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TEAM

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5th International Scientific and Expert Conference of the International TEAM Society

(Technique, Education, Agriculture & Management)

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Editors

Prešov 4th – 6th November 2013

This book contains the papers suggested by the reviewers for publishing and presentation at the 5th International Scientific and Expert Conference of the International TEAM society to be held during 4th – 6th November 2013 in Prešov, Slovak Republic, EU.

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Brief Contents

Chairman Foreword

There is (no) I in TEAM or how to unlock our doubts

Dear Reader,

somewhere I read that there is on „I“ in the TEAM. I think that there is very important I hidden in A – Interdisciplinary.

Angela F. Orviz remarked in her study “Effective Collaboration in Multidisciplinary Teams following „Usually project is not only related just to one area or study. They can be analysed from the perspective of different disciplines. If they are working independently, they can only see the information related to their piece of work. That can have two negative effects in the process. It the pieces of work cannot be joint, it is a waste of time. If the results are similar, it is waste of resources.“

Clean lines, which are kept straightforward by supplemented graduated education, lose their creative fertility. By the way, original discoveries are made by people who stand on the border line and have yet each leg in another space. These border areas are today very frequent. Best researchers are derived from two or more professional fields.

How do we effective create reality? It depends on readiness and kindness, novelty, and mentioned Interdisciplinary.

Crucial milestone on the way to discovery is an idea. It is said that “one” gets the idea. During intellectual adventure, in science, nothing is obtained for free. Everything is paid by talent, education, experience, hard work and interpersonal relationships. If that did not exist, scientific research would look like undemanding moments in the meanwhile.

Even so-called coincidence, e.g. when an apple dropped to Newton´s head, someone had to notice it, to make good conclusions, to understand what was going on and to estimate what could be. Louis Pasteur said that coincidences served only to a ready man. The work of a scientist is a detective work, it is a form of adventure. We discover reality and the “truth”. But the truth is like a coffee bean. Boiled beans after the second and third times: weak smell impresses anyone.

Einstein said "Most people say that it is the intellect which makes a great scientist. They are wrong: it is the character." We are missing the nature, that of unaffected children. Children are not afraid to try their luck. If they do not know, they try. They are not worried to doubt. What is really wrong today? Myth of truth and different opinion. Do not fear about a different opinion. Truth is temporary. Problem is only a challenge. Be sure that no one is perfect. The truth is something we still have to find and improve. Being true is not fixed to academic title or position. If we want to do good research first we have to break all the rules. If we are not prepared to make mistakes, to see the problems we‘ll come out with anything original.

It happened in 2005 in one “innocent” e-mail from Prof. Dražan Kozak during ATDC conference held in Slavonski Brod. This minor incident caused an explosion of the cooperation between Mechanical Engineering Faculty in Slavonski Brod signed by Prof. Dr. Ivan Samardžić and the Faculty of Manufacturing Technologies, Technical University of Košice with a seat in Prešov signed by Prof. Dr. Jozef Novák-Marcinčin. Almost daily communication, many hours spent in scientific discussion, joint meetings, realized incoming and outcoming mobility (Erasmus, Ceepus), projects for industry, collaboration with other institutions, and taking part in the conferences gave as a result 13 joint papers in Journals referred in Web of Knowledge database, 3 monographs, 1 university handbook, and 7 papers published in the International Conference Proceedings.

Currently the great success of the cooperation of Mechanical Engineering Faculty in Slavonski Brod and the Faculty of Manufacturing Technologies is the implementation of approved international scientific project IPA IIIC project OrtoFlex - Flexible manufacturing of customized spinal orthoses, thanks to great work of Prof. Dr. Pero Raos and his project manager assistant Assoc. Prof. Dr. Tomislav Galeta.

Because of a very successful cooperation between the Faculty of Manufacturing Technologies TUKE with a seat in Prešov and two out of three International TEAM Society founders (Mechanical Engineering Faculty and the University of Applied Sciences from Slavonski Brod) our Faculty was invited to host this year TEAM Conference by the president of TEAM Society Prof. Dr. Sc Antun Stoić.

On behalf of TEAM 2013 organization committee, I am pleased to invite You to the 5th International Scientific and Expert Conference of the International TEAM Society (Technique, Education, Agriculture & Management) which will take place on November 4 - 6, 2013, in one of the most dynamic cities of Slovakia - Prešov with a beautiful restored city center and youthful atmosphere under patronage Prof. Dr. Jozef Zajac, the Dean of Faculty of Manufacturing Technologies TUKE with a seat in Prešov.

