GpsOne: a New Solution to Vehicle Navigation

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Abstract: GpsOne, which fuses GPS and wireless base station positioning signals, is a hybrid wireless assisted GPS technology proposed by Qualcomm Inc. It provides positioning service through wireless communication networks. Compared with GPS, gpsOne is more suitable for vehicle navigation due to its wider workable regions (urban, rural and even underground areas), higher positioning accuracy, lower price and no cold start. However, single gpsOne cannot be used for vehicle navigation due to its large positioning error (more than 100m) when GPS signals cannot be received completely. Therefore, gpsOne should be assisted with other positioning modes to promote the reliability, redundancy and fault-tolerance of vehicle navigation system.

Keywords: gpsOne; vehicle navigation; GPS; ITS

I. INTRODUCTION

With the elimination of Selective Availability (SA) policy and improvement of GPS signal receiving technology, it is possible to apply GPS to vehicle navigation and related research is being boomed. However, "losing satellites" happens easily in the process of GPS signal receiving. That is to say, GPS receivers cannot receive signals from four or more than four satellites for a long time due to the effect of tall buildings and overpasses in cities, coverage of forestation trees and others. Therefore, in the vehicle navigation solutions based on GPS, GPS must be assisted with other positioning modes to provide positioning information with a definite accuracy when less than four GPS satellites' signal can be received. At present, the most widely applied assistant positioning modes are Dead Reckoning (DR) and Map Matching (MM). However, DR cannot provide accurate positioning information for a long term (less than 5 minutes) due to its positioning error that cumulates rapidly with time and MM's ability of error correction is also limited. In applications, vehicles cannot get useful positioning information for a long time frequently, which is one of the main factors that ITS doesn't come into the stage of large-scale application, whereas it is crucial to get real-time positioning information with a definite accuracy for vehicle navigation and ITS. [1-8]

GpsOne is a hybrid positioning technology that combines GPS with base station positioning. Compared with GPS, gpsOne is a new mobile positioning technology with many advantages, such as higher positioning accuracy, higher reliability, no cold start and lower price. This article mainly analyzes the feasibility of substituting GPS with gpsOne in vehicle navigation to grope for a new solution to vehicle navigation.

This article first briefs the principle of gpsOne and mainly analyzes the outstanding advantages of gpsOne. Then the feasibility of applying gpsOne to vehicle navigation is discussed in detail after making references to the demands of vehicle navigation.

II. PRINCIPLE OF GPONE

GpsOne is a new positioning technology that combines GPS and wireless communication positioning technology proposed by Qualcomm. GpsOne sends GPS positioning information received by mobile terminal and time information between the terminal and base stations to positioning center. Positioning center uses the information and related reference information to calculate the terminal's position information that will be sent to terminal through communication networks. GpsOne's structure and working principle are illustrated in Fig.1 and 2 respectively. [9-10]

The following work should be carried out on the client and the server respectively to implement gpsOne positioning:

(1) Communication module with gpsOne function should be

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installed on the client and the module includes Qualcomm's MSM5100 chip or MSM5500 chip with both communication function and gpsOne positioning one.

(2) Related positioning software developed by Snap Track, which is Qualcomm's subsidiary, should be installed on the server (positioning center) to fuse and filter positioning information.

Since there is no more change of communication networks except for the two alterations above, gpsOne can be implemented on the existing communication networks easily.

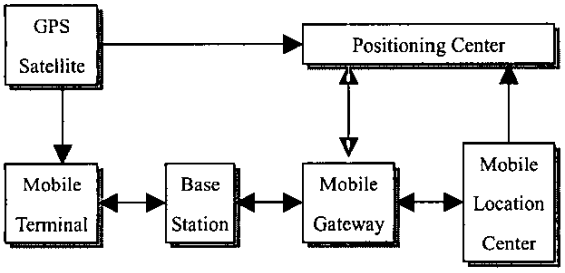

Fig.1 Structure of gpsOne

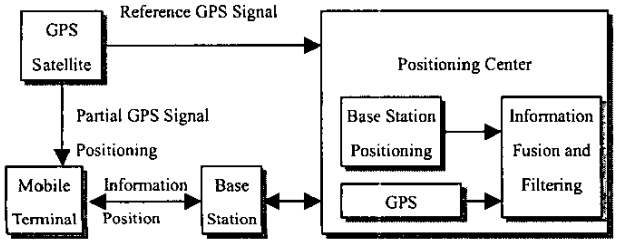

Fig 2 Working Principle of gpsOne

III. ADVANTAGES OF GPSONE

Compared with GPS, gpsOne has following outstanding advantages:

(1) The number of satellites observed is not the prerequisite condition of positioning.

