Chapter 5
Decision-Making Elements for the Design of Emerging Multi-Dimensional Auctions

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ABSTRACT
Auctions have known considerable and continuous growth during the past decades due to their logic and efficiency in price formation when the value of goods traded is not known or varies. Although earlier research has been based mainly on Microeconomics and Games Theory, recent advances extended relevant research in Operational Research and Information Technology. Today, auctions and their applications form a challenging topic not only for economists but for operational researchers, marketers, logisticians and management engineers. This paper examines contemporary emerging auction formats, including auctions in which bids consist of many other parameters. The study of these emerging auction formats proceeds through the analysis of critical auction parameters that directly affect the decision-making process and the problems that auction participants face. This paper presents, with a presentation in graphical form, the decision framework for the majority of approaches presented in contemporary literature to highlight the association between decision elements and auction design.

INTRODUCTION
The evolution of auctions over the years has been greatly assisted by the progress of information technology and the internet. The ability to exchange information in real-time, over long distances and to develop virtual auction environments where evaluation criteria are incorporated and decisions are obtained automatically, are only some of the factors that have boosted the more systematic investigation and implementation of more complex auction schemes than the so-called traditional ones. The need to define herein a “traditional” auction scheme is essential in setting a
benchmark for what will be called an “advanced” or “emerging” auction; yet, this definition is not a confining one and has a chronological flavor, since several of the schemes that have received attention recently have been first presented even in the very early works in auctions, at least as theoretical concepts. In this context, the term “traditional” or “classic” auction will be used to refer to single-unit, single-item, single-attribute (or single-criterion) that are conducted according to the English, Dutch, FPSB or Vickrey schemes. All other auction types that divert from this definition will be considered as advanced.

The present paper is focusing on auctions where bids consist of many parameters beyond price and auctions of multiple identical or complementary objects. The scope of the work is manifold: first, it serves as an extensive review of recent literature for emerging complex auction formats. Second, it provides a coherent analysis of these formats and the special design parameters. Last but not least, it is focusing on the decision-making problems the auction participants face before, during and after the auction process. The aim of the article is not to evaluate the efficiency of the models that researchers have presented through the years, neither to assess the computability, convergence to the equilibrium or other mechanism characteristics in these models. Rather, the article focuses on collecting and categorizing these scientific efforts, and on decoding these models with respect to their inherent decision making attributes. The article culminates with the presentation of three decision models that help the auctioneer and bidder in shaping their strategy for any multi-dimensional auction. The nature of this work maintains the characteristics of a research paper; however, it employs a significant part of survey work, since this serves as the foundation for building the decision making schemes.

This paper is organized as follows. In the first section, a brief description of emerging auctions is presented dealing with multi-attribute, multi-unit, multi-item, and combinatorial auctions. For each of these types, a review of decision problems and methods stated in the literature follows. Where appropriate, a graphical systematic formulation and depiction of approaches is attached so as to serve as a systematic and comprehensive formulation scheme. The final section summarizes the problems an auction-designer faces while planning an auction setting.

AN OVERVIEW OF AUCTIONS

The main participants and decision makers in any auction are the buyer(s), the seller(s) and the auctioneer; the latter is typically an independent entity. Buyers and sellers, depending on the environment an auction is conducted, may either have the role of an initiator (the one who initiates the auction in order to buy or sell a good) or that of a bidder (the one who makes an offer). In the so-called forward auctions, the seller acts as the initiator while a buyer is the bidder; in reverse auctions in the contrary, a buyer acts as the initiator while a seller is the bidder.

Auctions may be distinguished between single-good and combinatorial auctions, depending on the nature of the object of trade. An auction is called a single-good auction if the object of the trade is of the same type. An auction is called combinatorial if the object of the trade concerns (positively or negatively) inter-related goods of different types, characteristics or functionalities. In both cases, the number of units for the good(s) under auction helps in characterizing the auction as single-unit or multi-unit.

Auctions may further be distinguished between single-attribute and multi-attribute auctions, depending on the number of attributes (or criteria) used for the evaluation of a bid. In single-attribute auctions, a unique criterion is used to evaluate the bid; typically, this criterion is the bid price. In multi-attribute auctions, on the other hand, several criteria may be used for the evaluation of the bid, which are often combined to produce a value for the bid.