# A New Evaluation Model on Green Low Carbon Energy Network for Cloud Computing-- Quality of Green(QoG)

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*Abstract*—**The topic of the network energy consumption is going to be the key factor which can restrict the development of the whole environment of the network system under the significantly growth of the network devices and the sensor terminals. For in a variety of methods based on a single point of network equipment, energy-saving mechanisms, and new routing energy-saving strategies, how to make an evaluation of the green network is an urgent problem. Some traditional methods tend to be confined to a single property of the network system or focus on the overall energy consumption of the network system, either too one-sided or too general, which makes it hard to find the main crux of the high energy consumption of the network, the impact of quality of Green(QoG), as well as to make a better green network environment. The core meaning of the green network is simple indeed: to obtain the minimum of the network energy consumption under the basic promise of QoS. In this paper, a new evaluation model on green low-carbon energy network is proposed to solve such problem mentioned before. This new model is name by quality of green(QoG). In this paper, we use network measuring which be divided by three topics – performance, traffic and topology of the network to map the relationship between the QoS and the green evaluation and also to quantify green energy consumption index. The green energy consumption indexes are divided into eight indexes based on performance; two indexes based on the traffic and four indexes on the topology. Then we quantify four green fuzzy indexes as : Fluctuation F, vulnerability V, persistence P, recoverability R based on the statistical analysis. After that, we determine for the membership of the 14 green energy consumption indexes to the 4 green fuzzy indexes. Finally we build the evaluation matrix by fuzzy mathematics comprehensive evaluation method to get the standardized computing framework of QoG--quality of green. At last, we define a new concept as network exergy: the useful energy consumption during a conversion processs from a current network QoS conditions A to another QoS conditons B. After it reaches B, the network exergy is zero. The practical significance of this network exergy is that you must define the initial QoS and final QoS at the same time.**

***Keywords-QoG; green; low Carbon; quality of green; Fuzzy comprehensive evaluation; QoS; green energy consumption index; network exergy***

## I. Introduction

With the popularization of the IPv6 technology all over the world, this new technology has been providing a strong background support for many kinds of other new network architecture, infrastructure and computing modes such as the cloud computing, internet of things and the smart grid etc. Take the internet of things and the intelligent cloud as an example to make a further explanation. The patterns and concepts of them are to absorb a large number of devices and sensor terminals increasingly into the whole network and allocate new addresses to these devices, which is also an important incentive to develop the IPv6. However, under such situations, the energy consumption of the network system is going to become the key factor which can restrict the development of the network size, environment and all the economy[1-7]. It is a pity that the two main problem of the design of traditional network system can be concluded as : 1) explosion of resources; 2) redundancy. These two methods are inevitably designed to promise the QoS with extra energy consumption.

Fuzzy mathematical comprehensive evaluation method is a fuzzy inference method which has huge advantages in dealing with the division and mapping of the complex systems properties. In this paper, taking into account the complex mapping between QoS and green energy consumption evaluation and the division grades of the quality of green, we use the fuzzy comprehensive evaluation method to make the green low-carbon energy network evaluation model – the QoG model.

## II. Significance and Contribution

The great significance and contribution of this paper is to propose a new concept of QoG (Quality of Green) and combine the QoS and QoG to design a new standardized computing framework for green network low carbon energy evaluation which can solve some traditional green evaluation problem of incompleteness and limitation to some extent. The process can be concluded as follows. 1) design 14 green energy consumption indexes based on network measuring – 8 indexes on performance, 2 indexes on traffic, 4 indexes on topology. 2) design 4 green fuzzy indexes based on the statistics -- Fluctuation F, vulnerability V, persistence P, recoverability R. 3) use fuzzy mathematics comprehensive evaluation method to map the 14 green energy consumption indexes and 4 green fuzzy indexes to membership function. 4) build the final standardized computing framework of QoG – Quality of Green by fuzzy mathematics comprehensive evaluation method.

QoG has a strong expansibility, we can increase or decrease green energy consumption indexes and green fuzzy indexes based on different network architectures, features, number of users and the actual operation of the network.

## III. DEFINITION OF GREEN ENERGY CONSUMPTION INDEX

In this paper, we expand and improve the existing indexes and also propose some new indexes[8-12].

