Concept of projection

NETWORK ANALYSIS IN PYTHON (PART 2)

Eric Ma

Data Carpentry instructor and author of nxviz package

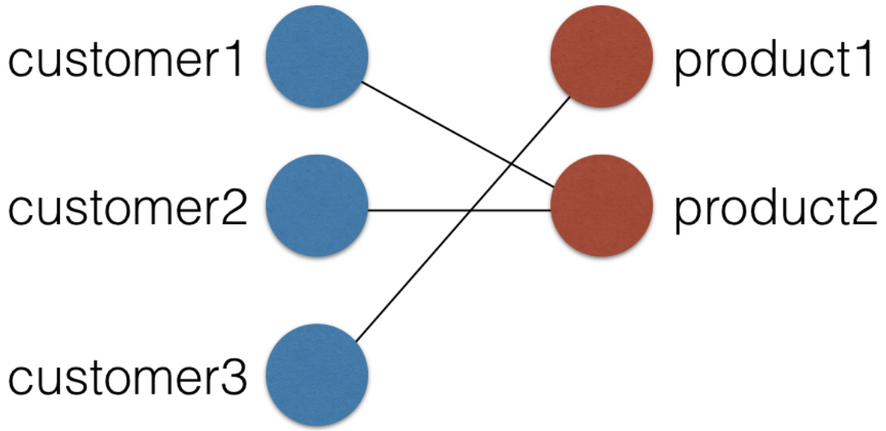
DataCamp

Projection

- Useful to investigate the relationships between nodes on one partition
    - Conditioned on the connections to the nodes in the other partition

