

MIS-QDeep Solver Results

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This report contains the results of Maximum Independent Set (MIS) calculations using the QDeep Hybrid Solver on various graph datasets from published papers and conferences.

Dataset Sources

All datasets used in this analysis are from well-established papers and conferences:

Social Networks

- **Zachary Karate Club** (1977): Journal of Anthropological Research
- **Dolphin Social Network** (2003): Behavioral Ecology and Sociobiology
- **College Football** (2002): Proceedings of the National Academy of Sciences
- **Les Misérables** (1993): Stanford GraphBase
- **Davis Southern Women** (1941): University of Chicago Press

DIMACS Challenge Graphs

- **Myciel3, Myciel4, Myciel5** (1955/1993): Colloquium Mathematicum / DIMACS Challenge
- **Queen5_5** (1993): DIMACS Challenge

Datasets Processed

College Football Network

Dataset Information:

- **Source Paper:** Girvan, M., & Newman, M. E. (2002). Community structure in social and biological networks. *Proceedings of the National Academy of Sciences*, 99(12), 7821-7826.
- **Conference/Journal:** *Proceedings of the National Academy of Sciences*
- **Year:** 2002
- **Description:** Network of American football games between Division IA colleges during regular season Fall 2000.
- **Repository:** Network Repository
- **Repository Citation:** Rossi, R. A., & Ahmed, N. K. (2015). The Network Data Repository with Interactive Graph Analytics and Visualization. AAAI.

Graph Information:

- Nodes: 115
- Edges: 613
- Solve Time: 6.16s
- Valid MIS: True

Graph Edges:

```
[(2, 1), (2, 26), (2, 28), (2, 34), (2, 38)] ... [(50, 49), (50, 84), (50, 89),
(49, 87), (84, 89)]
```

QUBO Matrix:

```
[-1.0  2.0  0.0  0.0  2.0 ...]
[ 0.0 -1.0  0.0  0.0  0.0 ...]
[ 0.0  0.0 -1.0  2.0  0.0 ...]
[ 0.0  0.0  0.0 -1.0  0.0 ...]
[ 0.0  0.0  0.0  0.0 -1.0 ...]
...
[ 0.0  0.0  0.0  0.0  0.0 ...]
```

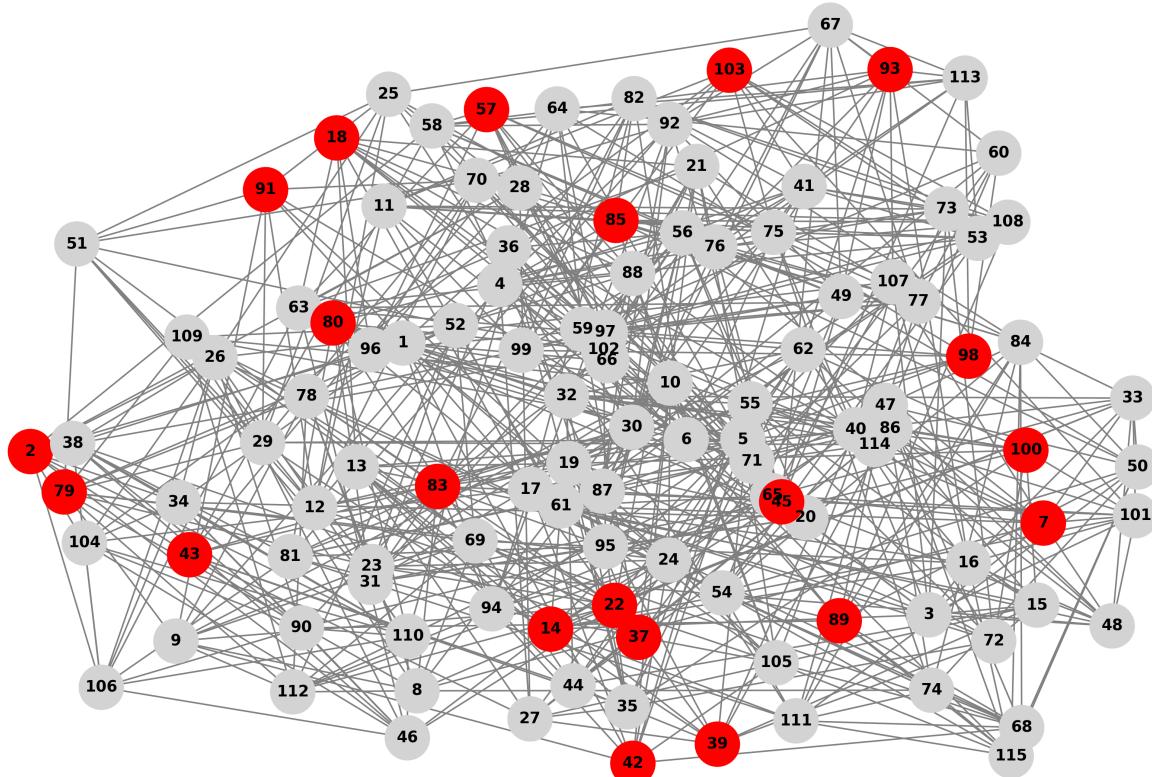
Matrix size: 115 x 115 (13225 elements)

MIS Result:

- MIS Nodes: [2, 7, 14, 18, 22, 37, 39, 42, 43, 45, 57, 79, 80, 83, 85, 89, 91, 93, 98, 100, 103]
- MIS Size: 21
- Energy: -21

Graph Visualization:

College_Football - Maximum Independent Set (Red Nodes)



Davis Southern Women Social Network

Dataset Information:

- **Source Paper:** Davis, A., Gardner, B. B., & Gardner, M. R. (1941). Deep South. University of Chicago Press.
- **Conference/Journal:** University of Chicago Press
- **Year:** 1941
- **Description:** Social network of 18 women in Natchez, Mississippi, showing their attendance at 14 social events.
- **Repository:** Network Repository
- **Repository Citation:** Rossi, R. A., & Ahmed, N. K. (2015). The Network Data Repository with Interactive Graph Analytics and Visualization. AAAI.

