# TEAM 2011

## 3rd International Scientific and Expert Conference of the International TEAM Society

## CO-MAT-TECH 2011
## 17th International Scientific Conference

## Technics, Education, Agriculture, Management

**October 19-21, 2011**
**Trnava, Slovakia**

# Conference Proceedings

# TEAM 2011

## Proceedings of the 3rd International Scientific and Expert Conference

with simultaneously organised
17th International Scientific Conference
**CO-MAT-TECH 2011**

**19th – 21st October 2011, Trnava, Slovakia**

**The Conference is organised under the auspices of the International TEAM Society:**

University of Applied Sciences of Slavonski Brod, Slavonski Brod, Croatia
Mechanical Engineering Faculty in Slavonski Brod, University Josip Juraj Strossmayer in Osijek, Slavonski Brod, Croatia
Kecskemét College, Faculty of Mechanical Engineering and Automation (GAMF), Kecskemét, Hungary
Slovak University of Technology, Faculty of Materials Science and Technology, Trnava, Slovakia

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Organizers International TEAM Society and Slovak University of Technology, Faculty of Materials Science and Technology in Trnava, Slovakia

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# CONTENT

## PLENARY LECTURES



## TECHNICS SECTION

## EDUCATION SECTION

## AGRICULTURE SECTION



## MANAGEMENT SECTION

# Survey on Routing Algorithms

**K. Medgyes, Z. C. Johanyák**

Kecskemét College, Izsáki út 10., H-6000 Kecskemét, Hungary,
medgyes.krisztian@gamf.kefo.hu, johanyak.csaba@gamf.kefo.hu

**Abstract**

People use computers and network capable devices in more and more aspects of their life, which results in an exponentially growth of the network traffic. Therefore there is an increasing demand on efficient routing algorithms.
An ideal routing algorithm should be quick and should take into consideration several essential aspects including technical and economical ones as well. In this paper, we do a survey on some traditional (e.g. Bellman-Ford, Dijkstra, etc.) approaches and some computational intelligence based (e.g. Fuzzy Routing, Vague Set Theory based Routing) ones, which are also able to incorporate knowledge gained from human experts.

**Keywords:** Routing algorithms; Computer network; Fuzzy logic; Vague set.

## 1. INTRODUCTION

The task of traffic management or routing is to design a way (route) through which the network traffic will pass. In packet-switched computer networks routing manages the transport of packages with logical addressing from the source towards the destination, through network nodes. Routing is based on a routing table, which is in the router's internal memory, and contains the details on the possible paths targeting different destination networks.

The routers update the stored information by communicating with other routers regularly,. So they can design the optimal route from the source to the destination at all times. The mode of this communication is defined by the applied routing protocol. Each router knows its neighbor routers and the networks attached to them. The router shares this information first with its direct neighbors and through them with the whole network. Thus the routers build the network graph. Routing protocols are used to create and regularly update the routing tables.

In this paper, we do a survey on five significant routing algorithms that represent both the fields of traditional approaches and computational intelligence based approaches. After describing their key ideas and characteristics we present their advantages and disadvantages as well.

## 2. BACKGROUNDS

The topology of the network can be described by a graph, whose the nodes are routers and whose edges are links. The main task of the routing is defining the path of the package in this graph. There can be several possible pathways from the source to the destination. To find the best, one may consider the length of the way (how many links it leads through), the delay, the reliability (package loss), the band width, the cost, the load of the pathway, and the telecommunication rules or policies.

According to these aspects the applied routing algorithm will designate the optimal route. It is possible and often necessary to distribute the traffic between two or more paths. Thus one does not prefer one or another, but uses both of them in some proportion (load balancing).

The routing table contains the IP address of the destination network, the subnet mask of the destination network, the next hop, the route type, the routing protocol, the distance (metric), the route age, and the default route, where the routers forward the package if they do not find the destination network in their routing table.

The basic functions of the routers are the followings.

- The router receives the package arriving through the input interface.
- The router matches the destination address of the package to the rows of the routing table.
- If there are more matching rows the router chooses the one with the longest identical prefix.
- If there is no matching row the destination is not available and the package cannot be forwarded. Therefore the router drops the package and sends an ICMP error notification to the sender.
- If there is a matching row the router forwards the package through the correct output interface to the neighbor given as the next hop or to the destination target if there is no other hop.

The main steps of the IP address matching are the followings.

- The router organizes the rows of the routing table in descending order by the height of the subnet mask.
- If there is no *matching* row in the routing table ($N$=0), the search ends.
- If there is a matching row ($N$=1), the router applies logical AND operation on the whole bit sequence between the target IP address and the network address of the $N$th row.
- If the result of the logical AND operation is equal to the value of the $N$th row destination subnet mask, then the address matches the N. row, and the algorithm ends.
- Else $N=N+1$, and continue the algorithm on point 2. Thus it ensures that if there are two or more matching rows, the one with the longest prefix (same as the destination addresses') will be chosen.

# 3. ROUTING ALGORITHMS

Most routing protocols fall into one of the following two classes: *distance vector* or *link state*. In this section we review shortly the basic concepts of five routing algorithms. The first three of them apply traditional approaches while the last two introduce new ideas and tools from the field of computational intelligence.

## 3.1. Distance vector (DV) algotithms

Distance vector (DV) algorithms are based on the work of R. E. Bellman, L. R. Ford, and D. R. Fulkerson and for this reason occasionally are referred to as *Bellman-Ford* or *Ford-Fulkerson* algorithms [4].

