.96 2025-05-12  2025-05-12

 [276 rows x 5 columns],
 datetime.date(2025, 4, 27):           sender   receiver   amount  timestam
p         day
 171    User_6585  User_1156   210.67 2025-04-27  2025-04-27
 182    User_5855  User_4059   630.44 2025-04-27  2025-04-27
 190    User_5535  User_8957   964.02 2025-04-27  2025-04-27
 1007   User_3177  User_8047   244.84 2025-04-27  2025-04-27
 1440    User_362  User_5234   706.08 2025-04-27  2025-04-27
 ...          ...        ...      ...        ...         ...
 49720  User_3927  User_7866    85.35 2025-04-27  2025-04-27
 49775   User_252  User_9609  1875.42 2025-04-27  2025-04-27
 49806   User_130  User_5809    86.69 2025-04-27  2025-04-27
 49812  User_7215  User_4355   737.61 2025-04-27  2025-04-27
 49880  User_5701  User_5611   288.92 2025-04-27  2025-04-27

 [282 rows x 5 columns],
 datetime.date(2025, 3, 5):           sender   receiver   amount  timestamp
day
 174    User_7554  User_4936   185.16 2025-03-05  2025-03-05
```

```
 209    User_9986  User_2783  2067.40 2025-03-05  2025-03-05
 212    User_7098  User_6324     0.44 2025-03-05  2025-03-05
 328    User_3863   User_396   911.99 2025-03-05  2025-03-05
 374    User_3124  User_7053   157.96 2025-03-05  2025-03-05
 ...          ...        ...      ...        ...         ...
 48906  User_7507  User_6811   117.46 2025-03-05  2025-03-05
 48995   User_199  User_2920   755.31 2025-03-05  2025-03-05
 49000  User_6198  User_9771   428.12 2025-03-05  2025-03-05
 49065  User_6030  User_8461    45.83 2025-03-05  2025-03-05
 49537  User_2601  User_6990  1146.05 2025-03-05  2025-03-05

 [281 rows x 5 columns],
 datetime.date(2025, 4, 14):          sender   receiver   amount  timestam
p         day
 179    User_4737   User_883   401.24 2025-04-14  2025-04-14
 185    User_5249  User_7072  1759.55 2025-04-14  2025-04-14
 410    User_5237     User_8  1730.98 2025-04-14  2025-04-14
 1057   User_4757   User_292    32.23 2025-04-14  2025-04-14
 1127   User_6150  User_8218  1402.07 2025-04-14  2025-04-14
 ...          ...        ...      ...        ...         ...
 49277  User_3905  User_6780  3203.89 2025-04-14  2025-04-14
 49389  User_6775  User_9235   102.05 2025-04-14  2025-04-14
 49449  User_5968  User_8666   128.38 2025-04-14  2025-04-14
 49681  User_5301  User_7513   255.90 2025-04-14  2025-04-14
 49804  User_2524   User_645   540.19 2025-04-14  2025-04-14

 [265 rows x 5 columns],
 datetime.date(2025, 3, 27):          sender   receiver   amount  timestam
p         day
 180     User_854  User_2704  1088.98 2025-03-27  2025-03-27
 292    User_5600  User_7208  1268.81 2025-03-27  2025-03-27
 324     User_569  User_9850  2018.36 2025-03-27  2025-03-27
 399    User_8308  User_4908   598.66 2025-03-27  2025-03-27
 487     User_728  User_2553   294.96 2025-03-27  2025-03-27
 ...          ...        ...      ...        ...         ...
 48441  User_8375   User_938  2998.99 2025-03-27  2025-03-27
 49152  User_9811  User_6428   233.29 2025-03-27  2025-03-27
 49433  User_2175  User_3964  1977.79 2025-03-27  2025-03-27
 49652  User_7432  User_5743  1387.51 2025-03-27  2025-03-27
 49929  User_1718  User_9611   304.25 2025-03-27  2025-03-27

 [247 rows x 5 columns],
 datetime.date(2025, 3, 14):          sender   receiver   amount  timestam
p         day
 181    User_8164  User_6441   777.94 2025-03-14  2025-03-14
 654    User_1838  User_2642   846.52 2025-03-14  2025-03-14
 679    User_5989  User_5735  1762.55 2025-03-14  2025-03-14
 765     User_671  User_1093   417.34 2025-03-14  2025-03-14
 777    User_2393  User_1405  1016.03 2025-03-14  2025-03-14
 ...          ...        ...      ...        ...         ...
 49244  User_4752  User_1022   473.28 2025-03-14  2025-03-14
 49323  User_6524  User_9014   327.71 2025-03-14  2025-03-14
 49386  User_2389   User_211    62.10 2025-03-14  2025-03-14
 49503  User_4099  User_1991   677.57 2025-03-14  2025-03-14
 49658   User_255  User_7956    91.27 2025-03-14  2025-03-14

 [278 rows x 5 columns],
 datetime.date(2025, 4, 29):          sender   receiver   amount  timestam
p         day
 183    User_7392  User_4318   592.47 2025-04-29  2025-04-29
 814    User_3086  User_8692   262.75 2025-04-29  2025-04-29
 896    User_5287  User_3187   433.14 2025-04-29  2025-04-29
 911    User_5256  User_1658  1267.86 2025-04-29  2025-04-29
 1178   User_7141  User_3979  2198.33 2025-04-29  2025-04-29
```

```
...          ...        ...      ...        ...        ...
49317  User_9766   User_625   547.56 2025-04-29  2025-04-29
49571  User_4304  User_5980  1128.48 2025-04-29  2025-04-29
49628  User_1005  User_2457   125.10 2025-04-29  2025-04-29
49851  User_6237  User_7672   318.31 2025-04-29  2025-04-29
49865  User_6519  User_9789   755.04 2025-04-29  2025-04-29

[289 rows x 5 columns],
datetime.date(2025, 6, 17):           sender   receiver   amount  timestam
p         day
187    User_1707  User_7618  1620.53 2025-06-17  2025-06-17
236    User_9208  User_1478    14.64 2025-06-17  2025-06-17
290    User_7022  User_9423   667.53 2025-06-17  2025-06-17
341    User_5596  User_4993   262.66 2025-06-17  2025-06-17
703    User_1077  User_7425    24.21 2025-06-17  2025-06-17
...          ...        ...      ...        ...        ...
48704  User_1184  User_6170   477.87 2025-06-17  2025-06-17
48945  User_3154  User_4080   621.58 2025-06-17  2025-06-17
49684  User_6952  User_9291  6170.33 2025-06-17  2025-06-17
49746  User_8940  User_5405   110.55 2025-06-17  2025-06-17
49826  User_7892  User_9519   417.10 2025-06-17  2025-06-17

[288 rows x 5 columns],
datetime.date(2025, 4, 7):           sender   receiver   amount  timestamp
day
191    User_4931  User_8539  1487.59 2025-04-07  2025-04-07
580    User_4186  User_4413   722.57 2025-04-07  2025-04-07
768    User_7956  User_9925   396.24 2025-04-07  2025-04-07
930    User_7577  User_2395  1632.51 2025-04-07  2025-04-07
961    User_8669   User_892   345.51 2025-04-07  2025-04-07
...          ...        ...      ...        ...        ...
49660   User_720  User_3480  1014.99 2025-04-07  2025-04-07
49731  User_1369  User_4054   300.68 2025-04-07  2025-04-07
49792  User_7466  User_3517  6001.57 2025-04-07  2025-04-07
49819  User_2150  User_2565  2289.95 2025-04-07  2025-04-07
49834  User_8745  User_7648  1501.42 2025-04-07  2025-04-07

[285 rows x 5 columns],
datetime.date(2025, 5, 14):           sender   receiver   amount  timestam
p         day
198    User_8004  User_1245   198.40 2025-05-14  2025-05-14
228    User_8155  User_2200  2995.95 2025-05-14  2025-05-14
871     User_846  User_4337  1858.30 2025-05-14  2025-05-14
1580   User_8920  User_7968     6.25 2025-05-14  2025-05-14
1600   User_6732  User_3832  2629.96 2025-05-14  2025-05-14
...          ...        ...      ...        ...        ...
49189    User_22  User_6053   969.60 2025-05-14  2025-05-14
49325  User_1926  User_4812   200.41 2025-05-14  2025-05-14
49378  User_6250  User_4408   547.72 2025-05-14  2025-05-14
49488  User_3926  User_4029  2674.31 2025-05-14  2025-05-14
49596  User_9256  User_3458  1079.16 2025-05-14  2025-05-14

[274 rows x 5 columns],
datetime.date(2025, 4, 2):           sender   receiver   amount  timestamp
day
200    User_7777  User_2619   334.30 2025-04-02  2025-04-02
278    User_9146   User_745  2124.18 2025-04-02  2025-04-02
322    User_5854  User_2727   158.77 2025-04-02  2025-04-02
359    User_6614   User_896  4312.12 2025-04-02  2025-04-02
538    User_5305  User_3367  1750.89 2025-04-02  2025-04-02
...          ...        ...      ...        ...        ...
48391  User_5135  User_5664   114.08 2025-04-02  2025-04-02
48575  User_2778  User_7025    68.61 2025-04-02  2025-04-02
48766    User_72  User_8971  5193.36 2025-04-02  2025-04-02
```

```
 49275  User_5553  User_1055  4688.30 2025-04-02  2025-04-02
 49444  User_7775  User_1782   597.87 2025-04-02  2025-04-02

 [316 rows x 5 columns],
 datetime.date(2025, 1, 12):           sender   receiver   amount  timestam
p         day
 204    User_6287   User_331  1563.85 2025-01-12  2025-01-12
 246    User_1154  User_5369   491.99 2025-01-12  2025-01-12
 287    User_3354  User_9654  1543.46 2025-01-12  2025-01-12
 390     User_635  User_1075  4635.00 2025-01-12  2025-01-12
 597    User_1531  User_3465   107.14 2025-01-12  2025-01-12
 ...          ...        ...      ...        ...         ...
 49269  User_2230  User_9747   483.83 2025-01-12  2025-01-12
 49292  User_3305  User_9103  1832.48 2025-01-12  2025-01-12
 49387   User_167  User_1333    25.58 2025-01-12  2025-01-12
 49452  User_4483  User_2585   231.60 2025-01-12  2025-01-12
 49821  User_9905   User_285  1039.43 2025-01-12  2025-01-12

 [265 rows x 5 columns],
 datetime.date(2025, 4, 13):           sender   receiver   amount  timestam
p         day
 210     User_659  User_5290  1022.12 2025-04-13  2025-04-13
 517    User_8082  User_6215   168.08 2025-04-13  2025-04-13
 609    User_5348  User_4469   227.09 2025-04-13  2025-04-13
 942    User_2190  User_8195   619.28 2025-04-13  2025-04-13
 1282   User_4430  User_5891   962.49 2025-04-13  2025-04-13
 ...          ...        ...      ...        ...         ...
 49356  User_4046  User_9101   519.13 2025-04-13  2025-04-13
 49398  User_4001  User_9782   227.18 2025-04-13  2025-04-13
 49552   User_113  User_8951   991.30 2025-04-13  2025-04-13
 49633  User_1690  User_4750   462.55 2025-04-13  2025-04-13
 49857  User_8248  User_4560   429.79 2025-04-13  2025-04-13

 [283 rows x 5 columns],
 datetime.date(2025, 5, 25):           sender   receiver   amount  timestam
p         day
 211    User_2811   User_248   673.80 2025-05-25  2025-05-25
 321    User_1816  User_4224   918.74 2025-05-25  2025-05-25
 909    User_8567  User_6870  2816.66 2025-05-25  2025-05-25
 1095   User_3335  User_5783   449.91 2025-05-25  2025-05-25
 1181    User_341  User_4900   244.16 2025-05-25  2025-05-25
 ...          ...        ...      ...        ...         ...
 49338  User_8077  User_1597   132.55 2025-05-25  2025-05-25
 49507  User_6482  User_9389   176.75 2025-05-25  2025-05-25
 49567  User_8532  User_7860   284.86 2025-05-25  2025-05-25
 49688  User_8107   User_820   734.47 2025-05-25  2025-05-25
 49772  User_5804  User_7420  1586.63 2025-05-25  2025-05-25

 [257 rows x 5 columns],
 datetime.date(2025, 4, 10):           sender   receiver   amount  timestam
p         day
 214    User_9561  User_5503   617.78 2025-04-10  2025-04-10
 223    User_5759  User_1597   695.11 2025-04-10  2025-04-10
 773    User_6677  User_4155   641.74 2025-04-10  2025-04-10
 793      User_55  User_9999   911.81 2025-04-10  2025-04-10
 834    User_4206  User_4267   696.94 2025-04-10  2025-04-10
 ...          ...        ...      ...        ...         ...
 49420   User_239  User_1367  1055.74 2025-04-10  2025-04-10
 49568  User_8187  User_7057    74.97 2025-04-10  2025-04-10
 49635  User_4970  User_7327   500.56 2025-04-10  2025-04-10
 49798  User_4744  User_4314    93.77 2025-04-10  2025-04-10
 49939  User_2204  User_8985     0.21 2025-04-10  2025-04-10

 [291 rows x 5 columns],
```

```
 datetime.date(2025, 2, 19):          sender   receiver   amount  timestam
p         day
 215    User_1986  User_4414   758.03 2025-02-19  2025-02-19
 392    User_9874  User_1475  1713.70 2025-02-19  2025-02-19
 563    User_5541  User_4663    67.27 2025-02-19  2025-02-19
 714    User_4673  User_5485  2189.30 2025-02-19  2025-02-19
 746    User_4300  User_3127  2317.74 2025-02-19  2025-02-19
 ...          ...        ...      ...        ...         ...
 48053  User_9434  User_3557   281.77 2025-02-19  2025-02-19
 48289   User_125  User_2835   923.55 2025-02-19  2025-02-19
 49661  User_2000  User_4142    84.74 2025-02-19  2025-02-19
 49662  User_3007  User_1872  1007.54 2025-02-19  2025-02-19
 49740  User_7857  User_8606   483.22 2025-02-19  2025-02-19

 [271 rows x 5 columns],
 datetime.date(2025, 5, 7):          sender   receiver   amount  timestamp
day
 216    User_8338  User_8891  1198.23 2025-05-07  2025-05-07
 1360    User_806  User_8998  2273.86 2025-05-07  2025-05-07
 1648   User_1927  User_2426   576.99 2025-05-07  2025-05-07
 1793   User_5238  User_8338  1995.42 2025-05-07  2025-05-07
 1830   User_5450  User_3663   263.05 2025-05-07  2025-05-07
 ...          ...        ...      ...        ...         ...
 49353  User_9966  User_6107   246.12 2025-05-07  2025-05-07
 49624  User_1601  User_8663  3354.03 2025-05-07  2025-05-07
 49687  User_7562  User_4955  2222.24 2025-05-07  2025-05-07
 49698  User_8770  User_3391  1975.34 2025-05-07  2025-05-07
 49917  User_2006   User_512  2199.03 2025-05-07  2025-05-07

 [278 rows x 5 columns],
 datetime.date(2025, 6, 5):          sender   receiver   amount  timestamp
day
 220    User_8680  User_9559   130.00 2025-06-05  2025-06-05
 264     User_956  User_1318    93.00 2025-06-05  2025-06-05
 349    User_5625  User_4921   828.52 2025-06-05  2025-06-05
 797     User_364  User_2398  3342.82 2025-06-05  2025-06-05
 808    User_8172  User_3384  2380.81 2025-06-05  2025-06-05
 ...          ...        ...      ...        ...         ...
 49394  User_2816   User_155  1949.34 2025-06-05  2025-06-05
 49556  User_5159  User_6937  2512.02 2025-06-05  2025-06-05
 49647  User_3433  User_4589   379.83 2025-06-05  2025-06-05
 49827  User_5553  User_3011   684.58 2025-06-05  2025-06-05
 49864  User_1227  User_1870   249.19 2025-06-05  2025-06-05