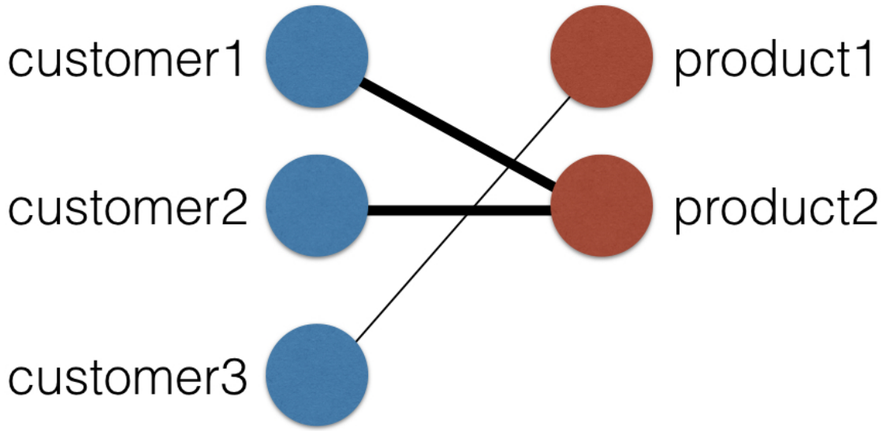
Projection

- Unipartite representation of bipartite connectivity



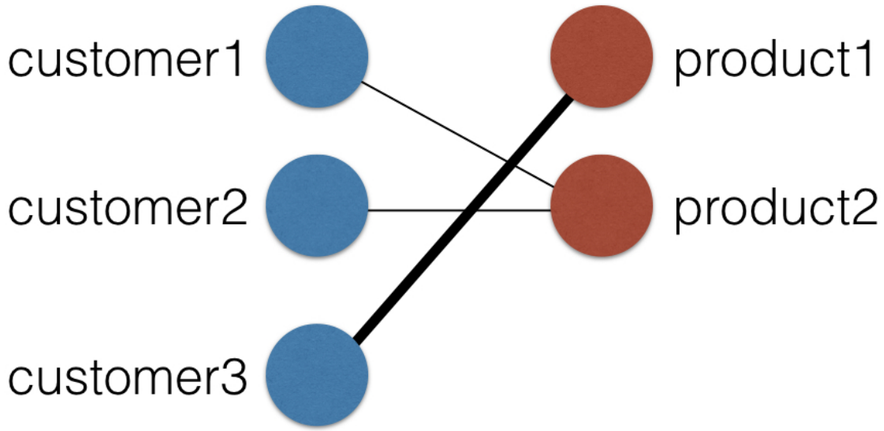
Projection

- Unipartite representation of bipartite connectivity



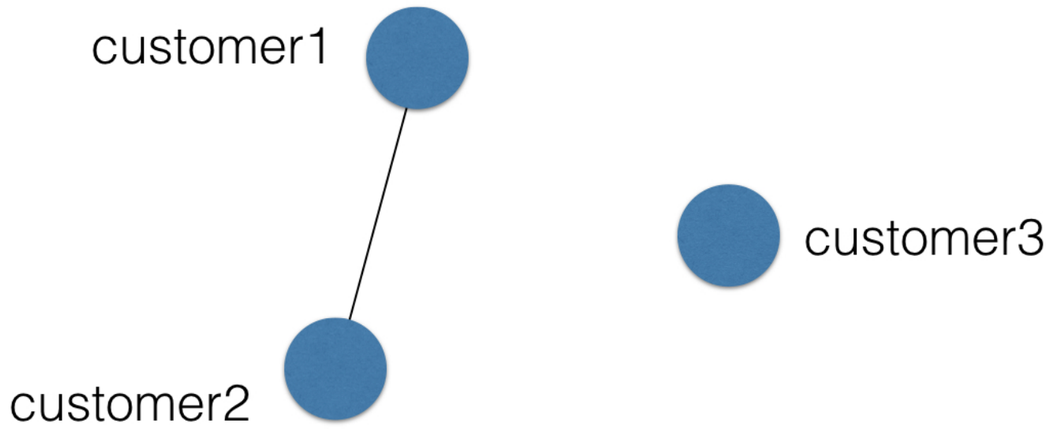
Projection

- Unipartite representation of bipartite connectivity



Projection

- Unipartite representation of bipartite connectivity



Graphs on Disk

- Flat edge lists
- CSV files: nodelist + metadata, edgelist + metadata

Reading network data

```
import networkx as nx
G = nx.read_edgelist('american-revolution.txt')
G.edges(data=True)[0:5]
```

```
[('Parkman.Elias', 'LondonEnemies', {'weight': 1}),
 ('Parkman.Elias', 'NorthCaucus', {'weight': 1}),
 ('Inglish.Alexander', 'StAndrewsLodge', {'weight': 1}),
 ('NorthCaucus', 'Chadwell.Mr', {'weight': 1}),
 ('NorthCaucus', 'Pearce.IsaacJun', {'weight': 1})]
```

- Text File

```
Barrett.Samuel LondonEnemies {'weight': 1}
Barrett.Samuel StAndrewsLodge {'weight': 1}
Marshall.Thomas LondonEnemies {'weight': 1}
Eaton.Joseph TeaParty {'weight': 1}
Bass.Henry LondonEnemies {'weight': 1}
```

Bipartite projection

```
G.nodes()
```

```
['product2', 'customer3', 'customer1', 'product3',
    'customer2', 'product1']
```

```
G.edges()
```

```
[('product2', 'customer1'),
 ('product2', 'customer2'),
 ('customer3', ‘product1')]
```

Bipartite projection

```
cust_nodes = [n for n in G.nodes() if G.node[n]
                  ['bipartite'] == 'customers']
cust_nodes
```

```
['customer3', 'customer1', 'customer2']
```

Bipartite projection

```
G_cust = nx.bipartite.projected_graph(G, cust_nodes)
G_cust.nodes()
```

```
['customer1', 'customer3', 'customer2']
```

```
G_cust.edges()
```

```
[('customer1', 'customer2')]
```

Degree centrality

- Recall degree centrality definition

$$\frac{\text{number of neighbors}}{\text{number of possible neighbors}}$$

- Denominator: number of nodes on opposite partition

Bipartite degree centrality

```
nx.bipartite.degree_centrality(G, cust_nodes)
```

```
{'customer1': 0.3333333333333333,
 'customer2': 0.3333333333333333,
 'customer3': 0.3333333333333333,
 'product1': 0.3333333333333333,
 'product2': 0.6666666666666666,
 'product3': 0.0}
```

Bipartite degree centrality

```
nx.degree_centrality(G)
```

```
{'customer1': 0.2,
 'customer2': 0.2,
 'customer3': 0.2,
 'product1': 0.2,
 'product2': 0.4,
 'product3': 0.0}
```

Let's practice!