Every index based on the QoS (calculated by network measuring) is obtained by two important ratings. One is the standard rating calculated by full load energy consumption dividing the maximum QoS-factor over a measuring cycle, the other one is the current rating calculated by current system energy consumption dividing the average QoS-factor over a measuring cycle.

The definitions of these indexes are as follows.

### *A. Green energy consumption index on performance*

In this paper, the green energy consumption indexes are divided into eight indexes based on performance based on eight network measuring indicators as: bandwidth, delay, shaking, bandwidth-delay product, packet loss rate, packet loss cycle, system recovery rate, data processing rate.

*1) For in network bandwidth*

ECR(Energy Consumption Rating) is defined as bellow.

$$ECR = \frac{Full\ Load\ Energy\ Consumption}{Throughput}$$

ECBR(Energy Consumption Bandwidth Rating) is defined as bellow.

$$ECBR = \frac{Current\ System\ Energy\ Consumption}{Average\ Specific\ Bandwidth}$$

Average Specific Bandwidth is the specific bandwidth to a related service traffic.

**GBI(Green Bandwidth Index)** is calculated by ECBR divided by ECR as bellow.

$$GBI = \frac{ECBR}{ECR}$$

It accounts for the power consumption level according to the situation of bandwidth demand.

*2) For in network delay*

ECSDR(Energy Consumption Standard Delay Rating) is defined as bellow.

$$ECSDR = \frac{Full\ Load\ Energy\ Consumption}{Maximum\ Delay}$$

ECDR(Energy Consumption Delay Rating) is defined as bellow.

$$ECDR = \frac{Current\ System\ Energy\ Consumption}{Average\ Delay}$$

**GDI(Green Delay Index)** is calculated by ECDR divided by ECSDR as bellow.

$$GDI = \frac{ECDR}{ECSDR}$$

It accounts for the power consumption level according to the situation of delay.

*3) For in network shaking*

ECSSR(Energy Consumption Standard Shaking Rating) is defined as bellow.

$$ECSSR = \frac{Full\ Load\ Energy\ Consumption}{Maximum\ Packets\ Interval}$$

ECSR(Energy Consumption Shaking Rating) is defined as bellow.

$$ECSR = \frac{Current\ System\ Energy\ Consumption}{Average\ Packets\ Interval}$$

**GSI(Green Shaking Index)** is calculated by ECSR divided by ECSSR as bellow.

$$GSI = \frac{ECSR}{ECSSR}$$

It accounts for the power consumption level according to the situation of network shaking.

*4) For in network bandwidth-delay product*

ECSBDPR(Energy Consumption Standard Bandwidth-Delay Product Rating) is defined as bellow.

$$ECSBDPR = \frac{Full\ Load\ Energy\ Consumption}{Maximum\ Bandwidth - Delay\ Product}$$

ECBDPR(Energy Consumption Bandwidth-Delay Product Rating) is defined as bellow.

$$ECBDPR = \frac{Current\ System\ Energy\ Consumption}{Average\ Bandwidth - Delay\ Product}$$

**GBDPI(Green Bandwidth-Delay Product Index)** is calculated by ECBDPR divided by ECSBDPR as bellow.

$$GBDPI = \frac{BCBDPR}{ECSBDPR}$$

It accounts for the power consumption level according to the situation of bandwidth-delay product.

*5) For in network packet loss rate*

ECSPLR(Energy Consumption Standard Packet Loss Rating) is defined as bellow.

$$ECSPLR = \frac{Full\ Load\ Energy\ Consumption}{Maximum\ Packet\ Loss\ Rate}$$

ECPLR(Energy Consumption Packet Loss Rating) is defined as bellow.

$$ECPLR = \frac{Current\ System\ Energy\ Consumption}{Average\ Packet\ Loss\ Rate}$$

**GPLI(Green Packet Loss Index)** is calculated by ECPLR divided by ECSPLR as bellow.

$$GPLI = \frac{ECPLR}{ECSPLR}$$

It accounts for the power consumption level according to the situation of packet loss rate.

