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Application of Fuzzy Sets theory to system integration

Tatsuo Yagyu

MEITEC Corporation, Research and Development Dept.
2-20-1,Kosei-dori,Nishi-ku,Nagoya 451 Japan

Abstract: The computer users who desire the comprehensive use of an advanced network system which permits to link the diversified types of computer from one to others, still tend to increase in number. However, one of the ways to install a highly reliable facilities relative to the network system is to inherit the know-how preserved in the specific technology. Therefore, we will propose the solution of this problem.

This paper describes COMNETS, an expert system for constructing distributed networks.

I. Introduction

The use of computers have been changing variously since appearance of personal computers in the 1980's. Also, Networking techniques have developed rapidly and standardized and spread since Ethernet have be released in 1976. Computer networks have revolutionized our use of computers.

Here, we have to define about the concept of networking before used in later chapters.

A computer network is a communication system for connecting end-system. We often refer to the end-systems as hosts. The hosts can range in size from personal computers to supercomputers. Some hosts on a computer network are dedicated systems, such as print servers or file servers, without any capabilities for interactive users. Other hosts might be single-user personal computers, while others might be general purpose time-sharing systems.

Computer networks pervade our everyday life, from airline reservation systems to electronic mail. There are many reasons for the explosive growth in computer networks.

In these environment, the roles of the system integrator are increasing more and more.At present the System Integrator research every kind of information and make a plan to solve problems concretely by himself. SI(System Integration)operations are divided concretely as follows:

STEP 1 : Planning stage from investigation and analysis to basic plan
STEP 2 : Preparation stage for installation from detailed design to order of networking related devices
STEP 3 : Operating stage from installation to testing until intended operating
STEP 4 : Supplementary stage after operation

However, the system integrator have not been already able to cope with the network construction that needs various supports by his intuition and his experience. On the other hand, in the case of introducing the expert system, it gives the most suitable guide about unsolved problems like these. COMNETS we will develop is a system which gives concrete plans to solve problems in STEP 1.

II. Problem of networking

The problem of networking is complex. So, we consider to divide the problem into reliability, security, difficulty of network expansion and terminal movement and layout.

1) Reliability

System reliability need not to be as high for business systems as for manufacturing systems. If business systems fail but have good program backup and data recovery and can be restored in a short time, there will be user frustration but probably little economic loss. However, reliability must be much higher at levels where failures could cause significant human or process problems. Communication system of telecommunication business company must have a very high fault tolerance, often achieved with redundancy. On the other hand, usual business systems need not stopping and continuous is not always necessary condition. We need good equipments for high reliability and it may be expensive by some requirement.

2) Security

In the past much of the security for network systems was achieved by control of physical access to the computers and by the numerous software programs and different communication protocols used. However, with the tend to more networking and standardized communications, such measures will be inadequate. The security requirements vary by manufacturing function and are normally higher in the business functions. As more computers are networked together, management must put in place a security plan tailored all areas of operation. The security for network system is the same with system reliability. If users demand it concretely, it is expressed clearly as content of logic design.

3) Difficulty of network expansion

In logical design, it predicts demand in future and calculates memory of communication units and communication line, but doesn't have all memory from the beginning. Therefore in physical design, it is need that consideration for that be easy operation to expand.

4) Difficulty of movement

Movement of terminals occurs in maintenance of network system in using. Therefore it is important that they can be moved with no stopping all system operation.

5) Difficulty of layout

In the system that many communication units are set, it is important to design arrangement of unit (floor layout, floor plan).

These are vague items. Here, the kind of vagueness is that the value is roughly presented, and not sure exactly. The system integrator must consider above items when he makes a network system.

III. COMNETS System Structure [1][5]

The problems constructing networks being dealt with this system would be cleared as follows.

a) The system integrator has to select the best computer of diversified types of them, but the base of selection is not clear.

b) The system integrator has to consider security, responsibility and reliability.

c) These cause have decided with his own subjectivity.

d) The way to solve these problems have not been clear yet.

Therefore, we are in the process of developing an expert system (COMNETS), capable of reasoning based on various vague data such as the previous chapter, but also evaluating for networks.

Usually the process of human decision can be divided into two phases, such as recognition or generation and evaluation of its. Now, we decide that this system is made up of a network generation and a network evaluation part of this result as illustrated in Fig. 1.

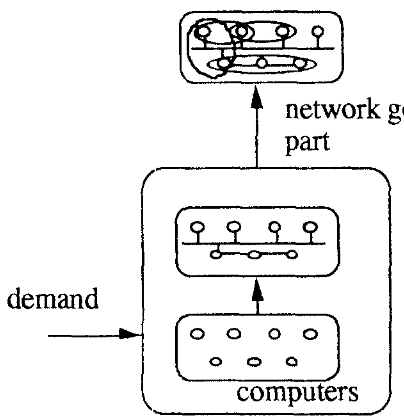


Fig. 1. Logical Structure of COMNETS

The following section describes each part of the system.

