A Proposal of Parallel Interworking Model for Broadband Access Network

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ABSTRACT

For future multimedia services, one of the most crucial issues is building an access network that can accommodate multimedia services in subscriber network. The VB5.2 interface of B-ISDN located between an access network and a service node allows dynamic allocation and release of ATM resources. The SG 13 of ITU-T is standardizing the B-BCC protocol, which is sequentially interworked with signaling protocols in the service node. To minimize a connection setup delay of the sequential interworking model, we proposed the parallel interworking model in which the SN executes simultaneously the connection control protocol of VB5.2 interface and signaling protocol. We simulate two interworking models in terms of a connection setup delay and a completion ratio. The results of simulation show that our proposed parallel interworking model for the VB5.2 interface reduces the setup delay and has the similar completion ratio compared to the sequential interworking model. However, the connection setup delay of parallel interworking model becomes about seven tenths of that of the sequential interworking model and the improvement becomes larger as the arrival rate increased.

광대역 액세스 망을 위한 병렬형 연동 모델의 제안

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요 약

미래의 멀티미디어 서비스들을 가입자망에서 수용하기 위한 중요한 이슈 중의 하나는 액세스 망을 구축하는 것이다. 액세스 망과 서비스 노드 사이의 VB5.2 인터페이스는 ATM 자원의 동적인 할당 및 해제 기능을 수행한다. ITU-T의 SG 13에서는 VB5.2 인터페이스에 대하여 서비스 노드에서 신호 프로토콜들과 순차적으로 연동하는 B-BCC 프로토콜을 표준화하고 있다. 본 논문에서는 순차형 연동 모델의 연결 설정 지연을 최소화하기 위하여 VB5.2 연결 제어 프로토콜과 신호 프로토콜들이 병렬로 진행할 수 있는 병렬형 연동 모델을 제안하였으며, 연결 설정 지연과 완료비 면에서 순차형 연동 모델과 병렬형 연동 모델에 대한 시뮬레이션을 수행하였다. 시뮬레이션 결과 두 모델의 연결 설정 완료비는 거의 일치하였으며, 연결 설정 지연 면에 있어서는 병렬형 연동 모델에서의 지연이 순차형 연동 모델의 약 7/10로 개선되었음을 알 수 있었다.

1. Introduction

Telecommunication networks have been evolving to support multimedia communication based on the remarkable achievements in Broadband Integrated Services Digital Network (B-ISDN) architecture, digital telecommunication technologies, personal computers, software, and consumer electronics. For future multimedia services, one of the most crucial issues is building an Access Network (AN) that can accommodate multimedia services in subscriber network. The AN is used to multiplex the signaling and data streams from User Network

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Interfaces (UNIs) in the most cost-effective manner and then carry the resulting multiplexed information stream back to a service node (SN : a local exchange) in such a manner that the service node can determine the source party [1,2].

Fig. 1 shows the access network with the UNI, SNI (Service Node Interface) and Network Node Interface (NNI) as defined in International Telecommunication Union - Telecommunication Standardization Sector (ITU-T) recommendation G.902 [3].

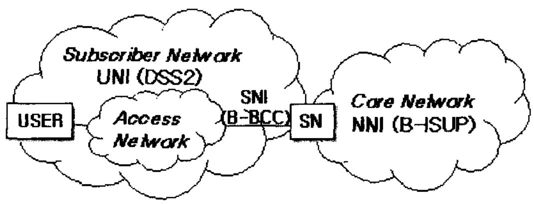


Fig. 1. Interfaces of subscriber, access and core networks

ITU-T recommended signaling protocols for the basic call/connection control of B-ISDN. Those are Digital subscriber Signaling System number 2 (DSS2) [4] and Broadband Integrated Services User Part (B-ISUP) [5] at the UNI and the Network Node Interface (NNI), respectively. Their purpose is to establish, maintain and release ATM connections in the subscriber and core networks. If the access network supports the configuration of on-demand Virtual Channel (VC) connections, control flow is required to allow the service node to request the access network to establish and release Virtual Channel Connections (VCCs) between specified UNI ports and SNI ports. For this function, a protocol named Broadband Bearer Connection Control (B-BCC) [6] and Broadband Access Network Connection Control (B-ANCC) [7,8] protocols were specified at SNI defined as VB5.2. These protocols enable the establishment, modification and release of bearer connections in the SNI between SN and AN.

