Impact of Call Setup Time on UPT Performance Based on AIN Platform

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ABSTRACT

This paper analyzes the impact of Call Setup Time on UPT performance based on the AIN platform. Call Setup Time is used as the performance parameter. In implementing UPT based on the AIN platform, the geographical location of VLR affects network performance. In order to find an optimum location of VLR among three different types of structures, i.e. VLR is located close to Service Switching Point and Cell Site Controller and located at Service Control Point, each Call Setup Time on proposed time delay model is calculated and compared. Network performance is analyzed by changing the number of STP in No.7 signaling network in UPT and the utilization ratio, ρ, for SSP, STP and SCP

AIN 플랫폼 기반의 UPT 성능에 대한 호 설정 시간의 영향

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요 약

본 논문은 차세대 지능망(AIN : Advanced Intelligent Network) 플랫폼 기반의 종합개인통신(UPT : Universal Personal Telecommunications)의 성능에 미치는 CST(Call Setup Time)의 효과를 분석하며 CST는 파라미터로 사용된다. 차세대 지능망을 기반으로 하는 UPT구현에 있어, VLR(Visitor Location Register)의 위치가 망의 성능에 많은 영향을 준다. VLR의 최적의 위치를 제시하기 위해, VLR이 위치할 수 있는 3가지 물리적 구조 : SSP(Service Switching Point)에 근접해 있는 경우, CSC(Cell Site Controller)에 근접해 있는 경우 그리고 SCP(Service Control Point)에 위치하는 경우를 고려하고 UPT망에서의 각 구간별 시간지연 모델을 제안하고 비교한다. 네트워크의 성능은 No.7 신호망에서 STP수와 SSP, STP(Signaling, Transfer Point), SCP, VLR의 가용율 ρ을 변화 시키면서 망 성능을 분석하여 VLR의 최적위치를 제안한다.

1. Introduction

Current telecommunication service has some limitation in use of service extension under restrictions of locality and terminal usage and so on. Universal Personal Telecommunications (UPT) service could be the ultimate goal of wire/wireless communication service that dynamically replaces the existing static terminal and user identification method. So it guarantees mobility to each person and gives communication access to the users everywhere. Through the UPT service, users can either ask for a call or receive signals with transparent UPT numbers whichever terminal the user uses or wherever the user located. In other words, this realizes the concept of personal mobility as an enhancement of the simple terminal mobility [1-3].

In UPT service, Visitor Location Register (VLR) is a physical entity that stores information of

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visiting mobile terminal entering an area. In implementing UPT based on the Advanced Intelligent Network (AIN) platform, the geographical location of VLR affects network performance [8, 9]. In this paper, in order to find an optimum location of VLR among three different types of structures such as VLR is located close to Service Switching Point (SSP) and Cell Site Controller (CSC) and located at Service Control Point (SCP), performance evaluation is performed. The motivation of this paper is to analyze the impact of Call Setup Time (CST) on UPT performance based on the AIN platform.

In order to analyze the performance, network model for UPT service based on AIN platform is suggested in Section II. Also three physical structures as network models with VLR located at three different locations are presented as well. Section III describes time delay model for the three different types of structures suggested in Section II and calculates the total time delay for UPT user identity authentication procedure. Simulation on time delay value with MATLAB is performed in Section IV. Finally, in Section V the conclusion is discussed.

2. Network model for UPT service

Fig. 1 represents a UPT network structure based on AIN platform [4].

Functions of network components given in Fig. 1 are as follows.

(1) SCP: SCP contains service logic (in the form of application program) and data used to support AIN service. A single SCP can communicate with multiple SSPs and IP via No. 7 signaling network and possibly with certain entities in other networks.

(2) HLR: HLR stores terminal information and user's, and personal mobility related data. It is located at SCP.

(3) SSP: SSP is a switching system that contains AIN switch capabilities. The AIN switch capabilities enable a SSP to identify calls associated with AIN service. A SSP can communicate with one or more SCPs by means of No. 7 signaling network.

