

Observing changes: Time-dependent social network visualization and community behavior pattern analysis

Yiheng Zhou
LeoCool



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Background & Introduction

Social Network

Social Network: A social structure consisting of many nodes. Nodes usually refer to individuals or organizations, while social networks represent various social relationships.



Examples of a social network

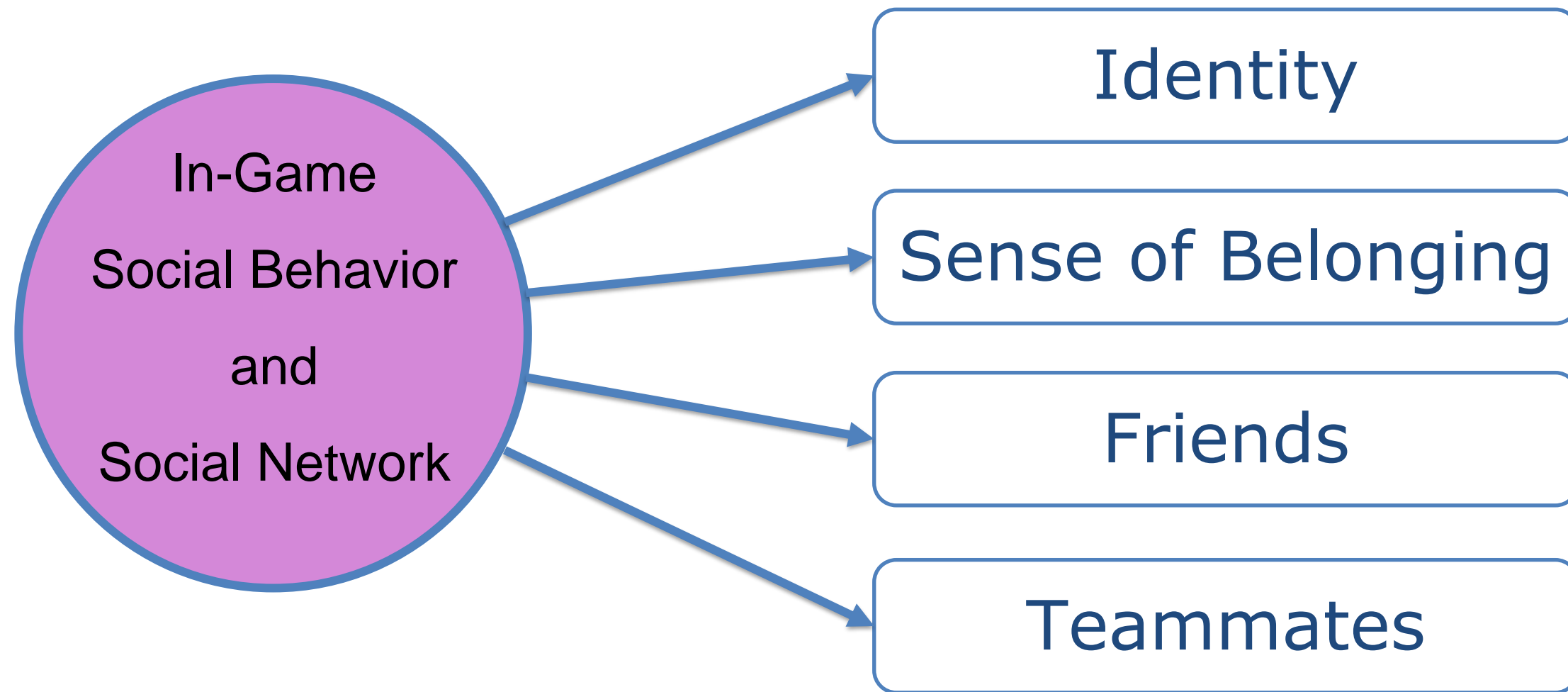
Social Network

Before the birth of the Internet, social network analysis was an important research branch of sociology and anthropology.

Here we specifically discuss **the social network in the online game** - of course, the social behavior of players can also be extended to other social media outside the game. Maybe in the future, the construction of a cross-platform digital identity (a big metaverse) will connect various virtual worlds. For now, only the in-game situation will be considered here.

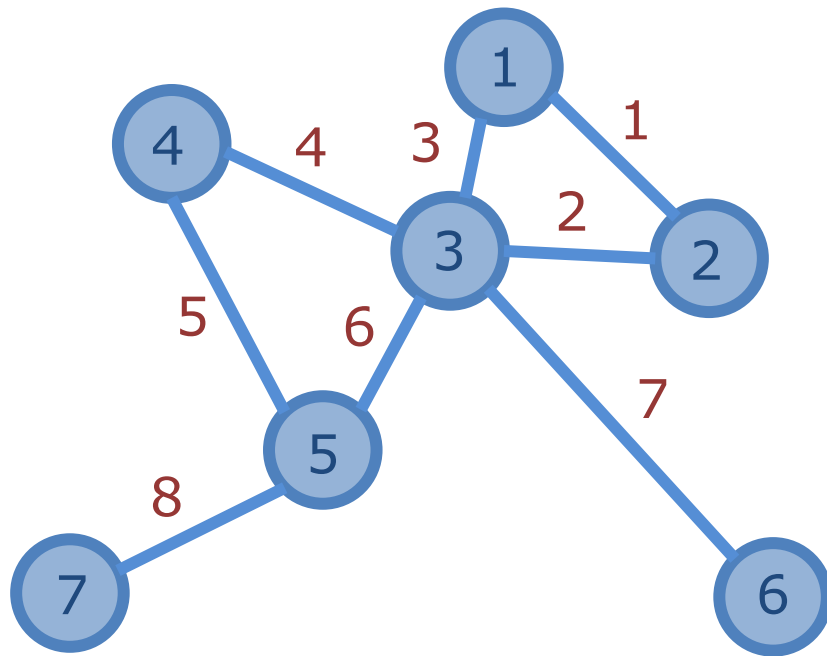
Social Networking in Online Game

In current online games, players' social behavior is critical to both player experience and retention.



Graph Model - Basic Model of Social Network

In mathematics, and more specifically in graph theory, a **graph** is a structure amounting to a set of objects in which some pairs of the objects are in some sense "related".



A graph with seven nodes and eight edges.

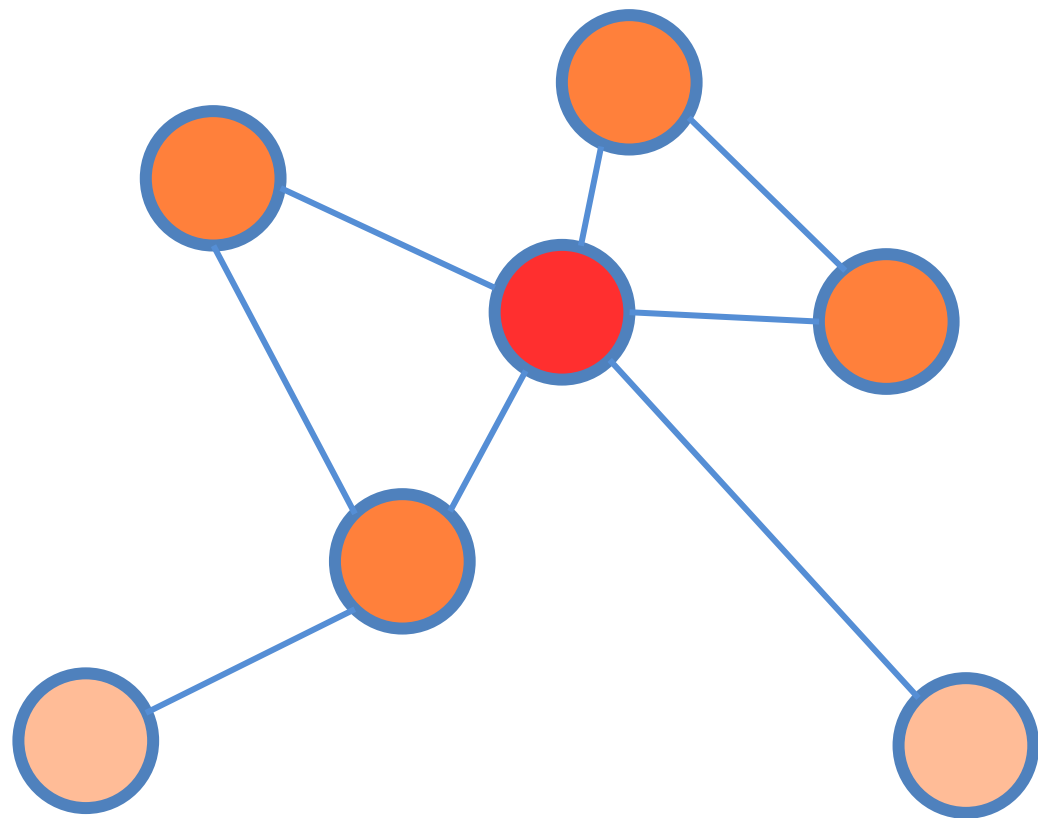
In online games:

Node – *players (or group, team, guild, etc.)*

edge – *social behavior or social relationship*

Graph Model - undirected graph

The edges in this kind of graph have no direction.



Typical undirected graph

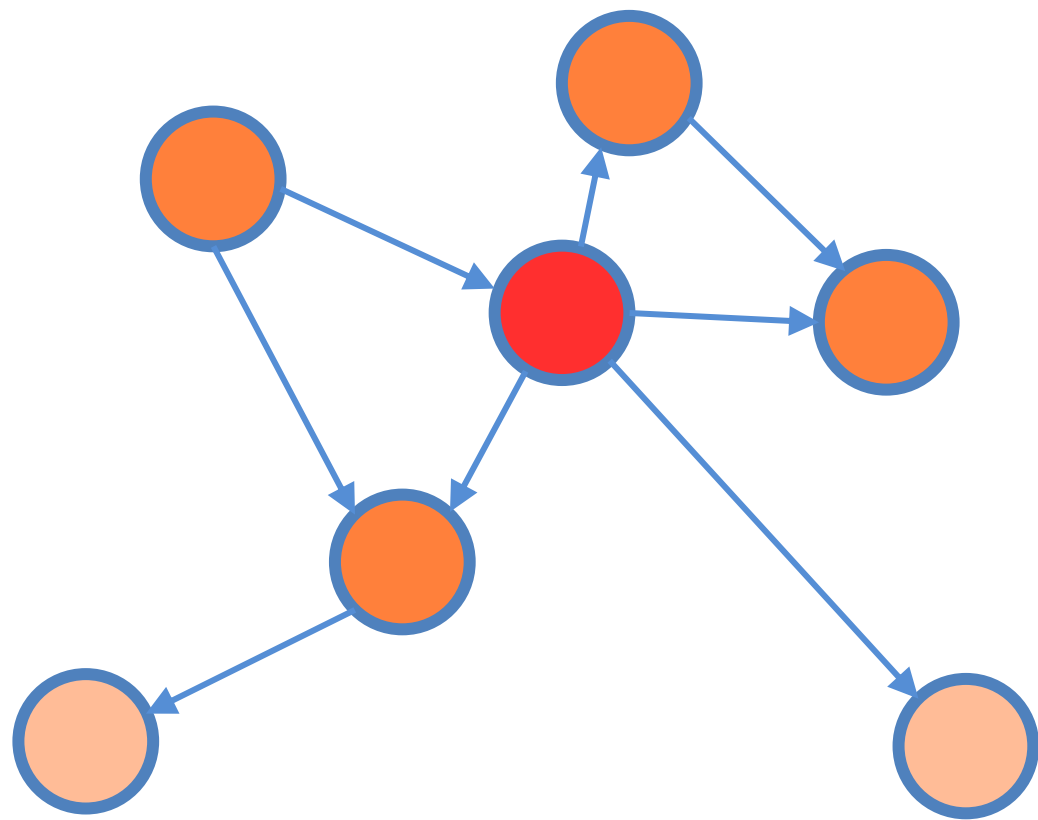
In online games, the undirected graph can represent the social behavior such as:

- *Participate in the same raid*
- *Matched to the same game*
- *Other **symmetrical** behaviors*

** that both parties involved in the act are equal in intention and action*

Graph Model - directed graph

The edges in this kind of graph have direction. Can be used to indicate directional social behavior.