According to these protocols the routers communicate only with the neighboring routers. Each router reports to all of its neighbors in an advertisement how expensive paths it knows to a given destination. They only change information about the costs. The path to the destination (which nodes it leads through) is unknown. After collecting these advertisements the router chooses the cheapest way, and forwards the package to the neighbor proposing it. Then it reports this route to the other neighbors adding its own costs to it.

The advantage of this approach is its simplicity and easy implementability. The disadvantage of this method is that "routing loops" can evolve and it does not take into consideration other aspects. Examples of distance-vector routing protocols include RIPv1, RIPv2, IGRP.

## 3.2. Link state protocol

The link state protocol is based on Dijkstra's algorithm [4]. According to this protocol the routers first map the whole network to a graph. Then they look for the shortest route to the destination in this graph. The routers change information about the state of their own interfaces with every router in the network. A link state advertisement contains the identification of the node producing it, the identification of the nodes connected to the producer, and a sequence number. So all the nodes can individually construct and frequently refresh their own topological graph.

The advantages of this approach are that it usually finds the optimal route, it is adaptive and responsible. When a router latches on to the network, the other routers quickly detect it. But when a router disconnects from the network, this information spreads not so rapidly. Other disadvantages are that it generates large data traffic and that calculating the optimal route needs time.

### 3.3. Open Shortest Path First (OSPF)

The OSPF [4] protocol can be an alternative for the RIP standard. There is a host that gets to know all the changes happening in the network, and immediately passes on the information to all other hosts. While the RIP sends out the whole routing table in every 30 seconds, OSPF forwards only the actual changes, when they happen. Routers using OSPF usually contain a built in RIP support.

The advantage of this protocol is that it generates less data traffic then the distance vector protocol or the link state protocol. When a router detects a network error, immediately forwards the information to the other routers. The disadvantage of it is that calculating the routs requires a strong CPU and time.

### 3.4. Vague Set Theory based Routing (VSTR)

Ali proposed in [1] a routing algorithm that applies the theory of vague sets. Vague sets [2] can be seen as an extension of the classic fuzzy set concept by expressing the vagueness in the available information in form of two membership functions. The first one is called truth membership function and expresses the lower bound of the grade of membership originated from evidence that supports the assumption. The second one is called the false membership function and arises from the evidence against the membership.

VSTR basically does a distance vector based routing based on one parameter, i.e. the estimated delay to reach other routers. Its key idea is that instead of creating a vector with crisp numbers expressing the delay values to reach other routers in the network VSTR builds a vector in which the individual delay values are expressed by the means of vague sets. After each data transfer a routing table is build on the receiver router side based on the vague sets which finally will be transformed into crisp vales.

The advantage of this approach is that allows expressing the inherent vagueness in the estimation of the delay times in a formalized way. Although the paper suggests the application in case of a special parameter (delay) it easily can be used in case of other frequently applied parameter types as well.

One could mention three main drawbacks of VSTR. Firstly, it increases the computational complexity of the routing process. Secondly, the description of the method is far too general, i.e. it is not specified how the vague delay times are estimated. Thirdly, although the paper claims the decrease of the network traffic as a result of the VSTR's application it is not entirely clear how and why that should happen.

### 3.5. Fuzzy Shortest Path First Routing (FSPFR)

Fuzzy logic is a very successful member of the family of soft computing techniques with a wide area of applications (e.g. [5]). Arnold et al. proposed in [3] a fuzzy version of the Shortest Path First Routing [4] algorithm. The key idea of FSPFR is that it replaces the classical link evaluation function by a fuzzy evaluation module and contrary to the most known shortest path strategies it uses not only one, but eight parameters as routing information, which are organized in three groups.

The first group representing the cost performance relation contains the link (data transfer) capacity, transmission cost, and the transmission time. The second one describes the delay situation on the link and contains the transmission delay (transmission time + processing time + queueing time) and the change of transmission delay. The parameters of the third group characterize the trust in the link. Here belong the link security (reliability), the node security (reliability), and the packet security (the packet does not get lost in overload situations).

The algorithm evaluates each link by the means of a crisp number called quality number, which is a result of a fuzzy inference based on the eight initial parameters. FSPFR first aggregates the parameter values in each group in intermediate linguistic variables using fuzzy inference and three separate rule bases. The resulting variables are the performance, the time, and the security. Next, a second inference step is involved to determine the fuzzy weight of the link. The final crisp evaluation value of the link is determined by calculating the reciprocal value of the fuzzy weight's defuzzified value. The rest of the routing procedure is identical with the classic SPFR.

The advantages of FSPFR are that the design and tuning is straightforward for a human expert in networking. Owing to the knowledge stored in form of fuzzy rules one can define, modify, and interpret the difference between the

importances of the parameters taken into consideration, i.e. complex routing strategies can be formulated.

The disadvantage of FSPFR is that it increases the computational complexity of the routing, which could have a negative effect on the speed performance.

## 4. CONCLUSIONS

Routing in computer networks is a complex task with many aspects to be taken into consideration and which needs sophisticated solutions. In this paper we examined briefly five approaches by presenting their key ideas, advantages, and disadvantages. There are simple and complex solutions that also can incorporate human experience applying fuzzy or vague set based approaches.

The simple solutions usually easily can ensure a quick decision; however, often this can be only a suboptimal solution because they do not take into consideration all the important factors. In contrast to them the newer solutions calculate with several aspects.

## 5. ACKNOWLEDGEMENTS

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