Container Terminal Modelling in Simul8 Environment

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Abstract: This paper gives overview of container terminal processes and related optimization models. Survey of some simulation-based model for intermodal systems is also presented. Upon the drawn conclusions from the surveyed papers, a novel simulation model is described which enables applicability of adaptive and intelligent methods, enables optimization of the certain modules and the whole model as well. The proposed simulation model was implemented in Simul8 logistic simulation software environment.

Keywords: container terminals, logistics, simulation, modelling

1. Introduction

The role of the intermodal transportation is steadily growing, and expected to grow further in the coming years. This statement is especially true for the container transportation segment. New technological achievements of the containers, handling machines and the related informatics were all necessary to reach the success of the intermodal containerization. The technology and particularly it's application processes however still embed great reserves, which may be surfaced only by overall analysis.

Container terminals implement complex processes using equipment of great value. In addition, for the incoming rail/road transport vehicles and ships waiting time is expensive. In order to operate economically, terminal's processes should be optimized. Optimization is however quite complicated in this case. The material handling system consists of different subsystems, and each faces different optimization problems. During operation of Quay cranes, most important factor is the greatest utilization available, and the minimization of serving time for the ships. Container transfer systems (towing tractors, straddle carriers, automated guided vehicles) however work by different principles: optimization of routing, scheduling, as well as traffic control. And yard cranes have entirely different priorities. For these handling machines important issues are container stacking problem and partitioning of yard space. Details of the above methods are discussed in Chapter 3. Preliminary it must be mentioned that for the different handling subsystems several well-formulated methods exist. However we

didn't find any methods dealing with the whole system. Cause of this that the terminals' structures and processes can be very different.

Seeking optimum for each subsystem may result undesired interference among them. Let's see an example. Optimization of quay cranes prioritizes such a serving container transport system that stands always for the cranes disposal. This means for the AGV or towing tractor and trailer subsystem that it should always position free transport vehicles for the quay cranes. This policy is however disadvantageous for the transport system, because it reduces utilization and influences the traffic patterns. We agree with authors saying that one of the most important performance measures in container terminals is the turnaround time of vessels, and quay cranes are the most expensive single units in terminals, therefore their optimized operation is very important [1]. However the transport system is not advisable to be subordinated entirely to the quay cranes, because there can be situations when the current status of the transport system causes unbearable problems at other segments of the terminal. Therefore we suggest monitoring and optimizing the processes at global level as well.

For the analysis of the terminal processes we see logistic simulation software the most appropriate tool. This has already been proposed by others (e.g.: [2], [3]). We started developing our model on these experiences but focusing more on the capability of handling global optimum as well. Next survey of terminal processes follows, which is necessary in order to set the focus of the model.

2. Container terminal processes

Due to increased volume of containers, intermodal terminals became important part of logistic networks. Intermodal container terminals may have various layouts, but can be divided into two main groups:

- inland, intermodal rail/road terminals,
- and maritime/waterway container terminals.

Airport-based terminals are not discussed, because air-cargo containers differ significantly from the widely used intermodal shipping containers.

Maritime terminals serve as hubs among sea, rail and road transport modes. Containers arrive at the seaside in special container ships. The containers are handled there using quay cranes, which place them on various, specialized transport systems. These can be various automated guided vehicles, manually driven towing tractors and trailers or straddle carriers. The above transporters carry the unit loads to the yard, where gantry cranes place them onto the container stacks. Movement of unit loads between the land side of the terminal and the storage blocks is carried out via the same transportation system. At the land side of the terminal loading and unloading of rail cars and trucks is executed by gantry cranes, reach stackers or container lift trucks. Besides the above there can also be direct movements between the sea and land sides of the terminal. The above elements are shown in Figure 1.

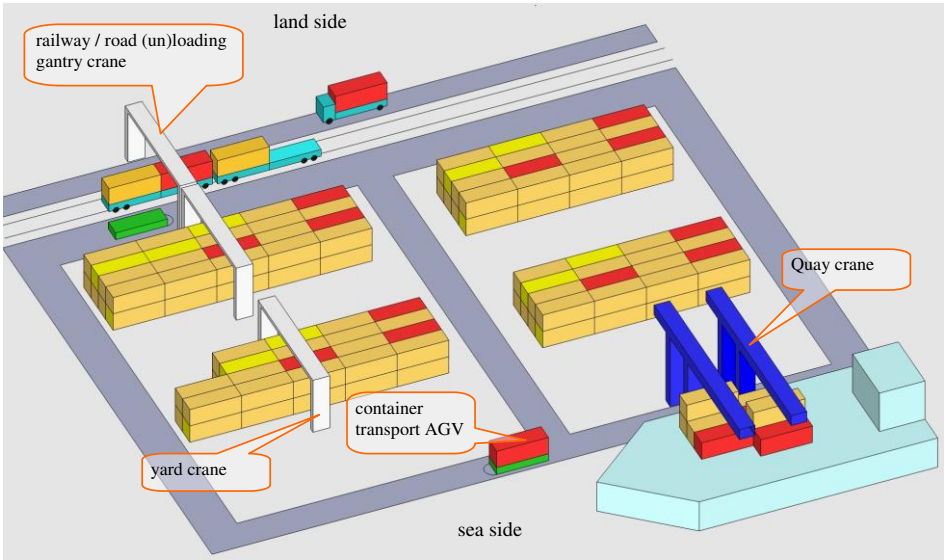


Figure 1. Material handling processes in container terminal

Next chapter surveys most typical optimizing problems and modelling for each subsystems, in order to gather information for the elements of the proposed model.

