Next Generation Network Design, Dimensioning & Services Innovation

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Summary
Telecommunication Next Generation Network NGN is a converged network aims to provide a multitude of services over a single integrated network infrastructure, rather than multiple separated and overlay networks, as have existed for decades. NGN designing have brought unique challenges in how to design and dimensioning the NGN to meet the uncertain market demands of the new bandwidth hungry services with a minimum cost. Building any NGN telecom network should pass through the three main phases, Network Planning, Designing, and Network Innovation with the new value added services VAS. This paper will present a precisely method based on mathematics criteria to calculate the essential resources and equipments needed for NGN deployment in its' three different phases. This method aims to reduce the capital expenditure (CAPEX) by determining the optimal quantities of the equipments that meet the highly required grade of services. Innovating the network with a high usability new NGN VAS services is very important phase of the network that enrich the life with the introduced services, attract and increase the subscriber's loyalty and the ARPU. This paper presents the items that directly or indirectly affects the successfulness of the introduced services .Final the calculation of the needed resources to migrate Yemen Telecom (YT) network to NGN and introducing new services will be also presented as a case study.

Key words:
Bandwidth, NGN Design , Traffic , Service Innovation.

1. Introduction

Telecommunication Next Generation Network NGN is a packet-switched network providing a range of telecommunications services, which uses transport technologies for several bandwidths and classes of services, in which service related functions are independent of the underlying transport technologies. NGN covers multiple networks and layers. It is a means of providing services across a range of technologies giving users consistent and ubiquitous service provision, and unrestricted access to different service providers, with supporting general mobility. NGN provides a single platform and integrate the existing separated voice and data networks into a simpler and more flexible network based on IP protocols. The aim of the telecom operators (fixed and mobile) in the whole world is to migrate their networks to NGN in order to benefit from the NGN features as well as to avoid the drawbacks coming from their legacy networks, beside other financial factors such as reducing the capital expenditure (CAPEX) and the operation expenditure (OPEX).Worldwide, NGN deployments still at an early stage , some operators are
planning or still in finalizing their plans to go to NGN, other operators are started to migrate Legacy networks to NGN taking different strategies based on their situations and conditions as illustrated in [1], beside other financial factors. Indeed, the economic slowdown that appeared recently in the world due to the world financial crisis is driving many operators to expand their early thinking on how best to migrate and implement the NGN taking financial and economic factors in consideration [2]. Reducing the CAPEX and increase the Average Returns Per Unit (ARPU) can be achieved by a scientific planning and designing for NGN, together with introducing new services with high Quality of Service (QoS). All the needed resources, equipments, and the estimation of the services usability should be determined prior to implement or deploy any new services. Plan, design or dimensioning based on mathematical calculations is better than the arbitrary and the traditional one used by operators or that provided from the vendors. Mathematical calculations guarantee that no extra equipments and resources will be ordered or implemented, and thus lead to reducing the CAPEX. From the other hand they also guarantee delivering the services with high QoS and minimum cost. Design or dimensioning is to choose the correct amount of equipments and resources to meet the required grade of service [3]. Over-design is cost-inefficient and will lead to inefficient use of the equipments. Under-design will lead to congestions, delays and deteriorated in the network performance. NGN should be deployed to meet uncertain market demands of the new bandwidth-hungry services and to be compatible with the old services introduced by the legacy networks such as POTS. NGN provides new services with different QoS characteristics, bandwidth requirements, and traffic delivery mechanisms (e.g., uni-casting, multicasting). Delivering these services to the end users with service intelligence in a reliable and cost-effective manner over various logical layers and physical network infrastructure [13] brings up the following difficult questions. What

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would be the effective bandwidth and resources needed for these services? What is the suitable technology option? And how effectively the network could be rightly sized and planned strategically and tactically with minimal capital investments? What are the criteria that guarantee the successfulness of the innovated NGN services? Calculations of some required resources and requirements such as bandwidths, number of links, number of E1s, ..etc, help to determine the needed quantities of hardware for NGN, based on the equipments specifications of the selected vendor/s. This paper addresses all the core issues of NGN planning, designing, dimensioning and service innovation. A mathematical approach for integrated end-to-end NGN design and capacity dimensioning to deploy the NGN in a most optimal and cost-effective manner will be presented. In section 2 a review on NGN architecture will be revised, section 3 will present a mathematical method to calculate the needed resources for NGN in the different phases. A case study for this method is presented in section 4. Section 5 will present the criteria that guarantee the successfulness of the innovated services and increase the using ratio of them .Finally section 6 will brief the conclusion.

