# Bachelor Thesis
# The Server Location Problem with Restricted Loads on Servers and Links

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September 8, 2013

## 1 Abstract

The server location problem with restricted loads on servers and links (SLRL) is an NP-Complete problem, introduced by Hiroyoshi Miwa et al. in the Paper "Method of Locating Mirror Servers to Alleviate Load on Servers and Links" [NM11]. The problem came up, because the massive volume of data distributed by content delivery networks (CDNs) require well located mirror servers in order not to badly influence the quality of their service. Two examples for CDNs would be "Amazon CloudFront" a traditional commercial CDN, or the "AT&T Inc." a Telco CDN which has advantages over traditional CDNs because they own the so called "last mile", the final leg of the telecommunications networks. CDN nodes are usually deployed in multiple locations, often over multiple backbones, reaching thousands of nodes with tens of thousands of servers. [Wik13a] [Wik13b] The two constraints induced by the choice of mirror servers is the number of maximum nodes accessing a mirror server and maximum number of nodes accessing a mirror server through a specific link. The constraint mentioned first, corresponds to the network load on the (mirror-)servers. The second constraint corresponds to the restricted load on the links. First I want to prove that SLRL is NP-complete. Next, I want to propose my own algorithm as a sequel to the existing greedy algorithm proposed by Miwa et al. [NM11].

# Contents

# 2 Introduction

## 2.1 CDNs

"A content delivery network is a collaborative collection of network elements spanning the Internet, where content is replicated over several mirrored Web servers in order to perform transparent and effective delivery of content to the end user."[BPV08, p. 3] To perform efficient delivery of data, CDNs need to have several mirrored Web servers and thus it is important to place them well, because placing the mirror server could be an expensive choice considering no prior calculation where it should go. The expensive choice

manifests in high link usages and or a maximal neighbourhood being too big for the server to handle. The mirror servers naturally serve the same data, as they are there to alleviate the load of the other servers providing the data.

## 2.2 Similar Problems

### 2.2.1 P-Center Problem

### 2.2.2 P-Median Problem

### 2.2.3 NA (Node to Area)-connectivity

## 2.3 Open Shortest Path First

# 3 Server Location Problem with Restricted Loads on Servers and Links

## 3.1 Formal Definition

### 3.1.1 Neighbour Set

### 3.1.2 Load on a Link

**Given:** *Undirected graph G(V,E) and positive integers k,r and c.*
*$k = \|S\|$, where S is the set of servers $S = \{s_1, s_2, \ldots s_k\} \subseteq V$*
*$r \geq \|V_i\|$ $(i = 1, 2, \ldots, k)$ where $V_i$ is the neighbour set of $s_i$ $(i = 1, 2, \ldots, k)$*
*$c \geq m(e)$, where m(e) is the maximum load $\forall e \in E$.*

**Wanted:** *A set of Servers $S = \{s_1, s_2, \ldots, s_k\} \subseteq V$ such that $|V_i| \leq r$ $(i = 1, 2, \ldots, k)$ where $V_i$ is the neighbour set of $s_i$ $(i = 1, 2, \ldots, k)$ and that $m(e) \leq c$ $(\forall e \in E)$.*

## 3.2 An Instance Of The Problem

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## 3.3 Proof of NP-Completeness

# 4 Algorithm

## 4.1 Prior Algorithms

## 4.2 Data (Testinstances)

## 4.3 Implementation

# 5 Conclusion

# References

[BPV08]  Rajkumar Buyya, Mukaddim Pathan, and Athena Vakali. *Content Delivery Networks*. Springer Publishing Company, Incorporated, 1st edition, 2008.

[NM11]  R. Nakamura and H. Miwa. Method of locating mirror servers to alleviate load on servers and links. In *Applications and the Internet (SAINT), 2011 IEEE/IPSJ 11th International Symposium on*, pages 513–518, 2011.

[Wik13a]  Wikipedia. Content delivery network, 2013. [Online; accessed 4-September-2013].

[Wik13b]  Wikipedia. Last mile, 2013. [Online; accessed 4-September-2013].