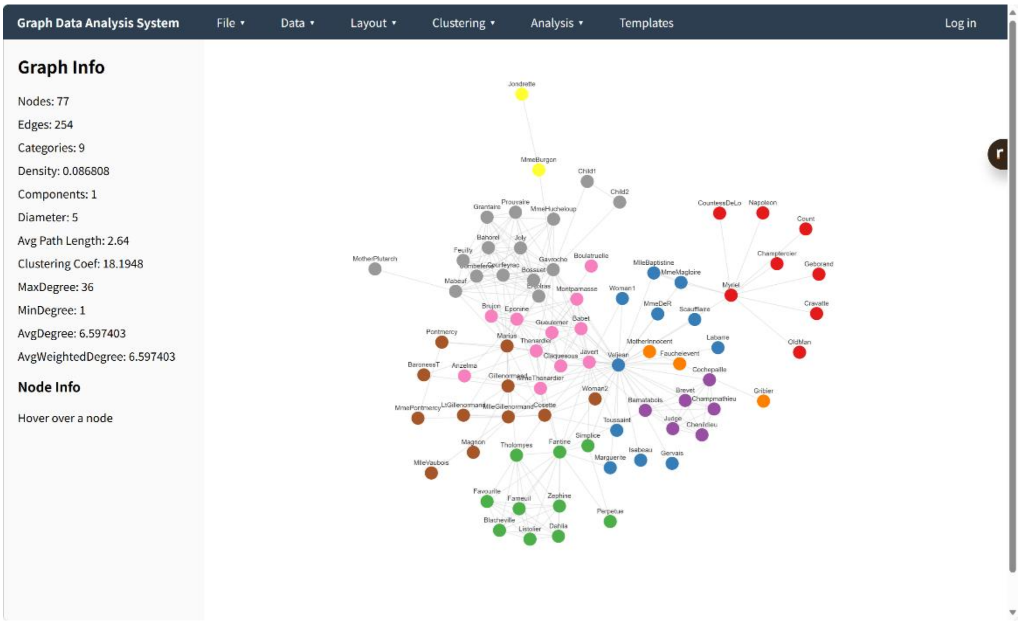
## System Architecture

The backend is implemented using Python, Flask, and MySQL for data processing and session management. The frontend uses Cytoscape.js and chart.js to support interactive graph visualization and user operations.

| Module | Feature Description | User Interaction Capability |
|---|---|---|
| **File** | Graph record management | Save visualized results as JSON/image, manage recent records |
| **Clustering** | Clustering result visualization | Toggle between Louvain, KMeans, and CW clustering results |
| **Layout** | Graph layout adjustment | Switch between force-directed, circular, etc,. |
| **Analysis** | Topological graph statistics | View degree distribution, community ratios, component sizes |
| **Filter** | Node/edge filtering | Apply attribute-based filters (e.g., degree > 5) |
| **Templates** | Preloaded dataset selection | Quickly load classic datasets such as Dolphins, Jazz |

## Homepage Overview

The system homepage includes user authentication (registration/login).



### Graph Info

Nodes: 77

Edges: 254

Categories: 9

Density: 0.086808

Components: 1

Diameter: 5

Avg Path Length: 2.64

Clustering Coef: 18.1948

MaxDegree: 36

MinDegree: 1

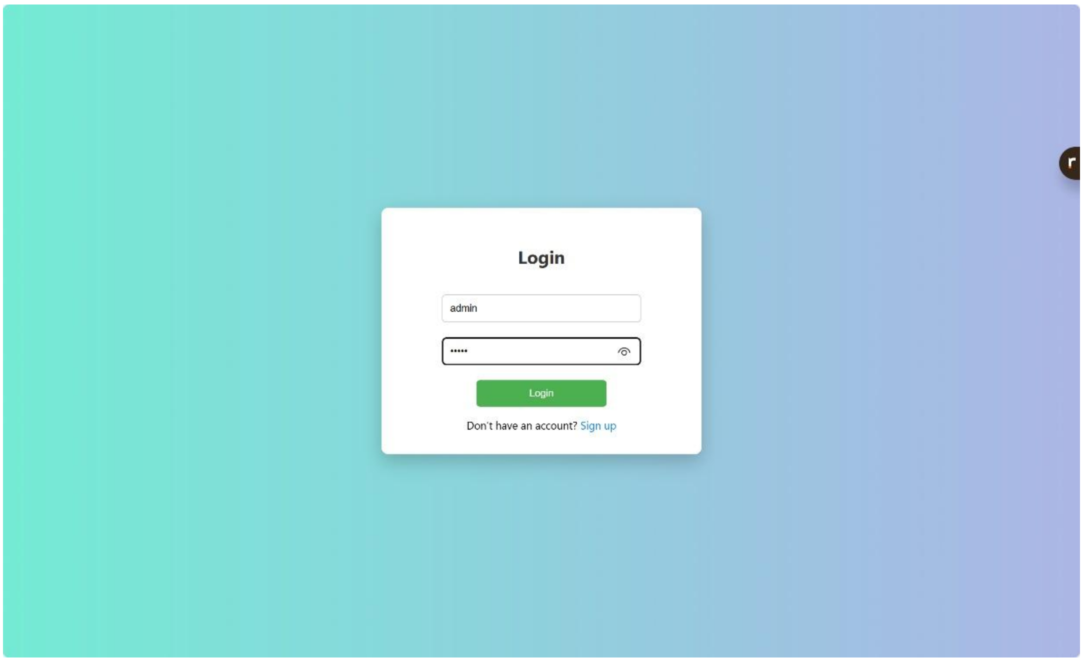
AvgDegree: 6.597403

AvgWeightedDegree: 6.597403

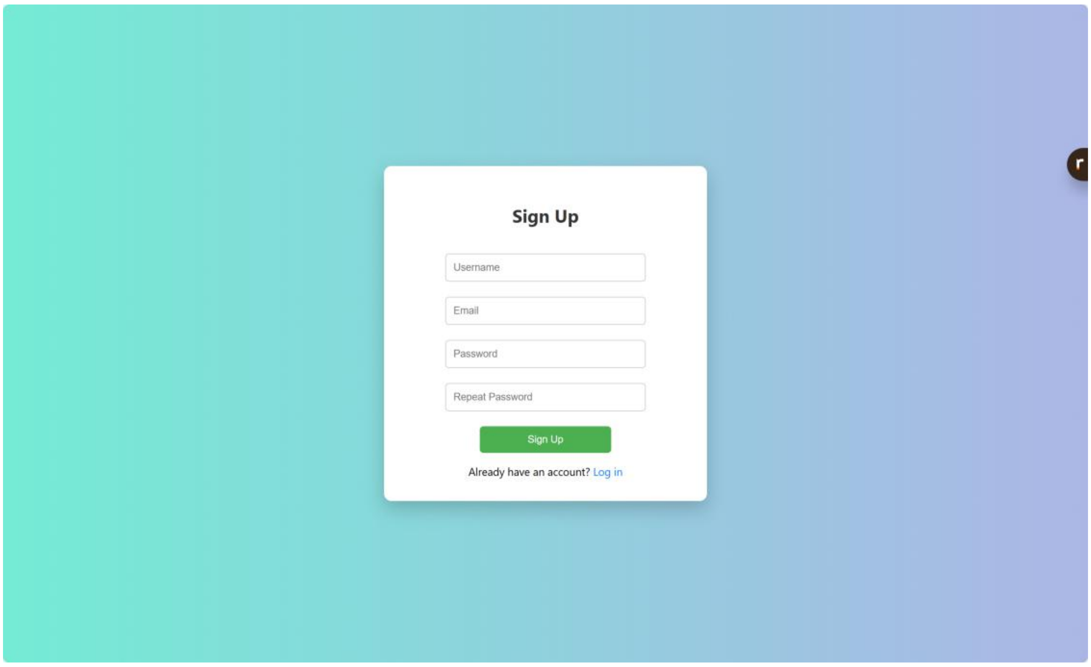
**Node Info**

Hover over a node

Registered users gain access to extended features including graph saving and record history. Guest users can upload and visualize their own graph data.



