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SHORT RANGE WIRELESS NETWORKS FOR TRANSPORT TELEMATIC SYSTEMS

Using the UN/EDIFACT technologies needs an effective network support A view on short range wireless LAN like Bluetooth piconet, a new UWB Ad-Hoc network and some others is presented. A new application of such type of networks in Supply Chain Management (ECM) and ECR (Efficient Consumer Response) logistic problems is shown. A queuing theory model of cargo tracking system network transactions is given. The necessary parameters of network performance are calculated.

BEZPRZEWODOWE SIECI KRÓTKIEGO ZASIĘGU W SYSTEMACH TELEMATYKI TRANSPORTU

Zastosowanie technologii UN/EDIFACT wymaga efektywnego wsparcia sieciowego. Zaprezentowano przegląd krótkiego zakresu bezprzewodowych sieci LAN typu Bluetooth piconet, nową sieć UWB Ad-Hoc i kilka innych. W referacie zaprezentowano nowe zastosowania tego typu sieci w problemach logistycznych typu Zarządzanie Łańcuchem Dostaw (ECM) oraz Efektywna Reakcja na Klienta (ECR). Podano model teorii kolejkowej operacji sieciowych systemu śledzenia ładunków. Przedstawiono wyniki obliczeń niezbędnych parametrów funkcjonowania sieci.

1.1 WIRELESS NETWORK STRATIFICATION

One of the network classifications is – according to the space sizes division and coverage area. The biggest ones according to this classification are WAN – world area networks, MAN – metropolitan area networks, LAN – local area networks and the smallest one is PAN – personal area networks. For wireless networks the above mentioned classification is true but would be more correct the difference according to the length of one wireless link between two network nodes. In this sense we should speak about long range wireless networks, if the distance is one km and more, medium range – from 100 m up to 1 km, and short range wireless networks where the direct connection between two network nodes might be set at the maximum distance of several tens. Such networks as GSM/GPRS, 3G would be referred to long range. They are the key elements in the transport telematic

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which provide information exchange services between transport units and access to fixed information networks. Such networks equipment has high energy consumption and cost. Short range networks are cheap enough and their terminals could work with no charge for a long period of time. Due to some reasons they are usually used only in offices, storehouses and other buildings. The present paper will show that such networks could be one of the most important key elements in the transport telematic system. Besides that the development of such networks could tremendously influence the appearance of new logistics technologies for Supply Chain Management and Effecient Consumer Response (ECR) tasks.

1.2 WIRELESS NETWORK SERVICES IN TRANSPORT TELEMATIC

Wireless networks are the acceptable solution in the need of information exchange with the terminals of moving transport units. We shall divide two types of information flow of such terminals:

a) information connected with the immediate moving transport unit control,
b) information that is not connected with the immediate moving transport unit control.

The flows of the first type are very critical to the losses and delays and that is why they are built, as a rule, on the base of specially dedicated channels like Digital Short Range Communication (DSRS) orRoad Transport and Traffic Telematics (RTTT) for control and telemetry. In the present paper we shall not take into consideration problems that are connected with such type of flows. Information flows of the second type allow delivery using general assignment networks. The subject of our investigation is the tasks of transport telematic that can be fulfilled only by the means of such information flows. Further on we shall focus on the task of cargo tracking that is transported by the means of different transport systems with repeated transfer. Sometimes this task is treated as a problem of information logistics. It is part of so called e-logistic. It is possible to use our approach to tracking by using United Nations Standard Products and Services Code (UNSPSC) . Let us put it this way. We shall speak about transported cargo as a set, the elements of which are indivisible transported packages. We shall call them atomic unit loads (AUL). Each AUL is unique and can have its own producer, owner and the rout of destination. Let us have several subjects, which have to get the information about the location of some subset AUL chosen at random at some certain regular chosen time periods. These subjects can be AUL owners, ferrymen, insurance companies etc. Further on we shall call these subjects the monitors. Monitors can be geographically remote from AUL location and the routs of their transportation. The aim of Cargo Tracking System building is to organize technical means to deliver information about every AUL condition and location to any monitor, which is authorized to get such information. One of the obvious solutions to this problem is to organize in the Internet a set of Web-sites, which will depict the actual information about every AUL to monitors. Besides that the Internet will be the source for the monitors to the virtual image of some set or even one particular AUL. In this case the most important problem will be automatic AUL information actualization, which should work with certain regularity needed for the monitors. The task of the network creation for AUL information renovation in real time is new and actual and this work is devoted to one of the possible solutions to this problem on the base of short range wireless networks.

