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ATM시스템에서 네트워크 시그날링 정보를 이용한 HTR(Hard-To-Reach) 등록방법 및 퍼지제어 방법

(HTR(Hard-To-Reach) Code Registration methods and Fuzzy controls using network signaling information in ATM systems)

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요 약

ATM기술은 ITU나 ATM Forum과 같은 표준화 기관에서 B-ISDN서비스를 전송하기 위한 기술로 표준화 되어 왔다. 현재는 ATM기술이 복잡하여 인터넷 트래픽을 전송하도록 MPLS와 같은 백본기술로 채택되고 있다. 그러나 ATM프로토콜은 BcN망등에서 많이 채택될 것이다. 본 논문은 ATM기반 시스템에서 네트워크의 정보를 이용하여 HTR코드를 기법을 적용하여, 코드를 검출하고, 등록하는 기법에 대해 논하고 자 한다. 고속의 circuit switching시스템에서 HTR코드 제어는 필수적이며, 본 논문에서는 HTR코드검출 및 Fuzzy제어방식을 통해 실험결과를 보인다. 본 방법에 의해 제시된 실험결과는 체증상태를 신속히 제어하며 시스템 자원을 최대한 활용하고, 적은 부하로서도 효율적으로 제어함을 보인다.

Abstract

ATM was recommended by the ITU and ATM Forum as a means of transportation for B-ISDN. At this time, due to the comprehensive nature of ATM protocol, ATM has been adapted as the backbone system for carrying Internet traffic[1,2,3,4]. But major conceptsregarding the ATM protocol will be used on future technology. This paper presents preventive congestion control mechanisms for detecting HTR(Hard-To Reach) code in ATM systems, in particular for an improved HTR call registration method using network signaling information will discussed. In high speed circuit switching system environments, a fast HTR control mechanism is necessary. We present research results for improving HTR call registration and control methods using network signaling information and fuzzy control mechanisms. We concluded that it showed fast congestion avoidance mechanisms with a fewer system load maximized the efficiency of network resources by restricting ineffective machine attempts.

Keywords : HTR Code, Fuzzy, signaling information in ATM systems

I. Introduction

1.1 Background

The broadband integrated services digital network(B-ISDN) is envisioned to be the universal communica-tions framework, integrating all types of networking services and applications[29]. Towards achieving these objectives, a B-ISDN should not only provide a frame-work to support emerging multimedia applications, but also support services that are currently deployed. Most telecom operators today use separate networks for voice and data services, with different protocols and different networking technologies. Cu-rrent packet switched networks are designed to support best-effort service and cannot provide service guarantees. Circuit switched networks can provide service guarantees, but

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they are inefficient at supporting data traffic.

The need to integrate interactive and distribution services, as well as circuit and packet transfer modes into a universal broadband network are gradually increasing[5]. The solution of integrating these services is ATM(Asynchronous Transfer Mode) recommended at ITU-T. ATM is a fast packet-switched technology based on a fixed length packet(cell). The fundamental unit of ATM is the ATM cell. The ATM cell is a fixed length(53bytes) and consists of a header field(5 bytes) and an information field(48bytes). An ATM cell can transfer burst and heterogeneous traffic by statistical multiplexing efficiently. ATM has the following advan -tages. First, it is flexible to assign bandwidth by virtually connecting packet form data that has a fixed cell length according to service requests. Second, ATM allows efficient use of bandwidth through statistical multiplexing for burst traffic by willingly allowing some cell loss and cell delay. The statistical multi -plexing method allows network users to use network resources efficiently. ATM was selected by ITU-T to realize these diverse services.

At the ATM forum, service architecture is recom -mended for five service categories, CBR(Constant Bit Rate), rt-VBR(Real-time Variable Bit Rate), nrt-VBR (non Real-time Variable Bit Rate), ABR(Available Bit Rate), UBR(Unspecified Bit Rate) [8]. For CBR and VBR, bandwidth is allocated to the network at the establishment of a connection. For the CBR, end system sends cells at the PCR(Peak Cell Rate) and the SCR(Sustainable Cell Rate), MBS(Maximum Burst Size) for the VBR. For both service categories, cell transfer with the required QOS is ensured by the network.