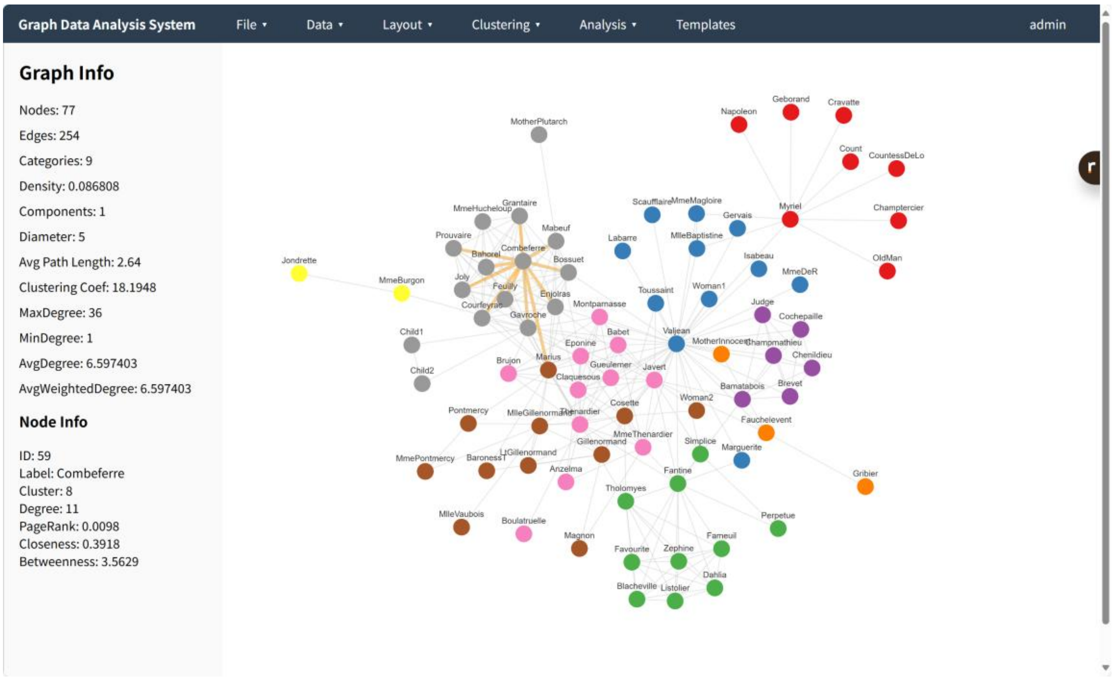
Don't have an account? Sign up



Already have an account? Log in

## Interaction Behavior

When hovering over a node, connected edges are automatically highlighted.



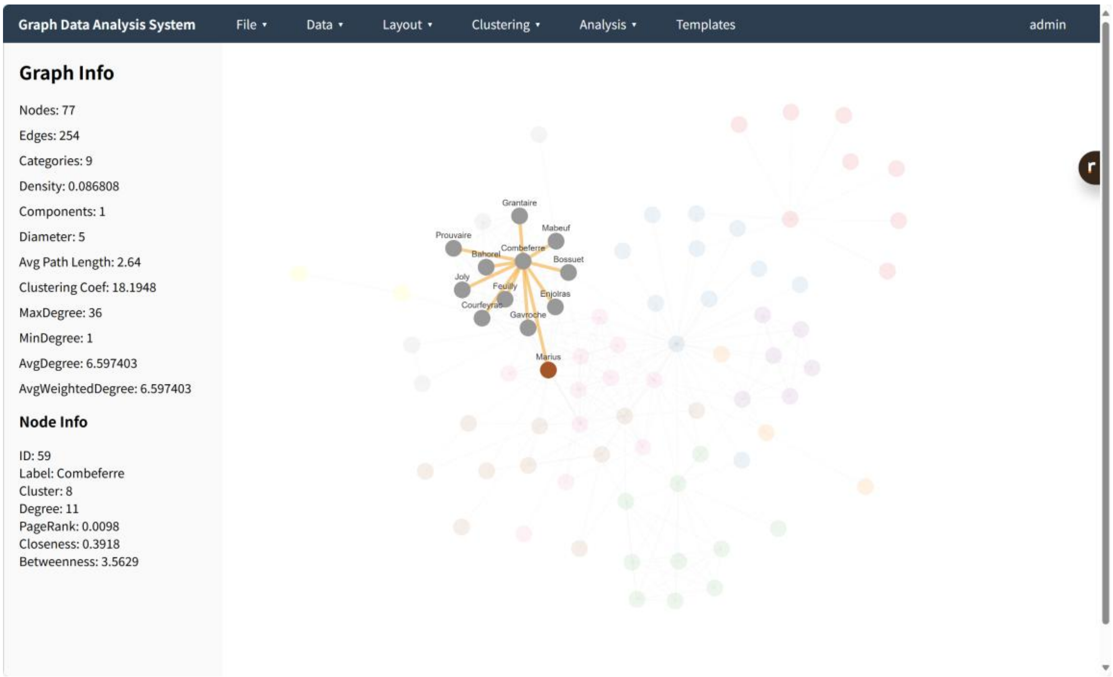
Graph Info

Nodes: 77
Edges: 254
Categories: 9
Density: 0.086808
Components: 1
Diameter: 5
Avg Path Length: 2.64
Clustering Coef: 18.1948
MaxDegree: 36
MinDegree: 1
AvgDegree: 6.597403
AvgWeightedDegree: 6.597403

Node Info

ID: 59
Label: Combeferre
Cluster: 8
Degree: 11
PageRank: 0.0098
Closeness: 0.3918
Betweenness: 3.5629

When clicking on a node, its local subgraph and properties are displayed in an info panel.



Graph Info

Nodes: 77
Edges: 254
Categories: 9
Density: 0.086808
Components: 1
Diameter: 5
Avg Path Length: 2.64
Clustering Coef: 18.1948
MaxDegree: 36
MinDegree: 1
AvgDegree: 6.597403
AvgWeightedDegree: 6.597403

Node Info

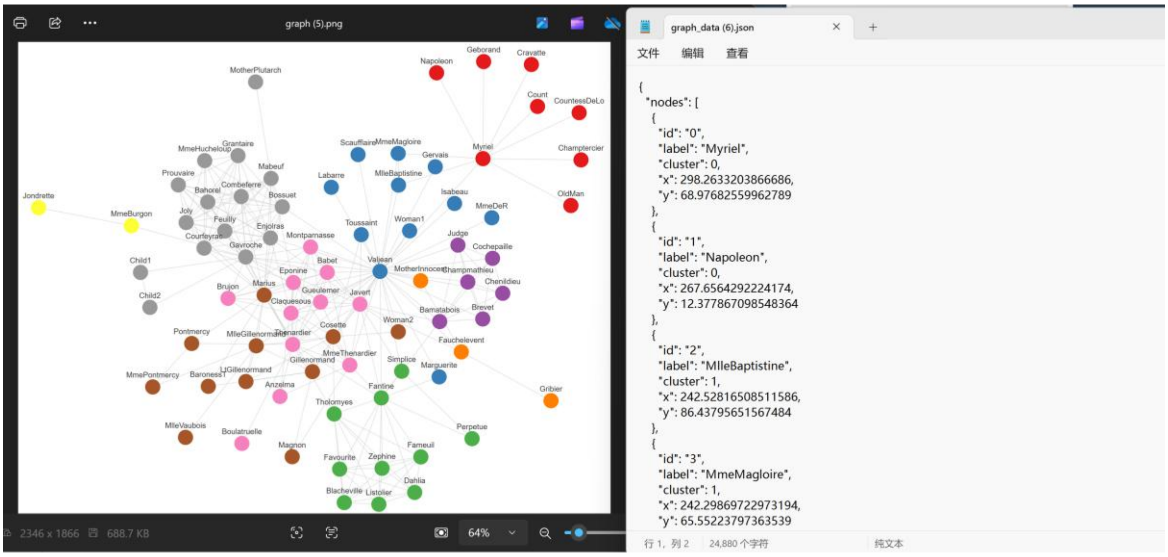
ID: 59
Label: Combeferre
Cluster: 8
Degree: 11
PageRank: 0.0098
Closeness: 0.3918
Betweenness: 3.5629

## Module Details

### File Module – Graph Record Management

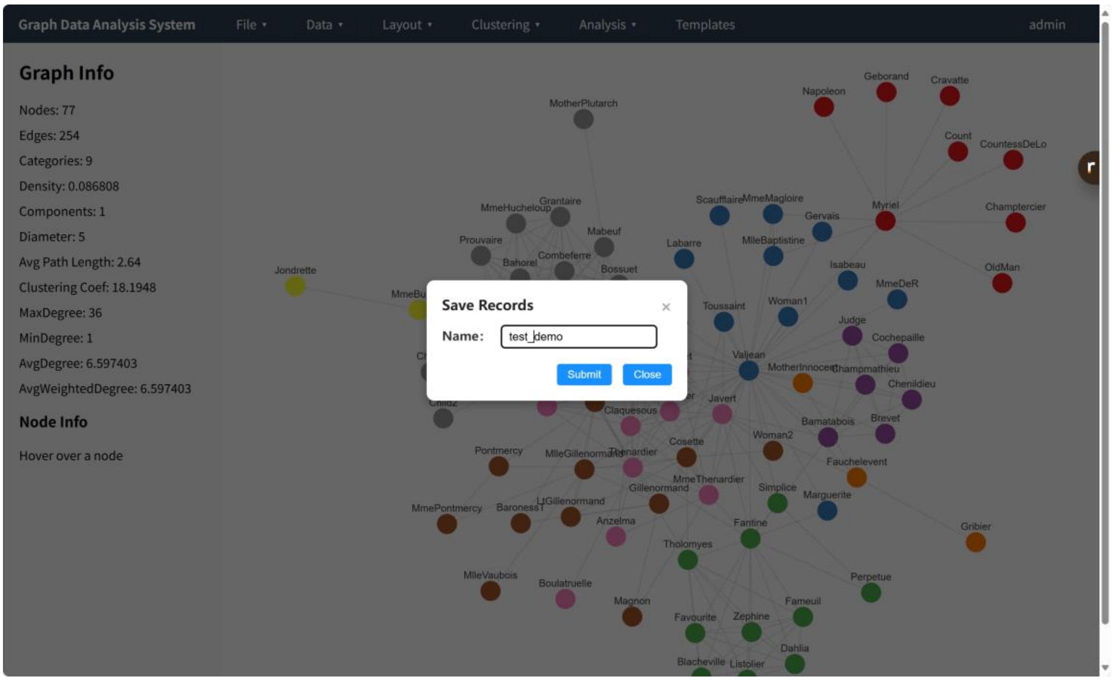
Users can:

