

CLIQUE PERCOLATION METHOD

(CPM)

CONTENTS

- What is CPM?
- Algorithm
- Analysis
- Conclusion

WHAT IS CPM?

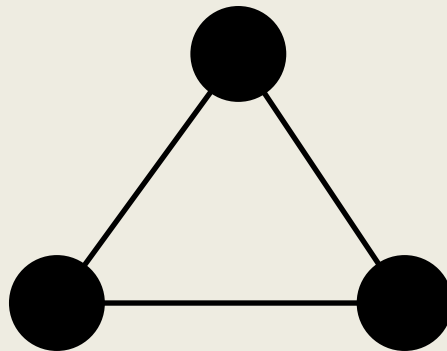
- Method to find overlapping communities
- Based on concept:
 - internal edges of community likely to form cliques
 - Intercommunity edges unlikely to form cliques

CLIQUE

- Clique: Complete graph
- k-clique: Complete graph with k vertices

CLIQUE

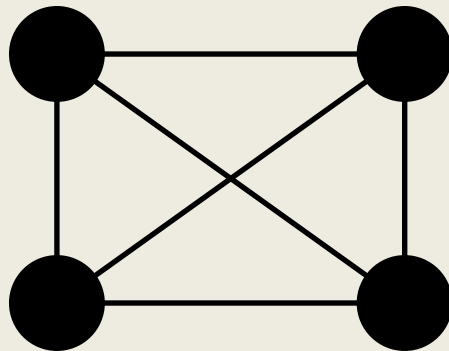
- Clique: Complete graph
- k-clique: Complete graph with k vertices



3-clique

CLIQUE

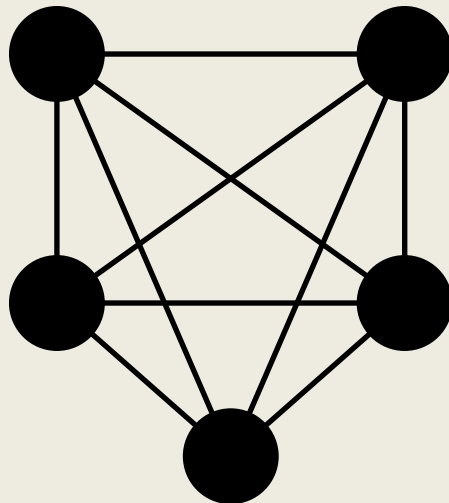
- Clique: Complete graph
- k-clique: Complete graph with k vertices



4-clique

CLIQUE

- Clique: Complete graph
- k -clique: Complete graph with k vertices



5-clique

K-CLIQUE COMMUNITIES

■ Adjacent k-cliques

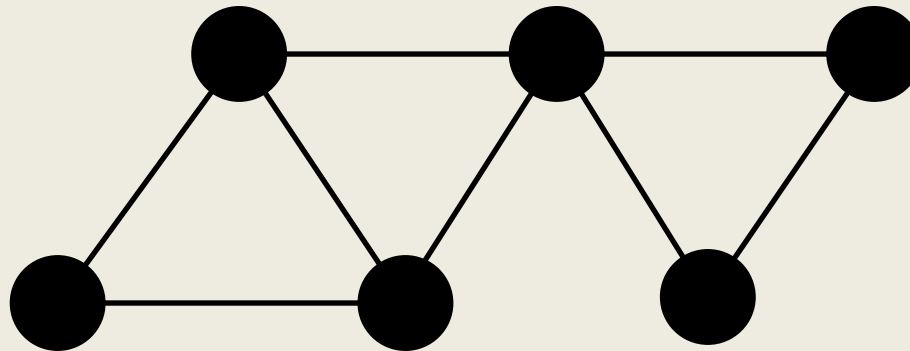
Two k-cliques are adjacent when they share **k-1** nodes

K-CLIQUE COMMUNITIES

■ Adjacent k-cliques

Two k-cliques are adjacent when they share $k-1$ nodes

$k = 3$

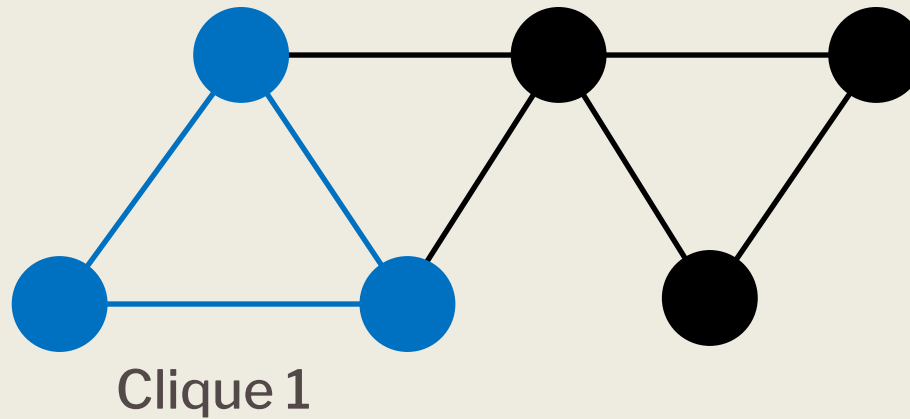


K-CLIQUE COMMUNITIES

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Two k-cliques are adjacent when they share $k-1$ nodes

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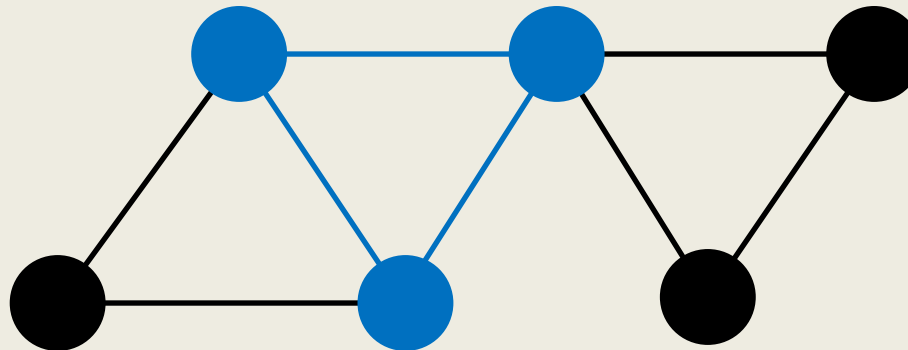
K-CLIQUE COMMUNITIES

■ Adjacent k-cliques

Two k-cliques are adjacent when they share $k-1$ nodes

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Clique 2

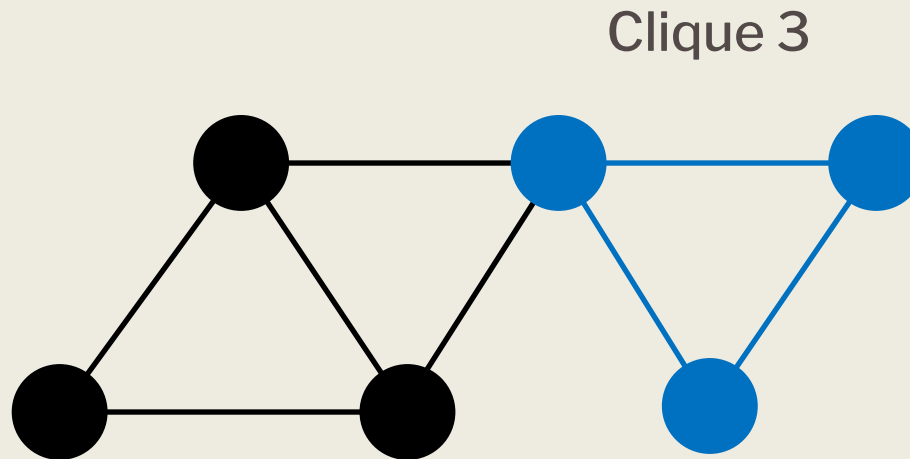


K-CLIQUE COMMUNITIES

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Two k-cliques are adjacent when they share $k-1$ nodes

