Radio Resource Management in Mobile Cellular Networks

Abstract

It has been predicted that the introduction of **G**eneral **P**acket **R**adio **S**ervice (GPRS), and ultimately **U**niversal **M**obile **T**elecommunications **S**ystem (UMTS), will stimulate demand for transmission of data over wireless networks, as the speed and diversity of the mobile services offered increase significantly. Future customers will use their mobile devices in the same way as they use desktop computers now and will, therefore, require very similar bandwidth and **Q**uality **o**f **S**ervice (QoS) performance. This growth in demand, coupled with the limited bandwidth of the mobile air interface, could result in shortage of radio resource capacity. For this reason, a mobile service provider needs good **R**adio **R**esource **M**anagement (RRM) techniques for an optimal use of the available resources and to recuperate the fixed investment, made for the network infrastructure. In mobile cellular communications, users are connected to network access points through radio channels, which is the least scalable resource. So, an efficient use of this resource will help a service provider earn more revenue for a given investment. This can be achieved by proper pre-deployment and post-deployment RRM strategies. In pre-deployment RRM, the prime objective is to achieve an efficient utilization of control and traffic channels, and, in post deployment RRM, the objective is to reduce the idle resources while increasing revenue earned.

A major control channel overhead for providing services to the mobile users in **G**lobal **S**ystem for **M**obile communication (GSM) network comes from the location management. Paging and location update are the two important processes used by the GSM network for location management. Whenever a call arrives for a mobile terminal, **M**obile **S**witching **C**enter (MSC) has to locate it before forwarding the call. MSC does it by raising paging signals in a set of cells through their base stations. The size of the paging area depends on the frequency of location update performed by a mobile terminal. In location update process, a mobile terminal updates the information about its current location area, maintained at MSC levels. Both paging and location update use some amount of network resource. The cost of the location update and paging depends on the location area planning. This location area planning is the problem of grouping cells into location areas and is popularly known as **C**ell to **S**witch **A**ssignment (CSA) problem in literature. The CSA problem can be fomulated as a combinatorial optimization problem and known to be NP-hard. We have proposed a **T**otal **C**ost of **O**peration (TCO) minimizing state space search formulation and a heuristic for CSA to solve it by heuristic search techniques, namely **I**terative **D**eepening **A*** (IDA*) and **B**ock **D**epth **F**irst **S**earch (BDFS). The TCO includes both recurring inter-location area handoff (registration) cost and amortized fixed cost. This study would help a service provider to reduce the control channel overhead considerably.

Higher utilization of traffic channels necessitates an efficient re-use. The basic constraint on re-use of radio channels is the interference from the environment or from other mobile devices. Interfering mobile devices may reside in the same cell or may reside in the adjacent cells. Thus, a cell can use only a subset of channels such that interference to a channel by another channel is within the acceptable limit. An efficient **C**hannel **A**llocation (CA) scheme can reduce these interferences, thereby increasing the channel utilization. CA is an NP-hard problem. We have formulated it as a **F**ixed **C**hannel **A**llocation (FCA) problem. In FCA schemes, a set of channels is assigned permanently to each cell satisfying interference constraints. We have formulated a state space for the FCA and developed a lower-bound (admissible) heuristic to solve it using the techniques, namely, IDA* and BDFS. This study would help a service provider in planning radio resource in pre-deployment stage and also in re-allocating channels online in case of a changed pattern of demands in the cells of a cellular network.

A **D**ynamic **D**ifferentiated **P**ricing **S**trategy (DDPS) could be used effectively to regulate demand, whilst offering a sensible means for the joint optimization of network utilization and service provider's revenue. Differentiated service will help a service provider serve its customers economically. In dynamic pricing, tariff varies according to the system's resource utilization. A high tariff rate is fixed during the peak demand period and low tariff rate during the off-peak demand period. This would help the service provider to reduce the idle network capacity during off-peak demand period. As a result, it encourages a more efficient use of available network capacity, and improving both the provided QoS and network provider's revenue.