GpsOne is a hybrid positioning technology that deeply integrates GPS and base station positioning. When four or more than four satellites can be observed, GPS is relied on to provide high-accuracy positioning information. When less than four satellites are observed, GPS signals are integrated with base station positioning information to calculate positioning information successfully, but positioning accuracy will be reduced with the number reduction of GPS satellites observed, which results from multi-path effect and other factors of base station positioning. Therefore, when there is no GPS satellite observed at all, gpsOne can only rely on base station positioning to provide positioning information, but the positioning accuracy is poorest now.

With the elimination of Selective Availability (SA) policy and improvement of base station positioning, gpsOne's positioning error has been reduced greatly. It has been reported that gpsOne's positioning accuracy can be 5-10m with a better receiving of GPS (4 or more than 4 GPS satellites observed) and 10-20m with a worse receiving (less than 4 GPS satellites observed). Nevertheless, positioning accuracy in application may be lower than that of Qualcomm's testing results for the difference of communication network condition or testing method, but the order of accuracy should be almost the same. Moreover, even though the positioning error will increase a little when GPS signals cannot be received well, but the error will not cumulate with time. It means that in despite of the large positioning error, MM can reduce the error further to satisfy the demands of vehicle navigation. Compensation of DR's error that cumulates with time is limited and it cannot satisfy the demands of vehicle navigation with time. Therefore, the terminals with gpsOne can obtain positioning information with a definite accuracy even in the place where GPS signals cannot be received completely, such as a long tunnel, and the positioning information is useful. This is one of the most outstanding advantages of gpsOne.

(2) GpsOne is more sensitive to GPS signal.

When the GPS signal is weak (because of the attenuation by the shade of foliage), GPS receivers need extend the integral time to obtain the whole positioning information. However, gpsOne can know partial contents of GPS signal (such as time information) through base station and shorten the integral time, that is, the sensitivity to GPS signal is enhanced. Qualcomm says that gpsOne can receive (–156dB) GPS signal, while common GPS can only receive more than (–136dB) GPS signal. [10-11]

It means that the influence of foliage and other obstacles on gpsOne is less than that on common GPS receivers. To improve the probability of receiving GPS signal for gpsOne successfully means to increase the ability of providing high-accuracy positioning information with a higher probability, which is of significance to vehicle terminal

positioning.

(3) Positioning is quick.

Because gpsOne knows time information of GPS signal, it can position without receiving the whole information of GPS signal. Moreover, base station can help gpsOne terminal obtaining the phase of GPS signal and other related reference information, so gpsOne can reduce the searching window width of GPS signal and shorten the receiving time.

Receiving only part of GPS signal and reducing the searching window width are helpful to shorten the receiving time of GPS signal and accelerate gpsOne's positioning. For example, the cold start time of gpsOne is less than 6 seconds, while that of common GPS receiver is commonly several minutes or even longer.

Quick positioning is propitious to increase the success rate of positioning and decrease the power consumption of positioning, which gives the convenience for users.

(4) Real-time positioning.

GpsOne's position information is sent to terminals by wireless communication networks, so the terminals' position information updated is real-time. However, refreshing frequency of GPS signals is commonly 1Hz, 4Hz and 10Hz. Additionally, with the increase of refreshing frequency, the price of GPS receiver will increase sharply, so the refreshing frequency of GPS receivers applied in vehicle or other civil fields typically is 1Hz.

(5) Low cost.

GpsOne deeply integrates GPS receiving module into the communication board and many of its chips can be shared with communication module, so the additional cost due to gpsOne is only 2-3 dollars, which is much cheaper than common GPS module.

(6) Small volume.

Since gpsOne is integrated into communication module, the volume added by gpsOne can be almost ignored, which makes for the miniaturization of vehicle terminal. At the same time, vehicle terminal also needs communication module to communicate with traffic platform or other terminals. Thus using a communication module with gpsOne can implement positioning and communication functions simultaneously.

