Chapter 21
A Fuzzy Real Option Model to Price Grid Compute Resources

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ABSTRACT

A computational grid is a geographically dispersed heterogeneous computing facility owned by dissimilar organizations with diverse usage policies. As a result, guaranteeing grid resources availability as well as pricing them raises a number of challenging issues varying from security to management of the grid resources. In this chapter we design and develop a grid resources pricing model using a fuzzy real option approach and show that finance models can be effectively used to price grid resources.

INTRODUCTION

Ian Foster and Carl Kesselman (I. Foster & Kesselman, 1999) describe the grid as an infrastructure that provides a dependable, consistent, pervasive, and inexpensive access to high-end computational capabilities that enable the sharing, exchange, selection, and aggregation of geographically distributed resources. A computational grid is analogous to an electrical power grid. In the electric power grid, electrical energy is generated from various sources such as coal, solar, hydro or nuclear. The user of electrical energy has no knowledge about the source of the energy but only concerned about availability and ubiquity of the energy. Likewise, the computational grid is characterized by heterogeneous resources (grid resources) which are owned by multiple organizations and individuals. The grid distributed resources include but not limited to CPU cycles, memory, network bandwidths, throughput, computing

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power, disks, processor, software, various measurements and instrumentation tools, computers, software, catalogue data and databases, special devices and instruments, and people/collaborators. We describe the grid compute resources as grid compute commodities (gccs) that need to be priced. This chapter focuses on the design and development of a grid resource pricing model with an objective to provide optimal gain (profitability wise) for the grid operators and a satisfaction guarantee measured as Quality of Service\(^1\) (QoS) requirements for grid resource users and resources owners through a regulated Service Level Agreements\(^2\) (SLAs)-based resource pricing. We design our pricing model using a discrete time numerical approach to model grid resources spot price. We then model resources pricing problem as a real option pricing problem. We monitor and maintain the grid service quality by addressing uncertainty constraints using fuzzy logic.

In recent times, research efforts in computational grid has focused on developing standard for grid middleware in order to provide solutions to grid security issues and infrastructure-based issues (I. T. Foster, Kesselman, Tsudik & Tuecke, 1998), and grid market economy, (Schiffmann, Sulistio, & Buyya, 2007). Since grid resources have been available for free there has been only little effort made to price them. However, a trend is developing due to large interest in grid for public computing and because several business operatives do not want to invest in computing infrastructures due to the dynamic nature of information technology, there is expected to be huge demand for grid computing infrastructures and resources. In the future, therefore, a sudden explosion of grid usage is expected. In anticipation to cope with the sudden increase in grid and grid resources usage, Amazon has introduced a Simple Storage Service (S3) (Palankar, Onibokun, Iamnitchi, & Ripeanu, 2007) for grid consumers. S3 offers a pay-as-you-go online storage, and as such, it provides an alternative to in-house mass storage. A major drawback of the S3 is data access performance. Although the S3 project is successful, its current architecture lack requirements for supporting scientific collaborations due to its reliance on a set of assumptions based on built-in trusts.

**BACKGROUND**

A financial option is defined (see, for example (Hull, 2006)) as the right to buy or to sell an underlying asset that is traded in an exchange for an agreed-upon sum. The right to buy or sell an option may expire if the right is not exercised on or before a specific period and the option buyer forfeits the premium paid at the beginning of the contract. The exercise price (strike price) specified in an option contract is the stated price at which the asset can be bought or sold at a future date. A *call option* grants the holder the right to purchase the underlying asset at the specified strike price. On the other hand, a *put option* grants the holder the right to sell the underlying asset at the specified strike price. An *American option* can be exercised at any time during the life of the option contract; a *European option* can only be exercised at expiry. Options are derivative securities because their value is a derived function from the price of some underlying asset upon which the option is written. They are also risky securities because the price of their underlying asset at any future time may not be predicted with certainty. This means the option holder has no assurance that the option will be *in-the-money* (i.e., yield a non-negative reward), before expiry.

A real option provides a choice from a set of alternatives. In the context of this study, these alternatives include the flexibilities of exercising, deferring, finding other alternatives, waiting or abandoning an option. We capture these alternatives using fuzzy logic (Bojadziew & Bojadziew, 1997) and express the choices as a fuzzy number. A Fuzzy number is expressed as a membership function that lies between