*6) For in network packet loss cycle*

ECSLCR(Energy Consumption Standard Loss Cycle Rating) is defined as bellow.

$$ECSLCR = \frac{Full\ Load\ Energy\ Consumption}{Maximum\ Loss\ Cycle}$$

ECLCR(Energy Consumption Loss Cycle Rating) is defined as bellow.

$$ECLCR = \frac{Current\ System\ Energy\ Consumption}{Average\ Loss\ Cycle}$$

**GALCI(Green Average Loss Cycle Index)** is calculated by ECLCR divided by ECSLCR

$$GALCI = \frac{ECLCR}{ECSLCR}$$

It accounts for the power consumption level according to the situation of packet loss cycle.

*7) For in network system recovery rate*

ECSSRCR(Energy Consumption System Recovery Cycle Rating) is defined as bellow.

$$ECSSRCR = \frac{Full\ Load\ Energy\ Consumption}{Maximum\ System\ Recovery\ Cycle}$$

ECSRCR(Energy Consumption System Recovery Cycle Rating) is defined as bellow.

$$ECSRCR = \frac{Current\ System\ Energy\ Consumption}{Average\ System\ Recovery\ Cycle}$$

**GSRCI(Green System Recovery Cycle Index)** is calculated by ECSRCE divided by ECSSRCR as bellow.

$$GSRCI = \frac{ECSRCR}{ECSSRCR}$$

It accounts for the power consumption level according to the situation of system recovery rate.

*8) For in network data processing rate*

ECSDPR(Energy Consumption Standard Data Processing Rating) is defined as bellow.

$$ECSDPR = \frac{Full\ Load\ Energy\ Consumption}{Maximum\ Data\ Processing\ Rate}$$

ECDPR(Energy Consumption Data Processing Rating) is defined as bellow.

$$ECDPR = \frac{Current\ System\ Energy\ Consumption}{Average\ Data\ Processing}$$

**GDPRI(Green Data Processing Rate Index)** is calculated by ECDPR divided by ECSDPR as bellow.

$$GDPRI = \frac{ECDPR}{ECSDPR}$$

It accounts for the power consumption level according to the situation of data processing rate.

### *B. Green energy consumption index on traffic*

The green energy consumption indexes are divided into two indexes based on traffic based on two network measuring indicators as: packet arrival rate, byte arrival rate.

*1) For in network packet arrival rate*

ECSPAR(Energy Consumption Standard Packet Arrival Rating) is defined as bellow.

$$ECSPAR = \frac{Full\ Load\ Energy\ Consumption}{Maximum\ Packet\ Arrival\ Rate}$$

ECPAR(Energy Consumption Packet Arrival Rating) is defined as bellow.

$$ECPAR = \frac{Current\ System\ Energy\ Consumption}{Average\ Packet\ Arrival\ Rate}$$

**GPARI(Green Packet Arrival Rate Index)** is calculated by ECPAR divided by ECSPAR as bellow.

$$GPARI = \frac{ECPAR}{ECSPAR}$$

It accounts for the power consumption level according to the situation of packet arrival rate.

*2) For in network byte arrival rate*

ECSBAR(Energy Consumption Standard Byte Arrival Rating) is defined as bellow.

$$ECSBAR = \frac{Full\ Load\ Energy\ Consumption}{Maximum\ Byte\ Arrival\ Rate}$$

ECBAR(Energy Consumption Byte Arrival Rating) is defined as bellow.

$$ECBAR = \frac{Current\ System\ Energy\ Consumption}{Average\ Byte\ Arrival\ Rate}$$

**GBARI(Green Byte Arrival Rate Index)** is calculated by ECBAR divided by ECSBAR as bellow.

$$GBARI = \frac{ECBAR}{ECSBAR}$$

It accounts for the power consumption level according to the situation of byte arrival rate.

### *C. Green energy consumption index on topology*

The green energy consumption indexes are divided into four indexes based on topology based on four network measuring indicators as: degree, clusting C, specific length L, betweenness B.

*1) For in network degree*

ECSDR(Energy Consumption Standard Degree Rating) is defined as bellow.

$$ECSDR = \frac{Full\ Load\ Energy\ Consumption}{Maximum\ Node\ Degree}$$

ECDR(Energy Consumption Degree Rating) is defined as bellow.

$$ECDR = \frac{Current\ System\ Energy\ Consumption}{Average\ Node\ Degree}$$

**GNDI(Green Node Degree Index)** is calculated by ECDR divided by ECSDR as bellow.

$$GNDI = \frac{ECDR}{ECSDR}$$

It accounts for the power consumption level according to the situation of network degree.

