Use of the Cournot Model for the pricing of Grid-based Computational Services

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October 23, 2005

Abstract

The Grid is a form of distributed computing that enables individuals and firms to have access to remote computing resources. The concept is often associated with that of the Electrical Grid where electricity is readily available by only the flick of a switch. The hope is that soon the Computational Grid will be able to achieve a similar level of abstraction as the Electrical Grid.

One of the areas that require a considerable amount of research is the *Grid Market*. The latter refers to the mechanisms by which people can trade their computing resources on the Grid. The literature in Economics is filled with descriptions of various economic models and market forms that can be applied to the Grid. However, the task of finding the most convenient one is made complicated by the number of factors that need to be taken into consideration.

The Global Grid Forum (GGF) has formed a special working group, called the Grid Economic Services Architecture (GESA) to look into issues pertaining to the Grid Market. However, as the name suggests, GESA is only responsible for defining "... an open extensible economic service architecture to enable the provision and consumption of Grid Services, (...) to enable a variety of economic models with these services but not to explore the economic models themselves. ". Hence, GESA is building the tools and providing the framework for trade on the Grid, without regards to the way the transaction is likely to take place.

The various other research that has been carried out on the Grid Market took a similar approach. Hence, previous research on this topic have focussed on finding an architecture that is generic enough to accommodate various economic models. However, a different approach can be taken where an economic model is associated with the Grid Market to begin with. This can give an insight into the prices that may be charged for Grid Services. The chosen model in this investigation is known as the Cournot model.

The Cournot Model is one of the popular pricing models used to study oligopolies. An *oligopoly* is the name given to a market which is dominated by a small number of sellers. Because there are only a few participants in this type of market, each oligopolist is not only aware of the actions of others but also influence, and is influenced by, the decisions of others. The electricity market is an oligopoly and because of the assumed similarity with the Grid Market, it seems natural to characterise the latter as an oligopoly, and use the Cournot Model to analyse it.

Cournot's model is essentially the direct predecessor of Nash's equilibrium concept in Game Theory. It deals with agents making simultaneous optimal choices based on assumptions about the behaviour of the other agents. The disequilibrium behaviour involves each firm observing the output of others and then choosing a new output level, assuming that the other firm will stay at its observed output level.

A Cournot analysis refers to an investigation into the oligopolistic behaviour of firms that are making quantity choices in a market where the consumers are represented by an aggregate demand function. Each firm is assumed to observe the other firm's output before choosing a new supply level based on the conjecture that the other firm stays at the observed output level. The strategy space for each player is assumed to be the same and actions are chosen simultaneously.

The market price is determined by the total output produced by all firms in the industry. No individual firm directly controls the market price and all firms receive for their products exactly the same market price. Cournot assumes that the products produced by all the firms are similar and all outputs appear on the market simultaneously. The Cournot model also assumes that the market price per unit of output is a decreasing function of the total output produced by all firms. This implies that as one firm increases its output, it not only reduces the price it receives for its own output but also reduces the price all other firms receive.