 [304 rows x 5 columns],
 datetime.date(2025, 2, 16):          sender   receiver   amount  timestam
p         day
 226    User_4736  User_8735   521.47 2025-02-16  2025-02-16
 389    User_4465  User_8329   172.49 2025-02-16  2025-02-16
 592    User_9576  User_6316     1.12 2025-02-16  2025-02-16
 704    User_8427  User_5752   615.83 2025-02-16  2025-02-16
 775    User_6376  User_8500  1017.46 2025-02-16  2025-02-16
 ...          ...        ...      ...        ...         ...
 48195  User_6954  User_8849   382.35 2025-02-16  2025-02-16
 48480  User_3801  User_3835    30.30 2025-02-16  2025-02-16
 48764  User_7282  User_1776   862.32 2025-02-16  2025-02-16
 48885  User_1388  User_6397  1806.68 2025-02-16  2025-02-16
 49734  User_3059  User_3499  3262.42 2025-02-16  2025-02-16

 [288 rows x 5 columns],
 datetime.date(2025, 5, 20):          sender   receiver   amount  timestam
p         day
 230    User_6616  User_8206  1112.85 2025-05-20  2025-05-20
 305    User_2327  User_6210   602.64 2025-05-20  2025-05-20
```

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377       User_4  User_2532   775.60 2025-05-20  2025-05-20
469    User_3373  User_8418    25.11 2025-05-20  2025-05-20
884    User_4234  User_5727   188.72 2025-05-20  2025-05-20
...          ...        ...      ...        ...         ...
49060  User_4376  User_5615  1462.00 2025-05-20  2025-05-20
49113  User_1488  User_7196   333.34 2025-05-20  2025-05-20
49344  User_6104  User_9129  1015.12 2025-05-20  2025-05-20
49366  User_7579  User_3473  2419.62 2025-05-20  2025-05-20
49430    User_30  User_5149   593.79 2025-05-20  2025-05-20

[288 rows x 5 columns],
datetime.date(2025, 2, 15):           sender   receiver   amount  timestam
p         day
231    User_5534  User_9658   739.44 2025-02-15  2025-02-15
277    User_4555  User_1345  1833.14 2025-02-15  2025-02-15
490    User_5988  User_7138  1829.87 2025-02-15  2025-02-15
782    User_6190  User_9091   360.38 2025-02-15  2025-02-15
861       User_5  User_4288   232.89 2025-02-15  2025-02-15
...          ...        ...      ...        ...         ...
48954   User_642  User_6626   141.74 2025-02-15  2025-02-15
49453  User_7229  User_8363   144.91 2025-02-15  2025-02-15
49481  User_6128  User_8681   691.62 2025-02-15  2025-02-15
49542  User_5085  User_3717   225.41 2025-02-15  2025-02-15
49846  User_4917  User_3943    63.80 2025-02-15  2025-02-15

[293 rows x 5 columns],
datetime.date(2025, 6, 13):           sender   receiver   amount  timestam
p         day
250    User_9888  User_3134   280.02 2025-06-13  2025-06-13
281    User_1045   User_877  1880.14 2025-06-13  2025-06-13
318    User_3327  User_9728  1429.17 2025-06-13  2025-06-13
694    User_4544  User_8654  1104.97 2025-06-13  2025-06-13
711    User_3374  User_7888  1827.94 2025-06-13  2025-06-13
...          ...        ...      ...        ...         ...
48929  User_5931  User_5792   188.18 2025-06-13  2025-06-13
48950  User_8210  User_5076   852.52 2025-06-13  2025-06-13
48951  User_4466  User_8604     1.03 2025-06-13  2025-06-13
49058  User_7655  User_7667  3625.63 2025-06-13  2025-06-13
49842  User_7923  User_6327  2278.66 2025-06-13  2025-06-13

[299 rows x 5 columns],
datetime.date(2025, 5, 23):           sender   receiver   amount  timestam
p         day
251    User_1648   User_814  1649.85 2025-05-23  2025-05-23
337    User_8096  User_9660   823.67 2025-05-23  2025-05-23
527    User_7266  User_9049  2978.96 2025-05-23  2025-05-23
560    User_9409  User_2124    49.97 2025-05-23  2025-05-23
635     User_539  User_7599   601.61 2025-05-23  2025-05-23
...          ...        ...      ...        ...         ...
48454  User_6974  User_5685   265.09 2025-05-23  2025-05-23
48849  User_4921  User_8476   152.20 2025-05-23  2025-05-23
48870  User_4655  User_9804   111.12 2025-05-23  2025-05-23
49270  User_1042  User_7847    38.30 2025-05-23  2025-05-23
49347  User_6116  User_9123  1732.06 2025-05-23  2025-05-23

[300 rows x 5 columns],
datetime.date(2025, 4, 22):           sender   receiver   amount  timestam
p         day
258      User_98  User_1484  1131.27 2025-04-22  2025-04-22
440    User_6905  User_7921   561.37 2025-04-22  2025-04-22
606    User_1852  User_6681  1297.30 2025-04-22  2025-04-22
652     User_255  User_7194   528.67 2025-04-22  2025-04-22
666    User_3925  User_9185   750.30 2025-04-22  2025-04-22
...          ...        ...      ...        ...         ...
```

```
49201  User_3530  User_3339  3736.38 2025-04-22  2025-04-22
49311   User_340  User_9013  1061.28 2025-04-22  2025-04-22
49402  User_9942  User_6515   700.07 2025-04-22  2025-04-22
49411  User_3860  User_8511  1424.40 2025-04-22  2025-04-22
49703   User_774  User_8696   321.22 2025-04-22  2025-04-22

[298 rows x 5 columns],
datetime.date(2025, 4, 28):           sender   receiver   amount  timestam
p         day
259    User_2200  User_2266   360.81 2025-04-28  2025-04-28
288     User_225  User_1347  2046.67 2025-04-28  2025-04-28
876     User_224  User_1778   144.49 2025-04-28  2025-04-28
925    User_9506  User_7525    80.58 2025-04-28  2025-04-28
938    User_6565  User_1950  1605.17 2025-04-28  2025-04-28
...          ...        ...      ...        ...         ...
48438   User_541  User_5553    32.16 2025-04-28  2025-04-28
48449  User_7151  User_6473   801.28 2025-04-28  2025-04-28
48783  User_8262  User_9701  2251.03 2025-04-28  2025-04-28
49018  User_5163  User_5815   653.18 2025-04-28  2025-04-28
49587  User_2482  User_1189    17.21 2025-04-28  2025-04-28

[284 rows x 5 columns],
datetime.date(2025, 1, 11):           sender   receiver   amount  timestam
p         day
271    User_3987  User_5439   193.76 2025-01-11  2025-01-11
411     User_559   User_250   882.11 2025-01-11  2025-01-11
500    User_9879  User_9643   333.10 2025-01-11  2025-01-11
842    User_1761  User_2984  1885.02 2025-01-11  2025-01-11
877    User_4208  User_8780    44.28 2025-01-11  2025-01-11
...          ...        ...      ...        ...         ...
48861  User_5999  User_4793   953.67 2025-01-11  2025-01-11
49033   User_789  User_4268    20.61 2025-01-11  2025-01-11
49078  User_6372  User_9865  4277.71 2025-01-11  2025-01-11
49101  User_8370  User_7262   118.17 2025-01-11  2025-01-11
49577  User_1762   User_777    85.53 2025-01-11  2025-01-11

[284 rows x 5 columns],
datetime.date(2025, 2, 24):           sender   receiver   amount  timestam
p         day
276    User_4735  User_6053  1990.09 2025-02-24  2025-02-24
360    User_9358  User_2433  1605.84 2025-02-24  2025-02-24
380    User_4869  User_3982    50.81 2025-02-24  2025-02-24
826    User_3596  User_3798   597.19 2025-02-24  2025-02-24
1122   User_8356  User_8993  1619.08 2025-02-24  2025-02-24
...          ...        ...      ...        ...         ...
49391  User_2479  User_8073   158.90 2025-02-24  2025-02-24
49555   User_808   User_968   272.91 2025-02-24  2025-02-24
49589  User_2840  User_2802  3601.96 2025-02-24  2025-02-24
49650  User_5873  User_4623    94.13 2025-02-24  2025-02-24
49909  User_8428  User_1893  2253.28 2025-02-24  2025-02-24

[249 rows x 5 columns],
datetime.date(2025, 3, 13):           sender   receiver   amount  timestam
p         day
289    User_4893  User_1364   728.72 2025-03-13  2025-03-13
362     User_853  User_7452   253.79 2025-03-13  2025-03-13
388    User_6799  User_6611    81.94 2025-03-13  2025-03-13
412    User_3672  User_8551   477.91 2025-03-13  2025-03-13
441    User_2489  User_3478   212.45 2025-03-13  2025-03-13
...          ...        ...      ...        ...         ...
49034   User_580  User_2639  2424.16 2025-03-13  2025-03-13
49227  User_9980  User_7915  2193.47 2025-03-13  2025-03-13
49260  User_5758  User_2118   739.08 2025-03-13  2025-03-13
49572  User_5633  User_5686  4084.86 2025-03-13  2025-03-13
```

```
 49758  User_5148  User_4828  1243.77 2025-03-13  2025-03-13

 [260 rows x 5 columns],
 datetime.date(2025, 6, 2):          sender   receiver   amount  timestamp
day
 294    User_9007  User_1579  1486.93 2025-06-02  2025-06-02
 345    User_5986  User_9013  1493.45 2025-06-02  2025-06-02
 590    User_8647  User_3887  2387.10 2025-06-02  2025-06-02
 725    User_4261  User_3077   387.93 2025-06-02  2025-06-02
 730    User_4854  User_2001   406.66 2025-06-02  2025-06-02
 ...          ...        ...      ...        ...         ...
 48987  User_4305  User_3762   104.01 2025-06-02  2025-06-02
 49341  User_5670  User_2237   894.04 2025-06-02  2025-06-02
 49459  User_5821  User_4998   123.13 2025-06-02  2025-06-02
 49527  User_9142   User_392  1423.85 2025-06-02  2025-06-02
 49539  User_7682   User_176   134.03 2025-06-02  2025-06-02

 [254 rows x 5 columns],
 datetime.date(2025, 1, 8):          sender   receiver   amount  timestamp
day
 295    User_7683  User_5599   345.80 2025-01-08  2025-01-08
 997     User_984   User_117   175.65 2025-01-08  2025-01-08
 1439   User_6924  User_6522   146.62 2025-01-08  2025-01-08
 1477    User_277  User_6318    61.01 2025-01-08  2025-01-08
 1941   User_2852  User_8274  2942.23 2025-01-08  2025-01-08
 ...          ...        ...      ...        ...         ...
 49382   User_608  User_1911   189.65 2025-01-08  2025-01-08
 49412  User_4728  User_1869   127.91 2025-01-08  2025-01-08
 49787  User_4391  User_9060  2354.80 2025-01-08  2025-01-08
 49822  User_4522   User_106   245.74 2025-01-08  2025-01-08
 49889  User_4156  User_4005  2350.45 2025-01-08  2025-01-08

 [261 rows x 5 columns],
 datetime.date(2025, 2, 2):          sender   receiver   amount  timestamp
day
 299    User_7339  User_3037  1984.27 2025-02-02  2025-02-02
 313     User_190  User_5913  1373.90 2025-02-02  2025-02-02
 342    User_5801  User_3079   703.66 2025-02-02  2025-02-02
 426    User_9435  User_4972  3266.71 2025-02-02  2025-02-02
 653    User_4804  User_1205  1749.08 2025-02-02  2025-02-02
 ...          ...        ...      ...        ...         ...
 49059  User_1402  User_2863   150.44 2025-02-02  2025-02-02
 49418  User_2000  User_6139   165.96 2025-02-02  2025-02-02
 49557  User_7900  User_6293  1185.83 2025-02-02  2025-02-02
 49585   User_763  User_2344   930.37 2025-02-02  2025-02-02
 49975  User_4149  User_4334    23.72 2025-02-02  2025-02-02

 [288 rows x 5 columns],
 datetime.date(2025, 5, 8):          sender   receiver   amount  timestamp
day
 301    User_2205   User_598   385.48 2025-05-08  2025-05-08
 416    User_9662  User_9626   130.66 2025-05-08  2025-05-08
 465    User_7723   User_631  1018.11 2025-05-08  2025-05-08
 783    User_5240  User_1107   966.44 2025-05-08  2025-05-08
 916    User_5415  User_2982  2379.44 2025-05-08  2025-05-08
 ...          ...        ...      ...        ...         ...
 49109  User_4626  User_8162    28.52 2025-05-08  2025-05-08
 49500  User_6231  User_9834   382.70 2025-05-08  2025-05-08
 49613  User_1452  User_5429   522.16 2025-05-08  2025-05-08
 49789  User_7904  User_1164  1706.80 2025-05-08  2025-05-08
 49854  User_3805    User_59   805.06 2025-05-08  2025-05-08

 [263 rows x 5 columns],
 datetime.date(2025, 5, 22):           sender   receiver   amount  timestam
```

```
p         day
 303    User_3444  User_8608   835.67 2025-05-22  2025-05-22
 378    User_5222   User_655  1219.36 2025-05-22  2025-05-22
 758    User_9091   User_211  1597.78 2025-05-22  2025-05-22
 1035   User_4212  User_2426   930.18 2025-05-22  2025-05-22
 1243   User_9650  User_6112   587.22 2025-05-22  2025-05-22
 ...          ...        ...      ...        ...         ...
 48525  User_1823   User_146    34.09 2025-05-22  2025-05-22
 48719  User_1075  User_9754  1898.69 2025-05-22  2025-05-22
 49427   User_162   User_506   154.05 2025-05-22  2025-05-22
 49610  User_3325  User_5866    14.95 2025-05-22  2025-05-22
 49809  User_4294   User_612   995.97 2025-05-22  2025-05-22

 [285 rows x 5 columns],
 datetime.date(2025, 2, 26):           sender   receiver   amount  timestam
p         day
 304    User_1060  User_3417   300.21 2025-02-26  2025-02-26
 1060    User_966   User_359  2353.56 2025-02-26  2025-02-26
 1669   User_8595  User_5339   132.84 2025-02-26  2025-02-26
 2158   User_6036  User_4278  4061.73 2025-02-26  2025-02-26
 2187   User_8980  User_5877   167.82 2025-02-26  2025-02-26
 ...          ...        ...      ...        ...         ...
 48564  User_2635   User_610   147.60 2025-02-26  2025-02-26
 48899  User_9097  User_9256   707.95 2025-02-26  2025-02-26
 48991  User_8060  User_6036   397.54 2025-02-26  2025-02-26
 49308  User_4197   User_690   411.59 2025-02-26  2025-02-26
 49960  User_2800  User_3768  1197.96 2025-02-26  2025-02-26

 [229 rows x 5 columns],
 datetime.date(2025, 6, 14):           sender   receiver   amount  timestam
p         day
 306    User_3420  User_2564  1609.71 2025-06-14  2025-06-14
 372    User_3854  User_5089   297.43 2025-06-14  2025-06-14
 403    User_7560  User_1740   329.68 2025-06-14  2025-06-14
 605    User_6316  User_6074  1988.21 2025-06-14  2025-06-14
 623    User_7114   User_757   196.22 2025-06-14  2025-06-14
 ...          ...        ...      ...        ...         ...
 49263  User_9176  User_5817   490.80 2025-06-14  2025-06-14
 49328  User_9597  User_5091   501.58 2025-06-14  2025-06-14
 49492  User_7311  User_3702    38.68 2025-06-14  2025-06-14
 49845  User_1070  User_2113   530.35 2025-06-14  2025-06-14
 49949  User_4974  User_7838    74.30 2025-06-14  2025-06-14

 [287 rows x 5 columns],
 datetime.date(2025, 6, 10):           sender   receiver   amount  timestam
p         day
 307     User_301  User_8141  1098.52 2025-06-10  2025-06-10
 1213   User_6766  User_1624   313.61 2025-06-10  2025-06-10
 1261   User_5895  User_1651  1064.67 2025-06-10  2025-06-10
 1388   User_7312  User_5330  1374.09 2025-06-10  2025-06-10
 1412   User_5370  User_8251   172.51 2025-06-10  2025-06-10
 ...          ...        ...      ...        ...         ...
 48961  User_7559  User_8629   739.44 2025-06-10  2025-06-10
 49173  User_2552  User_4430   697.52 2025-06-10  2025-06-10
 49474  User_6010  User_3628   599.63 2025-06-10  2025-06-10
 49733  User_8052  User_9283  2138.30 2025-06-10  2025-06-10
 49901  User_2847  User_5578    77.33 2025-06-10  2025-06-10

 [260 rows x 5 columns],
 datetime.date(2025, 5, 27):           sender   receiver   amount  timestam
p         day
 308     User_606  User_1082   682.77 2025-05-27  2025-05-27
 393    User_4752  User_6945    77.04 2025-05-27  2025-05-27
 575    User_3486  User_4994   931.15 2025-05-27  2025-05-27
```

