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A tabu search algorithm for the global planning problem of third generation mobile networks

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ABSTRACT

In this paper, we propose a tabu search (TS) algorithm for the global planning problem of third generation (3G) universal mobile telecommunications system (UMTS) networks. This problem is composed of three NP-hard subproblems: the cell, the access network and the core network planning subproblems. Therefore, the global planning problem consists in selecting the number, the location and the type of network nodes (including the base stations, the radio network controllers, the mobile switching centers and the serving GPRS (General Packet Radio Service) support nodes) as well as the interconnections between them. After describing our metaheuristic, a systematic set of experiments is designed to assess its performance. The results show that quasi-optimal solutions can be obtained with the proposed approach.

1. Introduction

Before deploying or updating any cellular network infrastructures, it is crucial to carefully plan this step. Maximizing the coverage, providing a good quality of service and minimizing the cost are just a few reasons to justify an adequate planning. As a result, planning tools can be very useful for large and complex infrastructures such as the third generation (3G) universal mobile telecommunications system (UMTS) networks.

As shown in Fig. 1, UMTS networks are typically composed of two different parts: the access network and the core network. Also called universal terrestrial radio access network (UTRAN), the access network is composed of base stations (also called node Bs) and radio network controllers (RNCs). The node Bs are mainly used to transmit/receive radio frequencies to/from the mobile users (MUs). More specifically, they deal with channel coding, rate adaptation, spreading, etc. The wideband code division multiple access (WCDMA) scheme is used as the air-interface between the users and the base stations. The latter is using the direct sequence CDMA (DS-CDMA) to provide higher speed (up to 2 Mb/s) and support more users compared to previous network generations. In WCDMA, the information sent is spread over a wideband of around 5 MHz. The RNCs deal with resource and mobility management (load balancing, admission control, code allocation, etc.) as well as concentrating and forwarding the traffic to the core network.

As depicted in Fig. 1, the core network is also subdivided in two different parts. These two parts inherit from previous network generations (see Table 1). In fact, the circuit switched network is the heritage of the global system for mobile communications (GSM) architecture while the packet switched network is the legacy of the general packet radio system (GPRS) infrastructure. In terms of equipment and utility, the circuit switched part is composed of mobile switching centers (MSCs)

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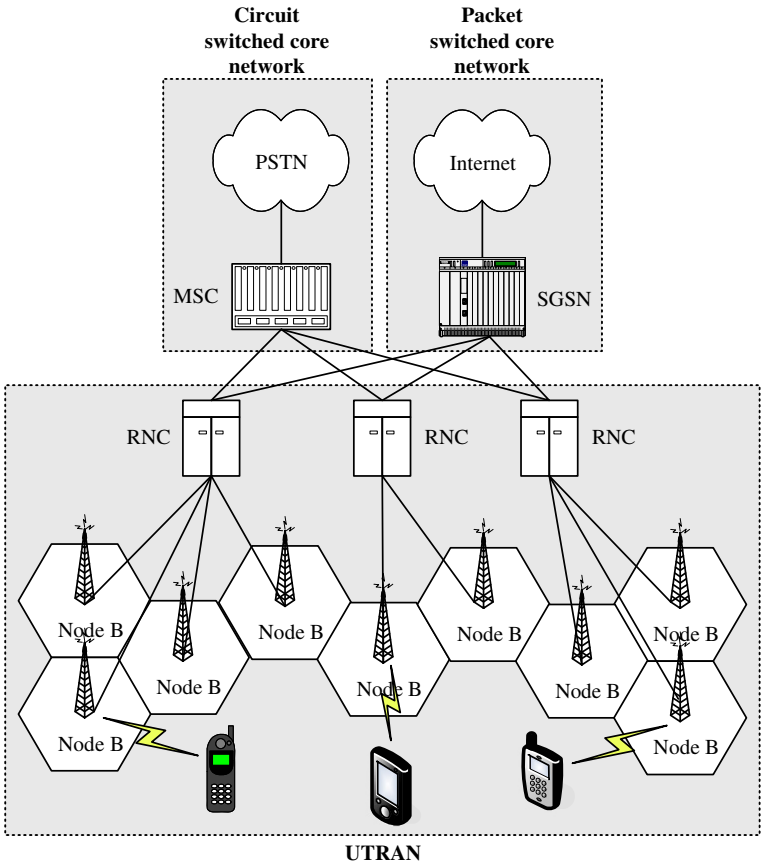

Fig. 1. The UMTS network architecture.

Table 1
Cellular network evolution

	2G	2.5G	3G
Main standard	GSM	GPRS	UMTS
Access technology	TDMA	TDMA	WCDMA
Speed (kb/s)	9.6	171.2	2000
Type of traffic	Voice	Voice and data	Voice and data

and provide access to the public switched telephone network (PSTN) while the packet switched part is composed of serving GPRS support nodes (SGSNs) and provides access to the Internet.

The UMTS network planning problem has been widely studied in the literature. In fact, several models and exact/approximate algorithms have been proposed to solve these problems. However, the majority of these studies only focus on a portion of the overall problem. Therefore, it is common to find papers about the different subproblems such as the cell, the access network and the core network planning subproblems. The following describe the technological aspects and the main challenges that need to be considered when planning each subproblem:

- *The cell planning subproblem*: When planning the radio part, the most important task is to consider the coverage and the capacity. In order to do that, we need to do an analysis of the radio links. This include the use of a propagation model and different link budget parameters. The goal is to find the optimal location of the sites, the antenna height, the tilt, the orientation, etc. Another important task is the radio resource management. This involves the admission control, the power control and handovers. In order to carefully plan these tasks, it is important to have an accurate prediction of the number of users. The most interesting papers about this subproblems are Amaldi et al. [1,2] and Thiel et al. [16].
- *The access network planning subproblem*: In general, when planning the access network, we first need to configure the network elements (RNC). This include, but not limited to, the location, the number and the capacity of equipment needed. Then, we need to consider the notion of homing (single or double) which state how the base stations will be linked to