Chapter

ANFIS to Quantify Maintenance Cost of IT Services in Telecommunication Company

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Abstract

The maintenance cost predication of information technology (IT) regarding their important role and well-time availability in organization is valuable for IT managers. Therefore their decision originated from the predication might be great effect on organizational budgeting, planning, and strategy management. In this regard, having enough knowledge of IT system behavior and their cost forecasting may help IT managers to develop their organization. In this chapter, adaptive neuro-fuzzy inference system (ANFIS) with capability of modeling and predication is introduced, respectively, for quantifying information technology services and their maintenance cost in one of the telecommunication companies in Iran. Because of easy accessibility in finding parameters and also prevention from the complexity of information resulting from some available services in case study organization, automation services are selected by author as kind of user-involved and widely used in finding and studying on the variable data for implementation of the model.

Keywords: information technology, ANFIS, IT maintenance cost, IT services, IT cost forecasting

1. Introduction

Today, it is important to predict the cost of information technology in each organization for cost-effective purposes, and it is possible with the correct strategy and new modeling help technology managers to estimate the implementation costs and also intangible IT costs of the organization. One of the main issues related to the cost of information technology is the determination of costs, especially those that are of an indirect nature [1].

Terminating amount of investment and budgeting for each year, especially in new technologies including IT, is heavily complicated. IT creates a lot of cost for organization if IT managers do not have enough knowledge and information related to. Therefore, correct recognition of cost factors and affecting factors can be associated to cost prediction in the area and having great support to the cost-effectiveness of any enterprise. IT investment has a positive effect on technical effects on the firms' production process. The increasing dependence of many businesses on IT and the high percentage of IT investment in all invested capitals in business environment [2] are essential functions that should be considered within every organization, providing possible solution and services expected to assess the achievement of business objective. The first step in IT investment is to know exactly what that investment is and measuring and tracking this expenditure over time against a convenient base [3]. If the cost follows an industrial standard, it enables the organization to have right understanding for enough investment in the area of IT in a specific period. The growth of revenue via offered technology solution enables organization to achieve strategy business goals and level of competitiveness. In order to assess achievement level related to such expectation, mechanism has to be determined. Researchers and practitioners have expressed concern about cost, benefit, and quality of software documentation in practice. In this chapter, IT cost is estimated for system maintenance phase by quantifying IT practical services tangible by users. Having available information enables organization to determine how much maintenance cost has been spent for IT services with consideration of their sub-components. To achieve these goals, it is necessary to develop a model based on experimental and historical data utilizing ANFIS modeling. In the past decades, numerous studies have been published on software cost estimation method including expert judgment, parametric models, and at least machine learning [4]. The results of modeling are shown in which the ANFIS is used for quantifying generated consumable services of IT to show the level of effectiveness of IT activities and also their maintenance cost forecasting. Neuro-fuzzy inference system adapted to the Takagi-Sugeno known as a fuzzy model was used for these models. ANFIS is trained with a volume of data to quantify the services with fuzzy data. Four fundamental components utilized and applied in maintenance channel and system lost include human resource, technology/infrastructure, and process and system downtime considered as IT cost factors and normally tracked in any organization and feed to model. All four variables include some components with diversity and difference in each organization related to their activity.

This model can be suggested and designed as a new module implemented in monitoring systems of the use case organization considered as significant innovation with incorporation of IT services quantification and cost estimation, concurrently practical in IT field. The reason that authors used ANFIS is that it not only includes the characteristics of both methods but also eliminates some disadvantage of their lonely use case. In this chapter, backpropagation learning in neural section is applied. Output variables obtained by applying fuzzy rule to fuzzy set of input variables in Takagi-Sugeno inference system. The results showed that the proposed model is a powerful technique and valuable tool for forecasting variables from known and achieved knowledge that is not easily measured.

2. Theoretical framework

The prediction of maintenance costs is one of the important parameters in the budgeting of IT systems. It can help organizations with cost-effective management, including the intangible costs of technology and measuring the effectiveness and efficiency of technology services with regard to spending everyday expenses.

2.1 IT operating costs

2.1.1 Definitions and concepts

In information technology, operating costs refer to the amount spent on information technology services on a daily basis. Operating costs may be due to expenses that are spent on personnel, maintenance, hardware, power and software requirements, space rentals, and security.

Operating costs are often calculated annually or every 3 months. Some costs and benefits are simply measurable by using operational data and research techniques, which we call tangible costs, while some topics, such as intangible costs, may not be easily measurable and cannot be quantified in monetary terms [5]. The investment should be financially proportional to the function and profitability of the organization. Considering IT investment in organizations, costs, technical discussions, implementation tools, risk assessments, procurement strategies, and benefits should be taken into account.