*2) For in network clusting C*

ECSCR(Energy Consumption Standard Clustering Rating) is defined as bellow.

$$ECSCR = \frac{Full\ Load\ Energy\ Consumption}{Maximum\ Clustering\ Coefficient}$$

ECCR(Energy Consumption Clustering Rating) is defined as bellow.

$$ECCR = \frac{Current\ System\ Energy\ Consumption}{Average\ Clustering\ Coefficient}$$

**GCI(Green Clustering Index)** is calculated by ECCR divided by ECSCR as bellow.

$$GCI = \frac{ECCR}{ECSCR}$$

It accounts for the power consumption level according to the situation of network clusting C.

*3) For in network specific length L*

ECSLR(Energy Consumption Standard Length Rating) is defined as bellow.

$$ECSLR = \frac{Full\ Load\ Energy\ Consumption}{Maximum\ Characteristic\ Path\ Length}$$

ECLR(Energy Consumption Length Rating) is defined as bellow.

$$ECLR = \frac{Current\ System\ Energy\ Consumption}{Average\ Characteristic\ Path\ Length}$$

**GLI(Green Length Index)** is calculated by ECLR divided by ECSLR as bellow.

$$GLI = \frac{ECLR}{ECSLR}$$

It accounts for the power consumption level according to the situation of specific length L.

*4) For in network betweenness B*

ECSBR(Energy Consumption Standard Betweenness Rating) is defined as bellow.

$$ECSBR = \frac{Full\ Load\ Energy\ Consumption}{Maximum\ Betweenness}$$

ECBR(Energy Consumption Betweenness Rating) is defined as bellow.

$$ECBR = \frac{Current\ System\ Energy\ Consumption}{Average\ Betweenness}$$

**GBI(Green Betweenness Index)** is calculated by ECBR divided by ECSBR as bellow.

$$GBI = \frac{ECBR}{ECSBR}$$

It accounts for the power consumption level according to the situation of network betweenness B.

## IV. EVALUATION MODEL ON GREEN LOW CARBON ENERGY—BASED ON FUZZY COMPREHENSIVE EVALUATION

Fuzzy mathematical comprehensive evaluation method is a fuzzy inference method which has huge advantages in dealing with the division and mapping of the complex systems properties[13]. In this paper, taking into account the complex mapping between QoS and green energy consumption evaluation and the division grades of the quality of green, we use the fuzzy comprehensive evaluation method to make the green low-carbon energy network evaluation model – the QoG model. We quantify four green fuzzy indexes as : Fluctuation F, Vulnerability V, Persistence P, Recoverability R based on the statistical analysis. After that, we determine for the membership of the 14 green energy consumption indexes and 4 green fuzzy indexes of the degree of membership. Finally we build the evaluation matrix by fuzzy comprehensive evaluation method to get the standardized computing framework of QoG--quality of green.

### *A. Green Network Fuzzy Index*

*1) Fluctuation F*

During a period of time, make analysis of variance of frequency of the high energy consumption index X on the time cycle T.

$$F = \frac{\sum_{i=1}^{n}(X_i - \bar{X})^2}{n-1}$$

The larger F means that the energy consumption flucatuates frequently during that period which is one of the main reasons that causes the situation of the high energy consumption.

*2) Vulnerability V*

During a period of time, do statistics of the high energy consumption indexes in a time cycle T, get the longest high energy consumption cycle TH and use it to divide by the average energy consumption time cycle TA.

$$V = TH / TA$$

The bigger one of V means the support of the current network infrastructure to the energy consumption on performance is weak to some extent.

*3) Persistence P*

Do statistics of the percentage of the time of high energy consumption indexes this index P can easily represent the situation of the persistence of the high energy consumption.

$$P = \sum_{i=1}^{n} K$$

*4) Recoverability R*

Recovery R describes the possibility from the high energy consumption status to the normal one. The higher R is, the more quickly the network system transform from the high consumption status to the normal one. We define it by the conditional probability.

$$\beta = P(X_t \in N \mid X_{t-1} \in H)$$

transform it by total probability

$$\beta = \frac{p\{X_{t-1} \subset H, X_t \subset N)}{P\{X_{t-1} \subset H\}}$$

define the constants

$$\mu_t = \begin{cases} 1, X_t \subset H \\ 0, X_t \subset N \end{cases}$$

$$U_t = \begin{cases} 1, X_{t-1} \subset H, X_t \subset N \\ 0, \quad others \end{cases}$$

then

$$\beta = \sum_{t=1}^{N} U_t / \sum_{t=1}^{N} \mu_t$$

$0 < \beta < 1$, it describes the possibility from the high consumption status to the normal one.