- Save the current visualization result as an image or JSON;



```
{
 "nodes": [
  {
   "id": "0",
   "label": "Myriel",
   "cluster": 0,
   "x": 298.2633203866686,
   "y": 68.97682559962789
  },
  {
   "id": "1",
   "label": "Napoleon",
   "cluster": 0,
   "x": 267.6564292224174,
   "y": 12.377867098548364
  },
  {
   "id": "2",
   "label": "MlleBaptistine",
   "cluster": 1,
   "x": 242.52816508511586,
   "y": 86.43795651567484
  },
  {
   "id": "3",
   "label": "MmeMagloire",
   "cluster": 1,
   "x": 242.29869722973194,
   "y": 65.55223797363539
```

- Store session records to the backend;



## Graph Info

Nodes: 77

Edges: 254

Categories: 9

Density: 0.086808

Components: 1

Diameter: 5

Avg Path Length: 2.64

Clustering Coef: 18.1948

MaxDegree: 36

MinDegree: 1

AvgDegree: 6.597403

AvgWeightedDegree: 6.597403

## Node Info

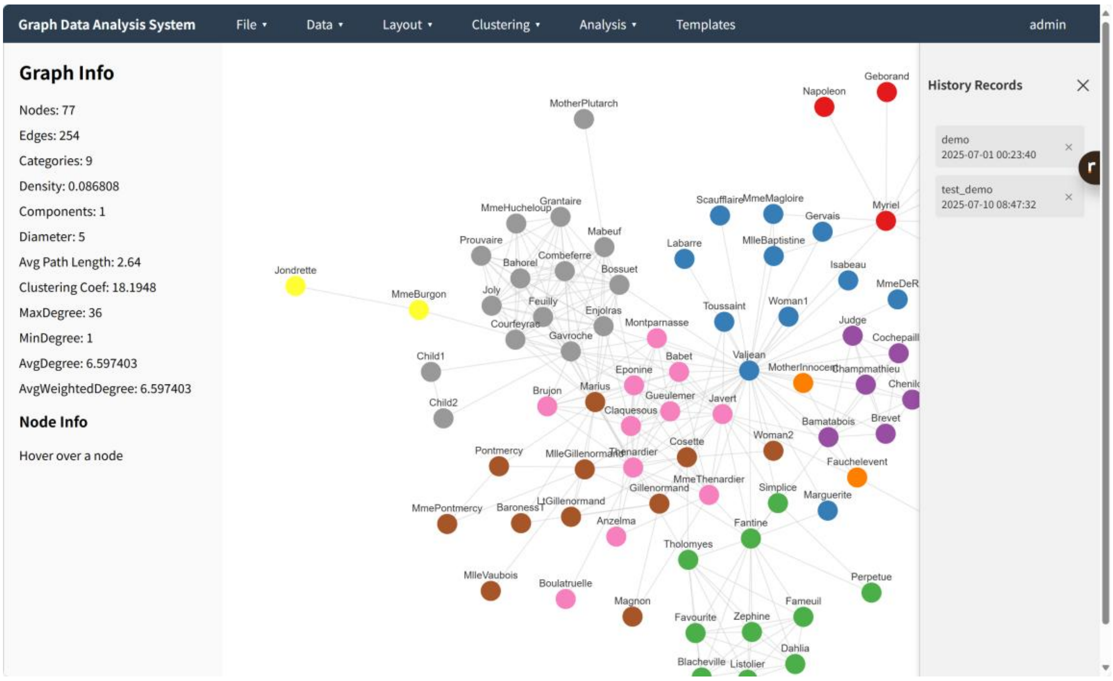
Hover over a node

Save Records ×

Name: test_demo

Submit Close

- View, retrieve, or delete recent history from the “Recent Records” list.



**Graph Info**

Nodes: 77

Edges: 254

Categories: 9

Density: 0.086808

Components: 1

Diameter: 5

Avg Path Length: 2.64

Clustering Coef: 18.1948

MaxDegree: 36

MinDegree: 1

AvgDegree: 6.597403

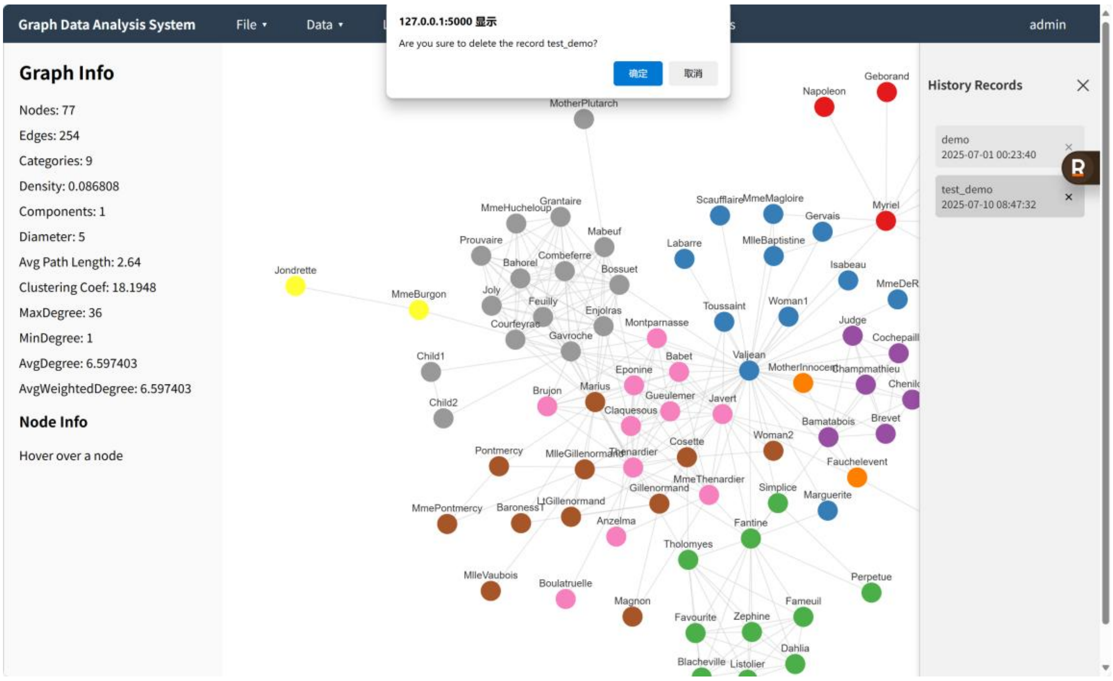
AvgWeightedDegree: 6.597403

**Node Info**

Hover over a node

demo
2025-07-01 00:23:40

test_demo
2025-07-10 08:47:32



127.0.0.1:5000 显示

Are you sure to delete the record test_demo?

**Graph Info**

Nodes: 77

Edges: 254

Categories: 9

Density: 0.086808

Components: 1

Diameter: 5

Avg Path Length: 2.64

Clustering Coef: 18.1948

MaxDegree: 36

MinDegree: 1

AvgDegree: 6.597403

AvgWeightedDegree: 6.597403

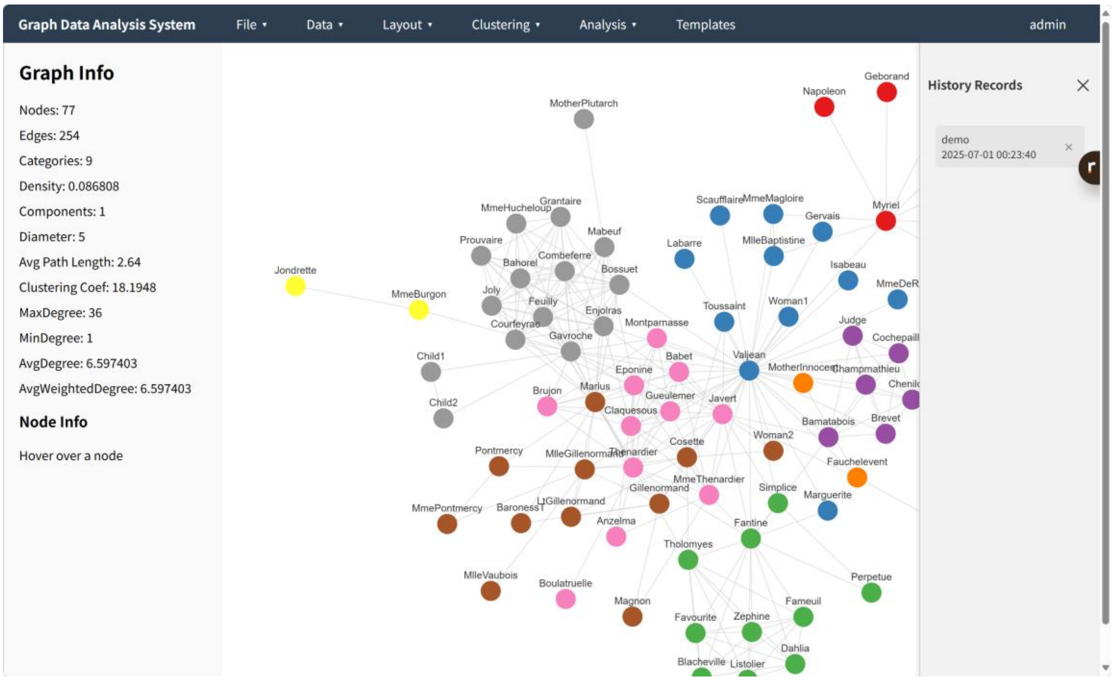
**Node Info**

Hover over a node

demo
2025-07-01 00:23:40

test_demo
2025-07-10 08:47:32

The history after deletion is as follows:



## Graph Info

Nodes: 77

Edges: 254

Categories: 9

Density: 0.086808

Components: 1

Diameter: 5

Avg Path Length: 2.64

Clustering Coef: 18.1948

MaxDegree: 36

MinDegree: 1

AvgDegree: 6.597403

AvgWeightedDegree: 6.597403

**Node Info**

Hover over a node

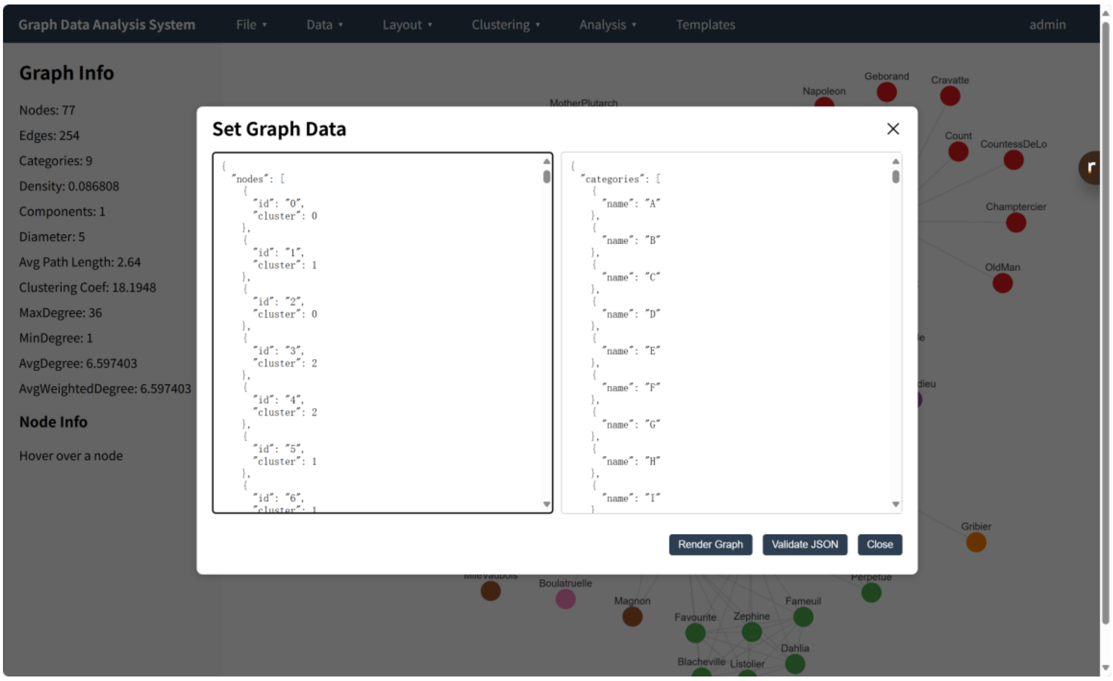
**History Records** ✕

demo ×
2025-07-01 00:23:40

## Data Module – Custom Graph Input

The system supports direct input of .json graph structures (e.g., via paste).

It will automatically parse the content and visualize the network—e.g., the Dolphin network.



## Graph Info

Nodes: 77

Edges: 254

Categories: 9

Density: 0.086808

Components: 1

Diameter: 5

Avg Path Length: 2.64

Clustering Coef: 18.1948

MaxDegree: 36

MinDegree: 1

AvgDegree: 6.597403

AvgWeightedDegree: 6.597403

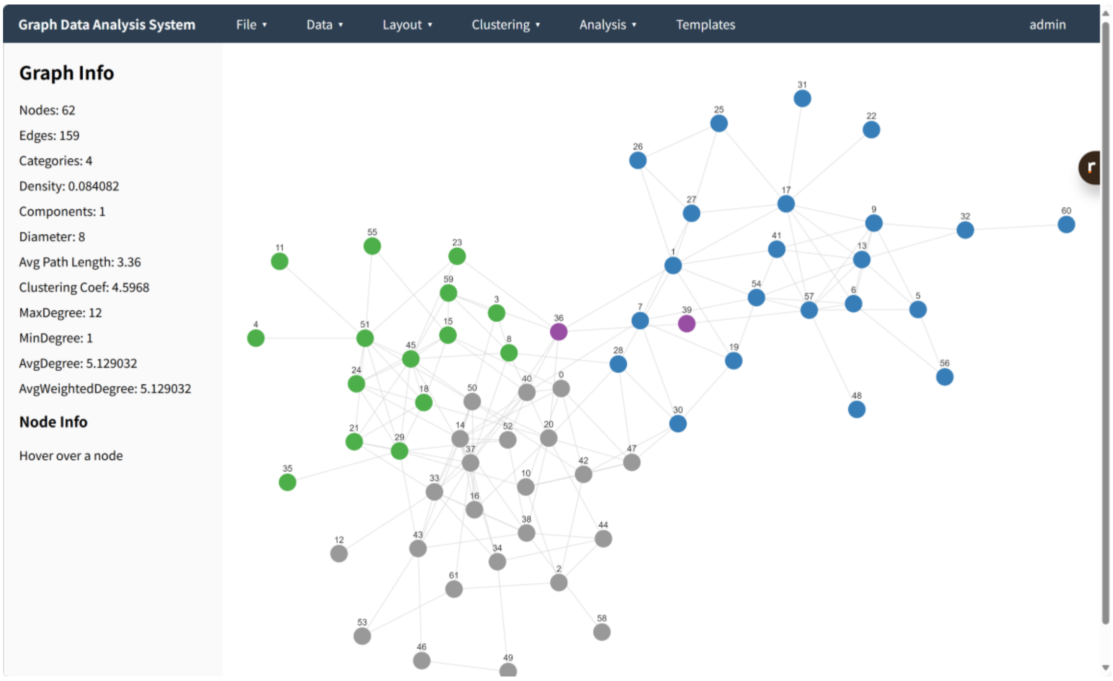
**Node Info**

Hover over a node

**Set Graph Data** ✕

```
{
  "nodes": [
    {
      "id": "0",
      "cluster": 0
    },
    {
      "id": "1",
      "cluster": 1
    },
    {
      "id": "2",
      "cluster": 0
    },
    {
      "id": "3",
      "cluster": 2
    },
    {
      "id": "4",
      "cluster": 2
    },
    {
      "id": "5",
      "cluster": 1
    },
    {
      "id": "6",
      "cluster": 1
```

```
{
  "categories": [
    {
      "name": "A"
    },
    {
      "name": "B"
    },
    {
      "name": "C"
    },
    {
      "name": "D"
    },
    {
      "name": "E"
    },
    {
      "name": "F"
    },
    {
      "name": "G"
    },
    {
      "name": "H"
    },
    {
      "name": "I"
    }
```



**Graph Info**

Nodes: 62

Edges: 159

Categories: 4

Density: 0.084082

Components: 1

Diameter: 8

Avg Path Length: 3.36

Clustering Coef: 4.5968

MaxDegree: 12

MinDegree: 1

AvgDegree: 5.129032

AvgWeightedDegree: 5.129032

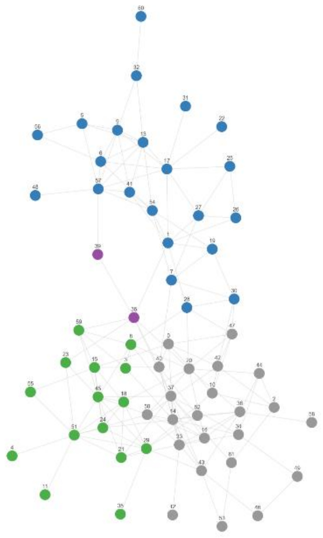
**Node Info**

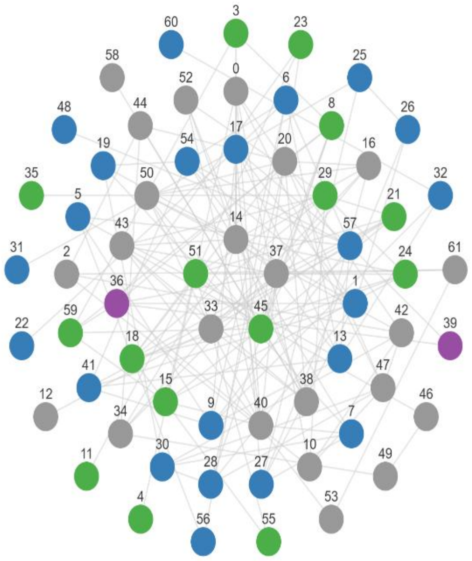
Hover over a node

## Layout Module – Structural Layout Switching

Users can switch layouts (e.g., force-directed, circular) to reorganize graph presentation.