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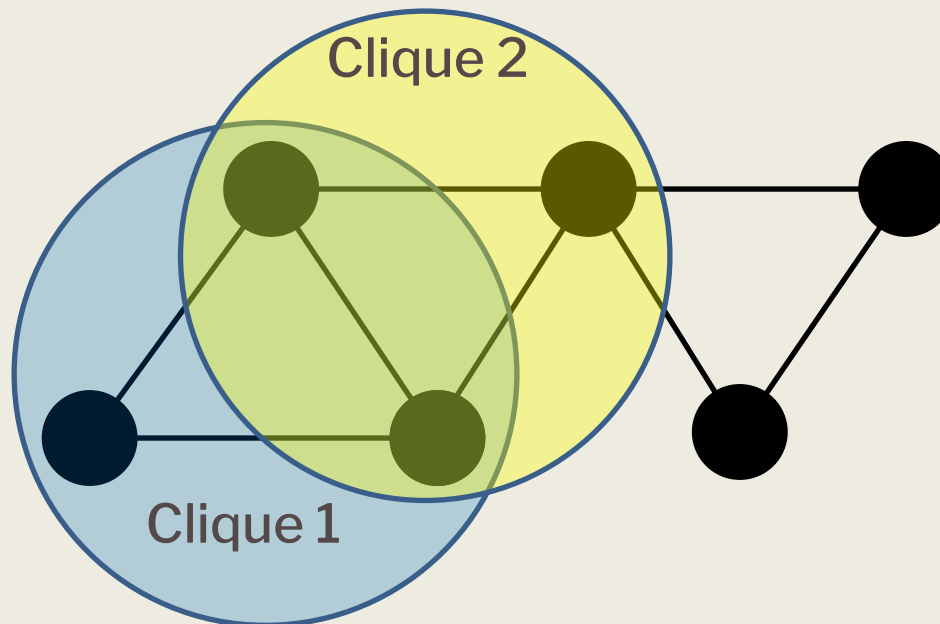


K-CLIQUE COMMUNITIES

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Two k-cliques are adjacent when they share $k-1$ nodes

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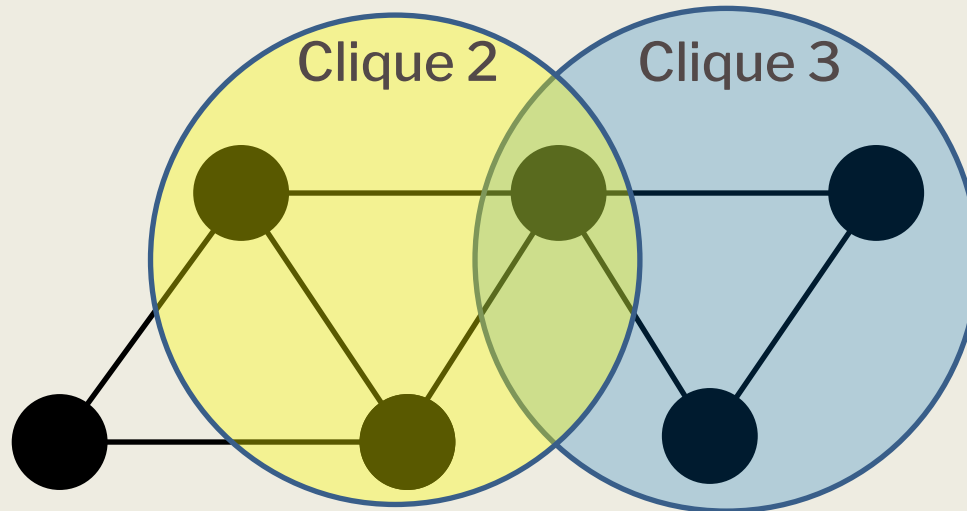


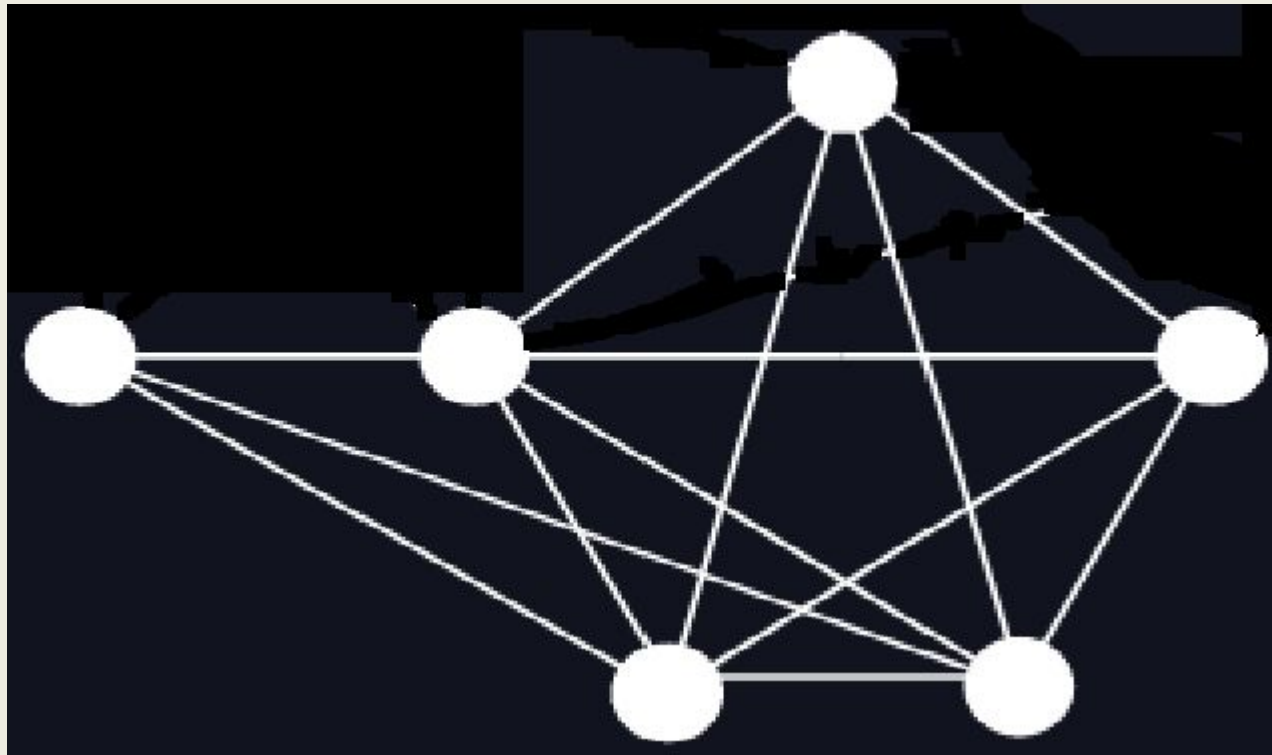
K-CLIQUE COMMUNITIES

■ Adjacent k-cliques

Two k-cliques are adjacent when they share $k-1$ nodes

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K-CLIQUE COMMUNITIES

■ k-clique community

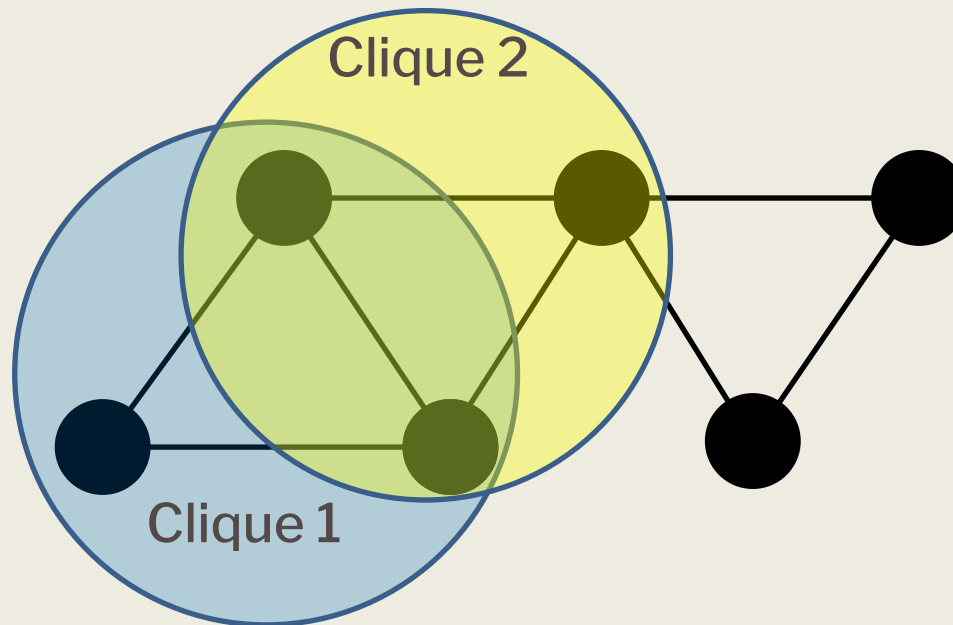
Union of all k-cliques that can be reached from each other through a series of adjacent k-cliques

K-CLIQUE COMMUNITIES

■ k-clique community

Union of all k-cliques that can be reached from each other through a series of adjacent k-cliques

