

# Bachelor Thesis

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

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### 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].

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## 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**

A lot of thought has already been put into the server location problem. Two problems that describe this problem would be the p-center and the p-median problem. The purpose of these problems is mainly to shorten delay time from the client to the server. There are several similar problems that are well known, like the p-center or the p-median problem.

### **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**

The neighbour set is the set, that belongs to a server. In our problem, it is defined as follows: If the node has a shortest path to a server node, he belongs to this server nodes neighbour set. If the node has several shortest paths to multiple server nodes, it will belong to all of those server nodes neighbour set. The server itself will belong to its own neighbour set.

### **3.1.2 Load on a Link**

The load on a link is defined as follows: It is defined as the sum of shortest paths, that cross a link. If there are several shortest paths with the same length to one or more servers every one of them is taken into account. This

is done, because we must always consider the worst case when locating a server.

### 3.1.3 The Problem

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

**Wanted:** A set of Servers  $S = \{s_1, s_2, \dots, s_k\} \subseteq V$  such that  $|V_i| \leq r$  ( $i = 1, 2, \dots, k$ ) where  $V_i$  is the neighbour set of  $s_i$  ( $i = 1, 2, \dots, k$ ) 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.
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[Wik13a] Wikipedia. Content delivery network, 2013. [Online; accessed 4-September-2013].

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