All,

All please give comments on the following paper.

There are some areas where I have not completed noted (subscript)

In particular need to complete and/or re-write the following areas:

**Scope
(papers read were somewhat broad, would like to narrow scope of paper, still reading MA specific papers)
**Development
(Gathering as to which application, technologies, platforms etc are best for developing MA)
**Applications
(Need to explain which types of applications are better suited for/as MA, if need better platforms that support MAs)
**Conclusion/Summary
(Wrap up/summarize paper)

Any feedback is greatly appreciated.

Thanks In Advance,
Nicandro G. Alanis

(12pt Font, 1.5 Spaced Lines, 2.5cm (~1inch) margins as indicated in term paper instructions)

Design Approaches & Challenges for Mobile Agents

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Abstract

(Explanation about mobile agents w.r.t. to paper)

A Mobile agent is software that is designed to assist a mobile user - inherently to act on the behalf of the user of which it is servicing. A mobile agent may be tied or bound to a user having to follow the user's movement throughout a network; or it may be a service hosted by a network node - which provides a service to an individual user (mobile agent). Both entities can created to aide a user accomplish a task (namely a tedious or multi-step task). In both instances (user agent & host served agent) information about the user, environment may be used in order to help streamline a task. In this paper we will be covering mobile agents background, motives for using agents, design development issues, expected performance benefits and challenges when designing, deploying and maintaining mobile agents.

1. Introduction/Background

(Introduction and Background of MA)

Mobile agents can be considered extensions of one's intentions. Additionally, the intentions of a person to be able to move around and perform tasks can be analogous to a mobile agents purpose for being mobile. Similarly, we may travel from post office, to grocery store, to school - at each point either performing a task or using a service. Similarly, a mobile agent purpose is to complete a task [JRS94]. A mobile agents motive to exist is to perform the task or set of tasks. It (a mobile agent) may complete all its work at a specific host, or it may not. If it does not, mobility is the important (and crucial) part of a mobile agent. Mobile because it must move throughout a network and agent because it acts as a 'proxy' for a user - in short handling the users requests at a remote location.

Mobile agents are a special type of distributed software. Unlike traditional types of distributed software, mobile agents doe not harness pieces of memory, processor speed or such from multiple machines. They can be classified as distributed because they are born, live and expire within a set network. The crux for mobile agents, is the need to safely, efficiently and securely move in and around a network; without being bogged down or overly stressed by providing identification, being 'light weight' in terms of runtime footprint and ensuring mobility.

2. Scope

(Scope of paper and discussion, Update to show 'angle' limitation of term paper)

Mobile agents are still somewhat difficult in understanding; in short they can also be thought as 'moving software' executing remotely from a mobile device. As moving software, it must have the environment such to be able to move around; the environment (being hosts) must contain or offer services where these applications can easily initiate, perform a task and return information back to a mobile device. Many areas of software can potentially benefit from a mobile agent approach to performing tasks. The benefits of agents are pretty broad, a balance has to be maintained as much of the work is still in academia - only few commercially available products have been successful. Whether the mobile agent is assisting in applications such as e-commerce, personal assistance, information retrieval, performing network services; all aspects are still affected by the same challenges in design and implementation.

3. Reasons for Agents

(Cover benefits of using agents)

As stated before, mobile agents are a special type of software - distributed software. Their evolution was highly related to the advance in networks. These networks opened up a large area of exploration and exploitation. Exploration in the sense of improving current methods of reusing software and exploiting since an idle node can be harness to use its power. The following is a list of area where mobile agents are deemed beneficial.

Reduce Network Load

Taking advantage of its distributed nature, agents relay on communications that involve multiple interactions. Agents allow for the packaging of an interaction to be processed and executed locally by the host. The mobile agent can simply order its desired

execution, wrap it up and have it sent to the host. The host's mobile agents job is to interpret the task, execute it and return its results if necessary. This can highly reduce the network traffic, by removing the dependencies between simple interactions and packaging up a set of interactions.

Improve Network Latency

For real-time applications, which need to respond to changes in their environment, mobile agents provide a solution. Real-time applications cannot afford the latencies of a centrally located process where messages are queued up by each event monitoring process. Mobile agents allow for distribution of agents from a central controller, each agent will have a real-time task to execute local to its operation. The central task need not worry about the details; the mobile agent is programmed that it can exist autonomously.

Encapsulate Protocols

Protocols may evolve from time of distribution. Between communicating entities, outgoing data must be properly coded, incoming data must be properly decoded. It may be difficult to impossible to upgrade the protocol as new requirements or security is needed. Mobile agents can help hosts create channels bases on specific protocols.