There is an interworking relationship between DSS2 and B-ISUP, which is typically provided in the SN [9,10]. In case that the SN supports an AN with the VB5.2 interface, the additional relationship between DSS2, B-ISUP and B-BCC or B-ANCC connection control protocol has to be considered. The interworking is limited to the handling of a bearer connection. ITU-T adopts the sequential interworking model in which the SN will sequentially carry out DSS2, B-ISUP and the protocols in VB5.2 interface [6]. Even though VB5.2 interface allows effective usage of resources and dynamic traffic control, a drawback is overall connection setup delay by the additional interworking functions of VB5.2 connection control protocol.

To minimize the connection setup delay by interworking functions, we propose a model for parallel interworking in which the connection control protocol of VB5.2 interface and signaling protocol proceed simultaneous in the SN. Among overall the connection control procedures, the parallelism of the interworking functions is applied to the establishment and modification phases. We simulate two interworking models, respectively, based on B-BCC and B-ANCC, in terms of a connection setup delay and a completion ratio. The results of simulation show that our proposed parallel interworking model for the VB5.2 interface reduces the setup delay and has the similar completion ratio compared to the sequential interworking model.

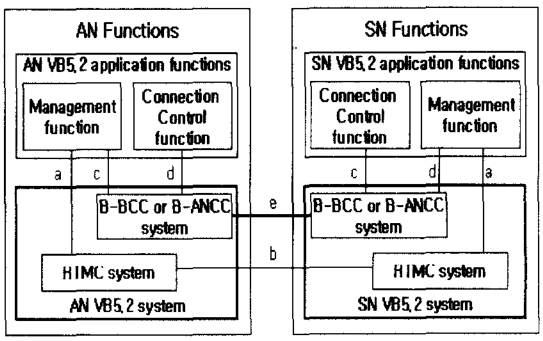
The remainder of this paper is organized as follows. Section 2 describes an existing interworking model of service node. Section 3 proposes the parallel interworking model and section 4 presents the simulation results of two interworking models with the B-BCC and the B-ANCC. Finally, Section 5 presents concluding remarks with some issues for further research.

2. Existing Interworking Model of Service Node

2.1 VB5 Interface

SNIs (VB5.1 [11] and VB5.2 [6]) for B-ISDN have been studied in ITU-T SG 13. VB5.1 interface supports allocation of resources via the management system. Real-Time Management Coordination (RTMC) system will be performed by a protocol that conveys information, mainly from the AN to the SN, regarding the availability of AN resources related to the service provisioned by the SN in real time.

In addition to the functions of the VB5.1 interface, the VB5.2 interface adds a mechanism for allocating AN resources under the control of the SN, enabling connection-by-connection concentration in the AN. For this function, a system named B-BCC will be specified at the SNI as VB5.2. The protocol entity of the B-BCC system shall send/receive B-BCC messages for the establishment/release of ATM connections, negotiation/modification of traffic parameters, and automatic congestion control [6]. Fig. 2 shows the overall model of the VB5.2 interface, which is described in the ITU-T SG 13.



a : Service primitives between management function and RTMC system
b : RTMC protocol messages across the VB5.2 reference point
c : Service primitives between management function and B-BCC system
d : Service primitives between connection control function and B-BCC system
e : B-BCC protocol messages across the VB5.2 reference point

Fig. 2. VB5.2 system model

2.2 Sequential interworking procedures with B-BCC

The VB5.2 connection control is triggered by external events(i.e., DSS2 or B-ISUP signaling protocol messages). The required interworking functions between the user and network signaling shall be provided in the SN [10]. The sequential interworking procedure, which is recommended by ITU-T SG 13 [6], is shown in Fig. 3 to establish an ATM connection using the B-BCC and signaling protocols. Fig. 3 shows the message interworking between signaling protocols and B-BCC for the establishment of a point-to-point bearer connection. The diagram shows the DSS2/B-ISUP messages, which are relevant for the interworking with the B-BCC protocol.