*B. Fuzzy mathematics Comprehensive Evaluation*

*1) Evaluation Model on Green Low Carbon Energy Network—QoG(quality of green)*

Define two limited domain $G = \{g_1, g_2, g_3, \cdots, g_m\}$ and $V = \{v_1, v_2, v_3, \cdots, v_n\}$.

G represents the set which comprised by all the evaluation indexes of green low carbon energy network; V represents the set comprised by the green evaluation result of green low carbon energy network. The comprehensive evaluation can by defined as the followed fuzzy transformation.

$$Y = X \times R, 0 \le \lambda_i \le 1;$$

$$Y = (y_1, y_2, \cdots, y_n), \quad 0 \le y_j \le 1;$$

X represents the fuzzy subset of the G, the evaluation result Y is the fuzzy subset of V. $\lambda_i$ represents the weight of the 14 green energy consumption indexes of the green evaluation $g_i$ to the total green evaluation. It can be calculated by the Entropy Method or Analytic Hierarchy Process. $y_j$ which represents the membership of the 14 green energy consumption indexes to 4 green fuzzy indexes is the final evaluation degree.

Relationship matrix can be defined as follows.

$$R = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix}$$

$r_{ij}$ represents the membership of the 14 green energy consumption indexes to 4 green fuzzy indexes is the final evaluation degree. The first row of R: $R_i = (r_{11}, r_{12}, \cdots, r_{1m})$ is the evaluation result of green energy consumption indexes $g_i$. $X = (\lambda_1, \lambda_2, \cdots, \lambda_m)$ represents the weight of the 14 green energy consumption indexes of the green evaluation $g_i$ to the total green evaluation. $\sum \lambda_i = 1$

The evaluation set of green low carbon energy consumption indexes $G = \{g_1, g_2, g_3, \cdots, g_m\}$ corresponds to the evaluation result set $V = \{v_1, v_2, v_3, \cdots, v_n\}$. $r_{ij}$ is the membership which can be calculated or predicted by the history data of the network system. In this paper, we assume that there are N-1 thresholds, so we can divide the evaluation result into N degrees as follows.

TABLE I. MEMBERSHIP DIVISION BY FOUR FUZZY INDEXES

| Degree | Fluct.. | Vulne.. | Persis.. | Recov.. |
|---|---|---|---|---|
| D1 | F<F1 | V<V1 | P<P1 | R<R1 |
| D2 | F1<F<F2 | V1<V<V2 | P1<P<P2 | R1<R<R2 |
| D3 | F2<F<F3 | V2<V<V3 | P2<P<P3 | R2<R<R3 |
| … | … | … | … | … |
| DN | FN-1<F | VN-1<V | PN-1<P | RN-1<R |

For in G, a measured indexes vector can be calculated as $A = (\phi_{11}, \phi_{12}, \phi_{13}, \phi_{14})$. $\phi_{ij}$ is the measured values of $g_{ij}$, $g_{v_i}(\phi_{ij})$ represents the evaluation degree of the membership of the 14 green energy consumption indexes to 4 green fuzzy indexes.

The membership matrix can be defined as follows.

$$R_U = \begin{bmatrix} g_{v_1}(\phi_{011}) & g_{v_2}(\phi_{012}) & g_{v_3}(\phi_{013}) & g_{v_4}(\phi_{014}) \\ g_{v_1}(\phi_{021}) & g_{v_2}(\phi_{022}) & g_{v_3}(\phi_{023}) & g_{v_4}(\phi_{024}) \\ g_{v_1}(\phi_{031}) & g_{v_2}(\phi_{032}) & g_{v_3}(\phi_{033}) & g_{v_4}(\phi_{034}) \\ g_{v_1}(\phi_{041}) & g_{v_2}(\phi_{042}) & g_{v_3}(\phi_{043}) & g_{v_4}(\phi_{044}) \\ \cdots & \cdots & \cdots & \cdots \\ \cdots & \cdots & \cdots & \cdots \\ \cdots & \cdots & \cdots & \cdots \\ g_{v_1}(\phi_{121}) & g_{v_2}(\phi_{122}) & g_{v_3}(\phi_{123}) & g_{v_4}(\phi_{124}) \\ g_{v_1}(\phi_{131}) & g_{v_2}(\phi_{132}) & g_{v_3}(\phi_{133}) & g_{v_4}(\phi_{134}) \\ g_{v_1}(\phi_{141}) & g_{v_2}(\phi_{142}) & g_{v_3}(\phi_{143}) & g_{v_4}(\phi_{144}) \end{bmatrix}$$

