EDA 導論 (Introduction to EDA)

94 學年下學期電機系選修課程

Programming Assignment #2

Solving Hamiltonian Cycle with Boolean SAT

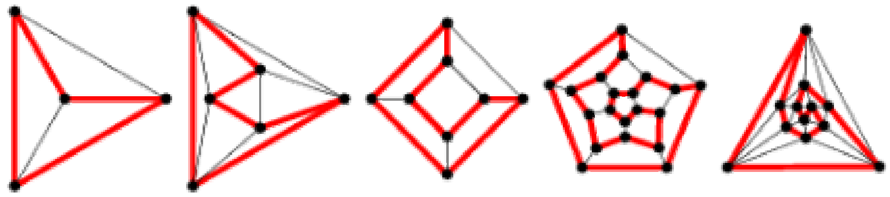
(Due: 5pm, June 13, 2006. Online)

Department:____________________________ Grade:__________

Id:_______________________ Name:________________________

1. Problem Statement

(From www.mathworld.com) A Hamiltonian cycle, also called a Hamiltonian circuit, is a graph cycle (i.e., closed loop) through a graph that visits each node exactly once (Skiena 1990, p. 196).



Above shown are examples of Hamiltonian cycles (in bold read lines) on some undirected graphs. In general, the problem of finding a Hamiltonian cycle is NP-complete (Garey and Johnson 1983), so the only known way to determine whether a given general graph has a Hamiltonian circuit is to undertake an exhaustive search. Rubin (1974) describes an efficient search procedure that can find some or all Hamilton paths and circuits in a graph using deductions that greatly reduce backtracking and guesswork.

In this programming assignment, you are asked to identify the Hamiltonian cycles in a simple graph. A simple graph, also called a strict graph (Tutte 1998, p. 2), is an unweighted, undirected graph containing no graph loops or multiple edges.

You should convert the Hamiltonian cycle problem into a Boolean satisfiability (SAT) problem, and then use the existing SAT solver (miniSat) to find the cycle, or prove that there is no Hamiltonian cycle in the graph.

2. Input/Output Specification

Input Format

Each testcase has one input file, describing the simple graph, in the following format:

```
<# of nodes>
<nodeId> [<adjacentNodes>...]
<nodeId> [<adjacentNodes>...]
....
```

<# of nodes> is a positive integer greater than 2. Each line contains a description of a node in the graph. The <nodeId> is numbered starting from 1, counting upwards until <# of nodes>. To save space, only the adjacent nodes with smaller ID's are shown. For example, the line "5 1 2 4" is legal, meaning there are 3 edges connected to node 5 from nodes 1, 2, and 4. On the other hand, the line "5 1 2 6" is illegal because 6 is greater than 5. The edge <5, 6> should be described in the line for node 6.

Output Format

You should output the message to an output file in one of the following formats:

```
Hamiltonian cycle:
<nodeId> <nodeId> <nodeId> ...
```

or

```
No Hamiltonian cycle.
```

The <nodeId>'s should be in the order as presented in the Hamiltonian cycle. You can pick any node in the cycle as the first node. However, please repeat it at the last (for example, "3 5 2 4 6 1 3").

Please describe a Hamiltonian cycle in a single line. Do not put "carriage return ('\n')" in between.

We will write a program to test whether the Hamiltonian cycle you provide is indeed a cycle and visits each node in the graph exactly once.

Example

Input ---

```
4
1
2 1
3 2 1
4 2 3
```

output ---

```
Hamiltonian cycle:
1 2 4 3 1
```

3. Language/Platform

- Language: C or C++.

- Platform: Windows or Linux/Unix.

4. Command-line Parameters

In order to test your program, you are asked to add the following command-line parameters to your program: (e.g. HamiltonCycle.exe input.gr output.rpt)

<executableFileName> <inputFileName> <outputFileName>

5. Advanced Features

Be able to generate ALL the Hamiltonian cycles in a graph. However, be careful not to output the same Hamiltonian cycle with different starting points (e.g. “1 2 4 3 1” and “2 4 3 1 2”. Print out one cycle in a line.

6. Submission:

You need to submit the following materials in a .tar or a .zip file (e.g., b90901130-p2.zip) at the course website by the deadline: (1) source codes, (2) executable binaries, (3) a text readme file (readme.txt), stating how to build and use your programs, (4) a report

(report.doc) on the algorithms used to model the Boolean SAT problem, and the data structures used in your program.

7. Evaluation

This programming assignment will be graded based on the (1) correctness of the program, (2) running time, (3) memory usage, (4) report.doc, and (5) readme.txt. Please check these items before your submission.

8. References

- The MiniSat page, http://www.cs.chalmers.se/Cs/Research/FormalMethods/MiniSat/Main.html

- Rubin, F. "A Search Procedure for Hamilton Paths and Circuits." *J. ACM* **21**, 576-580, 1974.

- Skiena, S. "Hamiltonian Cycles." §5.3.4 in *Implementing Discrete Mathematics: Combinatorics and Graph Theory with Mathematica.* Reading, MA: Addison-Wesley, pp. 196-198, 1990.

- Tutte, W. T. *Graph Theory as I Have Known It.* Oxford, England: Oxford University Press, 1998.

- CNF format (CNF format.pdf), or website, for example: http://logic.pdmi.ras.ru/~basolver/dimacs.html