$k = 3$

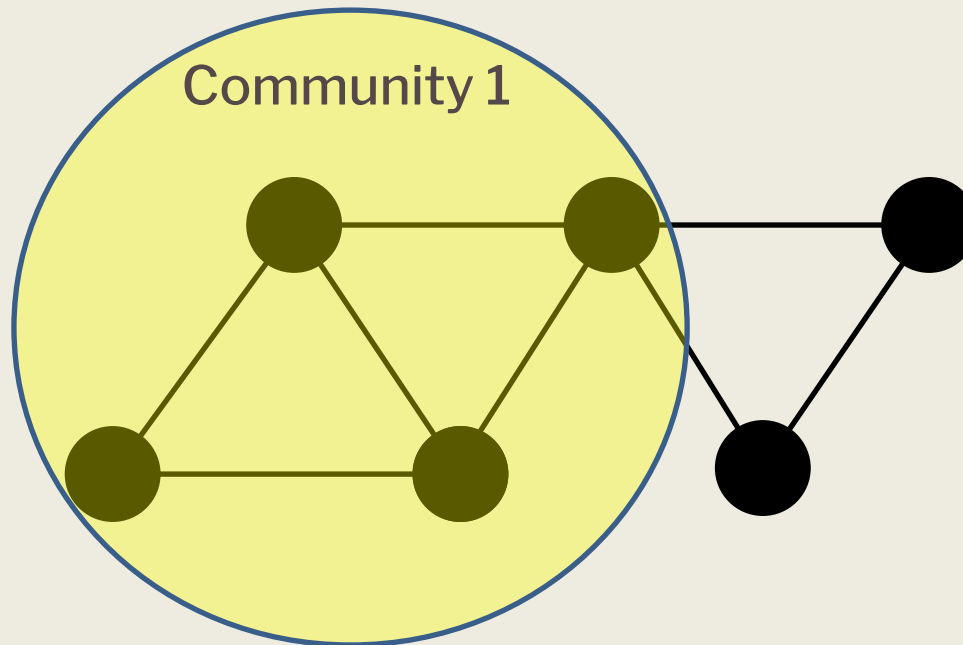


K-CLIQUE COMMUNITIES

■ k-clique community

Union of all k-cliques that can be reached from each other through a series of adjacent k-cliques

$k = 3$

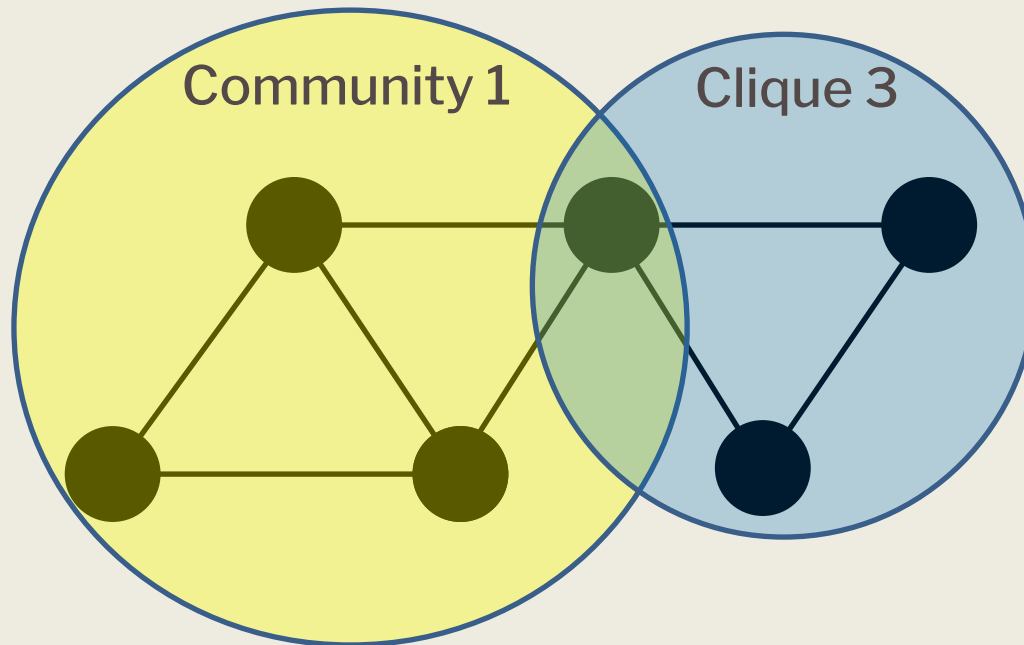


K-CLIQUE COMMUNITIES

■ k-clique community

Union of all k-cliques that can be reached from each other through a series of adjacent k-cliques

$k = 3$

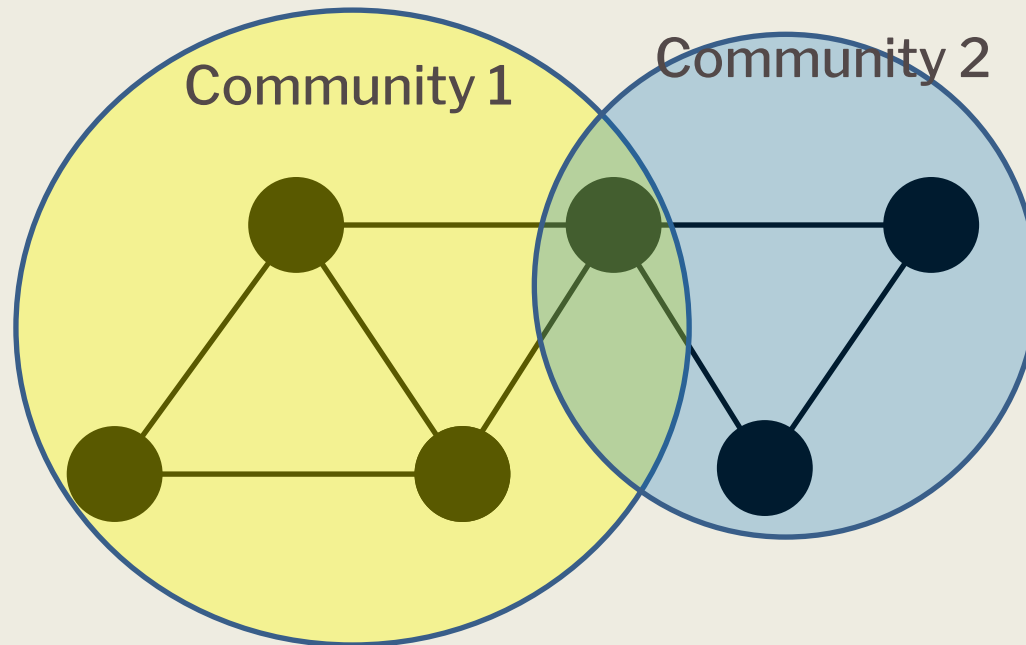


K-CLIQUE COMMUNITIES

■ k-clique community

Union of all k-cliques that can be reached from each other through a series of adjacent k-cliques

$k = 3$



ALGORITHM

- Locate maximal cliques
- Convert from cliques to k -clique communities

LOCATE MAXIMAL CLIQUES

- Largest possible clique size can be determined from degrees of vertices
- Starting from this size, find all cliques, then reduce size by 1 and repeat

