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Improving Quality of Business Networks for Information Systems

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Abstract**—**Computer networks are essential part in computer-based information systems. The performance of these networks has a great influence on the whole information system. Measuring the usability criteria and customers satisfaction on small computer network is very important. In this article, an effective approach for measuring the usability of business network in an information system is introduced. The usability process for networking provides us with a flexible and a cost-effective way to assess the usability of a network and its products. In addition, the proposed approach can be used to certify network product usability late in the development cycle. Furthermore, it can be used to help in developing usable interfaces very early in the cycle and to give a way to measure, track, and improve usability. Moreover, a new approach for fast information processing over computer networks is presented. The entire data are collected together in a long vector and then tested as a one input pattern. Proposed fast time delay neural networks (FTDNNs) use cross correlation in the frequency domain between the tested data and the input weights of neural networks. It is proved mathematically and practically that the number of computation steps required for the presented time delay neural networks is less than that needed by conventional time delay neural networks (CTDNNs). Simulation results using MATLAB confirm the theoretical computations.

Keywords**—**Usability Criteria, Computer Networks, Fast Information Processing, Cross Correlation, Frequency Domain.

I. INTRODUCTION

As computer networks become more and more complex. The difficulty of implementing, operating, and maintaining such networks increases. Now, there are a large number of companies which entered the network market and several new networking products which are very cheap and less reliability. Because of this reason, the need to set a criteria for usability and usability measure are very important. Although there are some white papers and reports which discuss the network usability as general, there is almost no paper which covers all sides of usability measure of small computer network [1,10,13,17,20,27,34]. This paper gives criteria for usability measure of Small Business Networks. Four appropriate network configuration models are introduced which cover the most frequent small computer networking configuration. It discusses all the networking tasks and duties. The process introduced here is a systematic series of some activities and procedures designed to measure and improve the usability of computer network. The described process in this paper is a wide and formal implementation of the general design principles set forth by Gould and Lewis as follows [17,27]:

1. Focus on users and tasks early in the product design cycle.
2. Measure the performance of real users doing real work to judge usability.
3. Do iterative usability testing throughout the design cycle.

The top (area) in the network usability is the user dissatisfaction which includes [1,13,18]:

1. Examine customer “dissatisfaction” data to identify important areas of user dissatisfaction and its causes.
2. Generate descriptions of the Desired User Experience (DUE) for each of these problem areas.

Many organization reports and scientific papers are concerned with the usability for networking at global view. The Nortel Networks Study corroborates why people select networking solutions. These motivating factors are shown in Table 1 which lists main reasons for purchasing a network cited by currently networked users [20].

Here, the studies reported in [37,70,71] is continued and developed. This paper is divided into six sections. Network models and tasks are discussed in Section II. Section III presents the criteria of networking usability. The ideas for measuring the different aspects of usability are presented in section IV. Customer and provider interface are introduced in section V. Fast Information processing over computer networks is presented in section VI. Finally conclusion is given.

II. NETWORK MODELS AND TASKS

In this section we will describe some of the main network models that are used and discuss their tasks and duties.

A) Network Models [14,16,20]

In this section, four appropriate network configuration models are introduces. Some users will alter their networking solutions from one model to the other over time as their requirements and knowledge expands. In the following figures, the arrows represent the internet connections. All possible connection types include modem dial-up and

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broadband connections (e.g., cable modems or DSL services) can be used [20].

Model 1: Two (or more) PCs Directly Connected With Internet Sharing

This model is simple and relatively inexpensive, so it provides the key elements of a networking solution for end-users (i.e. sharing of networking component devices and resources plus internet access including e-mail and Web surfing). Key features of this configuration include the following:

1. One of the PCs is used as the interface to the Web as a substitute of using a dedicated network device
2. The PC used for internet access (PC2) is also used for normal PC tasks such as word processing, playing games, etc.
3. A peer-to-peer connection is used to connect both PCs in the network.

At this time, the most frequent home networking configuration (the Nortel Networks Study estimates 30 percent of multiple-PC households have networks of some kind). This model is also found in small business ventures

Model 2: Multiple PCs Networked With Each other with Access to the Network through One of the PCs

This network model has been expanded from the previous network model. Multiple PCs are tied together through a data network-device (NWD). One of the PCs is also used to access the Internet. The Nortel Networks Study found that 38 percent of households with networked PCs are using NWDs to connect them, while 85 percent of small businesses with networks use NWDs. Key features of this configuration include the following:

1. Connections between several (more than two) PCs in the network are mediated by a network device (a computer dedicated to transmitting data).
2. One of the PCs is used as the interface to the Web instead of using a dedicated network device.
3. The PC used for Internet access (PC2) is also used for normal PC tasks such as word processing, playing games, etc.

Model 3: Multiple PCs Networked With Each other with Access to the Network through a Dedicated Device.

In this model, internet access is provided through a dedicated network device (for example, a router). Compared to the Network II model, the computer used as the router is not used for typical PC tasks, but serves only in a data management role.

The Nortel Networks Study found that this configuration is currently used in about seven percent of homes with networked PCs; 37 percent of small businesses with networks use this configuration.

