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TRAVEL TIME INFORMATION SERVICE UTILISING MOBILE PHONE TRACKING

ABSTRACT

This paper discusses the suitability of mobile phone positioning data for travel time information. The Finnish National Road Administration Finnra has carried out a study on the subject (1) and managed pilot installations on two road sections (6) in order to determine the feasibility of mobile phone tracking for traffic monitoring and management purposes. According to the study and the pilots, the mobile phone positioning can provide useful link monitoring data, i. e. the travel time and speed. Mobile phone tracking was found to be a very promising tool for implementing travel time information service to drivers.

KEY WORDS

mobile phone tracking, information service, travel time, travel speed, traffic monitoring and management

1. ABOUT TRAFFIC MONITORING METHODS

The focus area of the nearest future traffic management activities in Finland is provision of the basic traffic management services and implementation of the real-time traffic monitoring system required for these services on the whole main road network. Finnra has estimated that the costs of implementing a conventional traffic monitoring system on the main road network are about 42 million Euro and the annual maintenance costs are about 10 per cent of the investment.

The basic idea discussed in this paper is tracking of cellular telephone equipped vehicles as traffic probes. The task of Finnra's mobile phone tracking study (1) was to identify such positioning methods of existing telephones, that could provide accurate data for traffic management services, be easily expanded to the entire main road network, and that would not compromise privacy and would be economically feasible.

So far, Finnra alone has been responsible for traffic monitoring. The new techniques, such as mobile telephone tracking, involve more players in providing data. Innovative methods are introduced providing hopefully also lower costs of service and freedom of choice to the users. Private operators, on the other hand, get a new market area for their services.

Various positioning methods including both satellite based and several cellular telephone based methods were studied. Their accuracy, coverage, suitability

	Time table	Typical accuracy (rural), m	Typical accuracy (city), m	Coverage	Suitability for mass-location	Dependability from operator	Initial cost	Usage cost	Standardisation
Cell ID	available	2000-8000	200-1000	excellent	excellent	small	small	small	yes
Signal level	available	500-3000	100 - 500	moderate	moderate	small	small	small	no
Correlation (DCM)	2-3 years?	250-1500	50 - 200	moderate	moderate	small	moderate	moderate	no
Time difference	2-3 years?	200-1000	100 - 200	moderate	low	high	high	high	yes
GPS		10-30	30 - 100	good	low	none	none	none	yes
A-GPS	2-3 years?	10-30	30 - 100	good +	low	high	high	moderate	yes

