Self-Adaptive Economic-Based Resource Allocation in Ad-Hoc Grids

Behnaz Pourebrahimi, Delft University of Technology, The Netherlands
Koen Bertels, Delft University of Technology, The Netherlands

ABSTRACT

Resource allocation is the process of discovering and allocating resources to requested tasks in a way that satisfy both user jobs and resource administrators. In ad-hoc Grids, resource allocation is a challenging undertaking as tasks and resources are distributed, heterogeneous in nature, owned by different individuals or organizations and they may arise spontaneously at any time with various requirements and availabilities. In this paper, the authors address an economic-based framework for resource allocation in ad-hoc Grids to deal with the dynamic nature of such networks. Within the economic framework, self-interested nodes in ad-hoc Grids are considered as consumers (buyers) and producers (sellers) of resources. Consumers and producers of resources are autonomous agents that cooperate through a simple, single metric namely the price that summarizes the global state of a network in a number. Adaptation is achieved by individual nodes through adopting a bidding strategy that adjusts the price according to the current state of the network in order to optimize the local utility of the node.

Keywords: Ad-Hoc Grids, Economic-Based Framework, Market-Based Mechanisms, Resource Allocation, Self-Adaptive

1. INTRODUCTION

These days, CPU time is so cheap that simple screen saver program, which does not involve computationally complex tasks, are only stirring up pixels on the display screen. Such programs probably consume most of the world’s computational capacity compared to any other kind of software. At the same time, the digital age allows to collect terabytes of data on various aspects of our personal lives as well as on all kinds of business transactions. This paper looks at the ways to match the idle computing resources with the increasing need for data mining for which more computation power is required than can be provided by a single computer. More specifically, we look at the problem of resource allocation in a Grid based environment and study how the resources can be matched to tasks where the resources are neither necessarily dedicated nor it is predictable how many resources will be available at a certain time. We call such networks ad-hoc Grids. The ad-hoc Grid is a type of Grid that aims to harness un-
used computational resources inside or across organizations. In an ad-hoc Grid, any node in the network can spontaneously arise as a resource consumer or a resource producer at any time.

Conventional resource allocation schemes are based on relatively static models where a centralized controller manages jobs and resources. These resource allocation mechanisms may work well where resources are known in advance. However, they may fail to work in dynamic networks where jobs need to be executed by computing resources whose availability is difficult to predict. Due to the dynamic nature of ad-hoc Grids, mechanisms that are based on a system-wide performance metric to allocate resources, are not suitable. Therefore, resource allocation in an ad-hoc Grid needs mechanisms that are both system-centric as well as user-centric and can adapt to variations of tasks and resources. Market-based mechanisms provide promising directions for building such a resource allocation mechanism. One of the promises, taken from economic theory, is that the fulfillment of individual self-interest automatically or through an unspecified mechanism called the Invisible Hand proposed by Adam Smith (Minowitz, 2004), leads to maximal generation of utility for the entire community. When transposed to Grid environment, this implies that as long as individual nodes look after themselves, by buying or selling resources, the overall goal, namely to execute tasks, is also satisfied.

In this paper, we present an economic-based framework to study different design choices for market-based resource allocation. We discover more suitable choices for Grid user/owner under different network conditions. The paper is organized as follows. In Section 2, we address research challenges. In Section 3, related research is discussed. Economic-based framework is elaborated in Section 4. Market-based matchmaking mechanisms are discussed in Section 5. Section 6 explains pricing mechanisms including our proposed pricing mechanism. Experimental platform is described in Section 7 and the results are presented in Section 8. Finally, we conclude in Section 9.

2. RESEARCH CHALLENGES

A resource allocation mechanism for ad-hoc Grids should address the challenges presented in the following subsections.

2.1. Self-Adaptation

A self-adaptation mechanism can automatically initiate a modification according to changing circumstances within a system. An ad-hoc Grid in which the resources are not dedicated and their availability may change frequently cannot be managed by a single controlling authority. In such sporadic environments, a monitoring system or a centralized server to collect all network information is not feasible. Therefore, embedding self-adaptation mechanisms inside ad-hoc Grids is necessary.

A self-adaptation mechanism in an ad-hoc Grid can embrace two levels of adaptation namely system level adaptation and node level adaptation. In system level adaptation, the system organizes its structure according to the changing circumstance such as growing and shrinking the population. For instance, a self-adaptation mechanism at system level can organize the system structure in the continuum between fully centralized to fully decentralize by introducing more/less central servers. Scalability issue addressed by system level adaptation is not in scope of this paper. However, the challenge remains to find a way to generate system wide information on the basis of the individual states of the participating nodes to build such a self-organized structure. Self-adaptation at the node level can enable for the system level adaptation since the system level state is provided by state of the individual nodes. In the node level adaptation, individuals adapt to the variations in the network condition such as supply and demand for the resources. A way of providing self-adaptation at the node level is to learn network condition through interactions with the environment. Learning from interactions is a basic idea behind nearly all theories of learning and intelligence (Sutton & Barto, 1998).
Wireless Interface at 5.7 GHz for Intra-Vehicle Communications: Sensing, Control and Multimedia
www.igi-global.com/chapter/wireless-interface-ghz-intra-vehicle/62928?camid=4v1a