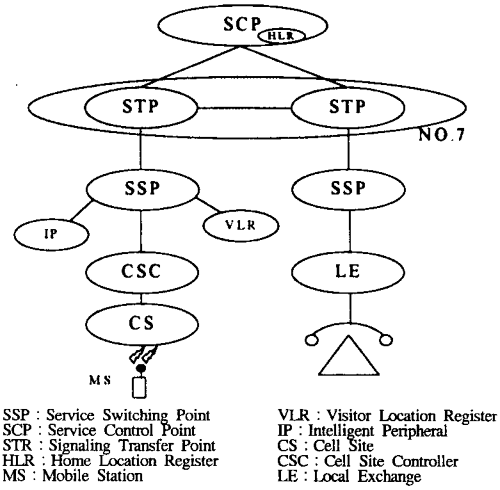

Fig. 1. UPT network structure based on AIN platform

(4) VLR: VLR stores information of mobile terminals which enter its area.

(5) IP: IP telecommunications resources service support functions such as 1) exchanging information with end users, 2) provide stand-alone service, 3) originate and terminate calls. IP communicates with SCP through SSP(s). IP is not capable of communicating with another IP.

(6) CSC: CSC as a BSC contains the features : BSC (Base Station Controller) operation, maintenance, and resource management.

(7) CS: CS provides function that connects with subscribers' terminals wirelessly as a BTS.

(8) LE: Local switch

(9) STP: STP has a signal transfer function for controls of bearer and connection

Based on the network structure described in Fig. 1, VLR can be located as three cases described below.

Case 1: VLR is located close to SSP.

Structure where VLR is directly connected with SSP and Signaling Transfer Point (STP).

Case 2: VLR is located close to CSC

Structure where VLR is connected with CSC and STP but not directly connected with SSP. Therefore, VLR should pass through CSC to connect with SSP.

Case 3: VLR is located at SCP.

Structure where VLR is directly connected to the STP.

3. Time delay model and Total time delay

Now in order to analyze a time delay model on UPT user identity authentication procedure, the necessary queue model related to CST is suggested in the next subsection.

3.1 CST

CST is defined as the time interval beginning from the end of dialing and ending when the caller receives audible ringing. The proposed total delay for CST is the sum of link propagation delays on all transmission lines and response time in each node. The response time of a network component is defined as the time interval beginning when the last bit of a message enters a network component and ends when the last bit of the response message leaves the same network component. And response time is the sum of system processing time and link output delay. Link output delay is the interval that begins when the message is placed in the output signaling link and ends when the last bit of the message is transmitted on the output signaling link [5].

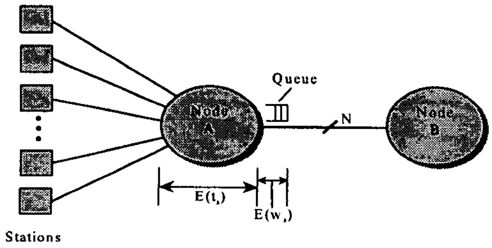

Fig. 2. Queueing model

In Fig. 2, $E(t_s)$ is system processing time and $E(w_s)$ is an average waiting time of a queue in a designated node. This $E(w_s)$, link output delay, is the average waiting time on the queue at node A until one of the N channels becomes free [6].

It is necessary to define relevant variables in the single-server queuing situation, so that we may build up formulas for dealing with queuing behavior. The following symbols will be used:

t_s = processing time for one item in a queue
$E(t_s)$ = mean processing time
σt_s = standard deviation of processing time
w_s = waiting time for one item
$E(w_s)$ = mean waiting time

The mean of processing time, t_s, is $E(t_s)$. Khintchine and Polloczek developed the basic formulae for single-server queuing theory. An average waiting time in a node is given as (1) [7].

$$E(W_s) = \frac{\rho E(t_s)}{2(1-\rho)} \left\{ 1 + \left[\frac{\sigma t_s}{E(t_s)} \right]^2 \right\} \tag{1}$$

In (1), σt_s is the standard deviation of system processing time. The minimal and maximal value of σt_s are 0 and $E(t_s)$, respectively.

The standard deviation of processing time, σt_s, can be replaced with $E(t_s)$ for the maximal waiting time, then the (1) can be derived to (2).

$$\frac{\rho}{(1-\rho)} E(t_s) \tag{2}$$

Utilization ratio, ρ, is the proportion of the maximum load that the system can handle. If utilization ratio, ρ, of each node is decided and average system processing time are given, then time delay of each node can be calculated.