Graph Information:

- Nodes: 18
- Edges: 78
- Solve Time: 5.16s
- Valid MIS: True

Graph Edges:

```
[(1, 1), (1, 2), (1, 3), (1, 4), (1, 5)] ... [(13, 14), (14, 14), (14, 15), (14, 17), (14, 18)]
```

QUBO Matrix:

```
[ 2.0  2.0  2.0  2.0  2.0 ...]  
[ 0.0  2.0  2.0  0.0  2.0 ...]  
[ 0.0  0.0  2.0  2.0  2.0 ...]  
[ 0.0  0.0  0.0  2.0  2.0 ...]  
[ 0.0  0.0  0.0  0.0  2.0 ...]  
...  
[ 0.0  0.0  0.0  0.0  0.0 ...]
```

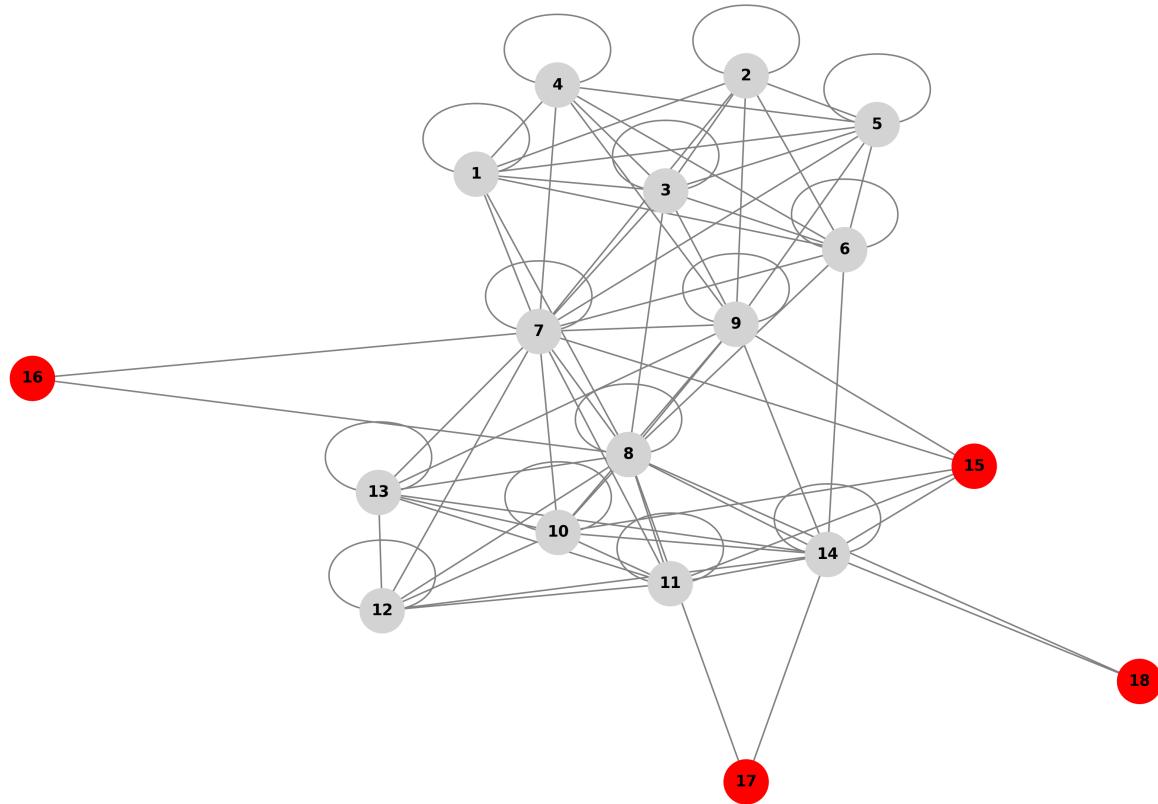
Matrix size: 18 x 18 (324 elements)

MIS Result:

- MIS Nodes: [15, 16, 17, 18]
- MIS Size: 4
- Energy: -4

Graph Visualization:

Davis_Southern_Women - Maximum Independent Set (Red Nodes)



Dolphin Social Network

Dataset Information:

- **Source Paper:** Lusseau, D., Schneider, K., Boisseau, O. J., Haase, P., Dawson, S., & Whitehead, H. (2003). The bottlenose dolphin community of Doubtful Sound features a large proportion of long-lasting associations. *Behavioral Ecology and Sociobiology*, 54(4), 396-405.
- **Conference/Journal:** Behavioral Ecology and Sociobiology
- **Year:** 2003
- **Description:** Social network of bottlenose dolphins in Doubtful Sound, New Zealand.
- **Repository:** Network Repository
- **Repository Citation:** Rossi, R. A., & Ahmed, N. K. (2015). The Network Data Repository with Interactive Graph Analytics and Visualization. AAAI.

