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Comparison of different meta-heuristics to solve the global planning problem of UMTS networks

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ABSTRACT

In this paper, we investigate and compare, through extensive simulation, the use of three meta-heuristic algorithms in order to find "good" feasible solutions for the global topology planning problem of universal mobile telecommunications system (UMTS) networks. The latter has been shown to be NP-hard as it is composed of three different subproblems (each one being NP-hard): the cell planning subproblem, the access network planning subproblem and the core network planning subproblem. As a result, we concentrate our effort on the development of approximate algorithms based on tabu search, genetic algorithm and simulated annealing. Numerical results show that these three algorithms perform relatively well. The tabu search algorithm returns the best solutions (on average, within 1.04% of the optimal solution) while the genetic algorithm seems to be slightly faster than the other two. Finally, simulated annealing finds the worst solutions (on average, within 4.91% of the optimal solution) and takes much more time than the other two algorithms.

1. Introduction

Nowadays, the universal mobile telecommunications system (UMTS) takes a very important role in the wireless communication market. Serious network planning helps network operators to plan/build their network according to the required performance with long term profitability. The primary task of the overall network planning process is the topology planning, which describes the network infrastructure and the required initial investment.

From the network infrastructure point of view, the UMTS network is composed of two parts: the radio access network (RAN), also called the universal terrestrial radio access network (UTRAN), and the core network (CN). The radio access network, which is based on the wideband code division multiple access (W-CDMA) technology, is composed of node Bs and radio network controllers (RNCs). The node B, formerly known as base station in 2G networks, houses the radio transceiver and provides the interface between the radio link and the network itself. The RNC, previously known as base station controller in 2G networks, provides connectivity between node Bs and the core network. It is also responsible for the call and mobility management and takes the full charge of radio resource management without involving the core network. The core network includes two domains: a circuit-switched (CS) domain and a packet-switched (PS) domain. On one side, the CS domain deals with real-time traffic, like voice, and provides connectivity to the public switched telephone network (PSTN). On the other side, the PS domain handles other types of traffic such as time non-sensitive services and ultimately provides a connection to the public IP network. The CN definitions are based on the 2G/2.5G network specifications. In fact, the CN makes use of the existing general packet radio system (GPRS) infrastructure, such as the mobile switching controller (MSC), the gateway MSC (GMSC), the home location register (HLR) and the visitor location register (VLR) for the CS side and the

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serving GPRS support node (SGSN) and the gateway GPRS support node (GGSN) for the PS side. A typical UMTS (release 99) network infrastructure is shown in Fig. 1.

1.1. UMTS network planning subproblems

The planning problem of UMTS networks is very complex to solve. In order to reduce its complexity, a decomposition approach is usually used. The proposed decomposition breaks down the problem into three different subproblems: the cell planning subproblem, the access network planning subproblem and the core network planning subproblem. It is important to note that each of these three subproblems is NP-hard.

The general idea behind the cell planning subproblem is to cover all mobile users in a given region with the minimum number of base stations. More precisely, the cell planning problem usually deals with one (or more) of the following item(s):

- The optimal number of base stations;
- The best location to install the base stations;
- The type/model of base stations;
- The configuration (height, orientation, tilt, power, etc.) of base stations;
- The assignment of mobile users to the base stations.

Depending on the network planner objective (and available amount of money), different goals can be achieved such as minimizing the cost, maximizing the coverage and maximizing the signal quality. However, some of these objectives are conflicting with each other. For example, maximizing the coverage may require extra base stations in order to cover a given region resulting in a cost increase. In order to find the best tradeoff, planing tools are required.

The second subproblem is the access network planning subproblem. The latter concentrates the connections and trunks the mobile traffic from the node Bs to the upper level core network [1]. Based on the cell planning results, the access network planning will cluster the node Bs into different RNC areas [2,3]. More specifically, it will determine one or more of the following aspects.

- The optimal number of RNCs;
- The best location to install the RNCs;
- The type (or model) of RNCs;
- The link topology and type between node Bs and RNCs;
- The assignment of node Bs to RNCs.

Currently, the objectives for the access network planning subproblem focus on two aspects: cost-based network topology planning and reliability-based network topology planning, which can be represented by the following three objectives.

- Minimizing the equipment and link cost;
- Minimizing handover cost;
- Maximizing the network reliability/survivability.

The core network is the center of the whole UMTS network. The traffic from mobile terminals, concentrated at the access network, will then be trunked to the core network. The core network planning subproblem deals with the following items:

- The best location to install the nodes (MGw, MSC and SGSN);
- The optimal number and the type/model of nodes;
- The link topology and the link type between the RNCs and the nodes from the core network;
- The assignment of RNCs to MSCs and SGSNs.

Usually, the main objective for the core network planning is to build a cost-efficient network that will respect the quality of service constraints [4].

Since each of the previous three subproblems is NP-hard, several exact algorithms and approximate methods

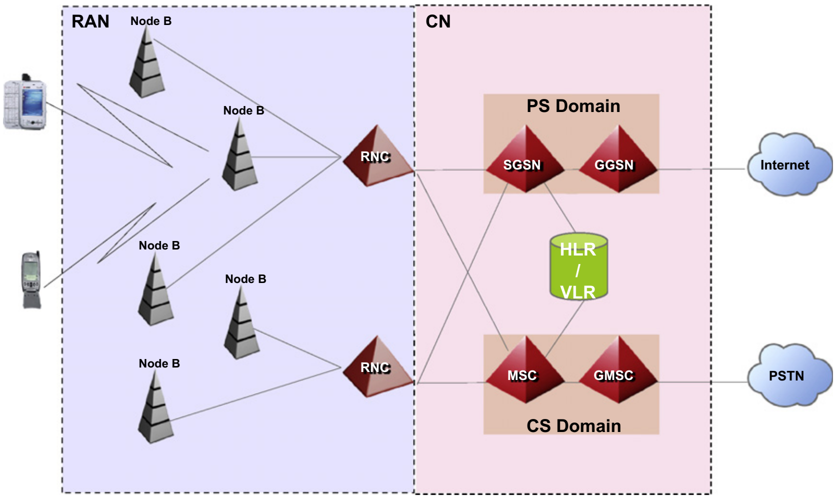

Fig. 1. UMTS network architecture.