An influential white paper from IBM (Gilbert et al. 1995) described intelligent agents in terms of a space defined by the three dimensions of agency, intelligence, and mobility: “Agency is the degree of autonomy and authority vested in the agent, and can be measured at least qualitatively by the nature of the interaction between the agent and other entities in the system. At a minimum, an agent must run asynchronously. The degree of agency is enhanced if an agent represents a user in some way... A more advanced agent can interact with... data, applications,...services...[or] other agents.”[41].

Reaching the end of the implementation, tests have been made to evaluate the service performance of DDS. Efforts have been focused on
testing the time spent by migrating agents under different conditions. In order to do that a test agent in charge of launching other migration agents has started and time measures have been done. This work has been published in paper[45].

6.1 PERFORMANCE EVALUATION

The objective of performance evaluation is to confirm how the migration System implemented influences the normal functioning of an agency[45]. The migration process involves many processes such as the serialization of agents, their encoding to Base64, the sending of large ACL messages, and dynamic class loading. The aim is to determine whether the implementation of the migration is feasible or whether it involves an acceptable decline in the performance of the agency.

It is observed how the proposal for migration sent agents within ACL messages. The JADE platform is able to support the massive sending and receiving of messages. The main difference between a migration of this type and sending inter-agency messages lies in two areas. Firstly, the size of an ACL message containing an agent’s code and data is in general significantly greater than the average size of a normal ACL message. Secondly, the pre-process involved in extracting the agents from the ACL message, as well as that of creating the message based on the agent, makes the typical treatment of a message somewhat complicated.

The trials carried out took place on machines based on Pentium IV at 2GHz with 256 Mb of RAM, a Java 2 virtual machine, and an Ethernet network switch of 100 Mbps, in stable and low load situations. The version of the JADE platform installed in each was 3.4.

The aim of the trials was to check the processing behavior of overloaded agencies faced with a significant number of simultaneous migrations. An agent with the test process using almost the entire computing capacity was used, to obtain the maximum decline in the agency's performance. Once the time taken for this process in a totally unloaded agency was calculated (see Row 1 of Table 6.1), this time was calculated again, but submitting the agency firstly to hundreds of simultaneous migrations from incoming agents, and then to hundreds of migration requests from outgoing agents. The aim of these two trials was to
confirm the performance in the two facets of migration - the sending and reception of agents. Finally, the process was repeated but loading the same amount of static agents. This enabled the comparison of the load of the agents with migration. The trials were carried out five times for each experiment. Table 6.1 shows the results for 300 agents, sized from 3,4 to 15 Kbytes. The processing of the line of messages in JADE, and therefore the requests for migration, was carried out using a limited number of execution threads, meaning that the processing of the sending and reception of messages was treated in an almost sequential way. The 300 migrations evaluated represent an overload situation in the transport system during a significant time period with regard to the duration of the test process.

The results in Table 6.1 show how the migrations carried out decrease the efficiency of the test process by an average of 15 seconds, but it can also be seen how the agents' temporary load weight (see Row 4 of Table 6.1) is similar to that of the migration (see Rows 2 and 3 of Table 6.1).

<table>
<thead>
<tr>
<th>Test/time (seconds)</th>
<th>Test 1</th>
<th>Test 2</th>
<th>Test 3</th>
<th>Test 4</th>
<th>Test 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Process (TP)</td>
<td>211 s</td>
<td>209 s</td>
<td>212 s</td>
<td>212 s</td>
<td>209 s</td>
</tr>
<tr>
<td>TP + 300 incoming migrations</td>
<td>227 s</td>
<td>228 s</td>
<td>226 s</td>
<td>228 s</td>
<td>226 s</td>
</tr>
<tr>
<td>TP + 300 outgoing migrations</td>
<td>225 s</td>
<td>227 s</td>
<td>227 s</td>
<td>227 s</td>
<td>226 s</td>
</tr>
<tr>
<td>TP + 300 loads</td>
<td>225 s</td>
<td>227 s</td>
<td>226 s</td>
<td>225 s</td>
<td>225 s</td>
</tr>
</tbody>
</table>

**Table 6.1: Performance Evaluation**

6.2 PERFORMANCE TESTS

Reaching the end of the implementation tests are conducted to evaluate DDS performance in comparison with the non interoperable Intra-PlatformMobility Service provided by JADE. Our efforts have been focused on testing the time spent by migrating agents under different conditions. In order to do that a test agent in charge of launching other migration agents has started and time measures have been done. The agents launched migrate from one site to another and then come back to the first one, in what it is called a round trip. This has been done a fixed number of times (1, 10, 100, and 1000 times), called from now on iterations. Moreover, these agents have launched concurrently, with 1, 10, and 100 instances running simultaneously. These tests have been done with the Intra-PlatformMobility Service and with the DDS, where a site respectively is a container or a platform.
The results are shown in Fig.6.1. We have used two Pentium IV at 2 GHz, with 256MB of RAM, 40 GB on an SATA 100 hard disk, and a Windows XP based operating system, both using a 100 Mbps switched Ethernet network. The tests with our DDS use a Message Transport Protocol based on HTTP, while the tests based on the Intra-PlatformMobility Service of JADE (IPMS-J) use an Internal Message Transport Protocol based on RMI. As it can be appreciated in the figure, performance increases with the number of agent instances. This is because moving an agent is a process that implies many steps. If there are many agents migrating concurrently, these steps can be parallelised and a lower average time per migration can be got.

![Fig.6.1: Performance test of two migration services](image)

But the most noticeable issue is the performance variation between DDS inter-platform migration and the JADE intra-platform migration as can be appreciated in Fig.6.1. From such result it can be seen that DDS is not as efficient as Intra-Platform Mobility Service provided by JADE. However, the new service has an important advantage: it follows standard FIPA methods for communication and a protocol that is a standard proposal.
Interoperability has an inherent cost due to the required mechanisms, as it has been seen. Albeit of this, this cost is affordable and not as expensive as it could seem in advance. Moreover, performance can be improved by defining new MTPs and content encodings.

6.3 SUMMARY

The conclusions to which the results obtained lead towards are as follows. Firstly, the decline in the system’s capacities during periods in which there is a massive and constant migration flow is not unacceptable, as this flow does not paralyze the system or markedly affect the processes carried out in the agency. Secondly, if the duration times for the test process during the migrations and during agent loading are compared, it can be deduced that most of the resources used during the migration process are due to the classloading of the agents. Classloading is not the typical migration process as although it is used here, it also takes place when new agents are introduced into the agency. From this it can deduced that the procedures that are exclusive to migration (negotiation, serialization, etc.) are a load that is hardly significant(Objective-4).