Graph Information:

- Nodes: 62
- Edges: 159
- Solve Time: 5.57s
- Valid MIS: True

Graph Edges:

```
[(11, 1), (11, 3), (11, 30), (11, 43), (11, 48)] ... [(39, 59), (44, 47), (44, 54), (19, 22), (50, 47)]
```

QUBO Matrix:

```
[-1.0  0.0  0.0  0.0  0.0 ...]
[ 0.0 -1.0  0.0  0.0  0.0 ...]
[ 0.0  0.0 -1.0  0.0  0.0 ...]
[ 0.0  0.0  0.0 -1.0  0.0 ...]
[ 0.0  0.0  0.0  0.0 -1.0 ...]
...
[ 0.0  0.0  0.0  0.0  0.0 ...]
```

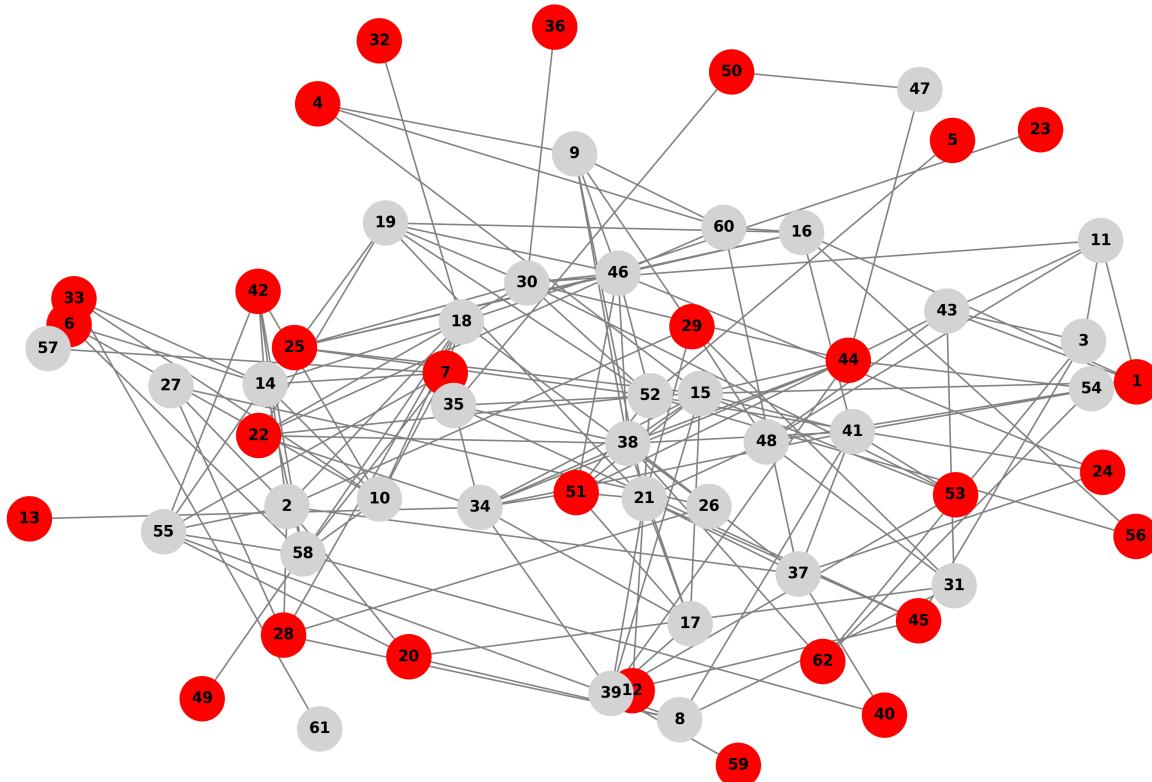
Matrix size: 62 x 62 (3844 elements)

MIS Result:

- MIS Nodes: [1, 4, 5, 6, 7, 12, 13, 20, 22, 23, 24, 25, 28, 29, 32, 33, 36, 40, 42, 44, 45, 49, 50, 51, 53, 56, 59, 62]
- MIS Size: 28
- Energy: -28

Graph Visualization:

Dolphin_Social_Network - Maximum Independent Set (Red Nodes)



Les Miserables Character Network

Dataset Information:

- **Source Paper:** Knuth, D. E. (1993). The Stanford GraphBase: a platform for combinatorial computing. Addison-Wesley.
- **Conference/Journal:** Stanford GraphBase
- **Year:** 1993
- **Description:** Co-appearance network of characters in Victor Hugo's novel Les Miserables.
- **Repository:** Network Repository
- **Repository Citation:** Rossi, R. A., & Ahmed, N. K. (2015). The Network Data Repository with Interactive Graph Analytics and Visualization. AAAI.