In ABR and UBR, the bandwidth is not allocated in the network on the establishment of a connection if the MCR(Minimum Cell Rate) is not greater than zero for the ABR[10]. The end systems send cells using the available bandwidth in the network. For the ABR, the CLR(Cell Loss Ratio) is specified. To obtain a low cell loss ratio and a fair share of the available bandwidth, an allocation policy for rate-based traffic control is being studied which adjusts cell flow in response to control information regarding congestion[15]. For UBR, traffic parameters regarding service guarantees are not specified. UBR sources transmit cells to support statisti -cal multiplexing according to the minimum specified parameters such as PCR[6]. ITU-T recommends an ATC(ATM Transfer Capability), such as DBR(Determi -nistic Bit Rate), SBR(Statistical Bit Rate), ABR (Available Bit Rate), ABT(ATM Block Transfer) and UBR(Unspecified Bit Rate). In the past few years, ATM has found a home in backbone networks, riding on top of synchronous optical network/synchronous digital hierarchy(SONET/SDH). Its primary contribu -tion has been the ability to provide quality of service functionality such as service-level guarantees as well as packet prioritization for real-time voice and multimedia traffic. However, ATM used to be regarded by its critics as too costly and complex. In contrast, IP-based intranets became more popular and are expected to dominate most LANs in the next few years. (It hasn't helped that the cheaper Ethernet has developed switched and gigabit capabilities.) The way the IP camp tells it, IP has evolved faster than ATM in terms of both ability and ubiquity. There's also the swifter-than-expected evolution of multi-protocol label switching(MPLS), which promises to give best-effort IP QoS capabilities that rival ATM. As such, the argument goes that IP has advanced to the point that it can run at the core of the network, running on SONET/SDH, or even running directly over dense wavelength division multiplexing(DWDM), eliminating the need for an ATM layer.

To be sure, many operators are still buying ATM equipment to improve core network performance. Some incumbent telcos have also been building ATM back -bones to offload their Internet traffic from their legacy public switched telephone networks. For example, in Europe, carriers like BT and Ireland's telecom now provide proprietary call control and signaling over ATM backbones for Internet offload or trunking appli -cations.

1.2 Motivation

This study investigates a Hard To Reach call registration method using network signaling informa-tion. A call for which the call completion ratio is lower than normal, is called a HTR code. A Conventio-nal PSTN is directed to check the call completion ratio with regard to the candidate code that was enter-ed by an operator[28].

Most of the traffic congestion on a communication network occurs due to an overload in the network exchange system.

This communication concentration or overload of the switching system occurs due to an overload of a specific switching system or due to a domino effect that occurs when many calls are requested at the same time. Such communication traffic congestion can also occur in a specific terminating system due to an unexpected communication equipment failure. Heavy call congestion on a specific terminating system(For example, when a predetermined public performance, or a very popular television program is broadcast) can occur even though the operator of the switching system has predicted such heavy call congestion without actually making a predetermined estimate regarding the congestion. When the number of calls that are concentrated on the destination is beyond the capability of the system, the system can only offer limited service, and the system can even go down due to the above-described problems[1,2,3].

Figure 1. is a graph illustrating the performance when a switching system is overloaded. As shown, the curved line Maximum Throughput indicates the theore-tical system performance which is obtained when an overload of the system occurs or traffic congestion occurs. Also, the curved line Without Overload control denotes system performance when there is no conges-tion control, Finally, the curved line With Overload control denotes the system performance which the system is maintained when a congestion control func-tion is operating. If the condition described above is continuously maintained, the system congestion that occurred due to the number of call attempts to a specific number can also cause congestion on the neighboring systems. Eventually, an entire system-wide failure may occur.

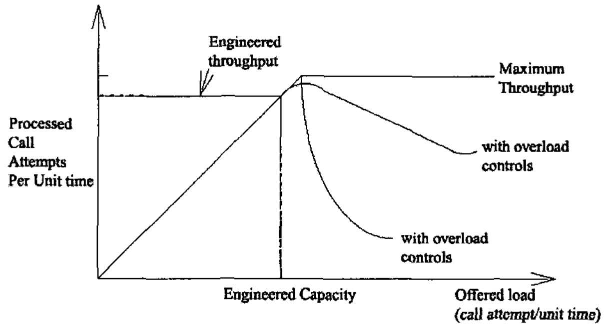

그림. 1. 과부하 상태에서 시스템의 Throughput
Fig. 1. Throughput Performance with Overload.

