The Adaptive Routing Algorithm Taking Into Account the Trust Level to the Remote Nodes

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Abstract. *An algorithm of the adaptive routing, which implies the data transfer on a communication channel, formed by the criterion of the maximum security of data transfers for each constituent sub-channels between nodes. The safety criterion is defined as the probability of threats realization to data safety on a particular sub-channel.*

Keywords

Adaptive routing, safety criterion, distributed computer systems

1 Introduction

The distributed computer system (DCS) consists of nodes including: servers, nodes, switches and communication channels, and the switches have a very important role there. In the DCS and switched networks the most of nodes-sources and nodes-receivers are not connected directly, and when the data are transferred between them, they must pass through routers and switches. The data flow may be forwarded (switched) from the source node to any receiver node. The principle of the switching, i.e. the routing algorithm and data packets buffering strategy determines which channels from the network topology can be used for maximum efficiency of the data transfers in the network. To form the directed secured communication channel we need to apply the special routing mechanisms that allow the direct data flow through the predefined routers, with respect that the communication channels between them are less prone to potential threats from the intrusions agents.

Routing mechanisms in the switched computer networks support the communications between the subjects or nodes in the network. In particular, these mechanisms determine the principle of the allocation, filling and releasing of the buffers and ports in the routers and also the time for data transfers to the next router along the path of the destination. In addition, the routing mechanisms determine the time intervals at which the resources are allocated in the routing process: the buffers and switch ports of the router and the parameters of the routing protocols for different network topologies [1]. Thus, these mechanisms have a key role for the conflict and deadlock situations resolution in the implementation of the routing protocols. It should be noted that significant influence on the time delay of the data transferred and on the network bandwidth has the mechanisms for the data processing and the characteristics of the network traffic. [2]

2 Adaptive routing algorithm on the safe route based on the criterion of trust level to the nodes of the DCS

The implementation of the adaptive routing algorithm by the safe route requires the additional parameters: weight of the data channel (or communication channel) in terms of its safety as a value that is proportional to the trust level for the corresponding DCS node, and is inversely proportional to the probability of the security threats realization on this channel and node. Each node (router) has its own the vector of weights of the communications channels, which is periodically updated by data from the other nodes, then also the routing tables are updated. Thus, each node supports three vectors.

So, each node n support SW_n – the vector of the safety of the communication channels:

$$SW_n = (SW(n,1),...,SW(n,M)) \quad (1)$$

where M – the number of networks to which the node n is connected directly, $SW(n, i)$ – the weight of the channel from the viewpoint of its safety.

Further two vectors are forming: NL_n – the distances vector for a node n:

$$NL_n = (NL(n,1),..., NL(n,N) \quad (2)$$

where $NL(n, j)$ – the current estimate of the weight of the safety of the channel from node n to the network j; N – the number of networks in the configuration; NT_n – the vector of the next hops for the node n:

$$NT_n = (NT(n,1),..., NT(n, N) \quad (3)$$

where $NT(n, j)$ – the next router in the current route with a maximum weight of a secure communication channel from node n to the network j.

Periodically, after a short time period, each node receives the weights of the safety of the channels from the all neighboring nodes. Basing on the all received vectors of the weights of the safety of the channels the node x updates all these vectors as follows:

$$NL(n,j) = min\ (NL\ (n, j)),\text{при } SW(n, j) \geq TL_{crit} \quad (4)$$

where $NL(n, j) = y$, y – the router, wherein the $NL(n, j)$ has the minimum value, TL_{crit} – the minimum value of the trust level to the node, which allows that the data can be transmitted to this node.

During the routing process the addresses of the routers on the packets route are added in the packet header field. The principle of the generation of the routers address is crucial, for example, for the directed routing it is necessary to ensure the packets transmission by the chain from the trusted routers only. Thus, the format of the packet, based on criteria of the nodes reliability (*NR*) and trust level to the nodes (*TL*) is the next:

comments	version	IP-1	NL-1	NR-1	TL-1
		IP-2	NL-2	NR-2	TL-2
		...	...	...	...
		IP-n	NL-n	NR-n	TL-n

Fig.1. Packet format according to the criteria of the nodes reliability (*NR*) and the trust level to nodes (*TL*)

3 The realization of the adaptive routing by the safe route

The routing algorithms are differ, in particular, by the point of the decision-making about the route: if for this goal is used the special central controller, such decisions defines centralized routing; next there is an variant of the source routing, when the decisions is making before packets are injected to the network, and the next variant: routing is performed in a distributed way, when the decisions are made during the packets transfers through the network – the distributed routing [3,4]. Also, the combined solutions are possible. The one of such solution is based on a multiphase routing, when the source node defines a set of the destination nodes, and the route between them is determined in a distributed way. Let us consider in detail the features of the multiphase routing algorithm.