Model 4: Multiple PCs Networked With Each other with Voice and Data integration

In the future, this type of models will become the common model for a small businesses networking. It will first provide fused voice and data networking over the same infrastructure. Later, it will develop into a system characterized by multiple media types within the network and out to the Internet, independent of the type of information being transmitted (voice, data, video, audio, etc.).

B) Networking tasks and duties[13,17,20,27]

The main networking tasks and duties can be summarized as follows:

1. Network selection and purchase:
   - Users can easily get clear information about networking and its value.
   - Available information helps users make decisions and tradeoffs about options.
   - Users feel secure in purchasing networks because they know product components will work together
2. Network setup and configuration:
   - Users easily connect and power up network components & devices.
   - Information is clear and procedural.
   - Networks feature automatic software
3. Data, resource, and Internet sharing:
   - Network components and Internet services are sold with networking enabled by default.
   - Resources detect parameters & each other automatically.
   - Shared resources are as easy to access and use as local resources.
   - Problems are immediately communicated to the user, along with clear solutions.
4. Network management, upgrades, and expansion:
   - The network maintains a robust environment without user intervention.
   - Data is never lost and metrics are available to monitor connection performance.
   - Information associated with networking components does not require special knowledge.
   - Upgrades are simple, with optional user interaction and are reversible if problems

III. The Criteria of Networking Usability

The themes for measuring and improving the network performance, products and services [13,22,29,31] are given by:

1. Measurement and Continuous Improvement: Usually comes in little steps, definitely many apparently minor improvements in product designs and processes can together produce dramatic improvements in quality. ……In order to improve its necessary to measure. To improve collaboratively …..it is essential that measurement methods and reporting are common.

2. Customer Orientation is critical for company as competition develops in their markets.

3. Evolving Customer Needs is that customer needs vary and are evolving continuously according to the state of maturity of the service as it appears, at times, to lead and at others to lag behind the improved quality and new capabilities that

technical advances afford. For example, customers focus strongly on the network performance when a service is new.
4. Inter-operability and Standardization, means that now there is a vast experience in designing and implementing networks. It is quite obvious that the construction of new networks to serve complex needs is a very expensive and to some extent less flexible solution. Only by using combinations of existing systems can we achieve flexible and cost-effective environments. Broadband networks are faced with three interconnection problems in that they must interconnect different networks, different layers of functions and different manufacturers equipment.

IV. Measuring the different aspects of Usability

Different emphases are placed on usability definitions depending upon whether they are defined from the viewpoint of customer, service provider or network provider. The most important of these views is that the customer view. A typical customer is not concerned with the network design or how the service is provided, but only with the perceived end-to-end service quality. Therefore, the level of quality must be expressed to the user by the following parameters [13,22,29,31]:

- Are network independent and understandable by the customer.
- Take into account all aspects of the service from the customer's experience and point of view.
- Focus on measurement of customer perceivable effects rather than their impact on the network.
- Do not depend on fixed assumptions about internal design of the network but are used to continuously improve QoS (Quality of Service)
- Should be published by the service provider
- Percentage of participants successfully completing task
- Percentage of participants having a favorable attitude toward the tools used to perform the task
- Average task completion time.
- Maximum task completion time.
- Average number of assists.
- Maximum number of assists.

A) Network Selection and Purchase

There are many studies provide data about both home and small business purchase-experience problems. Many studies prove that the main reason given for not using networks were that users perceived no need for what they thought networks offered: about 60 percent of both households and small businesses have multiple PCs, but currently don't use networks. These data show that network technology today is complex and requires both general education and specific expertise–neither of which are typically available in either home or small business environments. Table 2 summarizes these findings; for each group of users (home and business), the table provides the percentage of users that listed each area as a" problem" or a "major problem"[10,11,20,22].

B) Network Setup and Configuration [20,22]

Both home and small business users have difficulties setting up, installing, and configuring small networks. Problems encountered span most of the user interactions during setup, including wiring new lines or sharing existing lines, hardware component setup and connection, software installation and configuration, and finding answers to questions and issues that arise. Table 3 summarizes the primary causes of network setup and configuration problems as reported in the Nortel Networks Study [20,27].

Data collected from Roundtable participants support the Nortel Networks Study's results. System file and OS setup can account for 20-50% of network setup help calls and TCP/IP configuration adds another 10-25%. Small business and Home network usability testing data also confirm the network installation problem areas. Specific examples of issues from call center and usability testing data from networking vendors include:

- Users encounter overwritten or corrupted file settings, virus software conflicts, auto-run CD conflicts, and driver install failures (wrong drivers, no drivers installed, files located on separate CDs, etc.).
- Users are unaware they need to set up the necessary operating system networking services (e.g., printer sharing). The settings for these services are often located in multiple system locations.
- As shipped, operating system, network, and application settings are often incompatible.

C) Data, Resource, and Internet Sharing [5,20,22,33]

Home and small business network users cannot easily enable networked devices and share applications, data, peripherals, and Internet access. Most often, controls to configure these capabilities are located in multiple locations, and users frequently do not realize devices, applications, and services may not automatically recognize networks and provide access to multiple users on that network.

During setup, especially of networks that use previously stand-alone components, users don't realize that they have to enable networking through a series of steps. Likewise, when new components (PC or peripheral) are added, they often need to be specifically configured to "see" other elements of the network.. The Nortel Networks Study reports that 25% of networked households and 21% of networked small businesses report problems with enabling shared devices. After network components are enabled and configured, users encounter problems with shared resources. Table 4 summarizes the Nortel Networks Study's data for this topic.

