Scientific Report of the Exchange Visit to the Department of Computer Science of University of Lisbon

Simone Leggio
University of Helsinki
Department of Computer Science
simone.leggio@cs.helsinki.fi

1 Introduction

This scientific report summarizes the results of the visit that I carried out at the Department of Computer Science of the University of Lisbon, from the 20th to the 26th of November 2005. I wish to thank Prof. Luis Rodrigues who was able to arrange the visit within a very short time frame, Hugo Miranda with whom I had a very fruitful and professionally stimulating week of work, and all the other people of Lasige group, who welcomed me warmly and exchanged ideas with me.

The main objective of this short visit was to continue a work that was begun with Hugo Miranda after his visit at the Department of Computer Science of University of Helsinki last year. This common work puts together Miranda's research interests in distributed computing and my activities in networking protocol. It was a long term project, begun in June 2004 and still a work in progress.

The basic idea is to realize an algorithm for distributing information among nodes of an ad-hoc network, and subsequently build on top of the algorithm an application to exploit its functionalities. The principal focus of my research is the adaptation of the Session Initiation Protocol (SIP) [2] for use in ad-hoc networks; the solution is called *decentralized SIP or dSIP*. The first results of my research are published, e.g., in [1]; the adaptation of SIP targets a particular network environment, small-scaled ad-hoc networks, with few dozens of nodes at most, possibly directly connected with each other at link layer. I refer to such networks as proximity networks: an example of proximity network using SIP could be travelers in an airport

engaging in a chat session while waiting for their plane to leave. Although the solution proposed in [1] can be adapted to multi-hop ad-hoc networks, it is not optimized for such an environment. The algorithm being realized with Hugo Miranda constitutes the ideal tool for allowing dSIP to be used in multi-hop ad-hoc networks. Proving the effectiveness of dSIP in conjunction with this algorithm would make dSIP a complete solution in any type of ad-hoc environment.

The second goal of the visit was to get to know the research ongoing at the Department of Computer Science of University of Lisbon, to seek ideas for possible future collaborations. For the purpose, I had occasion to talk with several researchers and exchange ideas and research interests.

2 Developing the Algorithm

Our common algorithm has been developed for more than one year. Unfortunately, the fact that Hugo Miranda and I live in two different nations have made the algorithm development quite cumbersome. This meeting was needed so that the algorithm could be finalized and a related paper submitted in time to MobiHoc 2006, a premier conference on ad-hoc networking. Actually, the meeting in Portugal was finalized to submitting the paper describing the algorithm to MobiHoc.

Before the meeting in Portugal, the general structure of the algorithm was already defined. Similarly, the paper was already in large part written. In Portugal we mainly worked on fine tuning its parameters for achieving the best performance, adapting the existing text in the paper to the modifications given to the algorithm, and completing the missing parts.

The algorithm developed is probabilistic, and is used to spread and retrieve information among nodes in an ad-hoc network. Its goal is to efficiently replicate in the ad-hoc network the data items that nodes advertise so that every request for a given data item, issued by any arbitrary node in the network, can be satisfied in a minimum amount of hops. Ideally, the data item should be located within the 1-hop neighborhood of the querying node. Of course, this possibility is related to the total number of nodes present in the network, the number of items disseminated, and the amount of items (cache size) the nodes can store.

The algorithm uses three types of messages: dissemination, query and reply messages. Dissemination messages are used to advertise an item in the network, and they are broadcast. To prevent flooding, limiting the usage of bandwidth, and leverage geographic distribution of items, dissemination

messages are processed differently by all the nodes that receive them. Based on the algorithm, a message can be either totally dropped if a node judges that neighboring nodes already possess information on the items carried in the message. The message can also be forwarded, if a node judges that by forwarding it it is possible to advertise the item(s) carried in the message to a large number of nodes. The data carried in the message can also be probabilistically stored in the local cache. The probabilities of storing an item are chosen according to information carried in the message in order to achieve even distribution of data items.

Query messages carry the request for one or more data items, and are processed similarly to dissemination messages. Replies are returned by nodes that have locally a requested item. All the messages carry additional information, besides the one mandatory for the action specified by the message. The additional data is constituted by items present in the cache of the node that first generated the message. These optional items help in leveraging the even data distribution. Nodes can probabilistically replace the optional item present in a message when they forward it, according to specific algorithm rules. Nodes can also decide which items to (probabilistically) store in their cache; when the caches are full, existing items are replaced. Replacing rules for cached items are also dictated by the algorithm.

In Lisbon, we particularly concentrated on fine tuning all the probabilities regulating the algorithm, and improving the details of the algorithm, especially for the part where decision on the data items to discard had to be taken by an ad-hoc node. We run simulations, analyzed the results, and modified the algorithm accordingly.

