EDUCATION FOR THE NEW NETWORK ELEMENTS

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All communication networks are based on active elements, which process the data units transmitted, and on the basis of the processing results they pass the data units in the direction from the sender to the receiver. Today the most demanding task of active elements is determining at which instant of time and which data unit the system should process such that the processing corresponds to the priority assigned to individual data units. New network elements can use artificial neural networks for the given application area. Education for the design of a complex architecture of communication systems together with optimal deployment of individual network elements is here described.

Keywords: Network element, Neural network, Ethernet,

1. INTRODUCTION

The Ethernet technology has evolved to meet the increasing demands of packet-based networks. Due to its proven low implementation cost, reliability, and relative simplicity of installation and maintenance, Ethernet´s popularity has grown to the point that nearly all traffic on the Internet originates or terminates with an Ethernet Connection. Further, as the demand for ever-faster network speeds has been increasing, Ethernet has been adapted to handle these higher speeds, as well as the surges in volume demand that accompany them.

Classical sequential data processing is constrained by the speed of central processing unit. Increasing demands on the speed of processors place ever more increasing qualitative demands on the production technology. Another solution is offered by parallel data processing. In the parallel sequencing of more complex functional elements the demands on controlling their cooperation are greatly increased, so that the increase in the effectiveness of the whole system is not so pronounced. A more advantageous possibility is frequently parallel interconnection of simpler function blocks with distributed memory. Coordinating their mutual cooperation is simpler and thus the overall effectiveness is greater than in the case of more complex elements.

An example of the second method, i.e. parallel interconnection of a great number of comparatively simple function blocks, can be seen in the artificial neural network. Artificial neural network is an array of mutually interconnected elementary function blocks with a special architecture; in many cases it offers a very promising solution to data processing. Based on neural cells of living organisms, a number of different types of neural network have been created. The project concentrates on a special type of artificial neural network, the so-called Hopfield network, which can be used to solve optimization tasks.

On the basis of the architecture of active elements and on the basis of the tasks these elements realize, it can be said that neural networks could be used very effectively for their control. The aim of the project is therefore to seek an alternative way of increasing the performance of systems whose activities can be realized using the parallel architecture. In addition, the system in question must within its activity find a solution to the optimization problem. This intention characterizes relatively well the requirements on modern active network elements.

2. EDUCATION FOR THE USING OF NEURAL NETWORKS

The neural networks selected for the expected application area are: Multi Layer Perception (MLP) - layered perceptron network with learning Back-propagation algorithm (BP) and with BP algorithm modified by variable step of learning, Radial Basis Function (RBF) – network of radial bases with learning algorithm APCIII and with algorithm K-means, self-organizing Kohonen neural network with iterative algorithm for modification of input weights and the Hopfield network with the algorithm of synchronous and asynchronous of the output. Neural network topology was designed using an original developed genetic algorithm. An original simulation development environment in the object programming language Visual C++ for testing the selected neural networks, individual learning and optimization algorithms was designed. This original environment enables a flexible modification of the object structure of simulation environment by means of the new designed algorithms. Experiments in the simulation environment created enable making complex analyse of the results obtained with relevant conclusions and recommendations for the given application area.

It was designed a new architecture of nodal active network element that is powerful enough and supports priority processing of different types of connection. It is exactly the missing support of priority processing that constitutes the greatest drawback of the majority of present-day active network elements. The proposed new architecture is based on the technology of artificial neural networks. Neural networks are used to optimize switching input requirements to outputs.

An important purpose of the project is to show that the possibilities of employing artificial neural networks in communication systems that can be realized using the parallel architecture are wide-ranging. A system employing artificial neural network could be very effective and it would often offer a more advantageous solution than classical processor-oriented systems do. It follows from the basic structure of neural networks that functional units are concerned here that perform simple operations. The operating frequency of elements that realize these functional units can therefore be much higher than, for example, that of a complex processor. Furthermore, parallel processing of information can be made effective use of, which will result in further increasing the system's effectiveness.

The project aim is also the research, simulation and hardware implementation of selected problems of the fast evolving basic stage of the integration of communication systems while telecommunication (mainly telephone) systems exist

side by side with computer network systems, which serve data transmission and operate principally on IP basis, currently the 10 Gb Ethernet networks. The emphasis was given on the quality of service (QoS) when realizing telephone and videophone connections. It is usually set for telecommunication systems and must be additionally implemented for teleinformation systems. The education includes the design and testing of new communication protocols in integrated networks, connection of IP networks to other types of network, and research into new algorithms for good-quality, effective and secure transmission of information in converged networks.