LOCATE MAXIMAL CLIQUES

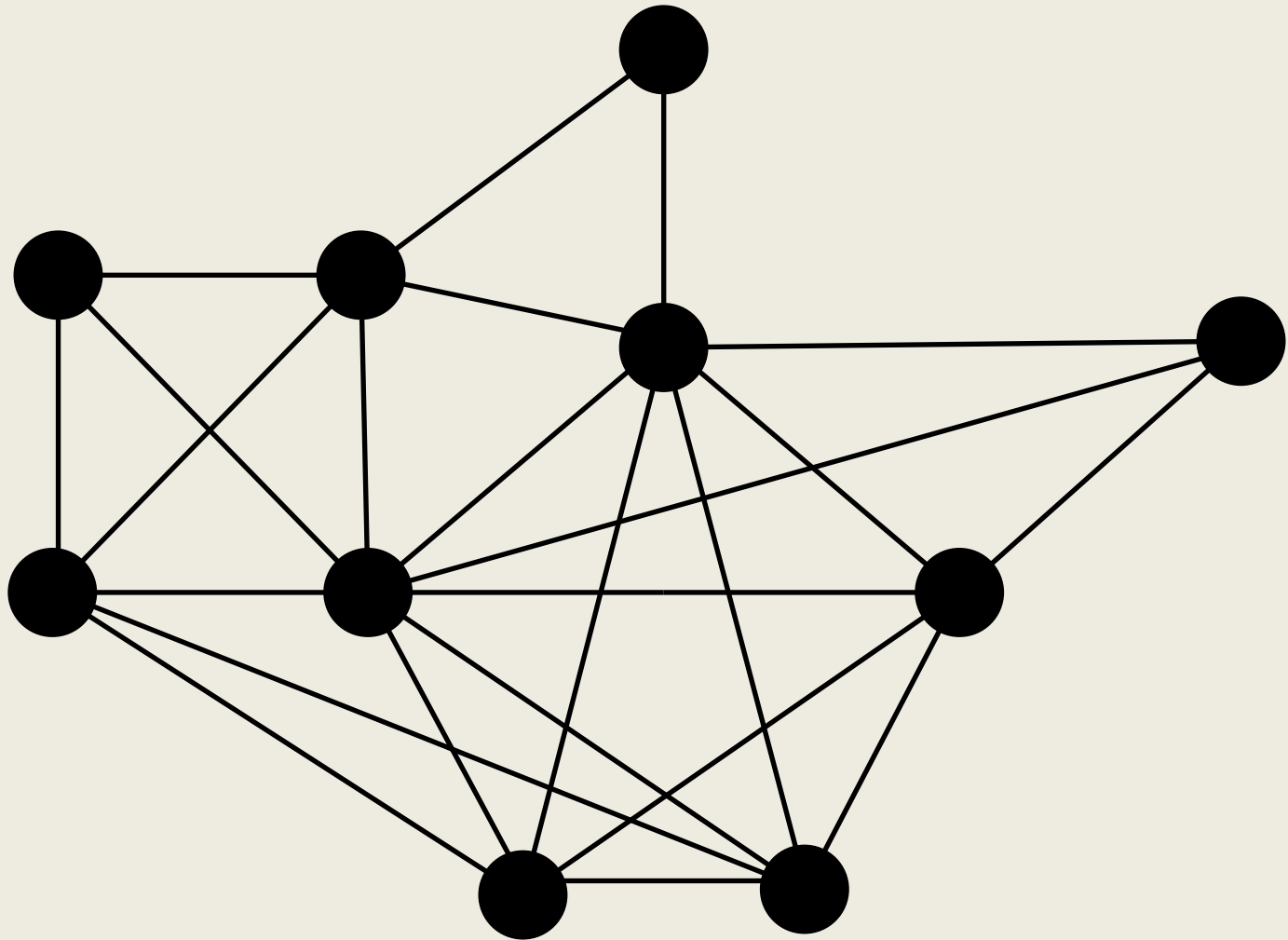
■ Finding all cliques: brute-force

1. Set A initially contains vertex v , Set B contains neighbours of v
2. Transfer one vertex w from B to A
3. Remove vertices that are not neighbours of w from B
4. Repeat until A reaches desired size
5. If fail, step back and try other possibilities