D) Network Management, Upgrades, and Expansion

At present, networks require monitoring and management, but home and small business network users often do not have the skills, desire, or time to perform these duties. Also, users find it is difficult to expand or upgrade their networks. Many of the problems encountered during initial setup and configuration recur as users add new hardware and software components to the network [20,22].

The problems users encounter when expanding their networks have the same root causes as problems encountered during setup and installation. The problems described in the "Network Setup and Configuration" section recur regularly during network use. Each time a component or application is upgraded or added, the potential for these problems (such as configuring the software to allow sharing and Internet access, mapping the devices and resources, etc.) increases.

- The Nortel Networks Study lists diagnosing seemingly unrelated problems after upgrading components as among the top network management and expansion problems. When a network node fails or performance degrades, network users cannot easily detect, troubleshoot, and repair the problem[20,22,27].
- The Nortel Networks Study also shows that 15 percent of both small business and residential users report some difficulty diagnosing problems such as software and hardware failures, Internet connection failures, and component failures during ongoing use of their networks. The relatively low 15 percent figure is misleading, however, because VARs report that 74 percent of small businesses receive help at least several times a month. Table 5 summarizes information gathered from networking OEMs and networking vendors at the March Ease of Use Roundtable meeting.
- Loss of Internet access and component sharing due to upgrades, expansions, etc. Industry members

report that ISP-access related questions (can't connect, can't see service, etc.) account for 15 percent to 20 percent of their calls. Reasons for network and Internet connection errors include mis-setting permissions, conflicts between factory default settings, and driver conflicts.

E) Customer and provider interface [13,20]

In the current networking environments, there is a strong need to maintain customer satisfaction by rapidly isolating and resolving problems. The resolution of customer satisfaction issues in networking is increasingly relevant within national markets as competition increases and where service providers will rely upon other network providers to deliver an end-to-end service. Often the fault resides not in the network of the provider receiving the customer trouble report but in another provider's network. Under such circumstances, the fault resolution can take a significant amount of time if a designated contact point does not exist. This results in considerable customer dissatisfaction as, in general, they do not care whose problem it is or where precisely the problem resides, they want only to have the trouble resolved as quickly as possible.

It is a goal to perform precise and unambiguous measurements which may provide results that are consistent over a number of measurements and measurement sites. To achieve this goal, the point where the measurement is taken must be well defined. A precise definition of where a measurement is taken is also necessary if the measurement shall serve within formal context

V. Fast Information Processing over Business Networks by using Fast Time Delay Neural Networks

Finding certain information, in the incoming serial data, is a searching problem. First neural networks are trained to classify the required information from other examples and this is done in time domain. In information detection phase, each position in the incoming matrix is tested for presence or absence of the required information. At each position in the input one dimensional matrix, each sub-matrix is multiplied by a window of weights, which has the same size as the sub-matrix. The outputs of neurons in the hidden layer are multiplied by the weights of the output layer. When the final output is high, this means that the sub-matrix under test contains the required information and vice versa. Thus, we may conclude that this searching problem is a cross correlation between the incoming serial data and the weights of neurons in the hidden layer.

The convolution theorem in mathematical analysis says that a convolution of f with h is identical to the result of the following steps: let F and H be the results of the Fourier Transformation of f and h in the frequency domain. Multiply F and H* in the frequency domain point by point and then transform this product into the spatial domain via the inverse Fourier Transform. As a result, these cross correlations can be represented by a product in the frequency domain. Thus, by using cross correlation in the frequency domain, speed up in an order of magnitude can be achieved during the detection process [42-71].

Assume that the size of the intrusion code is 1xn. In intrusion detection phase, a sub matrix I of size 1xn (sliding window) is extracted from the tested matrix, which has a size of 1xN. Such sub matrix, which may be an intrusion code, is fed to the neural network. Let W_i be the matrix of weights between the input sub-matrix and the hidden layer. This vector has a size of 1xn and can be represented as 1xn matrix. The output of hidden neurons h(i) can be calculated as follows:

$$h_i = g\left(\sum_{k=1}^{n} W_i(k)I(k) + b_i\right) \tag{1}$$

where g is the activation function and b(i) is the bias of each hidden neuron (i). Equation 1 represents the output of each hidden neuron for a particular sub-matrix I. It can be obtained to the whole input matrix Z as follows:

$$h_i(u) = g\left(\sum_{k=-n/2}^{n/2} W_i(k)\ Z(u+k) + b_i\right) \tag{2}$$

Eq.2 represents a cross correlation operation. Given any two functions f and d, their cross correlation can be obtained by [39]:

$$d(x) \otimes f(x) = \left(\sum_{n=-\infty}^{\infty} f(x+n)d(n)\right) \tag{3}$$

Therefore, Eq. 2 may be written as follows [42-71]:

$$h_i = g\left(W_i \otimes Z + b_i\right) \tag{4}$$

where h_i is the output of the hidden neuron (i) and h_i (u) is the activity of the hidden unit (i) when the sliding window is located at position (u) and (u) $\in$ [N-n+1].

