A Research about Cloud Reliability Evaluation Method

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***Abstract* -- In order to solve the problems of the transformation between qualitative information and quantitative information in the reliability evaluation and attain more intuitive evaluation results of the system, the paper combines with the stochastic process analysis method and cloud theory and puts forward a novel reliability evaluation method named cloud reliability evaluation method. The system state transfer model and the scale of the qualitative evaluation based on cloud theory are proposed for corresponding the quantitative variable and qualitative variable. At the same time, the cloud scale of the qualitative evaluation is constructed, and the quantitative variable and the qualitative variable in the system reliability evaluation are corresponded. The randomness and the fuzziness of the system reliability evaluation is considered in this method and the relationship between the quantitative variable and the qualitative variable is analyzed. The result is linguistic value and intuitive. Through the method, the corresponding relationship between the quantitative variable and the qualitative variable are found,and the linguistic value is understood and used in the process of system evaluation.Finally, an example is cited to validate the process and feasibility of the method.**

Keywords - cloud theory; cloud reliability; cloud model; one dimension normal cloud; stochastic process

I. INTRODUCTION

With the development of science and technology, the cost of complex system test is increased significantly. The most commonly used reliability information are experimental and filed data which are expensive and insufficient, so the collection of them would spend considerable cost and time.

In order to get rid of the widespread difficulties between economy and reliability constraints in the complex system, the designers and planners have been exploring practical methods for reliability evolution for decades.

The reference [1,2] uses probability theory in the description of system quantity reliability, which is limited by data and tools and particularly difficult to use in some special fields such as electric control. The reference [3] analyzes system reliability based on dynamic rule with time series. This method takes the values adopted by distribution parameters that performance degradation data obey in different time as a random variable. Or, some methods take the product performance degradation and related parameters as a function of time. All these ideas require pre-assume parameter function, which has a strong subjectivity and does not conform to the objective evaluation of the reliability of the requirements. The Reference [4,5] uses the D_S evidential theory and fuzzy sets in reliability evaluation. The method considers the reliability evaluation in complex system and thus involves many uncertain factors, but fails to build a relationship between quality and quantity. Above all, presently there are two main ideas to solve the problems in complex system reliability evaluation. One is quantitative analysis based on probability, and the other is qualitative analysis based on uncertain characters.

Stochastic process reliability model is an important method in reliability evaluation model for quantitative analysis ; it is also frequently and widely used in researches for the current reliability growth model and in actual project, and has shown good performance in many applications [6, 7]. Compared with above mentioned methods, it possesses more properties of complex system that can be effectively monitored and predicted. However, it has a higher demand in selection of mathematical model.

Stochastic process can describe the system failure behavior of change over time, and essentially, its behavior process only depends on the current state in the future but has nothing to do with history. The main advantage of stochastic process model is its simplicity and easy to understand and implement [8].

But, in life we often encounter some languages that contain qualitative values, for example, “about 20 kilometers”, “young people” and so on. In the reliability evaluation, we can also meet a lot of language values, for example “Voltage instability”, “cold” and so on.

It increases the qualitative and quantitative difficulties integrated in the process of evaluation; on the other hand, this is also the charm of reliability evaluation. Therefore, the methods, which process and make full use of this qualitative concept and establish the mapping and transformation between qualitative and quantitative variables, are important means to improve the system reliability evaluation results.

Cloud model is prompted by Dr.LiDeyi [9]. It is a part of cloud theory that based on the probability theory and fuzzy set theory, which uses specifically arithmetic and conforms the converse model between qualitative variable and quantitative variable.

When using cloud model for reliability evaluation, there are two points to note in evaluation results: firstly, the reliability evaluation result is not a definite value but locates basically within a certain range of fluctuation because the description of the working conditions of language contains uncertainty. Secondly, as time goes by, the range is different, which in general shows a higher beginning of system reliability, a small scope of its fluctuation, and that the longer the work time is, the lower its reliability will become, and the bigger the scope of its fluctuations will be.

The reliability assessment method is based on cloud model, in which a few problems are worthy of further study:

(1)How to use the cloud model for reliability assessment?

(2)When can we use the cloud model for reliability assessment? How to put these factors into consideration so that the result of evaluation can be more realistic?

II. RELATED WORK

Complex system refers to that the actual working condition and its reliability are simultaneously influenced by a number of working conditions, and different changes exist in the working conditions of the system.