NETWORK ANALYSIS IN PYTHON (PART 2)

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Bipartite graphs as matrices

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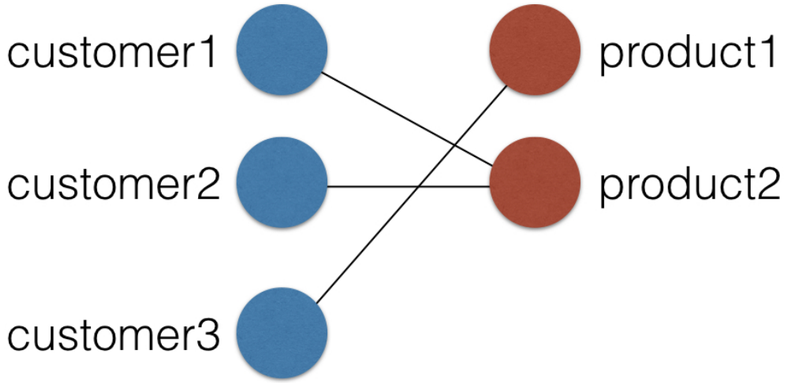
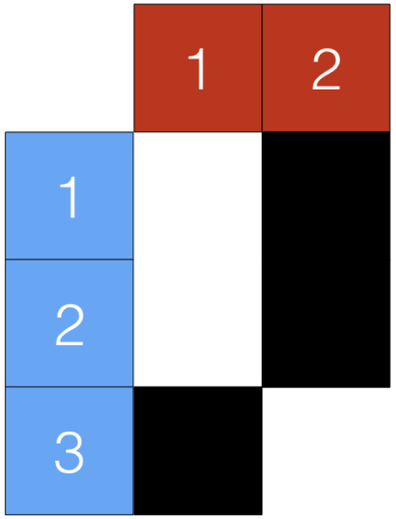
Matrix representation

- Rows: nodes on one partition
- Columns: nodes on other partition
- Cells: 1 if edge present, else 0

Matrix representation





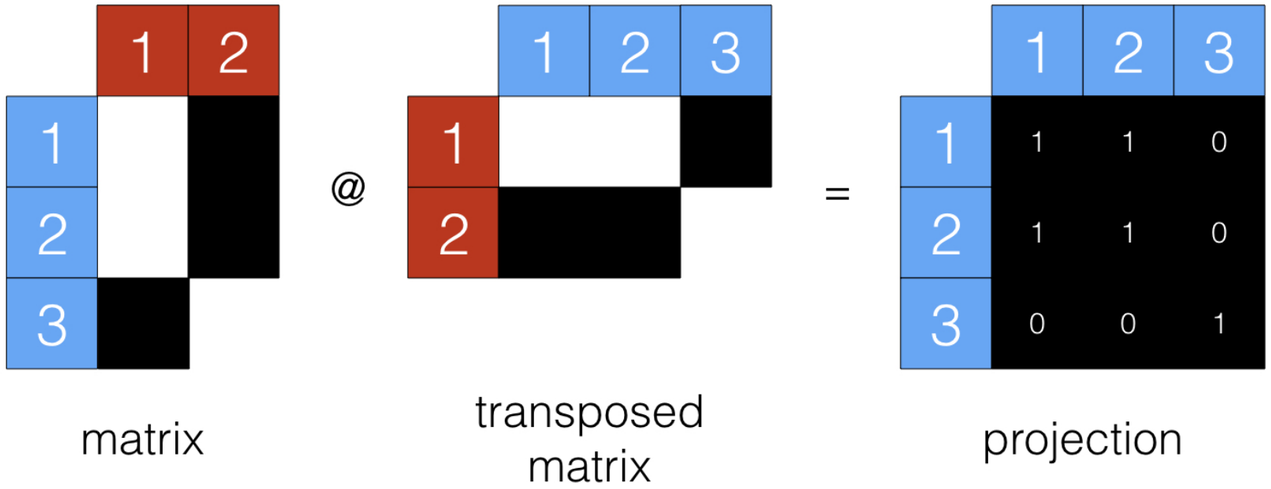
Example code

```
cust_nodes = [n for n in G.nodes() if G.node[n]
                ['bipartite'] == 'customers']
prod_nodes = [n for n in G.nodes() if G.node[n]
                ['bipartite'] == 'products']

mat = nx.bipartite.biadjacency_matrix(G,
          row_order=cust_nodes, column_order=prod_nodes)

mat
```

```
<3x2 sparse matrix of type '<class 'numpy.int64'>'
with 3 stored elements in Compressed Sparse Row format>
```

