D I S S E R T A T I O N D E F E N S E

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Ad Slotting and Pricing: New Media Planning Models for New Media

This thesis focuses on the planning, scheduling, and pricing of ad slots in technology-enabled modes of advertising, including webpage banner ads, video games, electronic outdoor billboards, and the next generation of digital TV. This work contributes to practice by being the first academic work to rigorously study the scheduling of dynamic in-game advertising; contributes to the body of theory by formally studying the aggregation of audience segments using duality theory; generates managerial insights for directing pricing strategy; and makes numerous modeling contributions, hence the title: New Media Planning Models for New Media. A synopsis of the three main chapters follows.

Chapter 1: ”Scheduling of Dynamic In-Game Advertising"

Dynamic in-game advertising is a new form of advertising in which ads are served to video game consoles in real-time over the Internet. We present a model for the in-game ad scheduling problem faced by Massive Inc., a wholly-owned subsidiary of Microsoft, and a leading global network provider of in-game ad space. Our model has two components: 1) a linear program (solved periodically) establishes target service rates, and 2) a real-time packing heuristic (run whenever a player enters a new level) tracks these service rates. We benchmark our model against Massive's legacy algorithm: When tested on historical data, we observe 1) an 80-87\% reduction in make-good costs (depending on forecast accuracy), and 2) a shift in the age distribution of served ad space, leaving more premium inventory open for future sales. As a result of our work, Massive has increased the number of unique individuals that see each campaign by on average 26\% per week, and achieved 33\% smoother campaign delivery, as measured by standard deviation of hourly impressions served.

Chapter 2: “Planning of Guaranteed Targeted Display Advertising"

As targeted advertising becomes predominant across a wide variety of media vehicles, planning models become increasingly important to ad networks that need to match ads to appropriate audience segments, provide a high quality of service (meet advertisers' goals), and ensure opportunities to serve advertising are not wasted. I define Guaranteed Targeted Display Advertising (GTDA) as a class of media vehicles that include webpage banner ads, video games, electronic outdoor billboards, and the next generation of digital television, and formulate the GTDA planning problem as a transportation problem with quadratic objective. By modeling audience uncertainty, forecast errors, and the ad server's execution of the plan, I derive sufficient conditions for when a specific quadratic objective is a good

surrogate for several ad delivery performance metrics. Moreover, the quadratic objective allows the construction of duality-based bounds for evaluating aggregations of the audience space, leading to two efficient algorithms for solving large problems: the first intelligently refines the audience space into successively smaller blocks, and the second uses scaling to find a feasible solution given a fixed audience space partition. A little bit of disaggregation goes a long way: near-optimal schedules can often be produced despite significant aggregation.

Chapter 3: “Pricing of Guaranteed Targeted Display Advertising"

This chapter focuses on the bundling and pricing of targeted audience segments when delivery of impressions is guaranteed. Fundamental components of the GTDA pricing problem are modeled: the cost of guaranteeing delivery, advertisers' spending targets, capacity constraints, and advertisers' heterogeneous preferences. We study the pricing problem from the perspective of a single monopolistic firm selling advertising space from two audience segments to two heterogeneous advertisers. The key bundling and pricing question is whether the seller should always agree to sell any bundle of inventory that an advertiser requests, or steer advertisers toward purchasing broader bundles of ad inventory in order to accommodate capacity-related costs. In this context, we study two models. The first assumes that advertisers will buy as much advertising as they can afford, while the second assumes each advertiser purchases an amount of advertising equal to their spending target. We characterize the space of optimal solutions in each and provide managerial insights.