For the reliability of system in each specific work condition, a number of related research have been conducted for point parameter selection problem at home and abroad. The main methods include comprehensive environmental testing method, relegation danger function model, fuzzy Markov model method, and so on [10-13]. To some extent, these methods can solve some practical problems, but they have their own disadvantages as well. For example, both integrated environment experiment method and relegation danger function model method require a large number of reliability test and statistical analysis, obviously difficult to meet the requirements of some expensive and small sample system. Fuzzy Markov model belongs to the analytical method, for that on the one hand the quantity of systems easily leads to NP problems, and on the other hand changes in the working conditions severely lead to sharp increase of calculation and unreasonable results.

About research on effects of complex conditions on system reliability, the problems mainly concentrated in how to describe in maths and how to reflect working conditions on reliability index.

The reference firstly introduces cloud theory into the field of reliability and respectively set up the adaptability model and working conditions model of electronic product, then Z conditions cloud generator is used to fuse above two models and finally generate MTTF (mean time to failure) so that above problems can be solved [14-18]. However, the system reliability modeling and analysis have not been involved. According to research results, based on the controlled hybrid system reliability modeling and analysis method of stochastic Petri nets, in complicated conditions under influence of reliability, the research on distributed system has achieved good results, but description ability is insufficient to reflect the influence of working conditions on independence of system reliability, .

The reference refers to the method which integrates cloud model with reliability block diagram method and conducts effective modeling and analysis on reliability of series and parallel system under complicated conditions [19-24] . The reference integrates cloud model with fault tree method and conducts reliability modeling and analysis on automatic monitoring system under complicated conditions, finally gets a good result [25-29]. For comprehensive reliability evaluation for complex functional systems, the qualitative/quantitative testing is a general choice.

The DARE method (Decision Alternative Ratio Evaluation System) is the simplest and easiest to use, but its evaluation result is relatively coarse. Expert opinion method is featured by its strong subjectivity but short of objectivity. Analytic hierarchy process takes the valuable experience of experts and mathematical theory as foundation so that possesses strong objectivity and logic, and therefore it is the most widely used method. The evaluation set can be expressed by fuzzy value, language value or cloud model, of which cloud model includes qualitative analysis and quantitative reflection, so it has a better effect of expression. Generally, the evaluation results are obtained by principle of maximum membership according to the membership degree of comprehensive evaluation index to each evaluation set.

The difference between various methods is mainly embodied in the comprehensive model, weight determination, evaluation set and evaluation result output.

In order to obtain a comprehensive reliability evaluation index, the currently comprehensive models are weighted model and cloud model.

III.THINKING OF THE CLOUD RELIABILITY ESTIMATION METHOD

In order to use and process the qualitative concept and improve the credibility of system evaluation, this paper united the cloud theory and the stochastic process theory and put forward a novel reliability evaluation method, named cloud reliability evaluation method. Both cloud theory and the stochastic process theory have their own advantage in processing qualitative information. The union of them can enable us to excavate more valuable implicit information. The method promoted in this paper is more scientific and visual and makes new exploration of combined use of the cloud theory and random process theory.

A. Stochastic process reliability analysis method

System reliability analysis method can be taken as a mathematical modeling method actually. Through the establishment of mathematical model for system reliability, it uses reliability analysis method to complete the analysis of system reliability.

Reliability mathematical analysis is generally divided into two aspects: one is the reliability analysis of static structure; the second one is the reliability analysis of stochastic process. Static structural reliability analysis is in the process of reliability analysis under a fixed system structure. It completes reliability analysis of the system by static structural reliability model and based on series-parallel model analysis method. For complex system, especially the high reliability computer system using computer or microprocessor technology, the reliability for relationships between each module and components are difficult to describe through static structure. The two cores of random process are state and state transition. For reliability model, each state represents the combination of effective and failure modules. With the passage of time, the system recombines due to failure of some modules. The system changes from one state to another state, while the process just reflects the change of reliability of complex system. So the random process reliability evaluation method can reflect the reliability of the system accurately [30].

System reliability of $R(t)$ refers to the probability of completing the required function under certain rules and regulation within working hours $[0,t]$. Markov process is a kind of good reliability modeling method, which can reflect various dynamic behavior through the transfer of state [31,32].

In order to use Markov model method to conduct modeling and analysis on system reliability, a system shall satisfy the following basic conditions:

(1) The life distribution and post-failure repair time of various components of the system shall obey exponential distribution.