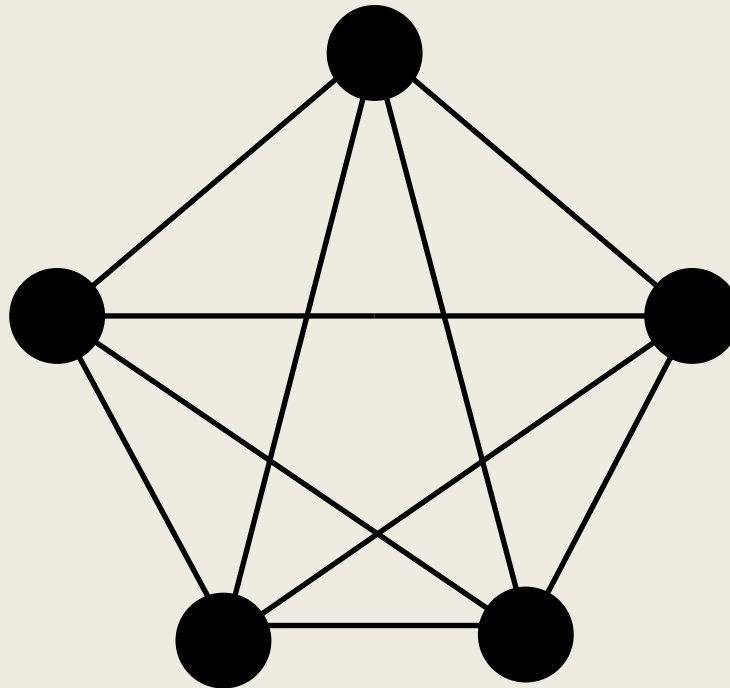
ALGORITHM

- Locate maximal cliques
- Convert from cliques to k -clique communities

CLIQUEES TO K-CLIQUE COMMUNITIES

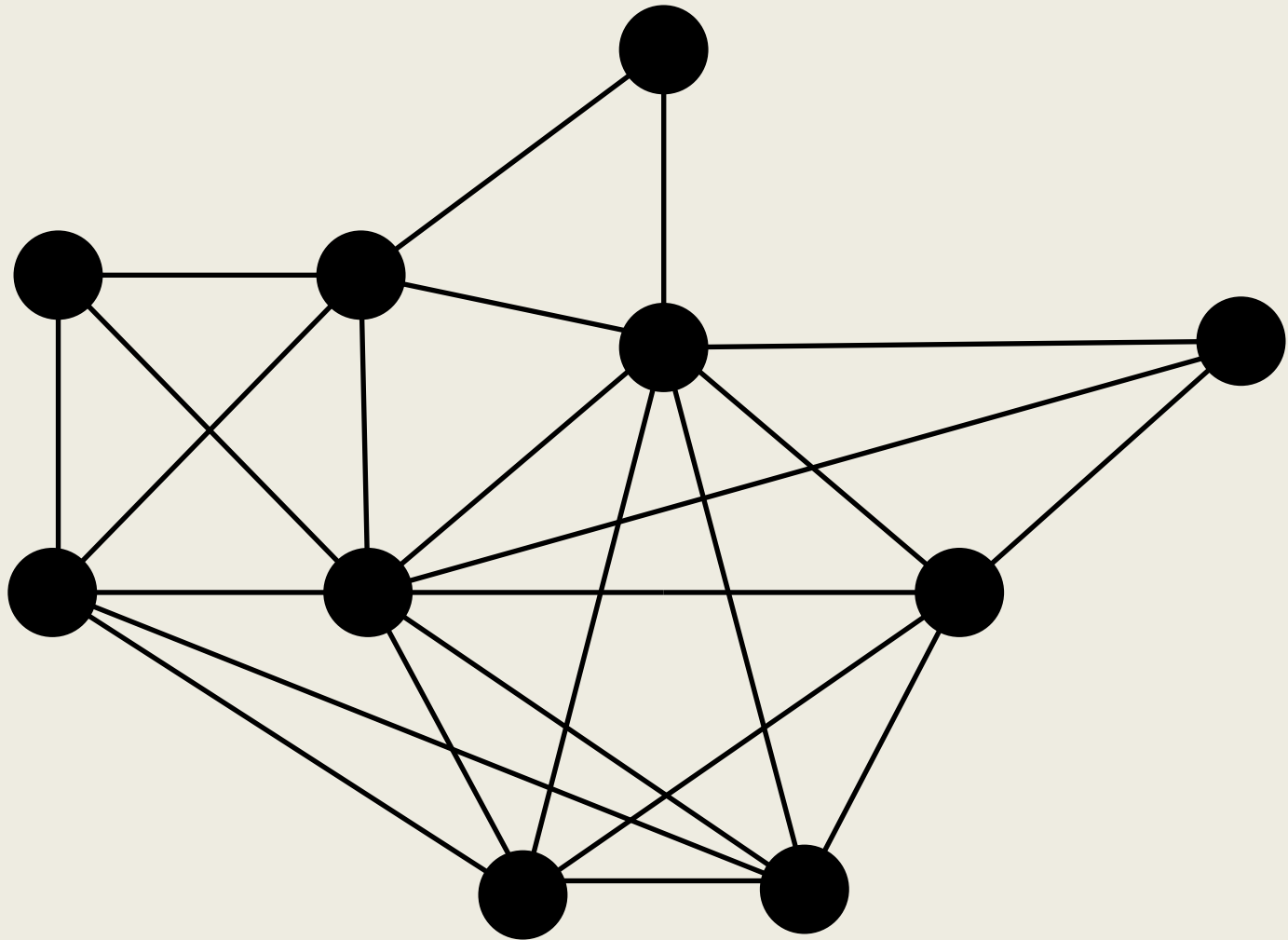


CLIQUE TO K-CLIQUE COMMUNITIES

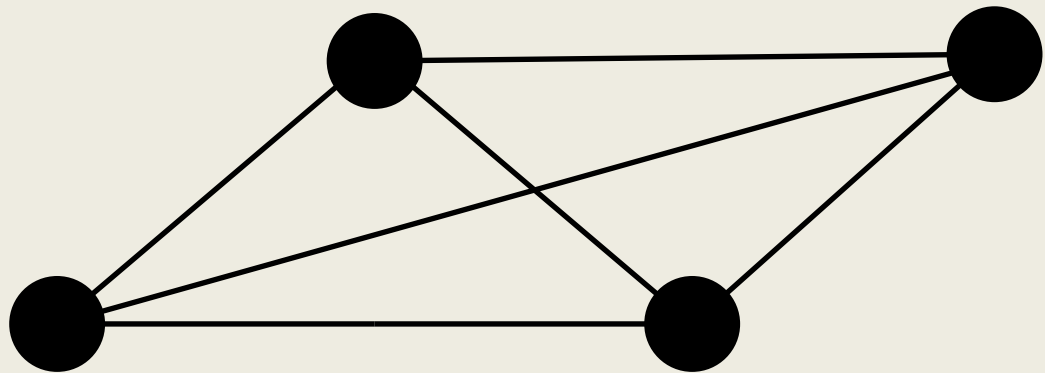


Clique 1: 5-clique

CLIQUEES TO K-CLIQUE COMMUNITIES

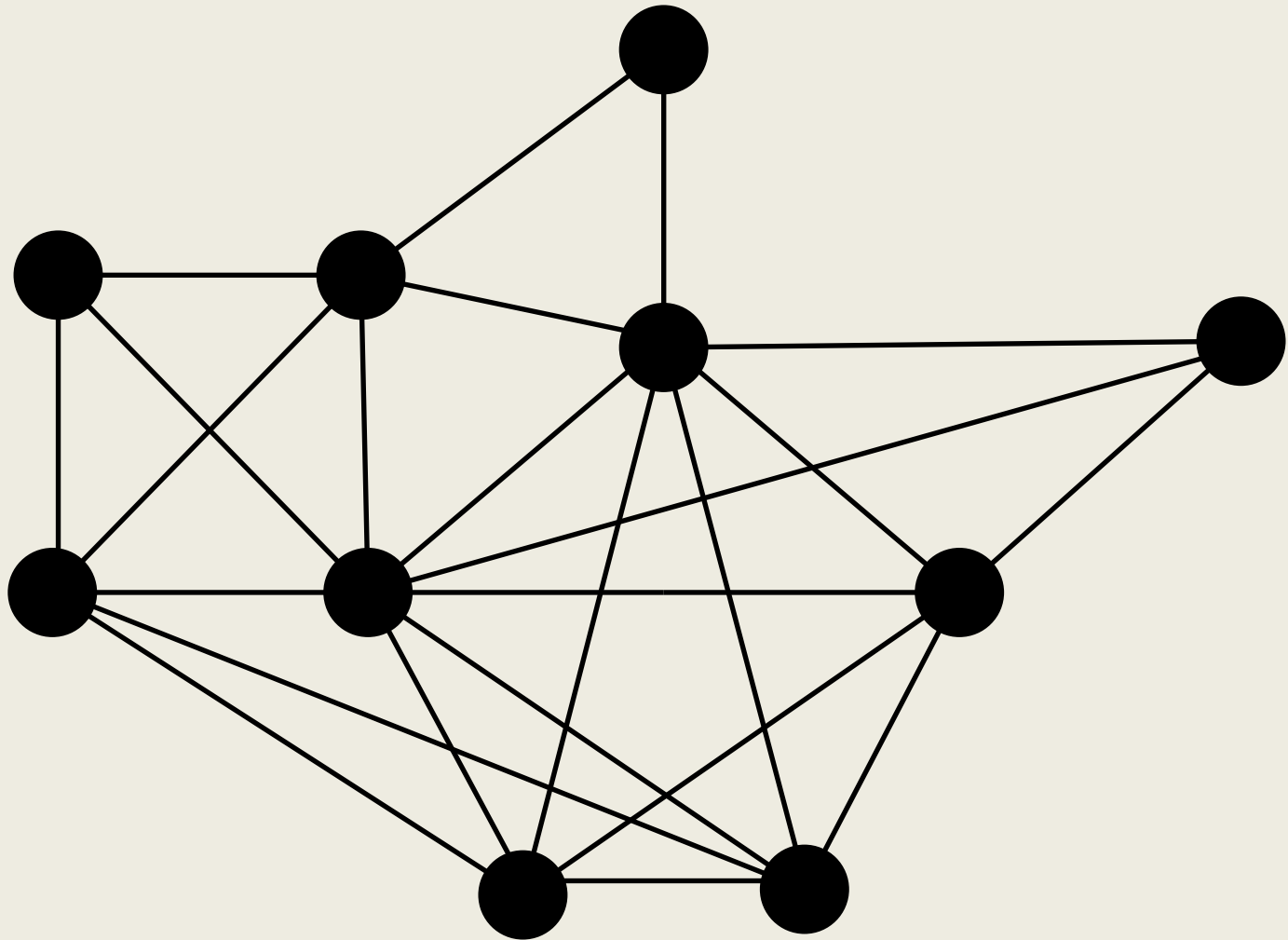


CLIQUE TO K-CLIQUE COMMUNITIES



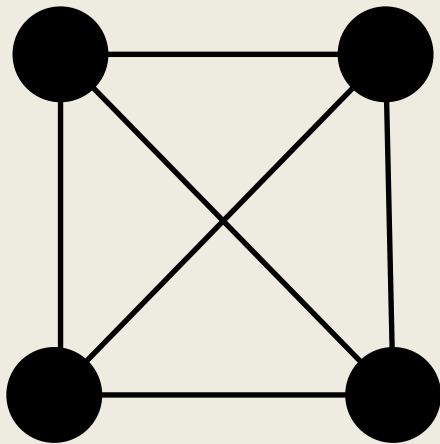
Clique 2: 4-clique

CLIQUEES TO K-CLIQUE COMMUNITIES

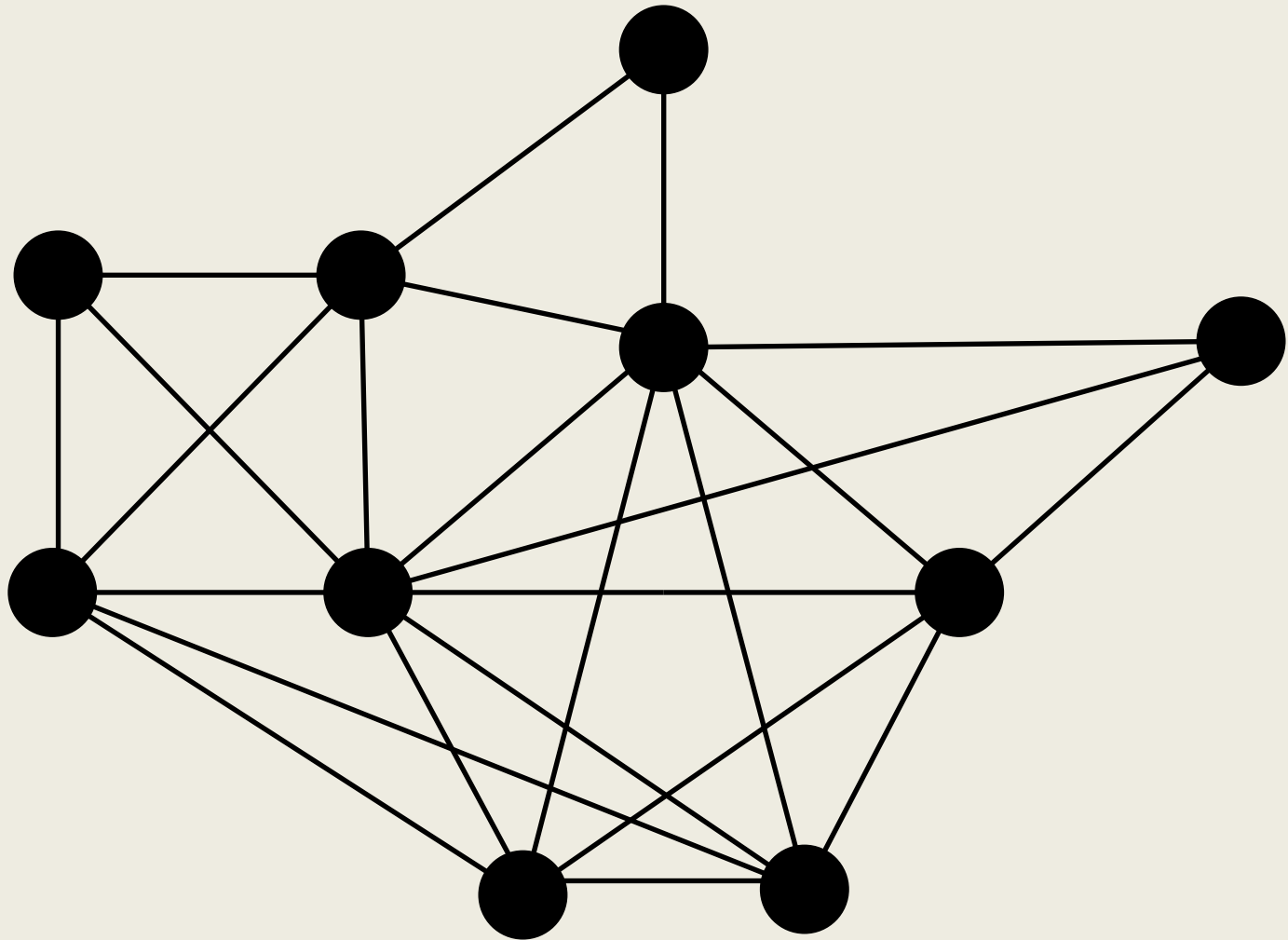


CLIQUE TO K-CLIQUE COMMUNITIES

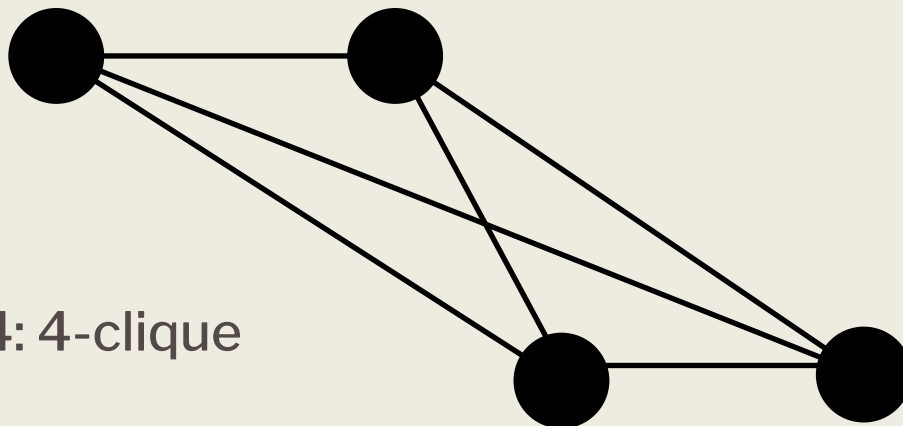