Typical directed graph

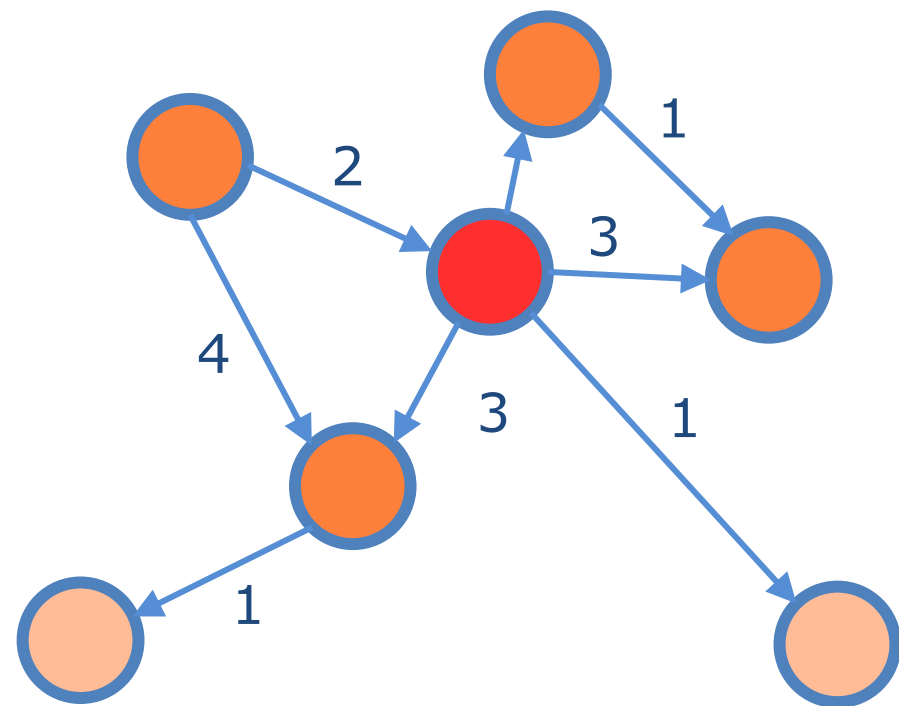
(The arrow is the direction of the edge)

In online games, the directed graph can represent the directional social behavior such as:

- *Invite (join a team, join a game, etc.)*
- *(buyer, seller)*
- *In-game relationship (e.g. master and apprentice)*
- *Other directional social behaviors*

Graph Model – the weight of the edge

Each edge has a corresponding value. At a more abstract level, the weight of edges can represent any information worthy of attention.



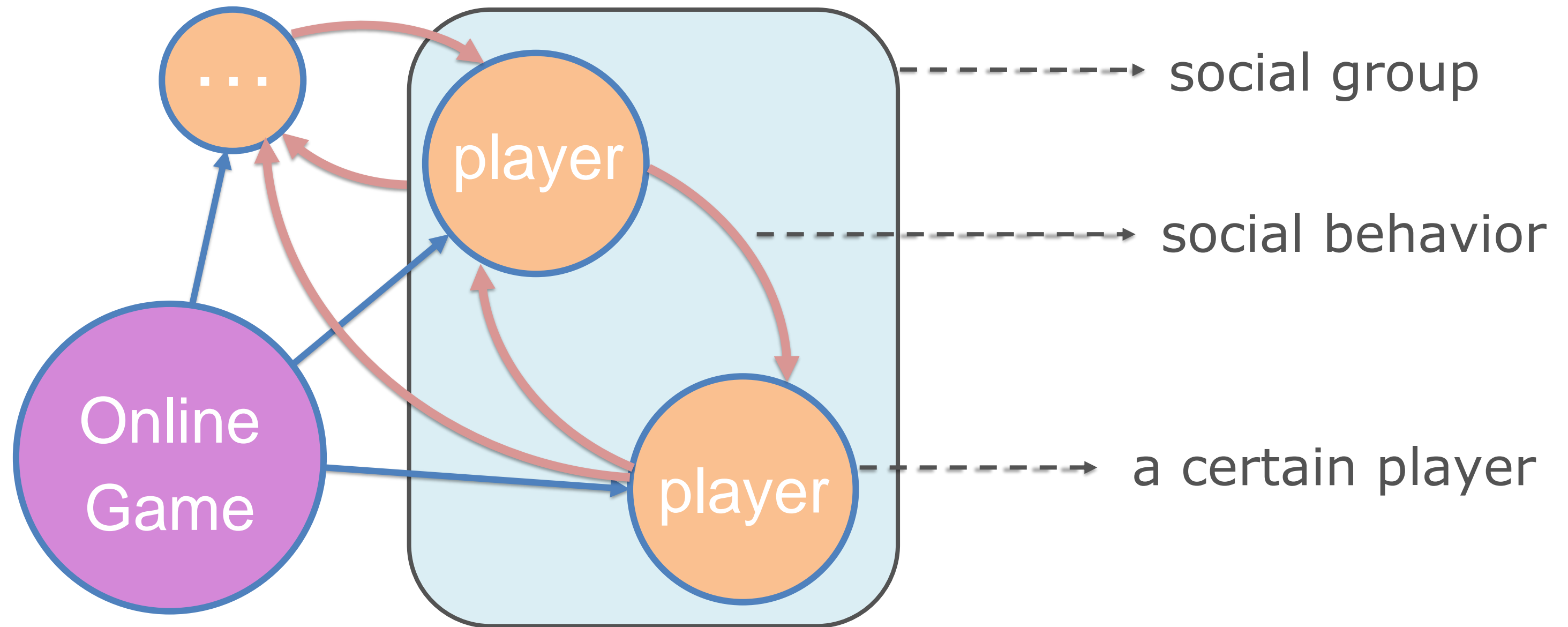
Typical graph with the weight on each edge

In online games, the weight of the edge can represent the degree of the social behavior such as:

- *Intimacy degree*
- *Number of team formation*
- *Transaction amount*
- *etc.*

Game Mechanics

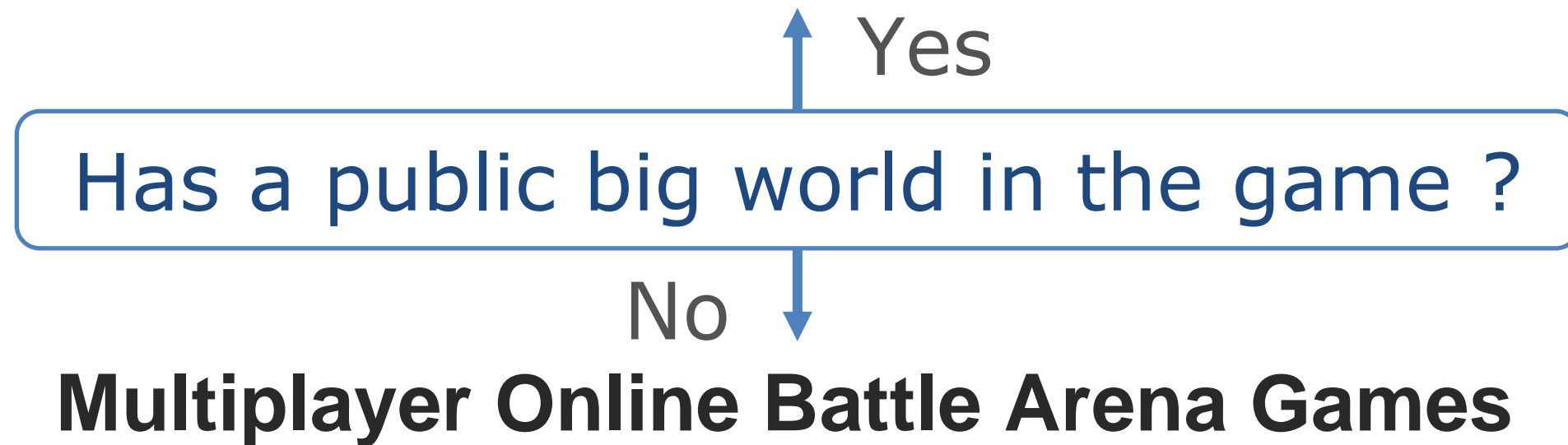
Basic online game model



Category of Online Games

There are many ways to classify game types. In terms of social network analysis, according to whether there is a public big world in the game, the online game can be divided into two categories:

Massive Multiplayer Online Role-Playing Game (MMORPG)



MMORPG

Players can travel, encounter and socialize freely in the big world. Players playing various identities (businessmen, explorer, PVP fighters and PVE fighters) will also meet in the same big world. The core gameplay(dungeon, quest, collection, etc.) are embedded in the big world.



Typical MMORPG game experience
(with other players in the same big world)

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MMORPG

The social behavior of players is similar to that in the real world, with strong diversity and randomness - helping players who meet occasionally, or conflict due to material grabbing in the big world.

MMORPG



For example, player A may try to defeat a elite monster and fails. At this time, player B passing by also needs to defeat the same monster. After communicating and cooperating with each other to complete the quest, they may become lasting friends - many classic MMORPGs design more difficult elite monsters in the field to encourage this.

Social Network in MMORPG

Advantage: There are many social behaviors that can be mined. Players' behavior is multifaceted.

Difficulty: The data mechanism of many behaviors is complex and difficult to define accurately. There is a problem of how to analyze quantitatively.