2. NGN Architecture

Next Generation Network architecture is designed to be the infrastructure of the future telecommunication networks and services, and meet the new requirements due to emerging of number of services and applications (Broadband, IPTV, Multimedia …..etc). Standards organization such as ITU and ETSI , are the primary workers for designing NGN architecture. TISPAN The technical committee for Telecommunication and Internet converged Services and Protocols for Advanced Networking continues the working on NGN architecture specification till today. TISPAN specification is known as TISPAN NGN R1[15]. It was composed by the leading telecom vendors and operators, to fulfill services providers requirements. The architecture highlight of TISPAN R1 can be summarized as.

- PSTN emulation subsystem to support legacy PSTN services over NGN.
- An independent access technology.
- Support Session initial protocol (SIP) and non-SIP based applications.
- IP Multimedia Subsystem (IMS) supporting SIP based applications.
- Road map for fixed/mobile convergence.
- Adaptable with other standards development organizations.

The overall NGN architecture is summarized in the below three layers.

A. Access Network Layer:

The access network layer consists of different types of equipments that help the end user to interconnect with the NGN such as : Multi-Service Access Nodes (MSAN) which able to deliver different services including telephony ,high speed internet access and video services using the same copper pair. Different Access Gate Ways (AGWs) will be installed in the customers campuses for access to NGN . It also support the access to narrow band services .

B. Edge/Core Network Layer:

Edge/Core network uses label switching technology MPLS with the ability to set up connection-oriented paths over a connectionless IP. This part of NGN network includes : Ethernet Service Switch (ESS), Service Routers (SR) and Routing Management (RM) .

C. Control Layer:

The control layer controls all the calls and bearer in the network. It consist of :

Soft Switch (SS) is the telephony signaling and control platform. Soft switch contains four functional blocks:

1. Residential Gateway Controller (RGC).
2. Call and Session Controller (CSC).
3. Subscription Location Server (SLS).
4. Media Gateway Controller (MGC).

Media Gateway (MG) is the equipment that converts the voice traffic from TDM into VoIP. MG offers services such as: VoIP Termination, VoIP Trunking , TDM to Primary Rate Interface (PRI) grooming, and Private Branch Exchange (PBX) Access.

Management Center is the management application converging all management elements from VoIP subsystem and OSP (Open System Platform). It gives centralized access from single server to all Graphic User Interfaces GUIs that used by operation application.

Based on the above architecture, different solutions for network design and migration from PSTN to NGN can be deployed. At the first step of migration NGN will based on soft switch solution that can separate the call control from bearer and services platform.

3. NGN Migration and Design

The planning for migration from legacy network to NGN can be achieved via many scenarios based on many factors as described in [1],[7],[8],[10]and[12].The goal of the telecom network planning is to construct a network that is able to handle current and future traffic, with an objective of minimizing CAPEX and OPEX while ensuring high QoS. This has always been a challenging task, since deploy the next generation services, with saving the cash caw coming from legacy network add complexity to the network planning. But a good planning and design could

avoid many complexities and yield with a good target planed and designed network.
For efficient NGN planning and design, some data is needed such as a snapshot of the current network infrastructure including, detailed information of the various existing equipments, links, physical and logical connections, and services. Existing and forecasted traffic demands (by service or, geographical region) and services to be introduced also important inputs for NGN planning, design and dimensioning.
The design should be accurate, based on scientific calculation and criteria, operators centric and far from vendors point of view [14]. It should consider the capacity needed, reliability, scalability, and the stability of the designed network beside the economical and financial factors. The location of each node should be specified clearly based on the predetermined criteria. The calculation of the needed equipments, signaling and traffic Bandwidths, number of Links, transmission media and the quantity of resources that needed for each phase of network migration, the connection baths and the configurations headlines between the different nodes in the network should be also determined. As well as The cut over plan for the sites to be migrated from PSTN to NGN and the decomposition process of the replaced PSTN sites should be specify clearly by the designer. The following steps will show a mathematic approach to calculate the most important items needed for the NGN design and capacity dimensioning.