We will also touch upon some other non common transport telematic tasks where short range wireless network can play the leading part. These are the systems of transport unit location identification and collision prevention system.

1.3 HIERARCHICAL WIRELESS NETWORK BASICS

The major aim of short range networks usage is to decrease the cost of terminal equipment but providing necessary functionality such as bandwidth. One of the positive side factors is the possibility of terminal localization without using expensive positioning systems (GPS) and essential increase of the number of terminals with common time-frequency resource. But the direct deployment of short range networks with direct connection within one city and more that cover all routs of transport system is impossible neither now nor in the nearest future. That is why the following hierarchical building system is more realistic. Short rang networks equipment is mounted on every AUL and transport unit. Such equipment could also be mounted in storage houses, sale places and cargo transfer places. All the urgent information about cargo and transport units will be concentrated in a mobile database of a transport unit or in a storage or cargo transfer place. A Long range wireless network could be used for the information access from the Internet form Web servers, which are AUL and transport units for monitors. Such network could be GPRS/GSM or 3G network. This way information integration is realized, which is coordinated with natural cargo flows integration. One transport unit is equipped with several AULs and information flows form them will be integrated in one long range network. In this case more expensive equipment GPRS/3G/GPS will be mounted on much fewer objects that the number of AUL. But individual information about every AUL will be given to the WWW.

2. CARGO TRACKING WIRELESS NETWORK BASED SYSTEM ARCHITECTURE

2.1 DATA MODELS AND INFORMATION FLOWS PRESENTATION

Let us think that every AUL has its own description, which contains information about objects packed in it, their producer, current owner, ferryman etc. It could be something like known Serial Sipping Container Code.or United Nations Standard Products and Services Code (UNSPSC). But our new concept is that very important part of the description is URL Web site, which presents this AUL. This description might be presented in XML file or in RDF and stored in a special chip, which contains flash memory and placed on every AUL while being packed as it is usually done now with the help of bar code. This chip contains also short range network terminal scheme, microcontroller and a battery power supply. The diagram that is shown in Fig.1 illustrates the access from monitor to AUL Electronic Identification (EID) file.

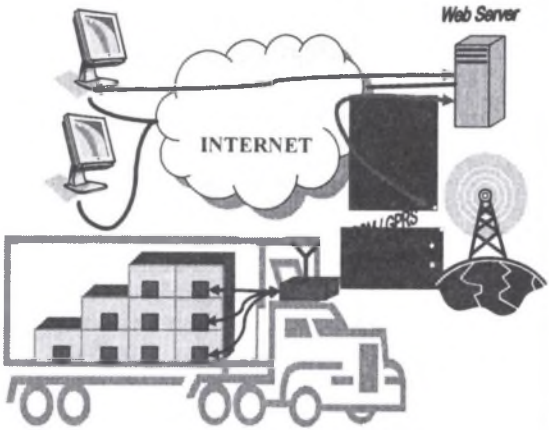

Fig.1. Cargo Tracking System

Transport unit computer initiates information updating in a regular regime, which periodically with a given interval asks all terminals that are in the short range network coverage zone. It reads their EID files, adds into them information about transport unit or cargo terminal, storage etc. It adds information from GPS and packs for further sending through GPRS/3G network to corresponding Web sites, URL of which are given in the file. After every update individual timers for every AUL are on and if there is no updated EID file AUL after previously given for each type of cargo timeout then the process of AUL search is started. In such emergency mode the initiative comes from Web site of AUL representation. A request for EID file of despaired AUL is sent through GPRS/3G network. All terminals of transport units and storage houses generate corresponding requests to associated short range networks, which search in their coverage zones. In this case the possibility of a multihopping Ad-Hoc network organization might be essential. Such network topology in the coverage zone of one long range network terminal is shown in Fig.2.

