Comparing the Performance of Message Delivery Methods for Mobile Agents

Andrei Olaru, Dragoș Petrescu, Adina Magda Florea

University Politehnica of Bucharest

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- Context
- Challenge
- Architecture
- Results
- Conclusion

Comparing the Performance of Message Delivery Methods for Mobile Agents

overview

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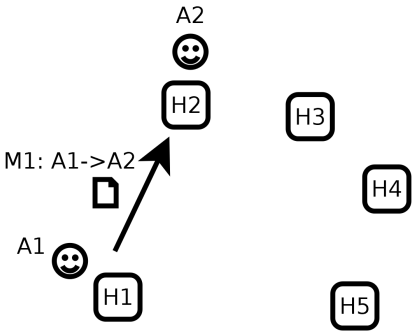
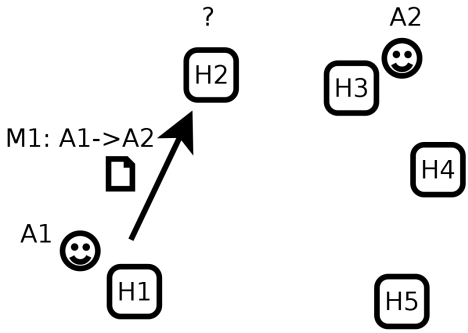
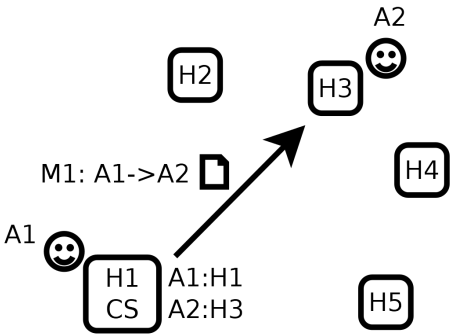
Mobile agents allow for an agentification model in which mobile code is part of autonomous agents which move between hosts (or nodes).

Applications include High-Performance Computing, fog computing, smart cities, and others, where moving computation units can be modeled as agents.

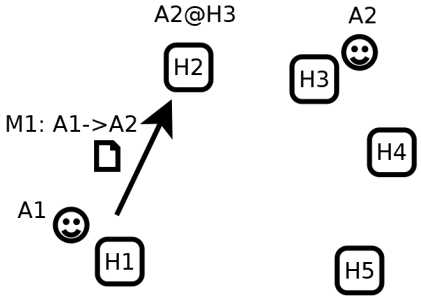

A2
H2
H3
M1: A1->A2
H4
A1
H1
H5



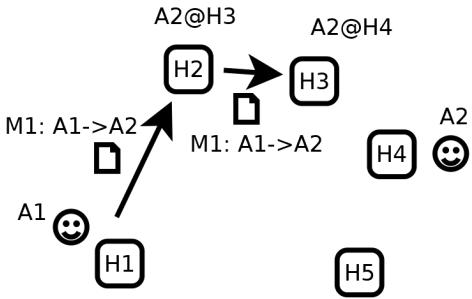
⇒ implementation of various *message delivery models* (or *protocols*)



Central Server Scheme



Forwarding Proxy



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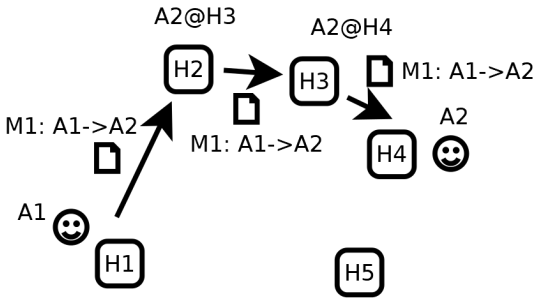

Forwarding Proxy

Many message delivery models have been proposed:

- *centralized* or partially centralized: Central Server Scheme; Home Server Scheme; hierarchical solutions based on domains [Wojciechowski, 2001] and regions [Yousuf and Hammo, 2012] ;
- *blackboard* solutions [Cabri et al., 2000, Choi et al., 2006] ;
- *forwarding proxy* solutions, including the Shadow Protocol and region-based solutions [Baumann and Rothermel, 1998, Di Stefano and Santoro, 2002] ;
- combinations of forwarding proxies and location servers [Jingyang et al., 2003, Cao et al., 2005, Roman et al., 2018]

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Which one is the *best* message delivery model, in each specific situation?