Shown below is a circular layout for the uploaded Dolphin network.

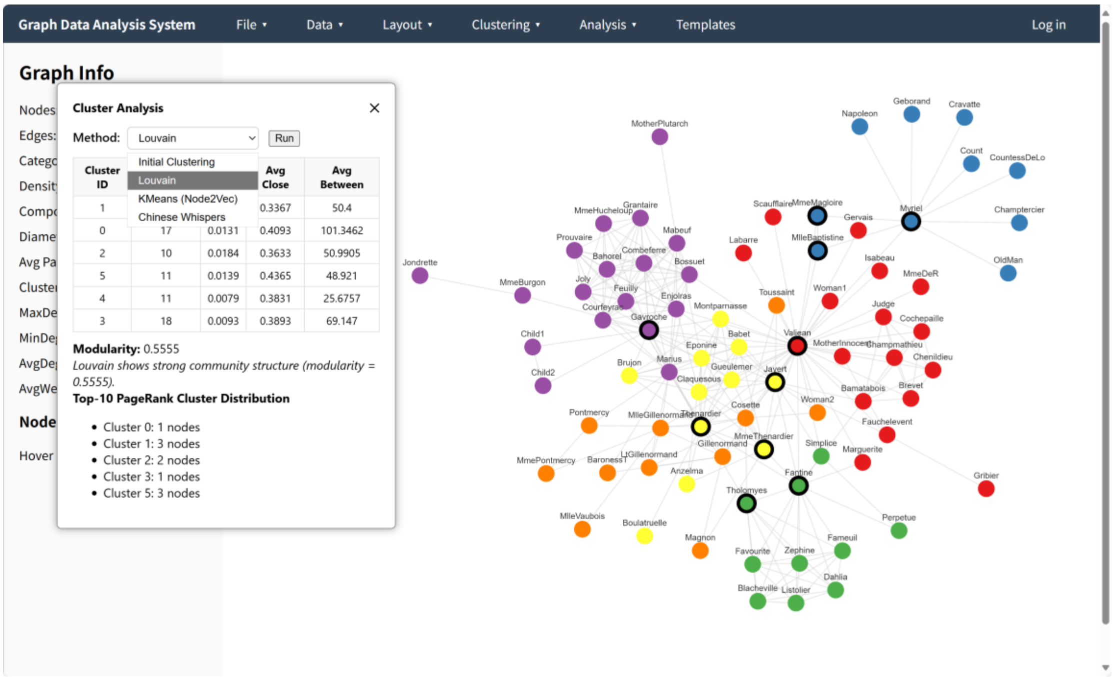




## Clustering Module – Community Detection Results

Users can choose from Louvain, KMeans, or Chinese Whispers.

- KMeans clustering supports configurable iteration parameters;
- After computation, the system updates and visualizes the results with colored node groups.



**Cluster Analysis** ×

**Method:** Louvain

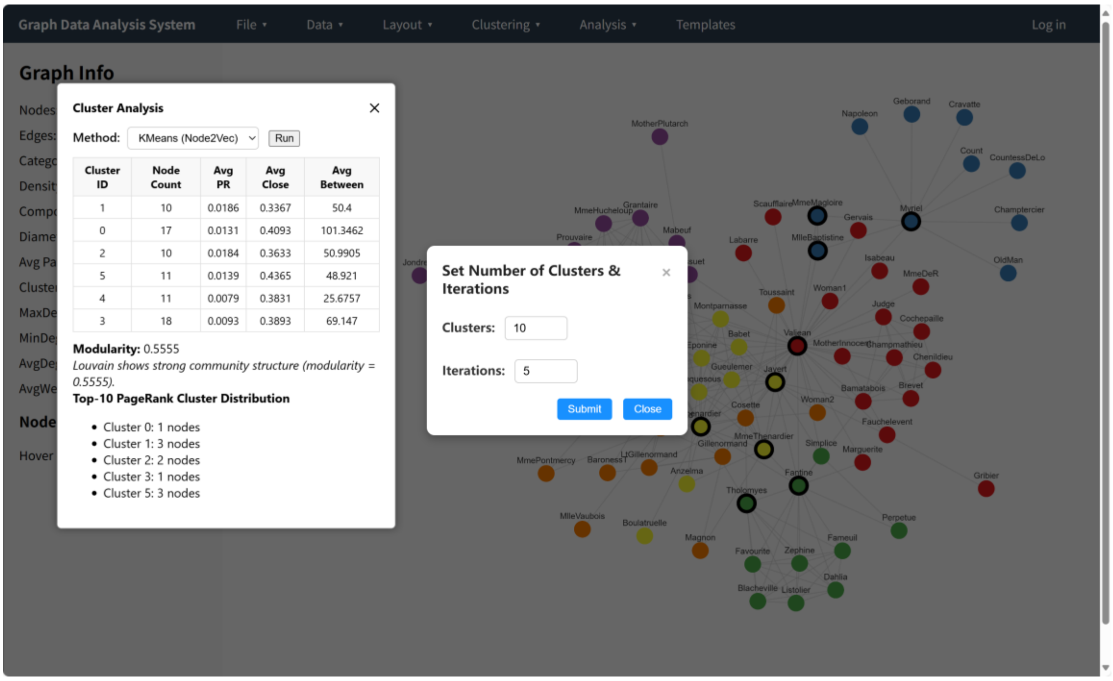
| Cluster ID | | | Avg Close | Avg Between |
|---|---|---|---|---|
| 1 | | | 0.3367 | 50.4 |
| 0 | 17 | 0.0131 | 0.4093 | 101.3462 |
| 2 | 10 | 0.0184 | 0.3633 | 50.9905 |
| 5 | 11 | 0.0139 | 0.4365 | 48.921 |
| 4 | 11 | 0.0079 | 0.3831 | 25.6757 |
| 3 | 18 | 0.0093 | 0.3893 | 69.147 |

**Modularity:** 0.5555

*Louvain shows strong community structure (modularity = 0.5555).*

**Top-10 PageRank Cluster Distribution**

- Cluster 0: 1 nodes
- Cluster 1: 3 nodes
- Cluster 2: 2 nodes
- Cluster 3: 1 nodes
- Cluster 5: 3 nodes



**Cluster Analysis** ×

**Method:** KMeans (Node2Vec)

| Cluster ID | Node Count | Avg PR | Avg Close | Avg Between |
|---|---|---|---|---|
| 1 | 10 | 0.0186 | 0.3367 | 50.4 |
| 0 | 17 | 0.0131 | 0.4093 | 101.3462 |
| 2 | 10 | 0.0184 | 0.3633 | 50.9905 |
| 5 | 11 | 0.0139 | 0.4365 | 48.921 |
| 4 | 11 | 0.0079 | 0.3831 | 25.6757 |
| 3 | 18 | 0.0093 | 0.3893 | 69.147 |

**Modularity:** 0.5555

*Louvain shows strong community structure (modularity = 0.5555).*

**Top-10 PageRank Cluster Distribution**

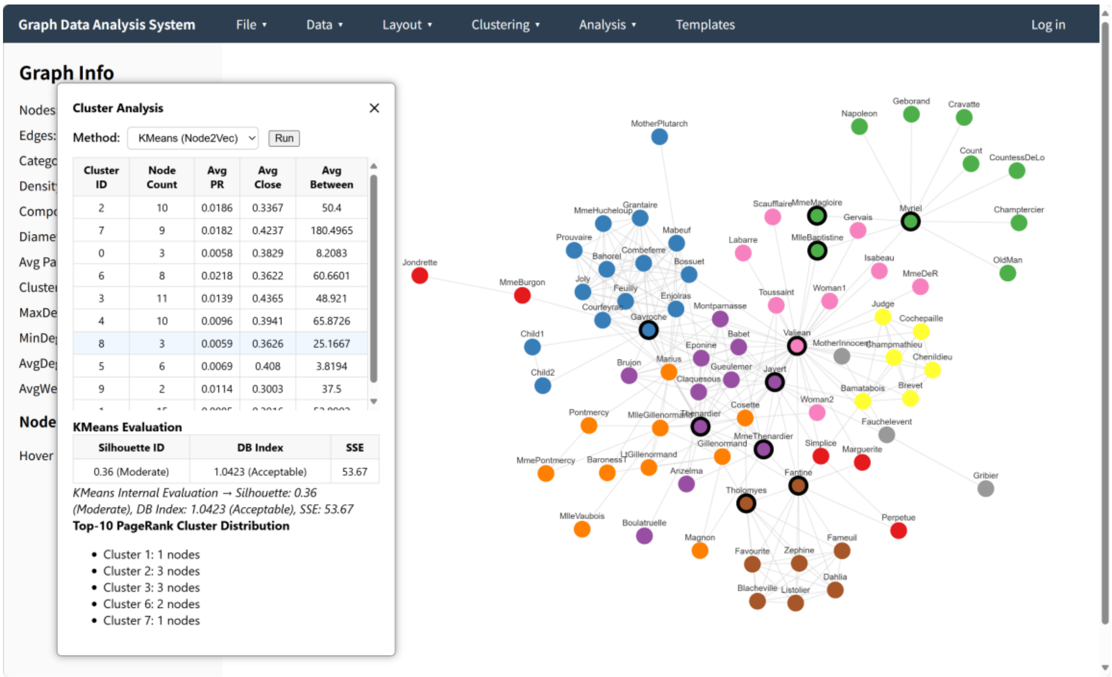
- Cluster 0: 1 nodes
- Cluster 1: 3 nodes
- Cluster 2: 2 nodes
- Cluster 3: 1 nodes
- Cluster 5: 3 nodes