A. Required data for NGN Design and Dimensioning.

An important issue to calculate the needed resources for NGN design or dimensioning is the availability of input data. The most precise and accurate formula for NGN design, or dimensioning of equipment is useless if the input data nor available to the designers. Proper design and dimensioning needs a vast amount of input data, and it is conceivable that all this information may not be available to the designer. In such cases, guiding values have been provided for parameters wherever possible. These values have been obtained primarily from field data recorded by various switches in different area. It is, however, strongly recommended that wherever possible, actual site specific values should be used instead of these guidance values since the network profile highly influences the designing [2].

B. NGN Resources calculation.

Since NGN is a unified network that will combine all the different networks into one unified network based on IP. NGN will be achieved in phases manner so there will be different kinds of co-existing equipments, links and bandwidths until NGN will fully replace the existing legacy network , so that the requirements and resources should be calculated for all kinds of services and network elements. These calculations should be carried out before and after, each migration phase, introducing new service, or when the network dimensioning is required. Below are the most important items that need to be calculated.

a) MGW PSTN Side E1 Ports Numbers:

During the migration phases MGWs will be connected to the non replaced PSTN switches and to the other operators network via E1s.The quantity of the needed E1s and the quantity of the E1 interface Cards on the MGW(if the vendor is known) will be worthly to be calculated. The following formula is used to calculate the numbers of E1 ports on MGW side [6] .

MGW PSTN SideE1 Ports=[ROUNDUP (traffic / traffic of busy hour per trunk / 31, 0)] (1)

b) Media Stream Bandwidth Towards MGWs IP Side.

Two types of BandWidths (BW) should be calculated between the MGW and the softswitche :Media Stream Bandwidth and Signaling Stream Bandwidth. The calculated bandwidth will be different based on the codec used. Table (1) shows the different bandwidths for one call using different codec techniques .So ,

IP Traffic BW (Mbps) = [(Traffic * media stream bandwidth of a call) / BWR] (2)

Equation (3) is used to calculate IP media stream BW for new installed access gateways.

IP traffic BW(Mbps)=[TotalErL*MsgNum*MsgLength*8) /(MHT*BWR*1000)] (3)

Where: TatalErl is the toatal traffic in Erl. MsgNum is the message number needed for one session. MsgLength is the length of the message. For H.248 and SIGTRAN the default parameters are shown in table (2).H.248 protocol communicate between MGW and soft switch for MGC. The BWR is a Band Width Redundancy to guarantee IP based voice quality, the default value is 0.5. MHT stand for Mean Holding Time.

c) Numbers of low signaling link between MGWs and TDM nodes.

The calculation of the N7 links could be done based on the default values listed in the table (3), or according to the real situation ,where the links load is given by.

Table 1 : Media Stream Bandwidth per Call

Encoding rate	**Encoding speed**	**Sampling period**	**Bandwidth of voice media stream**
G7.11	64.00	10	118.34
G7.11	64.00	20	91.94
G7.11	64.00	30	83.14
G7.29	8.00	20	34.59
G7.23	5.3	20	31.83
G7.23	6.3	20	32.85

Table 2 : H.248 and SIGTRAN Signaling Parameter

MsgNum	9
MsgLength 101	101
BWR 0.50	0.5(depend on operator)
MHT(mean holding time)	According Real situation

Table 3 : Guiding value for low signaling link

Param-eter.	**Description**	**Guiding value**	**Adopted value for YT**
A	Normal load of NO.7 Link .unit Erl	0	0.2
e	Average traffic load per circuit Unit = Erl /circuit	0.7 – 0.9	0.8
Mc	Average message unit number per call [MSU /call]	For ISUP = 7.3	7.3
L	Bytes of average signaling message length	For ISUP = 35	35
MHT	Mean holding time [second]	Real value	Real value
BW	Band width of signaling	7757 for 64kb/s links	7757
C	Voice channel number of inter office [circuits]	Real value	Real value

$$A= \{(e*Mc*L*c)/(BW*MHT)\} \quad (4)$$

And the number of the low signaling link is given by .

Low Signaling Links =ROUNDUP((MGW E1 ports)*30/C,0) +MOD(ROUNDUP((MGW E1 ports)*30/C,0),2) (5)

d) Signaling Stream Bandwidth:

Signaling stream bandwidth calculation means the calculation of the SIGTRAN bandwidth between soft switch and MGWs or AGWs.

