Minimizing the Negative Effects of Device Mobility in Cell-based Ad-hoc Wireless Computational Grids

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Abstract— This paper provides an outline of research being conducted to minimize the disruptive effects of device mobility in wireless computational grid networks. The proposed wireless grid framework uses the existing GSM cellular architecture, with emphasis placed on the "location area" concept, to aid in achieving the above-stated goal. This research is motivated by the increasing use of mobile devices, their increasing capabilities, and our increasing dependence upon these devices to perform ever-complex computations. Major related works are discussed and the process for performing further research is outlined.

Index Terms— computational grids, location areas, cellular networks, mobility management

I. INTRODUCTION

Grid computing is a resource sharing paradigm which leverages resources at remote sites. Resources may come in the form of any computational asset (software and hardware such as processors, storage resources, and special equipment, to name a few).

This paradigm has been successfully deployed in research institutions [1], with the benefits clearly demonstrated [9].

Although grid computing over wired networks has not fully matured, the ever-increasing importance of mobile wireless devices has driven the need to adapt the paradigm for the mobile wireless environment.

The grid computing paradigm is seen as the ideal method of leveraging collective resources to enable resource-starved mobile devices to initiate resource intensive tasks [2], and the GSM cellular infrastructure is seen as a potential infrastructure for enabling mobile wireless grids.

The recent announcement by Intel Corp. [4] and the GSM Association of the adoption of GSM technologies in laptops means that mobile devices with severe resource constraints are able to leverage the computational resources of these laptops.

This announcement is significant in that it enables laptops (and their associated resources) to become part of a wireless GSM-based computational grid.

The announcement also means that there is additional importance placed upon the wireless grid mobility management schemes in order to ensure the stability [3] and efficient functioning of the grid as these relatively resource-rich laptops move around.

This has prompted the research into minimizing the negative effects of device mobility in wireless grids supported by the GSM cellular infrastructure.

II. RELATED WORK

Kurkovsky et al employ an agent-based approach to the design of their wireless grid architecture in [2]. This approach models the mobile devices as intelligent agents.

Their work places the mobile wireless grid within the footprint of an individual cell, where the associated *Base Transceiver Station* (BTS) is charged with facilitating communication between mobile agents, the *Keep Alive Server* [5], [7], and the *Brokering Service* [2], [5], [7].

This architecture has several limitations, one of which being the inadequate consideration for the mobility of the mobile agents. Tasks are indiscriminately aborted by Subordinates [2], [7] and/or Initiators [2], [7] whenever these mobile agents move to neighboring cells.

Phan et al [8] propose the integration of mobile wireless devices into an existing computational grid. The integration is provided through the use of an *Interlocutor* [8], which acts as a proxy for a cluster of *Minions* [8].

This proxy-based cluster architecture does not adequately address the mobility of the Interlocutor. There is no selection strategy to replace an Interlocutor which has moved to another cell. A situation in which no suitable Interlocutor is available is also not addressed.

The Interlocutors advertise the collective resources of its Minions and thus are the only recipients of request messages. This scheme reduces the number of request messages being transmitted, thereby potentially consuming less bandwidth.

III. PROPOSED RESEARCH

In this research we propose an extension to the architecture by Kurkovsky et al based on the following additional assumptions: 1) the grid is available in densely populated areas, 2) the population density results in the use of micro or pico-cells, 3) the small cell footprint would result in an increase in the rate of inter-cell movement, 4) a higher probability of inter-cell movement may result in a higher task abortion rate.

These are reasonable assumptions in light of the expected users, their mobile device characteristics (resources), and the tasks that are expected to leverage the resources of the grid.

Key to the realization of this research is the concept of *location areas* in GSM cellular networks [6]. The *location areas* concept allows us to extend the wireless grid proposed by Kurkovsky et al [2], [7] from a single-cell wireless computational grid into a multi-cell wireless computational grid (as shown in Figure 1), while leveraging the GSM networks' mobility management capabilities.

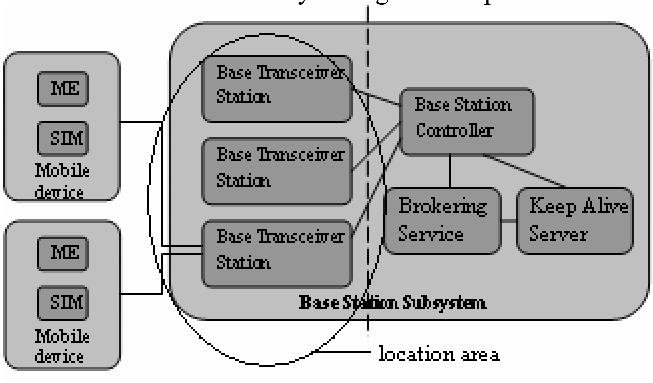

Fig. 1. Proposed Wireless Computational Grid Architecture

The proposed architecture affects only the Base Station Subsystem of the GSM network. The Base Station Subsystem is grid-enabled through the use of the Brokering Service and the Keep-Alive Server, as defined in Kurkovsky et al in [2], [5], [7].

The architecture proposes that each Base Station Controller be equipped with the two above-mentioned functional entities. These two functional entities are responsible for the management of the computational grid. The Base Station Controller (BSC) enforces the *location areas* concept by facilitating the handoff mechanisms within the cells serviced by the BTS's under its control. The addition of the computational grid management capabilities results in each location area becoming a computational grid. Given the assumptions stated earlier, this architecture accommodates increased mobility, with tasks only aborting when mobile devices move into new location areas.

IV. CONCLUSION

In this paper a framework is introduced for reducing the rate at which tasks assigned to the wireless computational grid are aborted due to device mobility.

The proposed architecture introduces a multi-cell wireless computational grid and integrates well into the existing GSM cellular architecture, thereby taking advantage of existing cellular network functionalities to aid in the mobility management of sub-task-assigned mobile devices.

It is envisaged that the characteristics of the proposed wireless computational grid architecture will result in a wireless computational grid that is capable of greater device mobility tolerance than the architecture proposed by Kurkovsky et al in [2], [5] .

Future work includes the development of the mobility management scheme, as well as the development of a prototype which will form the basis for the performance analysis of the above-mentioned scheme.

ACKNOWLEDGMENT

We acknowledge the support of the Telkom/Huawei Centre of Excellence programme and the Department of Computer Science at the University of Zululand.

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