(2) All parts only have two states: normal or failure. When start to timing, all parts and the system are in normal working condition.

(3) Within a short time interval, there is only one fault at most. For fault probability of twice or more than twice will be taken as zero..

Define a system model: the system is made up of n parts of the same type and a repair equipment. The parts life and repair time are independent and obey

the exponential distribution of parameters λ and μ. And the fault components can be repaired as new ones. The system is in working condition if and only if the fault parts number is not more than $N(N\langle n)$. In the period of system failure, all trouble-free parts stop working and no longer fail, until the repaired parts quit from the state of repair. $N-n$ normal components enter working status at the same time, and then the system return back to working condition.

Making

$$\mathbf{X(t)=i} \tag{1}$$

to refer to the number of fault parts in t moment, then the system state space is

$$\mathbf{E=\{0,1,2,...,N,N+1\}} \tag{2}$$

where, the system's normal working state and fault state sets are

$$\mathbf{W=\{0,1,2,...N\},F=\{N+1\}} \tag{3}$$

Assuming that the state transition is

$$\mathbf{T}=\begin{bmatrix} \mathbf{A} & \mathbf{B} \\ \mathbf{C} & \mathbf{D} \end{bmatrix} \tag{4}$$

where, A is the transfer rate matrix of normal state to normal state; D is the transfer rate matrix of fault state to fault state.

$$\mathbf{T}=\begin{bmatrix} -\lambda & n\lambda & & & \\ \mu & -(\mu+(n-1)\lambda) & & & \\ & \cdots & \cdots & \cdots & \\ & & & \mu-(\mu+(n-N)\lambda) & (n-N)\lambda \\ & & & \mu & -\mu \end{bmatrix} \tag{5}$$

$$\mathbf{A}=\begin{bmatrix} -n\lambda & n\lambda & & \\ \mu & -(\mu+(n-1)\lambda) & (n-1)\lambda & \\ & \cdots & \cdots & \cdots \\ & & \mu & (-\mu+(n-N)\lambda) \end{bmatrix} \tag{6}$$

$$\mathbf{B=[0,0,....0,(n-N)\lambda]^T} \tag{7}$$

$$\mathbf{C=[0,0,...,0,\mu]} \tag{8}$$

$$\mathbf{D=-\mu} \tag{9}$$

$$\mathrm{If}\{\mathbf{X(t),t>=0}\} \tag{10}$$

is homogeneous Markov process, thus the state transition probability in Δt is

$$\mathbf{P_j(k,t)=P\{N(t)=k\mid X(0)=j\}} \tag{11}$$

Which means that starting from the initial state

$\mathbf{X(0)=j}$, in $(\mathbf{0,t}]$ (12)

the fault probability's Laplace first-order convolution in *k* times is

$$\mathbf{P^*_{N+1}(0,s)=\frac{1}{s+\mu}\left[1+\frac{\mu\sum_{i=1}^{N+1}A_{iN+1}}{|sT-A|}\right]} \tag{13}$$

Take TMR (Triple Modular Redundancy) voting system for example, as shown in Fig. 1.

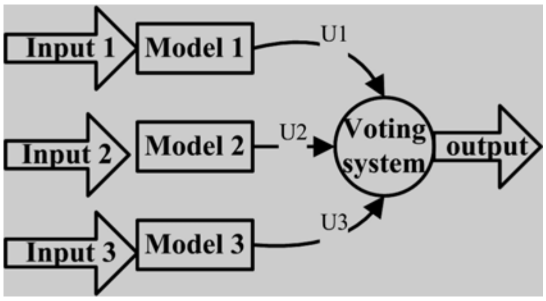

Fig. 1 The Structure of TMR Voting System

Get the TMR system reliability

$$\mathbf{R(t)=P^*_{30}(t)+P^*_{21}(t)+P^*_{20}(t)} \tag{14}$$

It is the quantitative representation of system reliability.

B. A consideration of the cloud theory

Cloud model is a kind of conversion model. It denotes the conversion between qualitative variable and quantitative variable by language value. Set U as a domain comprising accurate numbers. Set A as a qualitative concept, U is accorded with A. For any given element x in the domain, there is a random number with stable tendency $y \in [0,1]$, which is called certainty degree of x for A, and the distribution of y in domain is called cloud model ("cloud" for simple). Fig.2 shows the cloud model of nature language "about 20".