Table 4 : ISUP Guiding Parameter .

Msg Num	7	IP cost (byte)	20
Msg Length	36	Ethernet cost (byte)	26
M3UA cost(byte)	24	Cost	98
SCTP cost (byte)	28		

It depends on the protocols and the codec used and the total traffic

BW={(TotalErl*MsgNum*(MsgLength+cost)*8) / (MHT*BR*balancer*1000)} (6)

Where Balance R=2. Table (4) shows the default parameters used for ISUP.

For H.248 the following parameter should be used. MsgNum = 26 and MsgLength =101, according to protocol stack .

e) IP signaling BW for Media Servers MS (tones /announcements servers):

The requirements of bearer network bandwidth is determined as :

Media bandwidth = [(CAPS*Average announcement duration *Average announcement ratio* each call media bandwidth *activation) /BWR] (7)

And

Signaling bandwidth =[(CAPS * (message byte number + network header) * 8 * Link not balance factor) / BWR] (8)

Where :Usually one call have 8 messages ,each message total length 585 byte ,network header 66 byte, Link not balance gene 1.6~2 and BWR range from 0.5~0.7. CAPS stands for Call Attempt Per Second.

f) Network Management Bandwidth:

Network management bandwidth is the BW required to mange and maintain any network elements remotely from the management center .It can be expressed by the total network management bandwidth occupied by each NE * the number of NEs.

Network management BW = [∑ ((Bandwidth occupied by NE * NEs quantity)+ ∑ (Bandwidth occupied by MGW * MGW quantity , ..)) /BWR of Network Management IP] (9)

g) Billing Interface Bandwidth.:

In NGN, the billing interface bandwidth mainly refers to the bandwidth between the soft switches or the Billing Gateways BGWs and the billing center, which is used to transfer bills. Bill transfer between the BGWs and the billing center is performed once per day/once per week/once or multiple times per month, and could be in real time mode. The billing center obtains bills from the BGW through FTP, or the BGW uploads bills to the billing center. Therefore, the bandwidth requirements presented by bill collection must be considered.Equation (10) is used to calculate the required bandwidth for billing system.

Billing BW (Mbps) = [Traffic / (average duration per call (s) * 3600 * size of a bill (byte) * 8 * busy-hour duration per day (h) * period for obtaining bills (d)) / bill-obtaining duration (h) / BWR / 1000 / 1000 / 3600] (10)

h) IP signaling bandwidth between Soft switches .

The bandwidth between two softswitches used SIP-T signaling protocol as in [5] is calculated by .

SIP-T BW(Mbps)={(CAPS*MsgNum*(Number of payload bytes for each message+ Number of overhead Bytes for each message)*8 bits / BWR) } (11)

For back-up soft switch, each ISUP call needs 9 SIP-T messages , and 600 byte for each message. So, total bytes number of message is 9 * 600 = 5400 bytes. Total bytes number of network overhead is 9 * 66 = 594 bytes. So, signaling bandwidth between the two soft switches is given by

SIP-T BW= CAPS * (5400+594) * 8 /70%. (12)

4. Case Study: YT network Migration to NGN

Yemen Telecom YT is the incumbent telecom operator in Yemen that offering fixed voice services and data for all over Yemen. It has two separated networks one for voice and the other is for Data. The majority of switching technology used is TDM switching. YT decided to start the migration of its' legacy network to NGN. The best migration scenario for YT which is a hybrid scenario that combined from the PSTN replacement and NGN overlay strategies is proposed in [11]. It aims to achieve smoothly and economically migration to NGN with low cost and minimum risks , saving traditional business , focusing on customers' needs and getting a target network that could be evolved in the future to a full IP Multimedia System (IMS) architecture[9]. So NGN should be achieved in phase manner. The replacement of PSTN will be done for transit and tandem layers with two soft switches, six MGWs, two HLRs, and some AGWs as the first phase. All the previous mathematics formulas mentioned in this paper is implemented to design and calculate the needed resources for YT NGN network. This calculations should also be re-done during the migration plan to calculate the required resources before each phase .It should also valuable to be used in case of network dimensioning is required .

