

Chapter XII

Dynamic Channel Allocation in Cellular Communications Networks

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ABSTRACT

This chapter presents a description and performance evaluation of an efficient Distributed Artificial Intelligence (DAI) Dynamic Channels Allocation (DCA) scheme. Therefore, it is referred to as DAI-DCA scheme. It can be used for channel allocation in high traffic cellular communication networks (CCNs), such as the global system for mobile communication (GSM). The scheme utilizes a well-known DAI algorithm, namely, the asynchronous weak-commitment (AWC) algorithm, in which a complete solution is established by extensive communication among a group of neighboring collaborative cells forming a pattern, where each cell in the pattern uses a unique set of channels. To minimize communication overhead among cells, a token-based mechanism was introduced. The scheme achieved excellent average allocation efficiencies of over 85% for a number of realistic operation scenarios.

INTRODUCTION

The use of Cellular Communications Networks (CCNs) is experiencing revolutionary growth throughout the world, the growth is fuelled by: expansion of CCN, progress in data communica-

tions, spectacular development of the Internet, diversity of applications and offered services, etc. CCNs offer a number of advantages over alternative solutions, such as: increased capacity, reduced power usage, better coverage area, increased local availability, low cost, and ease of maintainability (Abeyesundara 2005, Salmenkaita 2001).

One of the main challenges that faces and limiting further expansion in CCNs uses is scarcity of channels in CCNs. This comes from: finite spectrum, low channel capacity, and electromagnetic interferences and multi-path fading. Furthermore, in CCNs, a channel c can be used by a cell i without any interference (co-channel) if it is not concurrently used by any other cell at a limited distance from cell i (called minimum reuse distance). Also, for better Quality-of-Service (QoS) and to minimize adjacent channels interference, channels adjacent to c should not be used within cell i or any of its first-hop neighbors. Therefore, it is essential to devise suitable solutions for allocating channels to cells so as to efficiently utilize the scarce resources, to eliminate channel interferences, and to satisfy any other network operation environment and demand. In addition, solutions should meet the main design objectives, such as: minimum channel acquisition time, minimum number of denied or failed calls, minimum control message complexity, minimum communication overheads, and minimum network interruption (Stallings 2005).

A number of techniques have been developed to combat impairments in rapidly varying radio channels and to obtain high spectral efficiencies in CCNs (Kostic 2002, Kostic 2001). Some of those are channel coding and interleaving, adaptive modulation, transmitter/receiver antenna diversity, spectrum spreading, and channel allocation. In general, channel allocation techniques in CCNs can be static, dynamic, or hybrid. Dynamic Channel Allocation (DCA) techniques provide better utilization of the channels at higher traffic loads albeit at the cost of higher acquisition time and some additional control messages. There are mainly two types of DCA schemes, these are: Centralized DCA (CDCA) and Distributed DCA (DDCA). However, these techniques also have their own drawbacks and limitations, such as: slow convergence, infinite loop, high communication overheads, etc (Modi 2001).

It is believed that more efficient and reliable techniques for DCA in CCNs can be developed based on Distributed Artificial Intelligence (DAI) techniques. In this chapter, we introduce, develop, and evaluate the performance of a DCA technique that convenes all requirements and constraints imposed by the user, service providers, and technology of CCNs. The technique is based on a well-know DAI algorithm, namely, the Asynchronous Weak-Commitment (AWC) algorithm. The AWC algorithm is, in turn, based on a formalism that is widely used for various application problems in DAI, called Distributed Constraint Satisfaction Problem (DCSP) (Yokoo 2000, Yokoo 1998).

In order to minimize the data communication overheads of the AWC algorithm, a token-based mechanism is introduced, in which a token is circulating between a group of collaborative cells passing information about the channels that are allocated or in operation within each cell. In addition, the token controls the channels allocation process by only allowing the cell that hold the token to update its channels. The algorithm is characterized by its minimum channel acquisition time, minimum number of denied or failed calls, minimum control message complexity, minimum communication overheads, and minimum network interruption.

CELLULAR COMMUNICATIONS NETWORKS (CCNS)

CCNs are considered as one of the most popular and spreading applications for wireless networks; and during the last two decades CCNs have shown a huge revolutionary growth and a rapid development. The essence of a CCN is the use of multiple low-power transceivers, and because of the limited-range of such transceivers, the network area is divided into small areas (cells). Thus, a CCN is a radio network made up of a number of

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