We would be delighted to have You, Dear reader, present at this conference to hear about the advancements of Your researches and their impact on our daily lives. We would also love to hear Your thoughts and opinions in this direction. Presented papers will be selected for publishing in Technical Gazette and the Journal of Manufacturing and Industrial Engineering. The cooperation between Mechanical Engineering Faculty in Slavonski Brod, Faculty of Manufacturing Technologies TUKE with a seat in Prešov and other mentioned institutions summarizes the words of Henry Ford. “Coming together is a beginning. Keeping together is progress. Working together is success”.

This book includes the proceeding of the 5th International Scientific and Expert Conference of the International TEAM Society, where the latest findings in science and engineering concerned with the technology systems operation are reported. TEAM 2013 conference is arranged under the patronage Dean of the Faculty of the Manufacturing Technologies Technical University of Košice with a seat in Prešov Prof. Dr. Jozef Zajac and TEAM president Prof. Dr.Sc. Antun Stoić.

This year, TEAM organizing committee received more than 110 submissions which authors and co-authors and participants are from 17 different countries of the world. Reviewers and members of the Program committee and their recommendations used for a selection of carefully reviewed all submissions in the spirit of Dražan´s words "Do not prove, but improve". According their advices were accepted more than 100 papers. In addition to the contributed papers, prominent researches were invited to give keynote lectures in their respective fields of competence. For running a conference of this magnitude, financial support is essential. We would like to thank you to LPH, Ltd. Vranov, 1PN Ltd., Prešov, MERCATOR DMS, Ltd. Bratislava, Interprofis v.m., Ltd., Prešov.

This conference bears all the hall marks of success. This is due to the great TEAM work. I would like to thank all those who helped in organization of the TEAM conference especially our colleagues Dr. Lucia Knapčíková, Assoc. Prof. Dr. Tomislav Galeta, Dr. Krunoslav Mirosavljevic, Assoc. Prof. Dr. Peter Monka, Prof. Dr.Sc. Dražan Kozak, Eng. Dominika Lehocká, Eng. Ján Cárach, Eng. Svetlana Radčenko and Eng. Alena Mihaľovová. Smooth running of the conference can be hardly imagined without the devoted presence of Dr. Lucia Knapčíková, Jozef Chomanič the owner of Via Magna and Metropolis.

Thanks belong to the reviewers for their diligence and expert reviewing. Last but not least are the authors who deserve big thank you, their research and development efforts are recorded in those proceedings. We wish you warm welcome and hope that your participation in TEAM 2013 will be enjoyable and also professionally rewarding and we are hoping that the proceedings will be helpful to all scientists and engineers.

To all who came in contact with TEAM in the role of the author or the reader I wish a lot of inspiring results during contact of sport with reality, a fair-play game the outcomes of which will be useful for future generations, papers which will be more than a record in scientific databases.

Instead conclusion I would like to address You some inspiriting words in fantastically written e-mail to me from Prof. Dr.Sc. Damir Markulak: „..it is so easy to recognize bright and motivating mind in today's mostly gloomy (unfortunately) surroundings, where the (even young) people are trying to cut corners, focus on satisfying the form only, engage only a small percent of their creativity that is necessary for acquiring of minimum demands...but, on the other hand, how can we blame them taking into account a role models set as examples of contemporary successful persons, where the only important things (too) often are just acquaintances or affiliations, prior to real skills and knowledge."

Dear reader, how do we want to create our reality?

Hloch Sergej, Assoc., Prof., Ing., PhD.

Foreword of the Mayor of the City of Prešov

Dear Ladies and Gentlemen,

I am delighted to attend today the fifth International Scientific and Expert Conference of the International TEAM society. I believe that this conference will be beneficial not only for the participants but also for the development of cooperation between University and the City of Prešov.

This Conference has encouraged us to see the future of the city and the faculty as a one entity on its way to become a modern and prospering ecological city that uses the advanced technologies.

Prešov has the great potential of the utilizable natural energy. Our main objective is especially the utilization of geothermal energy for heating and also using of the energy for development of tourism and for production of electricity. The unique sources of the geothermal energy are opening big opportunities for our citizens how to cut down energy costs and for its further usage. We would like to utilize the other alternative energy sources like solar energy and biomass. Clean and healthy environment belongs to the main priorities when we are talking about the City of Prešov.