Before we present the first phase of YT network migration, we will review YT legacy network architecture.

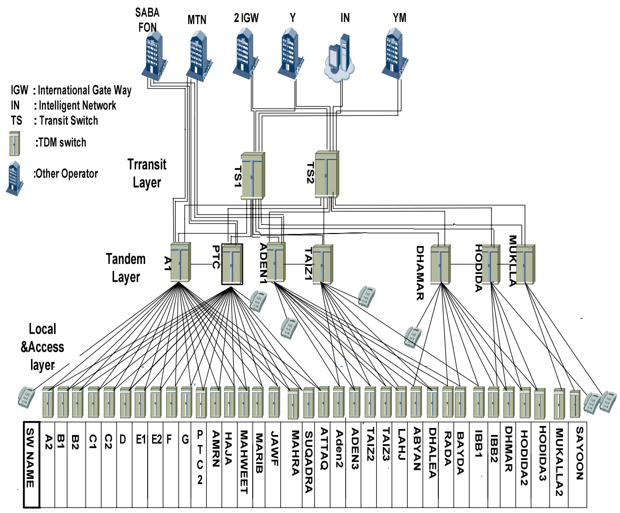


Fig. 1 Yemen Telecom Legacy Network Topology

A. YT legacy network:

Y.T legacy network consists of five TDM switching layers International, Transit ,Tandem, local ,and access layers as shown in" Fig. 1".

International Layer: Contains two international gateways used MGWs and soft switches. This layer is managed and operated by another company.

Transit Layer : Contains two TDM exchanges installed in the capital (Sana'a).This layer offers interconnection to tandem switches and interconnect them with international layer.

Tandem Layer: contains seven TDM switches offering Intraregional switching between local exchanges and interconnecting all regional traffic to and from transit layer.

Local Layer: contains forty two TDM switches with the lowest functional level of exchanges. The main role is to offer access and local switching to subscribers. Local level switches are connected to tandem Level exchanges.

Access Layer: Contains of 576 Subscriber Units (SU) distributed through 250 sites. And 53 main Optical Line Carrier (OLT) using V5.2 The access layer is distributed in the rural areas around Yemen.

In the existing topology each local switch is connected to two tandem switches, similarly, each tandem switch is also connected to two transit switches [16].

B. YT legacy network Migration and NGN Design:

Based on the selected scenario proposed in [11] to migrate YT legacy network to NGN. The first phase of migration is decided to be as follow:

- Replace the 2 transit and the 7 tandem switches with 2 soft switches, 6MGW, two HLR, and some AGWs to serve the PSTN subscribers of the replaced switches.

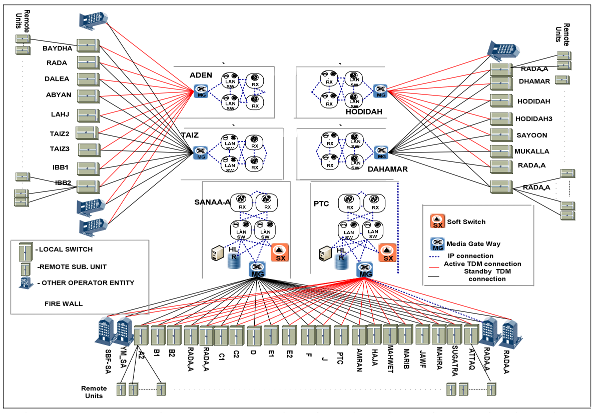


Fig. 2 Yemen Telecom Network After the First Phase of Migration

The equipments quantity decided based on the calculations method mentioned above in this paper.

- Connect the 6 MGWs to the local switches to be served by the soft switches and at the same time connect the MGWs to the other operators network as well (The number of E1s, signaling links and other resources are calculated by the formulas given above).

After phase one implementation will be finished. YT network topology will become as shown in the Fig. 2.

5. NGN Service Innovation

After the network is simplified to be controlled by the NGN equipments, the introducing of NGN new services is easy now and not tied to a specific location. Telecom operators should introduce some suitable new Value Added Services (VAS) to the network. These new services will increase the loyalty of the subscribers and the ARPU as well, hence the investment payback time will be reduced too. The question here what are the suitable services should be introduce? What are the criteria that guarantee the quality of the service? This section will briefly address these items.