Graph Information:

- Nodes: 77
- Edges: 254
- Solve Time: 6.55s
- Valid MIS: True

Graph Edges:

```
[(2, 1), (1, 3), (1, 4), (1, 5), (1, 6)] ... [(64, 77), (66, 67), (66, 77), (67, 77), (74, 75)]
```

QUBO Matrix:

```
[-1.0  2.0  2.0  2.0  2.0 ...]
[ 0.0 -1.0  0.0  0.0  0.0 ...]
[ 0.0  0.0 -1.0  2.0  0.0 ...]
[ 0.0  0.0  0.0 -1.0  0.0 ...]
[ 0.0  0.0  0.0  0.0 -1.0 ...]
...
[ 0.0  0.0  0.0  0.0  0.0 ...]
```

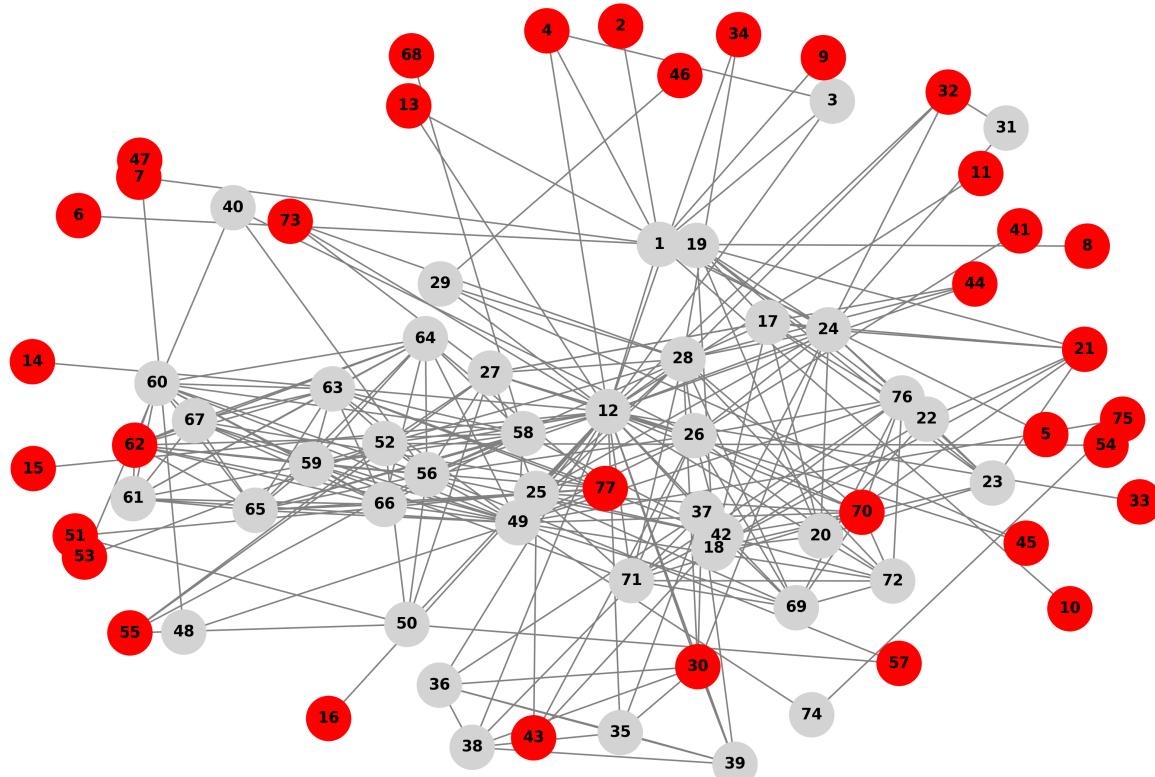
Matrix size: 77 x 77 (5929 elements)

MIS Result:

- MIS Nodes: [2, 4, 5, 6, 7, 8, 9, 10, 11, 13, 14, 15, 16, 21, 30, 32, 33, 34, 41, 43, 44, 45, 46, 47, 51, 53, 54, 55, 57, 62, 68, 70, 73, 75, 77]
- MIS Size: 35
- Energy: -35

Graph Visualization:

Les_Miserables - Maximum Independent Set (Red Nodes)



Myciel3 Graph

Dataset Information:

- **Source Paper:** Mycielski, J. (1955). Sur le coloriage des graphes. *Colloquium Mathematicum*, 3, 161-162.
 - **Conference/Journal:** *Colloquium Mathematicum*
 - **Year:** 1955
 - **Description:** DIMACS challenge graph based on Mycielski transformation. Triangle-free with increasing coloring number.
 - **Repository:** DIMACS Challenge
 - **Repository Citation:** Johnson, D. S., & Trick, M. A. (1996). Cliques, Coloring, and Satisfiability: Second DIMACS Implementation Challenge. *DIMACS Series in Discrete Mathematics and Theoretical Computer Science*.

Graph Information:

- Nodes: 11
 - Edges: 20
 - Solve Time: 4.13s
 - Valid MIS: True

Graph Edges:

```
[(1, 2), (1, 4), (1, 7), (1, 9), (2, 3)] ... [(3, 10), (6, 11), (8, 5), (8, 11),  
(10, 11)]
```

QUBO Matrix:

```
[-1.0  2.0  0.0  2.0  0.0 ...]  
[ 0.0 -1.0  2.0  0.0  0.0 ...]  
[ 0.0  0.0 -1.0  0.0  2.0 ...]  
[ 0.0  0.0  0.0 -1.0  2.0 ...]  
[ 0.0  0.0  0.0  0.0 -1.0 ...]  
...  
[ 0.0  0.0  0.0  0.0  0.0 ...]
```

