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SATELLITE TECHNOLOGY FOR ADVANCED RAILWAY SIGNALLING

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ABSTRACT

Global Navigation Planet Systems (GNSS) can be used for various farming lotion, especially for safety-related applications such as gear train localization and gondola localization for the purpose of control. Although a significant sum of money of wholeness assessment has been done in the discipline of zephyr traffic control, integrity or reliability studies related to train and car applications have generally not been done to date. The most difficult factor in land applications of GNSS is multipath wrong doing. It is known that GNSS signalling may be reflected by buildings, rampart, vehicles, and the ground. These reflected sign can interfere with reception of the signal coming directly from the satellites, a phenomenon known as multipath. To use GNSS based berth for these types of safe applications, not only positioning entropy but also reliability selective information have to be implemented. Therefore we need to evaluate the real number multipath error for the future reliability evaluation. In this study, we analyzed raw GNSS information obtained in a real railroad line condition to demonstrate the truth of GNSS. These answer s will be very important for proposing a better positioning algorithm and for railway reliability idea First, we evaluated the accuracy to establish the GNSS position computer error under real railway lines based on precise character place . Furthermore, to improve the accuracy of these data, several method acting including signal strength check, impostor -range check by Doppler frequency, and data showing by using the true distance between two antennae, were proposed. As a result, it was confirmed that large errors and jumps were greatly reduced. For example, the percentage of large horizontal error over 5 m was reduced approximately 66% by using our proposed multipath spotting techniques.
Keywords: GNSS (Global navigation planet system, IMU(Internal measurement unit), RTRI(Railway technical research institute),MPTCP(Multipath Transmission control protocol),PLMN(Public land mobilenetwork).

1. INTRODUCTION:

Rail is a vital service to global soceity and the transport backbone of sustainable economy. It has an unprecedented opportunity to achieve the sustainability which is required for the twenty first century. By this Rail will be able to respond to the expected growth in transport demand, both passenger and freight. In this study, we analyzed raw GNSS information obtained in a real railroad line condition to demonstrate the truth of GNSS. These answers will be very important for proposing a better positioning algorithm and for railway reliability idea. GNSS data were derived from a large number of test runs of more than deuce 2,000 kilo meter along several railway lines in the field of the West Japan Railway system Companionship in Japan. First, we evaluated the accuracy to establish the GNSS position computer error under real railway lines based on precise character place. The precise reference billet were prepared using local RTK-GNSS fixed positions, GNSS velocity , IMU , and a speed sensor equipped on the train. We analysed the temporal multipath errors for each satellite to show the error distribution. Furthermore, to improve the accuracy of these data, several method acting including signal strength check, impostor -range check by Doppler frequency, and data showing by using the true distance between two antennae, were proposed. As a result, it was confirmed that large errors and jumps were greatly reduced. For example, the percentage of large horizontal error over 5 m was reduced approximately 66% by using our proposed multipath spotting techniques.

In this study, we analyzed raw GNSS information obtained in a real railroad line condition to demonstrate the truth of GNSS. These answer s will be very important for proposing a better positioning algorithm and for railway reliability idea. GNSS data were derived from a large number of test runs of more than deuce, 2000 kilo meter along several railway lines in the field of the West Japan Railway system Companionship in Japan. First, we evaluated the accuracy to establish the GNSS position computer error under real railway lines based on precise character place. The precise reference billet were prepared using local RTK-GNSS fixed positions, GNSS velocity , IMU , and a speed sensor equipped on the train. We analysed Show the error distribution.

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Furthermore, to improve the accuracy of these data, several method acting including signal strength check, impostor -range check by Doppler frequency, and data showing by using the true distance between two antennae, were proposed. As a result, it was confirmed that large errors and jumps were greatly reduced. For example, the percentage of large horizontal error over 5 m was reduced approximately 66% by using our proposed multipath spotting techniques. Approximately 66% by using our proposed multipath detective work proficiency. The contents of this paper are mostly based on the following technical foul report at railway technical research institute (RTRI).

2. THE SATELLITE BANDS

Utilization of subjective radio standards with satellite frameworks requires incorporation of both earthbound and satellite stations. Channel models upon the recurrence band (and additionally data transfer capacity), height edges, and the client situations. Recurrence portions for FSS, MSS, and BSS are appeared in Table I for uplink (UL) and downlink (DL) frequencies.