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 735    User_7043  User_2907   847.91 2025-05-27  2025-05-27
 990    User_5779  User_9551   355.10 2025-05-27  2025-05-27
 ...          ...        ...      ...        ...         ...
 49432  User_8005  User_6263  1074.82 2025-05-27  2025-05-27
 49885  User_6318  User_4845  3183.85 2025-05-27  2025-05-27
 49943  User_3802  User_1704    71.89 2025-05-27  2025-05-27
 49986   User_916  User_9969    42.67 2025-05-27  2025-05-27
 49988  User_2094  User_8893   113.61 2025-05-27  2025-05-27

 [304 rows x 5 columns],
 datetime.date(2025, 6, 28):           sender   receiver   amount  timestam
p         day
 311    User_5088  User_3658   375.88 2025-06-28  2025-06-28
 582    User_5977  User_9964  1022.22 2025-06-28  2025-06-28
 988     User_793  User_4897   627.98 2025-06-28  2025-06-28
 1048   User_9146   User_361  1922.23 2025-06-28  2025-06-28
 1151   User_1387  User_8647   532.38 2025-06-28  2025-06-28
 ...          ...        ...      ...        ...         ...
 48747  User_7069  User_1255  1989.95 2025-06-28  2025-06-28
 48791  User_4159  User_2536   923.10 2025-06-28  2025-06-28
 49142  User_1967  User_4062  2301.41 2025-06-28  2025-06-28
 49756  User_6456  User_7610  2360.28 2025-06-28  2025-06-28
 49953  User_6203  User_6584  2895.88 2025-06-28  2025-06-28

 [273 rows x 5 columns],
 datetime.date(2025, 1, 7):           sender   receiver   amount  timestamp
day
 314     User_980  User_5026   817.43 2025-01-07  2025-01-07
 446    User_2839  User_9275  1062.58 2025-01-07  2025-01-07
 558    User_6938  User_9404    44.28 2025-01-07  2025-01-07
 670    User_4000  User_1376   569.08 2025-01-07  2025-01-07
 716    User_6881  User_6360   804.94 2025-01-07  2025-01-07
 ...          ...        ...      ...        ...         ...
 48366  User_7700  User_2533    67.29 2025-01-07  2025-01-07
 49362  User_5302  User_7983   179.57 2025-01-07  2025-01-07
 49591  User_2423  User_5713   551.89 2025-01-07  2025-01-07
 49755  User_4082  User_4294  1141.43 2025-01-07  2025-01-07
 49861  User_6163  User_5879  3864.07 2025-01-07  2025-01-07

 [291 rows x 5 columns],
 datetime.date(2025, 6, 29):           sender   receiver   amount  timestam
p         day
 315    User_2975  User_7054   205.59 2025-06-29  2025-06-29
 317    User_1184   User_780   298.48 2025-06-29  2025-06-29
 472    User_8967  User_2799   846.39 2025-06-29  2025-06-29
 507    User_4968  User_1612   231.89 2025-06-29  2025-06-29
 706    User_7901  User_2774   294.26 2025-06-29  2025-06-29
 ...          ...        ...      ...        ...         ...
 49514  User_2603  User_4550   390.20 2025-06-29  2025-06-29
 49743  User_4533  User_4343   705.74 2025-06-29  2025-06-29
 49921  User_9004  User_5840   116.35 2025-06-29  2025-06-29
 49955   User_837  User_5204    47.01 2025-06-29  2025-06-29
 49965  User_3286  User_4950  1750.42 2025-06-29  2025-06-29

 [231 rows x 5 columns],
 datetime.date(2025, 1, 5):           sender   receiver   amount  timestamp
day
 316    User_6102  User_9551  1161.91 2025-01-05  2025-01-05
 497    User_5073  User_7302   277.17 2025-01-05  2025-01-05
 991    User_6166  User_1307  2330.39 2025-01-05  2025-01-05
 1042   User_8070  User_1785  1466.76 2025-01-05  2025-01-05
 1044   User_8609  User_8029   961.78 2025-01-05  2025-01-05
 ...          ...        ...      ...        ...         ...
 49171   User_200  User_7040   464.70 2025-01-05  2025-01-05
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 49326  User_3519   User_664  1561.33 2025-01-05  2025-01-05
 49421  User_7439  User_4618   578.87 2025-01-05  2025-01-05
 49600  User_6707  User_8956   103.83 2025-01-05  2025-01-05
 49897  User_5247   User_477  3202.86 2025-01-05  2025-01-05

 [284 rows x 5 columns],
 datetime.date(2025, 2, 8):           sender   receiver   amount  timestamp
day
 330    User_4014  User_8031  1079.32 2025-02-08  2025-02-08
 457    User_5052  User_2111   120.77 2025-02-08  2025-02-08
 1390   User_7906  User_7326   832.51 2025-02-08  2025-02-08
 1807   User_4033  User_5770   416.52 2025-02-08  2025-02-08
 1964   User_6764  User_4059   709.92 2025-02-08  2025-02-08
 ...          ...        ...      ...        ...         ...
 49461  User_4477  User_1655   531.71 2025-02-08  2025-02-08
 49711  User_4906  User_3037  1047.86 2025-02-08  2025-02-08
 49801   User_998  User_1228   274.48 2025-02-08  2025-02-08
 49888  User_1397  User_6403    74.46 2025-02-08  2025-02-08
 49938  User_2702  User_2389  4810.94 2025-02-08  2025-02-08

 [280 rows x 5 columns],
 datetime.date(2025, 1, 14):           sender   receiver   amount  timestam
p         day
 347    User_8716  User_1164   139.52 2025-01-14  2025-01-14
 366    User_1148   User_822  2910.69 2025-01-14  2025-01-14
 493    User_2786  User_9748   195.56 2025-01-14  2025-01-14
 602     User_133  User_4935  2268.69 2025-01-14  2025-01-14
 640    User_7102  User_1284    72.58 2025-01-14  2025-01-14
 ...          ...        ...      ...        ...         ...
 48199  User_5261  User_8472   442.43 2025-01-14  2025-01-14
 48822    User_67  User_3491   582.37 2025-01-14  2025-01-14
 49004  User_8131  User_9301   877.01 2025-01-14  2025-01-14
 49617  User_3487  User_1762  1602.37 2025-01-14  2025-01-14
 49829  User_7154  User_4907   458.03 2025-01-14  2025-01-14

 [268 rows x 5 columns],
 datetime.date(2025, 6, 22):           sender   receiver   amount  timestam
p         day
 348    User_6971  User_2572  5111.51 2025-06-22  2025-06-22
 452    User_1687  User_5502  1181.29 2025-06-22  2025-06-22
 673    User_8702  User_4659   286.33 2025-06-22  2025-06-22
 848    User_1605  User_7179   717.75 2025-06-22  2025-06-22
 922    User_9444   User_635   914.92 2025-06-22  2025-06-22
 ...          ...        ...      ...        ...         ...
 48938  User_2587   User_252  1749.87 2025-06-22  2025-06-22
 49117  User_5149  User_9115   272.07 2025-06-22  2025-06-22
 49135  User_8897  User_6957   437.68 2025-06-22  2025-06-22
 49422  User_2190  User_9887  2377.80 2025-06-22  2025-06-22
 49970  User_8972  User_4873   262.02 2025-06-22  2025-06-22

 [291 rows x 5 columns],
 datetime.date(2025, 1, 31):           sender   receiver   amount  timestam
p         day
 358    User_6002  User_8414  7378.33 2025-01-31  2025-01-31
 370    User_9907  User_8505  1024.94 2025-01-31  2025-01-31
 531    User_7651  User_8968   750.16 2025-01-31  2025-01-31
 697    User_7239  User_2364   206.07 2025-01-31  2025-01-31
 785    User_2878  User_3305  2599.20 2025-01-31  2025-01-31
 ...          ...        ...      ...        ...         ...
 49563  User_9252  User_8732   855.39 2025-01-31  2025-01-31
 49614  User_6179  User_2744  2886.05 2025-01-31  2025-01-31
 49738  User_4566  User_9161  1520.06 2025-01-31  2025-01-31
 49761  User_9104  User_2958   452.83 2025-01-31  2025-01-31
 49945  User_1538  User_2836  1280.98 2025-01-31  2025-01-31
```

```
 [279 rows x 5 columns],
 datetime.date(2025, 1, 25):           sender   receiver   amount  timestam
p         day
 379    User_5315  User_3718   874.46 2025-01-25  2025-01-25
 406    User_1664  User_8288  1901.51 2025-01-25  2025-01-25
 705    User_8580  User_6976  2741.97 2025-01-25  2025-01-25
 748    User_3818  User_8598   418.17 2025-01-25  2025-01-25
 805    User_6506  User_3092   748.04 2025-01-25  2025-01-25
 ...          ...        ...      ...        ...         ...
 49368  User_5138  User_1765   422.07 2025-01-25  2025-01-25
 49423  User_4214  User_9558   189.73 2025-01-25  2025-01-25
 49607  User_8238  User_5407  1786.61 2025-01-25  2025-01-25
 49869  User_8168  User_3442   142.31 2025-01-25  2025-01-25
 49947  User_4164    User_21  5567.00 2025-01-25  2025-01-25

 [282 rows x 5 columns],
 datetime.date(2025, 6, 18):           sender   receiver   amount  timestam
p         day
 384    User_4142  User_7866  1629.27 2025-06-18  2025-06-18
 719    User_6241  User_5000  1327.32 2025-06-18  2025-06-18
 1016   User_5732  User_2169  2174.24 2025-06-18  2025-06-18
 1134   User_9106  User_5316   184.17 2025-06-18  2025-06-18
 1314   User_5468   User_234   847.69 2025-06-18  2025-06-18
 ...          ...        ...      ...        ...         ...
 48450  User_4814  User_7518   145.03 2025-06-18  2025-06-18
 48656  User_2957  User_1236   540.89 2025-06-18  2025-06-18
 49089  User_6238  User_3363   582.30 2025-06-18  2025-06-18
 49193  User_8408  User_3188  1798.74 2025-06-18  2025-06-18
 49683  User_9389   User_854  6228.82 2025-06-18  2025-06-18

 [279 rows x 5 columns],
 datetime.date(2025, 4, 17):           sender   receiver   amount  timestam
p         day
 385    User_6966  User_4015   238.76 2025-04-17  2025-04-17
 432    User_9827  User_6311  1281.00 2025-04-17  2025-04-17
 478    User_3974  User_8624  1889.73 2025-04-17  2025-04-17
 533    User_1167  User_3448    23.06 2025-04-17  2025-04-17
 659    User_7418   User_599  2082.24 2025-04-17  2025-04-17
 ...          ...        ...      ...        ...         ...
 49569  User_5953  User_5448  3384.03 2025-04-17  2025-04-17
 49686  User_6588  User_5072  1259.42 2025-04-17  2025-04-17
 49750  User_2953  User_8728    85.63 2025-04-17  2025-04-17
 49816     User_5  User_7069   626.94 2025-04-17  2025-04-17
 49837  User_9571  User_5265   192.13 2025-04-17  2025-04-17

 [265 rows x 5 columns],
 datetime.date(2025, 1, 24):           sender   receiver   amount  timestam
p         day
 398    User_8932  User_7096    42.28 2025-01-24  2025-01-24
 535    User_2156  User_7822   958.75 2025-01-24  2025-01-24
 621    User_8662  User_5191   906.42 2025-01-24  2025-01-24
 646     User_924  User_9832   162.41 2025-01-24  2025-01-24
 717    User_6949  User_1348   165.22 2025-01-24  2025-01-24
 ...          ...        ...      ...        ...         ...
 48864  User_5548  User_4860   300.22 2025-01-24  2025-01-24
 49404  User_4750  User_4509  1171.37 2025-01-24  2025-01-24
 49622  User_7488    User_30  1648.66 2025-01-24  2025-01-24
 49729   User_215   User_185   822.74 2025-01-24  2025-01-24
 49963  User_7286  User_4701    83.03 2025-01-24  2025-01-24

 [289 rows x 5 columns],
 datetime.date(2025, 5, 9):           sender   receiver   amount  timestamp
day
```

```
 420    User_3147   User_595   569.98 2025-05-09  2025-05-09
 680    User_1460  User_1205   346.16 2025-05-09  2025-05-09
 686    User_7245  User_3446  1230.05 2025-05-09  2025-05-09
 778    User_2593  User_6484   248.78 2025-05-09  2025-05-09
 807    User_1531  User_2632  2775.33 2025-05-09  2025-05-09
 ...          ...        ...      ...        ...         ...
 49195  User_2754   User_153     0.43 2025-05-09  2025-05-09
 49524   User_241  User_7927   713.92 2025-05-09  2025-05-09
 49551   User_234  User_5777   528.52 2025-05-09  2025-05-09
 49558   User_410  User_8172   146.70 2025-05-09  2025-05-09
 49952  User_5932  User_5665   634.29 2025-05-09  2025-05-09

 [271 rows x 5 columns],
 datetime.date(2025, 6, 21):           sender   receiver   amount  timestam
p         day
 422    User_1679  User_6964   140.14 2025-06-21  2025-06-21
 505    User_5644  User_7742   264.33 2025-06-21  2025-06-21
 764    User_4188  User_9652   304.44 2025-06-21  2025-06-21
 829    User_7561  User_6535   388.18 2025-06-21  2025-06-21
 883    User_1917  User_7628   542.04 2025-06-21  2025-06-21
 ...          ...        ...      ...        ...         ...
 49226  User_3592  User_7256   151.17 2025-06-21  2025-06-21
 49236  User_8055  User_8860  1813.36 2025-06-21  2025-06-21
 49370  User_4140  User_5384   783.96 2025-06-21  2025-06-21
 49867  User_6223  User_4193    64.00 2025-06-21  2025-06-21
 49878  User_6379  User_8162   277.51 2025-06-21  2025-06-21

 [257 rows x 5 columns],
 datetime.date(2025, 3, 26):           sender   receiver   amount  timestam
p         day
 430    User_2479   User_432   199.53 2025-03-26  2025-03-26
 655       User_9  User_6373   509.10 2025-03-26  2025-03-26
 683    User_3636  User_6142   815.69 2025-03-26  2025-03-26
 996    User_7783  User_8894  1725.99 2025-03-26  2025-03-26
 1047   User_6783  User_1381   719.96 2025-03-26  2025-03-26
 ...          ...        ...      ...        ...         ...
 49133   User_870  User_5054   627.13 2025-03-26  2025-03-26
 49295  User_6769  User_5565   885.97 2025-03-26  2025-03-26
 49406  User_8943  User_2775  1688.32 2025-03-26  2025-03-26
 49429  User_8541  User_6123  1977.73 2025-03-26  2025-03-26
 49545  User_9417  User_6884  2039.65 2025-03-26  2025-03-26