Clique 3: 4-clique



CLIQUEES TO K-CLIQUE COMMUNITIES

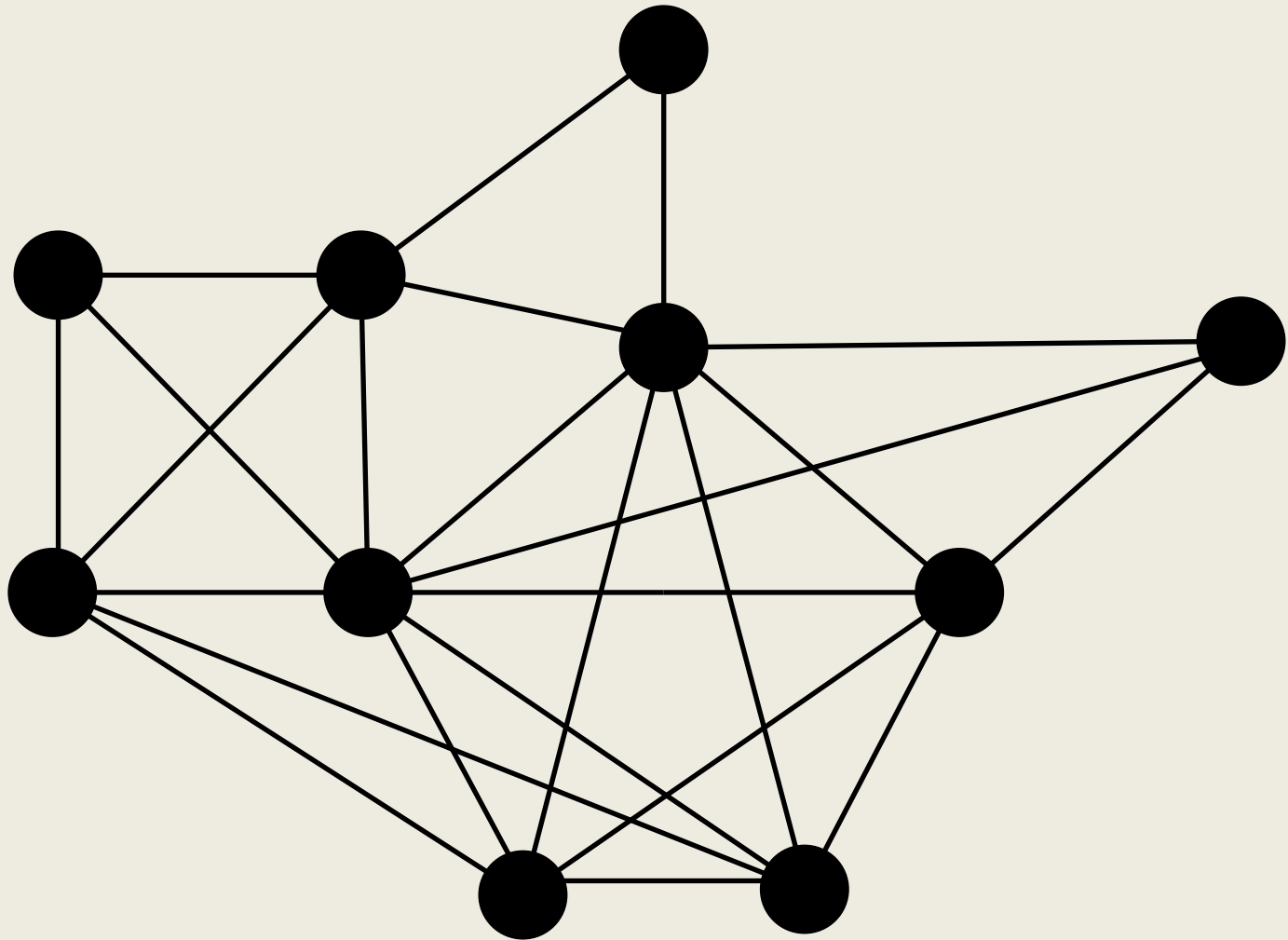


CLIQUE TO K-CLIQUE COMMUNITIES

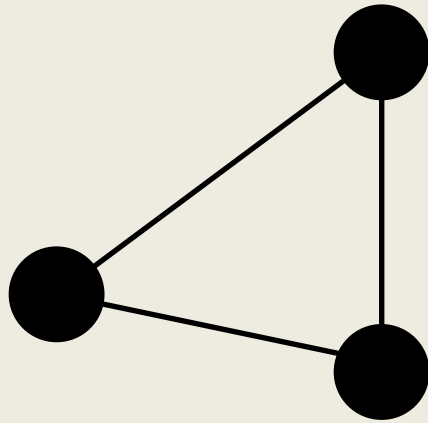


Clique 4: 4-clique

CLIQUEES TO K-CLIQUE COMMUNITIES

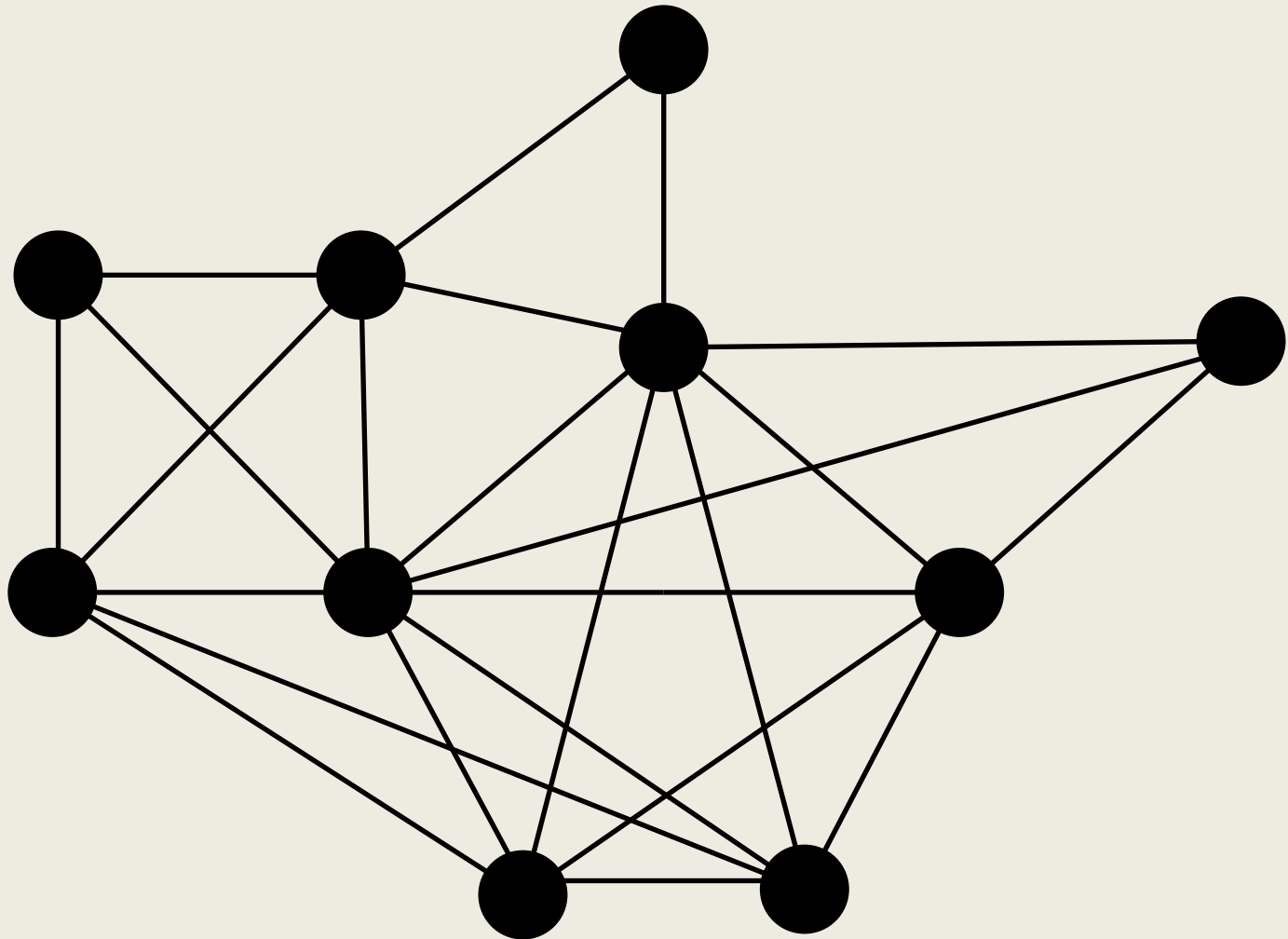


CLIQUEES TO K-CLIQUE COMMUNITIES



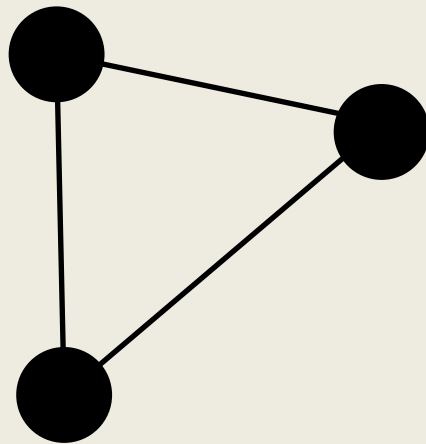
Clique 5: 3-clique

CLIQUEES TO K-CLIQUE COMMUNITIES



CLIQUE TO K-CLIQUE COMMUNITIES

Clique 6: 3-clique



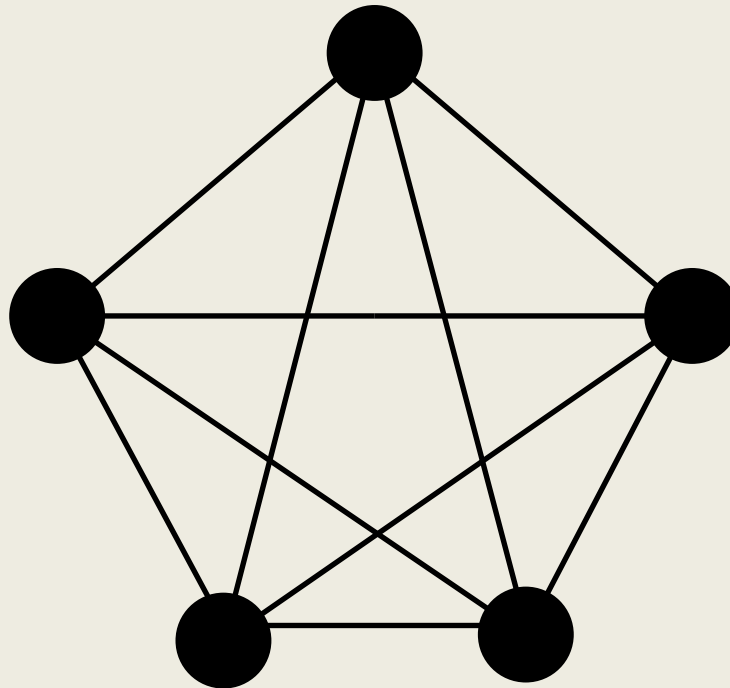
CLIQUE TO K-CLIQUE COMMUNITIES

	1	2	3	4	5	6
1						
2	5					
3		4				
4			4			
5				4		