3.2 Definitions of parameters

Necessary parameters for applying time delay model to physical entities are defined as follows:

RWPD: Radio Wave Propagation Delay between MS and CS

T_P: Link propagation delay between nodes
PT_A: System processing time in node A
QT_A: Link output delay in node A
RT_A: Response Time ($RT_A = PT_A + QT_A$) in node A
$TD_{A \rightarrow B}$: Time Delay from node A to B

3.3 Time delay model

UPT user identity authentication procedure is a procedure of subscribers' verification for security and it has a function to protect from usage of unauthorized user [8]. Fig. 3 is MSC description of UPT user identity authentication procedure.

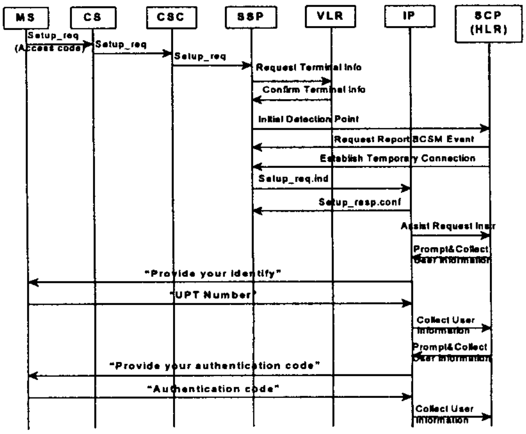

Fig. 3. MSC for UPT user identity authentication procedure

Three types of time delay model using parameters defined in Subsection 2 are calculated as shown below. They are distinct from each other by the location of VLR.

Case 1: VLR is located close to SSP

In a case where VLR is located close to SSP, time delay factors using parameters defined in Subsection 2 are described as follows:

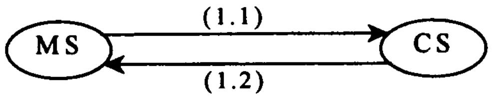

Fig. 4. Time delay features diagram for Case 1

(1.1) $TDMS \rightarrow CS = RWPD$
(1.2) $TDCS \rightarrow MS = RWPD$

Since the rest of pictures related formulae are drawn in the same manner as shown above, they are omitted.

(2.1) $TDCSC \rightarrow SC = TP + PTCS$
(2.2) $TDCSC \rightarrow CS = TP + PTCSC$
(3.1) $TDCSC \rightarrow SSP = TP + PTCSC$
(3.2) $TDSSP \rightarrow CSC = TP + PTSSP + QTSSP$
(4.1) $TDSSP \rightarrow VLR = TP + PTSSP + QTSSP$
(4.2) $TDVLR \rightarrow SSP = TP + PTVLR + QTVLR$
(5.1) $TDSSP \rightarrow SSP = TP + PTSSP + QTSSP + N(QTSTP + PTSTP + TP)$
(5.2) $TDSSP \rightarrow SSP = TP + PTSSP + QTSSP + N(QTSTP + PTSTP + TP)$
(6.1) $TDSSP \rightarrow LE = TP + PTSSP + QTSSP$
(6.2) $TDLE \rightarrow SSP = TP + PTLE$
(7.1) $TDLE \rightarrow USER = TP + PTLE$
(7.2) $TDUSER \rightarrow LE = TP$
(8.1) $TDSSP \rightarrow SCP = TP + PTSSP + QTSSP + N(QTSTP + PTSTP + TP)$
(8.2) $TDSCP \rightarrow SSP = TP + PTSCP + QTSCP + N(QTSTP + PTSTP + TP)$
(9.1) $TDVLR \rightarrow SCP = TP + PTVLR + QTVLR + N(QTSTP + PTSTP + TP)$
(9.2) $TDSCP \rightarrow VLR = TP + PTSCP + QTSCP + N(QTSTP + PTSTP + TP)$
(10.1) $TDSSP \rightarrow IP = TP + PTSSP + QTSSP$
(10.2) $TDIP \rightarrow SSP = TP + PTIP$
(11.1) $TDIP \rightarrow SCP = TP + PTIP + N(QTSTP + PTSTP + TP)$
(11.2) $TDSCP \rightarrow IP = TP + PTSCP + QTSCP + N(QTSTP + PTSTP + TP)$

Case 2: VLR is located close to CSC

In this case, time delay factors given in next diagram are applied only if it is in between (4.1) and (4.2). Otherwise it is the same as Case 1's.

