

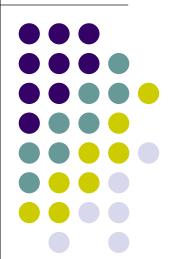
Graph Coloring with Ants *

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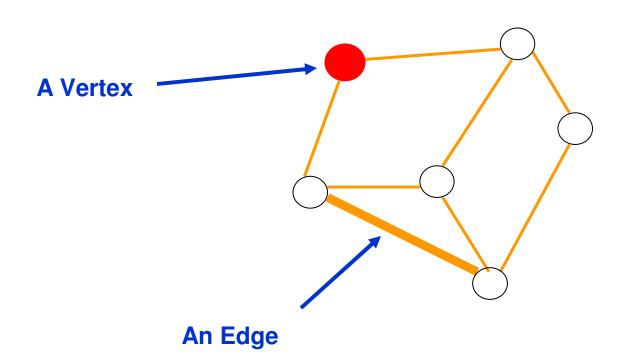
Outline



- Preliminaries
- Problem Definition
- Real Life Applications
- Our Algorithm
- Results

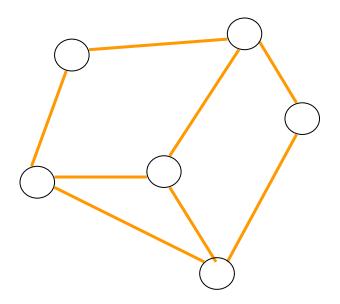


A Graph With 6 Vertices and 8 Edges



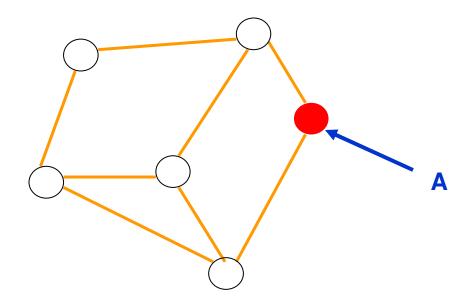


Adjacent vertices



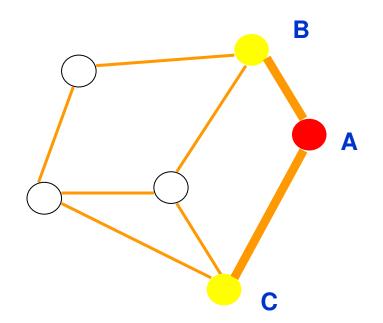


Adjacent vertices



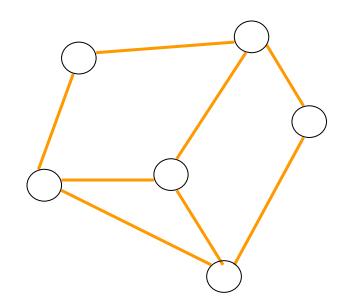


Adjacent vertices



B and C are adjacent to A

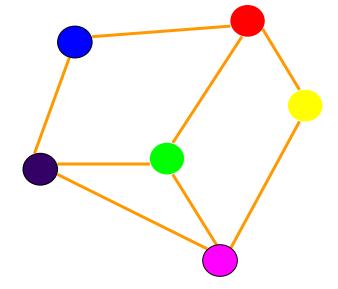




 Objective: Assign colors to vertices so that adjacent vertices do not have the same color and use as few colors as possible



A Valid Coloring

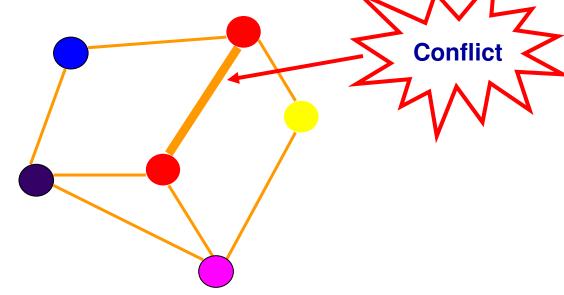


 Objective: Assign colors to vertices so that adjacent vertices do not have the same color and use as few colors as possible

