Developments in Fuzzy Sets, Intuitionistic Fuzzy Sets, Generalized Nets and Related Topics. Volume I: Foundations

Developments in Fuzzy Sets, Intuitionistic Fuzzy Sets, Generalized Nets and Related Topics Volume II: Applications

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Generalized net model for building a standard ad-hoc on-demand distance vector routing in a wireless network

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Abstract

This article examines the structure of a basic ad hoc connection in wireless network. It uses the apparatus of generalized nets for modeling the process flows in a mobile network.

Keywords: ad hoc on-demand distance vector (AODV), ad-hoc on-demand multipath distance vector (AOMDV), AODV routing, AOMDV routing, route discovery, route repair, generalized net, ad-hoc, wireless network, mobile connection.

1 Introduction

AODV is a method of routing messages between mobile computers. It allows these mobile computers, or nodes, to pass messages through their neighbors to nodes with which they cannot directly communicate [6,8].

The present Generalized Net model (GN) [2,3,11] investigates construction of an ad hoc connection over wireless network.

The AODV protocol is an example of a reactive routing protocol using the hop-by-hop routing method. For message forwarding, the information in a routing table is used. In order to prevent from looping and to acknowledge newer paths, the idea of consequent numbers of the Destination-Sequenced Distance-Vector Routing (DSDV) protocol is used. These identification numbers are included in each routing message; upon the reception of a message with a newer number the old path is deleted from the routing table no matter that the

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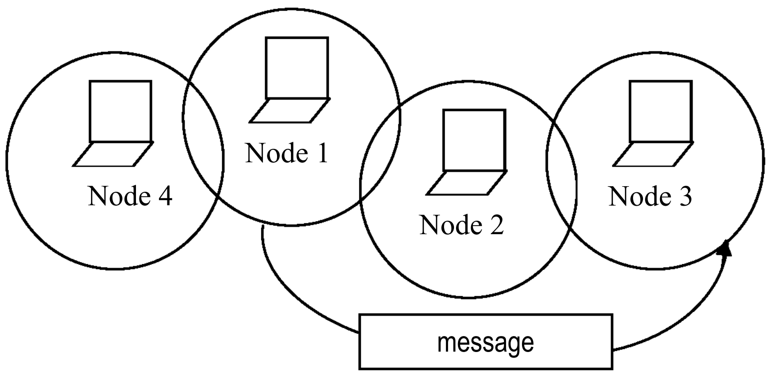
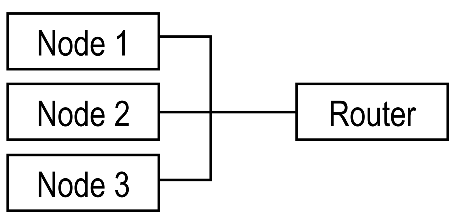
path may be still active. In addition to them timeout timers are used in which the information is also deleted no matter whether the path is active or not. The protocol supports usage of at most one path to the destination. Although well adapting for larger networks as well, the discovery of new route may be connected with a long delay, and its elimination leads to an additional delay and consumes more bandwidth. A modification of the protocol called Ad-hoc On-demand Multipath Distance Vector (AOMDV) allows for using alternative paths for reducing the number of the procedures for discovering a new path, which leads to significant improvements.

Node 1 wants to send a message to node 3. Unfortunately it is unsure of the route to get there. The figure shows a setup of nodes in a wireless network. The range of communication for each node is illustrated with circles in figures 1 a) and b).



a) Range of wireless coverage for each node



b) Node 2 as a router between nodes 1 and 3

Figure 1: Setup for message transmission from node 1 to node 3

In limited range, each node can only communicate with the nodes next to it. Nodes you can communicate with directly are considered to be Neighbors. A node keeps track of its Neighbors by listening for a HELLO message that each node broadcast at set intervals.

When one node needs to send a message to another node that is not its Neighbor it broadcasts a Route Request (RREQ) message. Example in the figure 1, Node 1 wishes to send a message to Node 3. Node 1's Neighbors are Nodes 2 and 4. Since Node 1 can not directly communicate with Node 3, Node 1 sends out a RREQ. The RREQ is heard by Node 4 and Node 2 [1,7,9].

When sending a RREQ message the source has two possibilities: if it knows the path to the destination or if the destination can send Route Replay (RREP) to the source; otherwise the neighbors will rebroadcast RREQ to their neighbors.

The Route Error Message (RERR) allows AODV to adjust routes when Nodes move around. Whenever a Node receives RERR it looks at the Routing Table and removes all the routes that contain the bad Nodes [1,4,5,11].