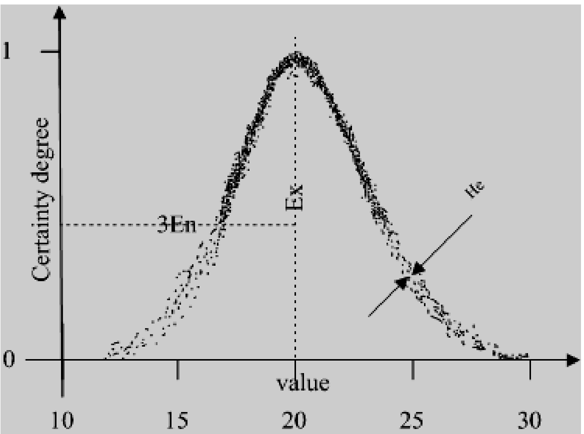

Fig.2 The Cloud Model of Nature Language "about 20"

From Fig. 2: The cloud consists of the number of drops, each of which represents one point projected from qualitative concept to numeral domain that is a concrete realization. For its every realization, cloud model can denote the certainty degree of one point reflecting some qualitative concept.

Cloud is identified by three digital characteristics, E_x (Expected Value), E_n (Entropy) and H_e (Hyper Entropy) which express the quantity features of qualitative concept [33].

E_x is a central value of qualitative concept in the universe of discourse. E_n expresses the degree of fuzziness for qualitative concept. H_e is the entropy of entropy (E_n). It reflects the random of the degree of membership to a qualitative concept. The larger the value of H_e is, the larger the randomness of membership degree will be.

The algorithm of generative cloud is called cloud generator, which includes forward cloud generator, condition X cloud generator, condition Y cloud generator and backward cloud generator. Condition X cloud generator and condition Y cloud generator are the basis of qualitative concept by cloud model. Integrating the forward and the backward cloud generators, the conversion between qualitative and quantitative values can be realized at any moment.

If the membership degree of elements within domain x to the qualitative concept A can meet

$$\mu_c(x) = \exp^{\frac{(x-E_x)^2}{2(E_{nn})^2}} \tag{15}$$

then the distribution of x in the domain U can be called a normal cloud.

C.Cloud model for the evaluation of system performance

The stochastic process method ignores the fuzziness in the process of system reliability evaluation. In the practical application, the ability of system to complete required function is different. Since big or small unit failure in the complex system occurs frequently, it is hard to say the system is normal or under failure, therefore, the absolutely normal MTTF (Mean Time To Failure) is almost meaningless. So we pay more attention to what extent can the system maintain its required functions, such as system without any fault, system with a fault or system having reached the critical function. In a word, there are many statement to express "the system can maintain its required functions to what extent" with language value. Because of the complexity of system, fuzzy language is more exactly, nature and effective than precise numerical methods. The evaluation of system performance uses the cloud model to depict qualitative concept. The flow chart is as shown in Fig.3.

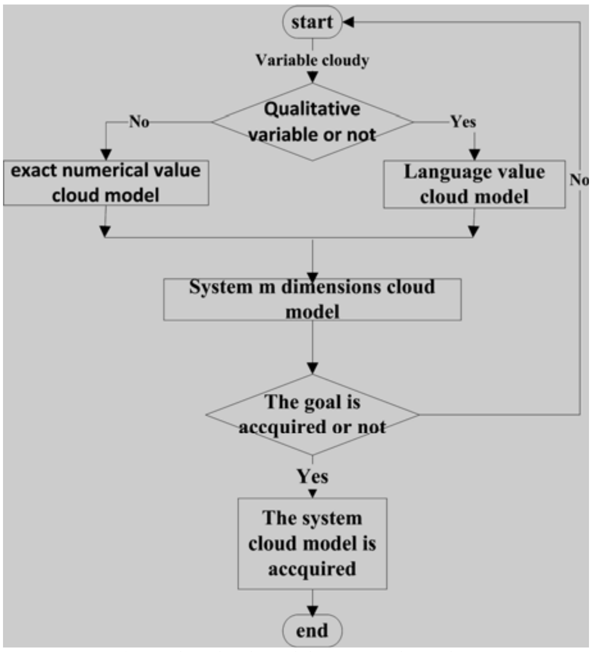

Fig. 3 The Cloud Model Process Flow Chart

1) Variable cloudy

According to the definition of cloud, for a quantity variable in the domain U, the set A of corresponding qualitative concept is constructed through the process P. The concept in set A is depicted by different cloud. Contrarily, the process P describes the qualitative variable with cloud, including the E_x, E_n, H_e and the shape of cloud. This reversible process is called variable cloudy.

