Simulation of Location Management Strategies of Timer, Location Area, and Movement Based Update/Paging for Wireless Networks

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Abstract **- This paper studies the problems related to the location management strategies, i.e., Location Area Based, Movement Based, and Timer Based for Wireless networks. The simulation models are based on user motion and call arrival is based on Poisson arrival process. The Timer-based Location Management strategy is one in which the user updates its location periodically after an interval of time. This time is based upon the user's mobility. The scheme seeks to minimize the average signaling cost for individual mobile users for both paging and registration. In the adaptive Location Area Based strategy, the user updates its location on each Location Area (LA) call boundary crossing. In this case the LA size is adaptive changing according to the user's mobility characteristics. In the Movement Based Location strategy, the user keeps track of the number of LA calls boundary and updates when the number exceeds a predefined value.**

Key Words: Wireless Networks, Location Management, update/paging

I. INTRODUCTION

Wireless personal communication networks have also emerged as an important field of activity in telecommunications. This surge of interest is due to several factors such as the increased availability of wireless personal computing, entertainment and communication devices, and liberalisation of spectrum allocation procedures and advances in digital signal processing and radio modem technologies. While these systems have initially focused only on voice and primitive packet data applications, it is recognised that they will have to evolve toward supporting a wider range of applications involving video and multimedia. The increased dependence on networking for business, recreation and communications, the growing demand for multimedia applications together with a human desire for mobility and freedom from office-only or home-only computing constraints makes a strong argument for wireless integrated networks. Efficient database and location management schemes are needed to meet the challenges from high density and mobility of users, and various service scenarios.

A. Radio Access Protocols

The basic idea in wireless ATM is to provide support for ATM virtual connections (VC) with QoS control on an end-to-end basis. Network level functions are handled with standard ATM cells, which are augmented with a wireless-specific header/trailer on the radio link to support wireless-specific protocols such as MAC, DLC, and wireless control. Standard ATM signalling functions is terminated at the mobile terminal. Extensions to the ATM signalling protocols have been proposed to handle terminal mobility related functions such as handoff and location management [1]. Thus, wireless ATM network specifications can be partitioned into two categories: The Radio access protocols to handle specific functions and Mobile ATM for radio independent, mobility management functions.

B. Mobile ATM

Mobile ATM is the term used to denote the set of enhancements needed to support terminal mobility within a fixed ATM network. The major functions of mobile ATM are location management for mapping of user names to their current locations, and handoff control for dynamic re-routing of VCs during terminal migration.

C. Routing and QoS Control

Mobile ATM requires extension to existing routing algorithms to dealwith route change and optimizations associated with handoff. In general, a handoff event may result in a significant change in the optimal route of each active virtual circuit associated with the mobile terminal. Routing in mobile ATM is closely related to Quality Of Service (QoS) control for maintaining selected service parameters through the duration of a mobile connection [8].

Handover

Handover or Handoff is a basic mobile network capability for dynamic support of terminal migration in both wireless ATM and PCS/cellular interconnection applications. Realisation of this function requires signaling and network control (e.g. Public Network to Network Interface (PNNI)) syntax extensions for dynamic re-routing of a set of VCs from on radio port to another. In general, this process involves terminal or radio port initiation of handoff for several VCs, which may be connected to different fixed or mobile end points. The re-routing mechanism involves path extension from one radio port to another and/or re-establishing VC subpaths through new ATM switches or ports [1].

D. Location Management

`Location management is a generic capability required in networks supporting terminal migration [2]. This function is required in both the end-to-end wireless ATM scenario and PCS/cellular/WLAN backbone scenario (where the mobile has a legacy telephone number, IP or MAC address). Location management provides a mapping between a uniq1ue mobile device "name" and "routing-id" which is used to locate the current endpoint to which the device is attached. More distributed location management algorithms which do not necessarily require call setups to go through a home location register are also possible, potentially reducing call establishment delay. An important implementation issue here is the degree to which location services should be integrated with existing ATM call control and routing software. This type of implementation offers the advantage of a fully integrated connection control capability with better performance and lower latency than a separated approach.

II. LOCATION MANAGEMANT IN WIRELESS NETORKS

Location management (LM) in wireless networks allows the permanent ATM address of a mobile terminal (MT) to be used in connection setup messages, regardless of the current location of the MT [2]. LM does not merely deal with address translation, but incorporates features for access control and privacy, the determination of user's service profile and the enforcement of policies related to accounting and inter-provider roaming.