After discussion in Energy-Cites Prešov has been selected as a pilot city for the IMAGINE Campaign. Energie-Cités is the association of European local authorities for the promotion of local sustainable energy policies. Ladies and Gentlemen, Prešov is a seat of the University of Prešov. The students from all parts of Slovakia are studying at the University. There are also other faculties in the city and one of them is the Faculty of Manufacturing Technologies, Technical University of Kosice. The city has an ambition to establish an environment that can offer opportunities for high-class education and also for students' employment. That is the reason why there must be connection between the city, educational institutions and industrial parks. The city needs educated and ambitious people in order to become a prominent European centre. It needs people who will not leave the city but people who will stay in the city that can care of them.

I hope that our collaboration will help us to establish a strong base for the graduates and their potential employers. The relationship with industrial parks will improve the level of the high education not only at this particular Faculty but also it is good opportunity for the other educational institutions in our city. It is also one of the solutions for students to gain experience in the field of their studies and it is the opportunity for the university to get feedback on their education programs directly from the practice. To become a professional, one has to be educated and have a good experience in the field of his study program. The connection of the city and the University will secure not only opportunity for graduates, but also opportunity for students to practice during their studies and see how the technologies are used in industry.

One of the ideas of the cooperation between the city of Prešov and the Faculty of Manufacturing Technologies is to make suitable environment for students in our city. One of the major aims of the city on this successful way is to help students to resolve the problem with an accommodation by building up of new flats. The Municipality has further ambition to build up wellness centres for students and for inhabitants of Prešov. We expect that the University graduates will fulfil the requirements and expectations of the growing city and new coming investors. Education will remain one of the priorities of the city's development. The cooperation of the City and the Faculty is a significant step forwards by reason that they lived independently until this time. Their connection is an important element for the experience of the graduates and for students.

At the present time, the City of Prešov makes an effort to belong to these fast growing cities that will be able to respond to solving such a big challenge as the climate changes and global warming are. The citizens of Prešov do understand the need to cut down energy usage and the importance of combat against climate changes. Municipality of Prešov has clear priorities to achieve concrete results for which the connection between the Faculty and the City will be beneficial.

The City of Prešov has an ambitious aim to be a leader in the Eastern Slovakia region. Prešov is on the best way to become modern and dynamic city that is interesting for its inhabitants as well as it is attractive for tourists. There are also OPAL MINES in our region that are very attractive touristic attraction with its unique "nobel opal". Our plan is to connect OPAL MINES, SALT MINES and GOLDEN MINES together under the open-air mine's museum and to create a great place to visit. We are pleased by the attention of foreign visitors, officials and representatives of the authorities of the European Union that we regularly welcome at our City Hall.

The message of this Conference would be to bring together Faculty and the City and thus enable Prešov to become the ecological and technological city. We look forward to our cooperation with Technical University in Kosice through its Faculty of Manufacturing Technologies with seat in Prešov.

I wish we will meet again on the further Conference in 2014.

JUDr. Pavel Hagyari

Mayor of the City of Presov

TEAM^{2013}

5TH International Scientific and Expert Conference of the International TEAM society

Idea for establishment of international TEAM Society was initiated in year 2009. The TEAM Society funders are Faculty of Mechanical Engineering and Automation, Kecskeméti Föiskola, Hungary, Faculty Mechanical Engineering in Slavonski Brod, University of Osijek and University of Applied sciences of Slavonski Brod.

TEAM Society offers a new identity for Conferences by joining together, networking the institution and changing the forms and importance of the events, since TEAM conferences are organised in the framework of international cooperation and by changing the country and host institution. TEAM Conference is organised to gather scientists and experts of European countries in fields of Technics, Education, Agriculture and Management (the first letter of fields are acronym TEAM) and it is based on results of fruitful international cooperation between institutions in recent years.