2.1.2 Real costs of information technology

In information technology and systems, the actual cost of developing them is divided into two categories of direct and indirect costs [6].

2.1.2.1 Direct costs

The direct costs relate to the factors for implementation and operation of information technology; direct costs in projects are often underestimated and beyond hardware, software, and installation costs. Direct costs may also include additional hardware that is unpredictable. This includes increased processing power, increased memory and storage facilities, and the cost of installation and implementation, which are categorized as direct costs and typically include consulting services, installation engineers, and software and network hardware [7].

2.1.2.2 Indirect costs

Indirect cost includes two categories of human and organization. Indirect human costs include management time. Expenditures related to management time are specifically designed to integrate new systems into common activities. In addition, due to the creation of new technology, more time management should be spent on revision, approval, product reform, technology-related strategies, and intelligence systems. Organizational indirect costs include organizational issues that move from old-time activities based on the impact of new systems [7].

One of the main issues and difficulties associated with information technology costs is the recognition of costs, especially those that are of an indirect nature [1]. Indirect costs can be four times higher than direct costs. Some executive managers do not know clear understanding of indirect costs, and some seek to reduce the portfolio by attracting the manager support and at the same time increasing their portfolio value.

One of the biggest indirect costs is human time management. When new technology is created, administrators may spend time for revising, approving, and subsequently reforming IT-related strategies. Sample lifetime of backup costs is at least 400% of the initial purchase price. Then indirect costs arise from the development of new knowledge in the employee and the increase of flexibility and their overall contribution to the organization. Some indirect costs arise from employee payments and rewards that this staff turnover should be considered in the assessment of information technology [6]. Irani and Mohamed introduced a two-layer system for categorizing indirect human costs. The first layer is related to management, staffing, finance, and maintenance, and the second layer is introduced for specific cost elements. In the first layer of management, it decides how much of the expenditure is spent on information technology. Employees are those involved in information technology. Finance is the allocation of funds and maintenance cost for the development and implementation of technology.

2.1.3 Types of costs

Costs in information technology can be classified into two types of hard and soft costs. The hard costs are related to purchasing, maintaining, upgrading, licensing, and so on.

Software are a kind of cost that can be hardly measured, such as unplanned system downtime costs, very complicated design structures, having bad software and hardware, and so on. Soft costs are often based on hard cost.

2.1.4 Classification of costs

The classification of costs created is based on that fundamental infrastructure technology (this does not include outsourcing and the like). These costs are often uncertain and require special attention. Having a group of defined cost of information technology that includes enterprise information technology can provide ease of cost estimation.

2.1.4.1 The cost of manpower

The cost of human resources in information technology has to be taken into account in particular. Each record includes who is doing it. How much time does it cost and how much does it cost? The cost of human resources relates to those who hold the systems. Part of the cost is given to the software mentor as a backup contract to resolve the malfunction. We calculate the cost of training in this study for manpower costs. In the corresponding organization, about 3–4 courses are planned for training each year, each of course estimates 40–60 h of training. To promote the creation of a new system, training contracts with outside companies are also signed, which are not calculated by the organization.

2.1.4.2 Infrastructure costs

Cost is better to be hard cost as possible. It's very convenient for us to be involved with physical costs, including servers and locations, rather than labor costs. Labor costs that are a part of the cost of information technology can be addressed.

2.1.4.3 Facilities and buildings

This is the basis for the information technology infrastructure in a company. Companies often have one or more data centers. This feature of the cost includes building costs and installation costs for the implementation of information technology equipment. This classification is a useful indicator for comparing costs between two different sites. Stem elements include indoor items, including electricity, floor, and the like. Water can also be considered in this category because some data centers require water to cool their equipment. WAN connections include physical links from data centers to Internet providers and other communications required. Backup generators are often diesel cars that are outside of the datacenter.

2.1.4.4 Primary infrastructure

This level, with the resources available in the facility and building, provides an environment for information technology equipment. This includes a large portion of the cost to build a data center including SAN, NAS, network, and backup.

2.1.4.5 Computer hardware

The point to be made here is how to define a server to consider function and size of the server. Servers have different costs due to their different features and capabilities. Sometimes it's easy to set up virtual machines on a server for ease of use. Virtual machines work differently using a server's resources. Only some of the resources on these computers should be selected with the best and highest rating, including RAM, CPU, and so on.

