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A Unified Architecture for the Design and Evaluation of Wireless Fair Queueing Algorithms

THYAGARAJAN NANDAGOPAL
Coordinated Science Laboratory, University of Illinois at Urbana-Champaign, USA

SONGWU LU
Department of Computer Science, University of California at Los Angeles, USA

VADUVUR BHARGHAVAN
Coordinated Science Laboratory, University of Illinois at Urbana-Champaign, USA

Abstract. Fair queueing in the wireless domain poses significant challenges due to unique issues in the wireless channel such as location-dependent and bursty channel errors. In this paper, we present a *wireless fair service* model that captures the scheduling requirements of wireless scheduling algorithms, and present a *unified wireless fair queueing architecture* in which scheduling algorithms can be designed to achieve wireless fair service. We map seven recently proposed wireless fair scheduling algorithms to the unified architecture, and compare their properties through simulation and analysis. We conclude that some of these algorithms achieve the properties of wireless fair service including short-term and long-term fairness, short-term and long-term throughput bounds, and tight delay bounds for channel access.

Keywords: wireless scheduling, fair queueing, wireless networks, wireless fair service

1. Introduction

The growing use of wireless networks has brought the issue of providing fair wireless channel arbitration among contending flows to the fore. The wireless channel being a critical scarce resource, it is imperative to provide both short-term and long-term fairness in channel access since providing only best effort service can result in channel starvation for some contending stations for long periods of time. In wireline networks, *fluid fair queueing* has long been a popular paradigm for achieving instantaneous fairness and bounded delays in channel access. However, adapting wireline fair queueing algorithms to the wireless domain is non-trivial because of the unique problems in wireless channels such as location-dependent and bursty errors, channel contention, and joint scheduling of uplink and downlink flows in a wireless cell.

In the past few years, several wireless fair queueing algorithms have been developed [2,6–10], that provide varying degrees of short-term and long-term fairness, short-term and long-term throughput bounds, average case and worst case delay bounds, and graceful degradation for flows in the presence of channel error. However, there has not been any work to precisely characterize the desired service model in terms of a *wireless fair service*, and define a *unified wireless fair queueing architecture* to achieve wireless fair service. This is important for two reasons: (a) it provides a single framework in which to compare different wireless fair queueing algorithms and evaluate tradeoffs between these algorithms head-to-head, and (b) it serves as an architectural framework in which to develop new wireless scheduling algorithms. Given the emerging importance of wireless fair queueing and the diversity of contemporary wireless fair queueing algorithms proposed in the literature, we believe that such a study is overdue. To this end, this paper makes three contributions:

1. We present a *wireless fair service model* that captures the scheduling requirements in the wireless domain.
2. We present a *unified wireless fair queueing architecture* that serves as a framework to design wireless fair queueing algorithms. We then map seven recently developed wireless fair queueing algorithms onto this unified framework. These algorithms are: Channel State Dependent Packet Scheduling algorithm (CSDPS) [2], Idealized Wireless Fair Queueing algorithm (IWFQ) [6], Channel Independent Fair Queueing algorithm (CIF-Q) [8], Server Based Fairness algorithm (SBFA) [9], Wireless Fair Service algorithm (WFS) [10], a variant of IWFQ called Wireless Packet Scheduling algorithm (WPS) [6], and an enhancement of CSDPS that provides class based queueing (CBQ-CSDPS) [7].
3. We evaluate and compare the seven algorithms mentioned above via both simulation and analysis. Based on our evaluation, we conclude that two of these algorithms, WFS [10] and CIF-Q [8], achieve all properties of wireless fair service in the general case.

The rest of this paper is organized as follows. In section 2, we describe the channel model, the wireless fair service model, and the key issues in wireless fair queueing. In section 3, we present the unified architecture for wireless fair queueing. In section 4, we map the seven wireless fair queueing algorithms as instantiations of the generic architecture. In