Table.1: Run of the mill recurrence band distribution for FSS, MSS and BSS.

Service type	Freq. bands for UL/DL	Usual terminology
Fixed satellite services (FSS)	6/4 GHz 8/7 GHz 14/12-11 GHz 30/20 GHz 50/40 GHz	C band X band Ku band Ka band V band
Mobile satellite services (MSS)	1.6/1.5 GHz 2/2.2 GHz 30/20 GHz	L band S band Ka band
Broadcasting satellite services (BSS)	2/2.2 GHz 12 GHz 2.6/2.5 GHz	S band Ku band S band

The data link is assumed melody -of-sight for the FSS system and for the service between the terrestrial gateway and the satellite both in the MSS and in the BSS systems where higher absolute frequency are applied. Shadowing due to the block consequence by Tree and buildings and multipath fading should be considered for L- and S-set applied in the MSS and BSS (e.g. DVB-SH), especially when the terrestrial component between the gateway and the receiving device is considered.

The attenuation caused by the precipitation, e.g. rain and clouds, in the troposphere is neglected if the applied frequency is lower than X band but the attenuation is strong in Ku, Ka, and V bands. FSS signal is affected also by troposphere scintillation. It is observed as rapid variations of the signal strength which results from small-scale fluctuations in air density usually related to temperature gradients. The effect is greatest at small elevation angles. Thus, the characteristics of the satellite bands and channel models are clearly different than in the popular TV band (from 54 to 862 MHz) that has been considered for CR operation.

Federal Communications Commission has adopted principle that allow unlicensed radio set receiver transmitters to operate in the broadcast TV spectrum at locating where the spectrum is not used by licensed services. Idiot box dance or chestra twist cannot be used exactly the same way in the artificial satellite ring. All the restrictions including time and transmission power limitation are designed for the TV band cognitive mathematical operation with terrestrial radio towers and rather low newsboy absolute frequency. In order to be used for satellite band operation, very thorough analysis and redesign are needed. Satellite footmark, locations of earth place, used frequency bands, satellite field , mobility of receivers etc. all have an impact that need to be considered before rules for satellite band operation can be solidifying.

3. INTRODUCTION TO MPTCP

MPTCP is a set of extension communications protocol to habitue TCP, which provides a Multipath TCP service, enabling a transport connecter via multiple course simultaneously. Use of MPTCP does not require modifications at application layer. In fact , from the application degree of view, the connection appears as if it were based on one bingle link , since, as shown in Fig.1, MPTCP MBD the additional MPTCP layer between the

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application and TCP layers. Although the MPTCP exposes to practical application a standard TCP interfaces, it brand use of several TCP connections, corresponding to different IP and physical interfaces, by dynamically airing the outgoing flow into sub flows and then, reassembling them at the receiver side. With this characteristic, MPTCP can provide a deep consolidation over existing engineering as 2G, 3G, LTE, Wi MAX, WiFi and Orbiter networks with few investment funds and modifications. Thanks to MPTCP intrinsic lineament, such as independence from operating system and transmission technology , MPTCP based computer architecture can easily integrate multiple new technologies.

4. PROPOSED ARCHITECTRUE

To guarantee the high availability of the communication subsystem required by current wagon train dominance standards, maximize the usage of radio resources and reduce the operational expenditure, both QoS guaranteed connectedness and best crusade links are employed in the proposed architecture. The QoS link is provided by the satellite net , meanwhile, the best endeavor links are provided by PLMNs operated by diverse hustler . The integrated architecture is display in Ficus carioca. Both the on board network accessing assemblies and the network assemblies in ascendancy center should be multipath aware. On board terminals are equipped at least with two kinds of network access devices corresponding to the employed radio technologies.