To overcome the problems described above, a con-ventional public switched telephone network(PSTN) is directed to check the traffic completion ratio for a candidate code(traffic received at a specific code for a predefined system) that the operation entered. When the call completion ratio for the corresponding code falls below a predetermined threshold value, the calls to the corresponding code are then controlled[2]. Such a method is intended to maximize the efficiency of the network so that exchange resources may be evenly distributed to calls except for those going to the conges-ted call. This is achieved by detecting a receiving code for which the call completion ratio is lower than for a normal call. Controlling the receiving code can be done at the exchange from which a desired call attempt is made or at the switching system that is the near an originating exchange. This call, for which the completion ratio is lower than normal, is called a Hard To Reach call. The main goals for controlling HTR codes are conserving trunk/CPU resources by restricting ineffective machine attempts.

Ⅱ. HTR Detection algorithm in PSTN

Large capacity switching systems should have the capability to automatically detect HTR traffic that has a very low chance of being completed. This traffic is identified by switching systems by the use of destination codes that are based on ineffective machine attempts and on effective networking attempts[27]. HTR code information should be able to be transmitted on a per-call basis via a CCS system to other switching systems. This is called control offices. This capability applies to CCS SS6, but at present is not supported by SS7. The control offices should automatically enter the received HTR codes onto an HTR code control list. Protective automatic controls, which can be used in response to received Dynamic Overload Control signals from control offices, or can be triggered by the Trunk reservation[27]. This is the dynamic control that res-ponds to trunk congestion in the outgoing trunk field. It should be triggered for a particular Trunk Group when the number of idle trunks in that group is equal to or less than the Trunk Reservation threshold level. Most PSTN switching systems can handle the HTR control by operator for a pre-scheduled event. For the case of the conventional PSTN, the cause of the incom-pletion is follows. First, when the trunk lines to a number from the originating switching system are all used, or when the resources of the switching system (such as a call mixer, and a tone generator) are all used. Second, a call is not connected due to a lack of switching resources on a transit system including the destination exchange. Third, a subscriber is on the line with another subscriber, or the subscriber does not respond to the call. Fourth, when the call is timed-out due to the originating exchange side, or when the subscriber gives up on the call. All of these events may result in a call incompletion[1,2,3,4].

The originating exchange processes the call attempt, as an incomplete call by sending a busy tone to the user or to the switching system. However, when judging all of the busy tones or a subscriber's absence of response to be HTR, there may occur numerous system errors This because the meaning of HTR is that the call completion ratio regarding the lack of resources in a specific toll/terminating exchange or the user busy. Therefore, it is necessary to measure the statistical probability of an incomplete call due to a lack of system resources and user busy.

In addition, when performing a function that is based on a conventional candidate code, the control will only be performed a predetermined length of time after the operator enters the predetermined code. Therefore, it is impossible to prevent the call concentration problems on a predetermined switching system due to the possi-bility of unpredictable failures in the system.

Ⅲ. Proposed HTR Code detection algorithms in ATM system

For PSTN, call related information can not be gathered during a call. However, for most current tele-communication technologies, call related information can be gathered during a call. The Following sections are the call related information in ATM during the call is activated.

3.1 EFCI/EBCI

EFCI/EBCI(Explicit Forward/Backward Congestion Indication) is a congestion notification mechanism which may be used to assist the network to avoid and recover from a congested state. In the ATM cell Header, there is a PTI(Payload Type Identifier) value indicating the payload type. It determines if it is user cell or a system cell and the status of the cell that are the cells experiencing congestion as they transit through the system. This is a 3-bit field used to indicate whether the cell contains user information or is connection association layer management informa-tion[31]. It is also used to indicate a network's congestion state or for network resource management

표 1. ATM셀에서 PTI코딩
Table 1. PTI Coding in ATM cells.

PTI Coding	Interpretation
000	User data cell, Congestion not experienced, SDU-type = 0
001	User data cell, Congestion not experienced, SDU-type = 1
010	User data cell, Congestion not experienced, SDU-type = 0
011	User data cell, Congestion not experienced, SDU-type = 1
100	Segment OAM F5 flow related cell
101	End-To-End OAM F5 flow related cell
110	Reserved for future traffic control and resource management
111	Reserved future functions

in ABR or ABT services. The detailed coding and use of the PTI field is shown in the following table.