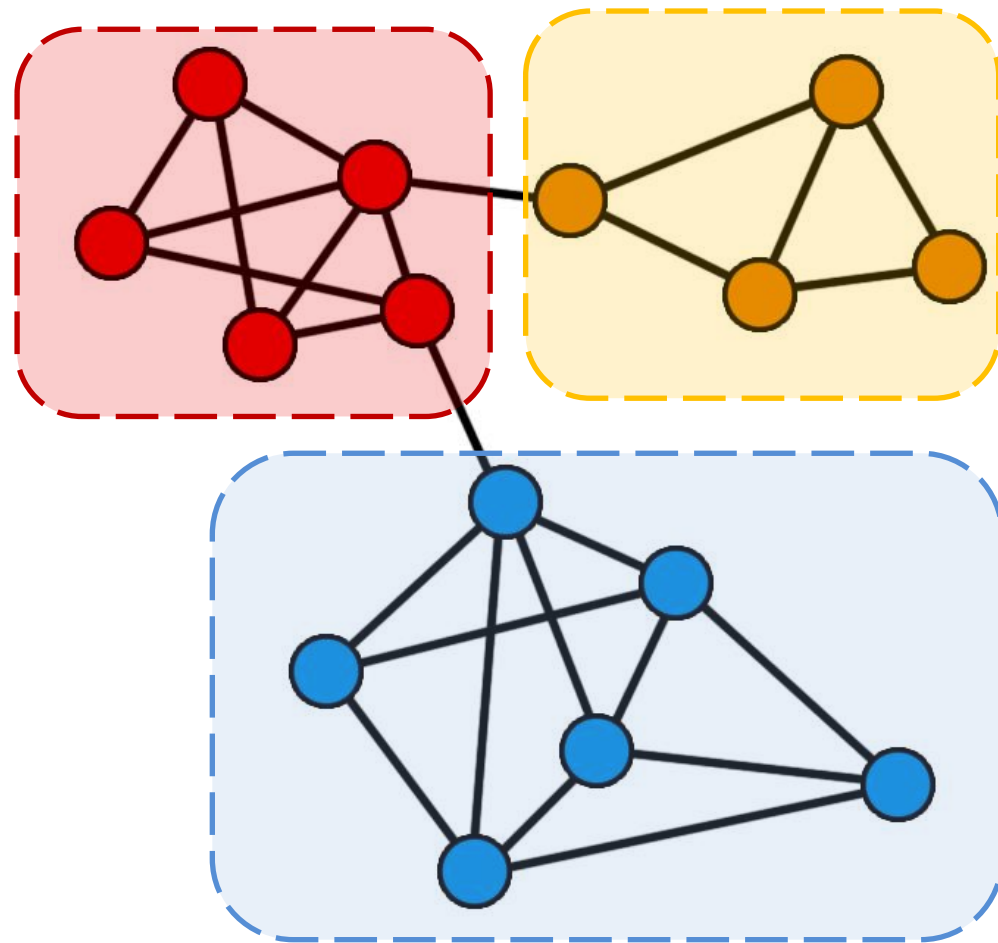
MMORPG – Guild

Although other multiplayer online games may also have the concept of community and guild, **there is no doubt that the guild in MMORPG is the most belonging.**

The guild provides a group with a sense of belonging in which players can communicate, interact, build guild territory and participate in guild specific activities (e.g., the Guild Wars).

MMORPG – Guild

This special and strong group structure provides great convenience for identifying players' social groups at this level.



The social group to which each player belongs in the social network can be easily identified based on the guild they belong to.

Multiplayer Online Battle Arenas Games

There is no public big world. Players start the match from the game menu, and directly enter the battle scene of the corresponding game mode they choose.



click Start Battle in the main menu



start fighting with matched opponents



Multiplayer Online Battle Arenas Games

Players with different identities and targets **will not meet.**

Players can fight in teams, or the system can assign teammates and enemies - they may become friends, but **more often they don't have a lasting relationship after the battle.**

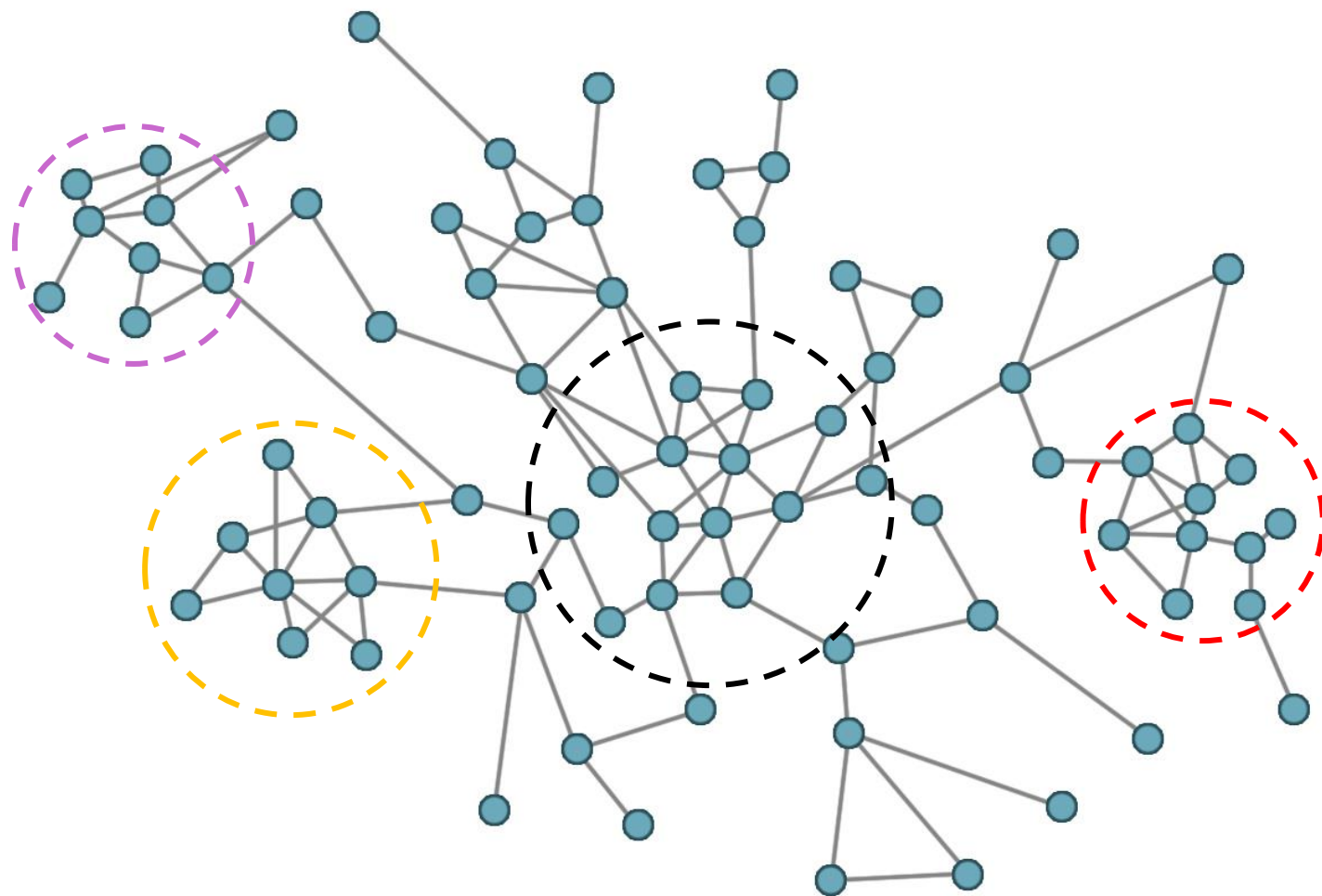
Multiplayer Online Battle Arenas Games

This type of game will also have a friend system or a guild system to some extent, but the player's group relationship is not as strong as MMORPGs.

Multiplayer Online Battle Arenas Games

Many players of competitive games have small teams organized spontaneously.

Effect on the game: convenient, random teammates, unbound social relationships.



The player does not clearly belong to a social group in the game mechanism, but the player's overall in-game social behavior obviously constitutes several social groups

 *Examples of spontaneous small groups*

Social Network in Multiplayer Online Battle Arena Games

Advantage : The data mechanism of player's behavior is rather simple. The boundary of player's behavior is clear. Taking the battle round as the unit, it can be clearly distinguished with the battle mode.

Difficulty: It is difficult to accurately define the social group to which a player belongs. Players may spontaneously (maybe through social media outside the game) form a small team, which needs to be identified by certain standards and algorithms.

Challenge for the game analysts

Unlike in the real world, the problems there are either too big and involving too many factors, or too focused on representative case.

Challenge for the game analysts

1. Social media communication - the cost required for the dissemination of media information is rather low (just a click for the app user), a large amount of data is mixed, it is **not easy to find the user's true intention**.
2. The social network analysis of sociological research based on human behavior is often limited by the actual situation and the sample is. It is **a representative and statistical sampling research method**.

Challenge for the game analysts

The situation in the game is between the above two:

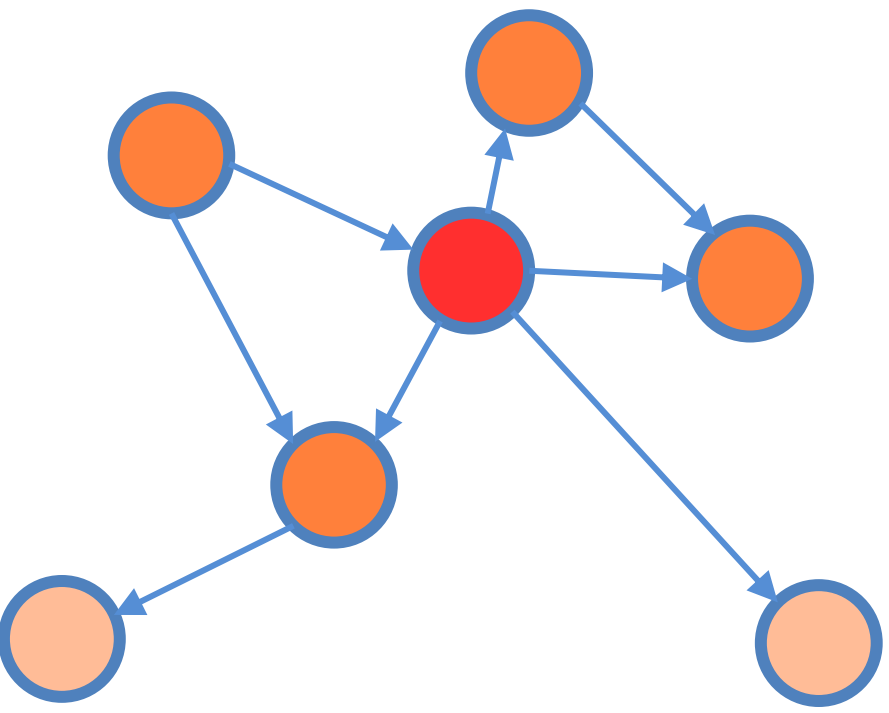
1. The player's behavior in the game is what the player needs to actually take action and make the effort to complete. It can better represent the player's behavior pattern under the game mechanism.
2. Successful online games have enough users and well-recorded data to build a very large and reliable social network for research and analysis.