Organised by:

Faculty of Manufacturing Technologies with a seat in Prešov, Technical University of Košice |SK

In cooperation

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PERFORMANCE OF THE WIRELESS DISTRIBUTION SYSTEM APPLIED IN A TRAFFIC INTERSECTION

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Abstract
This work examines the possibilities of maintaining a vehicle based mobile ad-hoc network (VANET) by a Wireless Distribution System (WDS). We introduce and treat the performance limitations of this system. In our case the examined VANET is considered to be a communication system in a busy intersection of four-lane roads, and the WDS Base Station is located in the center of the intersection. The traffic simulation is based on the Intelligent Driver Model. Computer simulation measurements of the time average of the size of the WDS network is given in this paper. It was obtained that size of the network is growing together with the density of the traffic, but, due to the highly mobile radio stations (cars) and the relatively high connection time, it is limited to the order of magnitude of several times the radio coverage.

Keywords:
wireless networking, WDS, VANET, vehicle network

1. Introduction

Wireless communication plays an increasing role in numerous area of traffic control. Even if only a few cars are participating in an ad-hoc network, a very efficient information service can be rendered for the driver in case of overtaking or a nearby accident [1]. However, if it is possible to maintain a large network participating more tens or maybe hundreds of cars, a very effective control of the traffic-flow can be achieved, which helps to avoid traffic jams. Therefore, the performance of the implementable vehicle networks became a highly studied area in the last decade [1, 2, 3, 4].
In the present work we investigate the performance of the WDS [5] in a situation, where a Base Station is set in the center if a busy intersection of four-lane roads by computer simulations. We suppose that all of the simulated cars are carrying a WDS radio station and tries to connect to the large wireless network formed around the intersection.

2. The Wireless Distribution System (WDS)

Connecting two or more wireless (distribution) systems can have several practical reasons. Wireless systems can most easily be created from Bluetooth or Wi-Fi networks. From previous publications [1] it is seen that the Bluetooth technology cannot provide coverage of suitable range, although it has low energy-consumption, which is important when implementing it on robots.
Due to the significance of range, the answer to the problem can be the Wi-Fi standard with a greater and higher quality range than of a Bluetooth solution – though with a bigger consumption of energy.
Network connections can be classified into two categories based on the type of connection. One is the Ad-Hoc connection, where two devices connect to each other directly (without an AP). The other is, when more clients connect via an AP, the connection is called an infrastructure mode in a wireless network.
There are 3 well-known wireless network modes which enable clients and APs to connect to one sub-network. First, the Wireless Client Bridge mode, which, however, disables clients to connect directly to a wireless network and makes connection possible for a client only through a wired link to an AP. The second is the Wireless Repeater Bridge mode, where incompatibility problems (potential ARP problems) with certain programs or protocols (dependent on the MAC address) may occur due to the translation of the MAC address (Proxy ARP). The third is the WDS mode, which has the advantage of the WDS-method, that it is easy to create a continuous and long-range wireless network. The equipment on the vehicles (or other mobile agents) (APs) not only connects to the Base Station in an infrastructure mode, but also transmits its signals to the other APs connected (SSID Broadcast) as a WDS Client. Thus, networks of arbitrary rooted-tree graphs can be formed without using any repeater, where the Base Station is the root. Each client must have a radio connection that leads to the Base Station directly or through another client. Let us call this connection as “uplink”.
Besides, any such a client may have more radio connection to other clients that are connected to the network only through this client at hand. So each client must have strictly one uplink and more downlinks. Thus, networks of arbitrary rooted-tree graphs can be formed without using any repeater, where the Base Station is the root (see Figure 1).

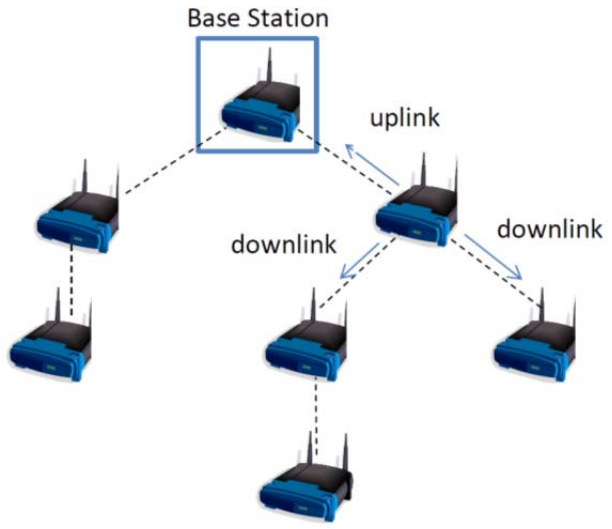

Figure 1. The typical rooted-tree graph of a WDS system

According to my measures, a client needs approximately 2 seconds to connect to the BASE STATON. (1,8 sec with use IEEE 802.11g 54 Mbps 2,4 GHz wireless adapter and 54 Mbps 2,4 GHz Access point).
To be more exact, any number of links (both wired and wireless) can connect to the points of the wireless backbone-network. For the installation of the WDS mode, all access points/devices to connect to the WDS master have to support the WDS client connection option.