3.2 ACL

In this paper, we provide an improved HTR call registration method by using a call incomplete cause message for ATM switching systems which can over-come the problems encountered with conventional methods.

In PSTN, ring and ringback tone indicates that the call has successfully progressed and if the destination user answers then the call is successfully connec-ted[1,2,3,4]. With a busy tone, we cannot know the reason why a call is unsuccessful. Generally, we can only know that the call is incomplete. With ATM, when a call is finished, a RELEASE message is sent to the user or network to indicate that the equipment sending the message has released the virtual channel(if any) and the call reference[9,32]. The virtual channel is then available for reuse, and the receiving equipment shall release the call reference. Included in the RELEASE message, there is a CAUSE information element that indicate the release state(normal/abnor-mal) of the call. The Cause message can be classified into several possible categories.

- sending equipment error, like an information element error/missing, wrong destination number
- originating exchange's reason
- transit exchange's reason
- destination exchange's reason
- terminating equipment's reason (ex. invalid bearer compatibility, User busy etc.)

When the call completion ratio is greater than a pre-defined threshold value, we register the calls as HTR.

3.3 AIS/RDI

AIS/RDI(Alarm Indication Signal/Remote Defect Indication) cells are fault management techniques that is responsible for detection, isolation and recovery from problems that can result in failure[31]. These cells reflect the physical layer fault like LOS(Loss of Signal), LOP(Loss Of Pointer), LOF(Loss Of Frame) etc. and ATM layer fault.

VP/VC-AIS cells are generated and sent down-stream on all affected active VPC/VCCs from the ATM network element which detects the VPC/VCC defect in order to indicate an interruption of the cell transfer capability at the VP/VC level. The generation frequency of VP/VC-AIS cells is nominally one cell per second and shall be the same for each VPC/VCC concerned. VP/VC-AIS cell generation shall be stopped as soon as defect indications (ex. transmission path AIS defect) are removed[31]. VP/VC-RDI cell is sent to the far-end from a VPC endpoint as soon as it has declared a VP/VC-AIS state. This information is used for determining the HTR code.

3.4 RM (Resource management) Cell

Resource management functions that have to operate on the same time-scale as the round trip propagation delays of an ATM connection may need ATM layer management procedures to use resource management cells associated with that ATM connection[6,7,30]. The values of dynamic parameters such as explicit cell rate(ECR), CI and NI, and Queue Length are deter-mined by network elements along the connection and are forwarded to the user of the ABR capability via RM cells. There are two parameters for indicating the congestion state on the ATM networks.

- **BECN indication**: this bit distinguishes a normal RM cell generated by the source and looped back by the destination from a RM cell generated by an intermediate congested switch. The BECN indication is set to 1 in the BECN RM cell.
- **Congestion Indication(CI)**: this bit indicates imminent congestion on the forward path[11].

A drawback for RM cells is that they can only be used as part of ABR services.

3.5 By Call Completion Ratio

This mechanism is the same as conventional HTR

표 2. OAM 기능
Table 2. OAM Functions.

Method	Gathering Unit	Characteristic
EFCI/EBCI	cell	EFCI/EBCI is a mandatory function. This mechanism can be used for all kinds of connections
ACL	call/ connection	Indicates the detailed call completion status
AIS/RDI	cell	indicates an interruption of the cell transfer capability at the VP/VC level
RM Cell	cell	Only for ABR and ABT service
Completion Ratio	call/ connection	Same as PSTN

call registration methods in PSTN. A problem for these methods is their late response time in determining the HTR code and improper call completion rates due to an inability to discriminate the exact reason for the HTR code[1,2,3,4,28].

3.6 Comparison of proposed HTR gathering methods

We propose 4 new HTR gathering techniques; however some proposed methods have some restric-tions that apply to them.

IV. HTR Code Control mechanisms

4.1 Conventional control mechanisms

There are two congestion control mechanisms used by PSTN, that is Automatic call gap and percentage based congestion control. These mechanisms are based on the call incompletion ratio. The time difference between congestion recognition and proper control ac-tion creates improper call/connection restrictions. The nominal time difference is 5 minutes for most conven-tional PSTN exchanges.