Challenge for Observation & Analysis

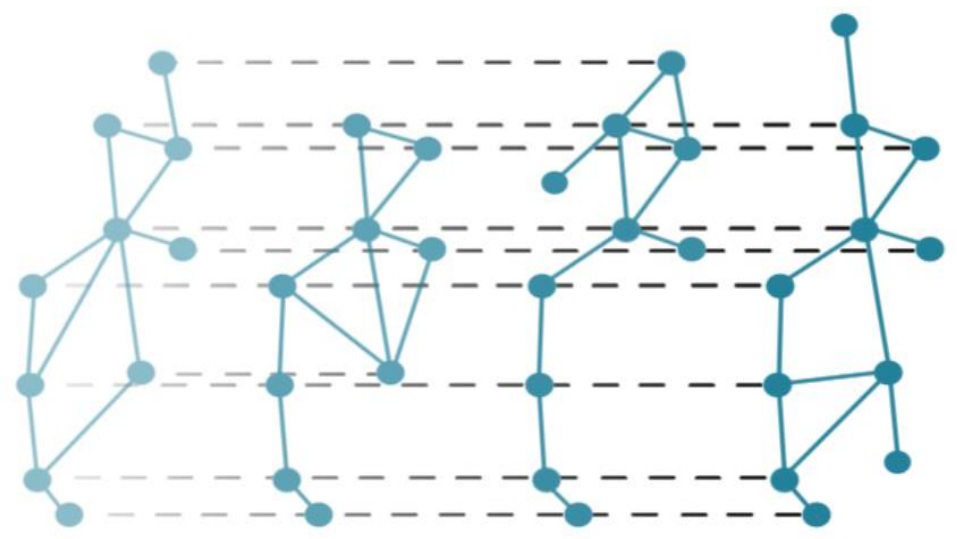
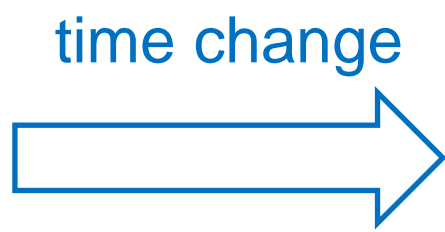
Common ways to learn about in-game social networks are:

- Public opinion observation - too much manpower, statistical deviation
- Observe top players - Can't represent the majority of the player group
- Feature index - The information of the graph is compressed into several limited dimensions
- Graphics - It may contain too much information and need to be processed to improve readability

Observation & Analysis - Static vs Dynamic

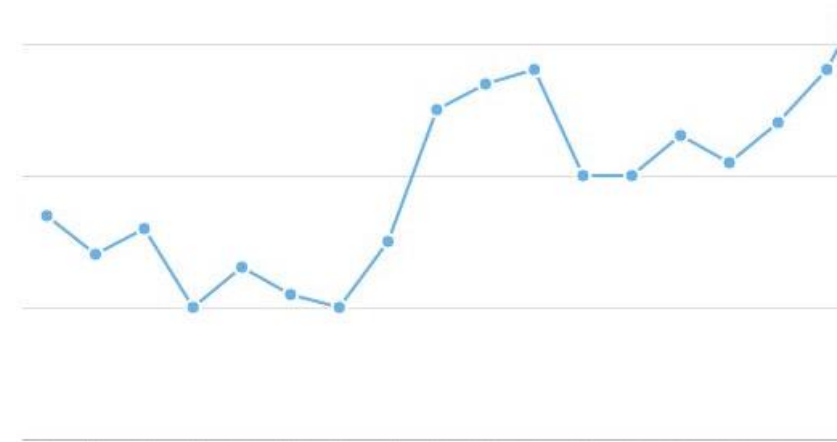


Graph model at a certain time



Time dependent Graph model

When there are too many nodes and edges, the readability decreases seriously



Only macro information can be displayed, and a lot of details are lost

Use feature index to describe changes in social networks

Models and methods

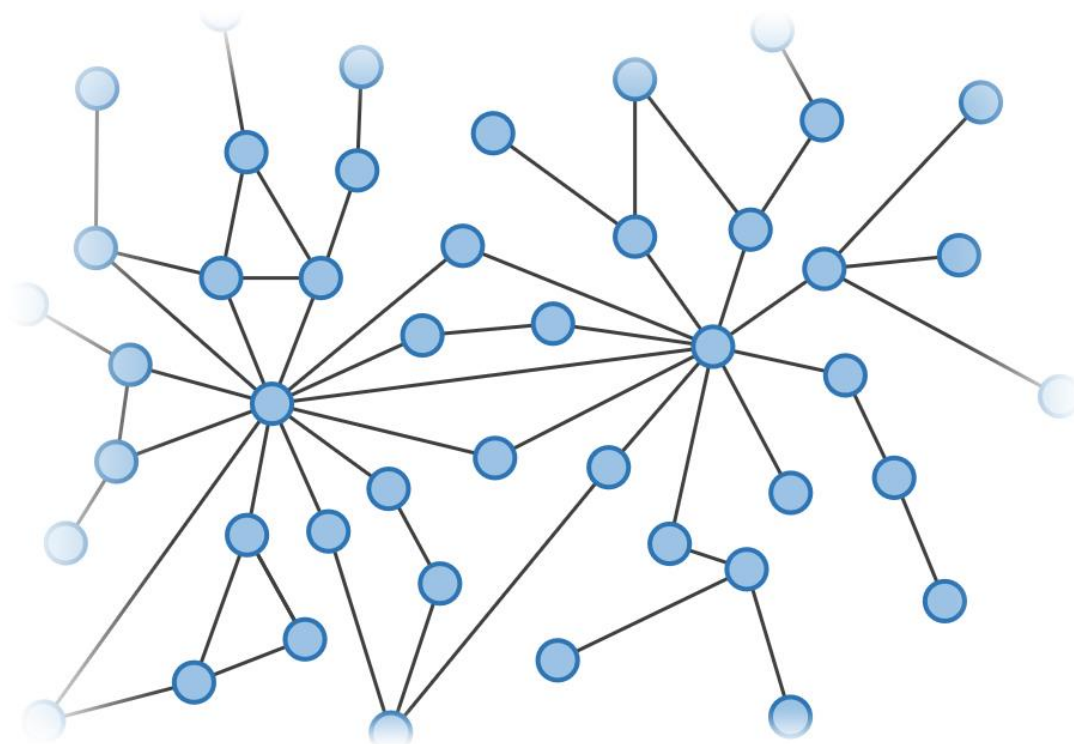
Model for Social Network

Statistical concepts commonly used in social network models.

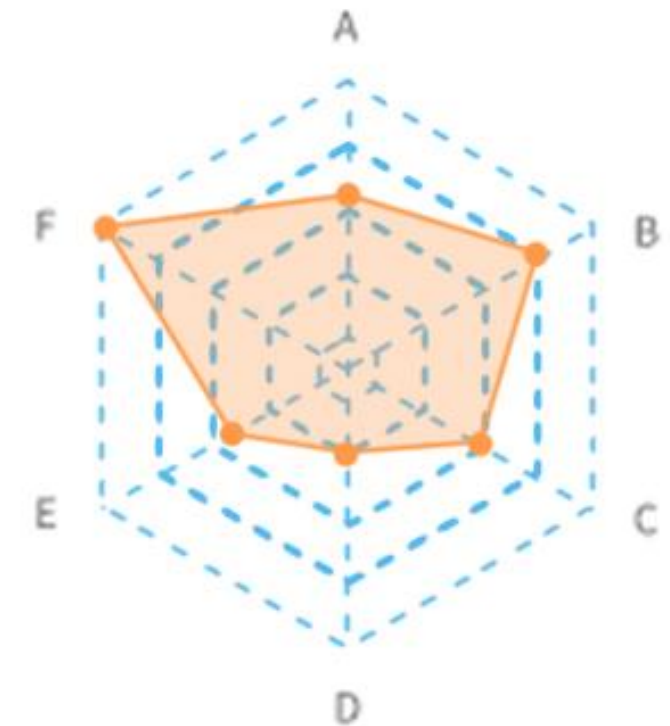
- **Degree of the Node:** the degree of a node is defined as the number of edges connected to the node.
- **Network density:** defined as the ratio of the actual number of edges in the network to the upper limit of the number of edges that all the nodes can have.
- **Clustering coefficient:** used to describe the degree that nodes connected to the same node in the network are also adjacent to each other. It reflects the aggregation in social networks.

Feature Index for Social Network

Unless there is a very obvious top aggregation, the readability of the whole graph is not very well, so some indexes are generally used for analysis and grasping the big picture.



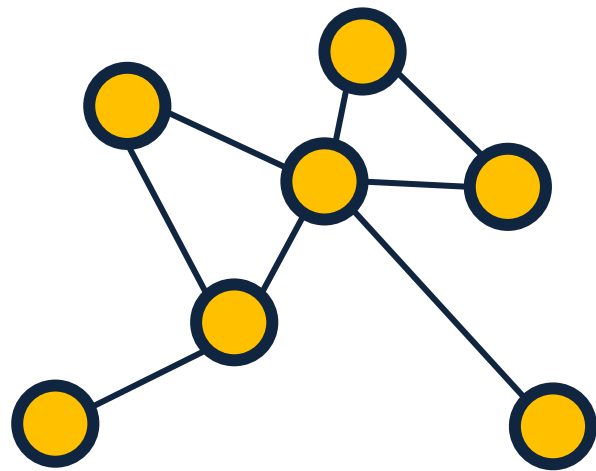
Extract features & indexes
Data dimensionality reduction



Feature Index for Social Network

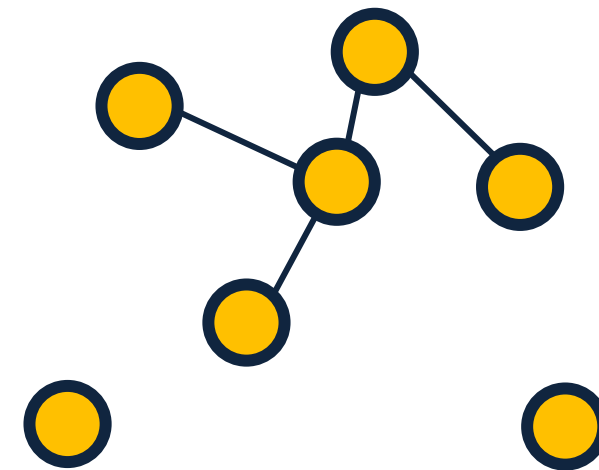
- Social Rate

Number of players who have socialized on certain period / Number of players logged in on the same period



High Social Rate

Means more players to participate in social



Low Social Rate

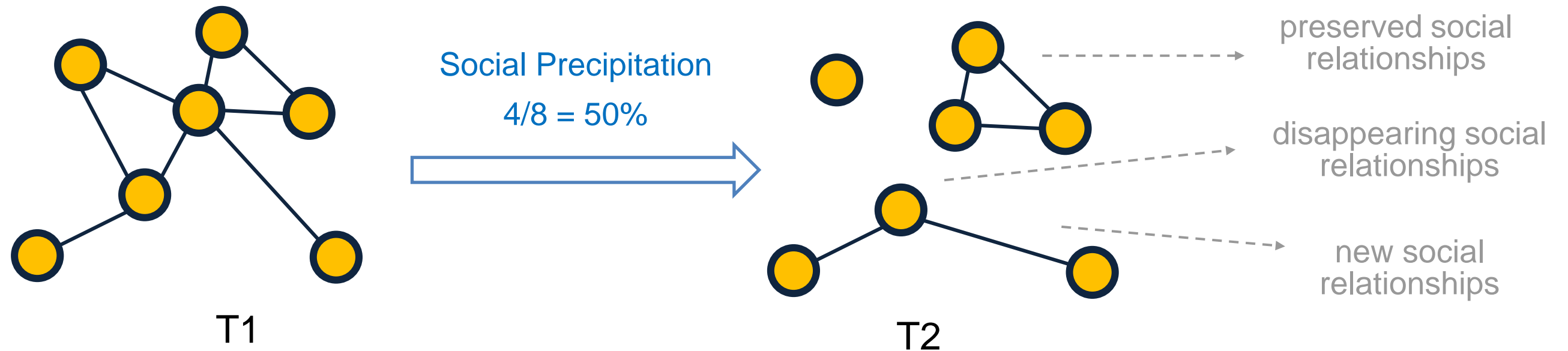
Means that few players are involved in social

Possibly a non-social game

Feature Index for Social Network

- Social Precipitation

The ratio of social relationships that existed at one period to another.