2.1.4.6 Operating systems and backup software

2.1.4.6.1 Virtual software, operating systems, backup software

Often, operating system license fees can be specifically calculated, as server costs. And this also applies for virtual software. Backup software is software that is installed on operating systems and has license fees like antivirus.

2.1.4.7 Environmental infrastructure

This level of costs includes costs that are commonly used for many information technology infrastructures including software and hardware monitoring and management.

- Supervision
- Software and hardware management

2.2 Periodic cost of information technology

The periodic costs of technology are categorized according to direct and indirect costs by the following types.

1. **Training:** In some cases, the costs of training are known as direct costs but are estimated as indirect costs. For example, direct costs involve double training for a staff member by a vendor over many years, but indirect costs include new workforce training by existing personnel.

2. **Evaluation:** Direct costs include consultants that will assess the performance of existing systems as they are. Indirect costs include staffing responsibilities for aggregation and analysis of applied statistics.

3. **Upgrade and replace:** These costs are used for the future of information technology. Hardware and software applications should be upgraded, replaced, or licensed.

2.3 Maintenance and development in information technology

Maintenance involves supporting successful operating systems during long-term use by doing the following:

1. Regular and sample tests

2. Planned and preventive replacement of system units

3. Troubleshooting failure

4. Provided with spare parts

Maintenance activity is limited to determining the defective unit and its replacement or a spare part. Defective units are repaired at a central location equipped with tester a software control.

2.3.1 Maintenance activity

Lalli et al. [8] said that maintenance is divided into two parts, which include the replacement of defective elements. Moreover, preventive maintenance, which includes scheduled maintenance in the design phase, separates maintenance activity into three phases:

In Phase I: This includes planning and designing maintenance capability, which is part of a design process that involves the construction of elements that are easy to maintain and repair. In analyzing the measuring capability, the number of errors is often used from predictable times to maintain N's maintenance. Secondly, the expected time to maintain n is the expected maintenance with the program, as well as the expected time to repair and replace items that have a limited life span and a scheduled change program. Suppose the system is shut down during maintenance, then we can measure its availability.

In Phase II: This includes handling failure and replacing items that are short-lived as well as preventive maintenance operations.

In Phase III: This involves handling fault elements that specify whether it should be repaired or replaced.

2.3.2 Maintenance and availability relationship

The maintenance ability of system measures the effectiveness of a system in terms of ease and speed when the system and equipment return after failure. The possibility of a broken system can be restored to a definite period in operational conditions. Maintenance of availability becomes meaningful:

- If the system is interrupted and cannot be fixed in a minor way, we need to find the problem in the least amount of time.

- If spare parts are not available if they are needed.

- If repairs need more time to fix.

- If installing spare parts is very hard.

- If the testing and alignment of spare parts are difficult.

This makes the system inaccessible in operational areas (not operational).

Accessibility does not mean that only the existing elements should be in operation but that backup systems require that, although we have a definite unit. The availability of a system can be related to the reliability of the system and the ease of repairing the system and sufficient reservoirs for spare parts. For mathematical analysis, we assume that there is a system that requires continuous operation, except in cases where we need preventive and planned maintenance. In this case, we estimate the temporary backup system, or the system will be definite for a short time, but it may be operational at this time, even though some of its elements are not available. This kind of failure can be tolerated until further preventive maintenance.

The ultimate goal of a system's operation is that it is available when the system is needed. In systems, things such as failure rate, average repair time, one-piece delivery time, and operational constraints are all influence in accessibility. In the context of system maintenance analysis, review and measure the operating system and backup needs in quantitative and qualitative terms regarding design criteria in hardware and backup requirements [8].

In order to a system to be available, system providers should provide the required support over the life of the software and product. The ability to support the system requires an effective combination of reliability and maintenance and logistics and operational engineering.

2.4 Metric software measurement

Measuring the desirable performance and operational requirements of a computer system depends on our requests from the system. Performance measurement depends on three factors [9]

1. Slow activity

2. How does a system deal with unusual failure and conditions?

3. How does the system use the available resources?

When a computer system typically employs several types of activity, measuring the first feature is best done separately for any type of workload. Possible classifications for workload include timed checking, transaction processing, interactive computing, and categories. Errors create a variety of failures for the system, so all measurements in the category and the second floor must be evaluated for each type of error. For example, we should only use two types of error classes:

- Catastrophic

- Benign

Failure is visible effect of error. A catastrophic failure involves losing a significant amount of information, for example, a well-designed system. The CPU error may be benign, but the disk error may be catastrophic.