4.1.1 Automatic Call Gap(ACG) Control mechanism

When an ACG control is initiated, a duration timer should be set to mark the duration of the control. Permissible values for the control's duration are 0.1, 0.25, 0.5, 1, 2, 5 , 10, 15, 30, 60, 120,300, 600 sec. as well as an infinite interval[27]. When the duration timer expires, the control should be removed. When an ACG control is initiated, a gap timer should also be set for a period called the gap interval. All subsequent calls to the controlled code should be blocked until the gap timer expires. The next attempt to arrive after the gap timer expires should not be blocked. This attempt should be processed normally, and if it fails then the gap timer should be reset to start another blocking period. This cycle should continue until the duration timer expires. When the duration timer expires, the control should be removed immediately without waiting for the gap timer to expire.

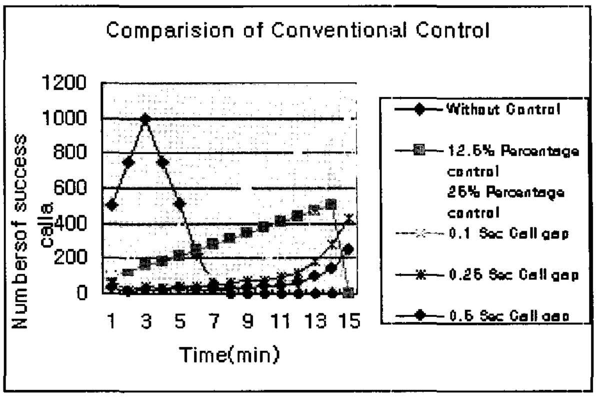

그림 2. 기존 제어 방법과의 비교
Fig. 2. Comparison of Conventional control.

4.1.2 Percentage based control mechanism

The percentage call/connection blocking algorithm is also useful for immediate traffic control[27]. A conven-tional percentage call/connection blocking algorithm uses the predefined input of an 8 class limit ratio from 0% to 100% with a 12.5% incremental unit for each congestion level. A percentage which is entered by an operator can also be accepted. Therefore, the system can be down when excessive calls become concent-rated.

4.2 Proposed Control mechanisms

4.2.1 Fuzzy HTR code control mechanisms

Zadeh established the mathematical base for fuzzy set theory and proposed a method to describe systems based on fuzzy set theory[22,26]. Only theoretical resear -ch was performed, until Mamdani[16] first introduced fuzzy control that based on Zadeh's theoretical resear -ch. Fuzzy control has since become one of the most successful fields of application. It is based on fuzzy logic and can be used effectively to describe uncertain phenomena in the real world because of similarities between the human way of thinking, natural language properties and fuzzy logic in comparison to other exis -ting logic systems. Many control system models do not appropriately deal with numerical analysis when obtaining data is difficult. Fuzzy control was introdu -ced successfully in industrial areas by replacing and also supplementing inappropriate control methods. In general, a Fuzzy control system shows better results than other controllers when known information about the system is not accurate and reliable[23]. In ATM networks, several research studies which apply FCS to traffic control have been reported[12,20,21,23]. The main part of an FCS is a set of control rules of linguistic form that comprise an expert's knowledge. Our FCS for HTR code control consists of a measurement part, fuzzification part, knowledge base part, inference en -gine part, defuzzification part and HTR pre-control part. Many previous research studies using UCR(Un -completed Call Ratio) with proper fuzzification rules are the same as conventional PSTN exchanges, but they use UCR from the measurement part as an input in addition to another input CUCR(Change of UCR) which is the difference between the current UCR and previous UCR. This method results in better performance and simpler control algorithms. However, gathering UCR data takes the same amount of time as conventional control mechanisms. This cannot reflect the current network status since UCR data can only be gathered after a call/connection is finished. The releva -nt performance criteria between conventional control mechanisms and FCS mechanisms are the predefined restriction ratio vs. the previous uncompleted call ratio. As stated previously, studies have show that FCS HTR control mechanisms can not indicate the previous network congestion status.