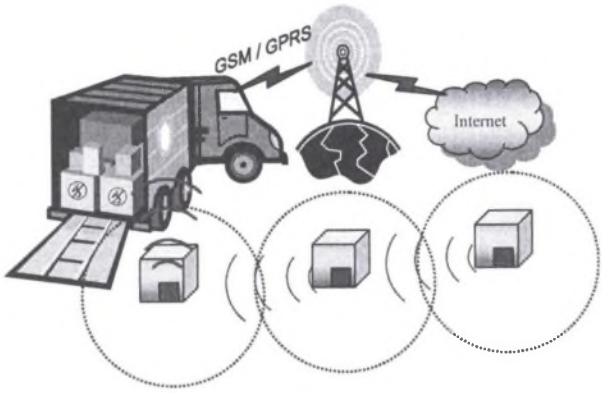

Fig.2. AUL connection by Ad-Hoc network

Ad-Hoc network allows to organize a request retranslating from transport unit terminal to AUL trough a chain of any other short range network terminals. So, the aim of network is EID files search and transmission.

2.2 ORDERED PERFORMANCE ANALYSIS

In this chapter we will present the mathematical model for estimation of required short range network performance and the dependence determination of data volume transmitted through GPRS/3G network on timeout period. Let's have up to N AULs in the coverage area of concentrating terminal (CT). Let's give a time interval at the end of which every AUL will have an attempt to update the information on the Web site that it represents. Let's mark this time interval T. Let the length of EID file be L bites with the consideration of all the expenses. Let assume that the short range network transmits data from AUL terminals through common medium according to some protocol of random multiple access. Ideally the influence of the access protocol can be depicted with the time service increase for each file transmission in k times comparing with file transmission of L bit length. Let the chosen short range network have capacity of W bps monochannel. In this case we can chose queuing theory model G/D/1 as the model of first approach. Time intervals distribution of arrivals can be is random in the interval from 0 up to T/N and the time service is deterministic and equal to $\bar{t} = kL/W$. For the average capacity evaluation let us find the average response time of request (EID file) in network. For the evaluation we shall use the value of the upper Kleinrock boundary [2] in the following type:

$$T \geq \frac{\sigma_a^{\,2} + \sigma_a^{\,2}}{2\bar{t}(1-\rho)}$$

The value of traffic intensity might be given by the following formula:

$$\rho = \frac{kLN}{WT}$$

The calculated average normalized time of network service as the traffic intensity function at the Fig.3 is given.

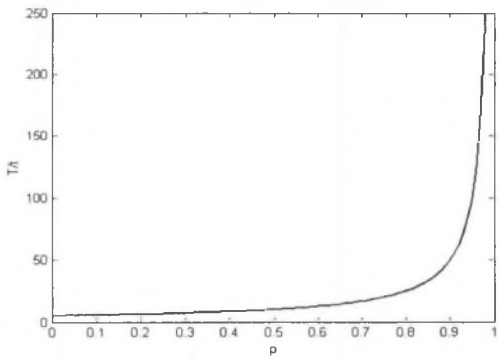

Fig.3. Average normalized time of network service

Let's regard the analysis results for minimum speed determination of information transmission in network, which provide the set timeout for all AUL terminals.

Carrying out the transform and think that AUL number is large enough we will derive transmission file condition at average from each AUL for the period of timeout at least once in the following type: $TW > kLN$

So, for example, using the Bluetooth network with 1Mbps bandwidth and thinking that there are 100000 AULs in coverage area with EID files of 10KB, we will get that the time of timeout can only be not less than 10000 s, which means 3 hours. To shorten timeout we need to increase transmission speed in short range network. It might also be needed while transporting a large number of AULs. It is clear that the above given evaluations are very approximate and many factors have not been taken into consideration. However, these approximations are very useful to make a conclusion about the necessity to use in the set task of short range cargo tracking with high enough speed of information transmission. Otherwise, the period of cargo information updating might be so long that there would be no sense in such tracking.

3. SHORT RANGE WIRELESS NETWORK TECHNOLOGY SELECTION

Let's consider possible variants of short range networks, which could be implemented in the relevant problem. First of all we should pay attention to the aspect connected with the system development cost. Since we speak about a comparatively big implementation of miniature wireless terminals, than their cost might be very essential. It is obvious, that the

most effective solution will be to use wireless technologies implemented in public devices, but not unique developments, which are oriented specially for this task. From the above mentioned we can make a conclusion that we must take into consideration the most famous and perspective technologies which are used in mobile phones, PDA, electronic identification systems etc. Let's take a look at the list of possible candidates.