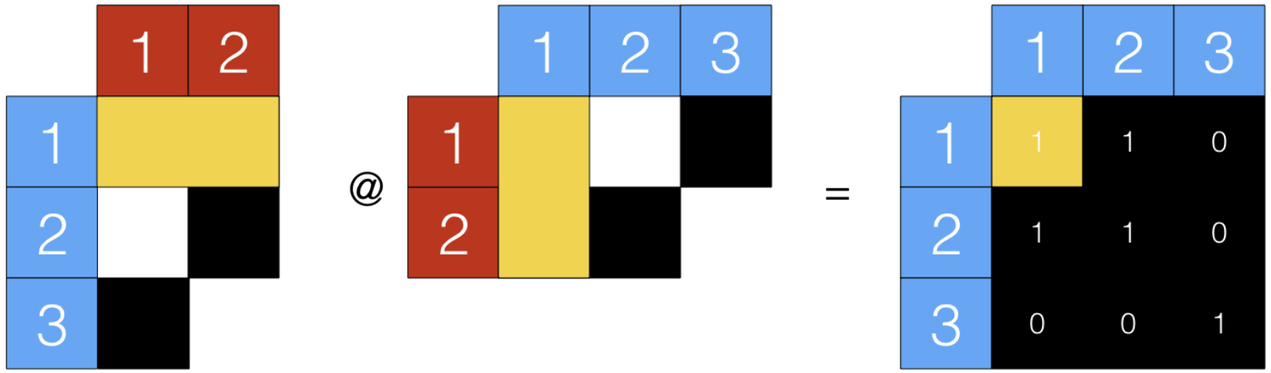
Matrix projection

- Projection computable using matrix multiplication



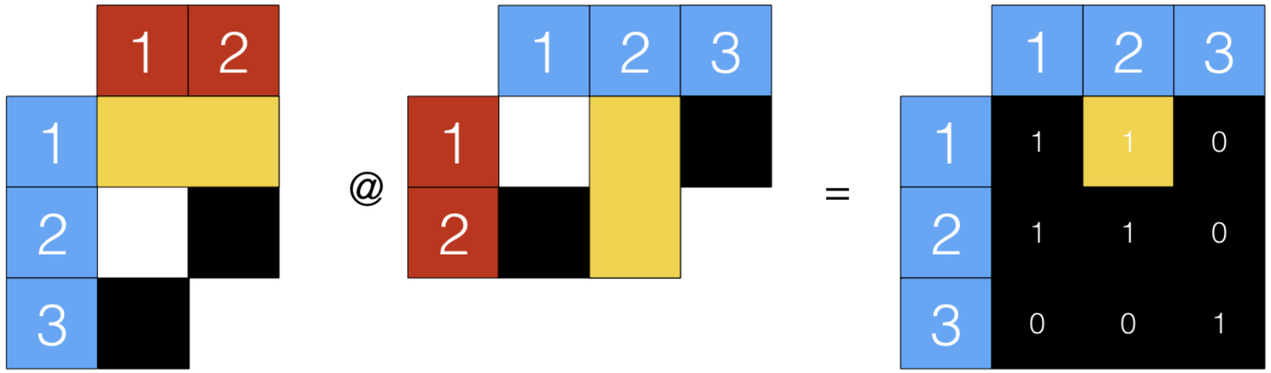
Matrix projection

- Projection computable using matrix multiplication



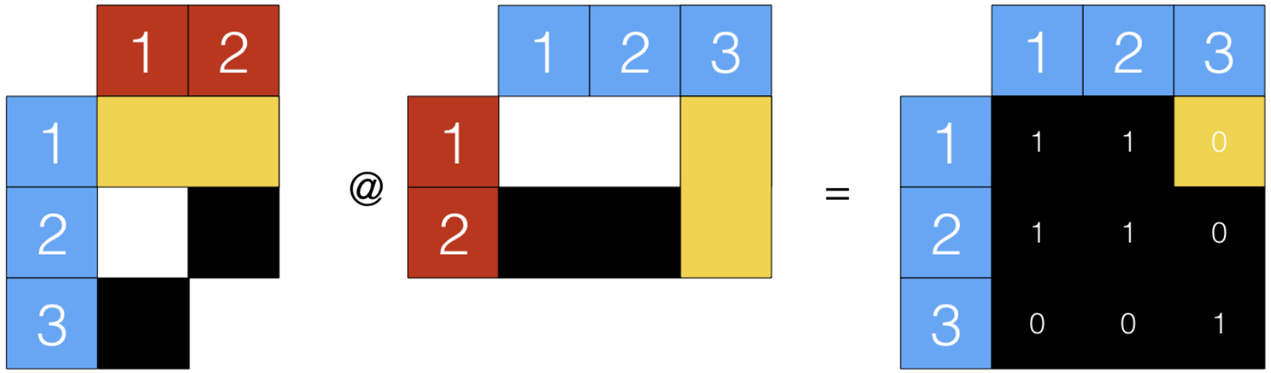
Matrix projection