**Set Number of Clusters & Iterations** ×

**Clusters:** 10

**Iterations:** 5

Submit Close



**Cluster Analysis**

Method: KMeans (Node2Vec)

| Cluster ID | Node Count | Avg PR | Avg Close | Avg Between |
|---|---|---|---|---|
| 2 | 10 | 0.0186 | 0.3367 | 50.4 |
| 7 | 9 | 0.0182 | 0.4237 | 180.4965 |
| 0 | 3 | 0.0058 | 0.3829 | 8.2083 |
| 6 | 8 | 0.0218 | 0.3622 | 60.6601 |
| 3 | 11 | 0.0139 | 0.4365 | 48.921 |
| 4 | 10 | 0.0096 | 0.3941 | 65.8726 |
| 8 | 3 | 0.0059 | 0.3626 | 25.1667 |
| 5 | 6 | 0.0069 | 0.408 | 3.8194 |
| 9 | 2 | 0.0114 | 0.3003 | 37.5 |

**KMeans Evaluation**

| Silhouette ID | DB Index | SSE |
|---|---|---|
| 0.36 (Moderate) | 1.0423 (Acceptable) | 53.67 |

*KMeans Internal Evaluation → Silhouette: 0.36 (Moderate), DB Index: 1.0423 (Acceptable), SSE: 53.67*

**Top-10 PageRank Cluster Distribution**

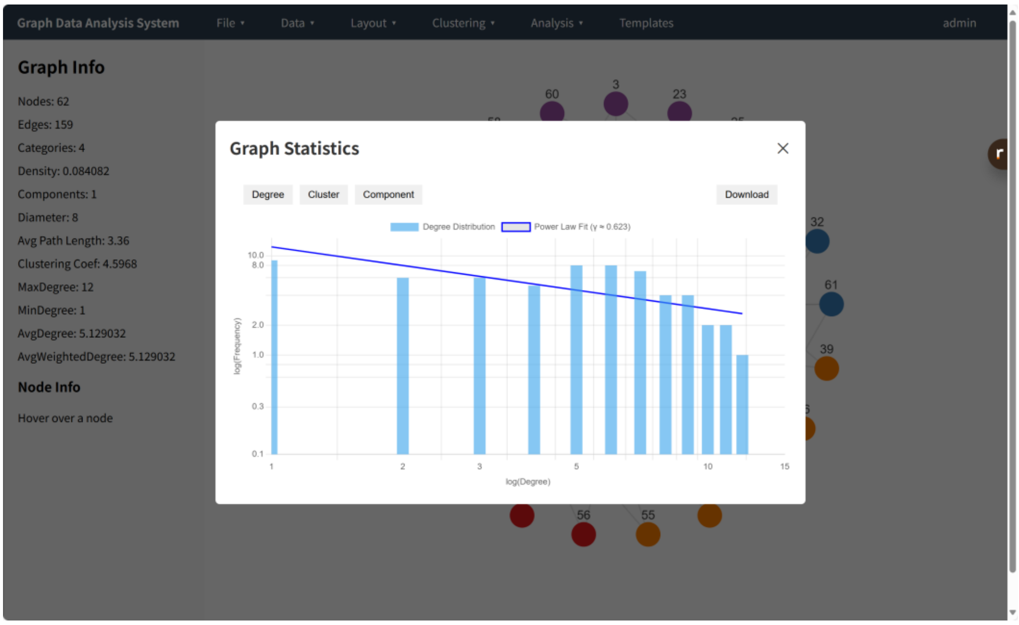
- Cluster 1: 1 nodes
- Cluster 2: 3 nodes
- Cluster 3: 3 nodes
- Cluster 6: 2 nodes
- Cluster 7: 1 nodes

## Analysis Module – Structural Metrics Visualization

The system displays:

- Graph Statistics
  - Node degree distribution
  - Cluster size distribution
  - Connected component statistics

All visualizations are downloadable for reporting purposes.



**Graph Info**

Nodes: 62

Edges: 159

Categories: 4

Density: 0.084082

Components: 1

Diameter: 8

Avg Path Length: 3.36

Clustering Coef: 4.5968

MaxDegree: 12

MinDegree: 1

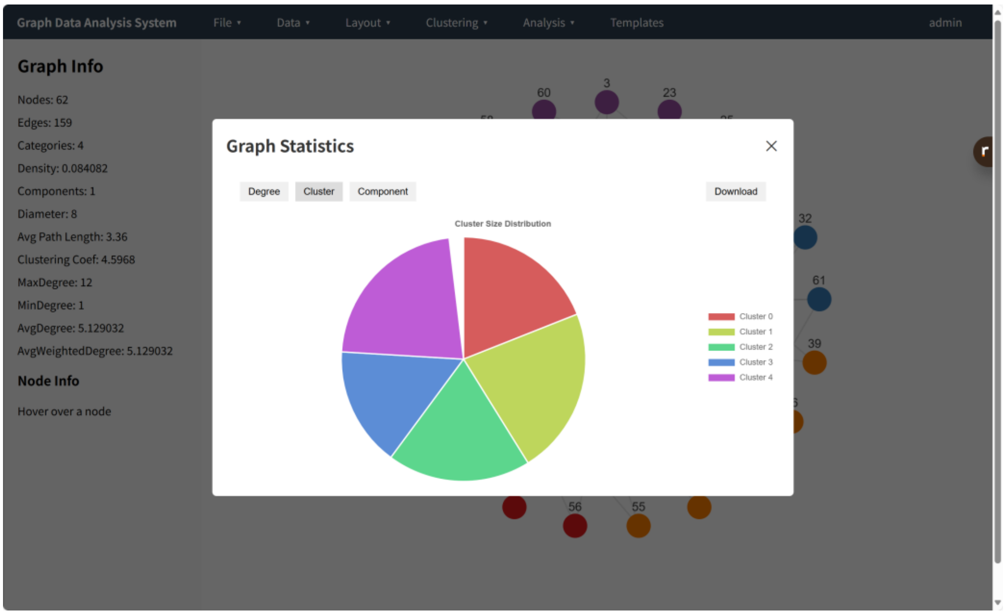
AvgDegree: 5.129032

AvgWeightedDegree: 5.129032

**Node Info**

Hover over a node

**Graph Statistics**



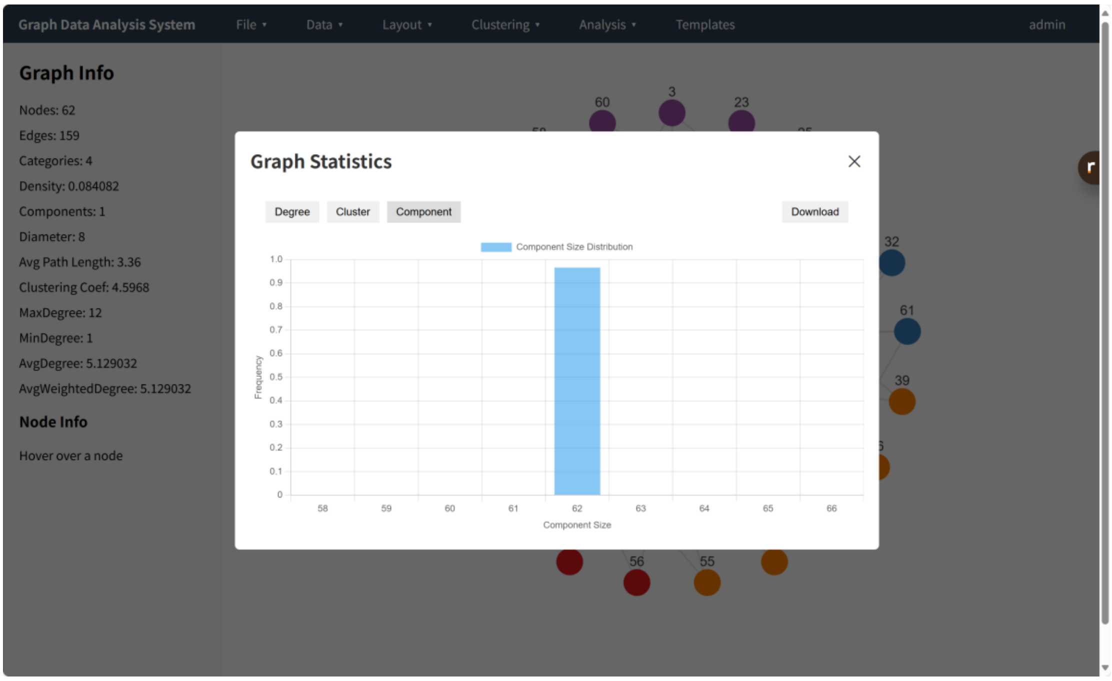
Graph Info

Nodes: 62
Edges: 159
Categories: 4
Density: 0.084082
Components: 1
Diameter: 8
Avg Path Length: 3.36
Clustering Coef: 4.5968
MaxDegree: 12
MinDegree: 1
AvgDegree: 5.129032
AvgWeightedDegree: 5.129032