2.4.1 Measuring system performance

System performance is measured by the following assessment factors [9]:

1. **Responsiveness:** This measure evaluates how a task is executed rapidly by the system. Possible measurements include waiting time, processing time, conditional wait time (the wait time for an activity requires a certain amount of processing time), queue length, and so on

2. **Level of use:** This measure evaluates how a system uses its elements and components well. Possible measurements include operating power and the use of

different resources. The purpose of this measure is to measure responsiveness and differentiation and differences. Since a system that is well used is generally slower than the responsiveness system is less used.

3. **Mission capability:** This measure indicates that it is constantly operating in its mission period. Possible measurements may include the distribution of tasks performed during the mission, the availability distance (the system may function successfully during the mission), and the life span (when unacceptable behaviors increase beyond the boundaries of the mandate). This measurement is useful when repair and adjustment are unprofessional or acceptable disastrous behaviors.

4. **Reliability:** This measure determines how long a system will be trusted. Its possible measurement, including MTTF (average failure time) and MTTR (average repair time, long-term availability, and failure cost), is a useful measure when repair is possible and the failure is tolerable.

5. **Efficiency:** This measure determines how a user can effectively perform his work. Possible measurements include friendliness, maintainability, and user comprehension. Because measurement has a problem, it is often overlooked.

2.4.2 Availability

The data were presented by Culnan's three dimensions of accessibility as a framework [10]:

1. **Physical dimension:** Access to a terminal and the findings of an existing system (such as waiting time)

2. **Communication dimension:** the use of grammatical language to formulate a command including the ability to use the system and its command language and the ability to find a person to help for system use

3. **Information dimension:** The ability to recover physical information independently

Relative availability is the time when a system, or a component, should be operational at all when it is expected. A short phrase is that a system can continue to work even when the element or set of elements is gone. To measure reliability we must first measure availability.

Most reliability models are also predicted for hardware based on failure fracture rather than failures based on defects. In hardware, failure based on physical (corrosion) is more likely than design failure. The relationship between these key concepts of reliability in hardware and its application for software is specified. If we consider a computer system, a simple measurement of the reliability of the mean time between failures (MTBF) is displayed as follows.

In a transaction processing system, you may be concerned about system performance that is different from system levels, for example, consider the computer system one, A and the other is B. For the failure type, system A has an average time between two high failure MTTFs and has an average repair time (MTTR), but the failures are because of a large amount of files loss, and the system B has a short MTTF and a high MTTR. But loses of a small amount of data due to failure make user know that B is better than A although MTTF and MTTR and cost criteria may support the system.

One aspect of measuring the availability and reporting is definite scheduled time. To upgrade hardware, operating systems, databases and software, changing system and application parameters, data management, and backup to test failure and for any type of purpose, many programs require a permanent failure.

2.4.2.1 Measurement of availability

According to the theory, Stuart Rance and Hewlett Packard include the following steps:

1. Collecting data from the service desk that specifies the job impact and the duration of each event, which is often not expensive, but there is little discussion about the accuracy of the data.

2. The tool of all the elements needed to provide services and calculate accessibility is based on understanding how an element is combined with the back services. This is an effective case, but it may lose intangible failures. For example, a small database failure may be due to the inability of users to deliver specific types of transactions.

Use a group of clients that sends known transactions from a point in the network to determine what services are in progress and what they are doing.

According to Stuart Rance and Hewlett Packard, the concept of "user definitive minutes" often measures and reports the number of affected users that is based on multiplying the number of users by the time the system that is out of reach in minutes is being impressed. The number of "user definitive minutes" is often compared with the number of "user potential per minute" to calculate a number for accessibility.

$$\text{Availability} * \mathbf{100} = (\text{user failure minutes} - \text{user potential minutes}) / (\text{user potential minutes}) \quad (1)$$

Accessibility is an indispensable part of to be considered. It is very necessary to understand what is and how it affects and how it is calculated. Although many methods are proposed to calculate the availability of a device and a simple system, calculating the availability of a business application in a complex organization cannot be easily accessed [11].

2.4.2.2 Different types of accessibility

1. **Intrinsic accessibility:** When an item works satisfactorily in particular point under conditions in an ideal supportive environment, including logistics, waiting and regulatory failure, and preventive maintenance of the failure. This includes crashing maintenance. Intrinsic accessibility is generally due to the analysis of an engineering design, and the average of MTTF failure time calculation, which is divided by the average failure time plus the average time for MTTR repair based on design control, is calculated.