IV. THE DEMANDS OF VEHICLE NAVIGATION

A. Positioning Accurancy

Real-time positioning information with a definite accuracy is the basis of vehicle navigation. Positioning information with large error easily leads to mistake of navigation and becomes valueless for ITS. However, too high positioning accuracy is also not practical. The reason is that high positioning accuracy means high cost of positioning, which will finally induce the price of vehicle positioning module too high to have market. Therefore, there is a balance between positioning accuracy and price.

Positioning accuracy for vehicle navigation is associated with the precision of in-vehicle electronic maps, road conditions and road information. Currently the error of electronic maps for vehicle navigation is about 1m and the standard width of arterial roads in China is between 22.5m and 25m (take arterial roads as example, other roads correspond with their grades) [11]. The accuracy of positioning module should be better than 20-25m. Otherwise, too small distance between two roads (less than 50m) may lead to a positioning error. For example, the position is displayed on one road while the car is actually running on another road. The reason is that Map Matching (MM) is usually used to improve positioning accuracy and the default condition in MM algorithm is that vehicles must ride on roads. However, if positioning information is shown in non-road zones, there must be positioning error. Then MM algorithm will be started to correct the positioning information onto roads according to definite rules. If the positioning error is too large, the mistake that vehicle running on one road is located on another road will happen easily and enlarge the positioning error actually.

In addition, if the driving direction of vehicles needs to be distinguished, positioning accuracy should be improved further, for example, superior to 10-15m.

B. Reliability

Positioning module needs not only to provide positioning information with a definite accuracy, but also to work with a high reliability under certain working conditions. In a sense, reliability of positioning module is more important. Therefore, attention should be paid to the reliability of positioning module under the definite working conditions. The working conditions here include working temperature, vibration and shock, affects of environmental electromagnetic fields and

maximum riding speed, etc.

Similarly the improvement of reliability is at the expense of increasing cost, so there is also a balance between reliability and cost.

C. Volume

If the positioning module is too large, it is difficult to install it in the narrow inside space of vehicle. Therefore, the miniaturization of positioning module is one of the aims for vehicle terminal design.

D. Price

Vehicle terminals are products for market. Therefore except that the technical parameters should meet the requirements, price; one of the important economic factors is emphasized.

As a part of vehicle terminal, price of positioning module should also be considered. Positioning module is composed with hardware and software. With a given positioning accuracy, hardware costs will be decreased by using chips with higher performance price ratio and developing costs will be reduced by optimizing positioning algorithm and reducing the complexity of software.

Besides costs of the products themselves, their additional costs due to management and circulation should also be reduced.

V. THE FEASIBILITY OF VEHICLE NAVIGATION BASED ON GPSONE

Compared with GPS, gpsOne has many advantages, so it is possible to substitute GPS with gpsOne in vehicle navigation. Then requirements for vehicle positioning are referred to analyze the feasibility of vehicle navigation based on gpsOne.

A. Positioning Accurancy

The positioning error required by vehicle navigation is less than 20-25m normally, and 10-15m for special application (for example to distinguish driving directions). GpsOne's error will be 5-10m when 4 or more GPS satellites can be received and 10-20m when less than 4 GPS satellites can be received. Therefore, GpsOne completely meets the requirements of vehicle navigation in positioning accuracy.

B. Reliability

As mentioned above, reliability is more important than positioning accuracy in a sense. GpsOne's reliability is higher than GPS's. The reasons are as follows:

(1) GpsOne receives GPS signals more easily.

As gpsOne is more sensitive to GPS signals and can receive GPS signals above -156dB, the probability of successfully receiving GPS signals for terminals is increased, and the effect of shade of leaves is weakened and the probability of losing GPS satellites is decreased.

(2) Time of gpsOne's tracking GPS satellites is shortened.

GpsOne only need to receive a part of GPS codes, which can shorten the tracking time for GPS satellites and increase the success of receiving GPS signals.

(3) No cold start.

GpsOne's cold start time is less than 6 seconds.

Although gpsOne is more suitable for vehicle navigation than GPS, as a vehicle navigation solution, single gpsOne still needs to improve its reliability further and the main reasons are as follows:

(1) GpsOne positioning mainly depends on base stations.