Figure 1 - Comparison of various positioning technologies

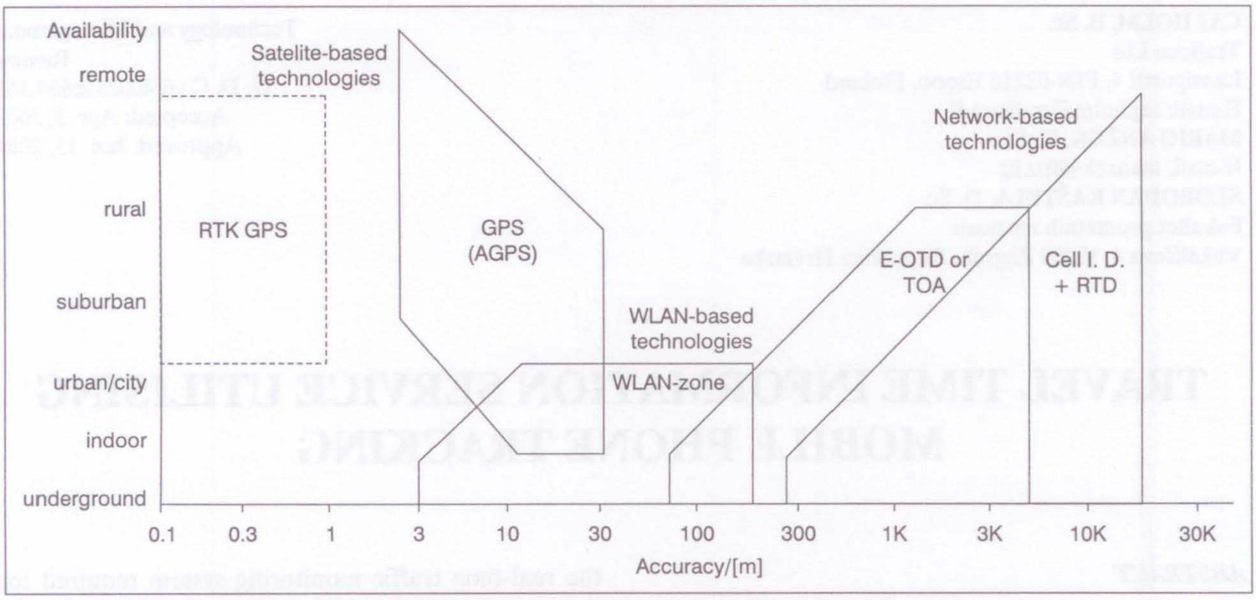

Figure 2 - Comparison of various positioning technologies

for mass positioning, operator dependability, initial and operational costs and standardisation level were assessed. The near future development, the possibilities offered by new techniques and privacy and legal aspects were also studied. The focus of this paper, however, is not to discuss the technologies but rather to give only an overview of the comparison of the technologies which are presented in Figures 1 and 2 (2 and 3).

2. THE USE OF MOBILE PHONE TRACKING FOR TRAFFIC MANAGEMENT

The second phase of the study defined the requirements for the monitoring data in various operational environments and for various traffic management services. The available methods enable observation of the passage of a telephone, observation of the passage time and putting an identifier (session-ID) on it in order to observe when the same device passes another point that is of interest for the monitoring task. A passage means that the device enters an observation area, the size of which varies from several tens of square kilometres (cell-ID method in rural areas) to a few hundred square metres (GPS).

According to the study, the mobile phone positioning can provide useful link monitoring data for information about the travel time and speed. The required basic data, passage of a vehicle (actually a mobile telephone) and the passage time can be reliably recorded. This data can be utilised both for individual links and for wider road or street networks taking into consideration the accuracy requirements of various operational environments.

Some potential obstacles for link monitoring were also identified. Actually, the movements of telephones, not vehicles are monitored. Various types of vehicles have typically different numbers of active mobile hand-sets onboard: a car may have only one hand-set while a bus may have dozens on board. In some cases the main roads that should be monitored and secondary roads, or even a main road and a railway run parallel for tens of kilometres. Mobile telephone tracking could in such cases monitor the whole transport corridor instead of the desired road. It was assumed that in networks, the telephones could quite easily be switching back and forth between two or even more cells.

Mobile phone tracking was not expected to be useful for point measuring. It could provide information about the passing phone and the passing time. However, there is no method for such a vehicle classification, speed measuring, etc. It would also not give traffic volumes at a measuring point but the volume of passing telephones. Mobile telephone tracking was in brief estimated not to be useful for point measuring. Another assumption was that incident detection making use of mobile telephone tracking would be a difficult task. It would most probably require development of new types of parameters, for instance a sudden accumulation of mobile phones, and their interpretation algorithms. Also, other questions should be solved, such as detecting on which carriageway on a dual carriageway road the incident is.

The main conclusion of the study is that the data gathered by mobile telephone tracking is most suitable for information about traffic fluency, traffic flows on a link and travel time, and information about road maintenance works. The travel time and average speed between two points can be calculated. The movement of road maintenance vehicles and other special vehicles can be monitored and corresponding information given to drivers.

3. PILOT INSTALLATIONS AND THEIR INITIAL RESULTS

Finnra has set up two pilot installations of providing monitoring data for travel time information service making use of mobile phone tracking. It was assumed that there were quite many open factors regarding the positioning technologies and their applications. The telecommunication operators could have had various new solutions available for such a service but for confidentiality reasons they did not provide the information. Finnra proceeded through tenders and detailed negotiations with the operators to implement the two pilots. The invitation to tender defined the quality requirements for travel time data but no exact method to produce these. Another basic requirement was that the pilot was not to violate the road users' privacy.

The chosen pilot sites gave the possibility for comparison between the two existing license plate recognition pilot systems installed on the same road sections in 1999. In tests, both license plate recognition systems were found to be effective and give correct travel time estimations (4). The latter of them was successfully used by Finnra Häme Region to give drivers travel time information making use of VMS displays.