2. **Achieved accessibility:** When an item works satisfactorily in particular point of time under the declared conditions in an ideal supportive environment, for example, people, tools, and parts, which include logistic time, waiting, and

regulatory failure, which can lead to preventive and corrective maintenance of the failure.

3. **Operational availability:** When an item works satisfactory, is employed at a point in time and used in a reasonable logic operation and regulatory environment Including logistic time, preparation time, waiting, or regulatory failure.

It both contains corrective and preventive maintenance. Its calculation includes the average time between failures, which is divided by the sum of the average time between failure and the average MDT breakdown. This size defines the availability of elements that are controlled by logistics and extends planners, such as the quality of parts, tools, manpower, and hardware.

2.4.3 Usability of the system

Non-quality usability and the amount of information used to rely on resources [7, 12]. Culnan [10] has come to the idea that the requirements for collecting information related to the occupation, and occupation of each person may limit access to resources. The ability to use resources generally defines both the social and economic costs associated with communicating information. The online information system is evaluated in two dimensions, including usability and ease of use. Usability is related to the physical and informational dimension or grammatical language. When a new system is introduced, the user needs to be trained and supported to be able to get familiar with the system's command language. Usability can play an important role in influencing an individual to select an information source from among other suggested sources. Usability is likely to be affected by two types of field of use and initial experience [10].

2.4.4 Accessibility metrics and reliability

Reliability and availability metrics are used to measure them in a software product [9].

2.4.4.1 Average time to failure of (MTTF)

MTTF 500 means that a failure can happen every 500 times. The time units are completely system-dependent and can even be identified in a large amount of transactions. MTTF is related to a system with long transactions. When the system processes take a lot of time, MTTF should be longer than transactions.

2.4.4.2 MTTR (average time to repair)

When errors occur, the times are needed to fix the errors. Mean MTTR is the average time it takes to track and repair the errors that cause the system to fail.

MTTR is the average time to replace the elements that were defeated. When a hardware element fails, then the failure occurs permanently, and the MTTR will spend time repairing and replacing a new element.

2.4.4.3 Average time between two failures (MTBF)

To get MTBF, we need to combine MTTF and MTTR. A 300-h MTBF is a failure. The next failure occurs only after 300 h. In this case, time measurement is timely.

2.4.4.4 Possibility of failure in demand (POFOD)

A probability that a system fails against a request. In POFOD 0.001 it means that, 1 out of 1000 requests may lead to failure. The POFOD is an important measure for the security of critical systems and should be kept as low as possible.

2.4.4.5 Failure rate (ROCOF)

This metric is sometimes referred to as failure. The number of repetitions of behavior is unpredictable. ROCOF 100/2 means 2 failures that are likely to occur per 100 operating times. This is related to operational systems or process flow systems when the system should execute a significant amount of similar requests like a credit card process system.

2.4.4.6 Accessibility (AVAIL)

Availability makes it possible for a system to be available at a specific time. Availability of 0.998 means that every 1000 times the system unit is probably available for 998 times.

2.5 Performance evaluation

To evaluate performance, we have three techniques that are as follows:

1. Measure
2. Simulation
3. Analytical modeling

2.5.1 Measurement technique

An early technique is important for analysis, simulation, and modeling and works well for hardware, software, and linking patterns.

2.5.2 Simulation software technique

Simulation involves creating a model for the behavior of a system and advancing it with an appropriate look at the workload. The benefits of it are general and flexible, which should be considered in order to simulate the following:

It should be decided what the level of simulation does not simulate. Doubling the minor behaviors of a system is often unnecessary, and its high cost is forbidden.

Simulation as well as measurement also produces many raw data that should be analyzed using statistical techniques. Simulation is also necessary, as measurement by a carefully experienced design, to reduce the cost of maintenance.

In simulation, as well as measurement, only the behavior of a system is determined for the stench of inputs by the results obtained from data analysis.

2.5.3 Analytical modeling technique

An analytical modeling is the creation of a mathematical model of the system's behavior and its solution. Its advantages over the two previous ones are as follows: (1) creating a good attitude to the work of a system that is valuable, even if the model has a complex solution. (2) Simple analytic modeling can often be solved simply and obtains an exciting result. (3) The results of analytical modeling are much better than the previous two measurements, which can be predicted.