In the system performance parameters, there is not only exact numerical value but also language value. The exact numerical value can be denoted with cloudy numeral

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character $(E_x,0,0)$. The language value can be denoted with (E_x,E_n,H_e) .

The n groups system status are extracted and compose the decision-making matrix. Then a performance parameter can be denoted by n exact numerical values. The formula is as shown in Eq.16.

$$E_x=(E_{x1}+E_{x1}+...+E_{x1})/n$$
$$E_n=\left(\max\left(E_{x1},E_{x2},...E_{xn}\right)-\min\left(E_{x1},E_{x2},...E_{xn}\right)\right)/6 \quad (16)$$

The performance parameter denoted by n language values is as shown in Eq.17.

$$E_x=\frac{\left(E_{x1}\bullet E_{n1}+E_{x2}\bullet E_{n2}+...+E_{xn}\bullet E_{nn}\right)}{\left(E_{n1}+E_{n2}+...+E_{nn}\right)}$$
$$E_n=E_{n1}+E_{n2}+...+E_{nn} \quad (17)$$

According to the algorithm of generate cloud, the cloud model denoted qualitative variable and quantity variable are gained.

2) Cloud model fusion

Put the cloud model of qualitative variable and quantitative variable into the same reference frame and a cloud cluster is produced.

If the system has m performance parameters, the m cloud models that denotes m performance parameters will be placed in the same reference frame, and m dimensions cloud cluster will be produced. When the system status changes, the cloud cluster will change as well.

3) System cloud model

According to the system cloud cluster, at any moment, qualitative variable and quantitative variable can attain sampling dots through activating the corresponding range in the cloud cluster. The dots will be taken as cloud drops. The system cloud model is gained by cloud generator.

D. Cloud reliability evaluation method

The paper puts the cloud theory into Markov model voting system and generates the cloud reliability evaluation method, as is shown in Fig. 4.

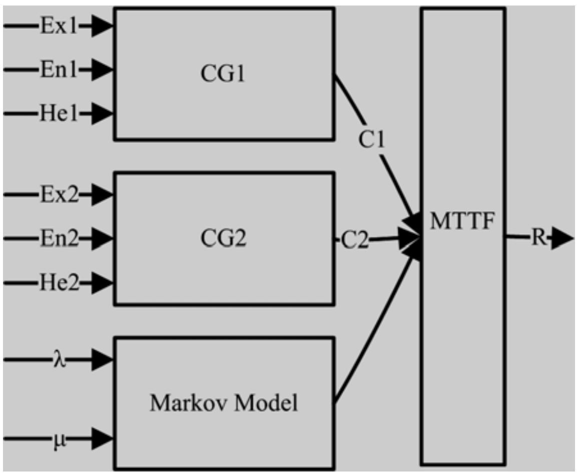

Fig. 4 The Cloud Reliability Estimation Method Diagram

The parameter λ and μ are

$$\tilde{\lambda}=C_1\left(E_{x1},E_{n1},H_{e1}\right) \quad (18)$$
$$\tilde{\mu}=C_2\left(E_{x2},E_{n2},H_{e2}\right) \quad (19)$$

Where, $C_n\left(E_{xn},E_{nn},H_{en}\right)$ is normal cloud generated by parameters $\left(E_{xn},E_{nn},H_{en}\right)$. The generation algorithm is as follows:

(1) $x=G(E_x,E_n)$. Generate the normal random number x with E_x expectations and E_n stand deviation.

(2) $E_{nn}=G(E_n,H_e)$. Generate the normal random number E_{nn} with E_n expectations and H_e standard deviation.

(3) Calculate

$$\mathbf{y_i=exp}^{-\frac{(x-E_x)^2}{2(E_{nn})^2}} \quad (20)$$

to make (x,y) as the cloud droplets.

It is feasible to use above algorithm to generate an arbitrary number of clouds droplets in order to generate normal cloud by three digital characteristic values (E_x,E_n,H_e) . Then put $\tilde{\lambda},\tilde{\mu}$ into Markov model to get the reliability of cloud system $\tilde{R}(t)$. If given confidence level, the lower limit of system reliability can be calculated by Y condition cloud generator.