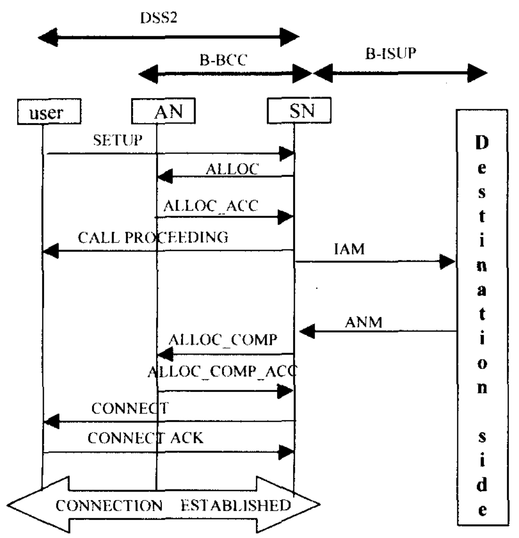


Fig. 3. Sequential interworking procedures with B-BCC

In the sequential interworking model with B-BCC, the SN will perform next signaling protocol message after reception of a B-BCC response message. At the originating side, the SN will transmit an ALLOC message to the AN on the receipt of a DSS2 SETUP message. The SN will process the B-ISUP IAM message after reception of an ALLOC_ACC message in the sequential interworking model. The originating SN will start the second negotiation procedures of the B-BCC protocol using ALLOC_COMP and ALLOC_COMP_ACC messages, when an ANM message from the destination side is received. On receiving an ALLOC_COMP_ACC message, the SN will transfer a CONNECT message to the calling party and then it will complete its overall connection establishment procedure.

In the sequential interworking model, a drawback is the overhead of connection setup delay by the operation of signaling protocols and VB5.2 connection control protocol in sequential manner. The SN can send the connection request message to the destination side after the successful indication from the AN. The destination SN can then send the connection request message to the called party after the successful indication from the AN. The originating SN will send the B-ISUP IAM message after transmitting an ALLOC message to the AN and reception of an acceptance message. So the sequential process of the interworking model will cause an overall connection setup delay, and the size of the delay will be larger according to the status of the AN message queue.

2.3 B-BCC call state diagram

On the VB5.2 interface, SN plays a principal role in the allocation of ATM resources. Thus, the SN and AN form a master-slave relationship. A request to establish a bearer connection in the VB5.2 interface is received from the call control coordination function. Fig. 4 shows B-BCC state diagram for establishment and negotiation of a point-to-point bearer connection.

A connection request is triggered at the SN B-BCC system by the SN VB5.2 application functions via an AllocReq primitive. This primitive contains relevant bearer connection parameters.

On receiving the ALLOC message, the AN B-BCC system indicates the request to the AN VB5.2 application function. Depending on the decision made by the AN VB5.2 application functions, either an ALLOC_ACC or an ALLOC_REJ message

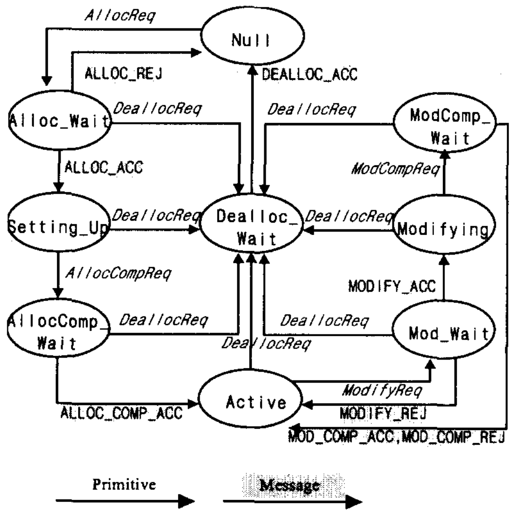


Fig. 4. State diagram of the SN B-BCC

will be sent back to the SN. The ALLOC_ACC message may contain bearer connection parameters which have been selected or changed by the AN.