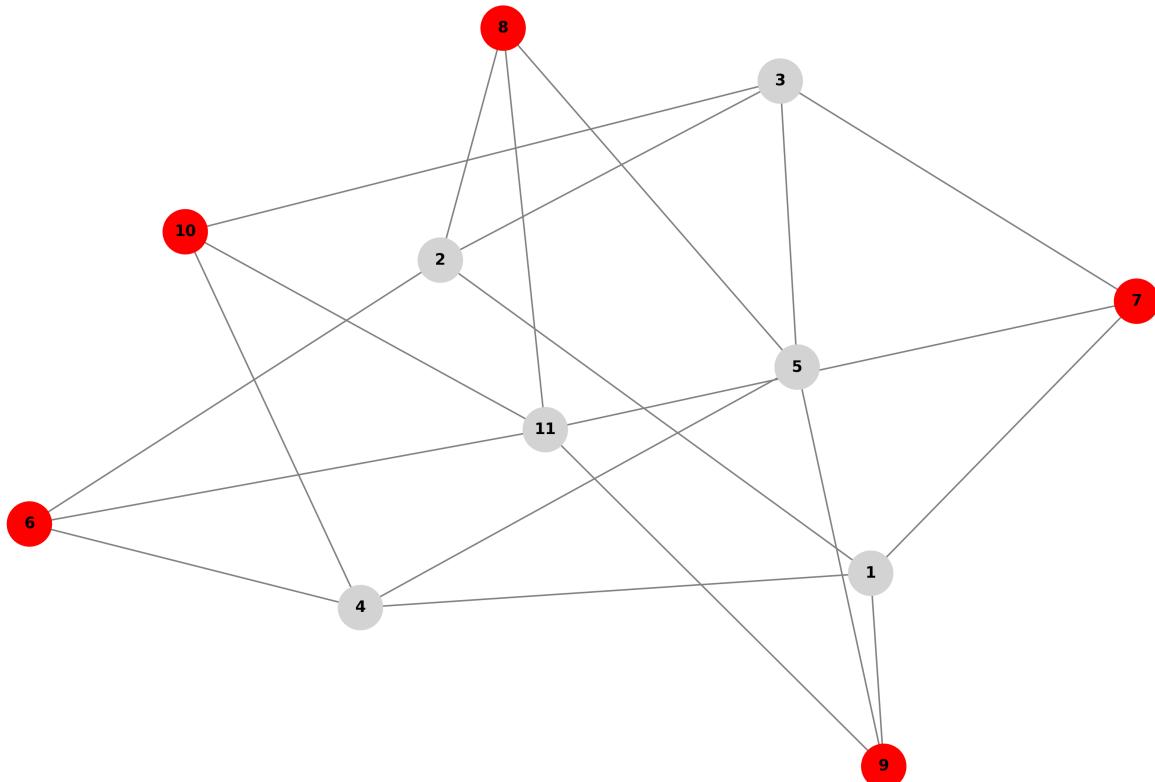
Matrix size: 11 x 11 (121 elements)

MIS Result:

- MIS Nodes: [6, 7, 8, 9, 10]
- MIS Size: 5
- Energy: -5

Graph Visualization:

Myciel3_Graph - Maximum Independent Set (Red Nodes)



Myciel4 Graph

Dataset Information:

- **Source Paper:** Mycielski, J. (1955). Sur le coloriage des graphes. *Colloquium Mathematicum*, 3, 161-162.
- **Conference/Journal:** DIMACS Challenge
- **Year:** 1993
- **Description:** DIMACS challenge graph based on Mycielski transformation. Triangle-free with increasing coloring number.
- **Repository:** DIMACS Challenge
- **Repository Citation:** Johnson, D. S., & Trick, M. A. (1996). *Cliques, Coloring, and Satisfiability: Second DIMACS Implementation Challenge*. DIMACS Series in Discrete Mathematics and Theoretical Computer Science.

Graph Information:

- Nodes: 23
- Edges: 71
- Solve Time: 4.81s
- Valid MIS: True

Graph Edges:

```
[(1, 2), (1, 4), (1, 7), (1, 9), (1, 13)] ... [(10, 22), (16, 23), (21, 11), (21, 23), (22, 23)]
```

QUBO Matrix:

```
[-1.0  2.0  0.0  2.0  0.0 ...]
[ 0.0 -1.0  2.0  0.0  0.0 ...]
[ 0.0  0.0 -1.0  0.0  2.0 ...]
[ 0.0  0.0  0.0 -1.0  2.0 ...]
[ 0.0  0.0  0.0  0.0 -1.0 ...]
...
[ 0.0  0.0  0.0  0.0  0.0 ...]
```