GpsOne is a hybrid positioning manner, which combines GPS and base station positioning, but the main factor deciding whether positioning can be implemented or not is the latter. Firstly, gpsOne sends the position information calculated by positioning center through base stations, so mobile terminal cannot get the position information in blind areas of base station coverage. Secondly, many advantages of gpsOne like no cold start and higher sensitivity to GPS signals are mainly due to the existence of base stations. Thirdly, base station positioning is also the important part of gpsOne. Therefore, gpsOne positioning needs a wide coverage of base stations and seamless coverage is ideal.

At present, the coverage rate of base stations in cities is very high while in rural areas it's relatively low, so gpsOne's application in rural areas depends on the improved coverage of base stations. In addition, there are still some blind areas of base station coverage in cities, which reduce the reliability of gpsOne to some extent.

(2) Single gpsOne lack of reliability.

GpsOne's positioning error is large (larger than 100m in the worst condition) when it cannot receive any GPS signals totally. For instance, when a vehicle is running form a broad way into a tunnel, its positioning accuracy will reduce rapidly from a high level (less than 15m) and there is no buffer

process, which will lead to mistaken navigation for the vehicle. Furthermore, when a malfunction happens to gpsOne, the terminal cannot obtain positioning information because there is no backup positioning systems. Therefore, the reliability of gpsOne need to be improved.

C. Volume

GpsOne is integrated into communication module, which is a kind of deep combination and the communication module is also necessary for vehicle terminals. The additional volume due to gpsOne is nearly ignored, which makes for terminals' miniaturization. From this point, gpsOne is totally suitable for vehicle terminals.

D. Price

The cost of positioning is due to hardware, software and network upgrade and service. The additional hardware cost introduced by gpsOne is about 2-3 dollars. Communication service providers share the cost of positioning software installed in positioning center. Communication networks in existence can provide gpsOne positioning without being altered, namely no additional cost for alternation, while service cost is not too much for large-scale application.

Therefore, gpsOne is suitable for large-scale application due to its low cost.

E. Others

Qualcomm owns gpsOne technology now and only this company has developed related chips based on the technology, so artificial factors and security problem may appear in the coming large-scale application. With the development of technology and devotion of other companies (including companies in China), similar technology and substitutes will come forth, so the problem should be paid attention to, but it's not a fundamental one.

From the analyses above, except that the reliability of gpsOne should be improved further and monopolization of the technology needs to be eliminated, other characteristics of gpsOne are suitable for vehicle navigation.

However, single gpsOne is not appropriate for vehicle navigation due to its lack of reliability. To improve its reliability, gpsOne needs to be integrated with other positioning modes to reduce the influence of base station blind coverage on vehicle positioning and increase the fault-tolerance and redundancy of positioning module. Further research and testing are needed to settle the integration mode in detail.

CONCLUSIONS

At present, gpsOne function can only be applied in CDMA networks and China Unicom has opened gpsOne services in all the provincial capital cities and some other central cities. With the expansion of China Unicom's network coverage area, gpsOne service will be implemented in China in the near future. In addition, Qualcomm is devoting to applying gpsOne technology into other wireless communication networks including GSM and GPRS. Moreover, more and more families will have cars with the development of Chinese economy and Beijing and Shanghai will host the 2008 Olympics and the 2010 Expos respectively. In order to relieve the traffic jam, provide convenience for citizens' outing and minimize the affect of large activities such as the Olympic Games to the normal running of national economy, it is imperative to develop ITS and its related services and the market also have much potential. Therefore with the enlargement of markets, related network service provider will provide gpsOne service sooner or later, which will further enlarge gpsOne's application.

From the aspects of positioning accuracy, volume, price and application convenience, gpsOne is better than GPS and more suitable for vehicle navigation. Although gpsOne's reliability needs to be improved further, the optimal filtering and integration with other positioning modes can implement it.

Dr. Wang Kedong, a postdoctor at Beijing Key Laboratory of Spatial Information Integration and Its Application, received his BS and MS degrees from Northeastern University of China in 1996 and 1999 respectively. He received his PhD from Tsinghua University in 2003. His research interests are navigation and control, GPS application and ITS.

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