YOUR TITLE GOES HERE

Your name

Adviser: Professor xxx

A Thesis

Presented to the Faculty of the Computer Science Department

of Middlebury College

December 2019

ABSTRACT

Your abstract goes here.

ACKNOWLEDGEMENTS

Your acknowledgements go here.

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CHAPTER 1

SYLLABUS

This chapter contains the course syllabus. See Chapter 2-6 for a sample structure for your thesis.

1.1 Learning Goals

- Engage in independent computer science research
- Communicate technical scientific ideas using various media and to various audiences
- Participate in academic culture

1.2 Assessment

You will be assessed on the following criteria:

Criteria	**Grade Percentage**
Execution	40%
Written Thesis	30%
Final Presentation	15%
Poster	5%
Participation	10%

Table 1.1: Rubric

1.2.1 Execution

A well-executed thesis consists of

- A well-defined hypothesis of appropriate scope
- Methods of investigating your hypothesis that demonstrate a deep understanding of the problem

- Sufficient effort towards a result, regardless of eventual outcome.
- Independent work

Each of these sub-criteria contributes approximately 10% to your final grade. We discuss each of these points in a bit more detail.

Hypothesis

The thesis should answer a research question (which may not be the research question you initially sought to answer). A research question can be phrased in terms of a hypothesis, which is a statement that you plan to test, analyze, or investigate in order to determine whether it is true. Some examples:

- By parallelizing all of the components of the XHMM algorithm with Apache Spark and ADAM we can achieve a speedup over the existing implementation.
- There is a quantum algorithm for directed st-connectivity that uses at most $O(n^{3/2})$ queries on an n-vertex graph.
- Commonly used apps are at risk of fuzzing attacks via local ports.

The hypothesis you attempt to investigate should be challenging but feasible (i.e. not overly ambitious) given the very short time frame of a single semester. Please consult closely with your advisor to choose an appropriate hypothesis. Execution is partly dependent on the scope of the hypothesis you investigate. Perfect execution of a simple project may not earn a better grade than imperfect execution of a more challenging project. But an impossible project will be exactly that, impossible to execute well.

Appropriate Methods

Methods will vary based on your topic. You should determine your methods through your reading of research in your subfield and/or in consultation with your advisor.

Sufficient Effort

You can't always predict the challenges you will face, and thus may not always be able to answer your research question in the time available. However you can demonstrate a thoughtful understanding of any limitations, and show creativity in your attempts to overcome those challenges.

Independent Work

The thesis is an independent project. It is not your advisor's role to give you a task list or a set of project deliverables. However, your advisor is a resource to provide advice as needed. One of your first tasks will be to discuss with your advisor how you plan to work together on this project.

1.2.2 Written Thesis

The final written thesis will be one of the key ways we assess your execution of the thesis. However, we are also assessing your ability to communicate technical scientific ideas in writing, which is the standard way of expressing a scientific result. This criteria deals with your ability to clearly and appropriately convey the work you did via writing. See Appendix B.1 for more specific guidelines and requirements regarding writing.

1.2.3 Final Presentation

Another key way that scientific results are communicated is through talks. You will give a final short presentation that should distill the ideas of your thesis into a talk that is accessible to a 3rd year undergraduate Computer Science major. Your presentation should focus on the motivation for your project, the methods *you* employed, and the results you obtained. (It should not focus on background; you are not teaching a class!)

1.2.4 Poster

Another important way that scientific results are communicated is through posters and poster presentations. You will create a poster that is accessible to a 3rd year undergraduate Computer Science major. Your poster should focus on the motivation for your project, the methods *you* employed, and the results you obtained. (It should not focus on background!)

1.2.5 Participation

You are expected to attend class sessions and any computer science seminars. (The seminar schedule will be posted on the course website as it becomes available.) Deliverables (e.g. drafts, elevator pitches, responses to seminars, practice presentations) should be completed in a timely way and to any specifications.

1.3 Timeline

In addition to the below rough timeline, you are required to attend all department seminars and talks, and to write a short response to each. (See the course website for further details). A more precise timeline can be found on the course website.

Week	Class Topic/ Deliverable
Week 1	Due In Class: Elevator pitch of hypothesis, Description of Advisor-Advisee Plan
Week 2	Class Meeting: Reference Managers
Week 3	No class.
Week 4	No class. Due: Annotated Bibliography
Week 5	Class Meeting: Giving an Academic Talk
Week 6	Due in class: Updated elevator pitch and 5-minute presentation on current results
Week 7	Class Meeting: Scientific Writing
Week 8	No class. Due: First draft of thesis (skeleton)
Week 9	No class. Write and create your presentations!
Week 10	Practice presentations. Due: Second draft of thesis
Week 11	Thesis presentations
Week 12	Final draft of thesis
Week 13	Poster Due

Table 1.2: Course Timeline

CHAPTER 2

INTRODUCTION

Motivation

Explain why what you are investigating is important.