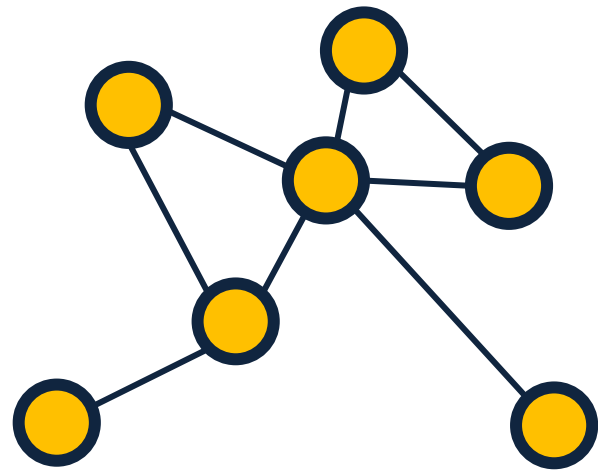


The higher the social precipitation, the more stable the social relationship in the game is.

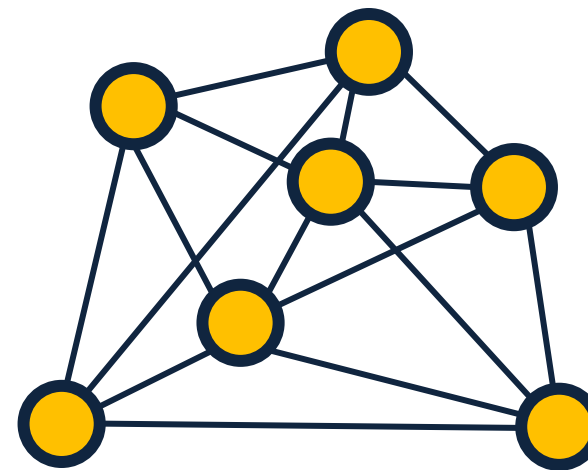
Feature Index for Social Network

- Social Cycle Per Player

Average number of objects each player interacts with.



sparse social relationships

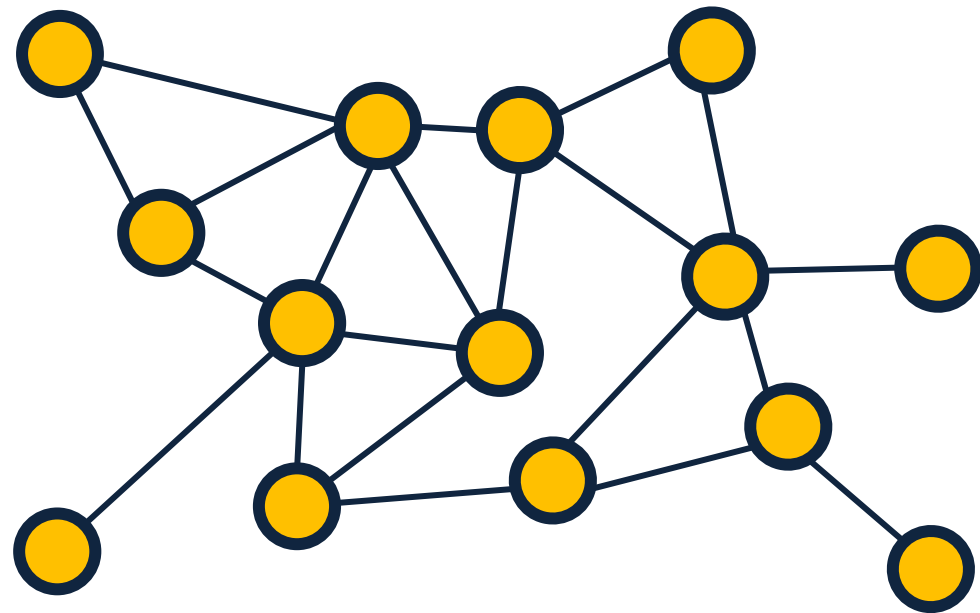


dense social relationships

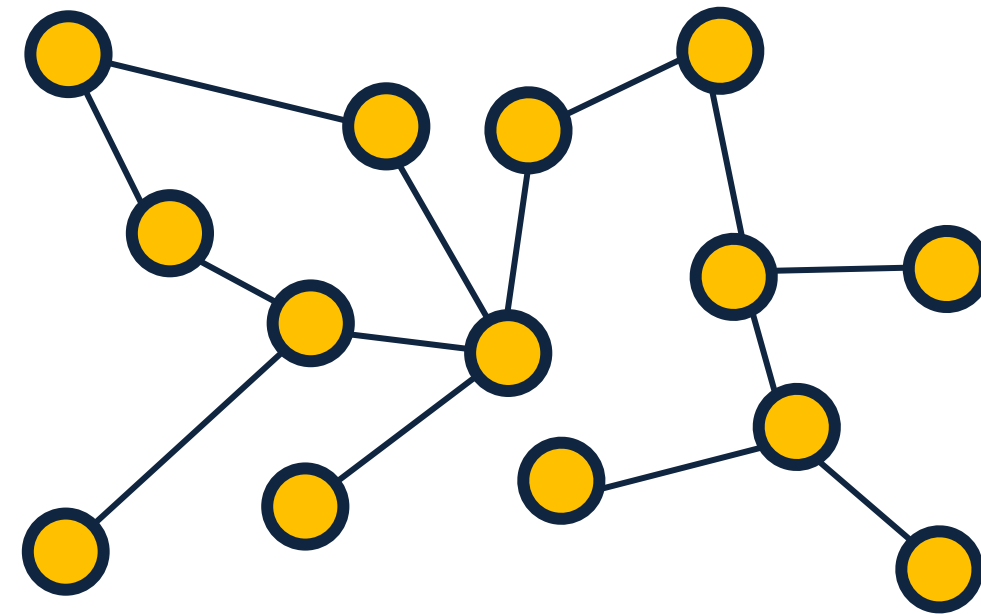
Feature Index for Social Network

- Reliability

The actual number of triangle relationships in the social network /
theoretical max number of triangle relationships



*more triangular
social relationships*



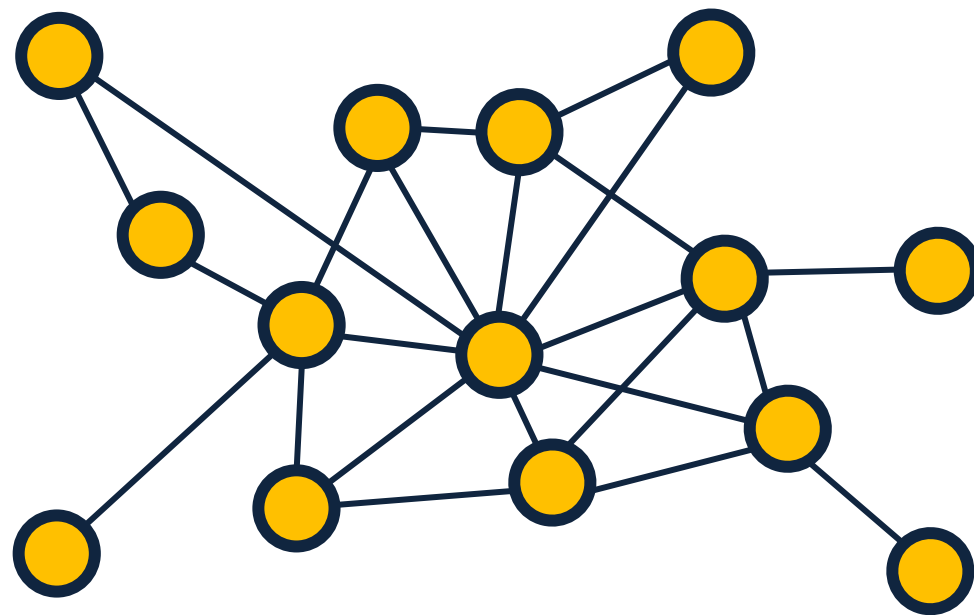
more socially isolated

the triangle relationship is considered to be the most stable social relationship

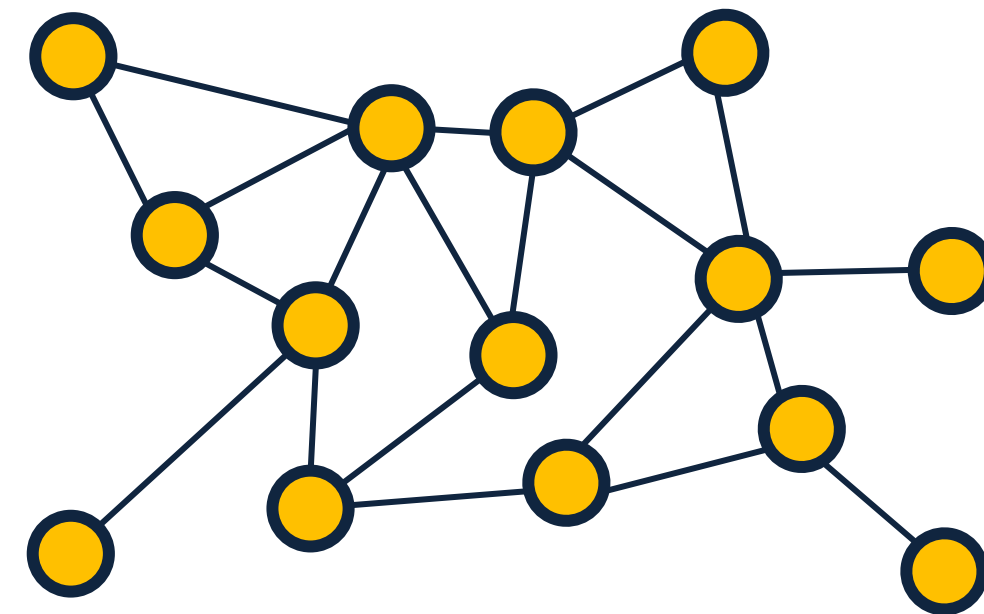
Feature Index for Social Network

- Degree of Difference

The value of the Gini coefficient of social faces per capita in the social graph.