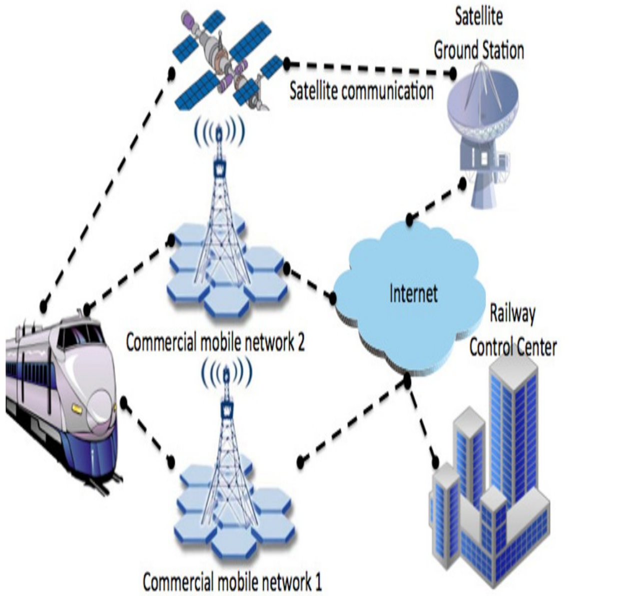

Fig. 1: Stallion architecture of integrated network

While the primary quill benifit of multiplexing user information flow into multiple admission networks is the throughput booster rocket , here we nidus our attention on the capableness of dynamically add and bead subflows, to prevent outage s of the remainder -to-death TCP connection. Let us remark that, adoption of MPTCP reduces the problem of the script over among heterogeneous access networks, into the origination and pearl of subflows on the basis of the status of each access network. Since outage and cost are of primary business organisation, using of the less expensive PLMN subflow is privileged with respect to use of satellite subflows. On the other hand, to reduce outage probability, opportunity of adding or removing a satellite flow is based on both actual link character status of each available PLMN, as well as on its service outage frequency map obtained by historical data (collected and update d daily during normal operation) and the electric current location of the railroad gearing. In fact, since a train is running twenty-four hour period by day on the same data track at the same time , carrying into action of each communication network can be well predicted on the basis of train location at a given time, so that, all the military operation , such as modify priority, associate or remove subflows, and update Information science addresses, can be done before outage appear. To illustrate the logic proposed here for subflows management in train ascendency applications let us consider a typical train journey.

5. Connection Setup and Release Function

In most pillowcase, the string dominance communicating Begin at a railway station, usually served by PLMNs with a QoS compatible with train control requisite. Thus, assuming that the current contact character

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status of a PLMN access meshing exceeded a predefined threshold and the outage hazard estimated from the historical outage oftenness map falls below the uttermost outage probability threshold, setup of the corresponding PLMN subflow is performed. This requires a three Synonyms/Hypernyms (Ordered by Estimated Frequency) of noun time handshake as the regular TCP does, and the exchanging of MPTCP info. Thus, when the first connecter subflow has been apparatus , both the train and the control center can advertise their auxiliary Informatics savoir-faire , and add the other subflows. Meanwhile, the train can decide the precedence for each subflow according to the network calibre , predicted availability (from historical outage frequency map) and the economical issuance . Of course, during the connection, the precedence of subflow(s) can be changed, and the subflow can be closed at any time.

6. Network Resources Management on Different Scenarios

City areas are usually well covered by PLMNs (with different manipulator). Meanwhile, the wagon railroad train generally moves slower in urban center areas than in the countryside or uncultivated land. For these reasons, in the city scenario, the train control communication will be essentially provided by PLMN links. If the cellular bandwidth and the transmission rate are good enough, train can even whirl wide-band connection to passengers.

When the car a van move across region covered by different hustler, the ”vertical handover” first. It can be processed in a seamless way, as described in the following. With reference Figure, communicating between gear train and bunko game trol heart and soul is established at area I, served by the cellular network I. Then the train goes inside the area 2, served by two overlapping networks: 1 and 2. Once quality status for network 2 exceeds the corresponding threshold, the train announces its new IP address to the command centre, then establishes a new subflow. The second subflow is setup after 4 times shake with authentication. In the overlapping area, data packets are delivered over two subflows. The throughput of each subflow is decided by the channel capacity and the network configuration scheduler. Then, the train moves toward the area 3, where the cellular network 1 becomes inactive. Train deletes PLMN 1 from the address list. Interior area 3, payloads are transmitted via PLMN 2 only. Thanks to the multipath transmission, the handover can be executed without breaking the joining.