Previous work

Explain how what you did relates to previous work. You should reference and describe previous work, but avoid going too far down rabbit holes that are unrelated to the present thesis [1].

Your work

Briefly explain your results

CHAPTER 3

BACKGROUND

Describe background information that is necessary for a moderately experienced computer scientist (think your professors) to understand your thesis.

3.1 Notation

Explain relevant notation. For example: Let $[N] = \{1, 2, \ldots, N\}$.

3.2 Probability

Consider independent random variables $X_1, \ldots, X_n$ where for each variable X_i, we have $0 \leq X_i \leq 1$. Let $\bar{X} = \frac{1}{n} \sum_{i=1}^{n} X_i$. Then Hoeffding's inequality states that

$$\Pr\left(\bar{X} - E[\bar{X}] \geq t\right) \leq e^{-2nt^2}. \tag{3.1}$$

CHAPTER 4

YOUR WORK PART 1

I first analyzed the graph shown in Fig. 4.1. You can see details of this analysis in Appendix A.

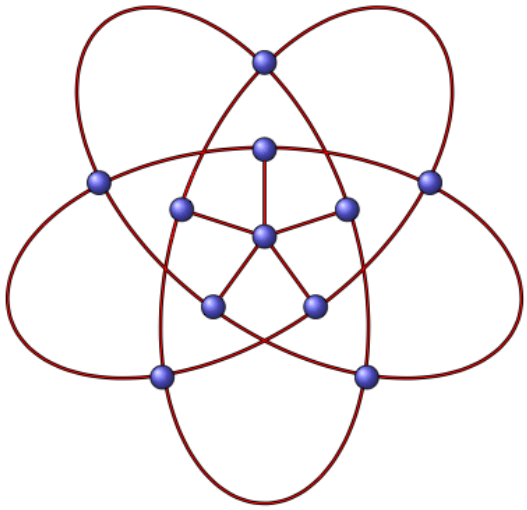

Figure 4.1: A non-planar graph.

To study this process, I used the algorithm 1.

Input : Array A of integers of length n
Output: Array containing sorted elements of A

```
for k = 2 to n do
    for j = k to 2 do
        if A[j] < A[j − 1] then
            Swap A[j] and A[j − 1];
        else
            Break;
        end
    end
end
return A;
```

Algorithm 1: `InsertionSort`(A)

I proved the following Lemma:

Lemma 4.0.1. *Soy yo.*

I used this lemma to prove the following theorem:

Theorem 4.0.2. *Fix any $\kappa > 1$ and $\lambda > 0$. For any family of connected graphs G and $X \subseteq \{0,1\}^{E(G)}$ such that $\forall x \in X$, either $\lambda_2(G(x)) \geq \lambda$, or $G(x)$ has at least κ components, $\text{CONN}_{G,X}$ can be solved in bounded error in time $\widetilde{O}\left(\sqrt{\frac{nd_{\text{avg}}(G)}{\kappa\lambda_2(G)}}\left(\mathsf{S} + \sqrt{\frac{d_{\max}(G)}{\lambda}}\mathsf{U}\right)\right)$.*

I discuss the idea of the proof here. The full proof can be found in Appendix A.

CHAPTER 5

YOUR WORK PART 2

CHAPTER 6

CONCLUSION

In this thesis, I have addressed the question...

6.1 Open Problems

There are many areas in which one could continue this work...

APPENDIX A

DETAILS OF CODE, PROOFS, ETC.

You might have some code:

```
function swap=swapmat(n,q1,q2)
// Creates a matrix that swaps qubits
// q1 and q2 of an n qubit system

// The new swap matrix will be stored in swap
swap=eye(2^n);

for i=1:2^n
    index=i;
    if indexswap>index
        swap(indexswap,:)=test(index,:);
        swap(index,:)=test(indexswap,:);
    end
end
end
```

We now prove Theorem 4.0.2, restated here for convenience:

Theorem 4.0.2. *Fix any $\kappa > 1$ and $\lambda > 0$. For any family of connected graphs G and $X \subseteq \{0,1\}^{E(G)}$ such that $\forall x \in X$, either $\lambda_2(G(x)) \geq \lambda$, or $G(x)$ has at least κ components, $\mathrm{CONN}_{G,X}$ can be solved in bounded error in time $\widetilde{O}\left(\sqrt{\frac{nd_{\mathrm{avg}}(G)}{\kappa\lambda_2(G)}}\left(\mathsf{S}+\sqrt{\frac{d_{\max}(G)}{\lambda}}\mathsf{U}\right)\right)$.*