(4.1) $TDSSP \rightarrow VLR = PTSSP + QTSSP + PTCSC + TP$
(4.2) $TDVLR \rightarrow SSP = PTVLR + QTVLR + PTCSC + TP$

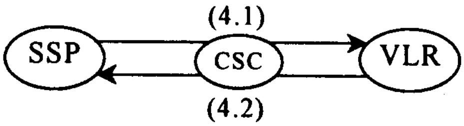

Fig. 5. Time delay features diagram for Case 2

Case 3: VLR is located at SCP

In this case, time delay factors in the following diagram are applied only if it is in between (4.1) and (4.2), otherwise it is the same as Case 1's.

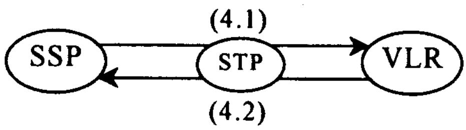

Fig. 6. Time delay features diagram for Case 3

(4.1) $TDSSP \rightarrow VLR = PTSSP + QTSSP + TP + N(QTSTP + PTSTP + TP)$

(4.2) $TDVLR \rightarrow SSP = PTVLR + QTVLR + TP + N(QTSTP + PTSTP + TP)$

3.4 Total time delay

Fig. 7 is a modeling of the total time delay CST obtained from MSC description in Fig. 3.

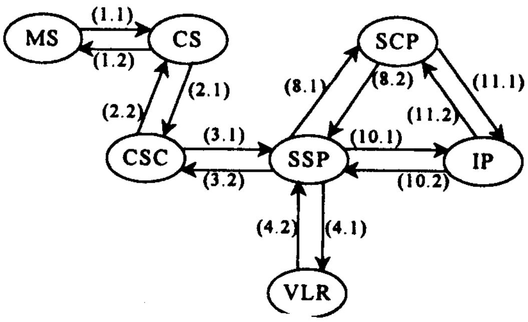

Fig. 7. Time delay model of UPT user identity authentication procedure's information flows

As the time delay model given in Fig. 7, the traffic flows in location of VLR using CST modeling can be listed as follows:

1.1→2.1→3.1→4.1→4.2→8.1→8.2→8.2→10.1→10.2→
11.1→11.2→10.2→3.2→2.2→1.2→1.1→2.1→3.1→10.1→
11.1→11.2→10.2→3.2→2.2→1.2→1.1→2.1→3.1→10.1→
11.1

As defined in Case 1, all equations from (1.1) to (11.2) are applied to the traffic flows given above. Time delay of CST where VLR is located close to SSP is calculated as below.

$$3\times(1.1)+2\times(1.2)+3\times(2.1)+3\times(3.1)+(4.1)+(4.2)+(8.1)+2\times(8.2)+3\times(10.1)+3\times(10.2)+3\times(11.1)+2\times(11.2)+2\times(3.2)+2\times(2.2)=(26+8N)\times TP+3\times PTCS+6\times PTIP+5\times PTCSC+7\times PTSSP+7\times QTSSP+4\times PTSCP+4\times QTSCP+PTVLR+QTVLR+8N\times PTSTP+8N\times QTSTP$$

As defined in Case 2, applied equations such as (4.1) and (4.2) are different from that of Case 1 where CSC is between SSP and VLR. The total time delay is calculated as below.

$$(26+8N)\times TP+3\times PTCS+6\times PTIP+7\times PTCSC+7\times PTSSP+7\times QTSSP+4\times PTSCP+4\times QTSCP+PTVLR+QTVLR+8N\times PTSTP+8N\times QTSTP$$

Similarly with the Case 2, different equations of (4.1) and (4.2) are applied to Case 3 where VLR is located at SCP. The calculation for Case 3 is as below.

