Moving Grid Systems into the Mobility Environment

Sheng Jiang and Peter Kirstein

Department of Computer Science, University College London

Abstract: This article focuses on what needs to done to provide the mobility support in Grid systems. Among many mobility solutions, we chose MIPv6 to provide mobility support from the lower-layer network infrastructure.

1 Introduction

Up to now, most research of Grid systems [1, 2] has focused only on the fixed systems. Against this fact, in the wide-area distributed computing, a lot of Grid devices, either Grid clients or Grid servers, are not fixed or required to move. They need the mobility support to be able to nomadic among networks.

In this article, we discuss what needs to done to extend the Grid systems to be mobile-enabled. We discuss what the specific requirements of mobile-enabled Grid systems. In order to meet these specific requirements, we investigated the general mobility technologies giving considerations to most of Grid systems are based on Internet Protocol (IP) [3]. Though most of general mobility technologies can provide some kind of mobility support in Grid systems from the lower-layer network infrastructure, some certain mobility technology can serve the Grid purpose better than others. There are two major factors that we used to examine general mobility technologies: first, when Grid devices move from a network into another, they should be able to access the new network and access to the IP-based networks, through the new network; second, Grid devices should be identified as the same so that their previous linked Grid servers could return job results to them.

As result, we chose Mobile IPv6 [4] to provide mobility support in Grid systems with the capability that link-layer mobility technologies can also be used underlying it. Though we did not design or implement Mobile IPv6 ourselves, it is central that Mobile IPv6 be introduced into the mobile-enabled Grid systems. With IPv6 auto-configuration functions, Mobile IPv6 solves most generic mobile access problems, such as allocating care-of address, stateless reconfiguration, home address tunnelling, avoiding triangular routing, etc. It provides automatic and transparent service for Grid systems. The combination of Mobile IPv6 and Grid systems is based on our previous research efforts of integrating IPv6 and Grid systems together [5].

2. Requirements of Mobile-enabled Grid systems

Grid systems operate over a number of networking hosts. In the mobile-enabled Grid systems, some of these hosts need to be mobile-enabled. Our investigation focuses on what kind of mobility support the lower-layer network infrastructure should provide to mobile-enabled Grid nodes. It can be separated into two parts: generic mobile access issues; and Grid-specific mobility requirements.

Distinguishing from the normal nodes, the status of the mobile nodes may change frequently. When the mobile nodes move across network, their location, access point, attach network, bandwidth, networking neighbours, etc. are changing as well. Therefore, it requires some extra support from networking. We abstract these particular requirements as the following:

- To support a nomad's motions effectively, the mobile systems must be able to be dynamic and automatically reconfigured. Conversely, the networks and correspondent nodes may need to be changed as well;
- The networking neighbours of the mobile node may change as well. Correspondingly, the network connection may need to change or reset as well;
- The mobile node should be accessible at its home address all the time in order that the remain networks can be able to access or communicate with it;

- There should be no forced changes for most of the networks, while the changes on correspondent nodes may provide improved performance;
- All communication should be secure;
- The above-mentioned operations should be automatic and transparent to the upper-layer applications.

Further from above mobility requirements, mobile-enabled Grid devices have more requirements referring to Grid particularities.

- Grid systems mainly work in IP networks. Therefore, the mobility solution in Grid systems should allow mobile-enabled Grid nodes to communication with other Grid nodes through IP.
  When a mobile node moves in a foreign network, it needs to be assigned a temporary IP address. It will be used for all connections to the IP networks;
- A Mobile-enabled Grid devices should be identified as the same, no matter to which network they are attached, so that their previous linked Grid servers could return the results to them;
- There should be minimum modification required to the existing Grid systems.

3. Mobile IPv6 is the best mobility solution for Grid systems

Most of existing mobility solutions have given enough consideration for generic mobile access issues. Therefore, in this section, we examine mobility solutions referring to above-mentioned Grid-specific mobility requirements.