4.2.2 Membership functions and Fuzzy Rules

PSTN HTR control mechanisms and previous research have used UCR data for controlling HTR code[28]. In this paper, we use NCS(Network Congestion Status) and CNCS(Change of Network Congestion Status) as two inputs, to create a FCV(Fuzzy Control Value). The first input, NCS indicates the network congestion status and is gathered during data transmi -ssion. This information is contained in the ATM cell header. The second input CNCS is the change in the network congestion status, i.e., the difference between the current NCS and the previous NCS. The CNCS is used to predict the next NCS. If the CNCS is negative, then the NCS will tend to decrease and the blocking rate will also tend to decreased. The measured value of NCS and CNCS are scaled to divide by 100. The scaled inputs for NCS and CNCS, and the output FCV(Fuzzy Control Value) each have their own fuzzy values in the most popular set {NB(Negative Big), NS (Negative Small), ZO (ZerO), PS (Positive Small), PB (Positive Big)}. The elements of each fuzzy set have their own triangular shaped membership functions.

Using heuristic knowledge to decide the call bloc -king rate, we present the next three rules.

- If NCS is high, then it increases CNCS fast.
- If NCS is not high, but not too low neither, when CNCS is positive, it increases the Call Blocking rate fast, but if it is negative or equal to zero, it holds the current Call blocking rate
- If NCS is low, when CNCS is positive, it increases the call blocking rate moderately, and

표 3. Fuzzy 집합
Table 3. Fuzzy Set Summary.

Inference rule		CNCS(Change of Network Congestion Status)				
		NB	NS	ZO	PS	PB
NCS	ZO	NS	NS	ZO	ZO	PS
	PS	ZO	ZO	PS	PS	PS
	PB	-	PS	PB	PB	-

when CNCS is negative or equal to zero, it decreases Call blocking rate slowly.

Based on the above rules, the knowledge based part of the FCV consists of 13 specific rules that uses two inputs and creates one output as shown in the follo -wing table.

V. Performance Evaluation

5.1 Simulation Model

The simulation model used in our research consist of a local exchange and its adjacent toll/tandem ATM exchanges. This Toll/tandem exchange can process 1000 concurrent calls and the non-blocking switch has a scalable capacity of 2.5 160Gbps that was developed by ETRI.

Generally, processor's call handling capacity is expressed as Erlang. In this simulation model, call dura -tion is highly related to the call processing capacity

We use the following HTR code control methods.

- It does not block any call at the toll/tandem exchange. We then know system will be down when call/connection requests exceeds the engi -neered capacity.
- This represents and traditional HTR code control methods which include most of the PSTN ex -changes are deployed. When the duration timer expires, the control is removed. When an ACG control is initiated, a gap timer is also set for a period called the gap interval. All the subsequent calls to the controlled code will be blocked until the gap timer expires. The next attempt to arrive after the gap timer expires will not be blocked. We use three call gap times 0.1, 0.25 and 0.5sec for the purpose simplification.
- Almost all existing HTR code control methods measure the UCR of the HTR codes every 5 to 10 minutes. After that a system operator applies a 12.5%, 25%, 37.5%, 50% 62.5%, 70%, 82.5%, 100% Call blocking rate according to the conges -tion level. There is some difficulty in determi -ning the congestion level necessary to control the HTR code by the operator. In this simulation we only use two blocking rates for simplification (12.5% and 25%).
- Previous research methods used the Fuzzy Control System on a call basis data.
- We dynamically use the call control information during the call/connection. Therefore the reaction time is short and even for a temporary conges -tion, the performance is better than any other control methods. This method is the key idea in this paper.

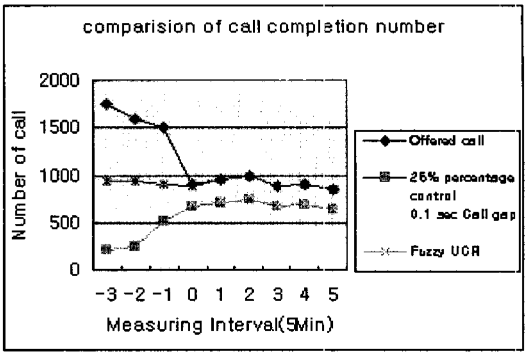

그림 3. 측정주기와 호처리 수
Fig. 3. Measuring interval vs. call processing.