According to first results of the pilots, mobile telephone tracking was a very promising solution for travel time monitoring. The measured travel times were generally very close to those achieved by license plate recognition. No needs for modifications of the GSM-network were identified. Finnra started together with VTT a thorough evaluation that was completed last November (6).

The pilots made use as probes of all the mobile phones that were switched on in the area. Using anonymous session-IDs protected privacy of the owner. The positioning was done when a telephone switched from one cell to another but only certain points were monitored, three points on the Ring Road I and four points on Highway 4. The data was collected in one-minute intervals. Figures 3 and 4 show results of both the mobile phone tracking and license plate recognition systems on the same links on Highway 4 (Figure 3) and Ring I (Figure 4).

The pilot study showed the advantages and the disadvantages of the system. A significant advantage is the capability to produce travel time observations regardless of the predominant traffic situation or the environmental circumstances. Figure 5 shows the difference in observations between licence plate recognition and mobile phone tracking in bad weather.

Because of the large amount of observations, the traffic situation could be interpreted easily and the statistical variances and parameters based on travel times calculated and estimated reliably. The major disadvantages of the system are related to travel time observations that do not come from the monitored road or come from the same vehicle. Observations from parallel roads, phones onboard public transport vehicles, bicycles or pedestrians can affect the calculated statistical parameters.