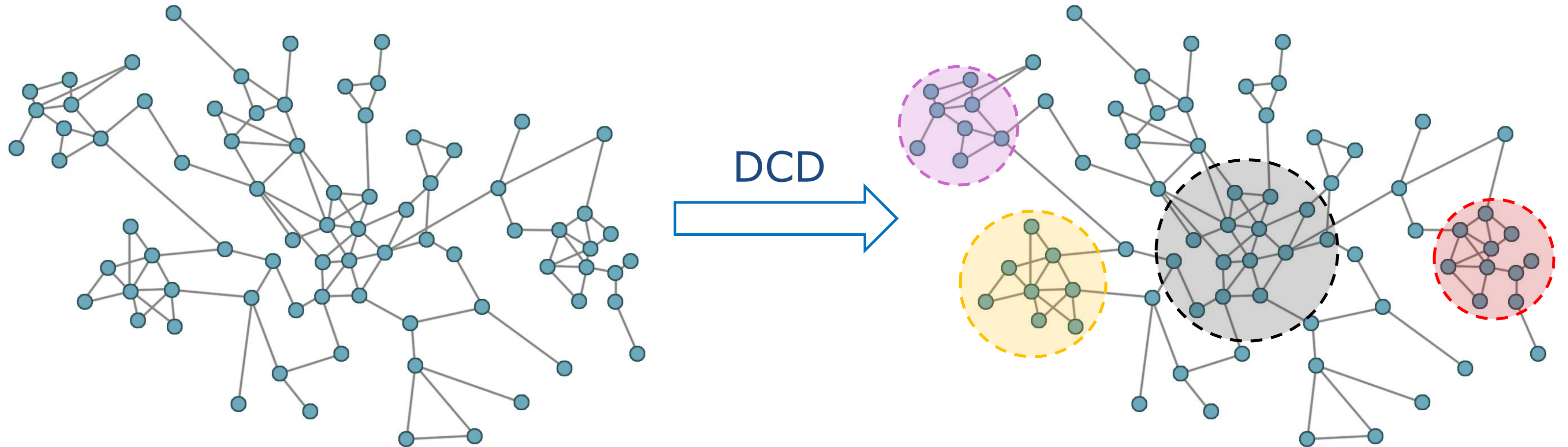


Social opportunities vary widely, and there is a "social center"



Equal social opportunity

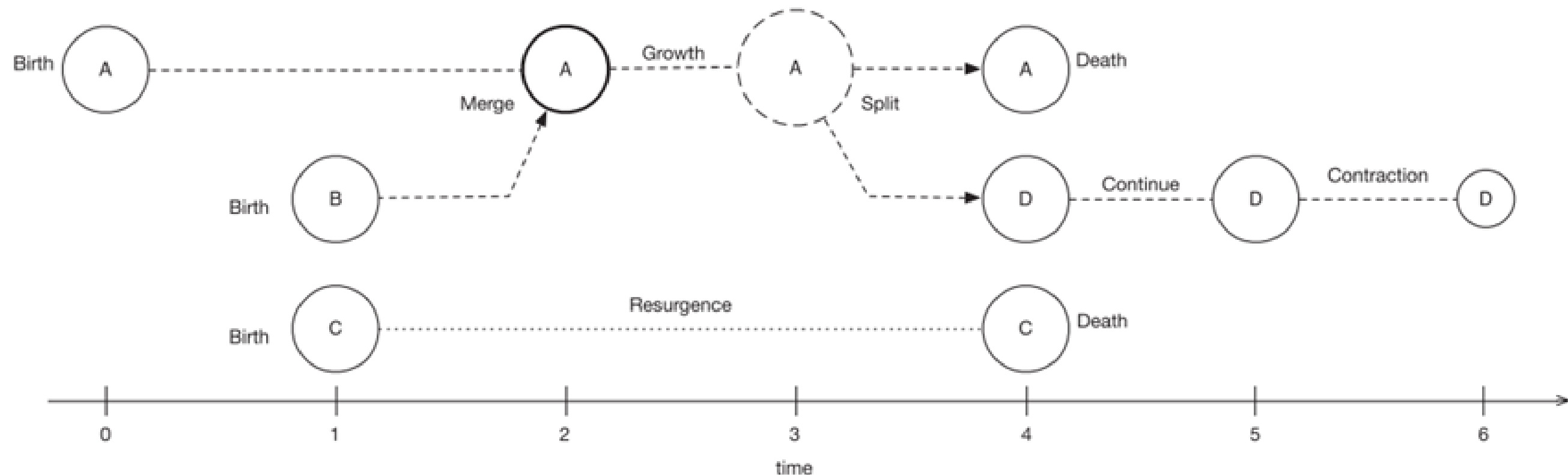
Dynamic Community Discovery



Communities, intuitively, refer to some dense groups in the network. The connections between nodes within each community are relatively close, but the connections between communities are relatively sparse.

Dynamic Community Discovery

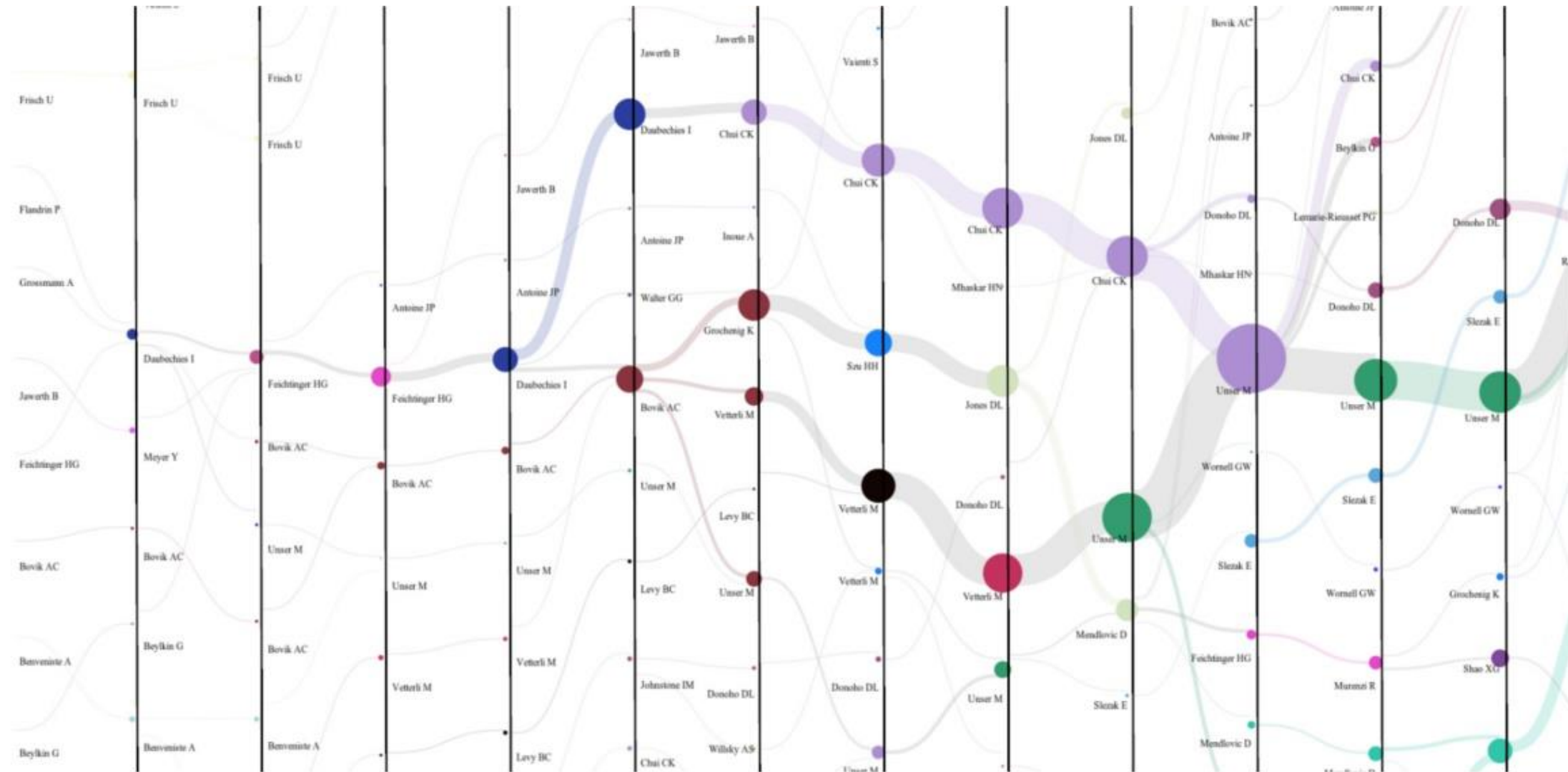
The life cycle of a dynamic community can be represented by a directed acyclic graph.