As for the work on the paper, we defined the evaluation section; this operation was not the easiest one, as we had a wide choice in the data that could be inserted in the paper, and a limited amount of space. We finalized the metrics to use, choose the parameters for the baseline configuration for the algorithm, and decided how they had to be presented. At the end of my visit, the paper was ready except for the evaluation and the conclusions. Simulations for producing the results presented in the paper were carried out after I returned to Finland.

3 Exchange of Research Interests

Knowing which type of research was going on at University of Lisbon was my second target of the visit; the hope was finding possible contact points so that it would be possible to initiate a future collaboration (besides, of

course, the one already ongoing between me and Hugo Miranda).

For the purpose, I have spoken with the following people: Liliana Rosa, Miguel Pupo Correja, Felipe Araujo, Susana Guedes, Jose' Mocito and Nuno Carvalho. Hugo Miranda also gave me an introductory talk on the software framework developed by their research group over the years, and called Appia.

In general, the research interests of all the people I have spoken to are mainly related to distributed systems, like distributed databases. I address issues related more to networking protocols. However, since networking protocols are run by network nodes, which in their whole form a distributed system, I was confident to find some common point.

An interesting contact point is given by the Appia framework itself. Appia is a middleware layer that can be placed between transport and application layer in a networked node. By implementing this platform, it is possible, among other things, to ensure efficient group communication among nodes. It is possible to configure Appia so that particular characteristics of message delivery in a group are ensured. For example, Appia can guarantee that messages sent by the group members are delivered in order. The characteristics of reliability of Appia allow the implementation of distributed databases, where the order of messaging is important in order to ensure data consistency.

One of my research interests is indeed group communication, meant in realization of application and signaling services for allowing messaging among a group of people. I have recently implemented, with my research group, services enabling point-to-point instant messaging in wireless ad-hoc networks. Extending the framework to multi-point communication (chat), requires changes at the application. It could be interesting to use Appia to help the application in handling message sending to all the group members.

The main problem in the realization of such a scenario is that Appia was designed for wired nodes, and in network configurations where bandwidth availability is not an issue. Moreover, Appia is also heavy, and it is not well suited for small devices with limited computing capabilities. As it resulted talking with Jose' Mocito, Appia should be adapted for use in wireless environments.

The work being performed by Liliana Rosa, adaptation of Appia, can also find application in the common framework. Felipe Araujo investigates a DHT-based system optimized for use in wireless environments. This system could be an alternative to our algorithm for indexing and retrieving data in the ad-hoc network. The main problems of DHT-based algorithm is in the amount of signaling traffic they generate, and in the maintenance

expenses. Our algorithm, which is optimized for operations in wireless ad-hoc networks, could be compared to Felipe Araujo's one, to see whether it can be improved.

4 Future Collaboration

As said in the previous section, the discussion with researchers at University of Lisbon, gave me indications on possible collaborations between University of Lisbon and University of Helsinki. A future common research project could foresee a framework where Appia is used with a chat (and not only) application in ad-hoc networks. University of Lisbon would take care of the adaptation of Appia in wireless networks, and University of Helsinki can implement the application taking into account the presence of Appia at middleware layer.

Future collaboration include the continuation of my work with Hugo Miranda. The common work does not conclude with the finalization of the algorithm, but we plan also to build and test an application to exploit its functionalities. The application would be the SIP protocol, and the algorithm would be used to disseminate and retrieve in a multi-hop ad-hoc networks the pairings SIP user name - device address. Further cooperation with Hugo Miranda is possible, although not planned at this stage.

5 Publications

The visit to Lisbon was mainly meant for producing a paper to be sent to Mobihoc, whose deadline was few days after my return from Lisbon. This paper presents the algorithm and evaluates its performance. At the time of writing this report, the paper has been submitted and its review pending.

The next planned publication would be the one describing how SIP can use our algorithm. However, the structure of the paper, and how the interaction can be performed, must still be evaluated. The estimated submission time for this paper is early next year.

Finally, we plan to submit a joint technical report between University of Helsinki and University of Lisbon, where we describe the algorithm and (possibly) how SIP can use it. The report extends the analysis presented in the Mobihoc paper, possibly joining in a single publication the algorithm in general, and its use by a real application.

6 Conclusions

This document has presented the report of my visit to University of Lisbon, Department of Computer Science. The visit was very fruitful, and it allowed me to finalize the work begun with Hugo Miranda, thanks to another MiNEMA grant. This work ideally completes my Ph.D., so in the context of my post graduate studies, I can say that this visit provided a key contribution.

The visit also launched the basis for future collaboration between my home university and the host university. Both universities, and the MiNEMA organization will benefit from the extension of the contact network and from the publications that will result from this visit.

References

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