$$(26+10N)\times TP+3\times PTCS+6\times PTIP+5\times PTCSC+7\times PTSSP+7\times QTSSP+4\times PTSCP+4\times QTSCP+PTVLR+QTVLR+10N\times PTSTP+10N\times QTSTP$$

4. Simulation and Results

In this section, we analyze the performance of three different types of network structure those are dependent on the location of VLR by comparing it with CST. CST value is calculated with provisional values, which are selected from current reports of Bellcore and ITU-T [5, 9]. The selected provisional values are the maximal values that they have indicated to achieve for the best result. The three different results depending on the location of VLR using MATLAB are compared to analyze.

System processing time and link output delay of physical entities of UPT network are shown in Table 1. It is based on recommendation of Bellcore [10, 11]. System processing time in IP is considered arbitrarily chosen as equal to the system processing time of VLR. Link output delay of CS, CSC, and LE is considered as 0 since those are not physical entity of AIN.

Table 1. Performance parameters, its system processing time and link output delay of physical entities in UPT network

	PT	QT
CS	300ms	0
CSC	300ms	0
VLR	150ms	$\frac{\rho}{1-\rho} \times PT_{VLR}$
SSP	200ms	$\frac{\rho}{1-\rho} \times PT_{SSP}$
SCP	150ms	$\frac{\rho}{1-\rho} \times PT_{SCP}$
STP	20ms	$\frac{\rho}{1-\rho} \times PT_{STP}$
IP	150ms	Not applicable
LE	200ms	0

The simulation result is calculated by changing parameters such as the utilization ratio, ρ, for SSP, SCP, STP, and VLR and the number of STP from 0 to 0.6 and 0 to 10, respectively. This simulation is performed with the calculated values on the UPT user identity authentication procedure given in Section IV.

Fig. 8 shows a simulation result of UPT user identity authentication procedure which is varied by changing of the utilization ratio, ρ, and the number of STP.

According to the result of simulation, the case 1 where VLR is located close to SSP has the shortest time delay than the others.

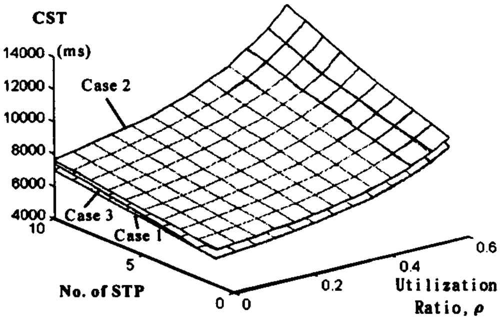

Fig. 8. Simulation result on UPT user identity authentication procedure related to utilization ratio, ρ and the number of STP

5. Conclusion

In this paper, CST depending on the locations of VLR was calculated with the recommended provisional values in Bellcore technical documents. The simulation of calculated CST is performed with MATLAB. The simulation result is calculated by changing parameters, utilization ratio, ρ, and number of STP.

Simulation result given in Fig. 8 has more meaning on relative values of CST precedence order than on the real mathematical values. The simulation result of this paper, showed that the best performance is achieved when VLR is located close to SSP.

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백인관

96년에 부경대학교 정보통신공학과를 졸업하고 97년부터 현재까지 부경대학교 정보통신공학과 석사과정에 재학중임.

관심분야 : 프로토콜 공학, VHDL

조준모

95년과 97년에 경북대학교에서 석사학위 및 박사과정을 수료한 후, 98년이후 동명대학에 교수로 근무하고 있음. 관심분야는 ATM 교환기, VHDL임.

김성운

90년과 93년에 프랑스 파리 7대학 석사 및 박사학위를 취득하였다. 82년부터 85년까지 한국전자통신연구원에서 근무하였으며, 86년부터 95년까지 한국통신연구개발원에서 근무하였음. 96년 이후 부경대학교 정보통신공학과 조교수로 재직중임.

관심분야 : 초고속망 및 프로토콜공학분야임.

정신일

76년도와 88년 경북대학교에서 석사 및 박사학위를 취득하고, 현재 부경대학교 정보통신공학과의 교수로 재직중임.

관심분야 : 가상대학, 광전송 및 신호처리