6					3	

CLIQUEES TO K-CLIQUE COMMUNITIES

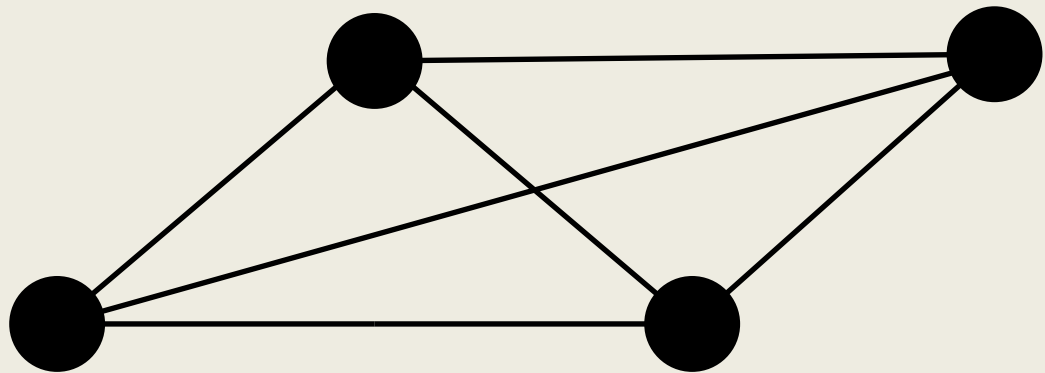
	1	2	3	4	5	6
1	5	3	1	3	1	2
2	3	4	1	1	1	2
3	1	1	4	2	1	2
4	3	1	2	4	0	1
5	1	1	1	0	3	2
6	2	2	2	1	2	3

CLIQUEES TO K-CLIQUE COMMUNITIES



Clique 1: 5-clique

CLIQUE TO K-CLIQUE COMMUNITIES



Clique 2: 4-clique

CLIQUE TO K-CLIQUE COMMUNITIES

	1	2	3	4	5	6
1	5	3	1	3	1	2
2	3	4	1	1	1	2
3	1	1	4	2	1	2
4	3	1	2	4	0	1
5	1	1	1	0	3	2
6	2	2	2	1	2	3

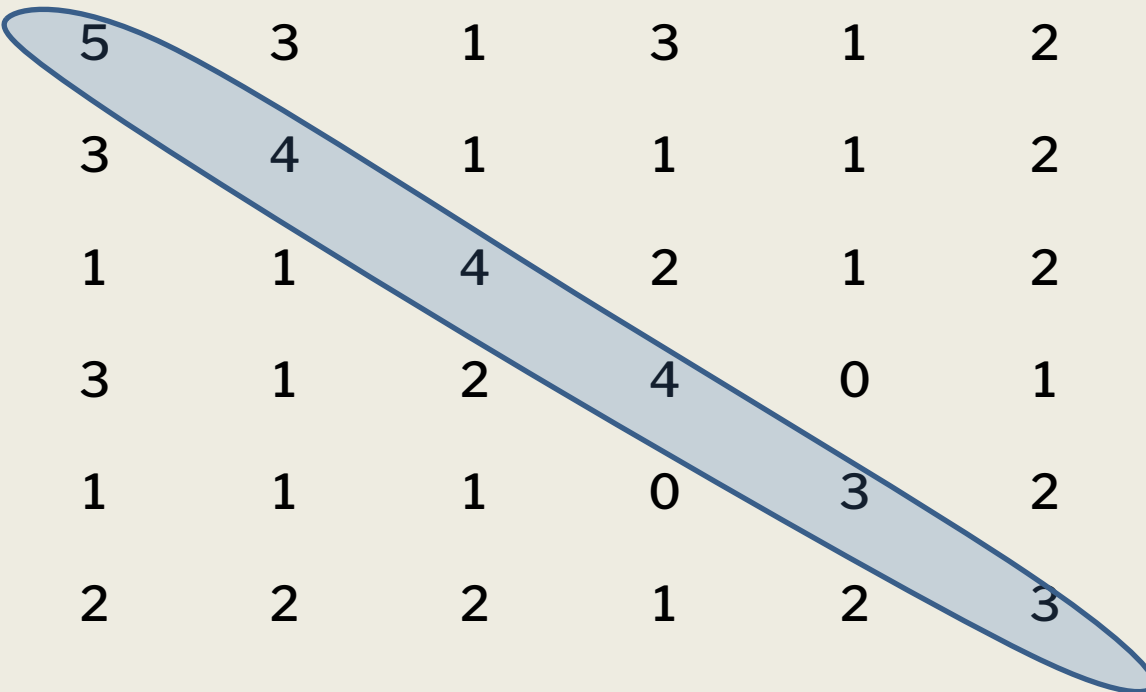
CLIQUEES TO K-CLIQUE COMMUNITIES

k=4

	1	2	3	4	5	6
1	5	3	1	3	1	2
2	3	4	1	1	1	2
3	1	1	4	2	1	2
4	3	1	2	4	0	1
5	1	1	1	0	3	2
6	2	2	2	1	2	3

