



## Master Thesis for Daniel Meier

Task Description: Andri Lareida, Prof. Dr. Burkhard Stiller

Title: **Network Locality Metrics for Decentralized Systems**

Start Date: February 20, 2015

End Date: August 20, 2015

Supervisor: Andri Lareida, Christos Tsiaras

Location: Room 1.D.17, Home

Support: Java, P2P, SmartenIT - Locality

### 1. Introduction and Motivation

Decentralized systems, such as Peer-to-Peer (P2P) systems or content delivery networks (CDN), typically form a virtual network, called overlay network, on top of a physical network, called underlay. Overlay networks are typically not aware of the structure of the underlay network. This leads to inefficiencies in network traffic and increases cost of internet service providers (ISP), especially if large amounts of data are transferred, as in P2P file sharing applications.

The problem is that the structure of the Internet is not known and therefore it is challenging to determine which nodes of an overlay are close to each other from an underlay perspective. Application Layer Traffic Optimization (ALTO) [6] is a solution to this problem but is limited to the domain of a single ISP since every ISP needs to deploy its own ALTO server. The reason for this is that ISPs refuse to give information of their network topology to third parties. Therefore, it is not possible to determine the actual underlay topology but it can be approximated.

In BitTorrent (BT) [2] solutions, *i.e.* using DNS redirection to determine the underlay distance between peers [3], have been implemented and evaluated showing great benefit [1][3][5]. However, DNS redirection might not work in some cases, such as inside CDNs, and it relies on a central service. Therefore, this thesis will investigate the potential of metrics, that are generally available to nodes in an overlay network, *e.g.* AS hop count [4], to determine the underlay distance between nodes. The thesis will evaluate several metrics and discover which metric or which combination of metrics is suited best for the task.



## 2. Description of Work

The first phase starts with the detailed planning of the thesis work and its milestones until the final deadline. At the same time the student will start with researching literature with the goal of learning about existing related work and similar solutions but also to identify potential metrics and their limitations. A theoretical evaluation of metrics will be conducted to build a basis for the experimental prototype implementation.

In a second phase the student will focus on designing and implementing a prototype which can use a set of metrics evaluated in the first phase. The purpose of this implementation is the evaluation of said metrics in real world conditions. The prototype must be able to apply the metrics chosen in the first phase in a lab environment such as EmanicsLab. The design must be flexible to allow easy exchange and combination of metrics. The prototype will be implemented preferably in Java. The implementation shall be resource efficient, that it can be run in resource constrained devices, e.g. RaspberryPI.

The third phase focuses on the design and execution of an experimental evaluation. For this purpose a distributed lab infrastructure, i.e. PlanetLab, shall be used. Metrics for the evaluation will have to be selected and measured. The goal is to find how the previously selected metrics compare to each other and which performs best in determining locality. If possible existing data sets shall be re-used. The results of the evaluation shall be interpreted and explained.

In the final phase 4 the thesis report will be written, which covers, related work, prototype design and implementation, experiment design and results, conclusion and outlook. With a final presentation the thesis work will be completed.

## 3. Thesis Goals

The main goal of this thesis is to determine and evaluate metrics that can be used to improve locality in decentralized systems, such as BitTorrent or CDNs. To reach this goal several smaller goals need to be achieved:

- Research literature on existing work and network metrics for locality
- Theoretically evaluate these metrics found
- Select at least 3 metrics for an experimental and prototypical implementation
- Design a prototype
- Implement flexible prototype
- Design experiments
- Design evaluations
- Run experiments and analyze results
- Write a well-structured report that documents all findings, including related work, design decisions, implementation details, evaluation procedures, and results of the analysis
- Run an intermediate (after half time of the thesis) and final presentation (after the conclusion of the work and the formal submission of the thesis in paper)

## 4. Activities

Based on the description of work, the following tasks targeting the required milestones need to be accomplished:

- Milestone 1: Planning  
Discuss your initial planning with the supervisors.
- Milestone 2: Design  
List of metrics with theoretical evaluation

- Milestone 3: Running prototype  
Experiment prototype implementation complete.
- Milestone 4: Prototype completed  
Evaluation planned and ready to execute
- Milestone 5: Evaluation completed  
Experiments completed results in presentable form.
- Milestone 6: Hand in and final presentation.  
Evaluation done and thesis written.