}



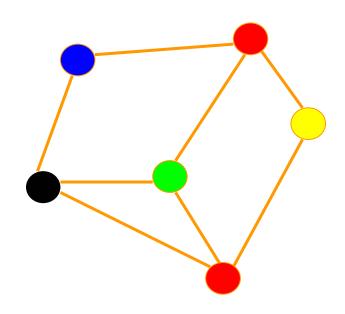
An Invalid Coloring



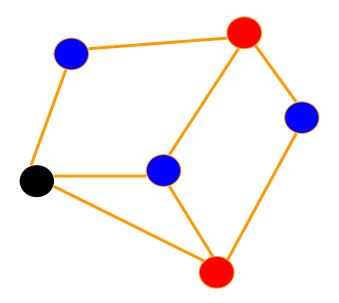
 Objective: Assign colors to vertices so that adjacent vertices do not have the same color and use as few colors as possible



• Objective: Minimize the number of colors used



Total Colors Used: 5



Total Colors Used: 3

Coloring Graphs Naïvely



- Question: Can an *n*-vertex graph be colored with *k* colors? (This question is equivalent to the graph coloring problem.)
- Naïve algorithm: try all possible ways of assigning k colors to the n vertices
 - If a valid coloring is found then answer yes. Otherwise, answer no
 - **Time:** there are **k**ⁿ possible colorings to check
 - Example: Can a 30-vertex graph be colored with 3 colors?
 - 3³⁰ possible colorings
 - 10⁶ colorings per second
 - 6 MILLION YEARS !!!





Complexity: NP-Hard

(That is, it is believed that any algorithm for finding the optimal solution requires exponential time.)

 Heuristics: Find good solutions in a reasonable amount of time







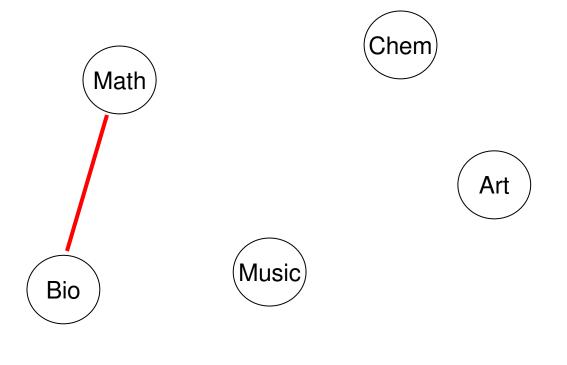






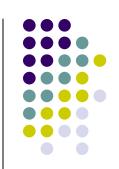
- Math Bio
- Math Chem
- Bio Music
- Bio Econ
- Music Chem
- Music Econ
- Chem Art
- Art Econ

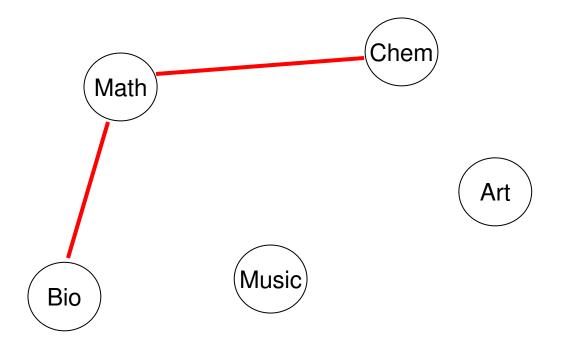




Econ

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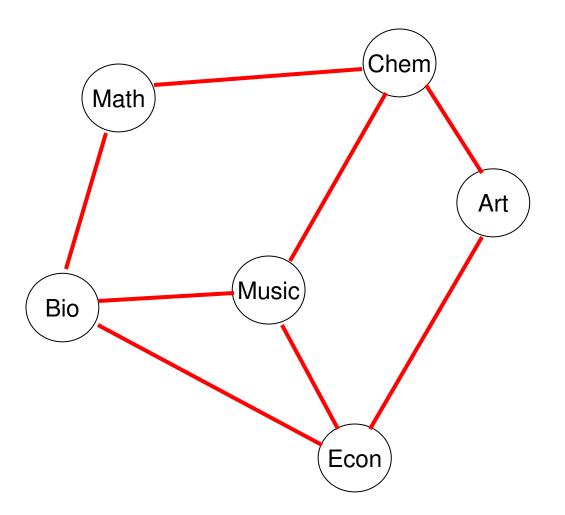