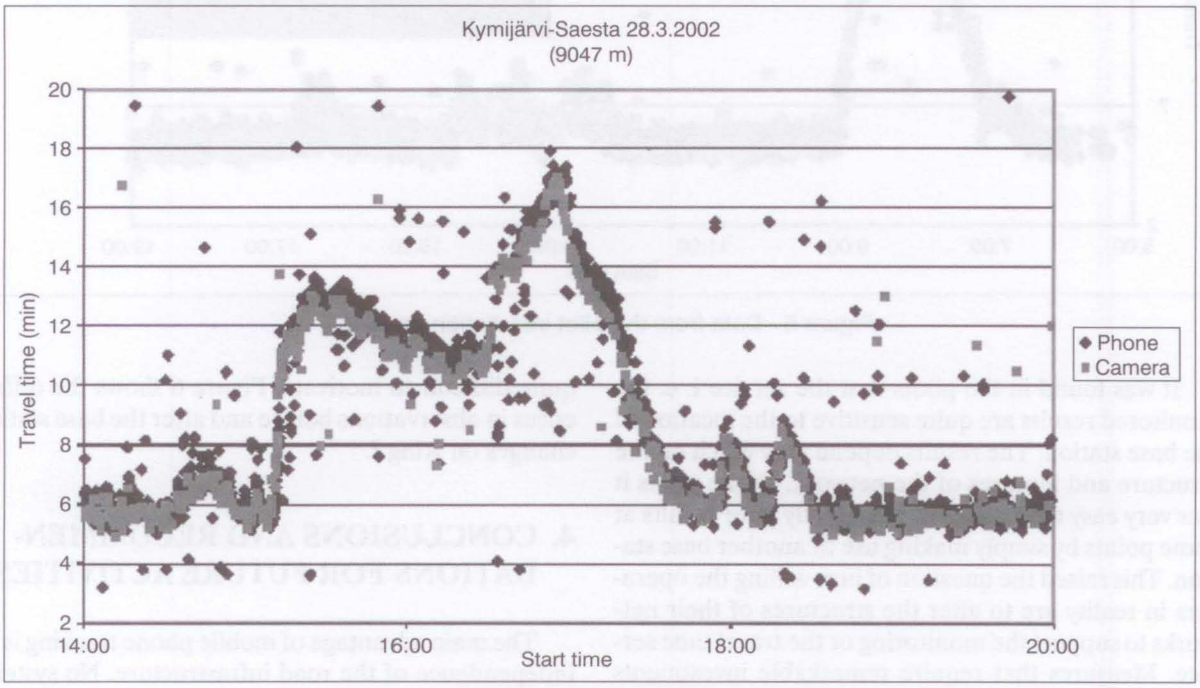

Figure 3 - Data from the pilot installation on Highway 4

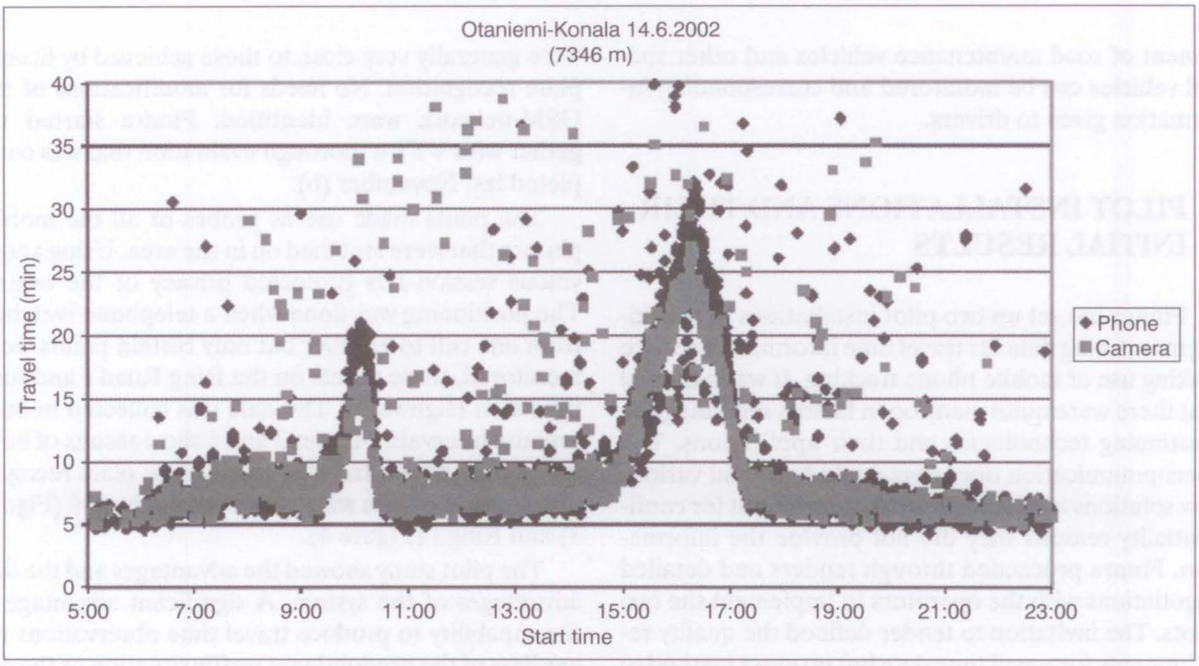

Figure 4 - Data from the pilot installation on Ring I

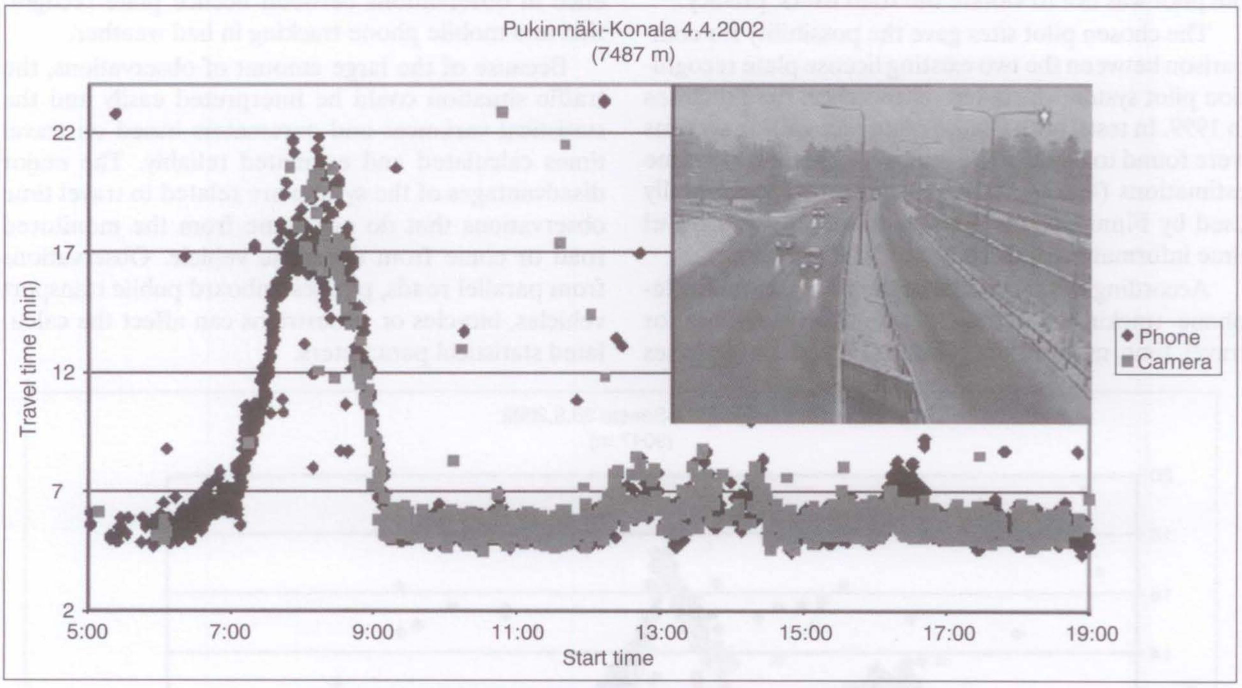

Figure 5 - Data from the pilot installation on Ring I

It was found in the pilots that the service i. e. the monitored results are quite sensitive to the location of the base station. The results depend very much on the structure and features of the network. In the pilots it was very easy to improve the originally poor results at some points by simply making use of another base station. This raised the question of how willing the operators in reality are to alter the structures of their networks to support the monitoring or the travel time service. Measures that require remarkable investments or endanger the main function of the network may be quite difficult to motivate. Figure 6 shows the differences in observations before and after the base station changes on Ring I.

4. CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE ACTIVITIES

The main advantage of mobile phone tracking is its independence of the road infrastructure. No systems or data connections are necessary in the road network.