Now, the above cross correlation can be expressed in terms of one dimensional Fast Fourier Transform as follows [42-94]:

$$W_i \otimes Z = F^{-1}\left(F(Z) \bullet F^*\left(W_i\right)\right) \quad (5)$$

Hence, by evaluating this cross correlation, a speed up ratio can be obtained comparable to conventional neural networks. Also, the final output of the neural network can be evaluated as follows:

$$O(u) = g\left(\sum_{i=1}^{q} W_o(i)\, h_i(u) + b_o\right) \quad (6)$$

where q is the number of neurons in the hidden layer. O(u) is the output of the neural network when the sliding window located at the position (u) in the input matrix Z. W_o is the weight matrix between hidden and output layer.

The complexity of cross correlation in the frequency domain can be analyzed as follows:

1- For a tested matrix of 1xN elements, the 1D-FFT requires a number equal to $N\log_2 N$ of complex computation steps [38]. Also, the same number of complex computation steps is required for computing the 1D-FFT of the weight matrix at each neuron in the hidden layer.

2- At each neuron in the hidden layer, the inverse 1D-FFT is computed. Therefore, q backward and (1+q) forward transforms have to be computed. Therefore, for a given matrix under test, the total number of operations required to compute the 1D-FFT is $(2q+1)N\log_2 N$.

3- The number of computation steps required by FTDNNs is complex and must be converted into a real version. It is known that, the one dimensional Fast Fourier Transform requires $(N/2)\log_2 N$ complex multiplications and $N\log_2 N$ complex additions [38]. Every complex multiplication is realized by six real floating point operations and every complex addition is implemented by two real floating point operations. Therefore, the total number of computation steps required to obtain the 1D-FFT of a 1xN matrix is:

$$\rho=6((N/2)\log_2 N) + 2(N\log_2 N) \quad (7)$$

which may be simplified to:

$$\rho=5N\log_2 N \quad (8)$$

4- Both the input and the weight matrices should be dot multiplied in the frequency domain. Thus, a number of complex computation steps equal to qN should be considered. This means 6qN real operations will be added to the number of computation steps required by FTDNNs.

5- In order to perform cross correlation in the frequency domain, the weight matrix must be extended to have the same size as the input matrix. So, a number of zeros = (N-n) must be added to the weight matrix. This requires a total real number of computation steps = q(N-n) for all neurons. Moreover, after computing the FFT for the weight matrix, the conjugate of this matrix must be obtained. As a result, a real number of computation steps = qN should be added in order to obtain the conjugate of the weight matrix for all neurons. Also, a number of real computation steps equal to N is required to create butterflies complex numbers ($e^{-jk(2\Pi n/N)}$), where 0<K<L. These (N/2) complex numbers are multiplied by the elements of the input matrix or by previous complex numbers during the computation of FFT. To create a complex number requires two real floating point operations. Thus, the total number of computation steps required for FTDNNs becomes:

$$\sigma=(2q+1)(5N\log_2 N) +6qN+q(N-n)+qN+N \quad (9)$$

which can be reformulated as:

$$\sigma=(2q+1)(5N\log_2 N)+q(8N-n)+N \quad (10)$$

6- Using sliding window of size 1xn for the same matrix of 1xN pixels, q(2n-1)(N-n+1) computation steps are required when using CTDNNs for certain information detection or processing (n) input data. The theoretical speed up factor η can be evaluated as follows:

$$\eta = \frac{q(2n-1)(N-n+1)}{(2q+1)(5N\log_2 N)+q(8N-n)+N} \quad (11)$$

Time delay neural networks accept serial input data with fixed size (n). Therefore, the number of input neurons equals to (n). Instead of treating (n) inputs, the proposed new approach is to collect all the incoming data together in a long vector (for example 100xn). Then the input data is tested by time delay neural networks as a single pattern with length L (L=100xn). Such a test is performed in the frequency domain as described before. The combined information in the incoming data may have real or complex values in a form of one or two dimensional array. Complex-valued neural networks have many applications in fields dealing with complex numbers such as telecommunications, speech recognition and image processing with the Fourier Transform [40,41]. Complex-valued neural networks mean that the inputs, weights, thresholds and the activation function have complex values. In this section, formulas for the speed up ratio with different types of inputs (real /complex) will be presented. Also, the speed up ratio in case of a one and two dimensional incoming input matrix will be concluded. The operation of FTDNNs depends on computing the Fast Fourier Transform for both the input and weight matrices and obtaining the resulting two matrices. After performing dot multiplication for the resulting two matrices in the frequency domain, the Inverse Fast Fourier Transform is determined for the final matrix. Here, there is an excellent advantage with FTDNNs that should be mentioned. The Fast Fourier Transform is already dealing with complex numbers, so there is no change in the number of computation steps required for FTDNNs. Therefore, the speed up ratio in case of complex-valued time delay neural networks can be evaluated as follows:

1) In case of real inputs

A) For a one dimensional input matrix

Multiplication of (n) complex-valued weights by (n) real inputs requires (2n) real operations. This produces (n) real numbers and (n) imaginary numbers. The addition of these numbers requires (2n-2) real operations. The multiplication and addition operations are repeated (N-n+1) for all possible sub matrices in the incoming input matrix. In addition, all of these procedures are repeated at each neuron in the hidden layer. Therefore, the number of computation steps required by conventional neural networks can be calculated as:

$$\theta=2q(2n-1)(N-n+1) \quad (12)$$

The speed up ratio in this case can be computed as follows:

$$\eta = \frac{2q(2n\text{-}1)(N\text{-}n+1)}{(2q+1)(5N\log_2 N)+q(8N\text{-}n)+N} \qquad (13)$$

The theoretical speed up ratio for searching short successive (n) code in a long input vector (L) using complex-valued time delay neural networks is shown in Tables 6, 7, and 8. Also, the practical speed up ratio for manipulating matrices of different sizes (L) and different sized weight matrices (n) using a 2.7 GHz processor and MATLAB is shown in Table 9.

