Reuse partitioning in cellular networks with dynamic channel allocation

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Great interest in recent years has been devoted to mobile communications. The research effort has been directed to increasing the capacity of radio systems by applying space reuse techniques. Higher efficiency in the usage of the available frequency spectrum can be obtained either by reducing the cell size, thus requiring the provision of new base stations, or by reusing the available spectrum more efficiently without cell size reduction. In this paper we present a dynamic frequency allocation algorithm for cellular networks that exploits a given reuse pattern. The performance of the proposed scheme, in terms of blocking probability, is evaluated by means of computer simulations both when the position of the mobiles remains unchanged and when mobility is taken into account, under both uniform and hot-spot traffic. The numerical results show that the capacity of the proposed scheme is sensibly higher than that of a dynamic channel allocation without reuse partitioning. The effects of both user mobility and reuse partitioning on the signalling load are also considered.

1. Introduction

The demand for mobile telephone services is expected to grow rapidly. Increasing the capacity of modern cellular systems, i.e., the number of subscribers per unit of area handled at some minimum quality of service, is one of the main issues for the research about these systems. In this direction the key role is played by the limited radio spectrum available. The cellular concept (see [16]) represents a milestone for the efficient use of the radio spectrum. In a cellular mobile system, the service area is divided into a number of small sub-areas named *cells*. Radio bandwidth is divided in orthogonal channels (frequency channels or time slots). The system allows communication on a given channel in a certain cell and further allows the same channel to be reused in a number of different cells without unacceptable co-channel interference, as long as there is a sufficient distance (*reuse distance*) between the co-channel cells. The reuse distance depends both on the cell radius R and on the minimum SIR (Signal-Interference Ratio) allowed, which determines the ratio D/R [15].

To increase the capacity of the system, three different approaches can be followed: reducing the cell size (i.e., R), enhancing the freqeuncy reuse and optimizing the frequency allocation policy. The first method has the drawback of requiring the increase of the number of base stations proportionally to the requested capacity growth.

The enhancement of the frequency reuse requires the reduction of the reuse distance D. Since the D/R ratio depends on $\mathrm{SIR}_{\mathrm{min}}$, the reduction of D can be achieved either accepting a lower $\mathrm{SIR}_{\mathrm{min}}$ or reducing R. A lower $\mathrm{SIR}_{\mathrm{min}}$ can be accepted if more efficient and robust modulation and coding methods are developed. On the other hand, lowering R without increasing the number of base stations results in an unacceptable radio signal quality in the outermost region of the cells. Nevertheless, it is possible to enhance in such a manner the reuse of a subset only of the available frequencies. The method is referred to in the literature as *reuse partitioning* [7,9,12,23,24]. The underlying principle of reuse partitioning is that a channel that is used by mobiles close to their respective base stations is generally received with a higher power level than a channel used by more distant mobiles. Thus closer users can tolerate a higher co-channel interference level and their channel may be reused according to a smaller reuse distance.

With regard to the allocation policies we can effectively classify them [20] into three categories: fixed strategies, flexible strategies and dynamic strategies. The common concept in all fixed assignment strategies or FCA (*Fixed Channel Allocation*) is the permanent allocation of a set of radio carriers to each cell. In the basic FCA a call attempt in a cell can only be served if there is an idle channel among those available on the carriers preassigned to the cell. In the technical literature some works [4,5,25] deal with optimizing the distribution of radio resources among the cells considering different network scenarios and performance indices. Some other works [10,11,21,22] study borrowing techniques that can be considered variations of the basic fixed assignment scheme. Fixed assignment schemes have been shown to be effective in systems with high and constant loads. However, they fail to provide high capacity under non-stationary traffic due to users mobility.

The key idea of the dynamic strategies, or DCA (*Dynamic Channel Allocation*), is to perform a real-time radio resource allocation based on the actual cell conditions, instead of relying on a priori information. Several implementations of this concept have been proposed and studied in previous works [1–3,6,17,26].

In this paper we present a DCA algorithm for a cellular network where a first-order reuse partitioning is exploited.