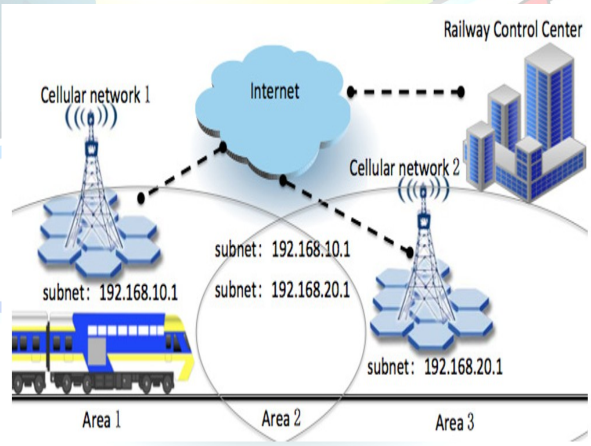

Fig. 2: City scenario with two different cellular web available

7. Assessment of outage carrying into action

In the proposed architecture, based on the adopted logic for adding and dropping subflows and assigning antecedence to them, the communicating is mainly supported by PLMNs, while the satellite network is essentially used as a backup. Unlike the dedicate GSM-R network, along railways areas not served by any PLMN or where the QoS required for successful gear control is not reached for the absolute majority of the time, denoted in the following as PLMN radio set holes, see Libyan Islamic Fighting Group .5. In those radio holes, communication is provided by satellite networks. In order to assess the continuity and availability and reliability of the PLMN service, and compute how many percentage of the communication need to relyon satellite net works, we adopt the methodology presented in for the depth psychology of PLMN outage performance.

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Let li be the clock time interval for the train to cross the ith sphere, served by two PLMNs: namely PLMN 1 and PLMN 2, and let Ttot be the aggregate time of the travel. Then, the overlap percent L is defined as:

$$L = \frac{\sum_{i=1}^{N_l} l_i}{T_{tot}}$$

Let Qi be the prison term interval required for the train to cross the ith tuner holes, and Ttot be the overall time required for a ride, then the outage pct Pout can be expressed as:

$$P_{out} = \frac{\sum_{i=1}^{N_Q} Q_i}{T_{tot}}$$

Let us comment that, here, the outage proportion represents the fraction of fourth dimension in which traffic essentially flows through the orbiter mesh. In practice, for a more accurate evaluation of the use of the satellite channel, one has to take maintenance of the sum of money of traffic generated in the neighbour of the tuner holes, by the proactive vertical handover procedure, as well as by those cases in which the sub flow priority logic still produces satellite flows in country where service can be granted by some PLMN. Therefore, for a more accurate evaluation of the use of the satellite net, we resorted to a Monte Carlo simulation. The result supported here refers to an Italian scenario. In Italy the accessibility of each PLMN, with regard to Edwin Herbert Land insurance coverage, including 2G and 3G, is not worst then 87%, while the handiness of at least one PLMN is 91%. In our computer simulation, the conservative hypothesis of single PLMN handiness match to 85% and overall PLMN availability of ninety % have been adopted. A lot of synthetic substance scenario compliant with this hypothesis is reported in Table 2

Group	Availability of Cellular Network 1	Availability of Cellular Network 2	Overlap Percentage (%)	Average Outage Percentage(%)	Outage Variance (%)
1	85%	85%	80	26.00	3.81
			70	18.25	3.33
			60	10.50	2.86
2	85%	90%	80	23.99	2.65
			70	15.99	2.32
			60	8.00	1.99
3	90%	90%	80	24.00	2.66
			70	15.50	2.32
			60	7.00	1.99

Table.2: Synthetic Scenarios for PLMN Outage Performance Evaluation

8. CONCLUSION

In order to evaluate the performances of the proposed computer architecture, a curing of tests based on both city and harsh environment scenarios has been carried out. A cloud based simulator, where each node has been simulated by a virtual machine has been implemented. Two virtual machines with Ubuntu 14 .04 trey 2bit surgical operation system were installed in Virtual Corner. In each virtual machine, a Multi path TCP capable Linux Kernel (version 3.16) was loaded. Every virtual machine was bunko game figured with three network adapters. Two of them were used to respectively simulate the best effort and the QoS guaranteed route , while the third one was employed to synchronize the virtual motorcar by means of NTP. The traffic was generated by D-ITG (Distributed Net Traffics Generator) . Both inbound and outbound traffic was monitored and recorded through Wire shark. The network surroundings emulator has been written in Python. It allows to dynamically changing the statistics characterizing each link at run time without stopping the simulation.

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