- Projection computable using matrix multiplication



Matrix projection

- Projection computable using matrix multiplication



Matrix projection

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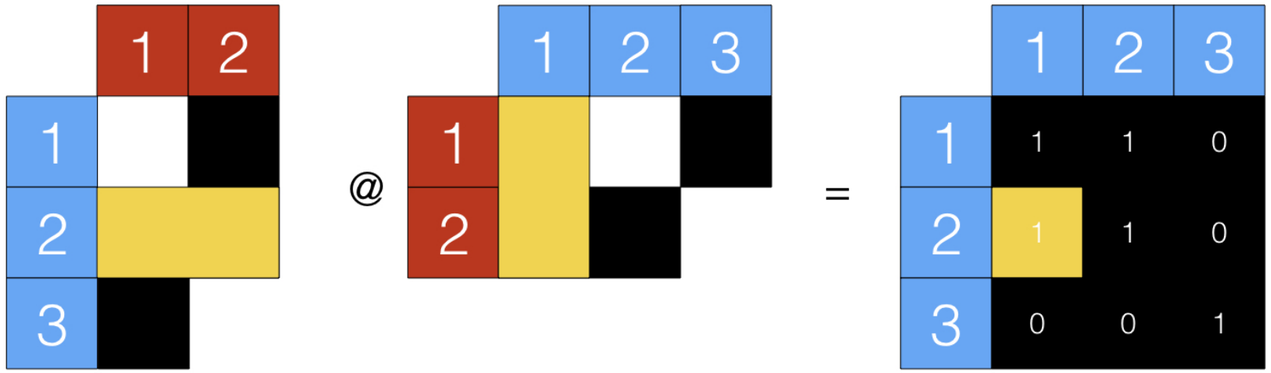
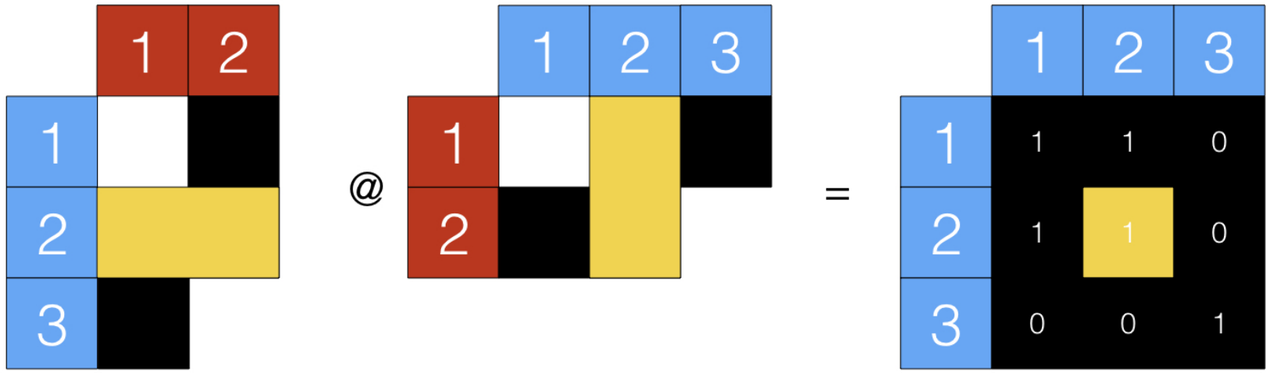