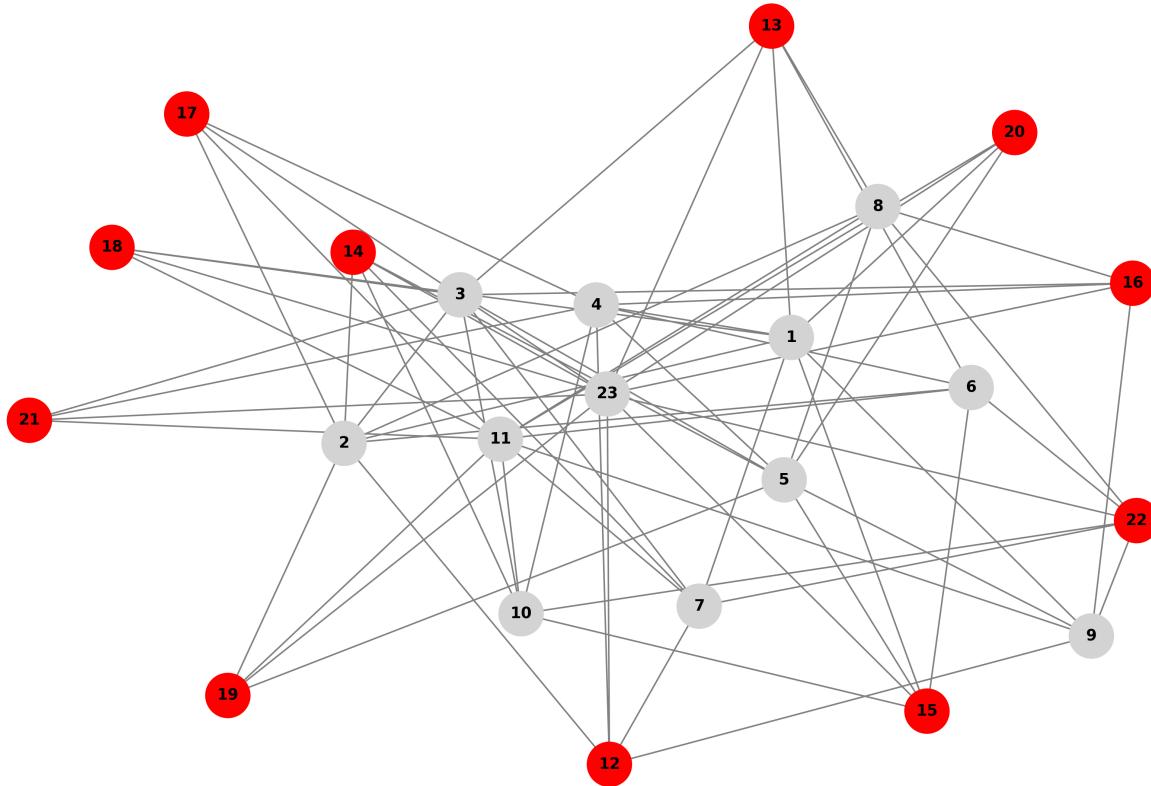
Matrix size: 23 x 23 (529 elements)

MIS Result:

- MIS Nodes: [12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22]
- MIS Size: 11
- Energy: -11

Graph Visualization:

Myciel4_Graph - Maximum Independent Set (Red Nodes)



Myciel5 Graph

Dataset Information:

- **Source Paper:** Mycielski, J. (1955). Sur le coloriage des graphes. *Colloquium Mathematicum*, 3, 161-162.
- **Conference/Journal:** DIMACS Challenge
- **Year:** 1993
- **Description:** DIMACS challenge graph based on Mycielski transformation. Triangle-free with increasing coloring number.
- **Repository:** DIMACS Challenge
- **Repository Citation:** Johnson, D. S., & Trick, M. A. (1996). Cliques, Coloring, and Satisfiability: Second DIMACS Implementation Challenge. *DIMACS Series in Discrete Mathematics and Theoretical Computer Science*.

Graph Information:

- Nodes: 47
- Edges: 236
- Solve Time: 6.30s
- Valid MIS: True

Graph Edges:

```
[(1, 2), (1, 4), (1, 7), (1, 9), (1, 13)] ... [(22, 46), (34, 47), (45, 23), (45, 47), (46, 47)]
```

QUBO Matrix:

```
[-1.0  2.0  0.0  2.0  0.0 ...]  
[ 0.0 -1.0  2.0  0.0  0.0 ...]  
[ 0.0  0.0 -1.0  0.0  2.0 ...]  
[ 0.0  0.0  0.0 -1.0  2.0 ...]  
[ 0.0  0.0  0.0  0.0 -1.0 ...]  
...  
[ 0.0  0.0  0.0  0.0  0.0 ...]
```

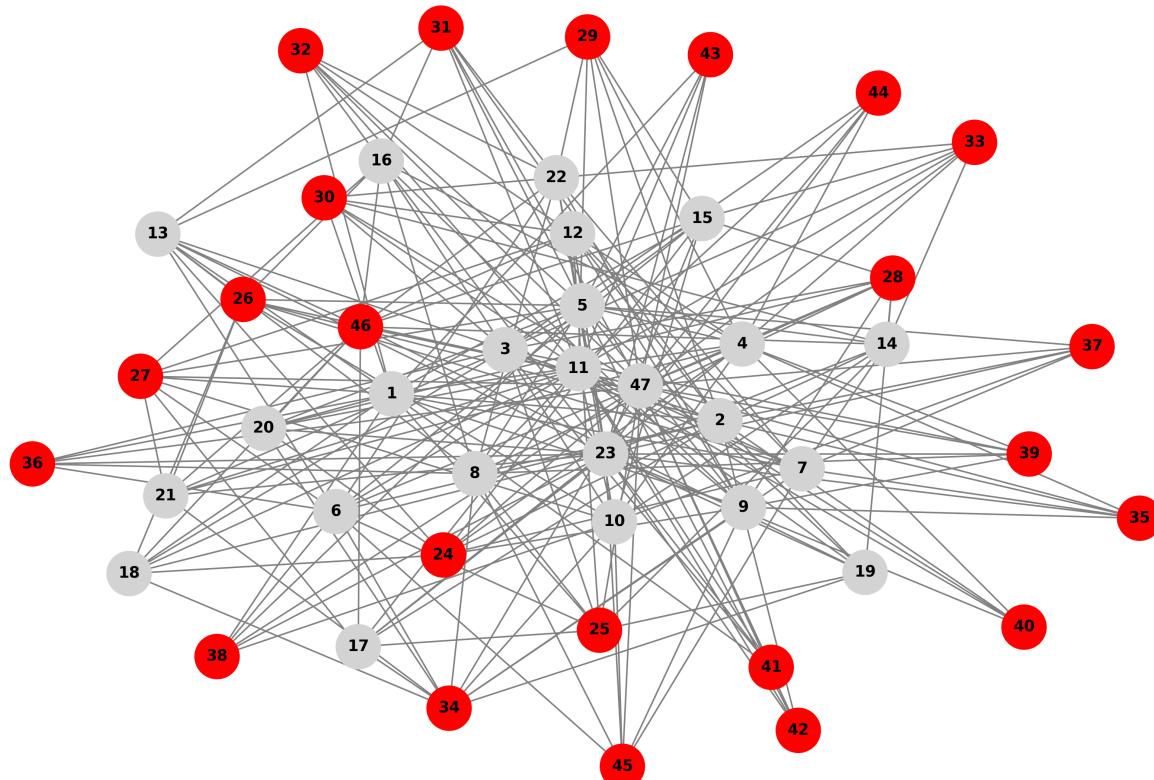
Matrix size: 47 x 47 (2209 elements)