 [290 rows x 5 columns],
 datetime.date(2025, 5, 1):           sender   receiver   amount  timestamp
day
 436    User_5881  User_6071  1633.41 2025-05-01  2025-05-01
 579    User_5301  User_7739   395.41 2025-05-01  2025-05-01
 645    User_2779  User_5103  1451.60 2025-05-01  2025-05-01
 724    User_1331  User_9792   698.26 2025-05-01  2025-05-01
 1121   User_5619  User_5397   951.61 2025-05-01  2025-05-01
 ...          ...        ...      ...        ...         ...
 48787  User_1883  User_5619  2265.24 2025-05-01  2025-05-01
 49605  User_4465  User_8099     1.32 2025-05-01  2025-05-01
 49815  User_4198  User_9753   667.54 2025-05-01  2025-05-01
 49899  User_1349  User_9549   343.93 2025-05-01  2025-05-01
 49989  User_6269  User_2302  1758.18 2025-05-01  2025-05-01

 [282 rows x 5 columns],
 datetime.date(2025, 3, 22):           sender   receiver   amount  timestam
p         day
 439    User_7390  User_7023  3527.48 2025-03-22  2025-03-22
 926    User_4820  User_3622  1233.56 2025-03-22  2025-03-22
 1108   User_3310  User_9054   105.56 2025-03-22  2025-03-22
 1164   User_7368   User_515   642.07 2025-03-22  2025-03-22
```

```
 1380   User_7214  User_7298   195.30 2025-03-22  2025-03-22
 ...          ...        ...      ...        ...         ...
 49675    User_81  User_8175   937.88 2025-03-22  2025-03-22
 49700  User_8353  User_2267  2242.18 2025-03-22  2025-03-22
 49782  User_7807   User_995   869.64 2025-03-22  2025-03-22
 49803  User_7830  User_6439   287.17 2025-03-22  2025-03-22
 49904  User_5585  User_9861   614.49 2025-03-22  2025-03-22

 [300 rows x 5 columns],
 datetime.date(2025, 1, 22):           sender   receiver   amount  timestam
p         day
 442    User_9823  User_2797   115.20 2025-01-22  2025-01-22
 749    User_1906  User_1461  1299.62 2025-01-22  2025-01-22
 891    User_6038  User_2254  4055.85 2025-01-22  2025-01-22
 1244   User_3549  User_2082   147.66 2025-01-22  2025-01-22
 1341   User_2050  User_9038   420.84 2025-01-22  2025-01-22
 ...          ...        ...      ...        ...         ...
 49265  User_1526  User_2631   198.97 2025-01-22  2025-01-22
 49342  User_5218  User_7357   637.27 2025-01-22  2025-01-22
 49396  User_1474  User_8263   809.85 2025-01-22  2025-01-22
 49532  User_1632  User_4069   210.34 2025-01-22  2025-01-22
 49575  User_1888  User_2047   546.66 2025-01-22  2025-01-22

 [273 rows x 5 columns],
 datetime.date(2025, 3, 6):           sender   receiver   amount  timestamp
day
 471    User_2082  User_8383   289.77 2025-03-06  2025-03-06
 549    User_6731  User_2114  4096.62 2025-03-06  2025-03-06
 1109   User_3300   User_592   534.42 2025-03-06  2025-03-06
 1196   User_3067  User_4464   310.85 2025-03-06  2025-03-06
 1623   User_5383  User_6364  2951.24 2025-03-06  2025-03-06
 ...          ...        ...      ...        ...         ...
 49279   User_823   User_864  2974.15 2025-03-06  2025-03-06
 49302  User_6315  User_9947  2275.04 2025-03-06  2025-03-06
 49408  User_6081  User_6185    58.57 2025-03-06  2025-03-06
 49485  User_2796   User_172  1407.46 2025-03-06  2025-03-06
 49972  User_1028  User_3117   550.84 2025-03-06  2025-03-06

 [310 rows x 5 columns],
 datetime.date(2025, 3, 20):           sender   receiver   amount  timestam
p         day
 476    User_8306  User_3545   438.98 2025-03-20  2025-03-20
 509    User_8787  User_3464  2111.67 2025-03-20  2025-03-20
 723    User_7002  User_2446   627.57 2025-03-20  2025-03-20
 821    User_6229  User_8298    11.23 2025-03-20  2025-03-20
 852    User_3517  User_6474   892.26 2025-03-20  2025-03-20
 ...          ...        ...      ...        ...         ...
 48552  User_3916  User_2703   897.83 2025-03-20  2025-03-20
 49077  User_3376  User_3291   321.69 2025-03-20  2025-03-20
 49285  User_8239  User_8835  1344.52 2025-03-20  2025-03-20
 49666  User_5112  User_3220   436.70 2025-03-20  2025-03-20
 49871  User_6183  User_9032   438.98 2025-03-20  2025-03-20

 [277 rows x 5 columns],
 datetime.date(2025, 3, 29):           sender   receiver   amount  timestam
p         day
 506    User_2914  User_2389   385.55 2025-03-29  2025-03-29
 900    User_2832  User_8235  4360.47 2025-03-29  2025-03-29
 910    User_3530  User_2162   130.75 2025-03-29  2025-03-29
 1281    User_390  User_5973   443.40 2025-03-29  2025-03-29
 1425   User_2396  User_4926    68.31 2025-03-29  2025-03-29
 ...          ...        ...      ...        ...         ...
 49184  User_8308   User_521   657.42 2025-03-29  2025-03-29
 49621  User_1790   User_427  1577.49 2025-03-29  2025-03-29
```

```
 49670  User_1580  User_7099   939.60 2025-03-29  2025-03-29
 49749  User_4601  User_4390  2113.97 2025-03-29  2025-03-29
 49891  User_1530  User_5405  1452.35 2025-03-29  2025-03-29

 [265 rows x 5 columns],
 datetime.date(2025, 4, 21):           sender   receiver   amount  timestam
p         day
 520    User_2502  User_2153   238.06 2025-04-21  2025-04-21
 767    User_7570  User_5053  3063.24 2025-04-21  2025-04-21
 1277   User_8592  User_1989  1698.92 2025-04-21  2025-04-21
 1437   User_2139  User_7468  1174.29 2025-04-21  2025-04-21
 1511   User_9078  User_8133  1002.71 2025-04-21  2025-04-21
 ...          ...        ...      ...        ...         ...
 48942  User_9861  User_3352   108.16 2025-04-21  2025-04-21
 49118  User_5752  User_8427   466.96 2025-04-21  2025-04-21
 49501  User_8591   User_366  1018.37 2025-04-21  2025-04-21
 49920  User_2203  User_4734  3682.81 2025-04-21  2025-04-21
 49973  User_6545  User_3693   520.68 2025-04-21  2025-04-21

 [257 rows x 5 columns],
 datetime.date(2025, 2, 5):           sender   receiver   amount  timestamp
day
 585    User_4849  User_3865   222.51 2025-02-05  2025-02-05
 642    User_5320  User_6158  1606.10 2025-02-05  2025-02-05
 1079   User_2717  User_2032  2909.02 2025-02-05  2025-02-05
 1218   User_5408  User_7315   203.51 2025-02-05  2025-02-05
 1432   User_9477  User_5612  1582.64 2025-02-05  2025-02-05
 ...          ...        ...      ...        ...         ...
 49145  User_5080    User_13   358.35 2025-02-05  2025-02-05
 49590  User_5346  User_6559   310.17 2025-02-05  2025-02-05
 49630  User_6576  User_7553    20.79 2025-02-05  2025-02-05
 49856  User_8121  User_6050   178.88 2025-02-05  2025-02-05
 49898  User_7656  User_8102   560.08 2025-02-05  2025-02-05

 [271 rows x 5 columns],
 datetime.date(2025, 4, 16):           sender   receiver   amount  timestam
p         day
 588    User_9273  User_9906  2534.31 2025-04-16  2025-04-16
 715    User_4530  User_3566  2333.85 2025-04-16  2025-04-16
 1046   User_3600  User_4577   461.43 2025-04-16  2025-04-16
 1266   User_7119   User_954   107.05 2025-04-16  2025-04-16
 1930   User_7000  User_8394   406.78 2025-04-16  2025-04-16
 ...          ...        ...      ...        ...         ...
 49513  User_7646  User_8211  2154.35 2025-04-16  2025-04-16
 49562  User_9779   User_795  2585.75 2025-04-16  2025-04-16
 49629   User_231  User_5275    43.10 2025-04-16  2025-04-16
 49776  User_9190   User_489  2233.11 2025-04-16  2025-04-16
 49892   User_774  User_2979  1066.53 2025-04-16  2025-04-16

 [287 rows x 5 columns],
 datetime.date(2025, 3, 8):           sender   receiver   amount  timestamp
day
 598    User_7576  User_6190  1973.23 2025-03-08  2025-03-08
 759    User_9911  User_4796   470.68 2025-03-08  2025-03-08
 784    User_6493  User_8175  5448.31 2025-03-08  2025-03-08
 843     User_876  User_5636  1033.28 2025-03-08  2025-03-08
 869    User_5560  User_6288  1148.60 2025-03-08  2025-03-08
 ...          ...        ...      ...        ...         ...
 49084  User_7012  User_2098  1507.58 2025-03-08  2025-03-08
 49188  User_7653  User_8198   366.01 2025-03-08  2025-03-08
 49599  User_6786  User_5616  2174.42 2025-03-08  2025-03-08
 49604  User_4398  User_5491   781.13 2025-03-08  2025-03-08
 49805  User_6735  User_4526   670.86 2025-03-08  2025-03-08
```

```
 [254 rows x 5 columns],
 datetime.date(2025, 3, 11):           sender   receiver   amount  timestam
p         day
 633    User_2745  User_3243   102.36 2025-03-11  2025-03-11
 698    User_9766  User_7921   587.60 2025-03-11  2025-03-11
 745    User_5569  User_4294  1554.92 2025-03-11  2025-03-11
 820    User_1296  User_3914   427.27 2025-03-11  2025-03-11
 1212   User_4150   User_595   335.64 2025-03-11  2025-03-11
 ...          ...        ...      ...        ...         ...
 48948  User_2778  User_9480   288.45 2025-03-11  2025-03-11
 49247  User_8722  User_2551  1309.37 2025-03-11  2025-03-11
 49479  User_6126  User_2170   374.28 2025-03-11  2025-03-11
 49618  User_4060  User_9541   604.26 2025-03-11  2025-03-11
 49732  User_8477  User_3350   300.14 2025-03-11  2025-03-11

 [255 rows x 5 columns],
 datetime.date(2025, 1, 15):           sender   receiver   amount  timestam
p         day
 643    User_6132  User_8279  1909.47 2025-01-15  2025-01-15
 801    User_5122  User_1312    68.79 2025-01-15  2025-01-15
 824    User_4632  User_3131   381.07 2025-01-15  2025-01-15
 980    User_3719  User_5192   124.03 2025-01-15  2025-01-15
 1416   User_8228  User_3766   498.67 2025-01-15  2025-01-15
 ...          ...        ...      ...        ...         ...
 49092  User_9648   User_749   707.58 2025-01-15  2025-01-15
 49182  User_2553  User_5158  3726.51 2025-01-15  2025-01-15
 49491  User_8680   User_187   401.38 2025-01-15  2025-01-15
 49531  User_8979  User_8820    22.59 2025-01-15  2025-01-15
 49831  User_3982  User_8495   871.44 2025-01-15  2025-01-15

 [288 rows x 5 columns],
 datetime.date(2025, 4, 12):           sender   receiver   amount  timestam
p         day
 700    User_8865  User_3540     2.38 2025-04-12  2025-04-12
 1041   User_8577  User_7887  1475.68 2025-04-12  2025-04-12
 1052   User_5299  User_8521   581.88 2025-04-12  2025-04-12
 1182   User_2074  User_4659   745.78 2025-04-12  2025-04-12
 1352   User_2632  User_1287   625.55 2025-04-12  2025-04-12
 ...          ...        ...      ...        ...         ...
 49041  User_4345   User_911   318.89 2025-04-12  2025-04-12
 49159  User_5866  User_8454    49.68 2025-04-12  2025-04-12
 49410  User_4414  User_5021  2376.80 2025-04-12  2025-04-12
 49717  User_1412  User_4883  1654.36 2025-04-12  2025-04-12
 49788  User_6578   User_748   785.89 2025-04-12  2025-04-12

 [319 rows x 5 columns],
 datetime.date(2025, 2, 12):           sender   receiver   amount  timestam
p         day
 781    User_6937  User_2001    87.43 2025-02-12  2025-02-12
 818    User_1062  User_2294   968.46 2025-02-12  2025-02-12
 1285   User_4232   User_877   421.10 2025-02-12  2025-02-12
 1535   User_6635  User_1363  2208.69 2025-02-12  2025-02-12
 1852   User_9218  User_9177   691.54 2025-02-12  2025-02-12
 ...          ...        ...      ...        ...         ...
 48978  User_4383  User_4876    42.55 2025-02-12  2025-02-12
 49267  User_1036   User_913   302.58 2025-02-12  2025-02-12
 49271  User_7941  User_2535   401.68 2025-02-12  2025-02-12
 49272  User_6168  User_3100   532.44 2025-02-12  2025-02-12
 49346  User_2334  User_1638   527.12 2025-02-12  2025-02-12

 [290 rows x 5 columns],
 datetime.date(2025, 4, 24):           sender   receiver   amount  timestam
p         day
 823     User_125  User_8237  1684.24 2025-04-24  2025-04-24
```

```
984    User_4225  User_2235  1381.90 2025-04-24  2025-04-24
1103   User_3462  User_8589   421.08 2025-04-24  2025-04-24
1208   User_9328  User_3286   128.60 2025-04-24  2025-04-24
1373    User_824  User_7272   744.95 2025-04-24  2025-04-24
...          ...        ...      ...        ...         ...
49321  User_6308  User_2069   641.81 2025-04-24  2025-04-24
49414  User_2699  User_4520    46.58 2025-04-24  2025-04-24
49672  User_9185  User_5553    32.36 2025-04-24  2025-04-24
49874  User_7590  User_8061  1188.46 2025-04-24  2025-04-24
49977  User_7451  User_3829  1568.45 2025-04-24  2025-04-24

[281 rows x 5 columns]}
```

In [2]:

```python
# build graph

import networkx as nx

G = nx.from_pandas_edgelist(
    df_large,
    source='sender',
    target='receiver',
    edge_attr=['amount', 'timestamp'],
    create_using=nx.DiGraph()
)
print(f"Graph has {G.number_of_nodes()} nodes and {G.number_of_edges()} edge


# Note:
# Node  A point or entity in the network
# Edge  A connection or relationship between nodes
# Node: A bank account or customer
# Edge: A wire transfer between accounts
# Node: A user
# Edge: A friendship or message
```

```
Graph has 10000 nodes and 49982 edges
```

In [3]:

```python
# Engineer Features and Train a Model

# Add a circular fraud ring
ring_entities = [f"Fraud_{i}" for i in range(10)]
ring_tx = []

for i in range(len(ring_entities)):
    sender = ring_entities[i]
    receiver = ring_entities[(i + 1) % len(ring_entities)]
    ring_tx.append({
        'sender': sender,
        'receiver': receiver,
        'amount': np.random.randint(5000, 20000),
        'timestamp': pd.to_datetime('2025-03-01')
    })