Matrix projection

- Projection computable using matrix multiplication



Matrix projection

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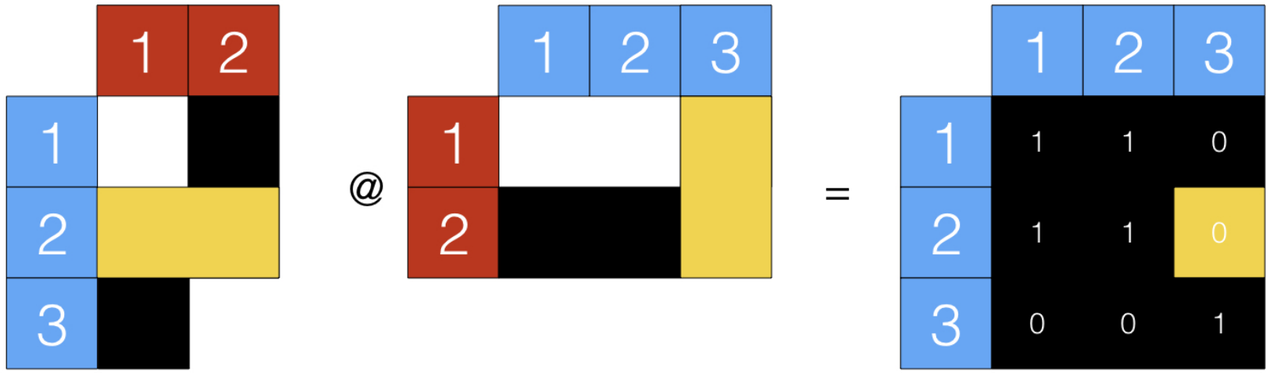
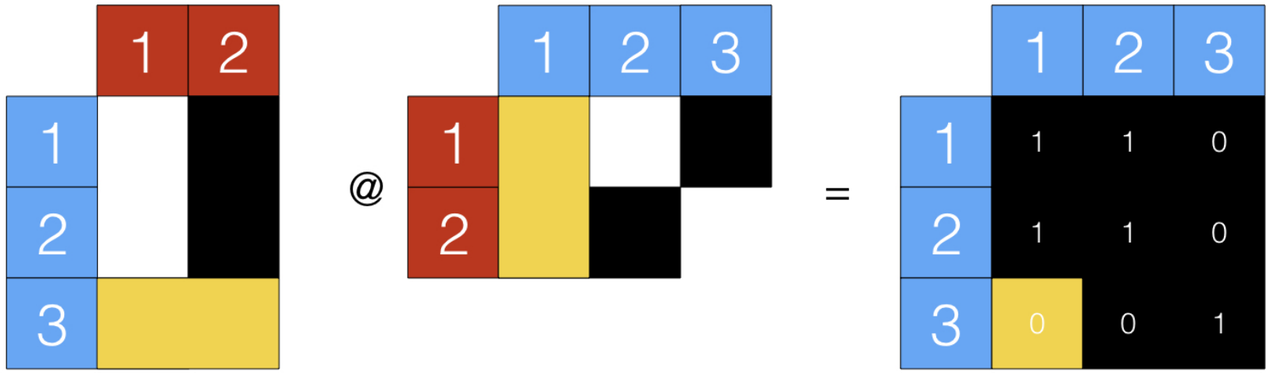