MIS Result:

- MIS Nodes: [24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46]
- MIS Size: 23
- Energy: -23

Graph Visualization:

Myciel5_Graph - Maximum Independent Set (Red Nodes)



Queen5_5 Graph

Dataset Information:

- **Source Paper:** Trick, M. A. (1993). Graph coloring instances. DIMACS Challenge.
- **Conference/Journal:** DIMACS Challenge
- **Year:** 1993
- **Description:** 5 ♚ 5 queen graph from DIMACS challenge. Represents the 5-queens problem on a 5 ♚ 5 chessboard.
- **Repository:** DIMACS Challenge
- **Repository Citation:** Johnson, D. S., & Trick, M. A. (1996). Cliques, Coloring, and Satisfiability: Second DIMACS Implementation Challenge. DIMACS Series in Discrete Mathematics and Theoretical Computer Science.

Graph Information:

- Nodes: 25
- Edges: 160
- Solve Time: 5.51s
- Valid MIS: True

Graph Edges:

```
[(1, 7), (1, 13), (1, 19), (1, 25), (1, 2)] ... [(15, 23), (18, 10), (18, 24),  
(18, 23), (23, 24)]
```

QUBO Matrix:

```
[-1.0  2.0  2.0  2.0  2.0 ...]  
[ 0.0 -1.0  2.0  2.0  2.0 ...]  
[ 0.0  0.0 -1.0  2.0  2.0 ...]  
[ 0.0  0.0  0.0 -1.0  2.0 ...]  
[ 0.0  0.0  0.0  0.0 -1.0 ...]  
...  
[ 0.0  0.0  0.0  0.0  0.0 ...]
```

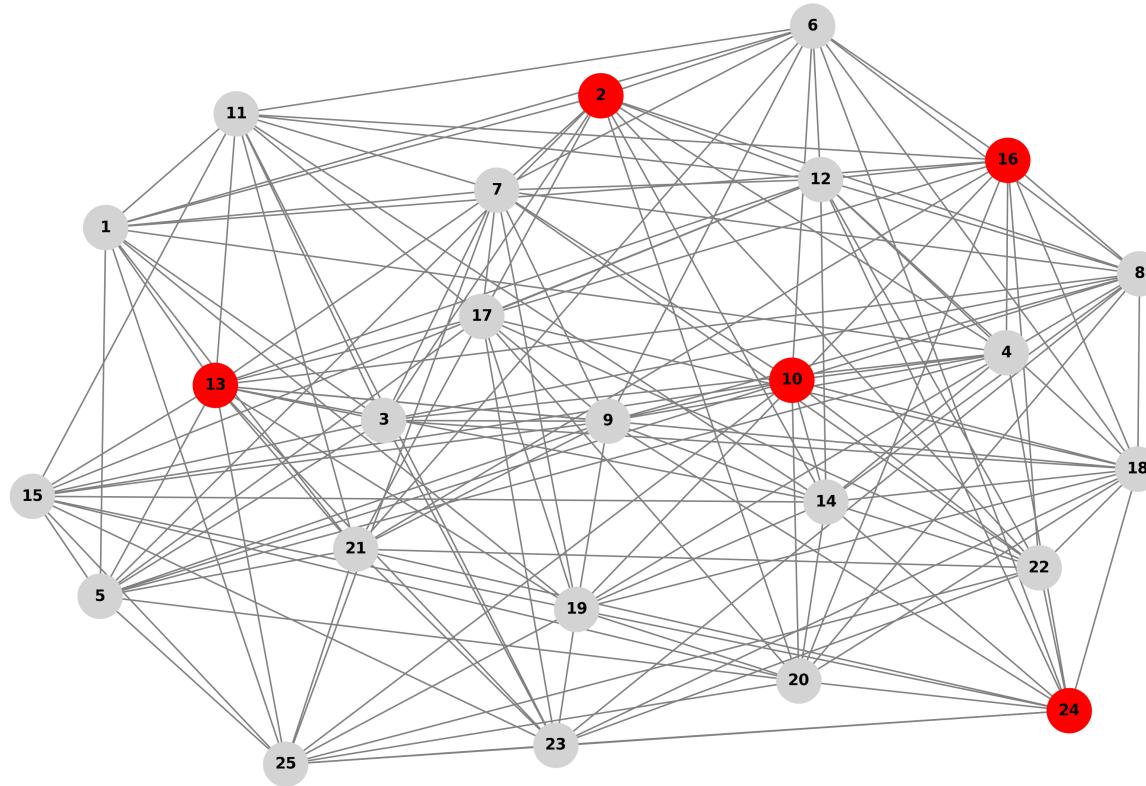
Matrix size: 25 x 25 (625 elements)