B) For a two dimensional input matrix

Multiplication of (n^2) complex-valued weights by (n^2) real inputs requires ($2n^2$) real operations. This produces (n^2) real numbers and (n^2) imaginary numbers. The addition of these numbers requires ($2n^2$-2) real operations. The multiplication and addition operations are repeated $(N\text{-}n+1)^2$ for all possible sub matrices in the incoming input matrix. In addition, all of these procedures are repeated at each neuron in the hidden layer. Therefore, the number of computation steps required by conventional neural networks can be calculated as:

$$\theta=2q(2n^2\text{-}1)(N\text{-}n+1)^2 \qquad (14)$$

The speed up ratio in this case can be computed as follows:

$$\eta = \frac{2q(2n^2-1)(N\text{-}n+1)^2}{(2q+1)(5N^2\log_2 N^2)+q(8N^2\text{-}n^2)+N} \qquad (15)$$

The theoretical speed up ratio for detecting (nxn) real valued submatrix in a large real valued matrix (NxN) using complex-valued time delay neural networks is shown in Tables 10, 11, 12. Also, the practical speed up ratio for manipulating matrices of different sizes (NxN) and different sized code matrices (n) using a 2.7 GHz processor and MATLAB is shown in Table 13.

2) In case of complex inputs

A) For a one dimensional input matrix

Multiplication of (n) complex-valued weights by (n) complex inputs requires (6n) real operations. This produces (n) real numbers and (n) imaginary numbers. The addition of these numbers requires (2n-2) real operations. Therefore, the number of computation steps required by conventional neural networks can be calculated as:

$$\theta=2q(4n\text{-}1)(N\text{-}n+1) \qquad (16)$$

The speed up ratio in this case can be computed as follows:

$$\eta = \frac{2q(4n\text{-}1)(N\text{-}n+1)}{(2q+1)(5N\log_2 N)+q(8N\text{-}n)+N} \qquad (17)$$

The theoretical speed up ratio for searching short complex successive (n) code in a long complex-valued input vector (L) using complex-valued time delay neural networks is shown in Tables 14, 15, and 16. Also, the practical speed up ratio for manipulating matrices of different sizes (L) and different sized weight matrices (n) using a 2.7 GHz processor and MATLAB is shown in Table 17.

B) For a two dimensional input matrix

Multiplication of (n^2) complex-valued weights by (n^2) real inputs requires ($6n^2$) real operations. This produces (n^2) real numbers and (n^2) imaginary numbers. The addition of these numbers requires ($2n^2$-2) real operations. Therefore, the number of computation steps required by conventional neural networks can be calculated as:

$$\theta=2q(4n^2\text{-}1)(N\text{-}n+1)^2 \qquad (18)$$

The speed up ratio in this case can be computed as follows:

$$\eta = \frac{2q(4n^2-1)(N\text{-}n+1)^2}{(2q+1)(5N^2\log_2 N^2)+q(8N^2\text{-}n^2)+N} \qquad (19)$$

The theoretical speed up ratio for detecting (nxn) complex-valued submatrix in a large complex-valued matrix (NxN) using complex-valued neural networks is shown in Tables 18, 19, and 20. Also, the practical speed up ratio for manipulating matrices of different sizes (NxN) and different sized code matrices (n) using a 2.7 GHz processor and MATLAB is shown in Table 21.

An interesting point is that the memory capacity is reduced when using FTDNN. This is because the number of variables is reduced compared with CTDNN.

VI. Conclusion

The usability measure rules for small business network has been presented. The usability approach for networking provides us with a flexible and a cost-effective way to assess the usability of network and its products. The proposed approach focuses attention on task-related usability problems, and ensures that the problems discovered are the problems that will be encountered by people who normally use these products in doing their jobs. The presented approach can be used to certify network product usability late in the development cycle. In addition, it can be used to help in developing usable interfaces very early in the cycle. Furthermore, the presented approach give us a way to measure, track, and improve usability, the process allows us to bring the product user into the product design cycle at a very early point. Moreover, new FTDNNs for fast detecting certain information over computer networks have been presented. Theoretical computations have shown that FTDNNs require fewer computation steps than conventional ones. This has been achieved by applying cross correlation in the frequency domain between the input data and the input weights of time delay neural networks. Simulation results have confirmed this proof by using MATLAB.