Matrix projection

- Projection computable using matrix multiplication



Matrix projection

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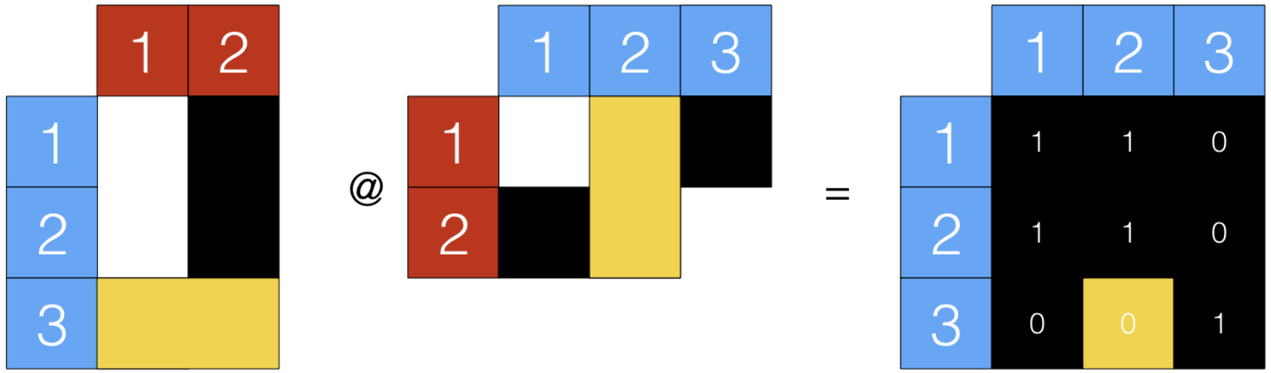
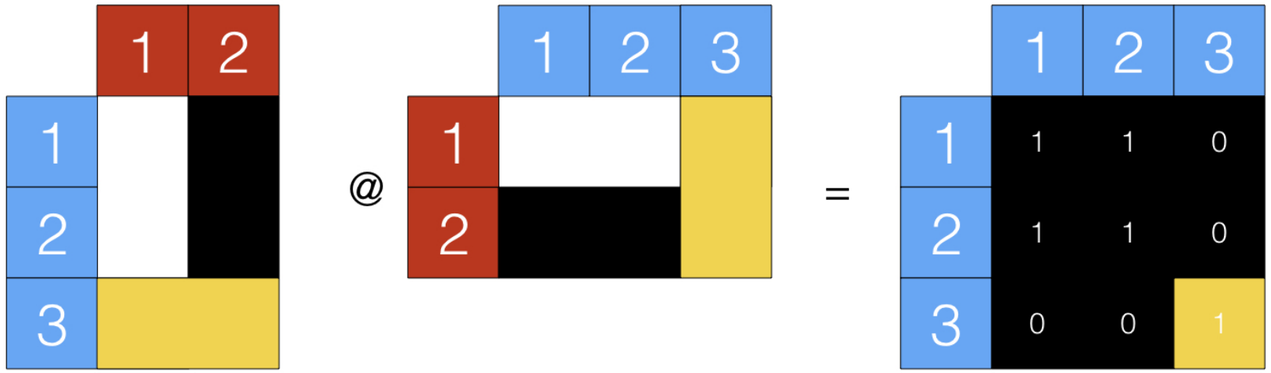