A. Location Management functions

The LM functions allow the unique identification of the mobile user and the routing of connections to a mobile terminal regardless of its location [7]

The LM functions involve:

- Assignment of unique service identifiers.
- Assignment of permanent ATM end system address (AESA) for mobile terminals.
- Location tracking, aids the network in keeping track of the current permanent –to- temporary AESA mapping.
- Connection routing.

B. Authentication and Roaming Functions

- Authentication: This function allows the network to verify the identity of the mobile user and allow the MT to register its location information.
- Roaming support: This function allows a mobile user to move from one mobile ATM network domain to another, while preserving the ability to initiate an terminate ATM connections.

C. Classification of LM Schemes

All location management mechanisms developed can be classified in two categories [9].

- **Location Register Scheme**, which is used to store the location of the mobile users and this information is used whenever a call has to be delivered to a MT.
- **Mobile PNNI Scheme**, new features are added in the PNNI protocol to achieve the required mobility support.

Location Areas

To implement LM, it is necessary to define location areas, which are radio coverage regions with a common ATM network prefix. An MT within a location area is reachable with a temporary ATM address whose network prefix is the same as that of the location area. When the MT moves to a different location area, its temporary address changes and a location update from the MT to the network is required to change the address association. The determination of the current location area is a function integrated into the radio layer. The location area information consists of two fields: a network identifier (e.g., ATM network prefix) and an index.

D. Paging

In cellular systems, a single location area can consist of multiple radio coverage areas (or cells). Since the precise location of the MT within the location area is not known, a broadcast page message must be sent on all cells of a location area to reach the MT during call setup. The location update procedure at the End-User Mobility Enabled Switch (EMAS) distinguishes between these two cases.

E. Location Update

In the location update control flow, MT sends a location update message to the network when it detects a change in location area. This detection is done in two ways [7]: During Handover where the MT invokes the Get Candidate Paging Areas (PA) and the new location area is conveyed in the Candidate PAs message or When the MT has no open connection: the need for handove does not arise. The MT must therefore periodically invoke the Get Candidate PA function to check if the location has been changed. Once a determination of the change in location area is made, the question arises as to how the MT must send the location update message to the network. The location update message carries the service identifier, the permanent ATM address of the MT and the previous location area the MT visited. The

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EMAS-e receiving the location update message carries out the procedure given in [7] to update the location server.

F. Mobility Modeling for Individual User

Mobility modeling for an individual user requires a model that describes the time-varying motion of an individual and has motion parameters readily available for analysis. A basic mobility characteristic is the increase in user location uncertainty with time since the last user-network interaction. For our simulation we assume a Brownian motion with drift model for each user for the sake of simplicity [3]. The one-dimensional Brownian motion with Drift process starting at position x_0 at time t_0 can be described as:

$$P_b(x,\tau) = \frac{1}{\sqrt{2\pi D(t-t_0)}} e^{-\frac{[x-x_0-v(t-t_0)]^2}{2D(t-t_0)}} \quad ....(1)$$

Where $t \geq t_0$ and D is the diffusion constant (length^2/time).It the parameter which represents the location uncertainty of the motion, and v the drift velocity (length/time) which represents the average velocity of a moving user.

G. Timer Based Update/Paging

Timer based methods as opposed to location-based methods do not require the user to record and process location information during the time between location updates. These results in a significant reduction in the signaling reduction in the signaling cost involved for locating a particular user. When an incoming call arrives, the network pages the cells where the user could be located since its last registration/update. Depending on the maximum paging delay allowed, the terminal paging process can take place in more than one step. In each step, the network selects of the cells for paging. The paging process terminates as soon as the mobile is found. The scheme seeks to minimize the average signaling cost due to both paging and registration for individual mobile users [5].

H. Overall Cost of Paging and Registration

The average overall cost for registration/paging for the optimum timer-based method is calculated as [4]:

$$\eta(t) = \frac{\lambda_p}{1-e^{-t}}\{\rho^{\frac{1}{2}} p\sqrt{2}(erf(\sqrt{t}) - 2\sqrt{(\frac{t}{\pi}e^{-t})} + e^{-t}\} \quad (2)$$