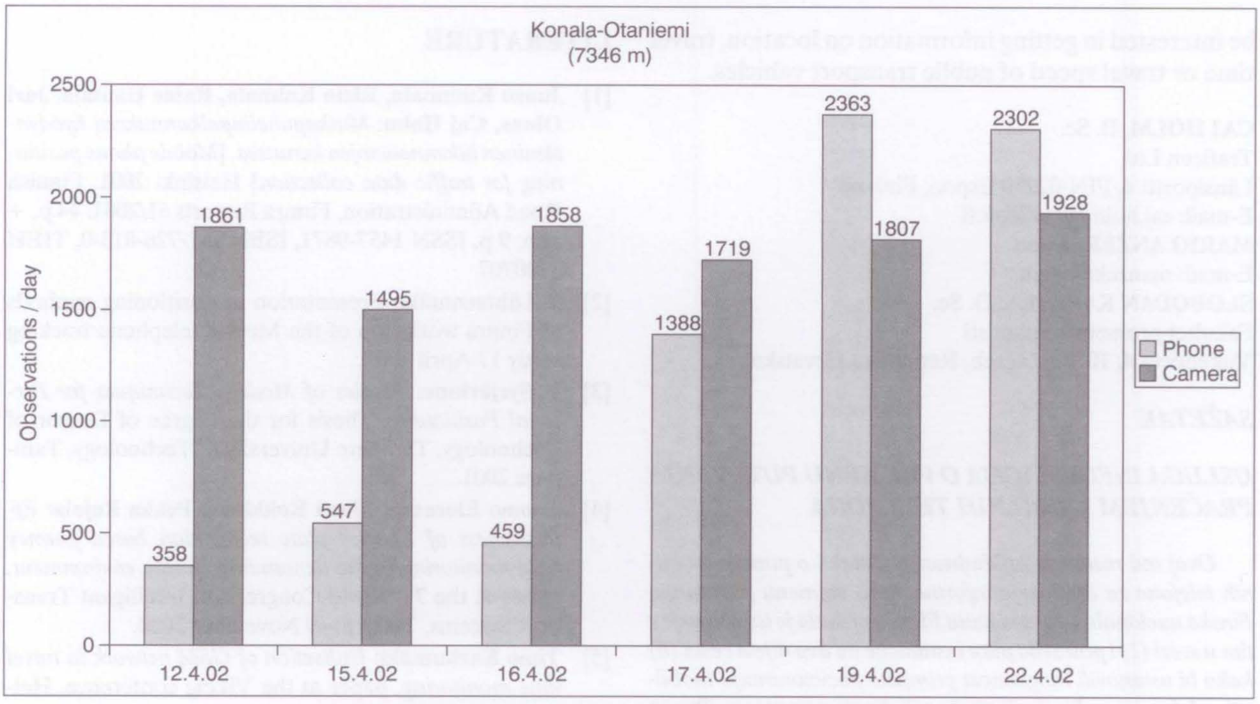

Figure 6 - Number of observations before and after base station changes

The operation and maintenance costs are low and, for instance, altering the monitoring link in the data and transmission networks is easy. The only limitation for alterations is the system's connection to the structure of the cellular network and the location of the observation point.

Another advantage is the high number of observations. These enable, for instance, easy detection and interpretation of variations in the traffic flow. The calculation of statistic variances is possible due to the large number of observations and travel time parameters can be more reliably calculated. On the other hand, the high number of observations results also in the drawbacks of the system. Telephones that are not on the monitored road but, for instance on a parallel road, on a bicycle road or public transport vehicles may distort the results. In the pilot phase, for example, the employed method could not distinguish phones onboard public transport vehicles. In some cases the travel times of PT vehicles differed from other traffic and affected the calculations.

The possibilities to extend the system to cover the whole trunk road network cannot be clearly estimated. In principle, the system could be used wherever the cellular network exists. However, the present location of the base stations is not always optimal for traffic monitoring purposes. At some locations, because of the structure of the cellular network, it might be necessary to cut the accuracy demands or change the optimal length of observation links or even modify the cellular network. However, the independence of the road infrastructure allows the road authorities to expand and/or move the observation link easily. The travel time service could be used also for network monitoring. This could enable the monitoring of roads as a network, not only as links e. g. tracking the merging and the exiting vehicles.

The pilot study showed that from the technical standpoint, expanding the system is reasonable, depending of course on the pricing of the production version. Possible new monitoring links must be planned based on the structure of the cellular network and traffic monitoring purposes. It seems that the system is well suited for traffic monitoring of long observation links (about 10 km) on which vehicles leaving or merging with the link or stopping on the link are rare. On such links travel time observations represent the traffic flow well, and the calculated parameters are reliable. Also, in urban settings the system can operate well and the results can be satisfying, as shown by the pilot on Ring Road I. The advantage of the system in urban areas is the large amount of observations, but on the other hand, the observations not belonging to the monitored road increase. The tested method allows observation links of at least approximately 2-3 kilometres in urban areas.

As follow-up it would be important to test and estimate the performance of the system on short observation links. It would also be interesting to study whether the travel time service could be used for traffic forecast purposes, or if the observations at the base station could be used as input for prediction models. The possibilities of selecting observations coming from parallel roads or from public transport should also be studied. Sorting would make the calculated parameters more reliable. Public transport operators might also be interested in getting information on location, travel time or travel speed of public transport vehicles.

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SAŽETAK

USLUGA INFORMACIJA O VREMENU PUTOVANJA PRAĆENJEM MOBILNIH TELEFONA

Ovaj rad razmatra prikladnost podataka o poziciji mobilnih telefona za dobivanje informacija o vremenu putovanja. Finska nacionalna uprava cesta Finnra provela je istraživanje s tim u svezi (1) i postavila pilot instalacije na dva dijela cesta (6) kako bi ustanovili mogućnost primjene pozicioniranja mobilnih telefona u svrhu praćenja i upravljanja prometom. Prema provedenom istraživanju i pilot instalacijama, pozicioniranje mobilnih telefona može dati korisne podatke praćenja tj. vrijeme i brzinu putovanja. Ustanovljeno je da je praćenje mobilnih telefona vrlo perspektivan alat kojim će se moći provesti usluga informiranja vozača o vremenu putovanja.

KLJUČNE RIJEČI

praćenje mobilnih telefona, služba informacija, vrijeme putovanja, brzina putovanja, praćenje i upravljanje prometom

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