In order to obtain the qualitative evaluation of system, it is necessary to adopt the lower limit value as input values, and then utilize X condition cloud generator to calculate the uncertainty that corresponds to different language values. Finally, the most appropriate language could be decided according to the maximum uncertainty principle.

Y condition generator and X condition cloud generator algorithm are as follows.

Qualitative assessment can be carried out in accordance with the priority, frequency and other indicators, so as to get N bar. If $X=X_i$, then $Y=Y_i, i=1,2...p$. It is the qualitative rules. Here we call it X rules or X condition cloud. On the other hand, it is also called Y rules or Y condition cloud.

According to the different conditions of X , it is possible to construct qualitative rules generator and qualitative input processing. If language atoms and corresponding relation of cloud are controlled, you can easily use cloud object to construct the qualitative rules.

Corresponding to different qualitative rules, the cloud model based rule generator includes 4 types: single rule, single condition and multiple rules, multiple conditions and single rule, and multiple conditions and rules.

For a single operation of the generator with multiple conditions and rules, when input a specific input value $X=X_{ij}$ on a plane to stimulate the first component $CGX_i(i=1,2...n)$ of each generator with single rule, each CGX_i will randomly generates a Y_j value.

These values reflect the activation strength of inputting

X_{ij} into the first component of each single-rule generator upon qualitative rules (i.e. Membership degree), which can be understood as the activation strength upon corresponding section of cloud scale. Choose a maximum of Y_j , the biggest value shows that these qualitative rules have the highest ratings and thus are selected as priority rules.

Give up the cloud droplets far from central value and construct qualitative variable sampling point set. Take these cloud droplets as input, import the reverse cloud generator CG^{-1} , and restore the final cloud figure features E_x , E_n and H_e . At this point, the expectations value E_x can be used not only as a quantitative output in this transformation, but also to generate new cloud droplets and feedback to the assessment experts to review; then experts put forward their assessment opinions again so as to form a new qualitative rule generator input and enter into the next round of conversion process.

After several cycles, finally we can get satisfactory expectations, or, take the average of all expectations as the final output, namely the qualitative quantitative transformation result of input. For multiple indicators, it is possible to extend the dimensions of above method and use a multidimensional cloud model so as to get the final quantitative results.

From above conversion process of qualitative and quantitative variables based on the theory of cloud , it is not hard to see that, for a correspondingly fixed input values, due to the uncertainty of output space in each layer formed by combination of cloud generator, so we can maintain the inherent uncertainty in the process of integrated research and achieve a good inheritance and transmission of uncertainty under multiple rules and conditions.

In the above mentioned cloud reliability evaluation, in the process of getting qualitative evaluation, it is necessary to construct a set of cloud model reviews evaluation, named cloud scale. For example, use 11 comments set (1:terrible 2:worst 3:worse 4:bad 5:poor 6:normal 7:good 8:better 9:best 10:perfect 11:excellent). The cloud scale as shown in Fig. 5.

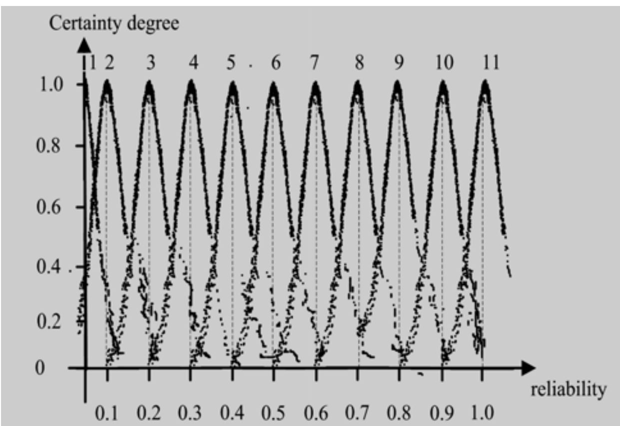

Fig.5 The Cloud Scale Diagram

Take a repairable three model vote system with cover factor for example. If cloud parameters are respectively:

$$\tilde{\lambda} = C_1\left(10^{-9}, 10^{-10}, 10^{-12}\right) \tag{21}$$

and $\tilde{\mu} = C_2\left(0.99, 10^{-3}, 10^{-4}\right)$,the cloud reliability of system is

$$\tilde{R}(t) = C\left(0.98, 2\times10^{-4}, 3\times10^{-5}\right). \tag{22}$$

Take expectations of 0.98 as X condition cloud generator's input value, then we can correspondingly get uncertainty of two different concepts: 0.16 and 0.9 (as show in Fig.5, with triangle mark). Finally, in reference to reliability evaluation sets, we can obtain the language value of system reliability evaluation to be "excellent".

