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QoS Performance Bounds and Efficient Connection Admission Control for Heterogeneous Services in Wireless Cellular Networks

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Abstract. Quality-of-Service (QoS) performance and connection admission control (CAC) for heterogeneous services in wireless multiple access networks are investigated. The heterogeneous services include constant bit rate (CBR), variable bit rate (VBR) and available bit rate (ABR) services. Multiple access control is handled by a polling-based scheme with non-preemptive priority. Tight delay variation (jitter) bounds for CBR connections and delay bounds for VBR connections are derived. A CAC scheme based on the derived bounds is developed. The CAC makes use of user mobility information to reserve an appropriate amount of system resources for potential handoff connections to achieve low handoff connection dropping rate (HCDR). Simulation results show that the proposed CAC scheme can achieve both low HCDR and high resource utilization.

Keywords: cellular networks, Quality-of-Service, multiple access control, performance bound, connection admission control

1. Introduction

The internetworking of broadband wireline networks and wireless cellular networks is expected to provide adequate multimedia service support for mobile users anywhere at anytime. Because of user mobility, limited radio frequency spectrum, radio channel impairment, etc., how to efficiently utilize the precious radio resources and provide more users with guaranteed Quality-of-Service (QoS) levels becomes a challenging issue in the wireless segment of the integrated networks. Connection admission control (CAC) is to make a decision about whether a connection should be admitted or not, and has effects on both the system resource utilization and the QoS provided to the users. QoS performance bounds, such as the maximum delay or delay variation (jitter) experienced by a connection if it is admitted in the system, may be used as the basis for making the admission decision. A CAC scheme based on QoS provisioning by using tight performance bounds can achieve more accurate resource allocation and improve the system resource utilization. A polling-based multiple access control scheme with non-preemptive priority is proposed in [1] and a slightly different version is in [2]. With these schemes, sufficient conditions are derived for all the constant bit rate (CBR) connections to satisfy their jitter constraints and all the variable bit rate (VBR) connections to satisfy their delay constraints in both [1] and [2]. However, these bounds are too conservative to be used in practical systems.

User mobility is a special issue in cellular networks. To efficiently utilize the limited radio spectrum and maximize the system capacity, the cell size of future cellular networks tends to be smaller. As a result, frequent handoffs may occur during a connection's lifetime. When a connection requests to handoff to a new cell, sufficient resource must be available in the cell in order to accept the handoff connection and maintain a continuous connection. Because interrupting an on-going connection is much more undesirable than refusing to admit a new connection from the user's point of view, admission decisions should give a higher priority to a handoff connection than a new request. The higher priority can be achieved by reserving a certain amount of system resources for handling potential handoff connections. By doing so, lower handoff connection dropping rate (HCDR) than the new connection blocking rate (NCBR) can be achieved. Different approaches have been proposed in the literature to do the resource reservation. The *Guard channel* approach is proposed in [3], where a fixed amount of resource is reserved for handoff connections. The *Virtual connection tree* (VCT) approach is proposed in [4] to support high rate handoffs in wireless ATM networks. The VCT is a group of pre-established connections between a fixed switch and a set of base stations (BSs) with which the mobiles could potentially associate. Each of the BSs in the VCT reserves 100% resources for each of the connections in the VCT. A mobile can freely handoff to any cell within the VCT without being subject to a further admission control. However, the resource utilization is relatively low for both guard channel and VCT approaches due to the potential waste of the reserved resource. The *shadow cluster* approach is proposed in [5]. A shadow cluster is a set of BSs that a mobile may influence in the near future and is updated based on the user mobility information. The influence area moves along with the mobile, like a shadow. As the mobile moves, new BSs which are within the mobile's new influence area are included in its shadow cluster, while the old ones which are out of the influence area are removed from the shadow cluster. The shadow cluster concept is used in the CAC scheme in [5] to predict the resource demand for homogeneous services in the near future and to reserve resources accordingly.

In general, admission decisions in wireless cellular networks are made to ensure guaranteed QoS for heterogeneous traffic, while maintaining high resource utilization and low