# Inject into main dataset
df_large = pd.concat([df_large, pd.DataFrame(ring_tx)], ignore_index=True)

display(df_large)
```

	sender	receiver	amount	timestamp	day
0	User_7270	User_6042	160.58	2025-03-01	2025-03-01
1	User_860	User_8812	37.13	2025-06-20	2025-06-20
2	User_5390	User_8962	588.82	2025-03-18	2025-03-18
3	User_5191	User_6731	264.47	2025-02-23	2025-02-23
4	User_5734	User_4793	2737.87	2025-02-28	2025-02-28
...	...	...	...	...	...
49996	Fraud_5	Fraud_6	10539.00	2025-03-01	NaN
49997	Fraud_6	Fraud_7	14786.00	2025-03-01	NaN
49998	Fraud_7	Fraud_8	7942.00	2025-03-01	NaN
49999	Fraud_8	Fraud_9	15160.00	2025-03-01	NaN
50000	Fraud_9	Fraud_0	9631.00	2025-03-01	NaN

50001 rows × 5 columns

In [4]:
```
# Create Pyvis Graph

# Inject synthetic fraud ring
fraud_ring_ids = [f"User_{900 + i}" for i in range(10)]
fraud_transactions = []

for i in range(len(fraud_ring_ids)):
    fraud_transactions.append({
        'sender': fraud_ring_ids[i],
        'receiver': fraud_ring_ids[(i + 1) % len(fraud_ring_ids)],
        'amount': 9999.99,
        'timestamp': pd.Timestamp('2025-03-01')
    })

# Add fraud to the main DataFrame
df_fraud = pd.DataFrame(fraud_transactions)
df_large = pd.concat([df_large, df_fraud], ignore_index=True).reset_index(dr

# Flag fraud
df_large['is_fraud'] = False
df_large.loc[df_large.index[-len(fraud_transactions):], 'is_fraud'] = True

display(df_large.head())
```

	sender	receiver	amount	timestamp	day	is_fraud
0	User_7270	User_6042	160.58	2025-03-01	2025-03-01	False
1	User_860	User_8812	37.13	2025-06-20	2025-06-20	False
2	User_5390	User_8962	588.82	2025-03-18	2025-03-18	False
3	User_5191	User_6731	264.47	2025-02-23	2025-02-23	False
4	User_5734	User_4793	2737.87	2025-02-28	2025-02-28	False

In [5]:
```
import pandas as pd
import numpy as np
from pyvis.network import Network

# Step 1: Create large transaction dataset
```

```
np.random.seed(42)
n_entities = 10000
n_transactions = 50000
entities = [f"User_{i}" for i in range(n_entities)]

df_large = pd.DataFrame({
    'sender': np.random.choice(entities, n_transactions),
    'receiver': np.random.choice(entities, n_transactions),
    'amount': np.round(np.random.exponential(scale=1000, size=n_transactions
    'timestamp': pd.to_datetime('2025-01-01') + pd.to_timedelta(np.random.ra
})
df_large = df_large[df_large['sender'] != df_large['receiver']].reset_index(

# Step 2: Inject synthetic fraud ring
fraud_ring_ids = [f"User_{900 + i}" for i in range(10)]
fraud_transactions = [{
    'sender': fraud_ring_ids[i],
    'receiver': fraud_ring_ids[(i + 1) % len(fraud_ring_ids)],
    'amount': 9999.99,
    'timestamp': pd.Timestamp('2025-03-01')
} for i in range(len(fraud_ring_ids))]

df_fraud = pd.DataFrame(fraud_transactions)
df_large = pd.concat([df_large, df_fraud], ignore_index=True)
df_large['is_fraud'] = False
df_large.loc[df_large.index[-len(fraud_transactions):], 'is_fraud'] = True

# Step 3: Sample for visualization
df_sample = pd.concat([
    df_large[df_large['is_fraud']],
    df_large[~df_large['is_fraud']].sample(200, random_state=42)
])

# Step 4: Create interactive graph
net = Network(height="700px", width="100%", directed=True)
for _, row in df_sample.iterrows():
    edge_color = "red" if row['is_fraud'] else "green"
    net.add_node(row['sender'], label=row['sender'], color='orange')
    net.add_node(row['receiver'], label=row['receiver'], color='orange')
    net.add_edge(row['sender'], row['receiver'], color=edge_color, title=f"s

# Step 5: Show
net.write_html("fraud_detection_network.html", open_browser=True)
```

In [ ]:
```
pip install pyvis
```

In [6]:
```
import pandas as pd
import numpy as np
from pyvis.network import Network

# Step 1: Create large transaction dataset
np.random.seed(42)
n_entities = 1000
n_transactions = 5000
entities = [f"User_{i}" for i in range(n_entities)]

df_large = pd.DataFrame({
    'sender': np.random.choice(entities, n_transactions),
    'receiver': np.random.choice(entities, n_transactions),
    'amount': np.round(np.random.exponential(scale=1000, size=n_transactions
    'timestamp': pd.to_datetime('2025-01-01') + pd.to_timedelta(np.random.ra
})
df_large = df_large[df_large['sender'] != df_large['receiver']].reset_index(
```

```
# Step 2: Inject synthetic fraud ring
fraud_ring_ids = [f"User_{900 + i}" for i in range(10)]
fraud_transactions = [{
    'sender': fraud_ring_ids[i],
    'receiver': fraud_ring_ids[(i + 1) % len(fraud_ring_ids)],
    'amount': 9999.99,
    'timestamp': pd.Timestamp('2025-03-01')
} for i in range(len(fraud_ring_ids))]

df_fraud = pd.DataFrame(fraud_transactions)
df_large = pd.concat([df_large, df_fraud], ignore_index=True)
df_large['is_fraud'] = False
df_large.loc[df_large.index[-len(fraud_transactions):], 'is_fraud'] = True

# Step 3: Sample for visualization
df_sample = pd.concat([
    df_large[df_large['is_fraud']],
    df_large[~df_large['is_fraud']].sample(200, random_state=42)
])

# Step 4: Create interactive graph
net = Network(height="700px", width="100%", directed=True)
# Track nodes we've already added
added_nodes = set()

for _, row in df_sample.iterrows():
    edge_color = "red" if row['is_fraud'] else "green"

    for node in [row['sender'], row['receiver']]:
        if node not in added_nodes:
            # Check if this node appears in any fraud transaction
            is_fraud_node = df_sample[
                ((df_sample['sender'] == node) | (df_sample['receiver'] == r
                (df_sample['is_fraud'])
            ].any().any()

            node_color = "red" if is_fraud_node else "green"
            net.add_node(node, label=node, color=node_color)
            added_nodes.add(node)

    net.add_edge(row['sender'], row['receiver'], color=edge_color, title=f"s

# Step 5: Show
net.write_html("fraud_detection_network_1.html", open_browser=True)
```

In [7]:

```
# Sum of amounts sent + received per user
node_amounts = (
    df_sample.groupby('sender')['amount'].sum().add(
    df_sample.groupby('receiver')['amount'].sum(), fill_value=0)
)

import pandas as pd
import numpy as np
from pyvis.network import Network

# Step 1: Create large transaction dataset
np.random.seed(42)
n_entities = 10000
n_transactions = 50000
entities = [f"User_{i}" for i in range(n_entities)]

df_large = pd.DataFrame({
    'sender': np.random.choice(entities, n_transactions),
```

```
    'receiver': np.random.choice(entities, n_transactions),
    'amount': np.round(np.random.exponential(scale=1000, size=n_transactions
    'timestamp': pd.to_datetime('2025-01-01') + pd.to_timedelta(np.random.ra
})
df_large = df_large[df_large['sender'] != df_large['receiver']].reset_index(

# Step 2: Inject synthetic fraud ring
fraud_ring_ids = [f"User_{900 + i}" for i in range(10)]
fraud_transactions = [{
    'sender': fraud_ring_ids[i],
    'receiver': fraud_ring_ids[(i + 1) % len(fraud_ring_ids)],
    'amount': 9999.99,
    'timestamp': pd.Timestamp('2025-03-01')
} for i in range(len(fraud_ring_ids))]

df_fraud = pd.DataFrame(fraud_transactions)
df_large = pd.concat([df_large, df_fraud], ignore_index=True)
df_large['is_fraud'] = False
df_large.loc[df_large.index[-len(fraud_transactions):], 'is_fraud'] = True

# Step 3: Sample for visualization
df_sample = pd.concat([
    df_large[df_large['is_fraud']],
    df_large[~df_large['is_fraud']].sample(200, random_state=42)
])

# Step 4: Create interactive graph
net = Network(height="700px", width="100%", directed=True)
# Track nodes we've already added
added_nodes = set()

added_nodes = set()

for _, row in df_sample.iterrows():
    edge_color = "red" if row['is_fraud'] else "green"

    for node in [row['sender'], row['receiver']]:
        if node not in added_nodes:
            # Check fraud involvement
            is_fraud_node = df_sample[
                ((df_sample['sender'] == node) | (df_sample['receiver'] == n
                (df_sample['is_fraud'])
            ].any().any()

            node_color = "red" if is_fraud_node else "green"

            # Label with user ID and total transaction amount
            total_amt = node_amounts.get(node, 0)
            node_label = f"{node}\n${total_amt:,.2f}"

            net.add_node(node, label=node_label, color=node_color)
            added_nodes.add(node)

    # Add edge
    net.add_edge(row['sender'], row['receiver'], color=edge_color, title=f"s

# Step 5: Show
net.write_html("fraud_detection_network_send_receiver.html", open_browser=Tr
```

In [44]:

```
import pandas as pd
import numpy as np
import os
from pyvis.network import Network
from tqdm import tqdm
```

```
# --- Configuration ---
# Updated to use your specific PaySim file name
PAYSIM_FILE = 'PS_20174392719_1491204439457_log.csv'
# Removed CREATE_DUMMY_DATA flag as requested.

# --- Helper Functions ---

def load_paysim_data(filepath):
    """
    Loads PaySim data from the specified filepath.
    Exits if the file is not found, as dummy creation is disabled.
    """
    if os.path.exists(filepath):
        print(f"Loading data from {filepath}...")
        # Use low_memory=False for large files like PaySim
        df = pd.read_csv(filepath, low_memory=False)
        print("Data loaded successfully.")
        return df
    else:
        # Exit if the file is genuinely missing
        print(f"Error: PaySim file not found at {filepath}. Please ensure th
        return None

# --- Main Analysis Script ---

# Load data (must exist at the specified path)
df_full = load_paysim_data(PAYSIM_FILE)

if df_full is None:
    # Exit gracefully if loading failed
    exit()

# Rename columns to match the general graph analysis terms
df_full.rename(columns={'nameOrig': 'sender', 'nameDest': 'receiver', 'isFra

# Filter out transactions that don't represent a clear transfer of risk (lik
# For simplicity, we'll keep all transactions for now, but a sophisticated m
df_clean = df_full.copy()

# 1. Calculate the total transactional volume (sent + received) per user
# This is a key feature for detecting high-velocity users in a fraud ring.
print("Calculating total transaction volume per user...")
# Note: This operation can be memory intensive on the full PaySim dataset
node_amounts = (
    df_clean.groupby('sender')['amount'].sum().add(
    df_clean.groupby('receiver')['amount'].sum(), fill_value=0)
)

# 2. Sample data for visualization
# We must keep ALL fraudulent transactions (is_fraud == 1) to ensure the rin
# Then, sample a small number of legitimate transactions for context.
FRAUD_COUNT = df_clean['is_fraud'].sum()
# Reduce this number if the resulting graph is too slow to load in your brow
LEGIT_SAMPLE_SIZE = 10  # Increased sample size for better context from the

df_fraud = df_clean[df_clean['is_fraud'] == 1].copy()

# Ensure we don't try to sample more than available legitimate rows
num_legit = len(df_clean[df_clean['is_fraud'] == 0])
sample_size = min(LEGIT_SAMPLE_SIZE, num_legit)

df_legit_sample = df_clean[df_clean['is_fraud'] == 0].sample(
    sample_size,
```

```
    random_state=42
)
df_sample = pd.concat([df_fraud, df_legit_sample]).reset_index(drop=True)

print(f"Visualization Sample Size: {len(df_sample)} (Fraud: {len(df_fraud)},

# 3. Create interactive graph using pyvis
net = Network(height="800px", width="100%", directed=True, bgcolor="#222222"
net.heading = "PaySim Fraud Detection Network Analysis (Live Data)"
net.toggle_physics(True) # Enable physics for better clustering

added_nodes = set()

print("Building network visualization...")

# First pass: Determine node colors and calculate labels
node_data = {}
# Only iterate over the unique nodes present in the sampled dataset
all_nodes_in_sample = pd.concat([df_sample['sender'], df_sample['receiver']]

for node in tqdm(all_nodes_in_sample, desc="Processing Nodes"):
    # Check if the node is involved in ANY fraudulent transaction in the sar
    is_fraud_node = df_sample[
        ((df_sample['sender'] == node) | (df_sample['receiver'] == node)) &
        (df_sample['is_fraud'] == 1)
    ].any().any()

    node_color = "#E33E4D" if is_fraud_node else "#4CAF50" # Red for fraud,

    # Calculate total volume for the node
    total_amt = node_amounts.get(node, 0)

    # Create the label for the node
    node_label = f"{node}\n${total_amt:,.2f}"

    node_data[node] = {
        'label': node_label,
        'color': node_color,
        'value': total_amt, # Use amount as value for size scaling
        'title': f"Total Volume: ${total_amt:,.2f}"
    }

# Second pass: Add nodes and edges to the network
for node, data in node_data.items():
    net.add_node(
        node,
        label=data['label'],
        color=data['color'],
        value=data['value'],
        title=data['title'],
        # Use log scale for size to keep node sizes manageable
        size=min(40, 10 + np.log10(data['value'] + 1) * 5)
    )

for _, row in tqdm(df_sample.iterrows(), total=len(df_sample), desc="Adding
    edge_color = "#E33E4D" if row['is_fraud'] == 1 else "#50C878" # Red for

    net.add_edge(
        row['sender'],
        row['receiver'],
        color=edge_color,
        # Add transaction type to the hover title for better inspection
        title=f"Amount: ${row['amount']:,.2f} | Type: {row['type']} | Fraud
        value=row['amount'], # Use amount for line thickness
```

```
        arrows='to'
    )

# 4. Save and display
output_file = "paysim_fraud_network.html"
net.write_html(output_file)
print(f"\n--- Visualization Complete ---")
print(f"Open '{output_file}' in your browser to view the interactive networ
print(f"Fraudulent nodes and edges (potential fraud rings) are marked in RE
```

```
Loading data from PS_20174392719_1491204439457_log.csv...
Data loaded successfully.
Calculating total transaction volume per user...
Visualization Sample Size: 8223 (Fraud: 8213, Legit Sampled: 10)
Building network visualization...
Processing Nodes: 100%|██████████| 16402/16402 [00:27<00:00, 598.71
it/s]
Adding Edges: 100%|██████████| 8223/8223 [00:02<00:00, 2940.71
it/s]
--- Visualization Complete ---
Open 'paysim_fraud_network.html' in your browser to view the interactive ne
twork.
Fraudulent nodes and edges (potential fraud rings) are marked in RED.
```

In [9]:

```
import networkx as nx
import pandas as pd
import numpy as np

# --- Convert sample data (df_sample) into a graph ---
# We use NetworkX for graph analytics; PyVis is just for visualization
G = nx.DiGraph()

# Add weighted directed edges (sender → receiver)
for _, row in df_sample.iterrows():
    G.add_edge(
        row['sender'],
        row['receiver'],
        weight=row['amount'],
        is_fraud=row['is_fraud'],
        tx_type=row['type']
    )

print(f"Graph constructed: {G.number_of_nodes()} nodes, {G.number_of_edges()

# --- Compute key centrality measures ---

# Betweenness Centrality – identifies "brokers" or "intermediaries" controll
betweenness = nx.betweenness_centrality(G, k=min(1000, len(G)), weight='weig

# Closeness Centrality – identifies nodes that can reach many others quickly
closeness = nx.closeness_centrality(G)

# Degree Centrality – identifies high-activity entities (senders/receivers)
degree = nx.degree_centrality(G)

# Combine into a DataFrame
centrality_df = pd.DataFrame({
    'node': list(G.nodes),
    'betweenness': [betweenness.get(n, 0) for n in G.nodes],
    'closeness': [closeness.get(n, 0) for n in G.nodes],
    'degree': [degree.get(n, 0) for n in G.nodes],
})

