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Session 7 - New Methods and Technologies for Medicine and Biology
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Session 9 - Image Processing, Image Analysis and Computer Vision
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Session 11 - Education in Computer Science and Automation

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Preface

Dear Participants,

Confronted with the ever-increasing complexity of technical processes and the growing demands on their efficiency, security and flexibility, the scientific world needs to establish new methods of engineering design and new methods of systems operation. The factors likely to affect the design of the smart systems of the future will doubtless include the following:

- As computational costs decrease, it will be possible to apply more complex algorithms, even in real time. These algorithms will take into account system nonlinearities or provide online optimisation of the system's performance.
- New fields of application will be addressed. Interest is now being expressed, beyond that in "classical" technical systems and processes, in environmental systems or medical and bioengineering applications.
- The boundaries between software and hardware design are being eroded. New design methods will include co-design of software and hardware and even of sensor and actuator components.
- Automation will not only replace human operators but will assist, support and supervise humans so that their work is safe and even more effective.
- Networked systems or swarms will be crucial, requiring improvement of the communication within them and study of how their behaviour can be made globally consistent.
- The issues of security and safety, not only during the operation of systems but also in the course of their design, will continue to increase in importance.

The title "Computer Science meets Automation", borne by the 52nd International Scientific Colloquium (IWK) at the Technische Universität Ilmenau, Germany, expresses the desire of scientists and engineers to rise to these challenges, cooperating closely on innovative methods in the two disciplines of computer science and automation.

The IWK has a long tradition going back as far as 1953. In the years before 1989, a major function of the colloquium was to bring together scientists from both sides of the Iron Curtain. Naturally, bonds were also deepened between the countries from the East. Today, the objective of the colloquium is still to bring researchers together. They come from the eastern and western member states of the European Union, and, indeed, from all over the world. All who wish to share their ideas on the points where "Computer Science meets Automation" are addressed by this colloquium at the Technische Universität Ilmenau.

All the University's Faculties have joined forces to ensure that nothing is left out. Control engineering, information science, cybernetics, communication technology and systems engineering – for all of these and their applications (ranging from biological systems to heavy engineering), the issues are being covered.

Together with all the organizers I should like to thank you for your contributions to the conference, ensuring, as they do, a most interesting colloquium programme of an interdisciplinary nature.
I am looking forward to an inspiring colloquium. It promises to be a fine platform for you to present your research, to address new concepts and to meet colleagues in Ilmenau.

Professor Peter Scharff
Rector, TU Ilmenau

Professor Christoph Ament
Head of Organisation

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Ausama Yousef, Mohamed Abd rabou Kalil

A New Algorithm for an Efficient Stateful Address Auto-configuration Protocol in Ad hoc Networks

ABSTRACT

A mobile ad hoc network (MANET) is an autonomous system of mobile routers that are self-organizing and decentralized without any need for infrastructure support. A dynamic topology of MANETs makes any configuration process difficult to be handled with standard methods as known in the statical one. Therefore, the challenge is to make MANETs able to configure themselves automatically. Address assignment of nodes is the main issue of auto-configuration. Although many protocols have been created to handle address auto-configuration in MANETs, neither of them can handle this issue efficiently. In this paper we present a solution for an efficient auto-configuration protocol designed to work in MANET. We are developing Logical Hierarchical Addressing protocol (LHA) which is classified in a stateful protocol. The LHA protocol allows the nodes to get a unique address fast and dynamically. Also it efficiently manages and handles some scenarios such as merging and partitioning of networks.

I- INTRODUCTION

Wireless communication networks are developing rapidly. An Ad hoc network [1] is one of these networks, which is an autonomous system of mobile devices. These devices work as both hosts and routers. This enables the mobile nodes to interconnect each other through multi-hops without any need for a predefined communication infrastructure. The cost of infrastructure networks in uncovered areas is one of the main issues so that using MANETs can be a well solution. Because of the dynamics of MANETs and in order to support spontaneous networking, it is important to achieve the configuration process automatically. Address assignment of nodes is the main issue of auto-configuration. However, address auto-configuration protocols known from the infrastructure network, e.g. Dynamic Host Configuration Protocol (DHCP) [2], are not sufficient for Ad hoc networks for several reasons. One of them is the need for a centralized management. Although many protocols have been created to handle address auto-configuration in MANETs but neither of them can handle this issue efficiently. There are several limitations of these protocols. They suffer from low efficiency caused by large protocol overhead, resources limitations and potential address conflicts during merging operations. Thus, new protocols have to be developed to overcome these issues.