Setting the WDS master:
• Select the WDS master mode in the menu of the wireless router.
• Set individual SSID network in the required field.
• Select an available radio channel.
• Note the MAC address of the WDS Master AP – it will be necessary during the setting of the clients.

Setting a WDS client:
• Select WDS client mode in the menu of the wireless router.
• Give the preset SSID in the required field.
• Give the preset channels of the WDS master.
• Give the MAC identification of the WDS master in the BSSID field.

From the encryption standards supported by the WDS, one can use the WEP and the WPA(1) standards. But irrespectively, one can use a MAC address filter, both for the connection points and the clients connecting to them. One should also consider the fact that in terms of WDS connections, the connection speed for communicating between two access points can only be the half of the connection speed of the access point at maximum.

Since the vehicles or mobile agents use little data exchange for communicating between each other, their requirements are profusely met by the wireless Wi-Fi.

3. The Intelligent Driver Model

In order to simulate realistic traffic each individual vehicle equipped with microscopic features which influence of traffic flow and produce homogenous and oscillating congested traffic, moving clusters and traffic jams. In our simulation application the driving model of Martin Treiber et al. [6] is chosen included a car-following (Intelligent Driver Model – IDM) and a lane changing model (MOBIL) [7]. Both models are collision free and simulate the human driving behaviour, too.
The used microscopic car-following model is called Intelligent Driver Model (IDM). IDM describes accelerations and decelerations of a vehicle in a collision-free way. The model inputs are the own vehicle speed (v), the bumper-to-bumper gap (s) to the leading vehicle, and the speed difference (Δv) of the own and leading vehicle. Finally the output is the acceleration (dv/dt) chosen by the driver for current traffic situation. IDM acceleration is given by

$$\frac{dv}{dt} = a\left[1 - \left(\frac{v}{v_0}\right)^{\delta} - \left(\frac{s^*(v,\Delta v)}{s}\right)^2\right] \qquad (1)$$

where

$$s^*(v,\Delta v) = s_0 + \max\left[0,\ \left(vT + \frac{v\Delta v}{2\sqrt{ab}}\right)\right] \qquad (2)$$

In this expression the desired speed (free acceleration) signed with v_0, maximum acceleration a, b is the maximum braking deceleration, and δ exponent is responsible for characterizing how the acceleration decreases with velocity. T means the desired safety time headway when other vehicles are followed, s_0 parameter is the minimum bumper-to-bumper gap to the front vehicle. For more details see [6].
Besides, the car-following model, lane changing behaviour is needed in order to get realistic description of traffic. In the real world multilane model faster vehicles take lane changing maneuvers to improve their driving positions by passing slower vehicles. The lane changing model of Martin Treiber [7] (MOBIL – Minimizing Overall Braking Induced by Lane change) satisfies two important criterions. First is the incentive criterion which is satisfied when the potential new target lane is more incentive then the old lane. Second safety criterion, the lane changing has to be performed safely, thus MOBIL also a collision free model.

The lane changing is executed when safety criterion is satisfied so that the effects of lane changing have to analyse. The deceleration of back vehicle (a_n) on new lane must be lower than a certain limit (b_{safe}) to guarantee the collision free changing. b_{safe} is the maximum safe deceleration of vehicles, as it is expressed by eq. (3).

$$\tilde{a}_n \geq -b_{\text{safe}} \tag{3}$$

After safety criterion the advantage of the target lane is computed from current neighbor vehicles (see eq. (4)). In this expression the politeness factor (p) means the degree of egoistic behavior, a_{th} is the lowest acceleration of any vehicle. In case of the expression is true the new lane is more attractive for the current vehicle. Ref. [7] describes lane changing model in more details.

$$\underbrace{\tilde{a}_c - a_c}_{\text{driver}} + p\left(\underbrace{\tilde{a}_n - a_n}_{\text{new follower}} + \underbrace{\tilde{a}_o - a_o}_{\text{old follower}}\right) > \Delta a_{\text{th}} \tag{4}$$