2.6 Adaptive neuro-fuzzy inference system (ANFIS)

The disadvantages of fuzzy inference systems and neural networks are the reason why the neuro-fuzzy systems appeared, retaining the advantages of both methods and outweighing the disadvantages. The lack of fuzzy inference systems is solved by creating the knowledge about a problem from the neural inference system training data, while the complicated and hard-to-understand rules of neural networks are bypassed by using linguistic variables by means of which results are easily explained. A well-known neuro-fuzzy system is the adaptive neuro-fuzzy inference system (ANFIS) used in solving various problems. The fuzzy inference system of Sugeno type can be considered as an adaptive neuro-fuzzy inference system in the form similar to neural networks in which by training the system on input/output data set, the parameters of the fuzzy inference membership functions or antecedent parameters and the parameters of the Sugeno fuzzy system output function or consequent parameters (pi, qi i ri) are adapted [13].

3. Methodology

According to the research type, data and research variables from the automation system of one of the state-run companies have been collected over several successive years for evaluating the services and the percentage of estimated costs in the maintenance area. These data are used first to determine the parameters of information technology services and then to the cost variables. This modeling sample is selected with experimental data as the representative of the total available data and allows us to generalize the simulation results to the whole model. The results of this research can be used to develop organizational monitoring systems. Data and information collected by using libraries, databases, the Internet, published article in conferences, scientific and research journals related to information technology systems, interviews with experts of the department of automation maintenance of the organization, observation factors influencing their measurement, the historical data collection of the organization, as well as the information were obtained by the experts error weekly for 1 year.

3.1 Introduction of measured variables

Accessibility is defined as the probability that a system works desirable at any random point of time. In order to make the system always available, various factors make the system out of accessibility, which can be measured the percentage of availability including the definitive system failure with planned reasons, and the other sudden system failure. The downtime of the system should be lowered, or the system will get out of order when it is needed [14–24].

3.1.1 System availability

Measuring system availability is a growing process that evaluates the behavior of computer systems and the increasing dependence of organizations on the frequent use of operating systems and the emphasis on the design of tolerance. In this study, the measurement of the availability of hardware and software and their effect on the failure of the service has been evaluated. In addition, four effective indicators of measuring this service have been evaluated for failure.

3.1.2 Data availability

The purpose of this variable is how data is available when stored in a particular way. It is often referred as storage resource through remote storage media. The speed of user's accessibility to the data and its access level in this variable are evaluated. The storage area network (SAN) is a network of external systems that communicates with the data source and network-attached storage (NAS) that stores data through the connection to the data network. Many factors are considered in this variable, including available bandwidth, security and availability level, file system type and access level, hardware and software storage type, and AST assigned to the system administrator. In this model, four effective indicators have been evaluated to measure the availability of data in the event of a malfunction and failure of the service.

3.1.3 Application response time availability

An operational request that can complete and perform the user's job requirements. This measure is used to analyze a general application of request and examines its operational numbers in relation to the ability to perform the required activity. Accessibility of request is part of software monitoring and management by observers to determine the system's ability to send requests for operational requirements. The measurement index in this research is based on the speed of the response of the application, the number of unsuccessful transactions and the responsiveness of the request, and other measurement metrics. Three input indicators has been evaluated to measure this service.

3.1.4 Accessibility to service and backup services

The availability level and quantitative results in each organization vary according to their type of activity. The organization may evaluate the availability of 99% for 87 h per year, but another organization has 99/99% availability for 53 h, in this research the findings evaluated regarding with interviews of the executive directors of organization based on the type of organization approved by the allowed fault per year. Regarding the availability level of backup services, one needs to know what makes an activity work when it's needed at a specific time. As defined by Gartner, the level of availability of backup services is related to "decreasing failure."

3.1.5 Network availability

The availability of network resources relates to the timely behavior of a network and network equipment, that is, when the system is uptime and can work satisfactorily at any point of time, especially when the system is in repair. Accessibility is the key feature to any organization that exchanges vast amounts of data in their databases, and it is important in critical measurements, but it is important for daily operations. Some failures sometimes rise to concerns for network administrators. It may require some changes, but today, in large organizations, backup equipment is needed to reduce the risk of loss. In the studied organization of this research, the existence of backup equipment has reduced the downtime and raised availability of the system in this regard. There are four numbers of indicators measured in this study for this service.