Where, $t = \tau\lambda_p$ and p is the paging cost/signaling message, $\rho = D/\lambda_p$ is the mobility index. For simplicity we assume either that $\lambda_p = 1$ or that η is measured in cost per average page interarrival time, $1/\lambda_p$. Adaptive Location Area Based: The Adaptive Location Area Tracking Scheme proposal [3] is a scheme, which chooses the LA on a per-user basis. In this scheme, each mobile performs a location registration as it crosses the boundary of its current personal location area and is assigned a new location area. The size and shape of the new LA is determined based on the call and mobility characteristics of the user in the previous LA. The objective is to minimize the combined average signaling cost of both paging and registration activities for each individual mobile user such that the overall system wide signaling cost for location tracking can be minimized.The used model for user motion and call arrival is Brownian motion with drift process and Poisson arrival process respectively. Under the assumption of a one-dimensional cellular network environment, the effects of user mobility parameters such as average movement speed, location uncertainty and mean call arrival rate on the size and shape of individual location areas are investigated. The boundaries of the one-dimensional LA is given as B_1 and $B_2$with $B_1 \leq x_0 \leq B_2$; where X_0 is the initial position of the mobile. The "Mean First Passage Time" (MFPT) for a Brownian motion with Drift process starting at X_0 is derived in [3] as:

$$T(x_0,B_1,B_2) = \frac{1}{v}\left\{\frac{1-e^{-2v(x_0-B_1)/D}}{1-e^{-2v(B_2-B_1)/D}}(B_2-B_1)-(x_0-B_1)\right\} \quad (3)$$

Cost Structure

The overall signaling cost for paging and registration is calculated as [48]:

$$\eta = \{P\lambda_p\left(\frac{B_2-B_1}{L_c}\right) + \frac{1}{T(x_0,B_1,B_2)}\} \quad (4)$$

Position Optimization of Location Area

Fixing the LA size $L_{LA} = B_2 - B_1$, taking derivative of equation (4) with respect to B_1 and setting $d\eta/dB_1 = 0$ results is:

$$B_1 = x_0 + \frac{D}{2v}\ln\left\{\frac{D}{2vL_{LA}}(1-e^{\frac{-2v}{D}L_{LA}})\right\} \quad (5)$$

III. DESIGNING THE SIMULATOR

The process of designing the simulator includes a sequence of procedures: initially the movement of the user was modeled using the one-dimensional Brownian motion model with drift process [6]. This reference was used for developing the motion model for simulation.The call arrival process was assumed to be Poisson with exponential inter-arrival times. The average call arrival rate λ_p was taken to be 1/60, Diffusion Constant D = 200, and

v =0.For the timer-based strategy, the updates were carried out on two occasion's i.e., when the inter-arrival time exceeded the timeout parameter or when the time

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between two updates exceeded the timeout interval. The location of the user is also assumed to be known just after a call delivery.In the location area based strategy, updates were carried out each time the user crosses its LA boundary. It is assumed that an update has been made just before call arrival.

IV. PERFORMANCE ANALYSIS AND RESULTS

A. Timer Based Location Update/Paging

From equation (2) for the Overall Cost of Paging and Registration, i.e.,

$$\eta(t)=\frac{\lambda_p}{1-e^{-t}}\{\rho^{\frac{1}{2}}p\sqrt{2}(erf(\sqrt{t})-2\sqrt{(\frac{t}{\pi}e^{-t})}+e^{-t}\}\ (6)$$

Figure 1 is plotted for different mobility indices ρ, the optimum t is apparent for higher mobility indices. The optimum timer value is a function of D and λ_p. A higher mobility idex ρ requires a shorter update interval t and incurs a higher cost, which clearly indicates that if a user is location volatile and receives calls less often, it is better to track the user with smaller t. In contrast, if a user moves less and receives more calls, a longer t is more appropriate.

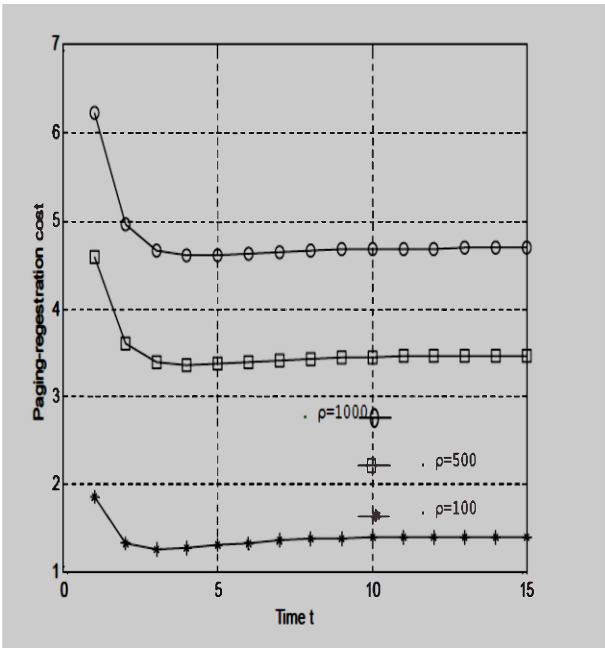

Fig. 1. The Total cost versous time for various values of mobility index ρ = 100, 500, 1000.