IV. EXAMPLE AND ANALYSIS

A.The example

In order to further illustrate the applicability of cloud reliability evaluation method, here we take the performance evaluation of distributing information fusion system for example. The system has a large number of multi-source information. The cloud model based evaluation method considers many factors in qualitative environment and works out a better evaluation method.

The factors that have influence on the system performance are shown in Fig 6.

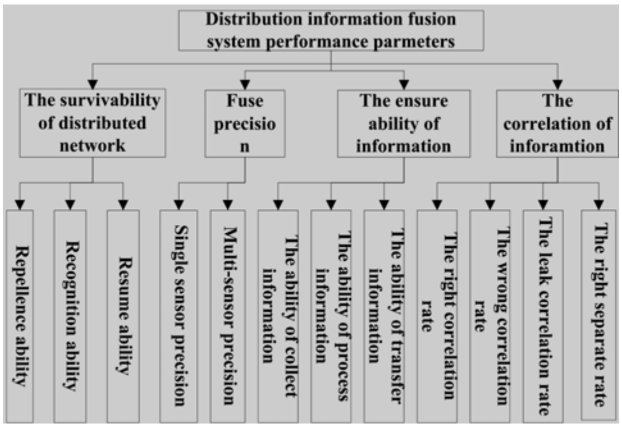

Fig.6 The System Performance Parameters

According to the method proposed in the paper, for exact numerical values, the cloud model is denoted by the picked n groups' parameter and suitable to use Eq.16. For language values, the cloud model is denoted by the picked n groups' parameter and suitable to use Eq.17. Finally, the cloud model of the system can be attained.

The following is the process of calculation. The data in the paper is design value.

For qualitative variable, 4 groups' data from the 3 parameters are picked up in the distributing network existent, as Table I shows.

TABLE I. PARAMETER STATUS

status	Repellence ability	Recognition ability	Resume ability
1	normal	good	normal
2	normal	good	normal
3	worst	worse	good
4	worse	worst	worse

Suppose the relations between comments and assessment value are: normal-0.5, good-0.6, worse-0.4, and worst-0.3. Then the decision-making matrix (B) is attained.

$$B = \begin{matrix} 0.5 & 0.6 & 0.5 \\ 0.5 & 0.6 & 0.5 \\ 0.3 & 0.4 & 0.6 \\ 0.4 & 0.3 & 0.4 \end{matrix}$$

Form the matrix, the digital characteristics (E_x and E_n) of the single parameter' s cloud model is attained, as Table II shows.

TABLE II.THE DIGITAL CHARACTERISTICS OF SOME PARAMETER'S CLOUD MODEL

Parameters	1.Repellence ability	2.Recognition ability	3.Resume ability
Ex	0.425	0.475	0.5
En	0.13	0.008	0.1

Then the cloud model of the three parameters of survival ability of distributing network is shown in Fig. 7.

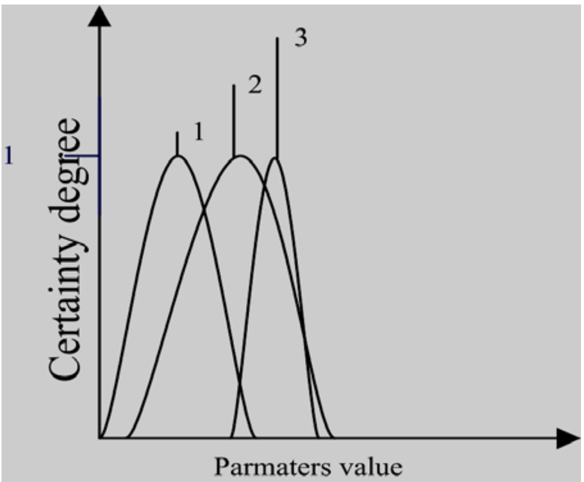

Fig. 7 The Three Parameters Cloud Cluster

Using the same method, the digital characteristics (E_x and E_n) of the other parameters can be attained, as Table III shows.