# Add fraud involvement info
```

```
centrality_df['is_fraud_node'] = centrality_df['node'].isin(
    df_sample.loc[df_sample['is_fraud'] == 1, ['sender', 'receiver']].values
)

# Rank by centrality
centrality_df['rank'] = centrality_df[['betweenness', 'closeness', 'degree']

# --- Identify top suspicious nodes (potential ring centers) ---
top_nodes = centrality_df.sort_values(by='rank').head(15)
print("\nTop 15 Central Nodes (Potential Coordinators or Ring Leaders):")
print(top_nodes[['node', 'betweenness', 'closeness', 'degree', 'is_fraud_nod

# Optional: Save to CSV
centrality_df.to_csv("centrality_analysis.csv", index=False)
```

```
Graph constructed: 16402 nodes, 8223 edges

Top 15 Central Nodes (Potential Coordinators or Ring Leaders):
             node  betweenness  closeness    degree  is_fraud_node
8200  C1827800010          0.0   0.000122  0.000122           True
194   C1013511446          0.0   0.000122  0.000122           True
7176   C505532836          0.0   0.000122  0.000122           True
3971  C2129197098          0.0   0.000122  0.000122           True
5735  C1460854172          0.0   0.000122  0.000122           True
810   C1827219533          0.0   0.000122  0.000122           True
9353    C14138104          0.0   0.000122  0.000122           True
3332  C1601170327          0.0   0.000122  0.000122           True
100    C904300960          0.0   0.000122  0.000122           True
5644   C643624257          0.0   0.000122  0.000122           True
82     C803116137          0.0   0.000122  0.000122           True
8368  C1837027614          0.0   0.000122  0.000122           True
4713  C1399829166          0.0   0.000122  0.000122           True
8360  C1148781766          0.0   0.000122  0.000122           True
69     C410033330          0.0   0.000122  0.000122           True
```

In [8]:

```
import pandas as pd
import numpy as np
import networkx as nx
import community.community_louvain as community_louvain   # Louvain
from collections import Counter

# Optional: For Leiden (requires installation)
# !pip install leidenalg igraph

import igraph as ig
import leidenalg as la

# --- STEP 1: Convert PaySim sample to NetworkX graph ---
G = nx.DiGraph()

for _, row in df_sample.iterrows():
    G.add_edge(
        row['sender'],
        row['receiver'],
        weight=row['amount'],
        is_fraud=row['is_fraud'],
        tx_type=row['type']
    )

print(f"Graph built: {G.number_of_nodes()} nodes, {G.number_of_edges()} edge

# --- STEP 2: Convert to undirected for community detection (optional simpli
# Fraud rings often have mutual transfers, so undirected simplifies modulari
G_undirected = G.to_undirected()
```

```
# --- STEP 3A: Louvain Community Detection ---
print("\nRunning Louvain community detection...")
partition_louvain = community_louvain.best_partition(G_undirected, weight='v
nx.set_node_attributes(G_undirected, partition_louvain, 'louvain_community')

# --- STEP 3B: Leiden Community Detection (more accurate, handles small comm
print("Running Leiden community detection...")
g_ig = ig.Graph.TupleList(G_undirected.edges(), directed=False, weights=True
leiden_partition = la.find_partition(g_ig, la.ModularityVertexPartition)

# Leiden returns a list of vertex clusters; map each node to its cluster ID
node_to_leiden = {g_ig.vs[i]['name']: cid for cid, cluster in enumerate(leid
nx.set_node_attributes(G_undirected, node_to_leiden, 'leiden_community')

# --- STEP 4: Build DataFrame of communities ---
community_df = pd.DataFrame({
    'node': list(G_undirected.nodes()),
    'louvain_community': [partition_louvain[n] for n in G_undirected.nodes()
    'leiden_community': [node_to_leiden[n] for n in G_undirected.nodes()]
})

# Add fraud info
community_df['is_fraud_node'] = community_df['node'].isin(
    df_sample.loc[df_sample['is_fraud'] == 1, ['sender', 'receiver']].values
)

# --- STEP 5: Identify suspicious communities ---
fraud_group_summary = (
    community_df.groupby('louvain_community')['is_fraud_node']
    .agg(['sum', 'count'])
    .rename(columns={'sum': 'fraud_nodes', 'count': 'total_nodes'})
    .assign(fraud_ratio=lambda x: x['fraud_nodes'] / x['total_nodes'])
    .sort_values(by='fraud_ratio', ascending=False)
)

print("\nTop Suspicious Louvain Communities:")
print(fraud_group_summary.head(10))

# --- STEP 6: Save and visualize ---
community_df.to_csv("fraud_communities.csv", index=False)
print("\nCommunity analysis saved as 'fraud_communities.csv'")

# Optional: Visualize top communities in PyVis
from pyvis.network import Network
net_comm = Network(height="750px", width="100%", directed=True, bgcolor="#22
net_comm.heading = "PaySim Fraud Ring Detection via Louvain + Leiden"

top_comms = fraud_group_summary.head(5).index.tolist()
selected_nodes = community_df[community_df['louvain_community'].isin(top_com

for node in selected_nodes:
    n_data = community_df.loc[community_df['node'] == node].iloc[0]
    color = "#E33E4D" if n_data['is_fraud_node'] else "#4CAF50"
    net_comm.add_node(node, color=color, title=f"Louvain: {n_data['louvain_c

for u, v, data in G_undirected.edges(data=True):
    if u in selected_nodes and v in selected_nodes:
        color = "#E33E4D" if (data.get('is_fraud') == 1) else "#50C878"
        net_comm.add_edge(u, v, color=color, title=f"Amount: ${data['weight

net_comm.write_html("paysim_fraud_communities.html")
print("Visualization saved as 'paysim_fraud_communities.html'")
```

```
Graph built: 16402 nodes, 8223 edges

Running Louvain community detection...
Running Leiden community detection...

Top Suspicious Louvain Communities:
                   fraud_nodes  total_nodes  fraud_ratio
louvain_community
4097                         2            2          1.0
6145                         2            2          1.0
5471                         2            2          1.0
5470                         2            2          1.0
5469                         2            2          1.0
5468                         2            2          1.0
5467                         2            2          1.0
5466                         2            2          1.0
5465                         2            2          1.0
5464                         2            2          1.0

Community analysis saved as 'fraud_communities.csv'
Visualization saved as 'paysim_fraud_communities.html'
```

In [ ]:
```
pip install python-louvain
```

In [ ]:
```
pip install leidenalg
```

In [10]:
```
df_clean['timestamp'] = pd.to_datetime(df_clean['step'], unit='s', origin='2
df_clean = df_clean.sort_values('timestamp')
```

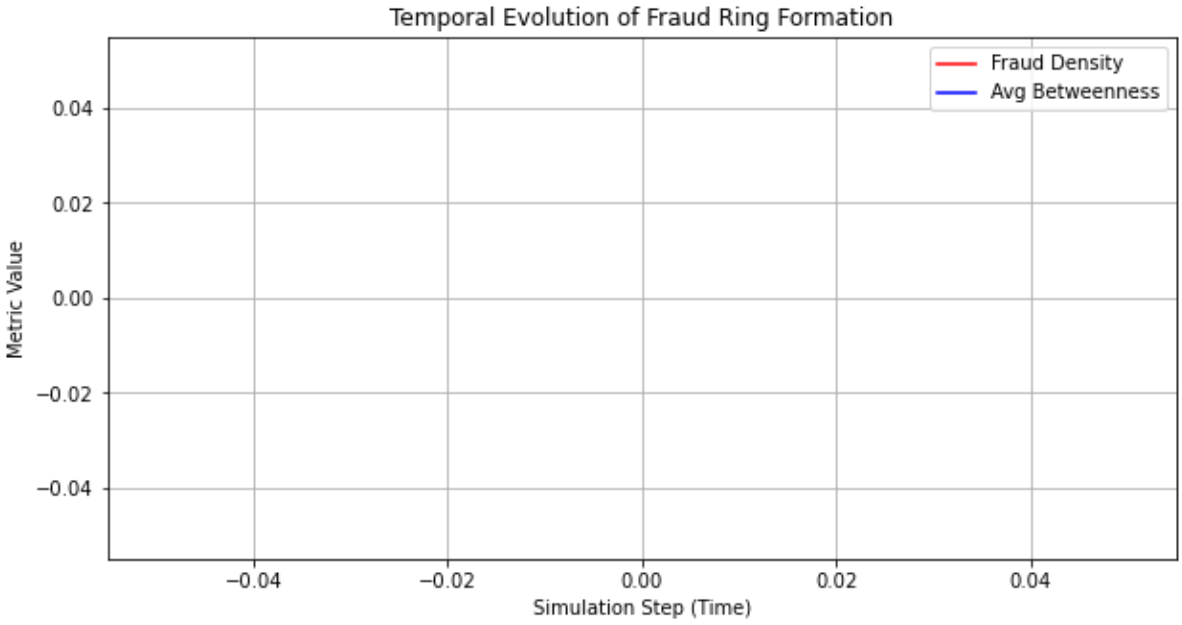
In [11]:
```
WINDOW_SIZE = 1000  # instead of 100
time_windows = range(0, int(df_clean['step'].max()), WINDOW_SIZE)
```

In [ ]:
```

```

In [12]:
```
import networkx as nx
import community.community_louvain as community_louvain
import matplotlib.pyplot as plt

evolution_data = []

for t in time_windows:
    df_window = df_clean[df_clean['step'] <= t]
    G = nx.from_pandas_edgelist(df_window, 'sender', 'receiver', ['amount',

    # Compute centrality
    betweenness = nx.betweenness_centrality(G, k=min(500, len(G)))

    # Louvain community detection
    partition = community_louvain.best_partition(G)

    # Compute fraud density per community
    df_window['community'] = df_window['sender'].map(partition)
    fraud_density = (
        df_window.groupby('community')['is_fraud'].mean().mean()
        if not df_window.empty else 0
    )

    avg_betweenness = np.mean(list(betweenness.values())) if betweenness els

    evolution_data.append({
        'time': t,
        'num_nodes': len(G),
```

```
        'num_edges': G.number_of_edges(),
        'avg_betweenness': avg_betweenness,
        'fraud_density': fraud_density,
    })
```

In [13]:
```
df_evo = pd.DataFrame(evolution_data)

plt.figure(figsize=(10,5))
plt.plot(df_evo['time'], df_evo['fraud_density'], label='Fraud Density', co
plt.plot(df_evo['time'], df_evo['avg_betweenness'], label='Avg Betweenness'
plt.xlabel('Simulation Step (Time)')
plt.ylabel('Metric Value')
plt.title('Temporal Evolution of Fraud Ring Formation')
plt.legend()
plt.grid(True)
plt.show()
```



In [14]:
```
if df_evo['fraud_density'].iloc[-1] > 0.3 and df_evo['avg_betweenness'].iloc
    print(" Fraud ring likely forming! Investigate high-centrality nodes.")
```

In [15]:
```
top_nodes = sorted(betweenness.items(), key=lambda x: x[1], reverse=True)[:1
print("Potential ring leaders:", [n for n, _ in top_nodes])
```

```
Potential ring leaders: []
```

In [ ]:
```
pip install networkit
```

In [ ]:
```
from datetime import datetime
from Levenshtein import distance as levenshtein_distance

print("Engineering behavioral features (temporal + cognitive metrics)...")

# Ensure we have timestamps if not already
if 'step' in df_clean.columns:
    # Each step in PaySim ~ 1 hour; simulate timestamps for temporal analysi
    df_clean['timestamp'] = pd.to_datetime(df_clean['step'], unit='h', origi
else:
    df_clean['timestamp'] = pd.to_datetime(np.arange(len(df_clean)), unit='h

# --- RISK AVERSION SCORE ---
# Measures how drastically a user deviates from their typical transaction be
def compute_risk_aversion(df):
    risk_scores = {}
```

```
    for sender, group in df.groupby('sender'):
        mean_amt = group['amount'].mean()
        recent = group.sort_values('timestamp', ascending=False).head(1)['ar
        deviation = abs(recent - mean_amt) / (mean_amt + 1e-6)
        risk_scores[sender] = min(deviation, 1.0)  # normalize
    return risk_scores

risk_aversion = compute_risk_aversion(df_clean)

# --- SEQUENTIAL SIMILARITY ---
# Compare transaction sequences to a "fraud grammar" using Levenshtein dista
def compute_seq_similarity(df, fraud_template=['TRANSFER', 'CASH_OUT']):
    seq_scores = {}
    for sender, group in df.groupby('sender'):
        seq = list(group['type'].values)
        dist = levenshtein_distance(''.join(seq), ''.join(fraud_template))
        seq_scores[sender] = 1 / (1 + dist)  # higher → more similar to frau
    return seq_scores

seq_similarity = compute_seq_similarity(df_clean)

# --- TIME-GAP ANALYSIS ---
# Measures how consistent (bot-like) the transaction timing is
def compute_time_gap_stability(df):
    stability = {}
    for sender, group in df.groupby('sender'):
        times = group['timestamp'].sort_values()
        gaps = times.diff().dt.total_seconds().dropna()
        if len(gaps) > 1:
            coef_var = np.std(gaps) / (np.mean(gaps) + 1e-6)
            stability[sender] = 1 - min(coef_var, 1.0)  # 1 → very regular -
        else:
            stability[sender] = 0
    return stability

time_gap_stability = compute_time_gap_stability(df_clean)
```

```
Engineering behavioral features (temporal + cognitive metrics)...
```

In [1]:
```
pip install swifter
```