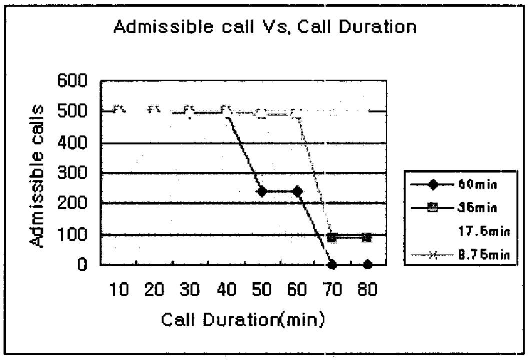

그림 4. 수락된 호수와 통화시간
Fig. 4. Admissible call vs. Call Duration.

5.2 Simulation Results

Connection/Call admission control contains the follo -wing functions.

- If the originating call is prohibited or not
- If the memory is available or not
- Whether System resources are available or not (call mixer, tone generator, concentrator, trunk etc)

표 4. HTR적용 및 비적용시 호수락수
Table 4. With/without HTR vs. call capacity.

	With HTR Control	Without HTR Control
Call attempts	4058/Min	2160/min
Number of completion calls	1427/min	2104/min
BHCA	243,480BHCA	129,636BHCA
Memory	1.73 M (10K per call)	173M (173K per call)

The HTR code control is performed before a call processing function. It then takes less CPU processing time. The time difference between HTR pre-control and call processing function determines that a call is concentrated beyond the system engineering capacity, prevents system shut down.

The same rules applied to memory and call proce-ssing functions will generate processes(task) that HTR pre-control do not generate.

Simulation results show that all of the five simula-tion results have the same performance when calls are under the engineering capacity. However, beyond the engineering capacity quite different results are generated.

If there is no HTR control, the system will be down gradually due to excessive call processing. In the case of call gap control, it is conducted based on an opera-tor's experience. This shows each of the call completion rates. Generally, call gap control algorithms shows a good performance when calls are peak within a short period. Similar to the call gap control, percen-tage control is also based on operator's experience. It is good for less than burst traffic but if the total allowed calls exceed to the system engineered capacity, the system will shut down.

Several research studies which have applied FCS to traffic control have been conducted. The results indicate better performance and simpler control algori-thms for FCS. However, gathering UCR data takes the same amount of time as conventional control mecha

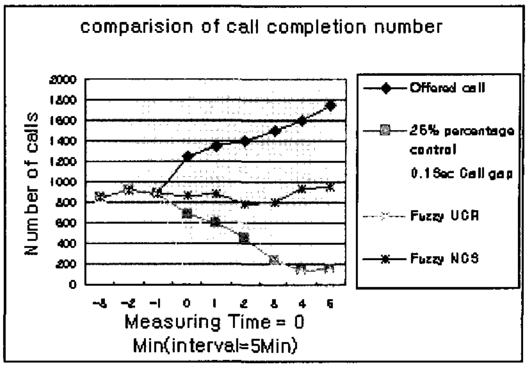

그림 5. Fuzzy UCR 과 NCS
Fig. 5. Fuzzy UCR vs. NCS.

-nisms. They cannot indicate the current network congestion status that can be gathered when data transmission and UCR data is gathered after a call /connection is finished. Performance comparisons bet-ween conventional control mechanisms and FCS mechanisms are the predefined restriction ratio vs. the previous uncompleted call ratio. Conventional HTR con-trol mechanisms can not indicate previous network congestion status. This results in worse performance than methods that can indicate the network congestion status.

The following results shows when the network congestion status is moderated. We believe that even when the network congestion status is moderated. Using conventional HTR control mechanisms(Call gap and percentage control) and several other studies that use fuzzy control based on UCR low call completion rates are the result.

Finally, for the case of FCS with UCR, the time interval for measuring the UCR is an important factor for improving the system performance. However, most PSTN exchanges have a 5 minute measuring intervals for minimizing system load. Within the 5 minute interval, congestion that lasts only a few seconds results in a low call completion rate. Accordingly, our mechanisms can control calls more efficiently.

VI. Conclusions

The simulation result shows that a traditional HTR code control mechanism and an FCS mechanism based on UCR can alleviate congestion states very little. On the other hand, even a simple FCS mechanism based on NCS shows that system congestion can be alleviated rapidly. The proposed mechanisms can more accurately control the network in the congestion state. It is therefore possible to maximize the efficiency of network resources by restricting ineffective machine attempts. More studies should be conducted into the combination of using NCS and UCR. This mechanism can be also used for the RSVP(Resource ReserVation Protocol) that is used in the Internet Protocol.

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