Econ

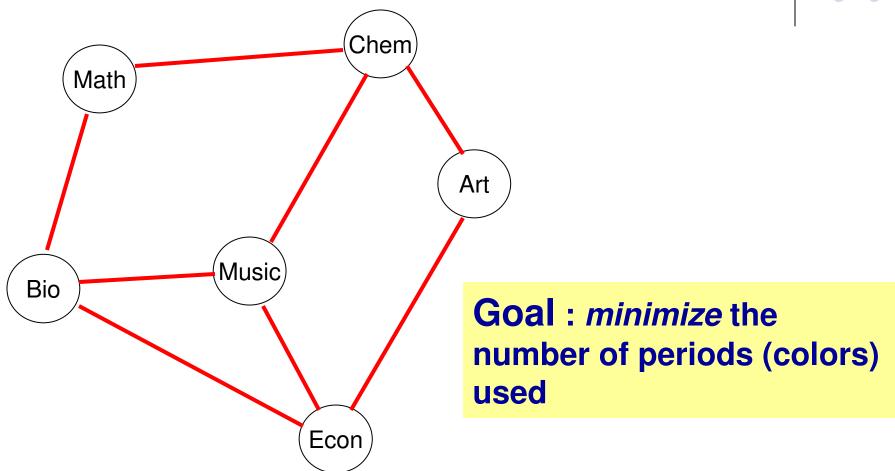
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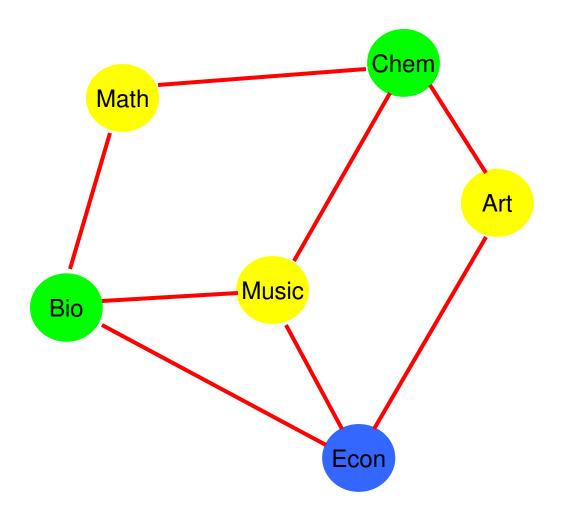


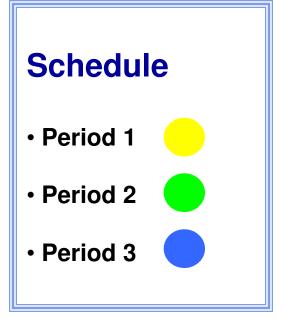
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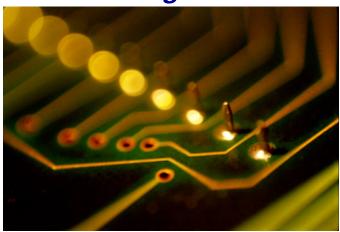




Other Applications of Graph Coloring



CPU Registers



Football games



Espatal Complete Senton
Complete Senton
Control Due on
Control Due

Classroom/Final Schedules



Radio Network

Generalizations of Graph Coloring

- More constraints
 - Colors used are actually numbers
 - Colors assigned to adjacent vertices must differ by a certain amount
 - Each vertex is assigned a set of colors not just one
- Cell Phone Network
 - Assigning channels to cell phones



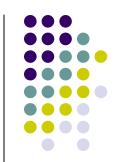


From Natural to Artificial Ants

- Mimic natural evolution
- Evolutionary Computations
 - Evolutionary Algorithms
 - Genetic algorithm
 - Evolutionary programming
 - Swarm Intelligence
 - Ant systems
- Ants
 - Social insects
 - Cooperative behaviors
 - Great success on many problems



ABOGC Algorithm Highlights



Ant Based Optimization for Graph Coloring

Use a simple and quick method to find a valid coloring (which may not be of good quality)

while stopping criteria not met



- Ants are placed on the graph
- Ants move around the graph and collaborate to recolor the vertices so that fewer colors are used

end-while

Return the best valid coloring found

Experimental Result



- Implementation
 - C++
 - Machine: Pentium 4, 3.0 GHz, 2GB ram, Linux
- Tested with over 100 standard instances (graphs)
- Perform very well against other algorithms
 - Mostly BETTER than other algorithms in both quality and efficiency (speed)

Conclusion

- Graph coloring and its generalizations
 - Difficult
 - Many real world applications
- ABOGC: ant based optimization for graph coloring
 - Ant-based approach
 - Ants cooperate to find solution
- Competitive results
- Future Directions
 - Parallelism

