Multilevel Location Trigger in Distributed Mobile Environments for Location-Based Services

Kyoung Wook Min, Kwang Woo Nam, and Ju Wan Kim

ABSTRACT—In location-based services, most trigger technologies have been implemented on the server side by periodically requesting the locations of mobile phones from mobile network servers. However, bottlenecks and communication interruptions occur when the servers are overloaded by trigger requests. In this letter, we propose a new multilevel location trigger specification which distributes the event detecting role to mobile phones and redesigns the location triggering into a multilevel step. Our suggested location trigger specification can reduce bottlenecks caused by triggers in a mobile core network and reduce power consumption caused by embedded GPS devices in mobile phones.

Keywords—Location-based services (LBS), location trigger, MS-assisted mode GPS, MS-based mode GPS, autonomous GPS.

I. Introduction

Recently, various applications of location-based services have been required such as buddy finding service, position tracking service, land navigation service [1], and so on. A location trigger (LT) detects events such as a mobile phone entering, existing in, or leaving pre-specified areas. The LT then sends an alert through a short message service, by e-mail or by activating other pre-defined actions to mobile subscribers or third parties.

The existing LT technologies have mainly been implemented on the server side in two ways. First, the LT functions have been implemented by extending the function of mobile-service switching centers (MSCs), visitor location registers (VLRs), and home location registers (HLRs) [2]. These mobile network servers support the roaming of mobile phones in base stations to guarantee voice telephonic communication in CDMA mobile networks. This causes a direct modification of the software of servers and communication interruptions when many requests by LTs are received, thereby inducing performance bottlenecks. More recently, in the second server side implementation method, the supply of the most up-to-date mobile phones with embedded A-GPS, position determination entity (PDE), and mobile positioning center (MPC) has become standard in the mobile network in compliance with the standards in 3GPP and 3GPP2 [3]. The LT functions can be implemented by periodically requesting cell or GPS locations from both MPCs and PDEs. Frequent requests for GPS locations lead to increasing power consumption by mobile phones, and frequent requests to MPCs and PDEs lead to the bottleneck problem. For these reasons, we have studied an optimization for LTs which can reduce triggering overheads on the server side and also minimize power consumption by mobile phones with embedded GPS devices by triggering a multilevel step.

II. Location Trigger Models

As shown in Table 1, LTs are classified into four models depending on whether the LT events are detected in the server or the mobile station (MS) side, and whether MLT is supported by cell or GPS locations.

In the server-simple LT, the location server periodically requests the cell location from the MPC in the mobile network using a time trigger. Then, LT events can be detected by comparing the cell location with geometrical trigger areas. This model is simplest and can be implemented easily with conventional technology.

In the MS-simple LT, the events of a cell-based LT are

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detected in a mobile phone. The location server transmits the information of cell IDs which overlap with the trigger area to the mobile phone. All mobile phone types receive signal data from the base station in order to guarantee voice telephonic communication; the base station ID can then be extracted from this data using the location API [4]. In a mobile phone, it is possible to detect an entering or leaving event by comparing the base station ID with cell IDs transmitted from the location server.

The MS-assisted LT and the MS-standalone LT models detect LT events in multilevel steps by acquiring the cell and A-GPS locations. The two models differ in terms of whether or not a GPS location can be calculated in mobile phones. In section III, these two models are described in greater detail.

Table 1. Location trigger models.

Mode	LT model	Location	Triggering side
0	Sever-simple LT	Cell	Server
1	MS-simple LT	Cell	MS
2	MS-assisted LT	Cell & GPS	MS, server
3	MS-standalone LT	Cell & GPS	MS

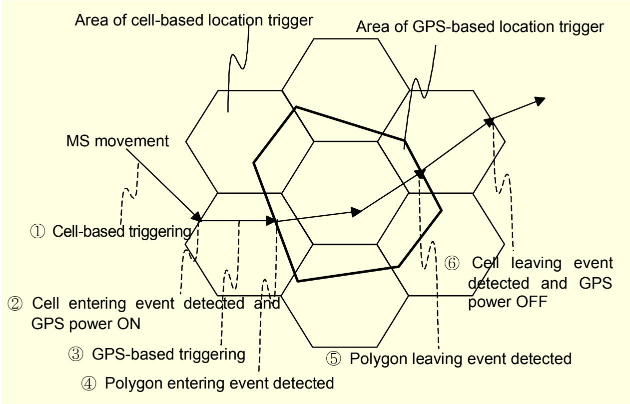

Fig. 1. The multilevel location trigger scheme.

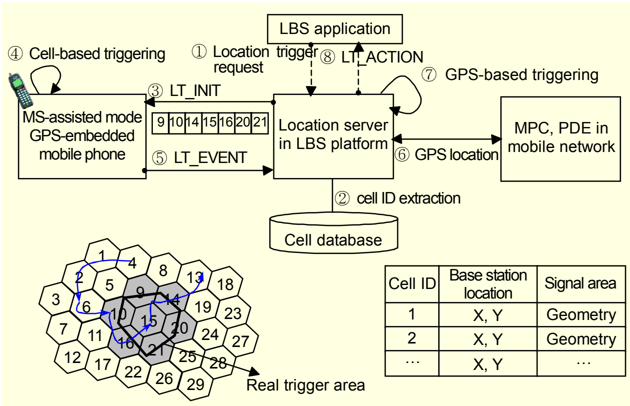

Fig. 2. MS-assisted location trigger model.