## 5. General Notes

- The student has to provide a written schedule for his/her full thesis steps within the first week of his/her work. Clarify details with your supervisor and finalize the schedule of tasks, basically in a weekly or bi-weekly fashion. Include the intermediate/public presentation(s), too.
- Prepare an intermediate internal presentation (20 min max plus Q&A) after half time of your thesis (date to be set) and discuss this with your supervisor. At the thesis' end (date to be set) a final public and self-containing presentation (20 min max plus Q&A) has to be given.
- The final written report will document all work undertaken and remember that this report must be self-contained. Major technical basics are to be included and detailed knowledge obtained during the work must be documented. Assumptions, design decisions, configuration choices, and results are part of the report as well as implementation details and usage information. Correct bibliographic references and a list of papers, recommendations, and descriptions used must be added, including those ones given below.
- Establish periodic meetings with the supervisor to report on progress and to discuss problems.
- Students involved in this thesis are required to read and answer e-mails related to this project at least three times a week. A more frequent, if needed, interaction will determine a better basis for supervision and progress.
- The information sheet on important hints for thesis work is required to be known.

## 6. Formal Results

Besides the intermediate and final oral presentation of your work the following written documents are part of your work and need to be handed in to the supervisor in time:

- A printed, double-sided report in a soft cover binding and in 3 copies (in English or German): It covers the motivation and introduction, the problem to be solved, the discussion of the design choices, a set of arguments on the final design choice, a list of solved and open issues. A critical consideration of the task, the work, and the result will conclude the report. Additionally, a table of content and figures (including tables), a valid list of bibliographic references, and optional appendices as required is part of the report, too. The official acknowledgement section is mandatory, a personal one optional, however recommended, as usually a number of people took part in the process of finalizing the thesis. The text processing shall be done in FrameMaker (preferred) or LaTeX and in rare cases in Word.
- A documentation of the implemented/configured system, covering the system's view point, an implementation description, a use and installation manual, a documentation of all program and data structures developed or utilized is essential. All of this may be part of the report above, however, in case it will not be included, it must exist in a separate document.
- A dedicated CD for each copy of the report has to be produced: (1) a collection of all program sources, software components, protocol implementations utilized, hardware/product documentation in PDF, related work papers in PDF or full HTML pages, and a directory description; (2) the written thesis (report) in source files, figures in source file and jpg or eps, and a full printable PS as

well as PDF file, the set of slides for the final presentation in PowerPoint; and (3) all further material used, if available in electronic form, such as all existing and documented test scenarios, testing plans, and test results.

- A German summary in a maximum of 2 pages (in case of a report written in German, this summary needs to be in English), which will enable a quick and clear survey of this work, tasks and results. This summary will be part of the bound report, and is included after the front page and before any other text will follow. It includes four short sections on: 1. Einleitung/Introduction, 2. Ziele/Aims and Goals, 3. Resultate/Results, and 4. Weitere Arbeiten/Further Work.
- The complete set of copies of the report, the CD, and the talk must be completed and handed in to the supervisor in time before the thesis will change into the "submitted" status. Note that failures of delivering those information and data after the formal hand-in time may result in a "non-passing" state of this work.

## 7. References

The following list of references addresses key aspects and serves as a starting point for the work. Further papers, scenarios, and document research is a must! It is more than highly recommended and may be essential for a successful completion of the work:

- [1] R. Bindal, P. Cao, W. Chan, J. Medved, G. Suwala, T. Bates, and A. Zhang. Improving Traffic Locality in BitTorrent via Biased Neighbor Selection. *26th IEEE International Conference on Distributed Computing Systems (ICDCS 2006)*, Lisboa, Portugal, July 2006.
- [2] BitTorrent. <http://www.bittorrent.org/>, Online, accessed Oct. 2014.
- [3] David R. Choffnes and Fabián E. Bustamante. Taming the Torrent: A Practical Approach to Reducing Cross-ISP Traffic in Peer-to-Peer Systems. *ACM SIGCOMM Computer Communication Review*, Vol. 38, No. 4, pp 363-374, October 2008
- [4] Zhuoqing Morley Mao, Jennifer Rexford, Jia Wang, and Randy H. Katz. 2003. Towards an accurate AS-level traceroute tool. *In Proceedings of the 2003 conference on Applications, technologies, architectures, and protocols for computer communications (SIGCOMM '03)*. ACM, New York, NY, USA, 365-378.
- [5] John S. Otto and Fabián E. Bustamante. The Hidden Locality in Swarms. 2013 IEEE Thirteenth International Conference on Peer-to-Peer Computing (P2P 2013), Seattle, USA, September 2013.
- [6] Jan Seedorf, Sebastian Kiesel, and Martin Stiernerling. Traffic Localization for P2P-Applications: The ALTO Approach. *IEEE Ninth International Conference on Peer-to-Peer Computing (P2P 2009)*, Seattle, USA, September 2009.

Zürich, February 20, 2015

Prof. Dr. Burkhard Stiller