Chapter 6 Research Implications and Conclusions

6.1 Research Implications

It is well known that good benchmarks drive the industry and technology forward. In this chapter, the managerial and technical implications of the research result are discussed. Based on the research model and implementation of the prototype, we summarize the research implications in the following sections. The major points of this study are described as follows.

- Summarize major web search algorithms and benchmarking methods for web searches by collecting and reviewing literature related to web searches.

Searching the web is an important issue because it is a vital way of finding information. The design of a web search engine is devoted to developing search algorithms to provide more precise searches. Benchmarking web searches is key to testing the efficiency and effectiveness of search algorithms. Naturally, web search is an important topic of academic study. Web search algorithms were previously just university projects like PageRank for Google so it was easy to get details on the algorithms. Now, algorithms are business kernels in web search engines so it is no longer easy to obtain the details. Our aim has been to collect all related literature on classical web search algorithms and benchmarking methods that most researchers have worked on. We have also reviewed the literature and ensured that these classical web search algorithms are fundamental and used them as representative examples in this study. Therefore, the first step of this research -- the priority for such a study -- was to collect and review literature related to web search algorithms and benchmarking methods. Subsequently, we summarized the key web search algorithms and benchmarking methods that are well known as well as typical algorithms referenced by many other algorithms and benchmarking methods. In addition, these key web search algorithms and benchmarking methods have been used to help develop new algorithms. We believe that these core web search algorithms and benchmarking methods summarized here are the representative items.

- Find out generic constructs by analyzing key web search algorithms and benchmarking methods.

The workload model we propose in this study has been developed in generic constructs. Generic constructs are extracted from the main web search algorithms and benchmarking methods we summarized from the literature study. We analyzed the representative web search algorithms and benchmarking methods to find out the crucial elements as generic constructs of the web search. Generic constructs are factors that affect the efficiency and performance of search algorithms and

benchmarking. For instance, PageRank is based on inlinks and outlinks of the page, so these are components of the algorithm. From PageRank, “hyperlink” tag of the web page can affect the importance of the page. Therefore “web page” as a generic construct and “tag” is the operation that operate the generic constructs. All generic constructs analyzed in this research are the components of the benchmark workload model.

- Build a more flexible workload model for benchmarking based on generic constructs.

From the literature we found that most web search benchmarks have a fixed workload model for a specific algorithm only. This kind of benchmark workload model is unchangeable and inflexible. The benchmark workload model in this research is developed from generic constructs that are extracted from key web search algorithm and benchmarking methods. Generic constructs can be used to define a new workload model for different web search algorithms. The generic constructs of a web page for benchmarking are considered for the page model. The generic constructs of the web search algorithms and search types are considered for the query model. Designed as such, this method meets the characteristics that are desirable in a good benchmark design including scalability, portability, simplicity and feasibility. In addition, the benchmark workload model in this research is more flexible. Because the workload model is a primitive component of a benchmark and experiments and test suites are used to verify the workload model to get performance metrics, the workload model used in this research is more flexible, allowing design of a new test suite for a new algorithm. If the generic constructs of the web search algorithm are included in the workload model, designing a new workload model and using a suitable test suite for the algorithm can be done easily in this research. In addition, we have included the generic constructs of the web search algorithm so the more flexible workload model can be applied to benchmarking of different web search algorithms.

- Build a computer-aided benchmarking environment based on a more flexible workload model.

A prototype based on the workload model in this research is designed to help perform benchmarking of automated web search. The prototype includes a user interface for test input selection, query script output, search result output and a scheduler that sets up the execution environment. The prototype is connected to Yahoo! Web Search APIs to search the internet. The input selections of the interface correspond to the request parameters. After specifying the input selection to generate the out search script for submission to the Yahoo! Web Search APIs, the search results and performance metrics will be automatically generated. The prototype is easy to use with any test suites for web search algorithms that are suitable for generic constructs in the workload model. This is an automated environment for benchmarking that can improve the efficiency of benchmarking.

6.2 Conclusions

For designers of web search engines who are striving to develop search algorithms to help internet user find information precisely, a benchmark that enables web search evaluation is necessary. It is very difficult to directly apply these measurements to the evaluation of web search engines because of the unique nature of the web such as precision and recall. Also, there are few open or generalized performance evaluation methods for a web search. In this study, we developed a more generalized workload for web search benchmarking as well as a prototype for workload generation. We reviewed literature related to web search algorithms and benchmarking to find motivates behind the design of workload models. The objective of this study is to develop a more generalized workload model for testing the web search performance. An easier way to apply workload models to different web search algorithms is designed in generic constructs. Finally, we validated the research model through prototype implementation. Results derived from this research include:

- Collecting and reviewing literature related to web search algorithms and benchmarking, as well as identifying the generic constructs of web search algorithms.
- Developing a more flexible workload model for web search benchmarking. The workload model consists of a page model and query model which are designed based on generic constructs and constraints. Also, a control model is created to set up a benchmark environment.
- Implementing a workload generation prototype based on the workload model in this research. The prototype illustrates the feasibility and validity of the research model.
- Designing a set of experiments to verify the workload model by using the prototype. The prototype can use Yahoo! Web Search APIs to do a web search test and generate search results and performance metrics automatically.

6.3 Future Research Work

This research has only built a simple prototype workload model for web search benchmarking because of the limitations of the Yahoo! Web Search APIs. The prototype only connects to a specific web search service. More effort is needed to expand its capabilities. We expect this work to continue and evolve in the future. Future research may take the following directions:

- Add more advanced generic constructs. Web search benchmarking and development of new algorithms is a continuing effort. Continue to collect and review new web search-related literature can help find more advanced generic constructs. Adding more advanced generic constructs to a workload model can expand its coverage, making it more complete.
- Enhance the complexity of tests. The experiments we designed here only include test suites

for algorithms we have reviewed. In order to completely verify the workload model, it is necessary to design a test for a new algorithm. And due to the limitations of the web search APIs, we have only designed ten simple tests that can be applied for the corresponding parameters. If the web search APIs can provide more request functions, more complex tests may be added to improve the accuracy of experimental results from the benchmark workload model in this research. Another improvement would be a comparison of experimental results with those returned by another web search engine and the application of more keywords for each test to enhance the accuracy of experimental metrics.

- Enhance the features of the prototype. Our primitive prototype has basic selections based on the workload model. The selections of our prototype should be more detailed, and the user interface can be refined. In addition, the prototype only connects to the Yahoo! Web Search APIs. The prototype could be modified to connect to more web search APIs provided by other web search engines and provide an interface to transfer to different web search APIs.