A connection completion is triggered at the SN B-BCC system by the SN VB5.2 application functions via an AllocCompReq primitive. This primitive may contain any final bearer connection parameters to be used by the AN to allocate the resources. On receipt of the ALLOC_COMP message, the AN B-BCC system indicates the request to the AN VB5.2 application function. Depending on the decision made by the AN VB5.2 application functions, either an ALLOC_COMP_ACC or an ALLOC_COMP_REJ message will be sent back to the SN.

During the data transfer phase it is possible to modify the ATM traffic parameters [12] of a bearer connection in the AN under the control of the SN. A modification request is triggered at the SN B-BCC system by the SN VB5.2 application functions via a ModifyReq primitive.

3. Proposed Interworking Model

3.1 Automatic congestion control

The Automatic Congestion Control (ACC) at connection level is responsible for supervising, limiting or reducing the number of connection requests handled simultaneously within the AN [6]. The ACC procedure shall be asymmetrical: the AN (at the instance which accepts or rejects connection requests) shall indicate its congestion status to the SN but not vice versa. In the AN, thresholds shall be established so that two levels of congestion can be identified, with congestion level 2 indicating a more severe performance degradation than congestion level 1. When either level of congestion in the AN occurs, the AN shall have the capability to notify the SN of the change in its congestion status. When the SN receives a signal that indicates a congestion problem at the AN, the SN shall have the capability to reduce the number of connection requests sent to the AN.

3.2 Parallel interworking model

If the AN has sufficient resources for establishment of connections, it will accept all requests coming from the SN. As the SN knows the congestion status of AN by the ACC procedure, it will try to request a connection establishment when there are sufficient resources in the AN. In this situation, most connection requests to the AN will be successful so it is not necessary for the SN to wait for a response from the AN. Based on the feasibility of ACC procedure, we propose a parallel interworking model. Fig. 5 shows the parallel interworking procedure to establish an ATM connection using the B-ANCC protocol. The SN will simultaneously transmit an ALLOC message to the AN and an IAM message to the destination side of the CN (Core Network) on the receipt of a SETUP message from the user side. The event occurring simultaneously is marked as Note 1) in Fig. 5.

As a result, in the parallel interworking model, the negotiation procedures are simultaneously progressed toward the local AN and destination sides. The establishment of the CBR connection will be

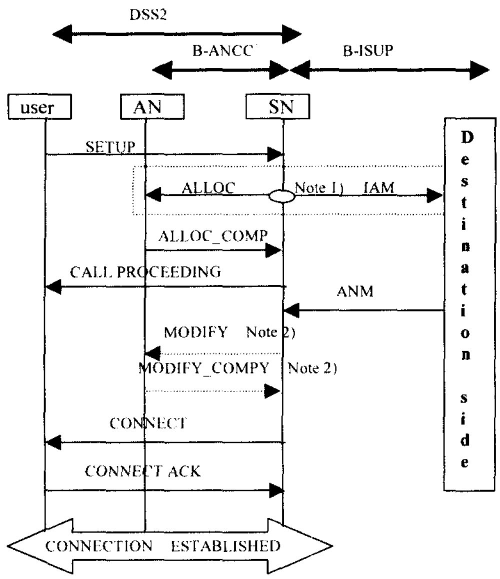


Fig. 5. Parallel interworking procedures with B-ANCC

completed on the receipt of the ALLOC_COMP and ANswer Message (ANM) message from the AN and destination side, respectively. If it is necessary to modify traffic parameters for a VBR connection, then the SN will transfer a MODIFY message to AN or MODify message (MOD) to destination side.