Technology	Frequency	Bitrate	Link length	Cost
IRd	More as 100 TGz	1-100 Mbps	On-Sight	low
Bluetooth	2.4 GHz	1 Mbps	1-50 m	medium
802.11a	5.1 GHz	54 Mbps	100 m	high
802.11b	2.4 GHz	11 Mbps	500m	high
802.11g	2.4 GHz	54 Mbps	400 m	high
802.15.3a UWB	3.1...10.6 GHz	110....12000Mbps	1-10 m	low ?

From the Fig.4 which is taken from a famous article [3] by Intel Corp. authors, we can make a conclusion that out of existed analyzed technologies the most appropriate is Bluetooth, and the most perspective is UWB technology.

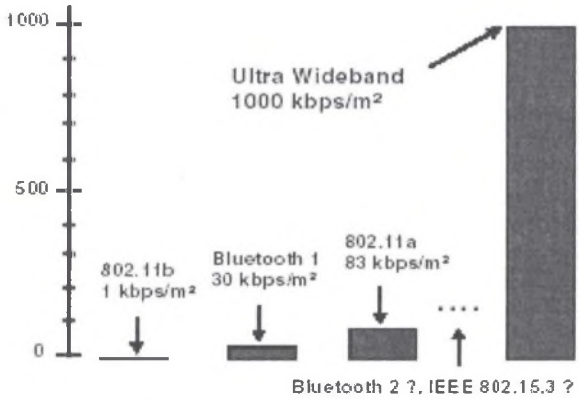

Fig.4. Short range network performance density

4. OTHER WIRELESS BASED TRANSPORT TELEMATIC SYSTEMS OVERVIEW

4.1 LOCATION AWARE SERVICE NETWORKS FOR TRANSPORT SYSTEMS

In such system short range network connects external information system with terminals based on vehicles. A typical Ad-Hoc network is formed. While a transport unit is moving its onboard terminal is logging on in chain of terminals of external network and asks for actual information, which is specific for this position. If the network provides fast enough connection than for a short period of time while moving close to terminal a big amount of information will be "dropped" to transport unit. This information could be of different types: further moving conditions, map updating, further directions about cargo, locality tourist routs description etc. Backwards the information about cargo condition, passengers' requests for

different types of service, medico-biological information about a driver and passengers etc. will be taken from a transport unit. Because of a small service radius of each terminal data exchange will always contain information about transport unit location at the time of exchange that is why the exchange content will be dependant and specific for the current point. The necessity to organize a high speed link of data transmission makes the implementation of network based on UWB technology very perspective. The developed standard at present time DSRC (EN300674) using special 5.8 GHz is much more expensive solution.

4.2 COLLISION PREVENTION SYSTEM

In such system short range network terminals are mounted on every transport unit that takes part in movement. While approaching information interaction appears and information exchange about type of transport unit, its parameters, movement etc. is realized. This information is depicted by a driver and might be used for the development of warning signals. In our paper [4] the possibility of usage of network based on UWB signals for mutual distance determination between transport units and even passive objects was shown. The necessity to use wide-band networks here is also very important.

5. CONCLUSIONS

Short range networks might be a very useful means in solving transport telematic problems. In spite of a common opinion about such networks as personal PAN networks, home networks, office networks the authors see the necessity to attract transport telematic systems developers' attention to such technologies. Future transport units might be equipped with several short range networks for the purposes of obtaining information about cargo, passengers, data exchange with transport infrastructure and even collision prevention. In its tern the present article is also addressed to those who develop new short range networks standards. Transport telematic is one of the mass fields where new short range networks might be implemented. Specific requirements that are dictated by these applications should be taken into consideration in new standards. The most important is the necessity to support Ad-Hoc regime and high speed exchange. The idea suggested in the present paper to use short range networks of mass implementation in transport systems will allow to save on development and increase the volume of equipment production for such networks which will lead to its low cost. Even now Bluetooth technology usage for RFID system building might be additional market for the devices using this technology. New standard development on UWB should also take into consideration possible implementations of this perspective technology in transport telematic systems.

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