Node Info

Hover over a node

Graph Statistics



Graph Info

Nodes: 62
Edges: 159
Categories: 4
Density: 0.084082
Components: 1
Diameter: 8
Avg Path Length: 3.36
Clustering Coef: 4.5968
MaxDegree: 12
MinDegree: 1
AvgDegree: 5.129032
AvgWeightedDegree: 5.129032

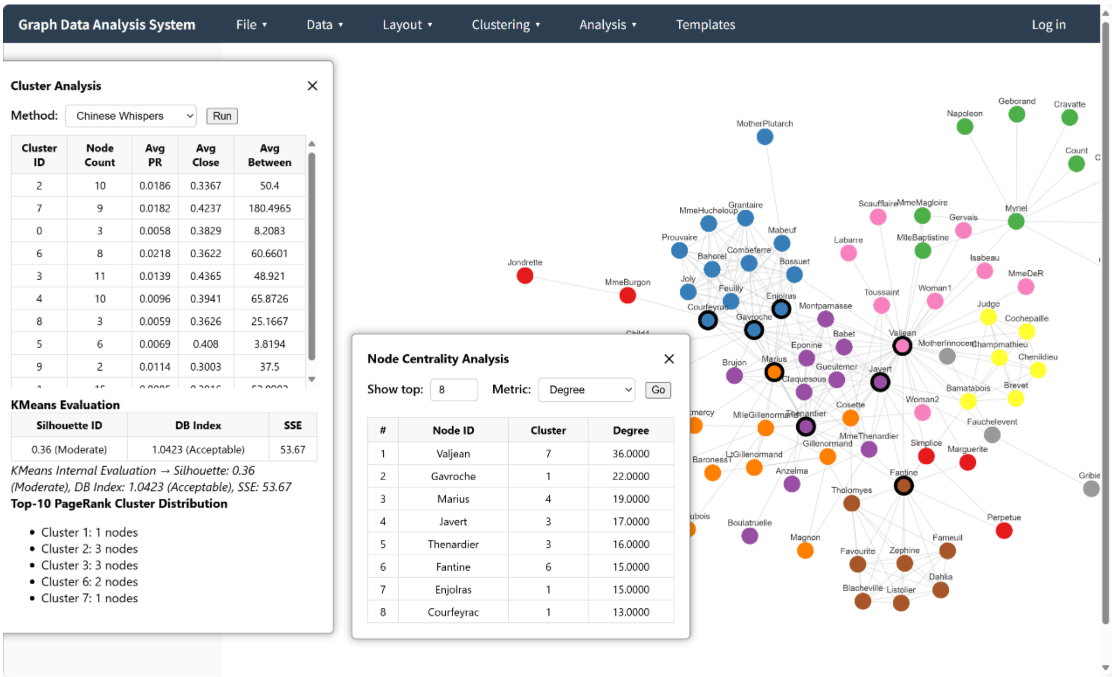
Node Info

Hover over a node

Graph Statistics

- Centrality Analysis
  - Degree
  - Closeness
  - Betweeneness
  - PageRank

You can combine this function with Clustering Analysis to better find important nodes in the graph.



Cluster Analysis ✕

Method: Chinese Whispers ▾ Run

| Cluster ID | Node Count | Avg PR | Avg Close | Avg Between |
|---|---|---|---|---|
| 2 | 10 | 0.0186 | 0.3367 | 50.4 |
| 7 | 9 | 0.0182 | 0.4237 | 180.4965 |
| 0 | 3 | 0.0058 | 0.3829 | 8.2083 |
| 6 | 8 | 0.0218 | 0.3622 | 60.6601 |
| 3 | 11 | 0.0139 | 0.4365 | 48.921 |
| 4 | 10 | 0.0096 | 0.3941 | 65.8726 |
| 8 | 3 | 0.0059 | 0.3626 | 25.1667 |
| 5 | 6 | 0.0069 | 0.408 | 3.8194 |
| 9 | 2 | 0.0114 | 0.3003 | 37.5 |

KMeans Evaluation

| Silhouette ID | DB Index | SSE |
|---|---|---|
| 0.36 (Moderate) | 1.0423 (Acceptable) | 53.67 |

*KMeans Internal Evaluation → Silhouette: 0.36 (Moderate), DB Index: 1.0423 (Acceptable), SSE: 53.67*

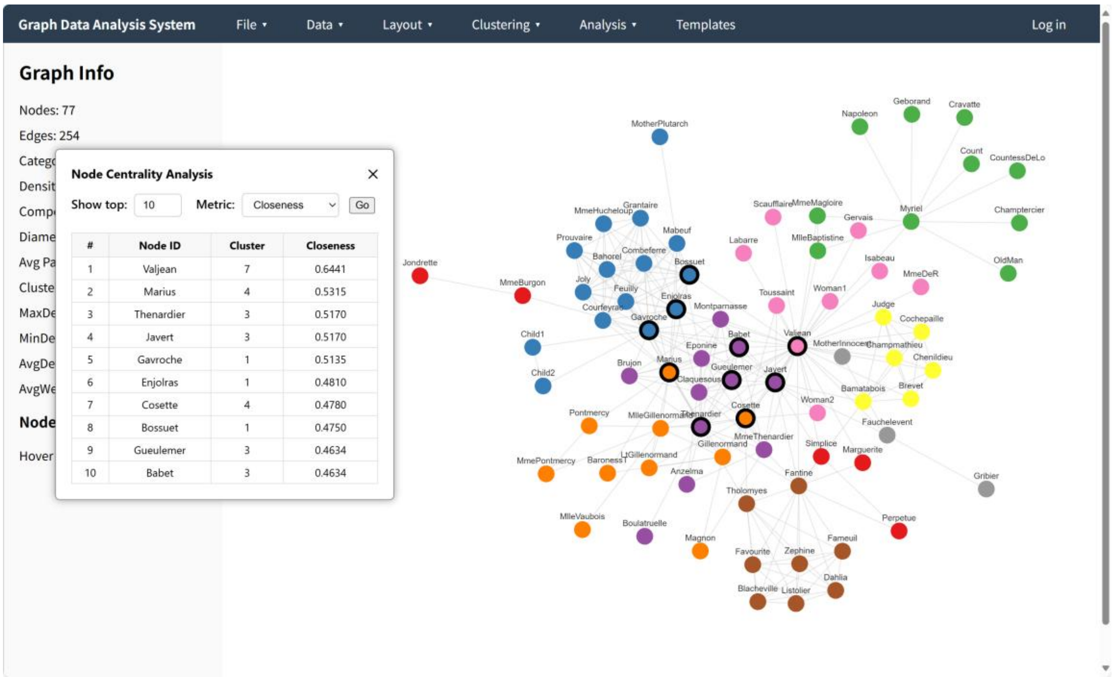
**Top-10 PageRank Cluster Distribution**

- Cluster 1: 1 nodes
- Cluster 2: 3 nodes
- Cluster 3: 3 nodes
- Cluster 6: 2 nodes
- Cluster 7: 1 nodes

Node Centrality Analysis ✕

Show top: 8 Metric: Degree ▾ Go

| # | Node ID | Cluster | Degree |
|---|---|---|---|
| 1 | Valjean | 7 | 36.0000 |
| 2 | Gavroche | 1 | 22.0000 |
| 3 | Marius | 4 | 19.0000 |
| 4 | Javert | 3 | 17.0000 |
| 5 | Thenardier | 3 | 16.0000 |
| 6 | Fantine | 6 | 15.0000 |
| 7 | Enjolras | 1 | 15.0000 |
| 8 | Courfeyrac | 1 | 13.0000 |