3. PROBLEMS SOLUTION - SOLUTION SCHEDULE

- Gathering present-day knowledge, experience of and conclusions from problems of converged networks

- Quality of Service Study. Connection of IP networks to other types of network. Accessible algorithms of selected neural networks (probably first of all Hopfield) preparation, their analysis and design of appropriate mathematical models.

- Accessible algorithms of selected neural networks (probably first of all Hopfield) in object environment C++ implementation. Preparation of the knowledge obtained for publishing. Beginning the work in the JAVA simulation environment.

-Examination of the JAVA simulating environment, comparison with the MATLAB programme, using the advantages of both of them. C++ implementation continue.

-The design and testing of new communication protocols in converged networks. Proposing a method for transforming the mathematical representation of optimization task into the mathematical description of neural network such that the relations that determine neural parameters are not damaged. Simultaneously, mathematical equations describing the artificial neural network will be tested by simulation and hardware using the development kit (FPGA, Xilinx Virtex).

- Quality of service implementation into converged network. Preparation of the first design of the partial blocks of the new nodal active network element architecture with neural network.

- Separating the limit criteria from the optimization task objective function and solving these components such that these two processes do not act against each other.

- Simulation of the operation of the designed architecture. Preparation of the knowledge obtained for publishing.

- The design and testing of new communication protocols in converged networks – continued.

- Connecting step-by-step the partial blocks of newly designed architecture of the switching element. Solving the optimization tasks. Running simulation of the design using the MATLAB program and our own environment in the JAVA language.

- Implementation of individual algorithms of selected neural networks (probably first of all Hopfield) in the developmental simulation environment.

- Further QoS implementation into converged networks. Research into new algorithms for good-quality, effective and secure transmission of information in

converged networks.

- Design of variant solutions, research into other types of neural networks. On-going examination of neural network functions with the aid of the development kit and by computer simulation.
- Introduction to simulation experiment in designed developmental environment and design of relevant correction in the object structure.
- Design of mathematical models of original optimalisation algorithms on the base of results of introduction simulation experiments.
- Implementation of original optimalisation algorithms of selected neural networks in the object environment C++.
- Making the designed systems with neural network more effective. Modifying the designed systems such that in the main parameters they solve all functions of the classical processor-oriented systems more effectively.
- Continuing in the optimization and in increasing the effectiveness .
- Alternative solutions. Preparation of the knowledge obtained for publishing.
- Collection of original designed optimalization algorithms into developmental simulation environment.
- Final version of the hardware implementation of the designed model using programmable logic arrays and development kits with computer simulation support. - Determining the type of cooperation between the designed blocks of network element. Implementation of individual algorithms of selected neural networks in the developmental simulation environment
- Solution of simulation experiments in new implementation algorithms and design of single algorithms correction. - Further QoS implementation into converged networks. Research into new algorithms for good-quality, effective and secure transmission of information in converged networks. - Design of other possibilities of using neural networks in communication systems, which can be realized by means of parallel architecture.
- Generalization.

4. PROSPECTS OF THE EDUCATION

Prospects of the education go from the prospects of the high-speed multimedia transmission through optical cables. Upgrade of up-to-date situation of the project will be to demonstrate a practical illustration of artificial neural networks in the area of optimizing the switching processes. An implementation area has intentionally been chosen where a comparatively simple operation is performed but where great demands are placed on the speed of executing these tasks. Optimizing the switching field of these active elements is a highly topical problem area. It is an area where a very effective use can be made of parallel processing. The project will include a switch architecture that contains an artificial neural network for optimizing priority switching. A procedure will be developed for modelling mathematically the given problems and also for realizing this mathematical model using the Hopfield neural network first of all.

The mathematical background presented can also be used as a general description of how to apply effectively the Hopfield neural network in the solution of other types of optimization tasks. In the project a method is given that can be used to separate the limiting criteria from the objective function of optimization task, and to solve the optimization task components such that the two processes given do not act against each other. On the other hand it must be emphasized that in the case of solving the optimization problem with the aid of neural network we are concerned with a stochastic process and thus the network need not case select the best solution in every case.

Within the project solution a simulation environment will be developed in the JAVA language to verify the validity of the mathematical relations derived. As shown by the results of extensive testing, the theoretical results obtained meet the expectations.

With the aid of software simulation a system will be developed that can be used to control the switching field designed for switching data units, with the priority of individual data units taken into consideration. A possible continuation of this work could be a specific hardware implementation of the above model, for example via programmable logic circuits.