4. Computer simulations and results

In this work we used a simple traffic environment: a four-way intersection together with the four connected roads each with the length of 1000 meters. The roads consisted of four lanes on all of their length except the last 50 meters on the way to the intersection, where was an extra lane added for the traffic going to right. The scheme of the intersection and its turning lanes can be seen in Figure TN. Altogether N simulated cars where started from the four ends of the roads under 600 seconds uniformly distributed in time, so that equally N/4 cars started from each end. The destination of each car was chosen randomly prior to its start to be one of the other three road-ends, so that the traffic flow densities in the intersection from one road to the other three roads were equal (see Figure 2). The traffic in the intersection was controlled by a traffic-lamp system working in an "opposite-green-together" scheme as it is shown in Figure 3.

Meanwhile the traffic simulation the radio connections of the cars were also examined. A Base Station radio was fixed in the center of the intersection, and this advertised its SSID in its Radio Coverage, and it was supposed to accept an arbitrary number of connections with the nearby radio cars. According to the WDS system, this radio network originated from the Base Station was the only one in the simulation. The working algorithm of a car radio was also based on the

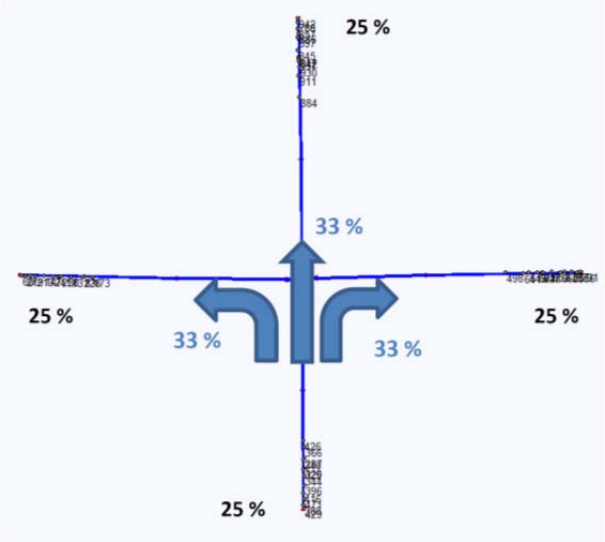

Figure 2.The main scheme of the simulated traffic environment.

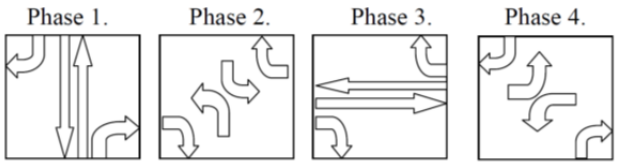

Figure 3. The opposite-green-together scheme of the applied traffic-lamp control.

WDS radio system. Corresponding to this, a car radio could connect to only one other radio as an uplink but could accept arbitrary number of connections as downlink. (An uplink connection leads toward, while a downlink leads away from the Base Station on the network tree) Besides, a radio could be in strictly one from the three following states:

1. Not connected;
2. Under uplink connecting process to another radio, which is part of the Base Station's network already;
3. Connected through an uplink to another radio, which is part of the Base Station's network already;

The algorithm of a car radio was as follows:
if it is in state 1 and there are radios within reach, then chose the closest of them and step into state 2 and start a connecting timer;

- **if** it is in *state 1* **and** there are radios within reach, **then** chose the closest of them and step into *state 2* and start a connecting timer;

- **if** it is in *state 2* **and** the connecting time is over **and** the radio chosen for connection is within reach, **then** connect to it as uplink and step into state 3; **if** it is not reachable anymore, **then** step back into *state 1*;

- **if** it is in *state 3* **and (** the radio to which it is uplinked is not reachable anymore **or** it stopped its downlinks**)**, then stop all of the downlinks of itself and step back into *state 1*;