3.1 Link-layer mobility is not enough for mobile-enabled Grid systems

The goal of cellular mobility standards has been to provide global connectivity, where the IP layer is not involved in the mobility management. This is called the link layer mobility. It supports the movement of wireless devices. It is mostly used to provide wireless communication. In order to communicate with IP networks, the mobile devices need to remain the same access point. If the mobile devices that require IP communication change their access point, their temporary IP address must be re-assigned. To automatic and transparent re-assigned IP address for moving mobile devices, some support mechanisms must be provided in network layer – IP layer. Only link-layer mobility is not enough for IP-based applications.

Grid systems are IP-based applications. Not only accessing to IP world, Grid systems require the moving Grid nodes maintain the same identities even when their temporary IP addresses changes. Therefore, some support mechanisms must be provided in network layer or layers above it.

However, in most of mobility Grid scenarios, link-layer mobility is useful to provide support underlying IP layer. It allows mobile-enabled Grid nodes to move around in certain ranges. It can always be used no matter what mobility support Grid systems required from those layers above it.

In some other mobility Grid scenarios, link-layer mobility may not necessary. For instance, a mobile-enabled Grid may just unplug in one network and plug in another network using cable.

3.2 Application-layer mobility does not suit to Grid systems

If is a some support mechanism in network layer to solve the temporary IP assigning issue, such as mobility support by Dynamic Host Configuration Protocol (DHCP) [6], application-layer mobility may used to maintain the same identity requirement of Grid systems.

In order to fulfil application-layer mobility in Grid systems, a central registration service is needed to be implemented and operated. In this solution, all Grid nodes should register their identities (it can be hostname) and IP addresses to this centre registration service. Then when a mobile-enabled Grid node changes its IP address, it reports the new IP address with its identity to the centre registration service. Afterwards, the Grid system uses the new IP address to communicate with the mobile-enabled Grid node.

However, there are two major problems to using application-layer mobility in Grid systems. First, the above modification requires considerable code. There is actually another mobility solution, which does not require forced modification in Grid systems. We will introduce this mobility solution in next section.

The second problem is vital: central registry is against the concept of Grid system, which is to coordinate resources without centralized control. Against this, a central registration service is the core in application-layer mobility solution. The solution of the next section avoids both these problems; it is much better suit to Grid systems than application-layer mobility.

3.3 Using network-layer mobility in Grid systems

3.3.1 Mobility support by DHCP cannot remain the host identity

Mobility support by DHCP aims to solve the temporary IP address assigning issue. It support mobile hosts move across IP networks transparently. However, Grid systems require further to remaining the identity of mobile-enabled Grid host. Therefore, mobility support by DHCP is simply not enough.

3.3.2 Mobile IP is the best mobility solution for Grid systems

Mobile IP is not the only mobility solutions, but it is the best mobility solution for Grid systems. It provides the direct connection between the mobile device and the IP-based internet. It is completely transparent for all layers above IP, e.g. for TCP, UDP and of course for all applications, include Grid systems.

One of the major benefits of Mobile IP is that there is no forced change to the upper layer application, in our case the latter are Grid systems. Mobile IP provides mobility support from the IP layer, which is lower layer to Grid systems. It separates Grid systems from the mobility operations. As long as Grid systems can communicate over IP, which they are, they can potentially be operated over Mobile IP.

Another major benefit is that Mobile IP keeps the identities of mobile hosts. When mobile hosts attach in a foreign network, it has its temporary IP address to communicate with IP hosts. At the same time, it is also accessible by its home IP address. Mobile hosts are identified as the same as they were home network.

3.3.3 Mobile IPv6 is better than Mobile IPv4

Since the IP is in the process of migrating from IPv4 to IPv6, correspondingly, there are two Mobile IP protocols – Mobile IPv4 [7] and Mobile IPv6. Both of them can meet Grid-specific requirements. As reviewed in [4], Mobile IPv6 is more advanced. Therefore, we chose Mobile IPv6 as our mobility solution for Grid systems.