5. CONCEPTIONAL AND METHODOLOGICAL APPROACHES PROPOSED FOR THE EDUCATION

The IEEE 802.3 a (10 Gigabit Ethernet standard) is different in some respects from earlier Ethernet standards, for example in that it will only operate in the full-duplex mode (collision-detection protocols are unnecessary). Ethernet can now progress to 10 Gigabits per second while retaining its critical Ethernet properties, such as the packet format, and the current capabilities are easily transferable to the new standard.

The 10 Gigabit Ethernet standard extends the IEEE 802.3ae standard protocols to a line speed of 10 Gbps and expands the Ethernet application space to include WAN-compatible links. The 10 Gigabit Ethernet standard provides a significant increase in bandwidth while maintaining maximum compatibility with the installed base of 802.3a standard interfaces, thus protecting previous investment in research and development, and retains the existing principles of network operation and management.

Under the Open Systems Interconnection (OSI) model, Ethernet is fundamentally a Layer 1 and Layer 2 protocol, 10 Gigabit Ethernet retains the key Ethernet architecture, including the Media Access Control (MAC) protocol. 10 Gigabit Ethernet continues the evolution of Ethernet in speed and distance, while retaining the same Ethernet architecture as used in other Ethernet specifications.

Quite a number of optimization tasks belong to the group of so-called combinatorial optimization tasks. During the solution of a combinatorial optimization problem the best of several possible solutions is being sought. The limiting criteria specify the basic limitation of the problem and only define the set of valid solutions.

After determining the evaluation of individual valid solutions, given by the objective function, some solutions will be of greater, some of lesser advantage. The aim of optimization is to find the best, optimum solution, with the objective function reaching its extreme.

There is a special group of optimization problems, for which no algorithm is known that could be applied to seeking the result. The only possible way of finding an optimum solution is to try all the valid combinations, to calculate the objective function for each combination, and to select a combination with which the objective function reaches its extreme. The greatest disadvantage of these optimization problems is the fact that the number of valid solutions grows exponentially with the growing size of the problem. Consequently, the time necessary for finding the optimum solution also increases exponentially.

6. EDUCATIONAL RESULTS AND ITS APPLICATION

The convergence of classical telecommunication networks and data networks is the first step in designing universal broadband integrated networks for different types of user services, inclusive of videoconference applications or multimedia services, and unified network management. The integrated network must be able to guarantee different transport parameters for different services. The problem is in the network elements, which must guarantee the required parameters and also offer a sufficiently broad bandwidth, all this at a reasonable price. That is why in the area of the development of high-speed networks the possibilities of increasing the throughput and effectiveness of active elements are sought.

On the basis of active element architecture and on the basis of tasks which these elements realize it can be said that artificial neural networks could be used very effectively for their control.

The education result will be also the design of an application of artificial neural networks in the area of optimizing the switching process, where great requirements are made on speed. It will be the design of a switch architecture with artificial neural network for priority switching optimization. A procedure will be developed how to model these problems mathematically and then how to realize this mathematical model using the neural network. The simulation model will be complemented with hardware implementation. The mathematical background presented within the solution can be used as a general description of using effectively the neural network in the solution of other types of optimization tasks. Generalized knowledge of neural networks in the direction of high-speed network elements will be made use of when applying neural networks to the communication technique.

Continued application of the web server http://access.comtel.cz (ISSN 1214-9675), installed with the support of the Grant Agency of the Czech Republic, is envisaged. Detailed results will be made public in printed form and thus generally available for application by physical and legal entities in the Czech Republic. The results will also be used in courses of full-time, doctoral and life-long studies.

7. ACKNOWLEDGMENTS

This research was supported by the grants:

No 102/07/1503 Advanced Optimization of the Design of Communication Systems via Neural Networks. The Grant Agency of the Czech Republic (GACR)

Grant 1800/2008/F1/a "Implementation of new educational system into laboratory works" (grant of the Czech Ministry of Education, Youth and Sports)

Grant 1927/2008/F1/a „ Conformation of converged network perspectives to regular and combined study" (grant of the Czech Ministry of Education, Youth and Sports)

No MSM 0021630513 Research design of Brno University of Technology " Electronic communication systems and new generation of technology (ELKOM)"

2E1860341 Lifetime education and professional preparation in the field of telematics, teleinformatics and transport telematics (grant of the Czech Ministry of Education, Youth and Sports)

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