3.3 B-ANCC call state diagram

The Constant Bit Rate (CBR) transfer capability [12], which is applied for the POTS or circuit emulation service does not require negotiation procedures in the establishment phase. The negotiation procedures are represented as Setting_Up and AllocComp_Wait states in Fig. 4. Some applications won't allow negotiation procedures but allow modification procedures in the active phase. For these applications, the Modifying and ModComp_Wait states in Fig. 4 will not be required.

To minimize the overall connection setup delay by introducing the access network, the B-ANCC protocol enhances the B-BCC protocol to meet various services requiring their ATM transfer capabilities [7,8]. Fig. 6 shows a simplified state diagram in the B-ANCC protocol. The Setting_Up, AllocComp_Wait, Modifying and ModComp_Wait states of the B-BCC protocol are simplified with a Mod_Wait state for the request and response of negotiation and modification procedures. A Mod_Wait state will not happen for the establishment of the CBR connection or will happen more than once during the lifetime of the Variable Bit Rate (VBR) [12] connection.

The B-ANCC protocol simplifies the procedures of the B-BCC protocol in the establishment and modification phases. The setup delay and completion ratio of the B-ANCC protocol are improved by about 33% and 8% compared with the B-BCC protocol [7].

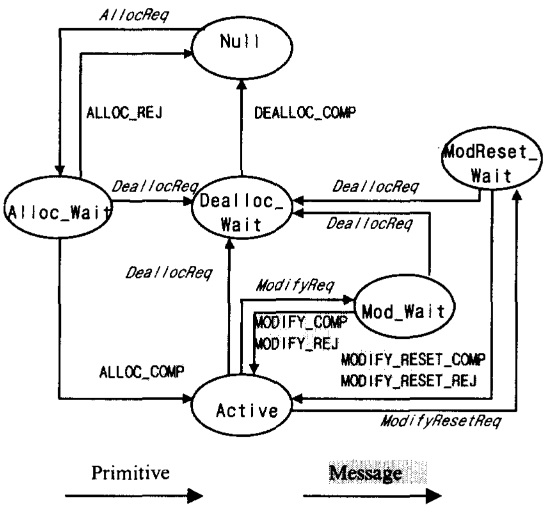


Fig. 6. State diagram of the SN B-ANCC

4. Simulation Results and Discussions

In this section, we discuss the connection setup delay, completion ratio and average queue length. We perform simulations to evaluate two interworking models whose VB5.2 connection control protocol is either B-BCC or B-ANCC. Fig. 7 shows the network configuration for the simulation of the two interworking models.

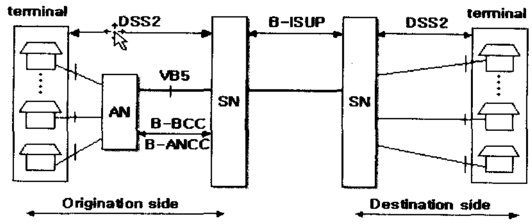
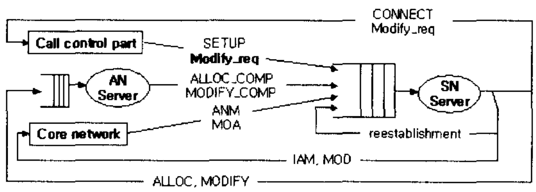


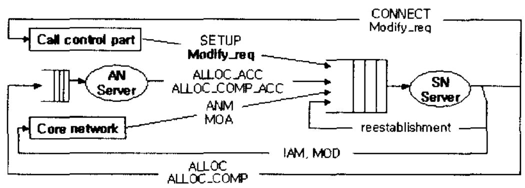
Fig. 7. Network configuration for simulation