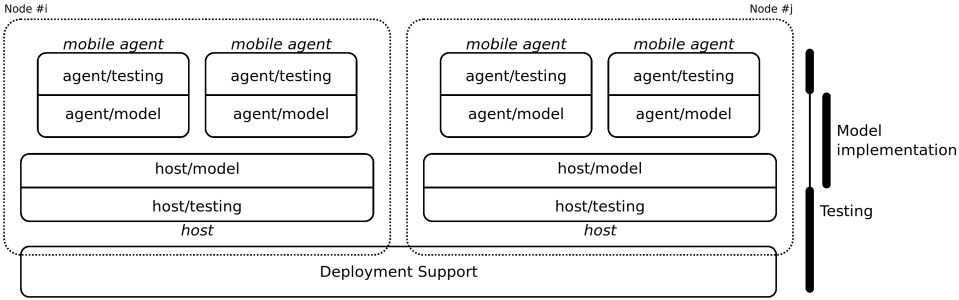
Challenge

· Our goal was to build a framework for the comparison of message delivery protocols in different difficult scenarios.

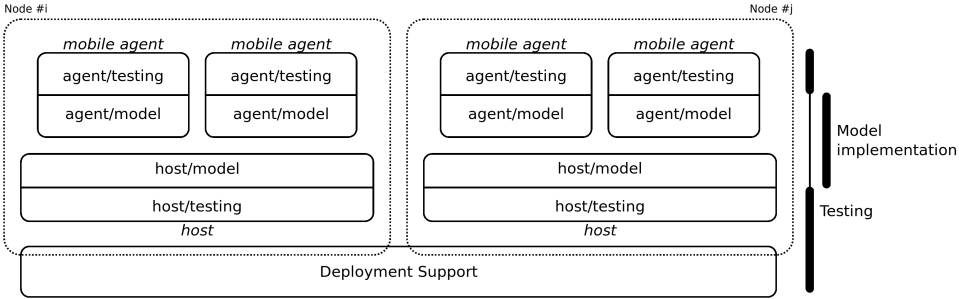
· Our contribution is twofold:

- the comparison framework
- a comparison between well-established message delivery protocols

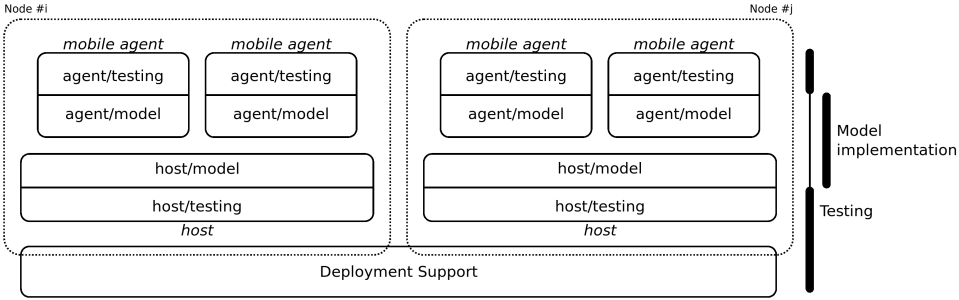
- the framework should separate message delivery model implementation from scenario generation and experimentation, such that:
  - the implementation of the message delivery model can be changed easily, without modifying the experimentation part
  - the implementation of a specific message delivery model can be used in a multi-agent application deployed in real life, exactly how it was used in the framework.
- scenarios can be generated to simulate difficult situations:
  - there are many messages
  - there are many agents who move around the system
  - agents move around the system very quickly
- the results of experiments can be analyzed quantitatively