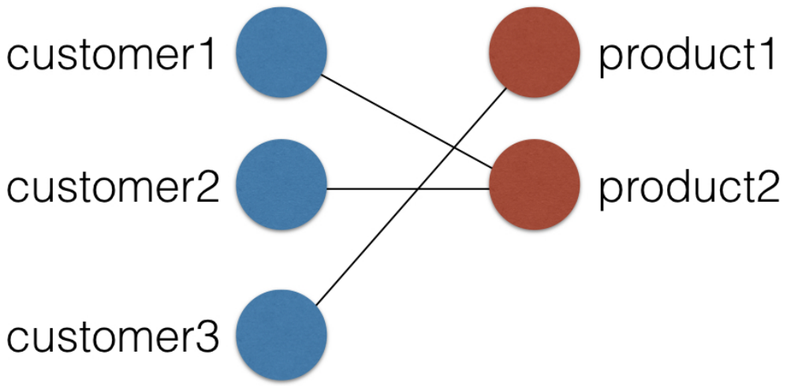
Matrix projection

- Projection computable using matrix multiplication



Matrix projection

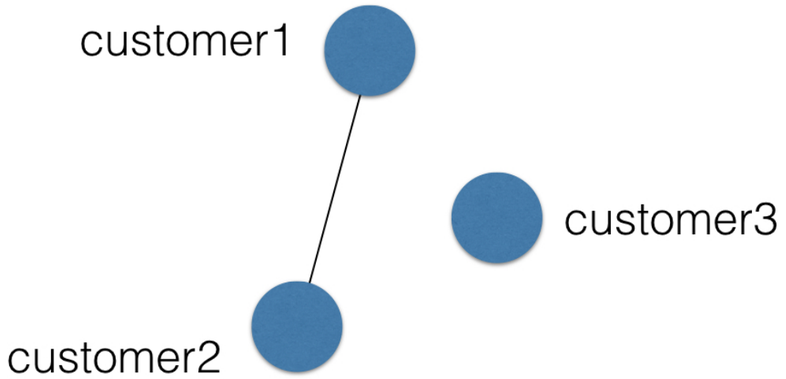
- Projection computable using matrix multiplication



	1	2	3
1	1	1	0
2	1	1	0
3	0	0	1

Matrix projection

- Projection computable using matrix multiplication



	1	2	3
1	1	1	0
2	1	1	0
3	0	0	1

Matrix multiplication in Python

```
mat @ mat.T
```

```
<5x5 sparse matrix of type '<class 'numpy.int64'>'
 with 23 stored elements in Compressed Sparse Row format>
```

```
mat.T @ mat
```

```
<10x10 sparse matrix of type '<class 'numpy.int64'>'
 with 50 stored elements in Compressed Sparse Column format
```

Let's practice!

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Representing network data with pandas

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CSV files for network data storage

- CSV File

```
person,party,weight
Barrett.Samuel,LondonEnemies,1
Barrett.Samuel,StAndrewsLodge,1
Marshall.Thomas,LondonEnemies,1
Eaton.Joseph,TeaParty,1
Bass.Henry,LondonEnemies,1
```

CSV files for network data storage

- Advantages:
  - Human-readable
  - Do further analysis with pandas
- Disadvantages:
  - Repetitive; disk space
- Two DataFrames: node and edge lists

Node list and edge list

- Node list
  - Each row is one node
  - The columns represent metadata attached to that node
- Edge list
  - Each row is one edge
  - The columns represent the metadata attached to that edge

Pandas and graphs

```
G.nodes(data=True)
```

```
[(0, {'bipartite': 0}),
(1, {'bipartite': 0}),
(2, {'bipartite': 0}),
...]
```

```
nodelist = []
for n, d in G.nodes(data=True):
    node_data = dict()
    node_data['node'] = n
    node_data.update(d)
    nodelist.append(node_data)
```

Pandas and graphs

```
nodelist
```

```
[{'bipartite': 0, 'node': 0},
{'bipartite': 0, 'node': 1},
{'bipartite': 0, 'node': 2},
{'bipartite': 0, 'node': 3},
{'bipartite': 0, 'node': 4},...]
```

Pandas and graphs

```
import pandas as pd
pd.DataFrame(nodelist)
```

```
  bipartite  node
0           0     0
1           0     1
2           0     2
3           0     3
4           0     4
5           1     5
6           1     6
7           1     7
```

```
pd.DataFrame(nodelist).to_csv('my_file.csv')
```

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