```
Collecting swifter
  Downloading swifter-1.4.0.tar.gz (1.2 MB)
     |████████████████████████████████| 1.2 MB 4.5 MB/s eta 0:00:01
Requirement already satisfied: pandas>=1.0.0 in /Users/saipranayreddy/opt/a
naconda3/lib/python3.9/site-packages (from swifter) (1.4.2)
Requirement already satisfied: psutil>=5.6.6 in /Users/saipranayreddy/opt/a
naconda3/lib/python3.9/site-packages (from swifter) (5.8.0)
Requirement already satisfied: dask[dataframe]>=2.10.0 in /Users/saipranayr
eddy/opt/anaconda3/lib/python3.9/site-packages (from swifter) (2022.2.1)
Requirement already satisfied: tqdm>=4.33.0 in /Users/saipranayreddy/opt/an
aconda3/lib/python3.9/site-packages (from swifter) (4.64.0)
Requirement already satisfied: partd>=0.3.10 in /Users/saipranayreddy/opt/a
naconda3/lib/python3.9/site-packages (from dask[dataframe]>=2.10.0->swifte
r) (1.2.0)
Requirement already satisfied: pyyaml>=5.3.1 in /Users/saipranayreddy/opt/a
naconda3/lib/python3.9/site-packages (from dask[dataframe]>=2.10.0->swifte
r) (6.0)
Requirement already satisfied: fsspec>=0.6.0 in /Users/saipranayreddy/opt/a
naconda3/lib/python3.9/site-packages (from dask[dataframe]>=2.10.0->swifte
r) (2023.12.2)
Requirement already satisfied: toolz>=0.8.2 in /Users/saipranayreddy/opt/an
aconda3/lib/python3.9/site-packages (from dask[dataframe]>=2.10.0->swifter)
(0.11.2)
Requirement already satisfied: packaging>=20.0 in /Users/saipranayreddy/op
t/anaconda3/lib/python3.9/site-packages (from dask[dataframe]>=2.10.0->swif
ter) (21.3)
Requirement already satisfied: cloudpickle>=1.1.1 in /Users/saipranayreddy/
opt/anaconda3/lib/python3.9/site-packages (from dask[dataframe]>=2.10.0->sw
ifter) (2.0.0)
Requirement already satisfied: numpy>=1.18 in /Users/saipranayreddy/opt/ana
conda3/lib/python3.9/site-packages (from dask[dataframe]>=2.10.0->swifter)
(1.21.6)
Requirement already satisfied: pyparsing!=3.0.5,>=2.0.2 in /Users/saipranay
reddy/opt/anaconda3/lib/python3.9/site-packages (from packaging>=20.0->dask
[dataframe]>=2.10.0->swifter) (3.0.4)
Requirement already satisfied: python-dateutil>=2.8.1 in /Users/saipranayre
ddy/opt/anaconda3/lib/python3.9/site-packages (from pandas>=1.0.0->swifter)
(2.8.2)
Requirement already satisfied: pytz>=2020.1 in /Users/saipranayreddy/opt/an
aconda3/lib/python3.9/site-packages (from pandas>=1.0.0->swifter) (2022.7.
1)
Requirement already satisfied: locket in /Users/saipranayreddy/opt/anaconda
3/lib/python3.9/site-packages (from partd>=0.3.10->dask[dataframe]>=2.10.0-
>swifter) (0.2.1)
Requirement already satisfied: six>=1.5 in /Users/saipranayreddy/opt/anacon
da3/lib/python3.9/site-packages (from python-dateutil>=2.8.1->pandas>=1.0.0
->swifter) (1.16.0)
Building wheels for collected packages: swifter
  Building wheel for swifter (setup.py) ... done
  Created wheel for swifter: filename=swifter-1.4.0-py3-none-any.whl size=1
6531 sha256=2ce2e2dc7b2971875acf246558277313c98bdc1b2ea7004cfac1fdd9ae191a3
8
  Stored in directory: /Users/saipranayreddy/Library/Caches/pip/wheels/7b/4
a/7e/bcc48cf10e10fcf5b4dae464a66b523756db6b950e02129680
Successfully built swifter
Installing collected packages: swifter
Successfully installed swifter-1.4.0
Note: you may need to restart the kernel to use updated packages.
```

In [16]:
```
# Keep all frauds and a small random subset of legits
fraud_df = df_clean[df_clean['is_fraud'] == 1]
legit_df = df_clean[df_clean['is_fraud'] == 0].sample(5000, random_state=42)
df_behav = pd.concat([fraud_df, legit_df])
```

In [17]:
```
df_behav
```

Out[17]:

	step	type	amount	sender	oldbalanceOrg	newbalanceOrig	
1869	1	TRANSFER	25071.46	C669700766	25071.46	0.00	C138
1870	1	CASH_OUT	25071.46	C1275464847	25071.46	0.00	C13(
1911	1	CASH_OUT	132842.64	C13692003	4499.08	0.00	C2
2301	1	TRANSFER	235238.66	C1872047468	235238.66	0.00	C11
2302	1	CASH_OUT	235238.66	C1499825229	235238.66	0.00	C21(
...	...	...	...	...	...	...	
5470894	379	PAYMENT	25917.76	C1742924516	0.00	0.00	M5
2499740	204	CASH_IN	173029.07	C593325346	5874679.64	6047708.71	C128
2885522	228	CASH_IN	186184.47	C1446661884	436.00	186620.47	C18
3928793	285	DEBIT	2118.98	C1461786979	20112.00	17993.02	C206
632188	35	PAYMENT	11344.51	C245433481	0.00	0.00	M182

13213 rows × 12 columns

In [18]:
```
print("Computing Risk Aversion (vectorized)...")


# Ensure we have timestamps if not already
if 'step' in df_clean.columns:
    # Each step in PaySim ~ 1 hour; simulate timestamps for temporal analysi
    df_clean['timestamp'] = pd.to_datetime(df_clean['step'], unit='h', origi
else:
    df_clean['timestamp'] = pd.to_datetime(np.arange(len(df_clean)), unit='h

# Keep all frauds and a small random subset of legits
fraud_df = df_clean[df_clean['is_fraud'] == 1]
legit_df = df_clean[df_clean['is_fraud'] == 0].sample(5000, random_state=42)
df_behav = pd.concat([fraud_df, legit_df])


recent_tx = df_behav.sort_values(['sender', 'timestamp']).groupby('sender')
mean_amt = df_behav.groupby('sender')['amount'].mean()
```

```
risk_aversion = (
    abs(recent_tx.set_index('sender')['amount'] - mean_amt) / (mean_amt + 1e
).clip(0, 1).to_dict()
```

```
Computing Risk Aversion (vectorized)...
```

In [19]:
```
risk_aversion
```

Out[19]:

```
{'C1000036340': 0.0,
 'C1000086512': 0.0,
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 'C1001875185': 0.0,
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 'C1002519727': 0.0,
 'C1002859898': 0.0,
 'C1002895272': 0.0,
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```

```
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```

```
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In [20]:
```
print("Computing Sequence Similarity (approx)...")

fraud_template = {'TRANSFER': 1, 'CASH_OUT': 1}

seq_similarity = {}
for sender, group in df_behav.groupby('sender'):
    counts = group['type'].value_counts(normalize=True).to_dict()
    overlap = sum(min(counts.get(k, 0), fraud_template.get(k, 0)) for k in 
    seq_similarity[sender] = overlap  # 0–1 score
```

```
Computing Sequence Similarity (approx)...
```

In [21]:
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seq_similarity
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Out[21]:

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In [22]:
```
print("Computing Time Gap Stability (optimized)...")

df_behav['time_diff'] = (
    df_behav.sort_values(['sender', 'timestamp'])
    .groupby('sender')['timestamp']
    .diff().dt.total_seconds()
)

gap_stats = df_behav.groupby('sender')['time_diff'].agg(['mean', 'std']).fi
gap_stats['stability'] = 1 - (gap_stats['std'] / (gap_stats['mean'] + 1e-6))
time_gap_stability = gap_stats['stability'].to_dict()
```

```
Computing Time Gap Stability (optimized)...
```

In [23]:
```
behavioral_features = pd.DataFrame({
    'sender': list(risk_aversion.keys()),
    'risk_aversion': list(risk_aversion.values()),
    'seq_similarity': [seq_similarity.get(u, 0) for u in risk_aversion.keys
    'time_stability': [time_gap_stability.get(u, 0) for u in risk_aversion.k
})
behavioral_features.to_csv("behavioral_features_cache.csv", index=False)
```

In [24]:
```
behavioral_features
```

Out[24]:

	sender	risk_aversion	seq_similarity	time_stability
0	C1000036340	0.0	1.0	1.0
1	C1000086512	0.0	1.0	1.0
2	C1000122340	0.0	1.0	1.0
3	C1000331499	0.0	1.0	1.0
4	C1000422828	0.0	1.0	1.0
...	...	...	...	...
13208	C999476777	0.0	1.0	1.0
13209	C999481173	0.0	1.0	1.0
13210	C999519169	0.0	1.0	1.0
13211	C999561448	0.0	1.0	1.0
13212	C99979309	0.0	1.0	1.0

13213 rows × 4 columns

In [25]:
```
for node in tqdm(all_nodes_in_sample, desc="Processing Nodes with Behavioral
    is_fraud_node = df_sample[
        ((df_sample['sender'] == node) | (df_sample['receiver'] == node)) &
        (df_sample['is_fraud'] == 1)
    ].any().any()

    node_color = "#E33E4D" if is_fraud_node else "#4CAF50"
    total_amt = node_amounts.get(node, 0)

    # Integrate new behavioral metrics
    risk = risk_aversion.get(node, 0)
    seq_sim = seq_similarity.get(node, 0)
    time_stab = time_gap_stability.get(node, 0)

    # Composite Cognitive Risk Index
    cognitive_risk = (0.5 * risk + 0.3 * seq_sim + 0.2 * time_stab)

    node_data[node] = {
        'label': f"{node}\n$ {total_amt:,.2f}",
        'color': node_color,
        'value': total_amt,
        'title': f"Total: ${total_amt:,.2f} | Risk Aversion: {risk:.2f} | Se
    }
```

```
Processing Nodes with Behavioral Features: 100%|█| 16402/16402 [00:43<00:0
0, 380
```

In [17]:
```
node_data
```

Out[17]:

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```

```
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```

```
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```

```
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ap: 1.00 | CognitiveRisk: 0.50'},
 ...}
```

In [18]:

```python
import networkx as nx

# Build multi-type transaction graph (Heterogeneous)
G = nx.MultiDiGraph()

for _, row in df_sample.iterrows():
    G.add_edge(row['sender'], row['receiver'],
               tx_type=row['type'],
               amount=row['amount'],
               fraud=row['is_fraud'])

# Counterfactual Risk Propagation: simulate if a high-risk node changes beha
def counterfactual_risk(G, node):
    if node not in G:
        return None
    neighbors = list(G.successors(node))
    simulated_risk = 0
    for n in neighbors:
        edge_data = G.get_edge_data(node, n)
        if edge_data:
            amt = np.mean([d['amount'] for d in edge_data.values()])
            simulated_risk += np.log1p(amt) * 0.1
    return simulated_risk

# Example: compute for top-5 high-value nodes
top_nodes = node_amounts.sort_values(ascending=False).head(5).index
counterfactuals = {n: counterfactual_risk(G, n) for n in top_nodes}
print("\n--- Counterfactual Risk Propagation ---")
print(counterfactuals)
```

```
--- Counterfactual Risk Propagation ---
{'C439737079': None, 'C707403537': None, 'C167875008': None, 'C20253152': N
one, 'C172409641': None}
```

In [32]:

```
pip install torch
```

```
Collecting torch
  Using cached torch-2.2.2-cp39-none-macosx_10_9_x86_64.whl (150.8 MB)
Requirement already satisfied: filelock in /Users/saipranayreddy/opt/anacon
da3/lib/python3.9/site-packages (from torch) (3.6.0)
Requirement already satisfied: networkx in /Users/saipranayreddy/opt/anacon
da3/lib/python3.9/site-packages (from torch) (2.7.1)
Requirement already satisfied: sympy in /Users/saipranayreddy/opt/anaconda
3/lib/python3.9/site-packages (from torch) (1.10.1)
Requirement already satisfied: fsspec in /Users/saipranayreddy/opt/anaconda
3/lib/python3.9/site-packages (from torch) (2023.12.2)
Requirement already satisfied: jinja2 in /Users/saipranayreddy/opt/anaconda
3/lib/python3.9/site-packages (from torch) (2.11.3)
Requirement already satisfied: typing-extensions>=4.8.0 in /Users/saipranay
reddy/opt/anaconda3/lib/python3.9/site-packages (from torch) (4.9.0)
Requirement already satisfied: MarkupSafe>=0.23 in /Users/saipranayreddy/op
t/anaconda3/lib/python3.9/site-packages (from jinja2->torch) (2.0.1)
Requirement already satisfied: mpmath>=0.19 in /Users/saipranayreddy/opt/an
aconda3/lib/python3.9/site-packages (from sympy->torch) (1.2.1)
Installing collected packages: torch
Successfully installed torch-2.2.2
Note: you may need to restart the kernel to use updated packages.
```

In [34]:
```
pip install --upgrade scipy
```

```
Requirement already satisfied: scipy in /Users/saipranayreddy/opt/anaconda
3/lib/python3.9/site-packages (1.7.3)
Collecting scipy
  Using cached scipy-1.13.1-cp39-cp39-macosx_10_9_x86_64.whl (39.4 MB)
Collecting numpy<2.3,>=1.22.4
  Using cached numpy-2.0.2-cp39-cp39-macosx_10_9_x86_64.whl (21.2 MB)
Installing collected packages: numpy, scipy
  Attempting uninstall: numpy
    Found existing installation: numpy 1.21.6
    Uninstalling numpy-1.21.6:
      Successfully uninstalled numpy-1.21.6
  Attempting uninstall: scipy
    Found existing installation: scipy 1.7.3
    Uninstalling scipy-1.7.3:
      Successfully uninstalled scipy-1.7.3
ERROR: pip's dependency resolver does not currently take into account all t
he packages that are installed. This behaviour is the source of the followi
ng dependency conflicts.
daal4py 2021.5.0 requires daal==2021.4.0, which is not installed.
thinc 8.1.10 requires pydantic!=1.8,!=1.8.1,<1.11.0,>=1.7.4, but you have p
ydantic 2.5.3 which is incompatible.
tensorflow 2.12.0 requires numpy<1.24,>=1.22, but you have numpy 2.0.2 whic
h is incompatible.
streamlit 1.30.0 requires numpy<2,>=1.19.3, but you have numpy 2.0.2 which
is incompatible.
spacy 3.5.4 requires pydantic!=1.8,!=1.8.1,<1.11.0,>=1.7.4, but you have py
dantic 2.5.3 which is incompatible.
pandas-profiling 3.3.0 requires joblib~=1.1.0, but you have joblib 1.3.2 wh
ich is incompatible.
pandas-profiling 3.3.0 requires numpy<1.24,>=1.16.0, but you have numpy 2.
0.2 which is incompatible.
pandas-profiling 3.3.0 requires pydantic<1.10,>=1.8.1, but you have pydanti
c 2.5.3 which is incompatible.
pandas-profiling 3.3.0 requires scipy<1.10,>=1.4.1, but you have scipy 1.1
3.1 which is incompatible.
numba 0.55.1 requires numpy<1.22,>=1.18, but you have numpy 2.0.2 which is
incompatible.
gradio 4.12.0 requires numpy~=1.0, but you have numpy 2.0.2 which is incomp
atible.
Successfully installed numpy-2.0.2 scipy-1.13.1
Note: you may need to restart the kernel to use updated packages.
```

In [48]:

```python
# GraphSAGE + Symbolic Rule Inducer (Decision Tree) pipeline
# Assumes df_sample (pandas DataFrame) is present in the environment
# and node_amounts (pandas Series) is available. If not, we recompute.

import os
import numpy as np
import pandas as pd
import networkx as nx
import torch
import torch.nn.functional as F
from torch_geometric.data import Data
from torch_geometric.nn import SAGEConv
from sklearn.tree import DecisionTreeClassifier, export_text
from sklearn.model_selection import train_test_split
from sklearn.metrics import classification_report, accuracy_score
from sklearn.preprocessing import StandardScaler

# -------------------------
# 0. Quick checks / prepare
# -------------------------
assert 'sender' in df_sample.columns and 'receiver' in df_sample.columns, \
    "df_sample must contain 'sender' and 'receiver' columns."
```

```
# Recompute node_amounts if not present
if 'node_amounts' not in globals():
    node_amounts = (
        df_sample.groupby('sender')['amount'].sum().add(
        df_sample.groupby('receiver')['amount'].sum(), fill_value=0)
    )

# Build node list (unique nodes in sample)
nodes = pd.Index(np.unique(pd.concat([df_sample['sender'], df_sample['receiv
node_to_idx = {node: i for i, node in enumerate(nodes)}
n_nodes = len(nodes)
print(f"Number of nodes in sampled graph: {n_nodes}")

# -------------------------
# 1. Build NetworkX directed graph for feature engineering
# -------------------------
G = nx.DiGraph()
G.add_nodes_from(nodes)
for _, row in df_sample.iterrows():
    s = row['sender']; r = row['receiver']; amt = float(row['amount'])
    # add edge; if multiple edges exist they're aggregated w/ weight
    if G.has_edge(s, r):
        G[s][r]['weight'] += amt
        G[s][r]['count'] += 1
    else:
        G.add_edge(s, r, weight=amt, count=1)
```

```
Number of nodes in sampled graph: 16402
```