It can be seen that the wireless network formed subject to this rules is a rooted tree, with the Base Station being the root, and if the uplink of a mobile car-radio is cut, then the whole branch, that was connected through this car will be cut from the network immediately. On the other side the building up of such a branch is much slower due to the connecting times needed for each uplink.
Meanwhile the simulations we examined the time-average and the variance of the distance of the furthest connected car, since these parameter inform us about the spatial range of the continuously changing ad-hoc network. Besides, we measured the rate of the connected cars compared to the total number of cars on roads at the moment. The parameters above were measured between the 100th and the 600th second after the start, so as to avoid the finite time effects of the simulations. (In the first 100 seconds the destination lanes and after the 600th second the starting lanes were empty). The connecting time and the radius of the radio coverage were taken to be 1.8 sec and 100 meters. The desired travelling speed of the cars was set to a fixed value for each car randomly selected from 40 km/h up to 60 km/h. The number of the cars (N) were chosen from the range of [150 ..1800]. With the help of this parameter the density of the traffic could be set, since, as it was mentioned before, all of the cars were started under 600 seconds. For example if N=1200 then 300 cars started from a source under 600 seconds, so one car started under two second. Calculated with 50 Km/h (13.89 m/s) average travelling speed, the spatial density of the traffic in this case was 1/27.78 car/meters. Note that there are two lanes for a specific direction, so this means 55.56 meters average follower's distance between the cars in one lane and 36 Km/car spatial traffic density on the two lanes leading in the same direction. For each value of N more simulations were run and finally the measured parameters were averaged.
The measured time averages of the network radius can be seen in Figure 4. It is shown by the data that the increasing traffic density results in an increasing network radius until the density reaches the value about 50 cars/Km. Above this value the radius does not grow further. This breakdown is caused by that the traffic lamp system retards the traffic and at this value of traffic density the lanes leading into the intersection are totally jammed by cars. However, it can be seen, that in the region below 50 cars/Km the network radius is in the range 200 – 600 meters, which means that in case of a non-jammed continuous traffic the communication range of the Base Station is extended to several times of its radius of radio-coverage (which is taken to be 100 meters in this work).
Even more interesting results are shown in Figure 5, where the time average of the ratio of connected cars is plotted against the spatial traffic density. The curve increases in the range 0—30 cars/Km and decreases in the range above 30 cars/Km. The reason of this behavior requires a more detailed theoretic investigation, which is outside the scope of the present work.

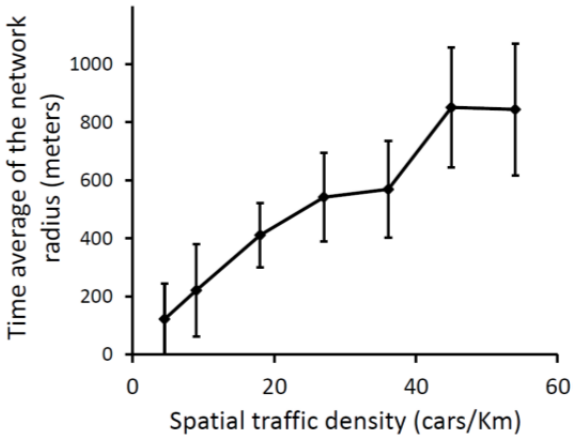

Figure 4.The measured time average of the radius of the network as a function of the spatial traffic density.

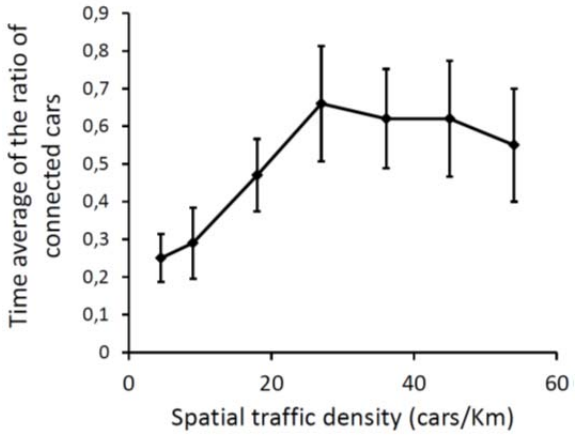

Figure 5. The measured time average of the radius of the network as a function of the spatial traffic density.

5. Conclusions

Based on the computer simulation result it can be concluded that the Wireless Distribution System with the parameters used here (connection time = 1.8 s and radius of coverage = 100 meters) is capable to extend the communication range of a Base Station situated in a busy traffic intersection. Provided that each car carries a WDS radio station, the time average of the radius of the communication network was measured as two to six times of the coverage radius of the base station under continuous (i.e. not jammed) traffic conditions. Besides, the increasing traffic density resulted in increasing network radius in a non-jammed traffic situation. It was obtained, however, that the time averaged ratio of cars connected to the network increases with the growing traffic density only in the range under 30 cars/Km.

6. Acknowledgement

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