Hopfield Neural Network for Dynamic Routing Based on Multi Parameters

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Abstract. The primary role of routing algorithms is to provide a support to network devices for the correct transmission of data from in the network. Bearing in mind the increasingly complex services which are offered to users, the need for more and more complex topology network is growing. In such circumstances, the routing algorithms is further complicated. Due to the popular multimedia services role of quality of services (QoS) is becoming more important. In real time streaming services, the more important parameter is the guaranteed QoS.

In our previous work we have developed several algorithms for routing which are based on a large number of real network parameters. These parameters include the link cost, link capacity, traffic density, time delay on the link and statistical indicators of availability of links. Each parameter is assigned to the individual links in an arbitrary network topology. The analysis of these parameters in order to determine the optimal routing path is based on the recurrent artificial neural networks - Hopfiled neural network.

Starting from the original Hopfield-Tank energy functions, and the modification proposed by Ali-Kamoun, in our previous article, we propose the extended form of energy function that includes all defined parameters. This energy function is implemented and integrated into the algorithm for routing in packet switched networks. Additional modifications of our algorithm are done for multicast routing.

The aim of this paper is to further enhance the proposed energy function, which will despite many parameters to take into account another important aspect of the impact of delay. So far, delay is analyzed in terms of the impact on individual parts of the final path, in order to find Pareto optimal solution. In this way, the delay on some links could be smaller than maximum allowed, but the overall trajectory, cumulative delay could be greater than allowed for a defined guaranteed QoS.

Starting from the work of Wand-Liu-Shi where they proposed solution for the analysis of the total delay on a particular path, this paper proposes an advanced solution that despite many influences, and additionally analyzes the impact of the total delay of the final path. The final routing path should have the minimum possible total delay, with the condition that it must not be greater than a initially defined.

Starting from the our previously defined forms of energy functions

$$E^{old} = \frac{\mu_1}{2}\sum_x \sum_{\substack{i\neq x \\ (x,i)\neq(D,S)}} C_{xi}v_{xi} + \frac{\mu_2}{2}\sum_x \sum_{\substack{i\neq x \\ (x,i)\neq(D,S)}} \rho_{xi}v_{xi} + \frac{\mu_3}{2}\sum_x\left(\sum_{i\neq x} v_{xi} - \sum_{i\neq x} v_{ix}\right)^2 + \frac{\mu_4}{2}\sum_i \sum_{x\neq i} v_{xi}(1-v_{xi})$$

$$+\frac{\mu_5}{2}(1-v_{DS}) + \frac{\mu_6}{2}\sum_x \sum_{\substack{i\neq x \\ (x,i)\neq(D,S)}} (1-M_{xi})v_{xi} + \frac{\mu_7}{2}\sum_x \sum_{\substack{i\neq x \\ (x,i)\neq(D,S)}} \tau_{xi}v_{xi} + \frac{\mu_8}{2}\sum_x \sum_{\substack{i\neq x \\ (x,i)\neq(D,S)}} (1-S_{xi})v_{xi}$$

where terms C_{xi} denote the link costs from node x to node i, the terms ρ_{xi} describe physical connection between nodes (the value of ρ_{xi} is set to 1 if nodes are not connected, and 0 for connected nodes), while v_{xi} are neurons' outputs, K_{xi} denote the link capacity, G_{xi} denote the *traffic density*, $M_{xi} = (K_{xi} - G_{xi})$ represents the free space in link capacity, τ_{xi} denote the links are their *delays* and S_{xi} the *statistics* of link occupancy. Coefficients μ_k, k=1,…,8, control the influence of particular terms on the energy function.

In accordance with work of Wand-Liu-Shi, we analyzed the cumulative impact of the delay on the path. Assuming that the sum of the delays on individual links, which belong to the final path must be less than a predefined delay delta, the following conditions must be satisfy

$$\sum_x \sum_{\substack{i\neq x \\ (x,i)\neq(D,S)}} L_{xi}v_{xi} \leq \Delta,\ v_{xi} \in \{0,1\}$$

In the some paper authors defined the impact of the cumulative delay effect of the energy function as

$$E_{LP} = \int h(z)dz, \quad h(z) = \begin{cases} 0, & \text{if } z\leq 0 \\ z, & \text{otherwise} \end{cases}$$

where z is defined as

$$z = \sum_x \sum_{\substack{i\neq x \\ (x,i)\neq(D,S)}} L_{xi}v_{xi} - \Delta.$$

In this way, the previously defined function E^{old}, is now modified by extension of another member. This is defined in function E^{new}.

$$E^{new} = E^{old} + E_{LP}$$

Starting from these relations, we have made Matlab simulation of proposed algorithm in order to realize the new routing algorithm. The simulation results, in different network environment, necessary modification of other functions and comparison with our previous results, will be presented.

Keywords: Hopfield neural network, routing algorithm, multi parameters routing, dynamic routing protocols.