The services should be introduced based on the market and user demands with considering the technical criteria and cost. The success of a certain service is measured by its' using ratio. The using ratio can be affected by many factors such as the QoS, availability, reliability, ease of use,.. and so on .If the

Service satisfies the user demands, easy to use, have high quality, availability and reliability, it's using ratio become higher. Hence the ARPU will increase.

It is worthily to consider all the factors that directly or indirectly increase the using ratio and the successfulness of the service to be introduced. Otherwise the subscription for such service will be limited which lead to an inefficient investment.

A. *Service Using Ratio*

This section outlines some issues that has some affects on the using ratio or the subscription rate of the communication services. Service acceptance, usability, and quality are the major initiative criteria that guarantee the successfulness of the communication services. ISO, the International Organization for Standardization, defines usability as follows.

-Usability.

The effectiveness, efficiency and satisfaction with which specified users can achieve in particular environments. Where

- *Effectiveness.*

The accuracy and completeness with which specified users can achieve specified goals in particular environments.

- *Efficiency.*

The resources expended in relation to the accuracy and completeness of goals achieved.

-*Satisfaction.*

The comfort and acceptability of the system to its users.

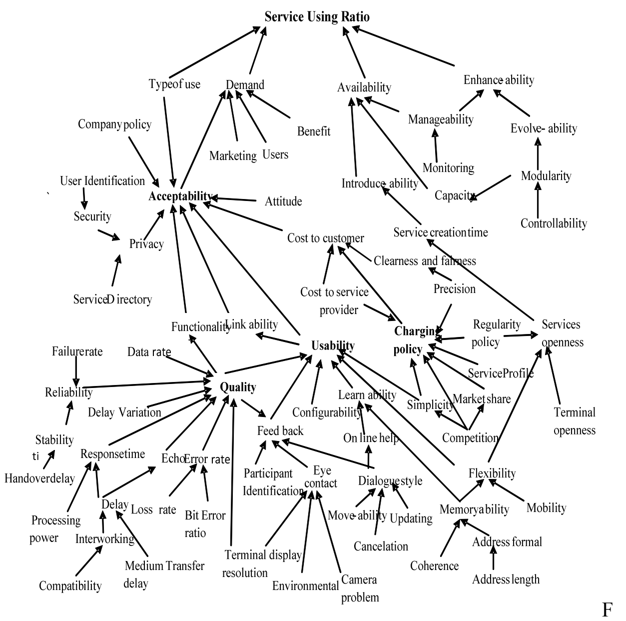
The usability appears to be primarily criteria which subjected to the users. Where the users not limited to "human end-user', but can be an intelligent device or any sophisticated application that cannot overcome inadequate functionality offered by an underlying communication service. Accordingly, communication services need to be considered from the usability point of view. Service using ratio has to be a major concern of any service provider.

In general Services providers are seeking on the determination of what are the required characteristics and items to increase the "Service using ratio". And what is the level of satisfaction and acceptance of the services the users wish or considered. Such items can be achieved by starting analyzing the users, the operators, and the market demands.

The most basic issues and criteria that could play important roles for increasing the service subscriptions or using ratio are as follow. Demands satisfaction, services distribution, integration, High QoS, services availability, services cost, enhance-ability, flexibility, openness and so on. Fig.3 shows all these issues and the relationship between them, together with the sub-items that contribute to estimate or improve each criterion.

6. Conclusion

The deployment of NGNs have brought unique challenges for network planners ,since they need to grow NGNs to meet uncertain market demands of the new bandwidth hungry services . Building new telecom network should pass through the three main phases, Networks Planning, Designing, and Expansion or Dimensioning. This paper presents an optimum method for planning, designing, and capacity dimensioning for the next generation network. A precisely method based on calculation criteria is introduced to calculate the optimum numbers of requirements and resources of the network (such as hardware nodes, required bandwidth, and transmission resources …etc) in Order to reduce CAPEX and introduce service with a high QoS. Calculation results for the needed resources to migrate YT legacy network to NGN are presented. These calculations should be done before each migration phase or when the network dimensioning is required. Innovation the network with new NGN services is an important step to achieving the benefits of NGN network. The relationship between the different criteria that should be considered for increasing the subscription ratio of the service and guarantee the service successfulness is presented in this paper



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ig. 3 Service Using Ratio Metric Parameters

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