TABLE III. THE DIGITAL CHARACTERISTICS OF THE OTHER PARAMETER'S CLOUD MODEL

Parameters	Ex	En
4. Single sensor precision	0.525	0
5 Multi-sensor precision	0.527	0
6 The ability of collect information	0.575	0
7. The ability of process information	0.6	0
8. The ability of transfer information	0.625	0
9. The right correlation rate	0.635	0
10. The wrong correlation rate	0.645	0
11 The leak correlation rate	0.65	0
12. The right separate rate	0.7	0

Put all cloud model into one reference frame, then the cloud cluster is attained, as Fig. 8 shows.

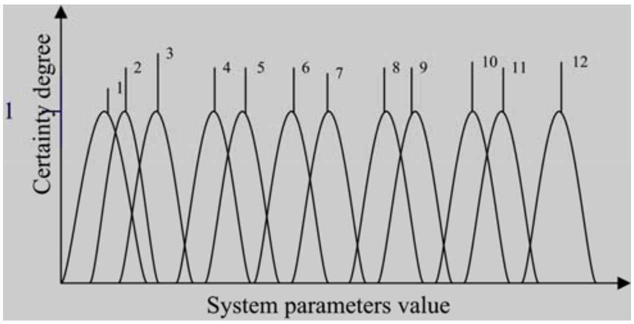

Fig.8 The System Cloud Cluster

Through many input of many time dots, the sample dot of every parameters can be attained. So the cloud model of the system is reverted, as Fig.9 shows.

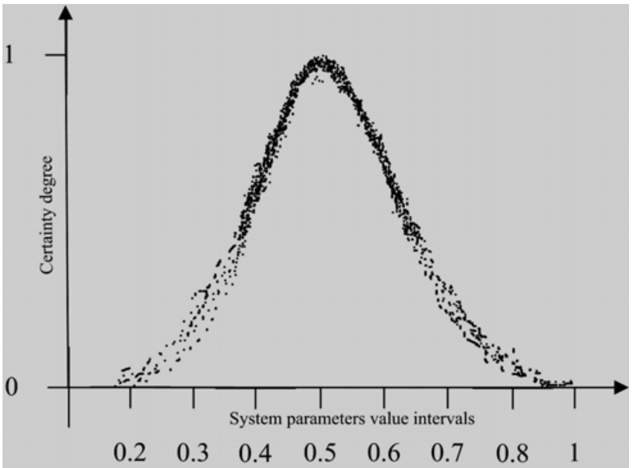

Fig. 9 The System Performance Cloud Model

From Fig. 8 and Fig. 9: The ability of process information, the ability of transfer information, the correlation rate and the separate rate are very good, but the repellence ability and the recognition ability are normal. This kind of circumstance causes the performance of the whole system to be common, it's assessment value is 0.5. If the ability of repellence and recognition is improved, the performance of the whole system will be improved too.

In summary, compared with the traditional quantitative evaluation method, the method proposed in the paper considers more factors and the conclusion is more scientific.

B. The analysis

In summary of above experimental process, its main motive is to consider the influence of different environmental factors on the reliability of the system. In the reliability assessment, given different weights to different environmental factors, if the factors with bigger weight change, they will have a great influence on reliability, while the factors with smaller weight will exert little impact to reliability. Such influence is mainly manifested in Fig. 9 point distribution of discrete degree.

The system reliability assessment method in this paper reflects a basic viewpoint that "quantitative exists inside of qualitative and further make up of qualitative". Its key point relies on that in each random process to realize system reliability, under same working condition, the reliability of each part is quantitatively calculated respectively, then one random realization of the whole system is calculated through systematic structure. Finally, these multiple random quantitative calculation results reflect the change of whole systematic reliability. The experimental results show the validity and practicability of this approach, and make evaluation results more in line with the actuality; in real life, it also has a wide range of usage.

V. CONCLUSION

The process of complex system evaluation involves a large number of natural language description of qualitative variables and digital description of quantitative variables. How to more accurately reflect the reliability of system and how to find out the responding relationship of the two in practice is the stating point of this paper. The proposed cloud reliability evaluation method is to find the corresponding relationship between language values description and quantitative numerical description of the system characteristics.

In this paper, integrating the random process with cloud theory, a novel reliability evaluation method is proposed. It can effectively deal with the uncertainty of multi-source information. The result shows that language has intuitive and scientific nature.

But, for the combination calculation of Markov model and cloud model involved in this paper, its computational complexity and time cost is larger. How to improve the algorithm is the next step.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflicts of interest.

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