2 Generalized net

Initially there are the following tokens in the generalized net:

- in place l_{11} - α_1 token with a characteristic "message for send";
- in place L_{1A} - α_2 – token with an initial characteristic "Route Request (RREQ) message"; RREQ message contains several key bits of information: the source, the destination, the lifespan of the message, sequence number which serves as a unique ID.
- In the initial moment of the GN in place L_{1A+1} there are α_3 –tokens with initial characteristic <0>, and the next characteristics are aggregated through the GN – estimation for messages that have come, routed table.

It is developed a generalized network model with set of transitions A:
A= { Z_1, Z_2, Z_{2+1},..., Z_{2+n}, Z_{3+n}}, where the transitions describe the following processes:

Z_1 ="Function of the source A"

Z_2 ="Process of sending RREQ"

Z_{2+1},...,Z_{2+n}="Function of the neighbors"

Z_{3+n}="Function of the destination B"

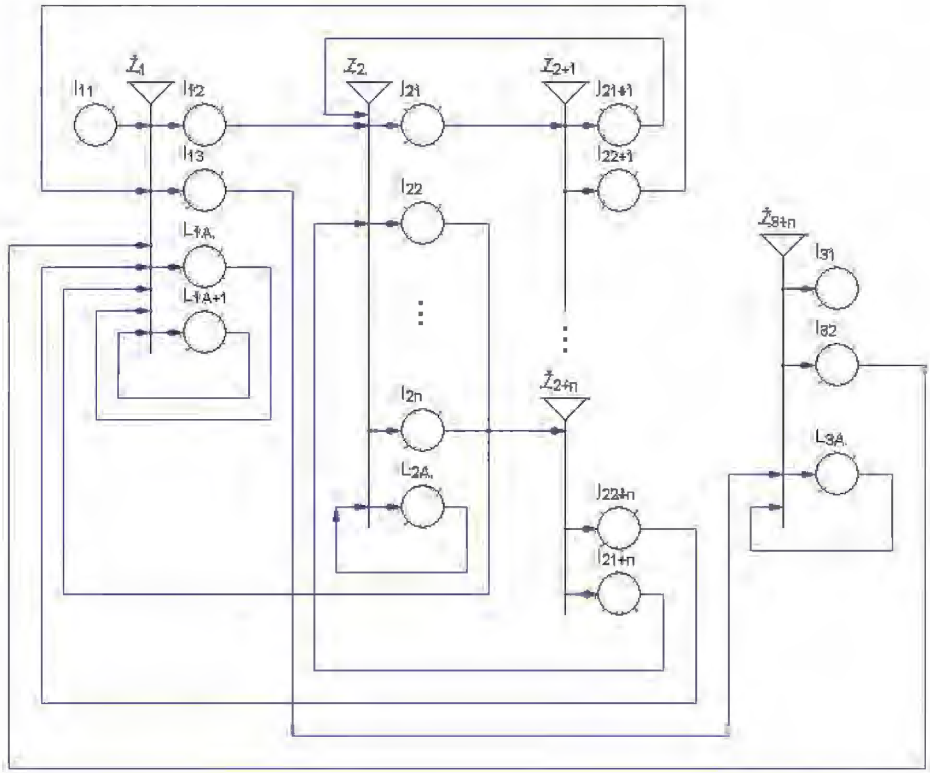


Figure 2: Generalized Net Model

Transitions have the following description:

$Z_1 = <\{ l_{11}, l_{21}, l_{22+1}, l_{22+n}, l_{32}, L_{1A}, L_{1A+1} \}, \{l_{12}, l_{13}, L_{1A}, L_{1A+1}\}, R_1, \vee(l_{11}, l_{21}, l_{22+1}, l_{22+n}, l_{32}, L_{1A}, L_{1A+1})>$

$R_1 =$

	l_{12}	l_{13}	L_{1A}	L_{1A+1}
l_{11}	*false*	*false*	*true*	*false*
l_{21}	*false*	*false*	*false*	$W_{21,1B}$
l_{22+1}	*false*	*false*	*false*	*true*
…	…	…	…	…
l_{22+n}	*false*	*false*	*false*	*true*
l_{32}	*false*	*false*	*true*	*true*
L_{1A}	$W_{1A,12}$	$W_{1A,13}$	*true*	*false*
L_{1A+1}	$W_{1B,12}$	*false*	*false*	*true*

where,
$W_{21,1B}$ = "a path is found to destination B";
$W_{1A,12}$ = "a new request has been sent for finding a neighbor to destination B";
$W_{1A,13}$ = "a message has been sent to destination B";
$W_{1B,12}$ = "an RREQ has been sent".