4. Providing Mobility Support in Grid Systems from the Lower-layer Network Infrastructure

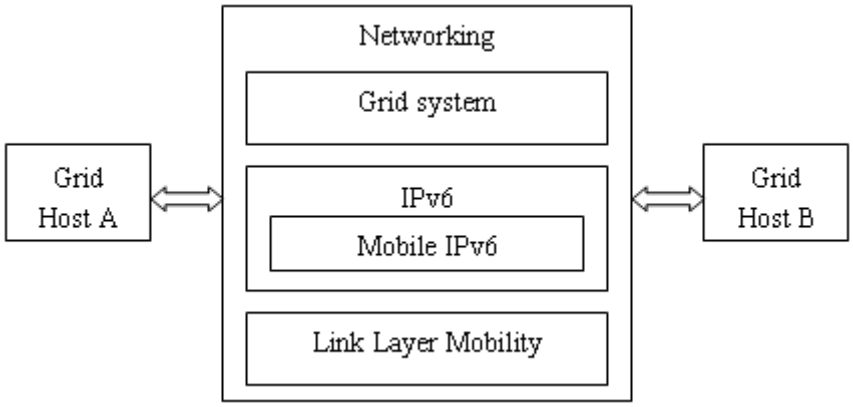

Figure: Lower-layer network infrastructure provide mobility support in Grid systems

As the result of our analysis in previous section, we have the mobility support in Grid systems provided from the lower-layer network infrastructure, shown in above figure.

4.1 IPv6-enabled is the prerequisite of Mobile IPv6

Mobile IPv6 is accessible using general IPv6 APIs, appearing transparent to the application layer. Thus, in an IPv6 implementation, there is potential support for roaming between different networks, with global notification when you leave one network and enter another. In order to operate Grid systems over Mobile IPv6, they should first be IPv6-enabled. We have provided a generic mechanism to make Grid systems IPv6-enabled [5].

4.2 Operating Grid systems over Mobile IPv6

Mobile IPv6 meets most of the requirements that we raised earlier in the article. In this section, we briefly describe how to operate Grid systems over Mobile IPv6.

First, the mobile-enabled Grid host needs to be IPv6-enabled itself and it needs to have Mobile IPv6 function loaded. This host should use address auto-configuration mechanism, rather than manual address configuration. The address auto-configuration mechanism enables the host to configure its IPv6 address automatically according to its own identity and the IPv6 router advertisement. It may not necessary when the host only access from one network. It will become a critical mechanism to allow mobile node to get its care-of address automatically, when it moves across the networks. The Mobile IPv6 function on the mobile-enabled Grid nodes should be set up as Mobile Node model.

Secondly, a Home Agent needs to be set up. It should have Home Agent model of Mobile IPv6 function operated on it. Mobile-enabled Grid nodes should have their Home Agent IPv6 address in their configuration and be registered on their corresponding Home Agent.

Thirdly, optionally, the fixed Grid nodes can be operated as Mobile IPv6 correspondent nodes. It can avoid the triangle-routing between these nodes and the mobile-enabled Grid nodes.

5. Conclusions

The mobility support from Mobile IPv6 provides the lower-layer network infrastructure for Grid systems. It does not require any forced changes in the implementation of Grid systems. All Grid systems need to do is to operate the mobile-enabled Grid nodes over Mobile IPv6 with the support from home agents. It provides the transparent Grid services to the mobile Grid users. It hides the operation details of middleware and network layers away from the mobile Grid users.

Further research is needed in the mobile-enabled Grid systems in order to improve their performance. Advanced functions, such as Grid resource mobility support, have been proposed in our research.

Acknowledgments

The authors wish to thank Soren-Aksel Sørensen, University College London, who made substantial contributions to the work of this paper. This work has done under the aegis of the IST, 6NET project. The support of the European Communities is gratefully acknowledged.

References

[1] Foster I. 2002. “The Physiology of the Grid: An Open Grid Services Architecture for Distributed Systems Integration”, Global Grid Forum.

[2] Foster, I. 2002. “The Grid: A New Infrastructure of 21st Century Science,” Physics Today Volume 55: 42-52.

[3] Comer, D. 2000. “Internetworking with TCP/IP, Volume 1, 4th edition,” Published by Prentice Hall.

[4] Johnson, D. 2004. “Mobility Support in IPv6”, RFC 3775.

[5] Jiang, S. 2005. “The Combination of IPv6 and Grid Systems” IPv6 and Broadband, Page 55 – 65.

[6] Droms, R. 1997. “Dynamic Host Configuration Protocol”, RFC 2131.

[7] Perkins, C. 1996. “IP Mobility Support”, RFC 2002.