MIS Result:

- MIS Nodes: [2, 10, 13, 16, 24]
- MIS Size: 5
- Energy: -5

Graph Visualization:

Queen5_5_Graph - Maximum Independent Set (Red Nodes)



Zachary Karate Club Network

Dataset Information:

- **Source Paper:** Zachary, W. W. (1977). An Information Flow Model for Conflict and Fission in Small Groups. *Journal of Anthropological Research*, 33(4), 452-473.
- **Conference/Journal:** Journal of Anthropological Research
- **Year:** 1977
- **Description:** Social network of a university karate club collected by Wayne Zachary in 1977. Each node represents a member, each edge represents a tie between members. The network is undirected.
- **Repository:** KONECT - The Koblenz Network Collection
- **Repository Citation:** Kunegis, J. (2013). KONECT -- The Koblenz Network Collection. Proc. Int. Conf. on World Wide Web Companion, 1343-1350.

Graph Information:

- Nodes: 34
- Edges: 78
- Solve Time: 6.10s
- Valid MIS: True

Graph Edges:

```
[(2, 1), (2, 3), (2, 4), (2, 8), (2, 14)] ... [(34, 30), (26, 24), (26, 25), (24, 30), (30, 27)]
```

QUBO Matrix:

```
[-1.0  2.0  2.0  2.0  2.0 ...]  
[ 0.0 -1.0  2.0  2.0  0.0 ...]  
[ 0.0  0.0 -1.0  2.0  0.0 ...]  
[ 0.0  0.0  0.0 -1.0  0.0 ...]  
[ 0.0  0.0  0.0  0.0 -1.0 ...]  
...  
[ 0.0  0.0  0.0  0.0  0.0 ...]
```

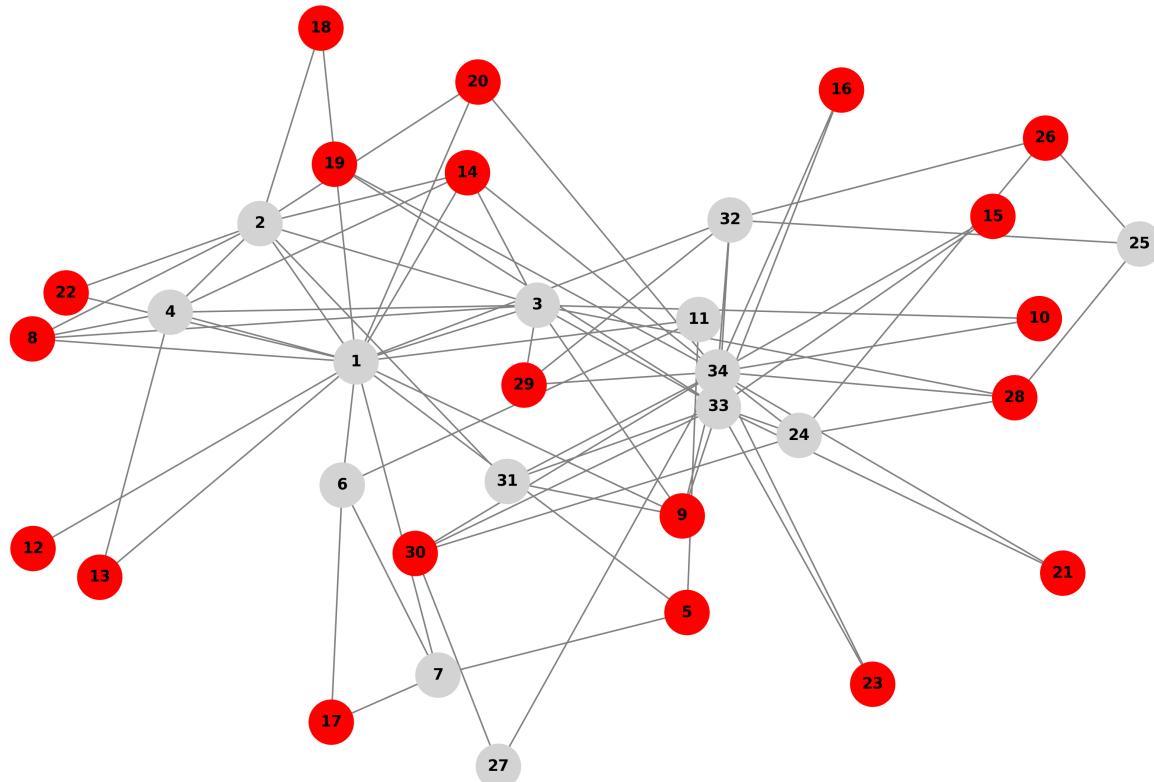
Matrix size: 34 x 34 (1156 elements)

MIS Result:

- MIS Nodes: [5, 8, 9, 10, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 26, 28, 29, 30]
- MIS Size: 20
- Energy: -20

Graph Visualization:

Zachary_Karate_Club - Maximum Independent Set (Red Nodes)



Summary

Total datasets processed: 9

The QDeep Hybrid Solver successfully processed all datasets, generating QUBO matrices and finding Maximum Independent Sets for each graph. Each result includes:

- Graph structure and edge information
 - Complete QUBO matrix representation
 - MIS solution with node list and size
 - Energy value from the solver
 - Validation of the MIS solution
-

Generated by MIS-QDeep Solver