Proof. The complexity of generating g is $\mathsf{Init} = O(\mathsf{S}+\mathsf{U}+\log n)$, and the initial state has overlap at least $\varepsilon = \Omega\left(\frac{\kappa\lambda_2(G)}{nd_{\mathrm{avg}}}\right)$ with any unit vector in $\ker A(x) \cap \mathrm{row}(A)$. Plugging

these values into the expression in Eq. 6 gives (neglecting polylogarithmic factors)

$$O\left(\frac{1}{\sqrt{\varepsilon}}\left(\mathsf{Init}+\sqrt{\frac{d_{\max}(G)}{\lambda}}\mathsf{U}\right)\right)=\widetilde{O}\left(\sqrt{\frac{nd_{\text{avg}}}{\kappa\lambda_2(G)}}\left(\mathsf{S}+\sqrt{\frac{d_{\max}(G)}{\lambda}}\mathsf{U}\right)\right). \quad \square$$

APPENDIX B

NOTES ON WRITING

B.1 Expectations

The thesis should

- Demonstrate your understanding in your own words. Plagiarism is unacceptable. See Appendix B.2.
- Be correct.
- Be written for your audience: professors in the department who are not experts in this area. You should keep your audience in mind when deciding how much background material to include, how much context to provide, and your use of field-specific terminology, notation, etc..
- Demonstrate high-quality scientific writing (see Appendix B.3):
  - Overall structure is coherent
  - Writing is clear
  - Minimal use of "weasel words" and other imprecise writing.
  - Minimal typos
- Cite references appropriately
- Be an appropriate length. Your thesis should be between 20 and 50 pages, excluding figures, appendices, and bibliography. (Extensions or retractions may be granted by your advisor.)

B.2 Plagiarism

As much as possible, the thesis should be in your own words. Prior results must be cited. Additionally, any material taken from a source, whether verbatim or paraphrased, must include a citation. If you copy text word for word you must use quotation marks to indicate that it is not your own writing. However, it is relatively rare to use quotations in scientific writing, so please do this sparingly.

You should also determine your own structure at the paragraph level. A paraphrasing that mimics point by point the sentences in a source is not acceptable. For the expository parts of your thesis, we suggest gathering the information and then expressing the ideas in your own words.

B.3 Best Practices

Good scientific writing is good writing and everything you have learned in other classes still applies. Some points of particular emphasis for scientific writing:

- You are telling a results-oriented story, not a time-oriented story. In other words, you should structure your thesis in order to maximize clarity and impact, not based on what you did first.
- Great papers have great figures. One way to write your thesis is to first create figures, and then write your story based on the figures.

Some more views on technical reading and writing you might find helpful

- Philip Fong, "How to Read a CS Research Paper" http://www2.cs.uregina.ca/~pwlfong/CS499/reading-paper.pdf
- Matt Might, Weasel Words (and passive voice) http://matt.might.net/articles/shell-scripts-for-passive-voice-weasel-words-duplicates/

B.4 Writing FAQ

I or We? Don't say "We implemented ..." when it was just you. Instead say "I implemented ...". It is fine to say "we" when it includes the reader: "We now examine ..."

Can we use the active voice, e.g. say "I did X..."? Yes! Technical writing typically uses active voice. That said, you will encounter different views on active vs. passive voice so make sure to find out the expectations of other faculty or the conventions in your subfield.

What tense do I use? If you look at Chapter 4 you will see the text is a combination of present and past depending on whether you are explaining something to the reader (present), or describing something you did (past). For example, you may write: "This thesis examines three questions. We first investigate..." Or: "I ran three experiments."

I am seeing weird characters, e.g. many "?"s, in my LaTeX document. What is happening? Be careful when copying from a WYSIWYG editor, like Word, into your LaTeX source. Word will replace certain punctuation, like double quotes, and combinations of letters, like "ff", into different character codes for fancy versions of those characters that LaTeX can't render. Make sure you copy over plain text.

How do I cite a GitHub repository (and URLs more generally)? You can cite a URL as a `@misc` BibTex entry [2], e.g.

```
@misc{HammerLab2017,
    author = {HammerLab},
    title = {pileup.js},
    url = {https://github.com/hammerlab/pileup.js/},
    lastchecked = {2017-02-06},
```

```
    year = {2017}
}
```

How do I cite a stack exchange posting? Again use a `@misc` Bibtex entry [3]

```
@MISC{KothariTCSSE,
    TITLE = {Open problems on the frontiers of {TCS}},
    AUTHOR = {Robin Kothari (https://cstheory.stackexchange.com/u
    HOWPUBLISHED = {Theoretical Computer Science Stack Exchange},
    URL = {https://cstheory.stackexchange.com/q/1015}
}
```

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[1] Lewis Carroll (Charles L. Dodgson). *Alice's Adventures in Wonderland*. George MacDonald, 1865. URL: http://arxiv.org/down-the-rabbit-hole.

[2] HammerLab. pileup.js, 2017. URL: https://github.com/hammerlab/pileup.js/ [cited 2017-02-06].

[3] Robin Kothari (https://cstheory.stackexchange.com/users/206/robin kothari). Open problems on the frontiers of TCS. Theoretical Computer Science Stack Exchange. URL: https://cstheory.stackexchange.com/q/1015 [cited 2019-08-23].