In [50]:

```
# -------------------------
# 2. Node-level feature engineering
# -------------------------
# Basic numeric features (can be extended)
total_amount = np.array([float(node_amounts.get(node, 0.0)) for node in node
in_deg = np.array([G.in_degree(node) for node in nodes], dtype=float)
out_deg = np.array([G.out_degree(node) for node in nodes], dtype=float)
degree = in_deg + out_deg
pagerank_dict = pagerank_safe(G)
pagerank = np.array([pagerank_dict[node] for node in nodes]) if n_nodes > 1


# Normalize numeric features
scaler = StandardScaler()
node_features_numeric = scaler.fit_transform(
    np.vstack([total_amount, in_deg, out_deg, degree, pagerank]).T
)

# Optionally add a one-hot indicator for "involved in fraud" at node-level a
node_is_fraud = np.zeros(n_nodes, dtype=int)
for i, node in enumerate(nodes):
    # if node occurs in any fraudulent transaction in df_sample
    is_f = df_sample[
        ((df_sample['sender'] == node) | (df_sample['receiver'] == node)) &
        (df_sample['is_fraud'] == 1)
    ].any(axis=None)
    node_is_fraud[i] = 1 if is_f else 0

print("Feature summary: total_amount (scaled), in_deg, out_deg, degree, page
```

```
Feature summary: total_amount (scaled), in_deg, out_deg, degree, pagerank
```

In [51]:

```
# -------------------------
# 3. Build PyG graph (edge_index)
```

```
# -------------------------
# Convert edges to index form (keep direction)
edge_index_list = []
edge_attr = []
for u, v, data in G.edges(data=True):
    ui = node_to_idx[u]; vi = node_to_idx[v]
    edge_index_list.append([ui, vi])
    edge_attr.append([data.get('weight', 0.0), data.get('count', 1)])

edge_index = torch.tensor(edge_index_list, dtype=torch.long).t().contiguous(
edge_attr = torch.tensor(edge_attr, dtype=torch.float) if edge_attr else Nor

x = torch.tensor(node_features_numeric, dtype=torch.float)  # shape [N, F]
y = torch.tensor(node_is_fraud, dtype=torch.long)           # shape [N]

data = Data(x=x, edge_index=edge_index, y=y)
print(data)
```

```
Data(x=[16402, 5], edge_index=[2, 8223], y=[16402])
```

In [52]:

```
# -------------------------
# 4. GraphSAGE model definition
# -------------------------
class GraphSAGE(torch.nn.Module):
    def __init__(self, in_channels, hidden_channels, out_channels, dropout=0
        super().__init__()
        self.conv1 = SAGEConv(in_channels, hidden_channels)
        self.conv2 = SAGEConv(hidden_channels, out_channels)
        self.dropout = dropout

    def forward(self, x, edge_index):
        x = self.conv1(x, edge_index)
        x = F.relu(x)
        x = F.dropout(x, p=self.dropout, training=self.training)
        x = self.conv2(x, edge_index)
        return x  # final node embeddings (logits if used for classificatio

# -------------------------
```

In [53]:

```
# -------------------------
# 5. Train GraphSAGE for node-level classification
# -------------------------
device = torch.device('cuda' if torch.cuda.is_available() else 'cpu')
model = GraphSAGE(in_channels=data.num_node_features, hidden_channels=64, ou
data = data.to(device)

optimizer = torch.optim.Adam(model.parameters(), lr=0.01, weight_decay=5e-4)
criterion = torch.nn.BCEWithLogitsLoss()  # using logits for binary node lab

# create train/test split of nodes (stratified)
train_idx, test_idx = train_test_split(np.arange(n_nodes), test_size=0.3, st
train_mask = torch.zeros(n_nodes, dtype=torch.bool)
test_mask = torch.zeros(n_nodes, dtype=torch.bool)
train_mask[train_idx] = True
test_mask[test_idx] = True
train_mask = train_mask.to(device); test_mask = test_mask.to(device)

y_float = y.float().to(device)

epochs = 140
model.train()
for epoch in range(1, epochs + 1):
    optimizer.zero_grad()
    out = model(data.x, data.edge_index).squeeze()       # shape [N, out_dim
```

```
    # For classification, reduce out to a single logit per node using a smal
    # Simple approach: take dot with a learnable vector to map embedding ->
    # We'll create a linear head on the fly:
    # (Better: define linear head in model; for brevity we use a small proje
    # But to keep training end-to-end, add a linear layer:
    # Re-define with small classifier:
    break

# Rebuild model with classification head properly
class GraphSAGEWithHead(torch.nn.Module):
    def __init__(self, in_channels, hidden_channels, hidden_emb, dropout=0.3
        super().__init__()
        self.sage1 = SAGEConv(in_channels, hidden_channels)
        self.sage2 = SAGEConv(hidden_channels, hidden_emb)
        self.cls = torch.nn.Linear(hidden_emb, 1)
        self.dropout = dropout

    def forward(self, x, edge_index):
        h = self.sage1(x, edge_index)
        h = F.relu(h)
        h = F.dropout(h, p=self.dropout, training=self.training)
        h = self.sage2(h, edge_index)
        logits = self.cls(h).squeeze(-1)  # [N]
        return logits, h  # logits for classification, h as embeddings

model = GraphSAGEWithHead(in_channels=data.num_node_features, hidden_channel
optimizer = torch.optim.Adam(model.parameters(), lr=0.01, weight_decay=5e-4)

for epoch in range(1, epochs + 1):
    model.train()
    optimizer.zero_grad()
    logits, embeddings = model(data.x, data.edge_index)
    loss = criterion(logits[train_mask], y_float[train_mask])
    loss.backward()
    optimizer.step()

    if epoch % 20 == 0 or epoch == 1:
        model.eval()
        with torch.no_grad():
            val_logits, _ = model(data.x, data.edge_index)
            val_pred = (torch.sigmoid(val_logits[test_mask]) > 0.5).cpu().nu
            val_true = y[test_mask.cpu()].cpu().numpy().astype(int)
            acc = accuracy_score(val_true, val_pred)
            print(f"Epoch {epoch:03d} Loss: {loss.item():.4f} Val Acc: {acc:
```

```
Epoch 001 Loss: 0.7037 Val Acc: 0.9988
Epoch 020 Loss: 0.0203 Val Acc: 0.9988
Epoch 040 Loss: 0.0134 Val Acc: 0.9988
Epoch 060 Loss: 0.0099 Val Acc: 0.9988
Epoch 080 Loss: 0.0089 Val Acc: 0.9988
Epoch 100 Loss: 0.0091 Val Acc: 0.9988
Epoch 120 Loss: 0.0097 Val Acc: 0.9988
Epoch 140 Loss: 0.0095 Val Acc: 0.9988
```

In [54]:

```
# -------------------------
# 6. Extract embeddings and produce node-level dataset for SRI
# -------------------------
model.eval()
with torch.no_grad():
    logits_all, embeddings_all = model(data.x, data.edge_index)
    probs = torch.sigmoid(logits_all).cpu().numpy()
    embeddings_np = embeddings_all.cpu().numpy()  # shape [N, emb_dim]
```

```
# Build a pandas DataFrame containing engineered features + embeddings + lab
feat_df = pd.DataFrame({
    'node': nodes,
    'total_amount': total_amount,
    'in_deg': in_deg,
    'out_deg': out_deg,
    'degree': degree,
    'pagerank': pagerank,
    'fraud_label': node_is_fraud,
    'graphsage_prob': probs
})

# attach embedding columns
emb_cols = [f'emb_{i}' for i in range(embeddings_np.shape[1])]
emb_df = pd.DataFrame(embeddings_np, columns=emb_cols)
feat_df = pd.concat([feat_df.reset_index(drop=True), emb_df.reset_index(drop

print("Feature DataFrame shape:", feat_df.shape)
print(feat_df.head())
```

```
Feature DataFrame shape: (16402, 40)
          node  total_amount  in_deg  out_deg  degree  pagerank  fraud_labe
l  \
0  C1000036340     253648.68     0.0      1.0     1.0  0.000043
1
1  C1000039615     380800.81     1.0      0.0     1.0  0.000079
1
2  C1000086512      33676.59     0.0      1.0     1.0  0.000043
1
3  C1000331499    2016790.84     0.0      1.0     1.0  0.000043
1
4  C1000367306     190815.79     1.0      0.0     1.0  0.000079
1

   graphsage_prob     emb_0     emb_1  ...     emb_22    emb_23    emb_24  \
0        0.999071  1.505597 -0.902397  ... -1.920001 -1.218021 -0.394654
1        0.997923  1.318480 -0.637971  ... -2.036075 -1.346355 -0.319629
2        0.999033  1.498021 -0.899669  ... -1.908687 -1.210359 -0.391796
3        0.999323  1.566784 -0.924287  ... -2.011262 -1.280510 -0.417582
4        0.997910  1.317533 -0.637065  ... -2.033994 -1.344947 -0.319204

     emb_25    emb_26    emb_27    emb_28    emb_29    emb_30    emb_31
0  1.894153  1.714095 -1.723087  1.561439 -1.535542  1.765153 -0.978831
1  1.592302  1.117226 -1.606150  1.292601 -1.378058  1.002004 -1.202497
2  1.885317  1.704801 -1.712932  1.553943 -1.525564  1.754036 -0.975130
3  1.965834  1.788697 -1.805040  1.621780 -1.615598  1.854655 -1.008513
4  1.590182  1.115330 -1.606775  1.292295 -1.377014  1.000581 -1.201398

[5 rows x 40 columns]
```

In [55]:

```
# -------------------------
# 7. Symbolic Rule Inducer: Decision Tree on combined features
# -------------------------
# Choose a concise set of interpretable features + top few embedding dims
selected_features = ['total_amount', 'in_deg', 'out_deg', 'degree', 'graphsa
X = feat_df[selected_features].fillna(0).values
y_sri = feat_df['fraud_label'].values

# split
X_train, X_test, y_train, y_test = train_test_split(X, y_sri, test_size=0.3,

sri_clf = DecisionTreeClassifier(max_depth=4, min_samples_leaf=5, random_sta
sri_clf.fit(X_train, y_train)
```

```
y_pred = sri_clf.predict(X_test)
print("\nDecision Tree (SRI) classification report:")
print(classification_report(y_test, y_pred))
print("Accuracy:", accuracy_score(y_test, y_pred))

# Export rules
feature_names = selected_features
rules_text = export_text(sri_clf, feature_names=feature_names)
print("\n--- Symbolic Rules (Decision Tree) ---\n")
print(rules_text)

# Save artifacts
os.makedirs('model_artifacts', exist_ok=True)
np.save('model_artifacts/node_embeddings.npy', embeddings_np)
feat_df.to_csv('model_artifacts/node_features_with_embeddings.csv', index=Fa
with open('model_artifacts/sri_rules.txt', 'w') as f:
    f.write(rules_text)

print("\nArtifacts saved to ./model_artifacts/ (embeddings CSV, SRI rules)")
```

```
Decision Tree (SRI) classification report:
              precision    recall  f1-score   support

           0       0.00      0.00      0.00         6
           1       1.00      1.00      1.00      4915

    accuracy                           1.00      4921
   macro avg       0.50      0.50      0.50      4921
weighted avg       1.00      1.00      1.00      4921

Accuracy: 0.9987807356228409

--- Symbolic Rules (Decision Tree) ---

|--- emb_1 <= -0.63
|   |--- emb_2 <= -1.41
|   |   |--- emb_1 <= -0.64
|   |   |   |--- emb_0 <= 1.51
|   |   |   |   |--- class: 1
|   |   |   |--- emb_0 >  1.51
|   |   |   |   |--- class: 1
|   |   |--- emb_1 >  -0.64
|   |   |   |--- emb_1 <= -0.64
|   |   |   |   |--- class: 1
|   |   |   |--- emb_1 >  -0.64
|   |   |   |   |--- class: 1
|   |--- emb_2 >  -1.41
|   |   |--- emb_1 <= -0.90
|   |   |   |--- class: 1
|   |   |--- emb_1 >  -0.90
|   |   |   |--- emb_4 <= -0.92
|   |   |   |   |--- class: 1
|   |   |   |--- emb_4 >  -0.92
|   |   |   |   |--- class: 1
|--- emb_1 >  -0.63
|   |--- emb_4 <= -0.55
|   |   |--- emb_4 <= -0.55
|   |   |   |--- emb_1 <= -0.63
|   |   |   |   |--- class: 1
|   |   |   |--- emb_1 >  -0.63
|   |   |   |   |--- class: 1
|   |   |--- emb_4 >  -0.55
|   |   |   |--- class: 1
|   |--- emb_4 >  -0.55
|   |   |--- class: 1


Artifacts saved to ./model_artifacts/ (embeddings CSV, SRI rules)
```

In [56]:

```python
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import classification_report
from sklearn.model_selection import train_test_split

# X = feature matrix (embeddings, degrees, totals, etc.)
# y = labels (0 = non-fraud, 1 = fraud)

# Split into train/test
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, ra

# Decision Tree with class balancing
dt = DecisionTreeClassifier(
    max_depth=5,           # limit depth for interpretable rules
    min_samples_leaf=5,    # avoid tiny leaves
    class_weight='balanced', # handle imbalance
```

```
    random_state=42
)

dt.fit(X_train, y_train)

# Predictions
y_pred = dt.predict(X_test)

# Evaluation
print("Classification Report:\n")
print(classification_report(y_test, y_pred))
```

```
Classification Report:

              precision    recall  f1-score   support

           0       0.00      0.75      0.01         4
           1       1.00      0.66      0.79      3277

    accuracy                           0.66      3281
   macro avg       0.50      0.70      0.40      3281
weighted avg       1.00      0.66      0.79      3281
```

In [66]:
```
# Example: embeddings + degrees + other graph features
# NumPy array X.shape = (n_samples, 11)
feature_names = [
    'emb_0', 'emb_1', 'emb_2', 'emb_3', 'emb_4',  # 5 embedding dims
    'in_deg', 'out_deg', 'degree',                # 3 degree features
    'total_amount',                               # transaction amount
    'pagerank',                                   # graph feature
    'clustering_coef'                             # graph feature
]
```

In [67]:
```
from sklearn.tree import export_text
tree_rules = export_text(dt, feature_names=feature_names)
print("--- Symbolic Rules (Decision Tree) ---\n")
print(tree_rules)
```

```
--- Symbolic Rules (Decision Tree) ---

|--- in_deg <= 1.51
|   |--- emb_0 <= 3511.47
|   |   |--- degree <= -1.41
|   |   |   |--- in_deg <= 1.31
|   |   |   |   |--- class: 1
|   |   |   |--- in_deg >  1.31
|   |   |   |   |--- degree <= -1.41
|   |   |   |   |   |--- class: 0
|   |   |   |   |--- degree >  -1.41
|   |   |   |   |   |--- class: 0
|   |   |--- degree >  -1.41
|   |   |   |--- clustering_coef <= -1.22
|   |   |   |   |--- class: 1
|   |   |   |--- clustering_coef >  -1.22
|   |   |   |   |--- class: 1
|   |--- emb_0 >  3511.47
|   |   |--- degree <= -1.41
|   |   |   |--- out_deg <= -0.65
|   |   |   |   |--- degree <= -1.58
|   |   |   |   |   |--- class: 1
|   |   |   |   |--- degree >  -1.58
|   |   |   |   |   |--- class: 0
|   |   |   |--- out_deg >  -0.65
|   |   |   |   |--- emb_0 <= 351184.95
|   |   |   |   |   |--- class: 0
|   |   |   |   |--- emb_0 >  351184.95
|   |   |   |   |   |--- class: 1
|   |   |--- degree >  -1.41
|   |   |   |--- class: 1
|--- in_deg >  1.51
|   |--- class: 1
```

In [62]:
```
feature_names
```

Out[62]:
```
['emb_0',
 'emb_1',
 'emb_2',
 'emb_3',
 'emb_4',
 'in_deg',
 'out_deg',
 'total_amount']
```

In [71]:
```
def predict_account(in_deg, emb_0, degree):
    if in_deg <= 1.31 and emb_0 <= 3511.47 and degree <= -1.41:
        return 1  # fraud
    else:
        return 0  # non-fraud
```

In [75]:
```
predict_account(1.01, 3211.47, 1.43)
```

Out[75]:
```
0
```

In [ ]:
```

```