* *Community Discovery in Dynamic Networks*, DOI:10.1145/3172867Corpus ID: 824375

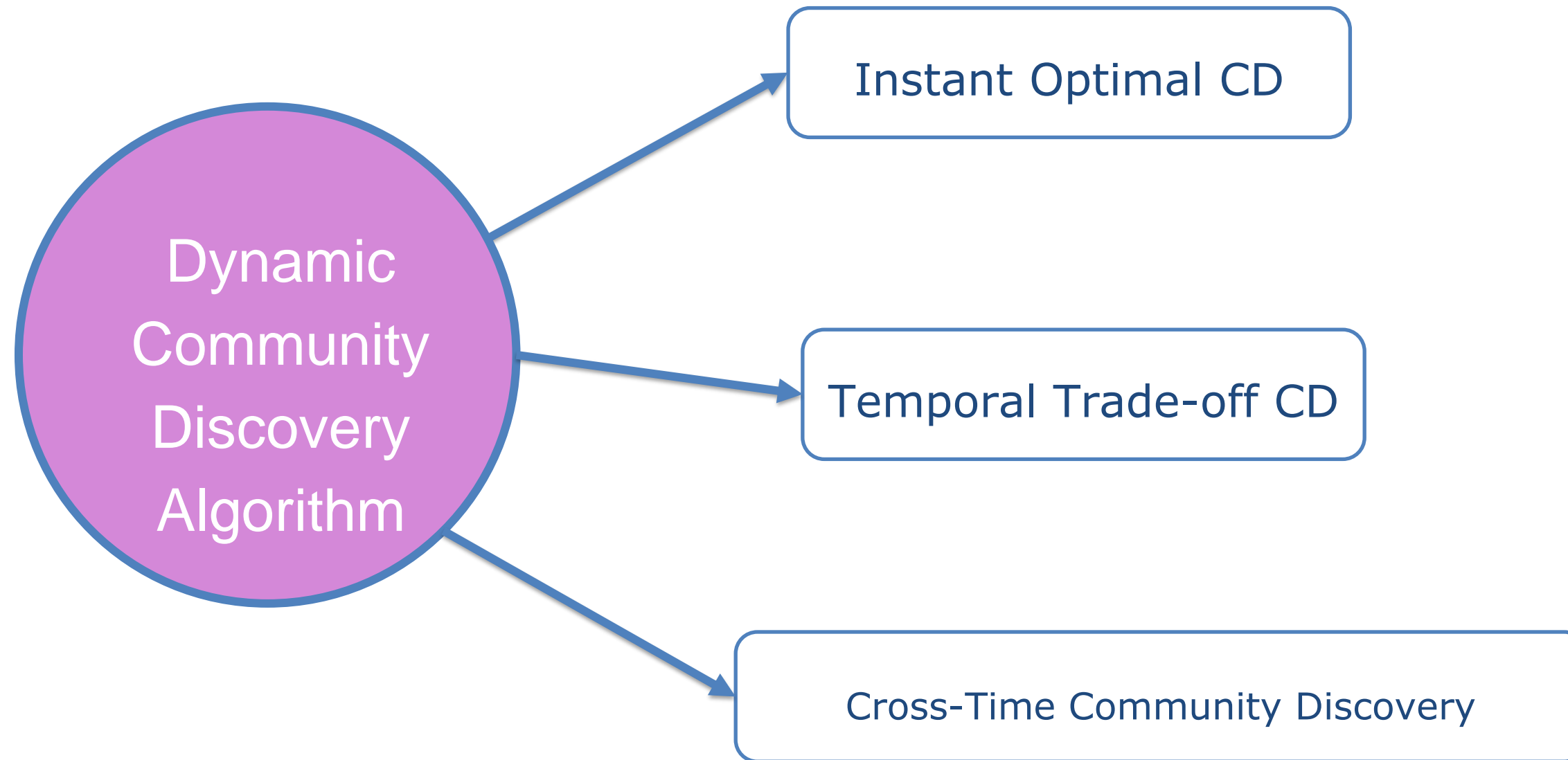
Dynamic Community Evolution

A example of visualization of the formation, merger, and death of dynamic communities



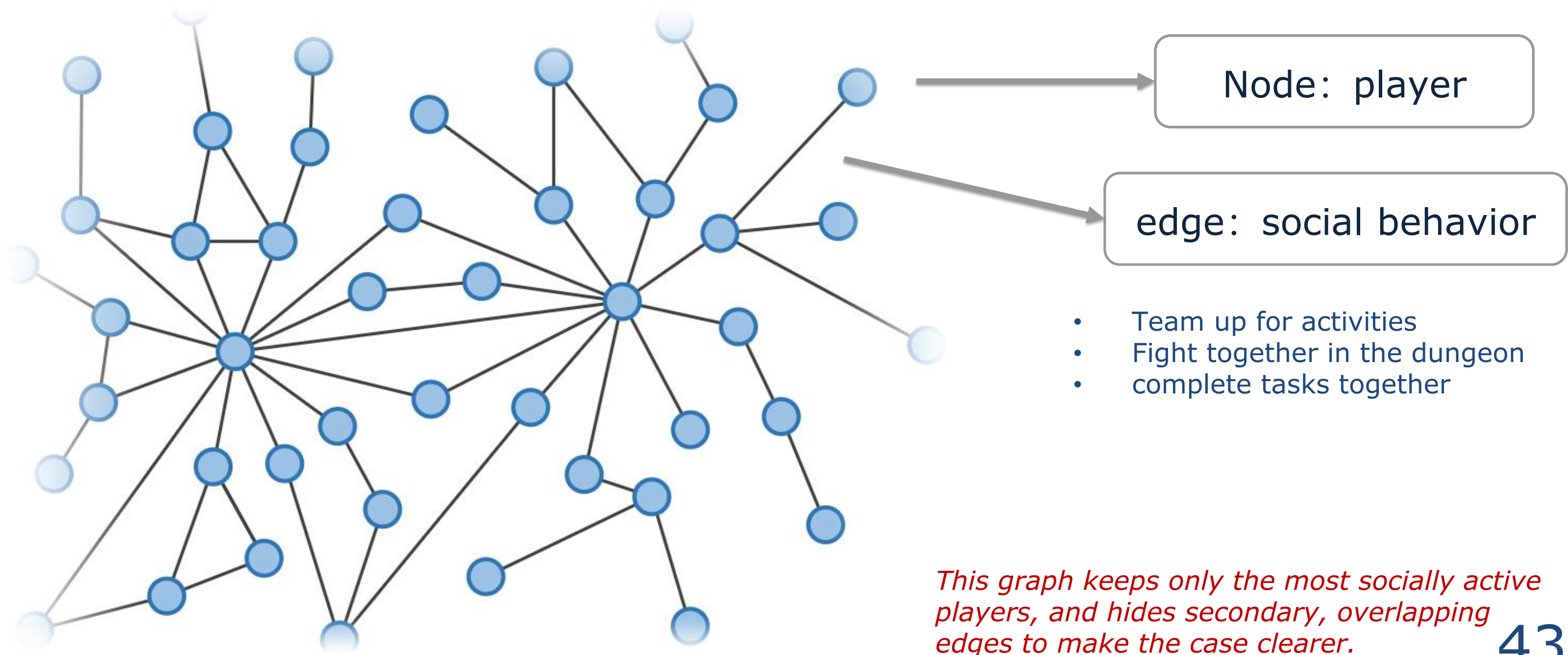
* *Community Discovery in Dynamic Networks*, DOI:10.1145/3172867Corpus ID: 824375