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TABLE I MAIN REASONS FOR PURCHASING NETWORKS [20]

Reason for Purchasing Network	Networked Households (%)	Networked Businesses (%)
File Sharing Capabilities	56	75
Printer Sharing	45	51
Internet Access Sharing	38	31
Cost Savings	21	18
Games	3	0
General Convenience	3	4
Communication	2	2
Other	7	13

TABLE II MOST FREQUENT CAUSES OF NETWORK SELECTION AND PURCHASE PROBLEMS[20]

Problem Area	Networked Households (%)		Networked Businesses (%)	
	Problem	Major Problem	Problem	Major Problem
Knowing How to Select the Correct Network Configuration	42	14	27	7
Expectation of Plug & Play Components Not Met	35	13	22	6
Lack of Technical Support during Purchasing Process	35	12	22	9
Knowing What Network Applications Are Appropriate	37	11	24	4
Knowing What Network Hardware to Purchase	36	11	25	5
Knowing What PC Hardware to Purchase	37	9	19	4
Knowing What Network Software to Purchase	31	9	21	5
Knowing What PC Software to Purchase	32	8	20	5
Finding Where to Get the Correct Hardware	31	7	21	3
Finding Where to Get the Correct Software	30	6	16	3
Encountering a Difficult Ordering Process	22	3	16	4

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TABLE III CAUSES OF NETWORK SETUP AND INSTALLATION PROBLEMS, ACCORDING TO THE NORTEL NETWORKS STUDY

Problem Area	Networked Households (%)	Networked Businesses (%)
Documentation, labeling, and error messages require too much technical sophistication (or refer to a nonexistent network administrator).	38	31
Number and quality of existing lines are inadequate and/or in the wrong place.	33	22
Hardware and software problems:		
Incompatible with PC	38	23
Incompatible with peripherals	34	26
Device driver installation	28	22

TABLE IV PERCENTAGE OF USERS EXPERIENCING PROBLEMS WITH RESOURCE SHARING

Type of Shared Resource	Networked Households Experiencing Problems (%)	Networked Businesses Experiencing Problems (%)
File	15	10
Printer	18	18
Internet access	24	12

TABLE V CALL RATE PERCENTAGES RELATING TO NETWORK MANAGEMENT [20]

Issue	Call Rate (%)
Component or device detection failures	21
Application conflicts due to drivers or registry problems	13
Device and drive mapping issues	12
Network or Internet connection errors	6 – 7

TABLE XI THE THEORETICAL SPEED UP RATIO FOR TIME DELAY NEURAL NETWORKS (1D-REAL VALUES INPUT MATRIX, N=400).

Length of input matrix	Number of computation steps required for classical complex-valued neural networks	Number of computation steps required for fast complex-valued neural networks	Speed up ratio
10000	4.6027e+008	4.2926e+007	10.7226
40000	1.8985e+009	1.9614e+008	9.6793
90000	4.2955e+009	4.7344e+008	9.0729
160000	7.6513e+009	8.8219e+008	8.6731
250000	1.1966e+010	1.4275e+009	8.3823
360000	1.7239e+010	2.1134e+009	8.1571
490000	2.3471e+010	2.9430e+009	7.9752
640000	3.0662e+010	3.9192e+009	7.8237

TABLE VII THE THEORETICAL SPEED UP RATIO FOR TIME DELAY NEURAL NETWORKS (1D-REAL VALUES INPUT MATRIX, N=625).

Length of input matrix	Number of computation steps required for classical complex-valued neural networks	Number of computation steps required for fast complex-valued neural networks	Speed up ratio
10000	7.0263e+008	4.2919e+007	16.3713
40000	2.9508e+009	1.9613e+008	15.0452
90000	6.6978e+009	4.7343e+008	14.1474
160000	1.1944e+010	8.8218e+008	13.5388
250000	1.8688e+010	1.4275e+009	13.0915
360000	2.6932e+010	2.1134e+009	12.7433
490000	3.6674e+010	2.9430e+009	12.4612
640000	4.7915e+010	3.9192e+009	12.2257

TABLE VIII THE THEORETICAL SPEED UP RATIO FOR TIME DELAY NEURAL NETWORKS (1D-REAL VALUES INPUT MATRIX, N=900).

Length of input matrix	Number of computation steps required for classical complex-valued neural networks	Number of computation steps required for fast complex-valued neural networks	Speed up ratio
10000	9.823 e+008	4.2911e+007	22.8933
40000	4.2206e+009	1.9612e+008	21.5200
90000	9.6176e+009	4.7343e+008	20.3149
160000	1.7173e+010	8.8217e+008	19.4671
250000	2.6888e+010	1.4275e+009	18.8356
360000	3.8761e+010	2.1134e+009	18.3409
490000	5.2794e+010	2.9430e+009	17.9385
640000	6.8985e+010	3.9192e+009	17.6018

TABLE IX PRACTICAL SPEED UP RATIO FOR TIME DELAY NEURAL NETWORKS (1D-REAL VALUES INPUT MATRIX).

Length of input matrix	Speed up ratio (n=400)	Speed up ratio (n=625)	Speed up ratio (n=900)
10000	17.88	25.94	35.21
40000	17.19	25.11	34.43
90000	16.65	24.56	33.59
160000	16.14	24.14	33.05
250000	15.89	23.76	32.60
360000	15.58	23.23	32.27
490000	15.28	22.87	31.99
640000	14.08	22.54	31.78

TABLE X THE THEORETICAL SPEED UP RATIO FOR TIME DELAY NEURAL NETWORKS (2D-REAL VALUES INPUT MATRIX, N=20).