This work proposes LHA protocol for a distributed address auto-configuration process in MANETs. The LHA provides a fast mechanism to configure a joining node with a unique address. It generates almost no protocol overhead since it uses routing protocol messages to update and distribute the required information.

A significant challenge for auto-configuration protocols is the frequent partitioning and merging of networks, which may cause address conflicts. The LHA protocol provides a good method to solve these address conflicts.

The rest of this paper is organized as follows: an overview of related research efforts is given in section 2. The basic algorithm of the LHA protocol is presented in section 3. Section 4 concludes the paper and gives an overview about the next steps and future research issues.

II- RELATED WORKS

Various auto-configuration approaches have been developed to meet the requirements of Ad hoc networks. These approaches can be classified as described in [3] into stateful, stateless and hybrid approaches, focusing on the way to maintain address allocation tables in the nodes.

Protocols following the stateless approach, assign a new address to a joining node faster than protocols of the stateful approach. Stateless auto-configuration protocols allow the new node to construct its addresses by itself. These addresses are typically based on a hardware ID or on a random number given by a random number generator. Of course there is no guaranty that this address is unique in the network. This means that a Duplicate Address Detection (DAD) mechanism is needed to verify the uniqueness of the address in the network. Thus the focus in this area has been on designing and optimizing the DAD mechanisms. The use of a DAD mechanism can slow down the attachment process of a mobile node. This is especially the case when the DAD is used before the address configuration is finished as in [4]. Even when the DAD mechanism is applied after the address has been assigned as is the case with Weak DAD (WDAD) [5] and Passive DAD (PDAD) [6], it can not meet the requirements of real time applications. This may occur if the connected node changes its address which may interrupt the transport layer connection.

In contrast, by using a stateful approach the uniqueness of the address can be ensured by concept. However, this has to be paid by a slower assignment process which does not suite the interworking aspects in hybrid networks, such as fast handoff. As presented in [7] the MANETconf protocol distributes the available address space to the nodes in network. It prevents the assignment of the same address to more than one node by maintaining additional allocation tables called pending allocation table. However, this approach needs a synchronisation procedure to ensure that the allocation tables of the nodes are always up to date. Hence an additional and reliable message exchange is needed among all nodes. These messages increase the overhead in the network. Also they cause difficulties in case of network partitioning and merging.

Another approach is used in [8]. Here, the authors propose a new protocol utilizing multiple disjoint allocation tables, which means that they split the global allocation table among all nodes. Here the already nodes can fast assign a unique address to the requester one without asking other nodes for permission. Problems can arise if a node crashes, because this crash would also destroy a part of the address space. A synchronisation procedure is needed to detect the resulting holes in the address space. This again increases the protocol overhead.

Summarizing, to integrate Ad hoc networks with infrastructure ones, a fast assignment of a unique address should be achieved, an address change due to an address conflict should be minimized and a high overhead of the already proposed protocols should be reduced.

III- LHA PROTOCOL

The Logical Hierarchical Addressing (LHA) protocol is a novel stateful approach. It enables every node in the network to quickly assign a unique address to new nodes. It synchronizes important parameters among nodes and implements a DAD mechanism by using the routing protocol messages. It can solve address conflicts in case of partitioning and merging of the network.

3.1 BASIC IDEA

In our approach there are two roles for a node in the network, predecessor and successor. Every node has a number N of free addresses. It can assign one of its free addresses to a requester node. This requester node chooses its Address Agent (AA) node from its neighbours, which will provide the address to it. Per definition the AA node is the predecessor of the requester which is called the successor. However, every predecessor could have N direct successors, whereas every successor has only one predecessor. Thus, an address hierarchy is built in the network. Every node maintains a table containing information on addresses and parameters of its successors and its predecessor, this table is called hierarchical table. The parameters are as follows:

- *Hl* is the number of levels in the hierarchy of the node.
- *AfA* is the number of currently available addresses at this node.
- *CAPS* is the number of all (direct and indirect) successors of this node.
- *Seq* is the sequence number of the current requester. This number will be calculated by AA node from the equation in (3) and will be saved by the successor.
- *MS* and *MP* are the number of lost successors and predecessors respectively.

3.2 ALGORITHM DESCRIPTION

To understand the algorithm we will describe it by starting with a single node initiating the configuration process. Then, other nodes can join and leave the network.

