Using Negotiation to Reduce Redundant Autonomous Mobile Program Movements

Natalia Chechina

Dependable System Group, Heriot-Watt University

March 4, 2010
Background

Autonomous Mobile Programs (AMPs)

Greedy Effects and cNAMPs

Greedy Effects
AMP Greedy Effect Analysis
cNAMPs

Conclusion & Future Work
Autonomous Mobile Programs (AMPs)

- **AMPs are mobile agents**
  - aware of their resource needs;
  - sensitive to the execution environment;
  - periodically seek a better location.

\[
\begin{align*}
T_h & > T_n + T_{\text{comm}} \\
\text{Time on the current location} & > \text{Min time in} + \text{Time to transfer the network}
\end{align*}
\]

- **Been investigated using**
  - Mobile languages (e.g. Java Voyager [Den07]);
  - Simulation [CKPT09].
Greedy Effects

- are redundant movements:
  - locally optimal choice;
  - globally non-optimal choice.
- occur when AMPs rebalance after a termination or new AMPs start.
- are observed in other distributed systems.
Greedy Effects

Scenarios

- **Scenario 1**: 25 AMPs on 15 locations with CPU speeds 3193 MHz (Loc1 – Loc5), 2167 MHz (Loc6 – Loc10) and 1793 MHz (Loc11 – Loc15).

- **Scenario 2**: 20 AMPs on 10 locations with CPU speeds 3193 MHz (Loc1 – Loc5), 2168 MHz (Loc6) and 1793 MHz (Loc7 – Loc10).

- **Scenario 3**: 10 AMPs on 3 locations with CPU speeds 3193 MHz.
Location Thrashing

Lack of information about other AMPs intending to move to the same location

Figure: Redundant rebalancing

Figure: Optimal rebalancing
Greedy Effects

Location Blindness

Lack of information about the remaining execution time of other AMPs.

Figure: Redundant rebalancing

Figure: Optimal rebalancing
AMPs have a large number of redundant movements.

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Initial distribution</th>
<th>Rebalancing after an AMP termination</th>
<th>Large AMP execution time, (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean No. redund. moves</td>
<td>Mean time, (sec)</td>
<td>Mean No. redund. moves</td>
</tr>
<tr>
<td><strong>Scenario 1</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25 AMPs, 15 loc.</td>
<td>64</td>
<td>60.4</td>
<td>6</td>
</tr>
<tr>
<td><strong>Scenario 2</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 AMPs, 10 loc.</td>
<td>43</td>
<td>50.5</td>
<td>11</td>
</tr>
<tr>
<td><strong>Scenario 3</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 AMPs, 3 loc.</td>
<td>13</td>
<td>26.8</td>
<td>6</td>
</tr>
</tbody>
</table>
Types of Movements (Scenario 1)

Figure: Initial AMP distribution

Natalia Chechina
Dependable System Group, Heriot-Watt University
Using Negotiation to Reduce Redundant Autonomous Mobile Program Movements
Types of Movements (Scenario 1)
Methods of AMP Negotiation

- Malicious
- Cooperative:
  1. queuing
  2. probabilistic
  3. relationship
  4. competitive.
cNAMPs

Negotiating AMPs

- cNAMPs are negotiating AMPs with a cooperative/competitive scheme:
  - announce their intentions to move;
  - compete with each other for permission to transfer.

- Two values of load:
  - actual load;
  - committed load.

- cNAMPs only reduce location thrashing.
AMP and cNAMP Comparison (Scenario 1)

Initial distribution.

**Figure:** AMPs

**Figure:** cNAMPs
AMP and cNAMP Comparison (Scenario 1)

Rebalancing after an AMP/cNAMP termination.

Figure: AMPs

Figure: cNAMPs

Natalia Chechina
Dependable System Group, Heriot-Watt University

Using Negotiation to Reduce Redundant Autonomous Mobile Program Movements
cNAMPs make **much fewer** Redundant Movements

<table>
<thead>
<tr>
<th>Configuration and type of experiment</th>
<th>Initial distribution</th>
<th>Rebalancing after an AMP/cNAMP termination</th>
<th>Large AMP/cNAMP execution time, (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Time (sec)</td>
<td>Mean number of redundant movements Time (sec)</td>
<td>Mean number of redundant movements Mean Standard deviation</td>
</tr>
<tr>
<td><strong>Scenario 1</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AMPs</td>
<td>60.4</td>
<td>64</td>
<td>22.5</td>
</tr>
<tr>
<td>cNAMPs Reduction</td>
<td>14.7</td>
<td>-</td>
<td>5.9</td>
</tr>
<tr>
<td>Reduction</td>
<td>4.11</td>
<td>64 moves</td>
<td>3.81</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Scenario 2</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AMPs</td>
<td>50.5</td>
<td>43</td>
<td>28.2</td>
</tr>
<tr>
<td>cNAMPs Reduction</td>
<td>12.4</td>
<td>-</td>
<td>7.8</td>
</tr>
<tr>
<td>Reduction</td>
<td>4.07</td>
<td>43 moves</td>
<td>3.62</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Conclusion

- **Identified** two types of AMP greedy effect;
- **Investigated** extent of AMP greedy effect using simulation;
- **Introduced** the concept of negotiating AMPs (NAMPs);
- **Reduced** the greedy effect (cNAMPs).
Future Work

- A mathematical analysis of location blindness on homogeneous and heterogeneous networks to estimate maximum number, and probability of, redundant movements [CKT10];
- Investigation of cNAMP behaviour on wide area networks.
Questions?