Size of input matrix	Number of computation steps required for classical complex-valued neural networks	Number of computation steps required for fast complex-valued neural networks	Speed up ratio
100x100	3.1453e+008	4.2916e+007	7.3291
200x200	1.5706e+009	1.9610e+008	8.0091
300x300	3.7854e+009	4.7335e+008	7.9970
400x400	6.9590e+009	8.8203e+008	7.8898
500x500	1.1091e+010	1.4273e+009	7.7711
600x600	1.6183e+010	2.1130e+009	7.6585
700x700	2.2233e+010	2.9426e+009	7.5556
800x800	2.9242e+010	3.9186e+009	7.4623

TABLE XI THE THEORETICAL SPEED UP RATIO FOR TIME DELAY NEURAL NETWORKS (2D-REAL VALUES INPUT MATRIX, N=25).

Size of input matrix	Number of computation steps required for classical complex-valued neural networks	Number of computation steps required for fast complex-valued neural networks	Speed up ratio
100x100	4.3285e+008	4.2909e+007	10.0877
200x200	2.3213e+009	1.9609e+008	11.8380
300x300	5.7086e+009	4.7334e+008	12.0602
400x400	1.0595e+010	8.8202e+008	12.0119
500x500	1.6980e+010	1.4273e+009	11.8966
600x600	2.4863e+010	2.1130e+009	11.7667
700x700	3.4246e+010	2.9425e+009	11.6381
800x800	4.5127e+010	3.9185e+009	11.5163

TABLE XII THE THEORETICAL SPEED UP RATIO FOR TIME DELAY NEURAL NETWORKS (2D-REAL VALUES INPUT MATRIX, N=30).

Size of input matrix	Number of computation steps required for classical complex-valued neural networks	Number of computation steps required for fast complex-valued neural networks	Speed up ratio
100x100	5.4413e+008	4.2901e+007	12.6834
200x200	3.1563e+009	1.9608e+008	16.0966
300x300	7.9272e+009	4.7334e+008	16.7476
400x400	1.4857e+010	8.8201e+008	16.8444
500x500	2.3946e+010	1.4273e+009	16.7773
600x600	3.5193e+010	2.1130e+009	16.6552
700x700	4.8599e+010	2.9425e+009	16.5160
800x800	6.4164e+010	3.9185e+009	16.3745

TABLE XIII PRACTICAL SPEED UP RATIO FOR TIME DELAY NEURAL NETWORKS (2D-REAL VALUES INPUT MATRIX).

Size of input matrix	Speed up ratio (n=20)	Speed up ratio (n=25)	Speed up ratio (n=30)
100x100	17.19	22.32	31.74
200x200	17.61	22.89	32.55
300x300	16.54	23.66	33.71
400x400	15.98	22.95	34.53
500x500	15.62	22.49	33.32
600x600	15.16	22.07	32.58
700x700	14.87	21.83	32.16
800x800	14.64	21.61	31.77

TABLE XIV THE THEORETICAL SPEED UP RATIO FOR TIME DELAY NEURAL NETWORKS (1D-COMPLEX VALUES INPUT MATRIX, N=400).

Length of input matrix	Number of computation steps required for classical complex-valued neural networks	Number of computation steps required for fast complex-valued neural networks	Speed up ratio
100x100	9.2111e+008	4.2926e+007	21.4586
200x200	3.7993e+009	1.9614e+008	19.3706
300x300	8.5963e+009	4.7344e+008	18.1571
400x400	1.5312e+010	8.8219e+008	17.3570
500x500	2.3947e+010	1.4275e+009	16.7750
600x600	3.4500e+010	2.1134e+009	16.3245
700x700	4.6972e+010	2.9430e+009	15.9604
800x800	3.9192e+009	6.1363e+010	15.6571

TABLE XV THE THEORETICAL SPEED UP RATIO FOR TIME DELAY NEURAL NETWORKS (1D-COMPLEX VALUES INPUT MATRIX, N=625).

Length of input matrix	Number of computation steps required for classical complex-valued neural networks	Number of computation steps required for fast complex-valued neural networks	Speed up ratio
100x100	1.4058e+009	4.2919e+007	32.7558
200x200	5.9040e+009	1.9613e+008	30.1025
300x300	1.3401e+010	4.7343e+008	28.3061
400x400	2.3897e+010	8.8218e+008	27.0883
500x500	3.7391e+010	1.4275e+009	26.1934
600x600	5.3885e+010	2.1134e+009	25.4969
700x700	7.3377e+010	2.9430e+009	24.9324
800x800	9.5868e+010	3.9192e+009	24.4612

TABLE XVI THE THEORETICAL SPEED UP RATIO FOR TIME DELAY NEURAL NETWORKS (1D-COMPLEX VALUES INPUT MATRIX, N=900).

Length of input matrix	Number of computation steps required for classical complex-valued neural networks	Number of computation steps required for fast complex-valued neural networks	Speed up ratio
100x100	1.9653e+009	4.2911e+007	45.7993
200x200	8.4435e+009	1.9612e+008	43.0519
300x300	1.9240e+010	4.7343e+008	40.6410
400x400	3.4356e+010	8.8217e+008	38.9450
500x500	5.3791e+010	1.4275e+009	37.6817
600x600	7.7544e+010	2.1134e+009	36.6920
700x700	1.0562e+011	2.9430e+009	35.8870
800x800	1.3801e+011	3.9192e+009	35.2134

TABLE XVII PRACTICAL SPEED UP RATIO FOR TIME DELAY NEURAL NETWORKS (1D-COMPLEX VALUES INPUT MATRIX).