3.1 Network generation part

Network generation part is for deciding the protocols of selected computers and the network topology.

The procedure is as follows.

1. Select devices(computers, harddisk, printer etc.) from the data base which have been constructed in this system.
2. Infer the protocols of each computer, then fit the relevant portions for the protocol's layers.
3. Decide the floor layout and network topology.
4. Generate the network by protocols and floor layout.

In order to implement this procedure, we use fuzzy reasoning, which is presented below.

3.1.1 The object oriented knowledge representation

In constructing disturbed communication networks, the system integrator deals with sets of various devices with arrangements to design on his experience.

Therefore, COMNETS needs two functions, representation of large information about devices rationally and easy description of designer's knowledge.

Thus, we decided to use HyperLisp, an object-oriented language from this point of view.

HyperLisp is Lisp implementation language that was developed as a description language in HyperBrain, a tool to construct object-oriented Expert system.

3.1.2 The internal representation of knowledge

We use object frame form in the internal representation of knowledge. The frame has individual information about network generator method.

When each of object frames receives message, they generates individual protocol that is suitable for object from information about network generator method.

The internal representation form is used in LISP , a list processing language, on the assumption that it is easy, flexible and very expandable.

We need to write rules with individual concept ,for example decisions of protocol at the forth layer.

3.1.3 Method of reasoning [1][3][4]

Generally speaking, human's knowledge is uncertain and fuzzy, as the rule " If the object is very big then it may be a elephant," where the words "very big", "may be" have fuzzy meaning.

In this paper, we describe the rules by using fuzzy reasoning and certainty factor.

For example,

(IF)

(condition part : A is more or less B)

(then)

(action part :D is very big <0.5>)

In this example, certainty factor is described 0.5.

The certainty factor can be represented as a number of boundary set such as [0,1] .

In this system, the rule of the form

if A1 and A2 and .... An then C

where A1, A2, ..., An are antecedents and C is a consequence will be considered.
The inference mechanism realizes a generalized modus ponents rule. It may be described as follows

if A1 and A2 and .... An then C	Cc
A1'	Ca1
A2'	Ca2
.	.
.	.
.	.
An'	Can
C'	Cd

where:
A1', A2', ... An' are fuzzy fact which match the antecedent of this rule.
Cc is an uncertainty of the rule
Ca1, Ca2, ...,Can are uncertainty of the fact
Cd is an uncertainty of the conclusion
The certainty factor of the conclusion is calculated as follows.

$$Cd = \min(Ca1, Ca2, ..., Can) * Cc \qquad (1)$$

The membership functions are defined as triangles shown in Fig. 2. and associated with 7 linguistic terms such as " very bad", "bad", "more or less bad", "normal", "more or less good",etc.

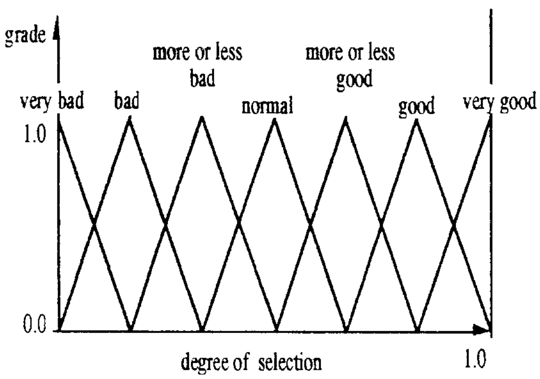


Fig. 2 . Example of Membership Function

We explain why the membership functions have been associated with 7 linguistic terms.
The basic function of network generation part is to choose the best one among various objects , that is to determine which object has the highest evaluation. Therefore, most of the rules described in this system are selective type. However, the number of linguistic terms that human can use to express such items is relatively limited in practice. For example, there are only about twenty words which might be used to describe the prices. These include words such as "very high", "high", "kind of high", "almost reasonable", "reasonable", "fairly low", etc. Therefore, in light of the analytical faculty of humans, it should not be necessary in practice to express such concepts over a continuous range.
On the other hand, as a case of choosing the best one among a few objects, it is meaningless to subdivide. The membership functions of this case is described as Fig. 3.