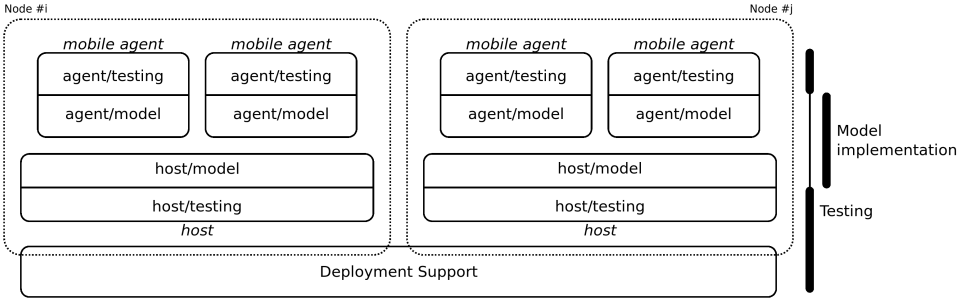
deployment support – modelling and simulating the underlying infrastructure which allows communication between hosts, complete with network topology and communication latencies.



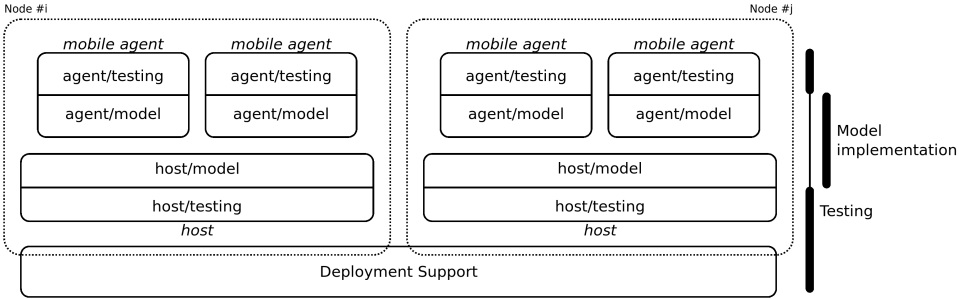
agent/model – the model-specific implementation that is bound to a mobile agent.



agent/model – the model-specific implementation that is bound to a mobile agent.
host/model – the model-specific implementation that is bound to a host.



agent/testing – the framework-related implementation that is bound to a mobile agent, sending and receiving messages according to a given scenario.



agent/testing – the framework-related implementation that is bound to a mobile agent, sending and receiving messages according to a given scenario.
host/testing – the framework-related implementation that is bound to a host (e.g. for packing/unpacking moving mobile agents).

	Agent/testing	Agent/model	Host/model	Host/testing	Deployment support
	1. A new message M is generated according to the scenario				
	2. M is passed to Agent/model				
Host A		3. M is prepared according to the delivery model			
			4. M is assigned a next hop		
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					6. M travels through network
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Host B			8. M is is assigned new next hop		
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Host C		13. M passed to target agent/testing			
	14. M reaches destination and measurements are updated				

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The scenarios are generated with the ability of setting:

- the number of nodes and the underlying network topology;
- the number of agents in the scenario;
- the probability of an agent migrating to another node in a given time unit (between 1 in 1000 and 1 in 10);
- the probability of an agent sending a message to another agent in a given time unit (between 1 in 100 and 1);
- the "CPU" power of hosts, specifying how many messages a host can process in a time unit - a number of 1 to 50 messages processed in every time unit;

Several quantitative results are returned by a scenario simulation:

$$\textit{Delivery rate} = \frac{\textit{number of messages which have been delivered}}{\textit{total number of sent messages}}$$

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$$\textit{Network Load} = \frac{\sum_i^{\textit{steps}} \textit{number of messages in transit at time unit } i}{\textit{number of steps}}$$

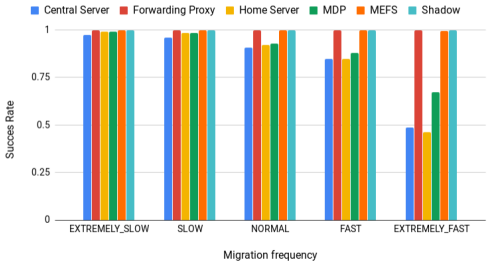
$$\textit{Wasted Time} = \frac{\sum_{\textit{failed messages}} \textit{time spent in transit}}{\textit{number of failed messages}}$$