4.1 Simulation parameters

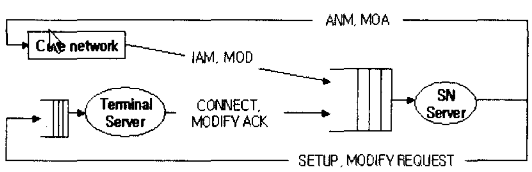
In order to run the simulation the following assumptions were made. There is one server in each node, and the length of each queue is 64. Each node is an independent process with a Poisson arrival pattern and an exponential service time distribution. We assume that the processing power of both SN and AN is equal, and there are only call and connection related messages in the network. Fig. 8 shows the logical simulation model for parallel and sequential interworking models with B-ANCC and B-BCC, respectively.



(a) Origination side with B-ANCC



(b) Origination side with B-BCC



(c) Destination side

Fig. 8. Logical simulation model

Based on the evaluated total arrival rates of the RACE's MAGIC project, the adopted proportions of connection requests for CBR and VBR transfer capabilities are 70% and 30%, respectively [13]. Among the VBR connections, it is assumed that the real modification probability of traffic parameters is 0.3. The modification probability toward the AN is one third of total connection modification probability, and the modification probability toward the CN is two third of total connection modification probability because there are two nodes in the CN and destination subscriber network.

As we perform simulations, we apply the same parameter values to the two interworking models for the accurate comparison. In the establishment phase, the signaling message processing time of each node in the CN and destination subscriber network is assumed to be 46*ms* that was measured by the HAN-BISDN test-bed [14]. The delay from the transmission of IAM message to the receipt of ANM message is assumed to be 92*ms* because we assumed that the connection setup delay of each node in the destination SN and destination subscriber network was 46*ms*.

4.2 Connection setup delay

Connection setup delays for the two interworking models are shown in Fig. 9. In this figure, the connection request is expressed as Busy Hour Call/Connection Attempts (BHCA). As expected, the connection setup delay of the parallel interworking model is less than that of the sequential interworking model and the difference becomes larger and larger as the arrival rate is increased. The SN simultaneously transfers the connection establishment messages to the local AN and destination side in the parallel interworking model. If the B-BCC or B-ANCC protocol is applied to the VB5.2 interface, the setup delay of the parallel interworking model becomes about seven tenths of that of the sequential interworking model.

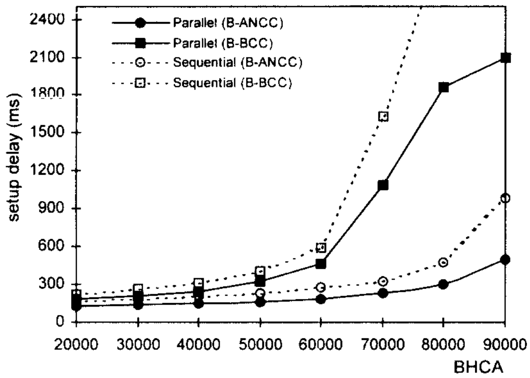


Fig. 9. Connection setup delay

In the establishment phase of the interworking model with B-BCC, the SN always informs the local AN of the selected traffic parameters of the destination side. In the interworking model with B-ANCC, the SN will initiate modification procedure toward the local AN, if the value of traffic parameters is changed by the destination side. Therefore, for the B-ANCC protocol, it is not necessary to take traffic modification procedures for CBR connections during the connection establishment phase. The parallelism of the interworking model and the simplicity of the B-ANCC protocol reduce the delay of connection setup time.

4.3 Connection completion ratio

Fig. 10 shows the connection completion ratio of the parallel and the sequential interworking models as the connection arrival rate is increased. For the sequential and parallel interworking models based on the same VB5.2 connection control protocol, the completion ratios of the two interworking models are near identical because the same numbers of messages are progressed by the two interworking models. In addition we can see that the completion ratio of the interworking model based on the B-ANCC is higher than that of the interworking model based on the B-BCC. This is why the B-ANCC protocol requires fewer messages than the B-BCC protocol to establish a connection. From the results of Fig. 10, we can conclude that the completion ratio is not affected by the interworking model, but is mainly affected by the number of messages arriving at the SN queue.