The multiphase routing algorithm is a combined mechanism. In this algorithm, the source node determines the node receiver or the some subset of the nodes-receivers, and the route between them is determined in a distributed way and consistently. The data transmission from the node is realized by the several neighboring nodes simultaneously, but only those nodes are used, that meet the criteria of possibility to transfer the data by them, for example, the trust level to these nodes. In fact, among all the neighboring nodes we need to choose the most trusted and reliable, and the data are transferred to these nodes. Further, the process of route constructing continues until the data will reach the destination node. This approach also improves the reliability of the data transmission due to their actual duplication and simultaneous transmission by the multiple channels.

The problem of implementation of this routing algorithm is a need for continuous and rapid exchange of metrics (*NL*, *NR*, *TL*) between all the DCS nodes, as well as the redundant data channels, which may reduce the performance of the DSC and the network bandwidth of the user data transmission.

Fig. 8 shows the variant of the multiphase routing realization for computer system with a single-channel links. To improve the efficiency of the routing mechanism there is used the approach based on the implementation of multi-channel links (Fig. 9).

In this case, the redundant transmission channels are realized simultaneously and without mutual interlocking, for example, in Time Division Multiple Access (TDMA) mode, and the transfers of the vector of the weights of the

communication channels (*NL*, *NR*, *TL*) is also simultaneously transmitted with these data that allow increase the data throughput.

In fact, in this case we have the combination of physical and topological multiple channels, which allows to change fast the data transmission route according to the current metrics of the nodes and communication channels and to provide sufficiently reliable data transmission from the node source to the receiver.