Length of input matrix	Speed up ratio (n=400)	Speed up ratio (n=625)	Speed up ratio (n=900)
10000	37.90	53.58	70.71
40000	36.82	52.89	69.43
90000	36.34	52.47	68.69
160000	35.94	51.88	68.05
250000	35.69	51.36	67.56
360000	35.28	51.02	67.15
490000	34.97	50.78	66.86
640000	34.67	50.56	66.58

TABLE XVIII THE THEORETICAL SPEED UP RATIO FOR TIME DELAY NEURAL NETWORKS (2D-COMPLEX VALUES INPUT MATRIX, N=20).

Size of input matrix	Number of computation steps required for classical complex-valued neural networks	Number of computation steps required for fast complex-valued neural networks	Speed up ratio
100x100	6.2946e+008	4.2916e+007	14.6674
200x200	3.1431e+009	1.9610e+008	16.0281
300x300	7.5755e+009	4.7335e+008	16.0040
400x400	1.3927e+010	8.8203e+008	15.7894
500x500	2.2197e+010	1.4273e+009	15.5519
600x600	3.2386e+010	2.1130e+009	15.3266
700x700	4.4493e+010	2.9426e+009	15.1206
800x800	5.8520e+010	3.9186e+009	14.9340

TABLE XIX THE THEORETICAL SPEED UP RATIO FOR TIME DELAY NEURAL NETWORKS (2D-COMPLEX VALUES INPUT MATRIX, N=25).

Size of input matrix	Number of computation steps required for classical complex-valued neural networks	Number of computation steps required for fast complex-valued neural networks	Speed up ratio
100x100	8.6605e+008	4.2909e+007	20.1836
200x200	4.6445e+009	1.9609e+008	23.6856
300x300	1.1422e+010	4.7334e+008	24.1301
400x400	2.1198e+010	8.8202e+008	24.0333
500x500	3.3973e+010	1.4273e+009	23.8028
600x600	4.9746e+010	2.1130e+009	23.5427
700x700	6.8519e+010	2.9425e+009	23.2856
800x800	9.0290e+010	3.9185e+009	23.0418

TABLE XX THE THEORETICAL SPEED UP RATIO FOR TIME DELAY NEURAL NETWORKS (2D-COMPLEX VALUES INPUT MATRIX, N=30).

Size of input matrix	Number of computation steps required for classical complex-valued neural networks	Number of computation steps required for fast complex-valued neural networks	Speed up ratio
100x100	1.0886e+009	4.2901e+007	25.3738
200x200	6.3143e+009	1.9608e+008	32.2021
300x300	1.5859e+010	4.7334e+008	33.5045
400x400	2.9722e+010	8.8201e+008	33.6981
500x500	4.7904e+010	1.4273e+009	33.5640
600x600	7.0405e+010	2.1130e+009	33.3197
700x700	9.7225e+010	2.9425e+009	33.0412
800x800	1.2836e+011	3.9185e+009	32.7581

TABLE XXI PRACTICAL SPEED UP RATIO FOR TIME DELAY NEURAL NETWORKS (2D-COMPLEX VALUES INPUT MATRIX).

Size of input matrix	Speed up ratio (n=20)	Speed up ratio (n=25)	Speed up ratio (n=30)
100x100	38.33	46.99	62.88
200x200	39.17	47.79	63.77
300x300	38.44	48.86	64.83
400x400	37.92	47.23	65.99
500x500	37.32	46.89	64.89
600x600	36.96	46.48	64.01
700x700	36.67	46.08	63.31
800x800	36.38	45.78	62.64

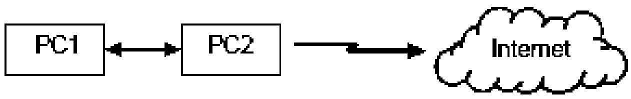

Fig. 1. Network Model

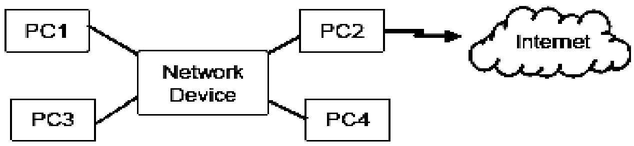

Fig. 2. Network Model2

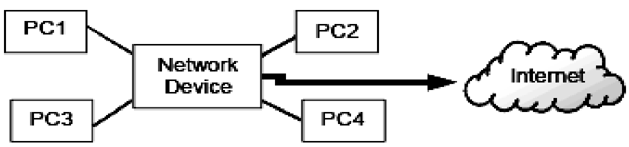

Fig .3. Network Model 3

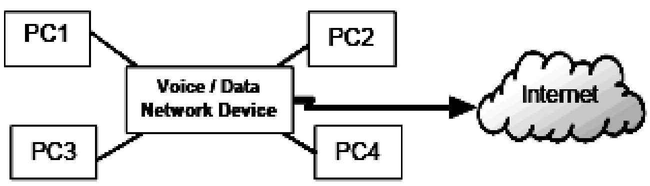

Fig. 4. Future Network: Model