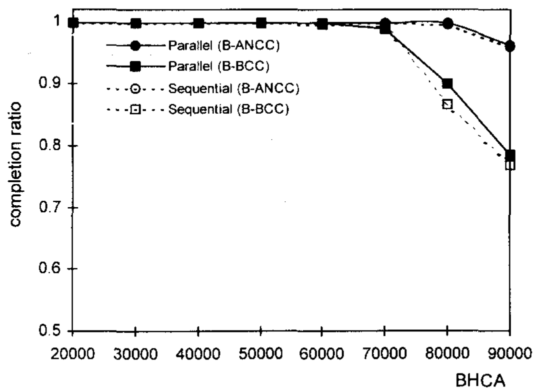


Fig. 10. Connection completion ratio

4.4 Message queue length at SN

Fig. 11 show the average queue length at SN as BHCA is increased. The average queue length of interworking models based on B-BCC is larger than that of interworking models based on B-ANCC, that is because the number of B-BCC messages to be processed in the establishment phase is more than that of B-ANCC messages. From Fig. 11 we find that connection setup delay and completion ratio of the interworking models are closely related to the message queue length at SN. The points of sudden change in average queue length coincide with the increasing points of setup

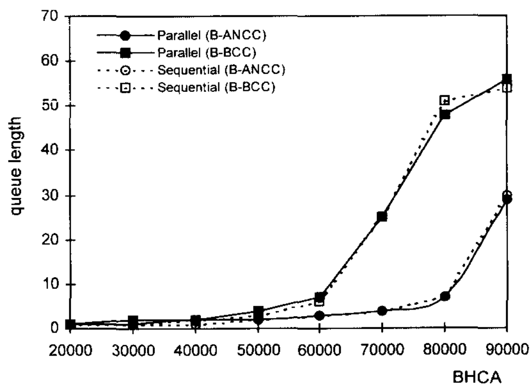


Fig. 11. Average queue length

delay and the dropping points of completion ratio. Those matched points are 70,000 BHCA in the interworking model with B-BCC and 90,000 BHCA in the model with B-ANCC in Fig. 11.

5. Conclusions

Telecommunication networks can be divided into two parts, subscriber networks and core networks. For future multimedia services, one of the most crucial issues is building an access network that can accommodate multimedia services in the subscriber network. There is an interworking relationship between DSS2 and B-ISUP, which is typically provided in the SN. In case that the SN supports an AN with the VB5.2 interface, the additional relationship between DSS2, B-ISUP and B-BCC protocol has to be considered. ITU-T adopts the sequential interworking model in which the SN will sequentially progress DSS2, B-BCC and B-ISUP protocols. This means that the next procedures of DSS2 or B-ISUP protocol will be progressed after the response from connection control protocol of VB5.2 interface. The drawback of the sequential interworking model is the overhead of connection setup delay by operations of signaling protocols and VB5.2 control protocol in sequential manner.

To minimize a connection setup delay of the sequential interworking model, we proposed the parallel interworking model in which the SN executes simultaneously the connection control protocol of VB5.2 interface and signaling protocol. In the parallel interworking model, the origination SN will simultaneously transmit an ALLOC message to the local AN and an IAM message to the destination side on the receipt of a SETUP message from the user side.

We evaluate two interworking models by simulation in terms of a connection setup delay and a completion ratio. In the environment in which there are mixed connection requests with CBR and VBR transfer capabilities, we observed that the completion ratios of the two interworking models are quite closed. However, the connection setup delay of parallel interworking model becomes about seven tenths of that of the sequential interworking model and the improvement becomes larger as the arrival rate is increased.

The following items will be of value for the future researches. The first is to analyze the configuration in which the AN is connected to the several SNs. The second is to study how the values of threshold levels in automatic congestion control will affect the performance of parallel interworking model.

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