Drawing Algorithms for Telecommunication Networks

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Abstract

Visualizing survivable telecommunication networks on the screen has proven to be useful and helpful for the network designers. In fact, they can easily identify rings, perceive the interaction between rings, and then rapidly spot possible problems. Given a ring cover of survivable telecommunication networks, we provide three techniques for drawing a ring cover. Our proposed algorithms produce drawings that require $O(n^2)$ area, where n is the number of nodes in the ring cover.

1. Introduction

The problem of drawing a graph in the plane has received increasing attention recently due to the large number of applications stated in [1]. The design and analysis of telecommunication network is a very important area (for more details see [2] and [3]). In this paper, we study techniques for visualizing telecommunication networks. We are motivated to design a network which (1) satisfies the traffic requirements, (2) can survives failures, and (c) the cost of the network is minimum. A network is *survivable* if it can survive the failure of a link e, that is, the removal of the link e does not disconnect the network, and the traffic that was originally supported by the link e, can be accommodated by another path. The *"Multi-Ring Architecture"* is considered to be a cost-effective survivable network because of its simplicity and improved survivability (see [4]).

2. Preliminaries

Consider a network N represented by a graph $G = (V, E)$, where V is the set of nodes representing the sites and E is a set of links representing the electrical links between nodes. A *ring* R in G is defined to be a cycle consisting of nodes $n_1, n_2, ..., n_p \in V$. For some specific rings in a network, we may have a high traffic. The network designers may decide to add more equipment to the nodes (sites) of these rings in order to increase the performance of the network. Therefore, one of the most important properties of Multi-Ring Architecture, is that rings should be easily recognizable. We focus on drawing networks on the computer screen so that properties of the Multi-Ring Architecture can easily be viewed. Similar to graph drawing, many criteria should be considered in order to enhance the readability. Usually, a general optimization method are used, i.e., minimize the crossings, the area, the number of bends (in orthogonal drawings), and the number of slopes (in polyline drawings). Readability is also our concern, because we have noticed, so far, that unnecessary crossings may create rings that do not exist in the original network. In this paper, we will address the issue of visualizing survivable telecommunication networks by presenting multi-ring architecture drawing techniques.

We define a *Ring Cover C* as a set of rings that covers all links in a network [5]. For a network N represented by a graph G, given a ring cover C, a *contact node c* is a node of G which belongs to the intersection of at least two rings of C. The *resolution* is a constant defined by the user which is considered to be the minimal distance between any two nodes in the drawing of the ring cover. The resolution rule is that the nodes must be kept far enough from each other, so that, the human eye can tell them apart. The resolution rule prevents the drawing algorithm from arbitrary scaling down the picture. The problem is defined as follows: let N be a telecommunication network represented by a graph $G = (V, E)$, where V is the set of nodes representing the sites of switches and E is a set of links representing the electrical wires or optical fiber links between nodes. Corresponding to the graph G, a $|V| \times |V|$ matrix T is defined so that: the entries $T_{i,j}$ denote the amount of traffic between the node i and the node j, where $1 \leq i, j \leq |V|$. In [5], some techniques are provided to find a ring cover in survivable networks by using the matrix T as input. Thus, for a network N, we assume that the ring cover C is given and therefore our task is to deal with the ring cover drawing. We shall present two different techniques of ring cover drawing. They take into account many criteria in order to produce layouts that are clear and easy to understand. In [6], Tollis and Xia presented three techniques of ring cover drawing. These three techniques are based on the following assumptions:

1.Any two adjacent rings share only one contact node.
2.The ring-contact node graph [6] is a tree and therefore it contains no cycles.

They proposed two open problems:
1. Drawing a ring cover when any two adjacent rings share one contact node and the ring-contact node graph is not a tree.
2. Drawing a ring cover when rings share more than one contact node.

In this paper we focus on expanding the conditions of the ring cover drawing. Our aim is to present new techniques of ring covers drawing. Our research includes the case treated in [6] where any two adjacent rings share exactly one contact node, augmented by the following contributions:
1. The ring cover contains rings that share more than one contact node.
2. The ring-contact node graph, which is considered to be the underlying structure of the ring cover is not a tree.
3. The design and the implementation of a new system for drawing telecommunication networks based on the Multi-Ring Architecture.

The following two theorems are for the inside drawing :

Theorem 1 : Given a ring cover *C* and its extended-ring-contact node tree[7], the inside drawing algorithm *InsDraw1_RadiusCalculation [7]* produces a ring cover drawing such that:
1. There are no crossings;
2. The area required by the drawing is $O(n^2)$, where n is the number of nodes in the ring cover.
3. the time complexity is $O(n + m^2)$, where n is the number of nodes in the ring cover and m is the number of the rings in the ring cover.

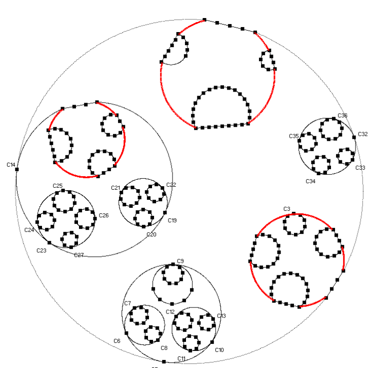

Fig.1: Snapshot of the system's screen. The case when the ring-contact graph is not a tree.

Theorem 2: Given a ring cover *C* and its ring-multi-contact node tree [7], the inside drawing algorithm *InsDraw2_RadiusCalculation* [7] produces a ring cover drawing such that :
1. there are no crossings;
2. the area required by the drawing is $O(n^2)$, where n is the number of nodes in the ring cover.
3. the time complexity is $O(n + m^2)$, where n is the number of nodes in the ring cover and m is the number of the rings in the ring cover.

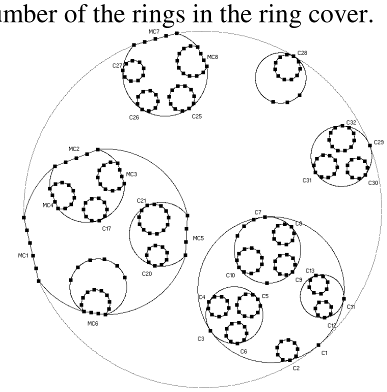

Fig. 2: The following ring cover contains rings which share more than one contact node with other rings generated by our system.

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