B. Location Area Update/Paging

Based on equation (5), figure 2 shows B_1 and $B_2 = B_1 + L_{LA}$ as a function of v for different values of D as L_{LA} is fixed. For the optimal positioning of an LA, the following results are observed. When there is no motion drift (v=0), the LA must be placed symmetrically with respect to the location registration renewal point x_0 , i.e., x_0 is always at the center of the new LA after each registration. The LA must be shifted in the direction of v and the distance shifted increases with v as shown in figure 2. Diffusion constant D represents a motion uncertainty region around the initial position x_0. When D is small, the uncertainty region is small. While with large D, there is a larger region, indicating that more cells between x_0 and B_1 that needs to be included in the new LA.Motion with larger v and smaller D suggests more deterministic motion, while motion with smaller v and a larger D represents a more random motion that needs a larger LA to cover.

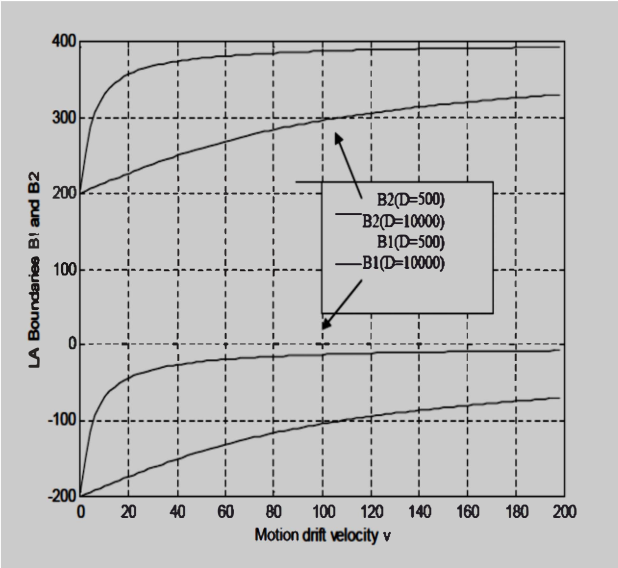

Fig.2.. Effect of motion Drift velocity and diffusion constant D on LA positioning, assuming LA size = B_2 –B_1 = 400 and the user initial position x_0 =0

V. CONCLUSION

The optimum timer based strategy proves to be the best choice for location updateamong the other strategy. It is also the simplest to implement since the user only has to maintain a clock to measure the time since its last update and sends an update when the timeout occurs. The timeout value is set according to the user's mobility and call arrival characteristics. The optimum timer value ***t*** is a function of Diffusion Constant ***D*** and call arrival rate ***λp***A higher mobility index ***ρ*** requires a shorter update interval t and incurs a higher cost,which clearly indicates that if a user is location volatile and receives calls less often, it is better to track the user with a smaller ***t***. In contrast, if a user moves less and receivesmore calls, a longer t is more appropriate.

The paper also showed that the timer – based minimum registration/paging cost isdependent on location uncertainly rather than mean user velocity. This is because amobile moving at a constant rate an a known direction has a mobility index of zerosince there is no uncertainty in its location. Therefore, cost incurred in tracking himdown is minimum.

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VI. REFERENCES

[1]A.Acharya, Jun Li, and DipankarRaychaudhuri, " Signalling Syntax extensuions for location management in mobile ATM", ATM Forum/96-1624, Dec. 1996.

[2] D. Raychaudhuri, L. French, R. Siracusa, S. Biswas, R. Yuan, and C. Johnston,"WATMnet: A Prototype Wireless ATM System for Multimedia PersonalCommunication" JSAC special issue on Wireless ATM, 95-R-036 (AP). 1995

[3]Z. Lei and Christopher Rose "Wireless Subscriber Mobility Management Using Adaptive Individual Location Area for PCS Systems", June 1998.

[4] C. Rose, "Minimizing the average cost of paging and registration: a timer – based method", ACM Wireless Networks 2(2), 1996.

[5] C. Rose and R. Yates "Minimizing the average cost of paging under delay constraints", ACM Wireless Networks 1(2): pp 211-219, 1995.

[6] Sheldon Ross, "An Introduction to Simulation" 1987.

[7] ftp://ftp.atmforum.com/atm/incoming/Lm3.doc.

[8] J. Ho and I. Akyildiz, "Local Anchor scheme for Reducing Location Costs in PCNs, IEEE/ACM transactions in Networking vol. 4, No.5, October 1996.

[9] E. Zervas, A, Kaloxylos, and L. Merakos, "An Efficient Location Management Protocol for Wireless ATM Customer Permises Networks", 1998.