CLIQUEES TO K-CLIQUE COMMUNITIES

k=4



	1	2	3	4	5	6
1	5	3	1	3	1	2
2	3	4	1	1	1	2
3	1	1	4	2	1	2
4	3	1	2	4	0	1
5	1	1	1	0	3	2
6	2	2	2	1	2	3

CLIQUEES TO K-CLIQUE COMMUNITIES

k=4

	1	2	3	4	5	6
1	5	3	1	3	1	2
2	3	4	1	1	1	2
3	1	1	4	2	1	2
4	3	1	2	4	0	1
5	1	1	1	0	0	2
6	2	2	2	1	2	0

Delete if less than k

CLIQUEES TO K-CLIQUE COMMUNITIES

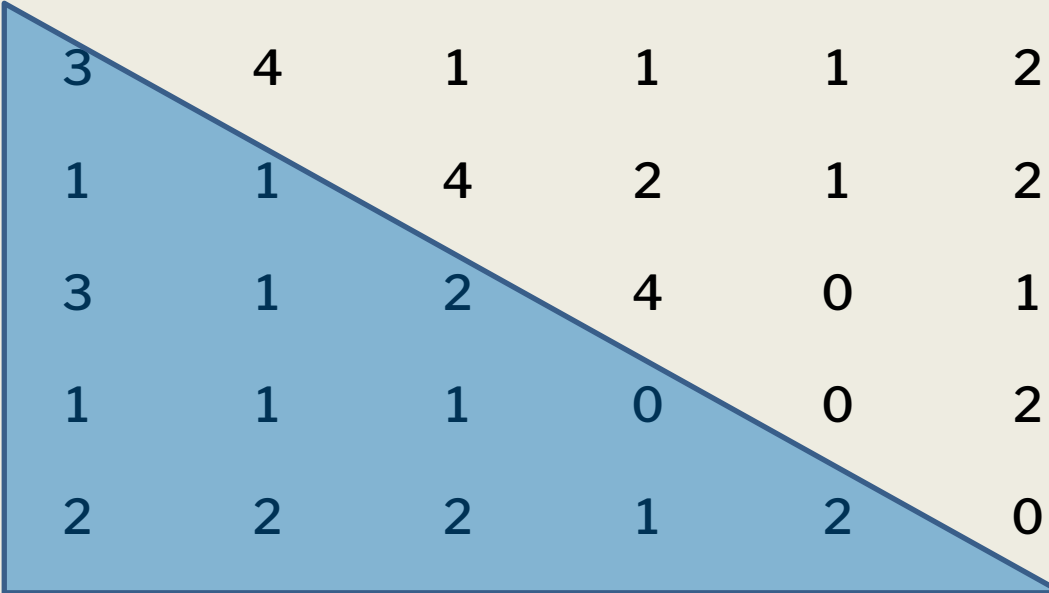
k=4

	1	2	3	4	5	6
1	5	3	1	3	1	2
2	3	4	1	1	1	2
3	1	1	4	2	1	2
4	3	1	2	4	0	1
5	1	1	1	0	0	2
6	2	2	2	1	2	0

CLIQUEES TO K-CLIQUE COMMUNITIES

k=4

	1	2	3	4	5	6
1	5	3	1	3	1	2
2	3	4	1	1	1	2
3	1	1	4	2	1	2
4	3	1	2	4	0	1
5	1	1	1	0	0	2
6	2	2	2	1	2	0



CLIQUEES TO K-CLIQUE COMMUNITIES

k=4

	1	2	3	4	5	6
1	5	3	0	3	0	0
2	3	4	0	0	0	0
3	0	0	4	0	0	0
4	3	0	0	4	0	0
5	0	0	0	0	0	0
6	0	0	0	0	0	0

Delete if less than

k-1

CLIQUEES TO K-CLIQUE COMMUNITIES

k=4

	1	2	3	4	5	6
1	5	3	0	3	0	0
2	3	4	0	0	0	0
3	0	0	4	0	0	0
4	3	0	0	4	0	0
5	0	0	0	0	0	0
6	0	0	0	0	0	0

CLIQUEES TO K-CLIQUE COMMUNITIES

k=4

	1	2	3	4	5	6
1	1	1	0	1	0	0
2	1	1	0	0	0	0
3	0	0	1	0	0	0
4	1	0	0	1	0	0
5	0	0	0	0	0	0
6	0	0	0	0	0	0

Change all non-zeros to 1

CLIQUE TO K-CLIQUE COMMUNITIES

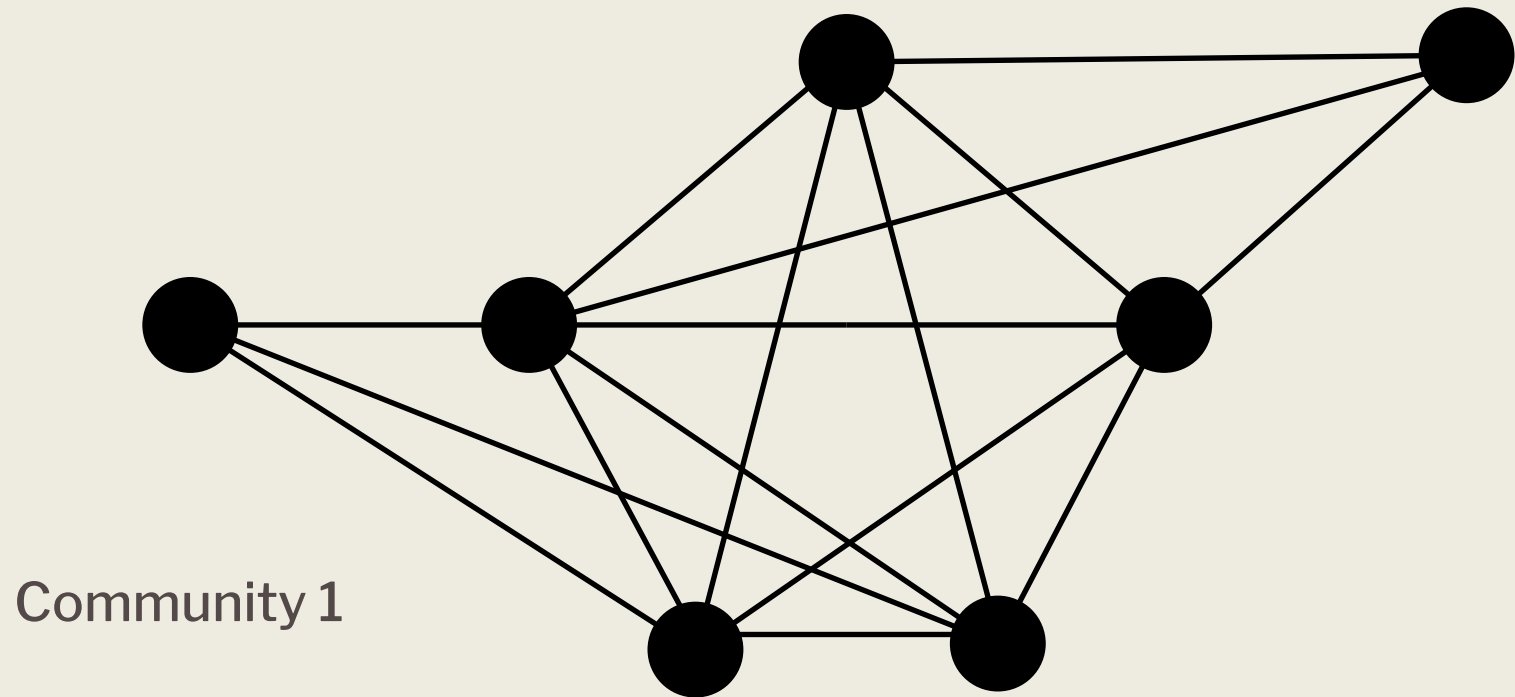
k=4

	1	2	3	4	5	6
1	1	1	0	1	0	0
2	1	1	0	0	0	0
3	0	0	1	0	0	0
4	1	0	0	1	0	0
5	0	0	0	0	0	0
6	0	0	0	0	0	0

Clique-clique overlap matrix

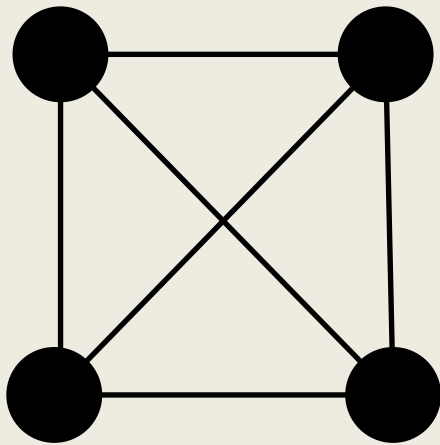
CLIQUEES TO K-CLIQUE COMMUNITIES

$k=4$



CLIQUEES TO K-CLIQUE COMMUNITIES

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Community 2