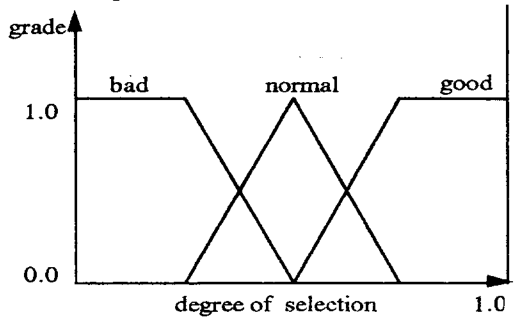


Fig. 3. Example of Membership Function

3.2 Networks evaluation part [2]

This part performs two functions as follows:1)Partial evaluation and 2)Global evaluation.
1) Partial evaluation
The partial evaluation is reliability concerning connection between two computers. And the whole system of computers is evaluated by the same method. This reliability is the certainty factor of protocol of each computer.
The reliability is described as follows.

$$Ct = \min (CA , CB) \qquad (2)$$

where:
CA is an uncertainty of protocol of computer A
CB is an uncertainty of protocol of computer B
Ct is an uncertainty of the conclusion
2) Global evaluation
The global evaluation of network based on each value of items as obtained from processing done in network generation part ,from a point of view , cost, speed, reliability and so on.
We can get global evaluation value using fuzzy integral based on fuzzy measure.
Here, we show the concepts of fuzzy measure and fuzzy integral.
[Definition 1. Fuzzy Measure]
Let Ω be a non-empty finite set and A, B the family subsets of Ω. A fuzzy measure, g is verified the following axioms:

$$g : 2^{\Omega} \rightarrow [0 , 1]$$
$$1)\ g(\phi)=0,\ g(\Omega)=1$$
$$2)\ A,B \in 2^{\Omega},\ A \subseteq B \Rightarrow g(A) \leq g(B) \qquad (3)$$

[Definition 2. Fuzzy Integral]
Let h be a measurable function. The fuzzy integral of h with respect the fuzzy measure g is defined by:

$$Z = \int h()g() = \max_{A \in \Omega, x_i \in A}[\min[\{h(xi)\} \wedge g(A)]] \qquad (4)$$

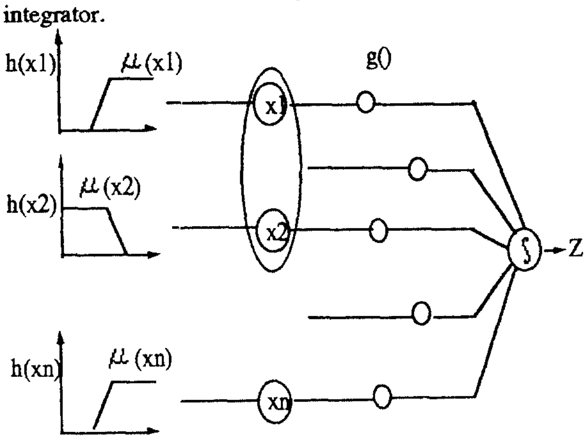
When Ω is finite, Hi={x1,x2,x3......,xn}, then without loss of generality we assume that h(x1)≥h(x2)≥.....≥h(xn), and (4) reduces to a form similar to (5):

$$Z = \int h() g() = \max[h(xi) \wedge g(Hi)] \quad (5)$$

3.3 Global Evaluation Model

Fig. 4. shows global evaluation model of constructed network.
we use the fuzzy measure as weight about partial evaluation, and the fuzzy integral as a utility function in order to get the global evaluation.

Therefore the weights depend on the preference of the decision maker, in this system, who is the system integrator.



xi : ith item

μ(xi) ith partial membership function

h(xi) : ith partial evaluatioı

g() : fuzzy measure

Z : global evaluation

Fig. 4. Global Evaluation Model

Let us denote by Ω= {x1,x2,...., xn } the set of decision items on which the fuzzy measure g is defined and (h(x1),h(x2),......., h(xn))
This kind of data, assessments very natural and the burden on the decision maker is very small. Now, let the universal set be:
$\Theta = \{\theta_i\}$ (i = 1,....., n)
where : θi fuzzy proposition concerning conditional item
For example,
Θ = { " price is low " ,..., " speed is fast " }
The membership functions are defined as follows.
μ_{high} = { 0.0/0.4, 0.5/0.5, 0.6/0.6, 0.7/0.7, 0.9/0.8, 1.0/0.9 }
μ_{low} = { 1.0/0.1, 0.8/0.2, 0.7/0.3, 0.6/0.4, 0.5/0.5, 0.0/0.6 }

Here, the function that decides the truth value of the fuzzy proposition θ_i is decided as follows.
$yi = \mu_i(xi)$
where: xi is a variable concerning fuzzy proposition θ_i obtained network generation part
Thus, we can decide on the degree of matching to the fuzzy proposition and partial evaluation.

IV. Conclusion

This paper has described the support system to construct distributed communication networks , COMNETS. A major feature of COMNETS is the fact that it can construct networks by performing evaluation using fuzzy integral. Although the COMNETS is still being developed, it is already significant in clearly showing the possibilities for new uses of fuzzy theory.

Acknowledgments

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