Graph Info

Nodes: 77

Edges: 254

Categ

Densit

Comp

Diame

Avg Pa

Cluste

MaxDe

MinDe

AvgDe

AvgWe

Node

Hover

Node Centrality Analysis ✕

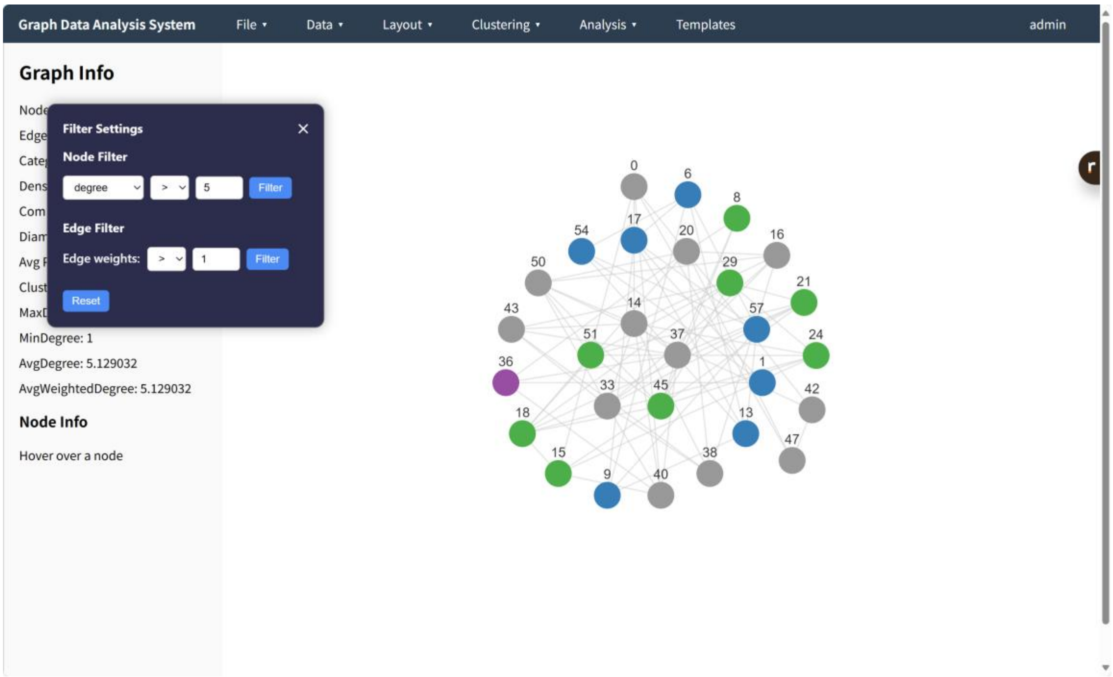
Show top: 10 Metric: Closeness ▾ Go

| # | Node ID | Cluster | Closeness |
|---|---|---|---|
| 1 | Valjean | 7 | 0.6441 |
| 2 | Marius | 4 | 0.5315 |
| 3 | Thenardier | 3 | 0.5170 |
| 4 | Javert | 3 | 0.5170 |
| 5 | Gavroche | 1 | 0.5135 |
| 6 | Enjolras | 1 | 0.4810 |
| 7 | Cosette | 4 | 0.4780 |
| 8 | Bossuet | 1 | 0.4750 |
| 9 | Gueulemer | 3 | 0.4634 |
| 10 | Babet | 3 | 0.4634 |

## Filter Module – Attribute-Based Filtering

Users can set attribute thresholds (e.g., degree > 5) using sliders and UI controls.

A reset button is available to return to the original full graph.



Graph Info

Node

Edge

Cate

Dens

Com

Diam

Avg P

Clust

MaxD

MinDegree: 1

AvgDegree: 5.129032

AvgWeightedDegree: 5.129032

Node Info

Hover over a node

Filter Settings ✕

Node Filter

degree ▾ > ▾ 5 Filter

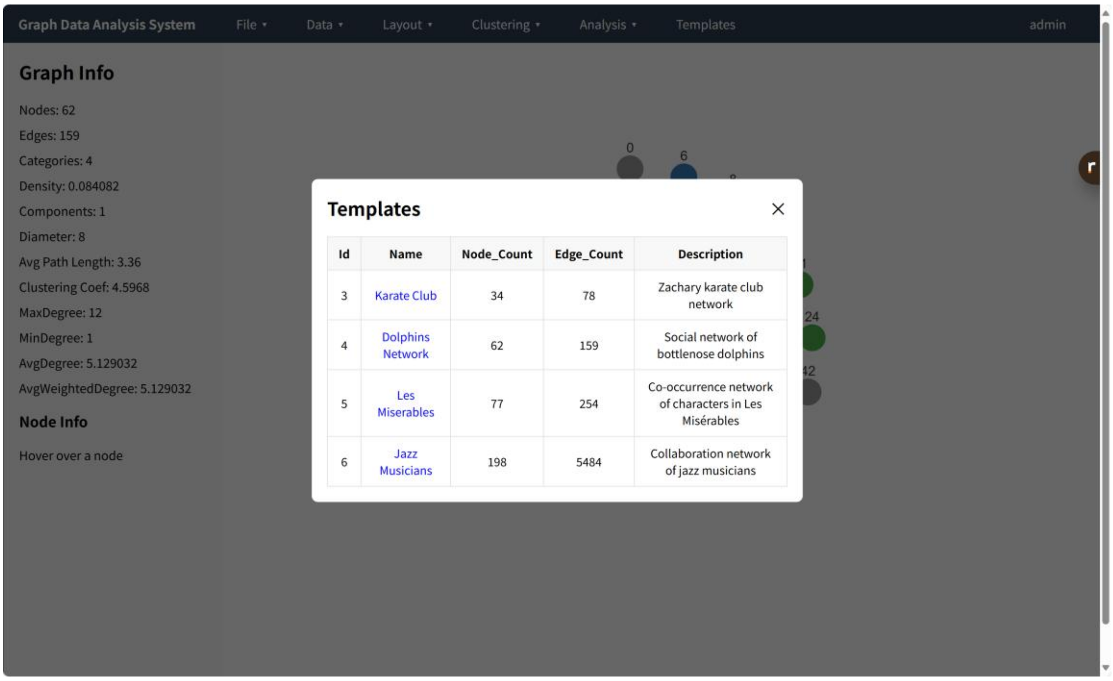
Edge Filter

Edge weights: > ▾ 1 Filter

Reset

## Templates Module – Built-in Dataset Selection

The system provides preloaded datasets such as: Les Misérables, Dolphins These can be loaded instantly for demonstration or analysis purposes. (Take Jazz Musicians as an example)



Graph Info

Nodes: 62

Edges: 159

Categories: 4

Density: 0.084082

Components: 1

Diameter: 8

Avg Path Length: 3.36

Clustering Coef: 4.5968

MaxDegree: 12

MinDegree: 1

AvgDegree: 5.129032

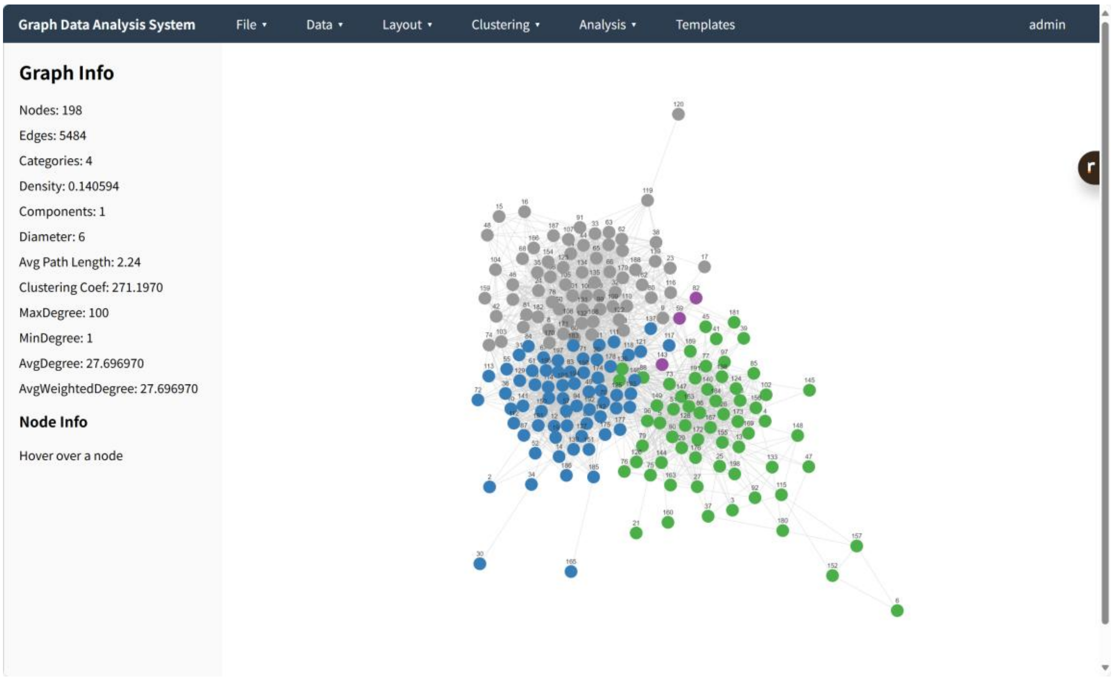
AvgWeightedDegree: 5.129032

Node Info

Hover over a node

Templates ✕

| Id | Name | Node_Count | Edge_Count | Description |
|---|---|---|---|---|
| 3 | Karate Club | 34 | 78 | Zachary karate club network |
| 4 | Dolphins Network | 62 | 159 | Social network of bottlenose dolphins |
| 5 | Les Miserables | 77 | 254 | Co-occurrence network of characters in Les Misérables |
| 6 | Jazz Musicians | 198 | 5484 | Collaboration network of jazz musicians |



## Graph Info

Nodes: 198

Edges: 5484

Categories: 4

Density: 0.140594

Components: 1

Diameter: 6

Avg Path Length: 2.24

Clustering Coef: 271.1970

MaxDegree: 100

MinDegree: 1

AvgDegree: 27.696970

AvgWeightedDegree: 27.696970

## Node Info

Hover over a node