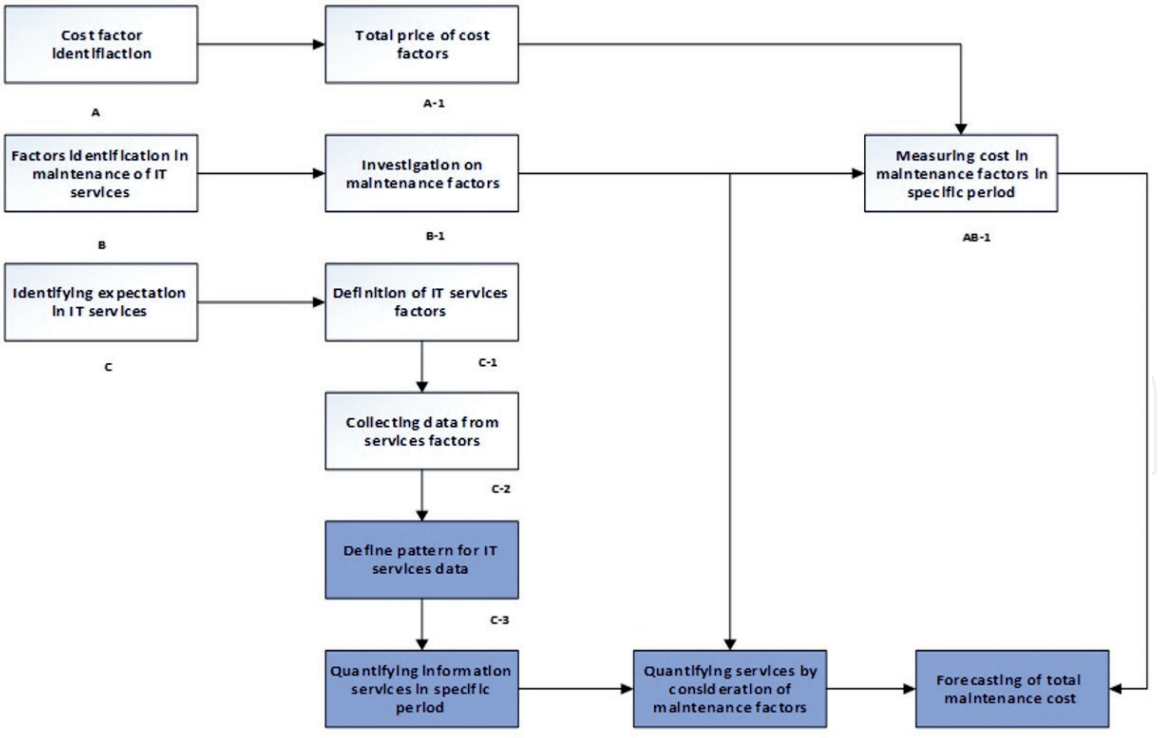

Figure 1.
Workflow diagram.

3.1.6 Turnaround time availability

The amount of time spent to do a specific request. The turnaround time is total time between sending a program, a processor, to a complete output for the client and the user. And sometimes it may return to the total time required to complete a process. And it can provide the expected output to the user after the program execution. An indicator turnaround time is used to evaluate the operating system programming algorithm. Here is the period of time a request is executed from the user's side.

3.2 Method

Adaptive neuro-fuzzy inference system (ANFIS) has been used to determine the quantity of automation ACS services by finding their indicators in the organization. Indicator data are derived from the available data in an effective organization, which finds the parameters of these indicators in measuring the level of service availability. And in each organization, there are different indicators based on the type of service being studied (**Figure 1**).

4. Research modeling and finding

4.1 Identify effective factors on the availability of IT services in office automation

The automation systems of the organization are evaluated based on availability for the user at normal and critical times, due to the service failure time. In calculating the availability metric for the above service, six main variables are defined as output for this service. Each of these outputs has different factors to check availability. Because these outputs were not measurable in organizations alone, their factors that contributed to its measurement searched for and evaluated for each of them.

Availability of consumed services in IT	Symbol	Number of attributes	Index measuring
System availability services	ACS1	4	min
Data availability services	ACS2	4	min
Application response time availability services	ACS3	3	Sec/millisec
Service support availability services	ACS4	3	min
Network availability services	ACS5	4	Min/milllisec
Turnaround time availability services	ACS6	3	min

Table 1.
Component of availability of IT services.

4.2 Find elements affecting the output

We discussed six main and effective variables on the measurement of the availability of information technology services (**Table 1**). ANFIS modeling with six below major variables with the abbreviations marked in front of them was written in the research. It consists of six elements:

These six major variables of research on information technology services were found and analyzed on automation services. Each of the six main variables has several sub-elements or indicators in collecting data and analyzing them. These indicators are events that assess the level of service availability from the point of view of definite time or out of service. The events from the point of view of failure and the number of endings in weekly periods are examined to predict the variable availability according to the time expected for the operation of a system (AST).