Execute Asynchronously and Autonomously

Connections may sometimes not be persistent throughout a mobile agent's lifetime. The connection may require continuous connection between a mobile device and the network. Mobile agents may be embedded with a range of tasks and dispatched into the network. During this time the connection could be lost and connected several times; all before the tasks are completed. Upon the agents return (and task completed), the mobile device will receive the results as if it would have been connected all along. The mobile agent can be triggered to perform its tasks, only when a connection is established. Thus a mobile user can continue productive work, without need worrying about connection.

Adapt Dynamically

As mobiles agents exist and live in the network, they are always aware of their execution environment. Mobile agents can react to changes in the network, much faster than the

mobile devices maintaining optimal configuration among the hosts in solving and executing a particular task.

Naturally Heterogeneous

When designed and implemented correctly, a mobile agent is naturally heterogeneous - from both a hardware and software aspect. Being computer and transport layer independent, mobile agents provide optimal conditions for integrating into their respective networks.

Fault Tolerant

The ability to react to unfavorable conditions and events; makes mobile agents fault tolerant. If encountering execution on a host that may be shutting down, the agent may be dispatched to a subsequent host in order to complete an operation [LO99].

The aforementioned are some of the areas where a mobile agent may be chosen as an application design paradigm. The requirements should be compared to the available benefits, and decisions about how the agent should be designed should be greatly considered.

4. Development

(Explain some development ideas/approaches/designs etc)

5. Challenges

(Cover some challenges)

The following are a subset of issues when developing mobile agents. These are some of the major hurdles that mobile agent designers and programmers must address when designing and deploying mobile agent software.

Security

One of the most important challenges in designing mobile agents (and henceforth mobile agent hosts) is the issue of security. In order to successfully design and address both issues, a balancing act must be accomplished wherein the mobility of the agent stays intact (mobility in sense of able to perform its intended design) when moving from host to host; as well as the ability of the host to provide a platform where these agents have a 'service layer' where they can perform meaningful work. Areas of concern are: protecting the host without limiting access

rights supplied to the agent, protecting the agent from malicious hosts and ability to protect an A.N. (autonomous network) which may not necessarily be under a single administrative control [KG99]. The challenges still remain to be adequately addressed. Taking any of the aforementioned issues as the primary concern, will limit the use of mobile agents within an entire network. One can always take the approach of designing a network with a custom layer at the host and only mobile agents created by trusted groups that are verified at each host possibly using a certificate type design to verify authenticity could be designed. But this seriously limits the mobility allowed to the mobile agent. A heterogeneous solution will surely be designed, but this must be inherit to the network; the mobile agent creator should shun away from designing an agent that solves these security issue.

Standardization

In order to accomplish a wide acceptance, deployment and usage of mobile agents; there must be a standardization within the networks on the services available to mobile agents. The system must allow the program to travel the network, node-by-node without interference. With not only its primary functionality to carry it forward, but also state specific information carried from a previous execution state before need of movement was initiated - must be carried forward too. Machines must be able to support a standardized environment wherein these mobile agents may come, execute and go without disturbing the host or one another. The OMG MASIF standard is an initial step, but address only cross system communication & administration [MBB98], which leads to a situation in which an agent can not migrate to a desired machine, limited only to mobility to a machine that is running the correct agent system [KG99]. This is still a largely debated area, as the agent community must agree on a solution that everyone can adopt with relatively low overhead/work in order to accomplish.

Applications

(Explain that needed applications not currently available such to catapult MA to be more prevalent, give example, platforms etc.)

6. Conclusion/Summary

(Give conclusion about MA, benefits, challenges etc.)

7. Acknowledgments

(Give credit to Dr Kumar & CSE6345 SP04 for input related to improving paper)

8. References

[LO99]
Danny B. Lange, Mitsuru Oshima - Seven good reasons for mobile agents. *Communications of the ACM*, 42(3):88-89, March 1999.

[KG99]
David Kotz, Robert S. Gray - Mobile Agents and the Future of the Internet Department of Computer Science / Thayer School of Engineering Darmouth College, May 1999

[MBB98]
D. Milojicic, M. Breugst, I. Busse, J. Campbell, S. Covaci, B. Friedman, K. Kosaka, D. Lange, K. Ono, M. Oshima, C. Tham, S. Virdhagriswaran, and J. White. MASIF: The OMG Mobile Agent System Interoperability Facility. In *Proceedings of the Second International Workshop on Mobile Agents*, volume 1477 of *Lecture Notes in Computer Science*, pages 50-67, Stuttgart, Germany, September 1998.

[JRS94]
D. Johansen, R. van Renesse, and F. B. Schneider. Operating System Support for Mobile Agents In *Proceedings of the 5th IEEE Workshop on Hot Topics on Operating Systems*, pages 42--45, May 1994.