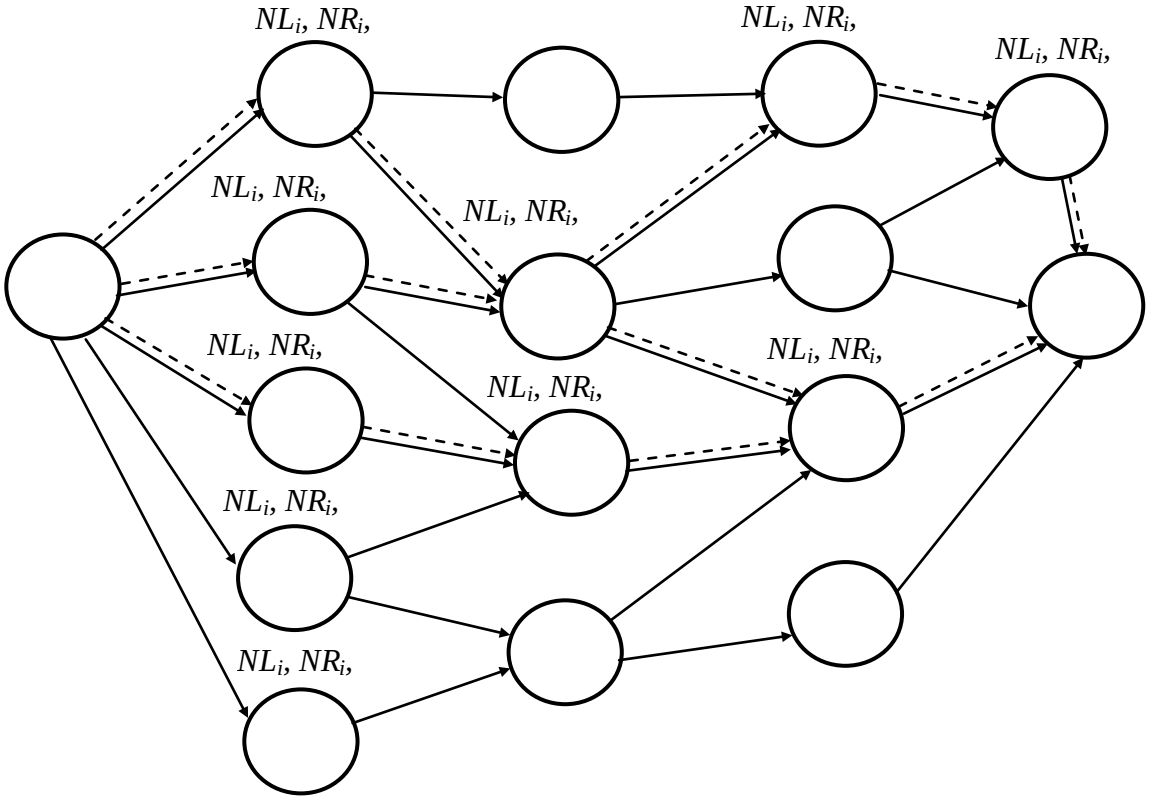

Fig. 2. The multiphase routing for the DCS with single-channel links

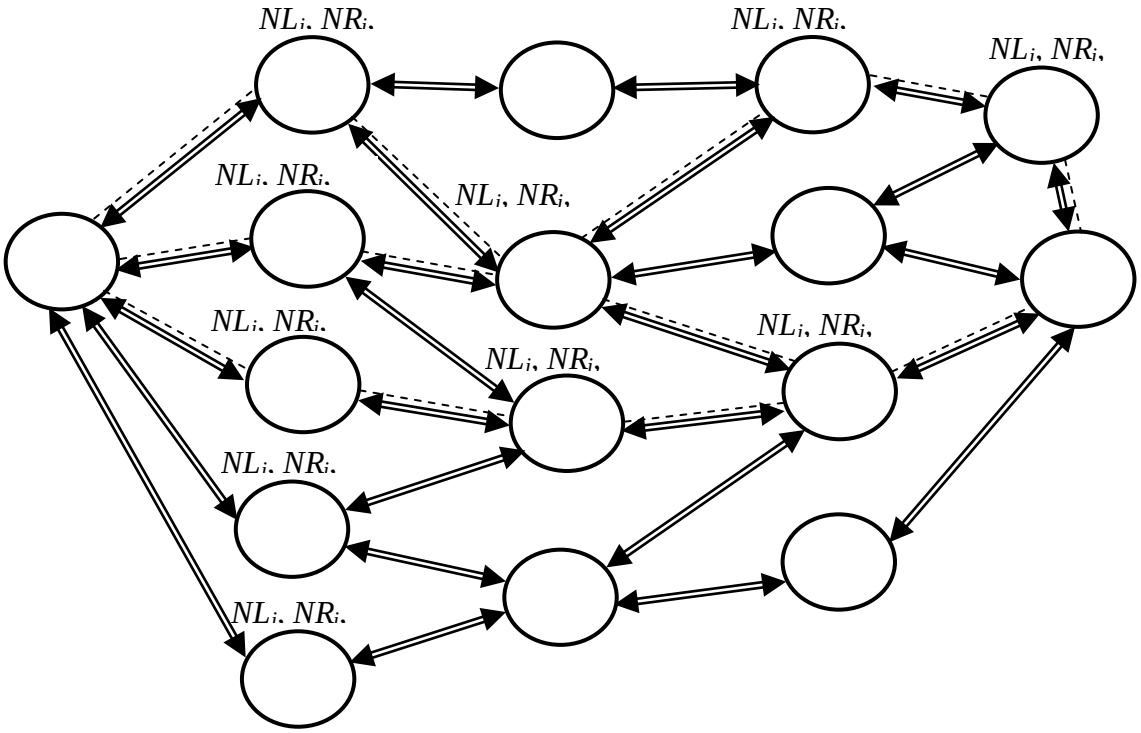

Fig. 3. The multiphase routing for the DCS with multi-channel links

4 Conclusion

The multiphase routing algorithm is the one of the most efficient for the directed data routing in the scalable computer systems. Additional efficiency is achieved through the use of computer systems with multi-channel communications, as in this case there is a combination of technologies and physical topology of multi-channel data that allows quickly re-route data according to the current parameters of the nodes and communication channels, and provide sufficiently reliable data transfer from the sources to the receivers.

References

[1] Д.А. Перепелкин, А.И. Перепелкин. Разработка алгоритмов адаптивной маршрутизации в корпора-тивных вычислительных сетях // *Информатика и прикладная математика: межвуз. сб. науч. тр. РГУ имени С.А. Есенина.* 2008. – с. 100 – 105.

[2] Д.Г. Королев Разработка механизмов определения маршрутов между произвольными точками // *Новые информационные технологии*. 2001. – с. 80 – 95.

[3] R. Perlman. Interconnections, Second Edition: Bridges, Routers, Switches, and Internetworking Protocols. *Addison-Wesley, Reading,* MA, USA, 2000.

[4] V.D. Park, M.C. Corson. A highly adaptive distributed routing algorithm for mobile wireless networks.// *IEEE Trans. on Communication,* N5, 1997. – 9 p.