The token α_1 from place l_{11} enters place L_{1A}, where will unite with the corresponding current token α_2. The token from place L_{1A} splits into two α-tokens with characteristic "a request for a neighbor". The original α_2-token stays in place L_{1A}, while the new token enters place l_{12}. The tokens entering place l_{13} obtain characteristic "a message to destination B".

$Z_2 = <\{ l_{12}, l_{21+1},\dots, l_{21+n}, L_{2A}\}, \{l_{21}, l_{22},\dots l_{2n}, L_{2A} \}, R_2, \vee(l_{12}, l_{21+1},\dots, l_{21+n}, L_{2A})>$

$R_2 =$

	l_{21}	l_{22}	…	l_{2n}	L_{2A}
l_{12}	*false*	*false*	…	*false*	*true*
l_{21+1}	*false*	*false*	…	*false*	*true*
…	…	…	…	…	…
l_{21+n}	*false*	*false*	…	*false*	*true*
L_{2A}	$W_{2A,21}$	$W_{2A,22}$	…	$W_{2A,2n}$	*true*

where,
$W_{2A,21}$ = "a path to destination B has been found";
$W_{2A,2i}$ = "an RREQ has been sent to the *i*-th neighbor", for i=2, …, n.

The α-token from place l_{12} enters place L_{2A} with characteristic "an RREQ". At the next step of the transition it splits into *n* in number tokens, with the original token staying in the current place and the remaining tokens entering places from l_{22} to l_{2n+1}. The tokens coming out of L_{2A} and entering places l_{21} … l_{2n+1} do not obtain new characteristic.

Z_{2+i}= <{$l_{2,i+1}$}, {$l_{2+i,1}$, $l_{2+i,2}$}, R_{2+i}, $\vee$($l_{2,i+1}$)>, за i=2, …, n

$$R_{2+i} = \begin{array}{c|cc} & l_{2+i,1} & l_{2+i,2} \\ \hline l_{2,i+1} & W_{2,i+1,2+i,1} & W_{2,i+1,2+i,2} \end{array}$$

where,
$W_{2,i+1,2+I,1}$= "B has not been found";
$W_{2,i+1,2+I,2}$= $\neg$ $W_{2,i+1,2+I,1}$.

Z_{3+n}= <{ l_{12}, l_{21+1},…, l_{21+n}, L_{2A}}, {l_{21}, l_{22}, l_{23},… l_{2n}, L_{2A} }, R_{3+n}, $\vee$(l_{12}, l_{21+1},…, l_{21+n}, L_{2A})>

$$R_{3+n} = \begin{array}{c|ccc} & l_{31} & l_{32} & L_{3A} \\ \hline l_{31} & false & false & true \\ L_{3A} & W_{3A,31} & W_{3A,32} & true \end{array}$$

where,
$W_{3A,31}$ = "sending has been finalized";
$W_{3A,32}$ = "a confirmation has been sent".

The tokens entering place L_{3A} do not obtain new characteristic.

3 Conclusions

Ad-hoc networks are often characterized by dynamic topology because of the fact that those nodes change their place by moving around. Generalized net model describes the main conception for constructing a standard ad-hoc on-demand distance vector routing over wireless network. The model allows the process flow to be characterized at its different stages and its behavior to be simulated in future.

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The papers presented in this Volume 2 constitute a collection of contributions, both of a foundational and applied type, by both well-known experts and young researchers in various fields of broadly perceived intelligent systems.
It may be viewed as a result of fruitful discussions held during the Eighth International Workshop on Intuitionistic Fuzzy Sets and Generalized Nets (IWIFSGN-2009) organized in Warsaw on October 16, 2009 by the Systems Research Institute, Polish Academy of Sciences, in Warsaw, Poland, Centre for Biomedical Engineering, Bulgarian Academy of Sciences in Sofia, Bulgaria, and WIT – Warsaw School of Information Technology in Warsaw, Poland, and co-organized by: the Matej Bel University, Banska Bistrica, Slovakia, Universidad Publica de Navarra, Pamplona, Spain, Universidade de Tras-Os-Montes e Alto Douro, Vila Real, Portugal, and the University of Westminster, Harrow, UK:

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The Eighth International Workshop on Intuitionistic Fuzzy Sets and Generalized Nets (IWIFSGN-2009) has been meant to commence a new series of scientific events primarily focused on new developments in foundations and applications of intuitionistic fuzzy sets and generalized nets pioneered by Professor Krassimir T. Atanassov. Moreover, other topics related to broadly perceived representation and processing of uncertain and imprecise information and intelligent systems are discussed.

We hope that a collection of main contributions presented at the Workshop, completed with many papers by leading experts who have not been able to participate, will provide a source of much needed information on recent trends in the topics considered.

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