Community Discovery(CD) Algorithm

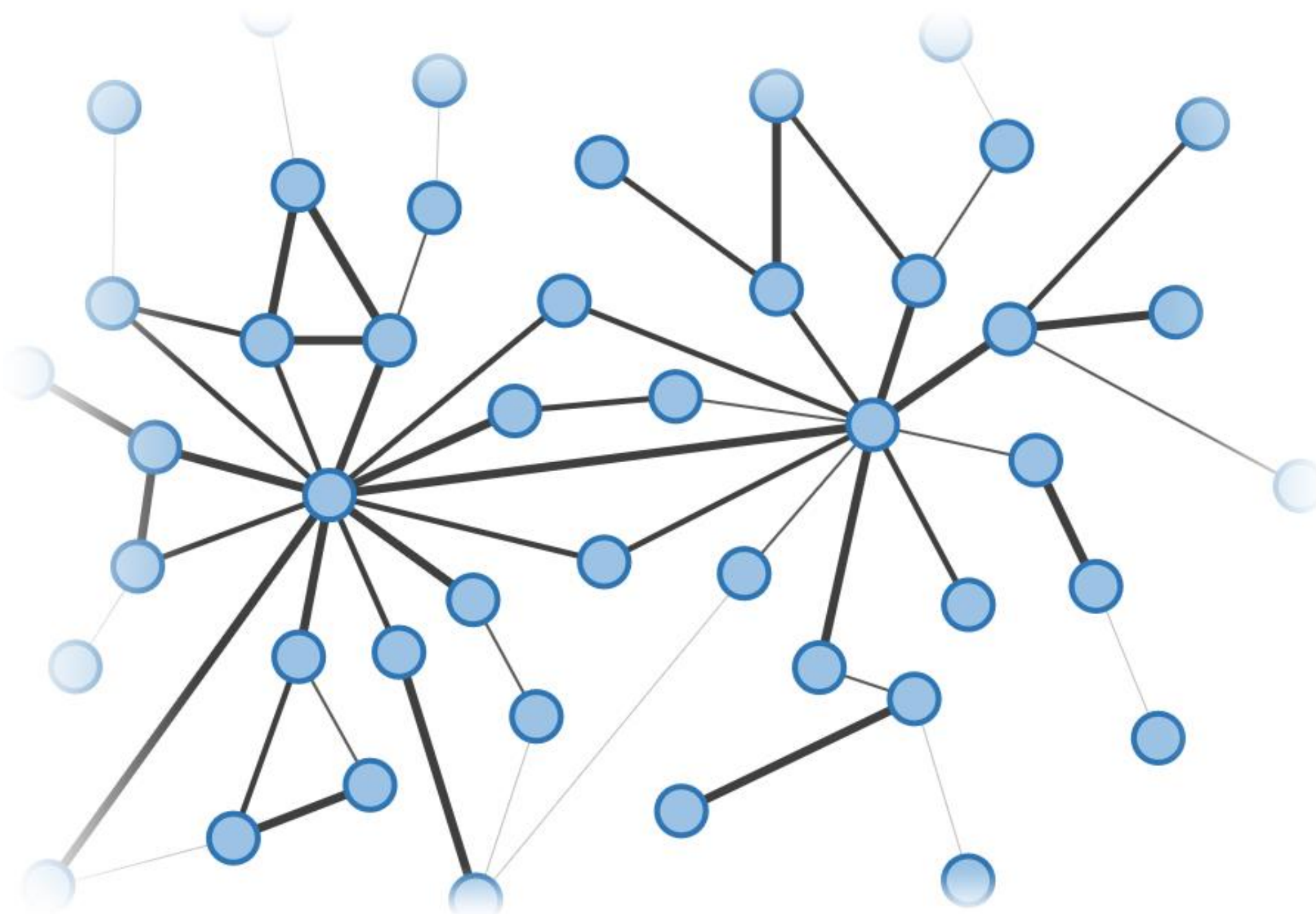


Case Analysis

MMORPG social network analysis case



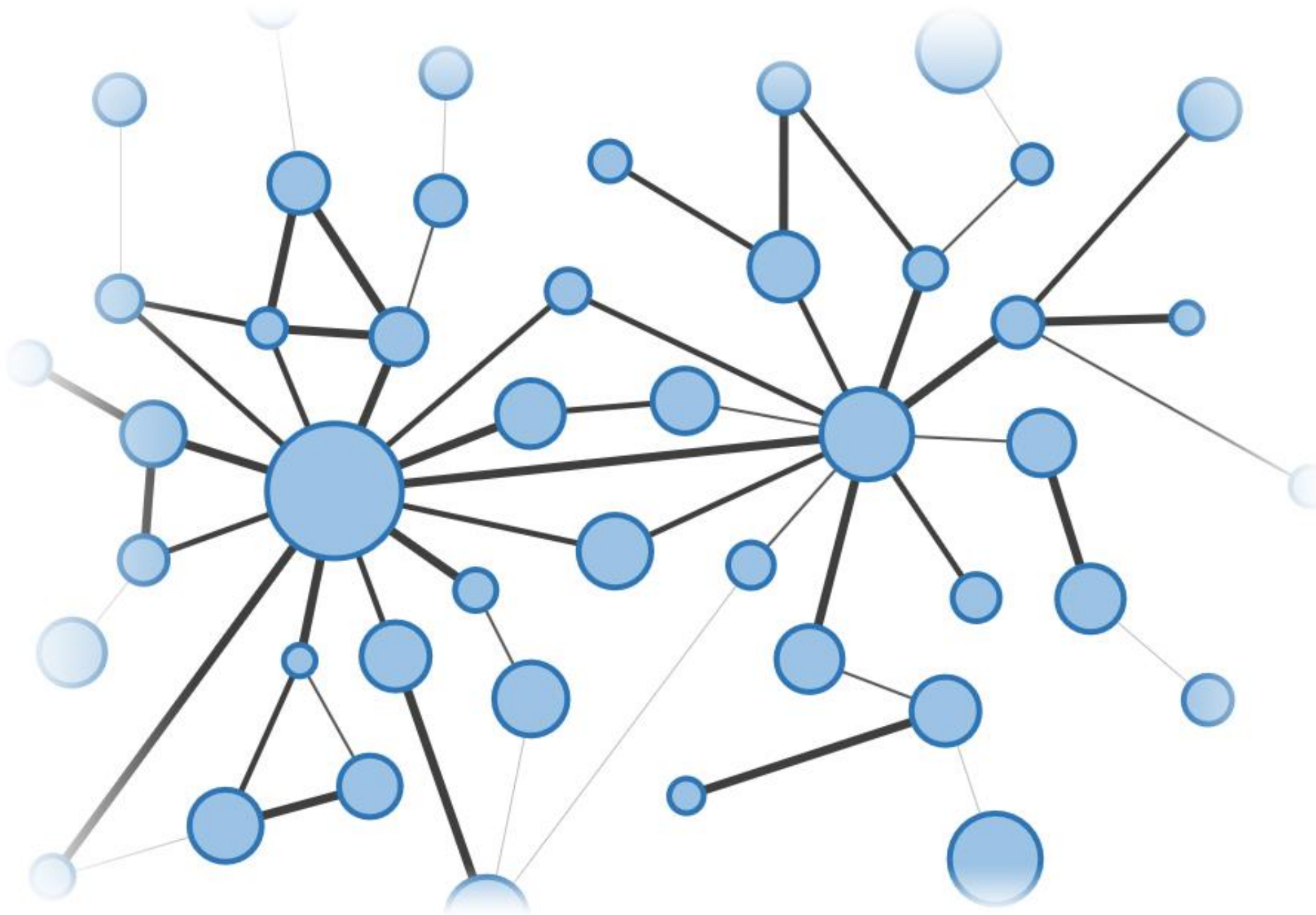
Graph with Edge Information



The thickness of the edge indicates the degree of social behavior between the two players.

In this MMORPG game, players can get social points from the social behavior between them, we use this points to measure the strength of social behavior.

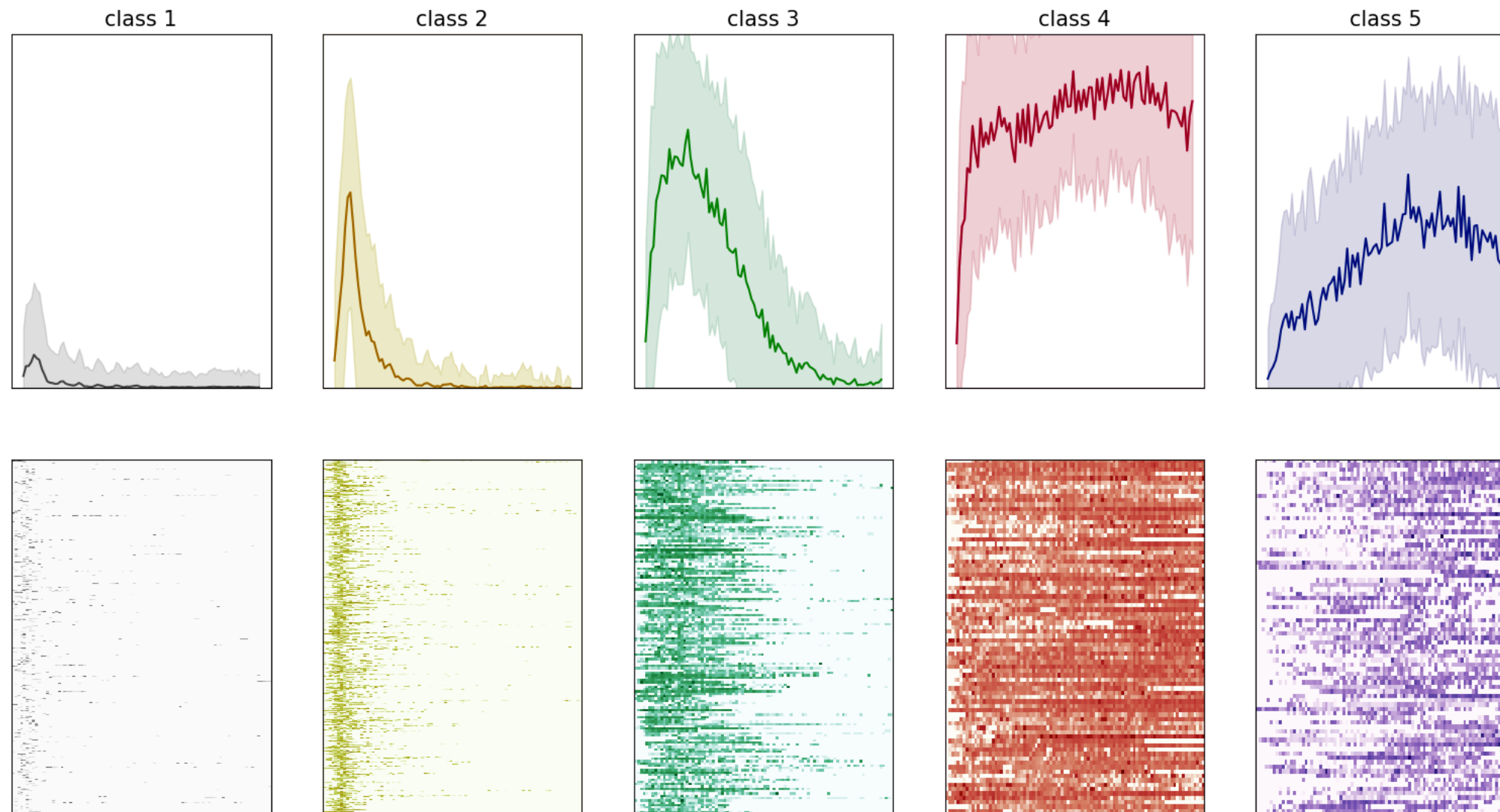
Graph with Node Information



The size of the nodes indicates the players' investment in the game.

In this MMORPG game, there is a value that measures the player's combat power (including factors such as character level, skill level, and equipment sophistication), which can be used as a measure of the player's overall investment in the game.

Behavior Pattern Cluster



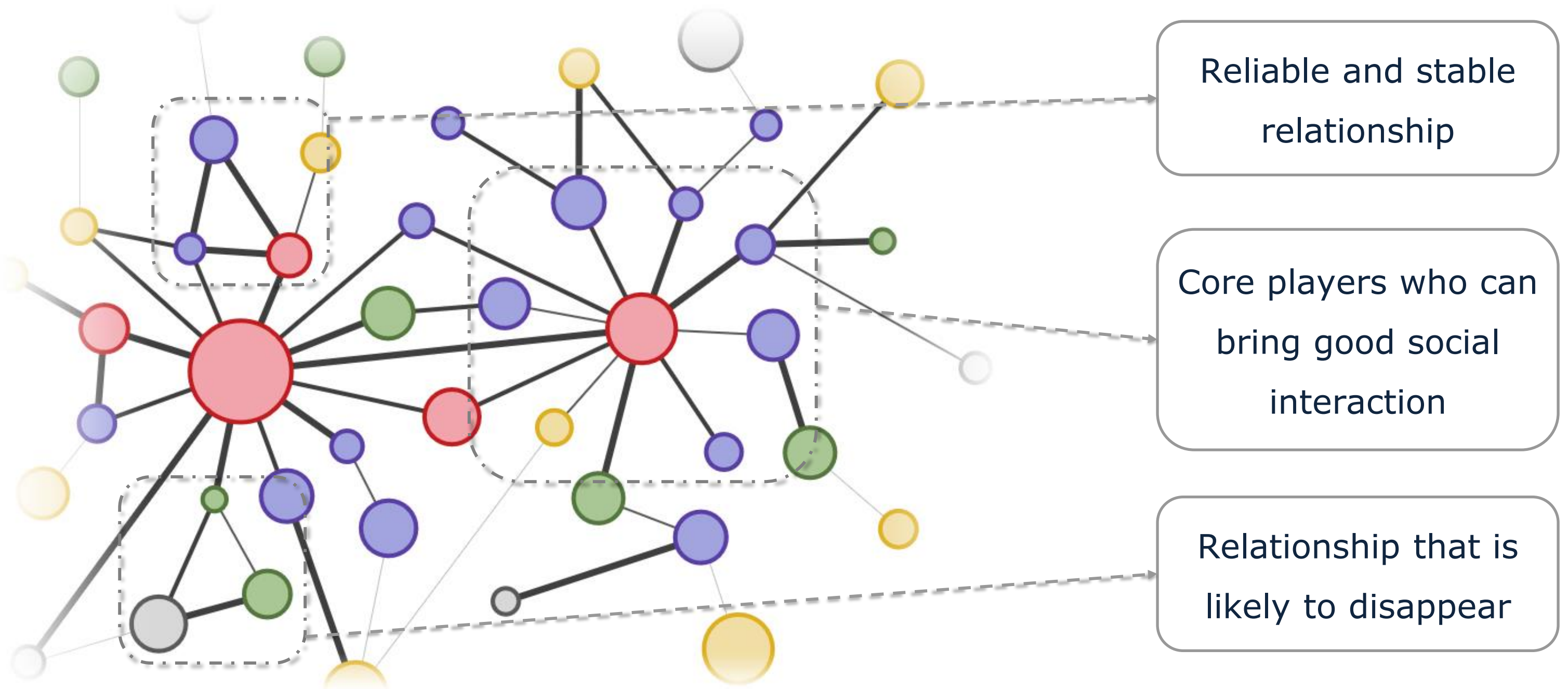
Clustering players based on the ***time series of their social behavior.***

Players can be divided into:

- Not interested in socializing at all
- Only attempt social behavior initially
- Give up after being keen on socializing
- Always actively participate in social activities
- Gradually interested in socializing

*The specific methods and details can be found in our published paper **Analyzing User Behavior Patterns in Casual Games Using Time Series Clustering**, DOI: 10.1109/CDS52072.2021.00070*

Graph with Time Information



Takeaway Points

Takeaway points

- Background and models of social networking
- Characteristics of social networks for online games
- A method of time-dependent behavior pattern analysis for social network visualization

Thank you