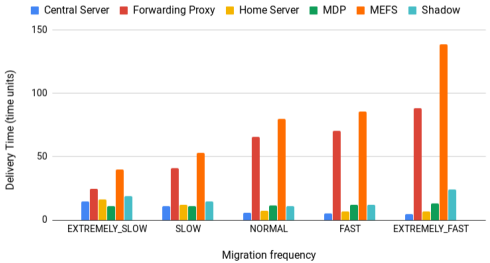
Experimental Results

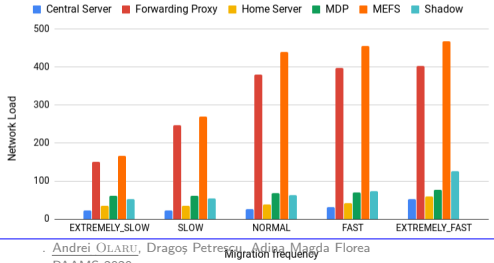
Several well-established protocols have been implemented:

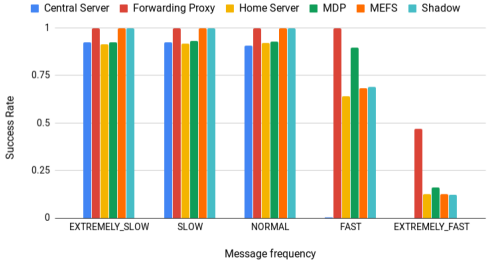
- Central Scheme(CS) – one host is informed of the location of all agents;
- Home Server Scheme (HSS) – each agent is assigned to a specific host, its *home server*, which knows where the agent is;
- Forwarding Proxy (FP) – an agent leaves a proxy on the host from which it moves; the proxy relays messages to the next hop;
- Shadow Protocol – combines HSS and FP; home server updated periodically;
- Message Efficient Forwarding Schema (MEFS) – combines CS and FP, with periodic updates to CS;
- Message Delivery Protocol (MDP) – creates a hierarchical topology for routing messages;
- Blackboard – agents need to visit the host where the blackboard is located in order to get their messages;
- Reliable Asynchronous Message Delivery Protocol (RAMDP) – groups messages in regions, each region with its own blackboard;

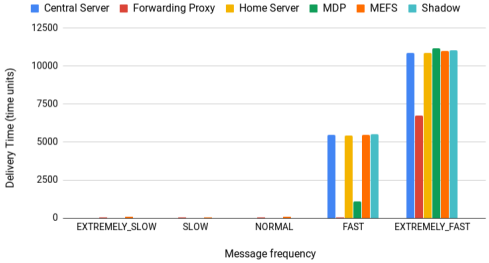
Experimental Results

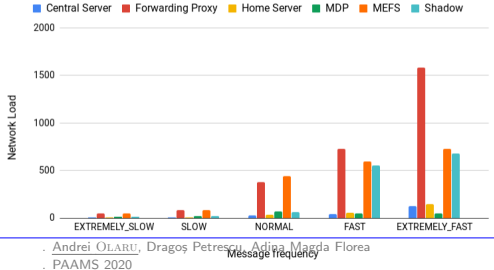







Central Server
Forwarding Proxy
Home Server
MDP
MEFS
Shadow
Success Rate
1
0.75
0.5
0.25
0
EXTREMELY_SLOW
SLOW
NORMAL
FAST
EXTREMELY_FAST
Message frequency


Central Server
Forwarding Proxy
Home Server
MDP
MEFS
Shadow
Delivery Time (time units)
12500
10000
7500
5000
2500
0
EXTREMELY_SLOW
SLOW
NORMAL
FAST
EXTREMELY_FAST
Message frequency


Central Server
Forwarding Proxy
Home Server
MDP
MEFS
Shadow
Network Load
2000
1500
1000
500
0
EXTREMELY_SLOW
SLOW
NORMAL
FAST
EXTREMELY_FAST
Message frequency

Conclusion & Future Work

- We have developed a framework for the comparison of message delivery protocols in mobile multi-agent systems.
- A user of the framework is able to set-up experimental scenarios with the required properties and analyze how various protocols handle the situation.
- A user is able to use an already implemented model or implement a new model and test it against existing ones.

- Faulty network and hosts will be modelled in order to check the robustness of the message delivery.
- Temporal distributions for scenario parameters will be modelled, analyzing the connection between the position in the distribution and the current value for qualitative measures.

Thank You!

Any Questions?

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