4.3 ANFIS to estimate maintenance costs for office automation

In the second modeling, ANFIS is used to predict the costs of maintenance of office automation service over a specific time by consideration of the fixed maintenance costs and the costs of the failure of the service, and the parameters obtained from the accessibility of the services in the first model weekly for these services were taught by the model. Given the importance of some indicators in measuring cost of service failure, the amount of these factors was determined and included in the cost factor.

$$\begin{aligned} Cost = \{&First\ variable\ failure\ cost + Second\ variable\ failure\ cost \\ &+ Third\ variable\ failure\ cost + Fourth\ variable\ failure\ cost \\ &+ Fifth\ variable\ failure\ cost + Sixth\ failure\ cost\} \\ &+ \{Cost\ of\ fixed\ maintenance\} \end{aligned}$$

$$(cost) = f(lost\ time\ (ACS1 + ACS2 + ACS3 + ACS4 + ACS5 + ACS6)) + fix\ cost$$

Although the maintenance cost represents a very small percentage of the company's revenue, the software and service failure rate, due to the amount of defects

Test number	Real cost (ml/r)	Forecasting cost (ml/r)
1	436	424
2	732	746
3	685	689
4	667	662

Table 2.
Output table of the model in four times of testing.

at intervals, and the decrease and drop in speed, have a great effect on increasing the cost of maintenance in the organization studied leading to more work hours and replacing faulty components and increasing the time of support contracts to minimize the criticality in the service data shown in (**Table 2**).

4.4 Summary

The availability of services was determined by the quantitative characteristics of measurable indicators in the organization as inputs to the model. These characteristics were selected after the analysis of the results of the questionnaire with the senior organization's experts and data recorded in the monitoring system of the maintenance unit. The error obtained from actual data comparison with the predicted model data was confirmed by managers and experts in the organization.

The variables of measurement indicators in system maintenance cost include human resources, equipment training, and processes and failure rates, in which behavior of each indicator in an organization varies depending on its type of activity.

5. Conclusion

Nowadays, the measurement of accessibility and availability of IT services for IT administrators and also consideration of their associate costs are essential factors for future-oriented decisions from the capability of the system based on user expectation to accurate investment in the field. Accurate investment in IT is complicated for some IT administrators based on the number of current services in their organization. Identification of new artificial intelligence methods will help them to know the level of effectiveness of IT services in their organization in each period. In the present study, to prove and verify proposed prediction framework, MATLAB fuzzy logic toolbox is used.

This tool provides us with ANFIS as a selected learning technique to present and develop the model in two phases: first phase is quantifying the level of IT services' availability (six variables), and second phase is prediction of their maintenance cost of system failure by finding of six variables' measurement of services. To prevent any complexity for data collection resulting from large number of services, automation system placed in system maintenance department of study organization was selected as a user-involved and widely used system to find out indicators, affective reasons, and implementation of the model. And also this department helps to estimate lost maintenance costs and find its effective indicators. Regarding the result of this study, ANFIS can predict well with lowest fault and near to real data. It is kind of effective, new, practical technique than others with precise prediction.

Table1: Inputs and outputs of ACS1

MF	HT	HDF	NDF	Target	Output
87.3	100	95.2	89	93.1	94

Table 2: Inputs and output of ACS2

TS	CL	LCS	NR	Target	Output
99.6	97.3	96.5	92.2	97.3	97

Table 3: Inputs and output of ACS3

EM	GT	HR	Target	Output
99.9	99.9	99.7	99.9	99.9

Table 4: Inputs and output of ACS4

RTP	RTN	RTO	Target	Output
62.5	89.8	100	98.3	97.9

Table 5: Inputs and output of ACS5

PT	ST	ND	BT	Target	Output
98.2	96.5	95.7	99	96.2	96.3

Table 6: Inputs and output of ACS6

TI	AR	DR	Target	Output
85.5	86.7	72.2	83.7	84.7

Table 7: Inputs and output of cost

ACS1	ACS2	ACS3	ACS4	ACS5	ACS6	Target	Output
93.1	97.3	99.9	98.3	96.2	83.7	1411	1419

Table 3.
Output of ANFIS training.

As for future work, (1) the model can be developed as a basic suggestive model to measure other kinds of cost-related service quantification; (2) it is practical for the understudy organization to develop a management module in monitoring systems by combination of both models' targets discussed in the article. It provides managers with views to check constantly the status of the system and the reasons of increased cost to be applied in future decisions; (3) more advanced method can be involved in the experiment as regression; and (4) extensive experiment on more variables and attributes can contribute to more realization.

Table 3 shows the outputs of the model with respect to forecasting of cost and quantifying IT services studied in automation services in the organization in specific periods.

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