In the initial case, when the node is the first one in the network, it observes the medium for beacon messages of other nodes. When a specific timer expires without receiving any messages, it configures itself with the first address from the address space of the network. Then, the node sets its parameters as in equation (1):

$$\{Hl = 1, AfA = N, CAPS=0, Seq=0, MS=0, MP=0\} \quad (1)$$

When a new node enters the network and receives the beacon message, it broadcasts an Address Agent solicitation *(AA_sol)* message to its neighbours. Upon receiving this message by the neighbour nodes each of them responses by sending an Address Agent replay *(AA_rep)* message including its *AfA* parameter. This parameter indicates that the node can assign directly a unique address to the requester. As soon as the new node receives the *AA_rep* messages, it selects its AA node depending on some conditions. If the *AfA* of some or all sender nodes is bigger than 0, then the AA node address is the smallest one of them. Elsewhere it chooses the smallest node address from all the sender nodes. After the selection process the new node sends to the selected sender an Address Agent selection *(AA_sel)* message. This mechanism solves the case when several *AA_rep* messages are received from several neighbours.

Upon receiving the *AA_sel* message by the selected node, two cases are possible. If the AA node has free addresses, then it uses equation (2) to calculate the new address *(New_ Ad)* of the requester node. In the equation, the term *Root_ad* is the address of the root node in the network. *Agent_ad* is the address of the AA node. In the same time the AA node updates the parameters of requester node depending on its own parameters as depicted in equations 3.

$$New\_Ad = Root\_Ad + N*(Agent\_Ad - (Root\_Ad -1)) - AfA+1 \quad (2)$$

$$\{Hl\ (successor) = Hl\ (AA) +1,\ AfA\ (successor) = N,\ CAPS\ (successor)=0, \quad (3)$$
$$Seq\ (successor) = N-AfA\ (AA),\ MS(successor) =0,\ MP(successor)=0\}$$

At last, the AA node updates its own parameters as the equations (4). Then the AA node sends an Address Agent confirm *(AA_conf)* message including the unique address and all information needed to the new node. From this information the new node knows the address of its predecessor, which is the AA node in this case. The *AA_conf* message enables the requester to build its hierarchical table which describes the node hierarchy in the network. The new node is now able to start to communicate.

$$\{Hl\ (new) = Hl\ (old),\ AfA\ (new) = AfA\ (old)-1,\ CAPS\ (new) = CAPS\ (old) +1, \quad (4)$$
$$Seq\ (new)= Seq\ (old),\quad MS\ (new)=MS\ (old),\ MP\ (new)=MP\ (old)\}$$

In the second case, if the AA node has no free address available, it sends an Address Agent Address request *(AA_A_req)* message to all its neighbours. Every node which receives this message checks its *AfA* parameter. If it has a free address, then it responses by sending an Address Agent replay *(AA_A_rep)* message. If the node has no free addresses, it will forward the *AA_A_req* message to its neighbours. The AA node selects one of the responding nodes according the described conditions above. Then it sends an Address Agent Address selection *(AA_A_sel)* message to the chosen node. This node proceeds with the same steps as described before to calculate the address and to set the parameters derived from the equations (2), (3) and (4). Then it sends a regular *AA_conf* to the AA node, which in turn forwards the message to the new node. From the information of this message the new node knows the address of its predecessor, which is not the AA node in this case.

The described algorithm solves the problems of partitioning and merging of networks. In case of a partitioning, the nodes continue to assign the unique addresses. Subsequently, if the two parts merge again, there are no duplicated addresses. Because all nodes in one part assign a unique addresses, which will not be duplicated in the other part according to the conditions and equations described above.

LHA protocol benefits from ongoing research in routing protocols. Every node using the control messages of these protocols can detect crashed nodes. Then, notification messages will be broadcast to all nodes in MANET to update their hierarchical tables. Thus the protocol overhead is reduced at minimum level.

V- CONCLUSION

We have presented a hybrid address configuration protocol (LHA) for nodes in a MANET. The protocol enables MANET nodes to be configured with an address very rapidly if they join a network. The proposed solution minimizes the control messages by using the ongoing routing protocol. Thus, the protocol is suiting the interworking aspects in hybrid networks.

Currently, we develop a mathematical model to evaluate the performance compared to other proposals. In addition simulations to study our approach and compare it with others are underway.

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