III. The Optimized Scheme for Location Triggering

The proposed MLT improves on conventional technology by two enhancements. First, to lessen the overheads of location servers, it distributes the location triggering role to mobile phones in mobile network environments. Second, to minimize the power consumption of mobile phones with embedded GPS devices, it operates by cell and GPS multilevel-based location triggering.

1. Overview of MLT

Figure 1 shows the MLT scheme. The location triggering works by detecting an entering event in a cell overlapping with an LT area, such as that of MS-simple LT; then, after activating the embedded GPS power, the GPS-based LT events are detected. As GPS location acquisitions are more expensive compared to cell ones, initially the events of a cell-based LT are roughly detected. Consequently, the events of a GPS-based LT are detected precisely.

2. MS-Assisted Location Trigger Model

In the MS-assisted LT, trigger events are detected in multilevel steps. In roughly defined areas, it detects the events of cell-based LTs in mobile phones. For precise location areas, it detects the events of an assisted-GPS-based location in the location server. This is because the assisted-GPS location cannot be calculated in a mobile phone with embedded MS-assisted mode GPS, rather it can be calculated in MPCs and PDEs in mobile networks [5].

In this model, the location server transmits the LT initialization information LT_INIT (cell IDs) to the mobile phone, and the events of the cell-based LT are then detected in the mobile phone. After event detection, the mobile phone transmits the resulting information LT_EVENT (entering, cell ID) to the location server, and in order to detect the events of the GPS-based LT in the location server, the location of the MS-assisted mode GPS device is acquired periodically from the MPC in the mobile network as in Fig. 2. During this process, a location server bottleneck may occur due to the frequent acquisition of the assisted-GPS data of subscribers.

3. MS-Standalone Location Trigger Model

The MS-standalone LT is different from the MS-assisted LT model in terms of detecting the LT events in the mobile phone side as regards GPS and cell locations. Specifically, there are no communication costs from the location server to the MPC to periodically obtain cell locations. Moreover, there are no costs from the PDE to mobile phones for obtaining GPS locations. The MS-based mode GPS and autonomous GPS locations can be calculated in mobile phones with these GPS devices embedded [5]; therefore, these phones can detect the events of LTs from the mobile phone side as a standalone function.

As shown in Fig. 3, the location server transmits the LT_INIT information containing actual trigger areas represented by geometrical polygons in addition to the cell IDs overlapping the trigger areas. In a mobile phone, cell-based triggering works in a similar way to the MS-assisted LT model. After a rough detection of events, the power of the based or autonomous-GPS device is turned on; then, GPS-based trigger events are detected in the mobile phone.

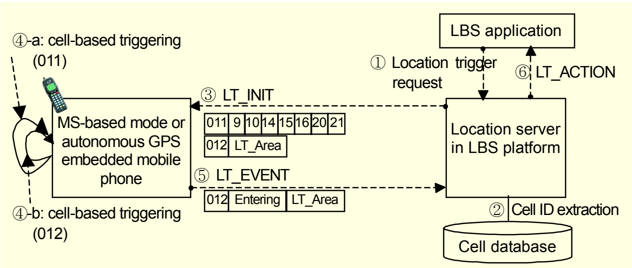

Fig. 3. MS-stand-alone location trigger model.

IV. Simulation Result

In this section, we discuss simulation results for the four LT models shown in Table 1. The test results are given in terms of processing time. The description of the test dataset is shown in Table 2.

To estimate the performance of each LT model, 25 to 200 moving objects were generated by a simulator [6], and the distance of the trajectory of each moving object was within 20 km. Then, 20 fixed trigger areas were created within a diameter of about 1 km. The radius of a cell was about 500 m, and all of the cell data was spread over a 20 km zone. In Fig. 4, the cost comparison result of each model is shown. According to the test results, the main cost of the LT is on the server side. On the server side, geometrical object comparisons that detect trigger events in addition to the management of a large number of moving objects and trigger areas cause the bottlenecks of the servers. Therefore, the MLT technology outperforms the server-simple LT in terms of cost.

Table 2. Simulation dataset.

# of moving objects	Distance moved	# of trigger polygons	Cell area
25 - 200	20 km	20 (non-overlapped)	Radius: 500 m Area: 20 km zone

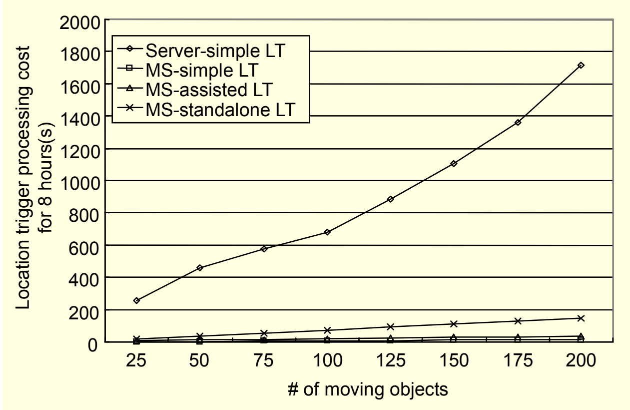

Fig. 4. Cost comparison results for each location trigger model.

V. Conclusion

In this letter, proposed LT technology distributes the LT events detection role to mobile phones and works through a multilevel step triggering method. This MLT has two remarkable advantages. First, in the detection of cell or GPS-based LT events in mobile phones overloading and bottlenecking of location servers can be avoided. Secondly, the power consumption of mobile phones can be reduced by initially detecting cell-based LT events and then detecting GPS-based LT events directly after powering on the GPS device. Thus, the proposed advanced MLT technology if utilized in a mobile phone can enhance the performance of the overall system that allows LTs in distributed mobile environments.

References

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