The weight of 14 green energy consumption indexes to the total green evaluation can be calculated by the Entropy Method. The weight matrix can be described as follows.

$$X = (\lambda_1, \lambda_2, \cdots, \lambda_{14})$$

Then, we can get the whole comprehensive equation of the green low carbon energy network – QoG( quality of green) as follows.

$$Y = X \circ R_U = \left\{ (\lambda_1, \lambda_2, \lambda_3, \lambda_4, \ldots \lambda_{14}) \circ \begin{bmatrix} g_{V_1}(\phi_{011}) & g_{V_2}(\phi_{012}) & g_{V_3}(\phi_{013}) & g_{V_4}(\phi_{014}) \\ g_{V_1}(\phi_{021}) & g_{V_2}(\phi_{022}) & g_{V_3}(\phi_{023}) & g_{V_4}(\phi_{024}) \\ g_{V_1}(\phi_{031}) & g_{V_2}(\phi_{032}) & g_{V_3}(\phi_{033}) & g_{V_4}(\phi_{034}) \\ g_{V_1}(\phi_{041}) & g_{V_2}(\phi_{042}) & g_{V_3}(\phi_{043}) & g_{V_4}(\phi_{044}) \\ \cdots & \cdots & \cdots & \cdots \\ \cdots & \cdots & \cdots & \cdots \\ \cdots & \cdots & \cdots & \cdots \\ g_{V_1}(\phi_{121}) & g_{V_2}(\phi_{122}) & g_{V_3}(\phi_{123}) & g_{V_4}(\phi_{124}) \\ g_{V_1}(\phi_{131}) & g_{V_2}(\phi_{132}) & g_{V_3}(\phi_{133}) & g_{V_4}(\phi_{134}) \\ g_{V_1}(\phi_{141}) & g_{V_2}(\phi_{142}) & g_{V_3}(\phi_{143}) & g_{V_4}(\phi_{144}) \end{bmatrix} \right\}$$

## V. Network Exergy

In 1953, Yugoslavs Bronte firstly proposed the concept of exergy which has a great meaning of the useful energy in the modern society [14]. We can see it as the energy needed to balance between the objects and the environment. After the energy consumption, the exergy is zero.

According to this concept, we define a new concept as network exergy: the useful energy consumption during a conversion processs from a current network QoS conditions A to another QoS conditons B. After it reaches B, the network exergy is zero. The practical significance of this network exergy is that you must define the initial QoS and end QoS at the same time. The QoS can be defined by different coefficients according to the physical circumstances in different environments. Trough the markov process, we can describe the different networks exergy conversion probability and overhead and calculate the optimal network energy consumption model.

## VI. Conclusion

In this paper, we use network measuring which be divided by three topics – performance, traffic and topology of the network to map the relationship between the QoS and the green evaluation and also to quantify green energy consumption index. The green energy consumption indexes are divided into eight indexes based on performance; two indexes based on the traffic and four indexes on the topology. Then we quantify four green fuzzy indexes as : Fluctuation F, vulnerability V, persistence P, recoverability R based on the statistical analysis. After that, we determine for the membership of the 14 green energy consumption indexes and 4 green fuzzy indexes of the degree of membership. Finally we build the evaluation matrix by fuzzy comprehensive evaluation method to get the standardized computing framework of QoG--quality of green. This new QoG has a strong expansibility. According to different network architectures, features, number of users and the actual operation of the network, new green energy consumption indexes or green fuzzy indexes can be added into the framework easily.

On the other hand, in this paper ,we propose a new concept of the green energy consumption -- network exergy which can describe a conversion processs from a current network QoS conditions A to another QoS conditons B.

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