3. Modelling and optimization of container terminal processes

Modelling and optimization can't be handled separately because the first limits the applicable optimization method. From our point of view models are divided into simulation based and solely equation based numeric models. Next a brief overview about the already researched models is given. First the numerical models are described, afterwards simulation based models follow.

Numerical models can be divided after the field of application, into the following groups:

- Modelling of the berthing and loading/unloading of ships via quay cranes is an important part of the container terminal research. A good overview is contained in [4]. The paper divides the ship loading/unloading process into 3 sub-problems. First of them is the berth allocation problem, where the ships' serving is planned for berthing time and the occupied position. The berthing time depends not only on the number of the moved containers, but on the number of the assigned quay cranes. Quay crane assignment is thus the second problem of the planning. Finally the load handling movements have to be optimized as well, this is called the quay crane scheduling problem. However the loading/unloading of ships is essential for the terminal modelling, in our case it will be a complicated part of the simulation, because the optimizing require complicated combinatorial numerical/heuristic methods, and it's implementation can't use beneficial features of a logistic simulation software.

- Transport systems' modelling can be best observed in the case of automated guided vehicles (AGV). Due to the automated operation these systems can be modelled deterministically. Main optimization issue for AGV's is the handling of the scheduling problem. Paper [5] presents a numerical optimization method for the AGV scheduling problem. The authors applied a complex goal function which minimizes the total AGV waiting time at the quay side, the total AGV travelling time in the route to the port and the total lateness times to serve the jobs. This method can be implemented in simulation environment as well, but it must be considered if it is necessary at all in our case, or a more simple method is preferred. Further there are some other works dealing with the finding of optimal vehicle routing in the terminal.

- Inside the terminals containers are stored at the yard in so called blocks. There are two types of related optimizing problems. First, some papers analyze optimal crane deployment among the blocks. Zhang et. al. [6] presents scheduling optimization for rubber tired gantry cranes. They formed an equations-based numerical model, which is solved via Lagrangean heuristics. The second problem for containers is the placing of the containers, in the blocks (called the container stacking problem). These must be placed so that the containers' movements are minimized, and the actual containers can be unloaded in short time. Both problems have complicated solutions and can be solved only by heuristics.

- Optimization of the land side processes at container terminals is rarely researched. An important paper for this part is [7], which presents yard partitioning problem for gantry cranes of intermodal rail/road terminals (the analyzed terminal layout can be seen in Fig. 2). This problem includes scheduling of service slots of trains, and the decision on the containers' positions on trains. Finally container moves are assigned to the cranes.

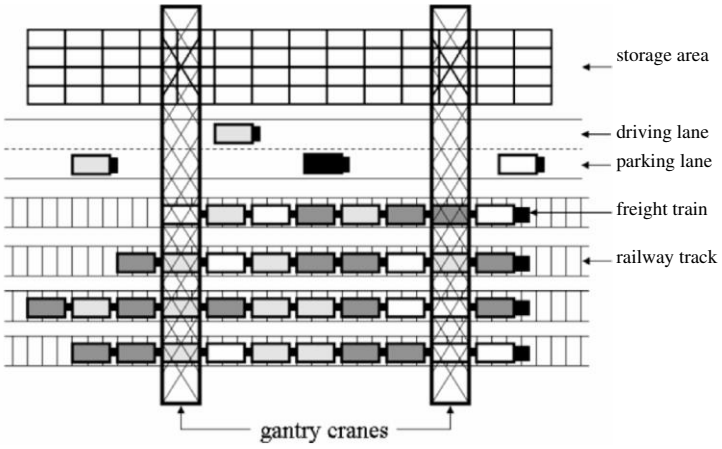


Figure 2. Intermodal rail/road terminal with gantry cranes (from [7])

There exist several simulation models for container terminals as well. We focus on one publication in this direction. Rizzoli et. al. [2] presented a commercial MODSIM III

based model. The used software is an object-oriented and process-oriented simulation language, which allows application of 'real world'-like software components. The paper outlines that features of an intermodal land rail/road terminal differs from it's maritime counterpart, because the residence time of the containers is much smaller (approx 24 h). We remark that the various types of handled units is also greater than maritime terminals, because solely land based intermodal system can handle additionally various domestic containers and swap bodies. The paper proposes four model modules by which modelling of the whole terminal can be solved. These are:

- the road gate, where the road traffic of empty and full containers enter and leave the terminal,
- the rail gate, where trains enter and leave the terminal,
- the platforms, which is a puffer area and a set of gantry cranes for the loading/unloading of rail/road vehicles,
- and the storage are, which is used for the longer storing of the containers, and served by reach stackers.

This simulation models the whole terminal; however it lacks sophisticated algorithms for the optimization of the various modules. The simulation doesn't contain spatial information (e.g. containers' position inside the terminal), it operates using directly given deterministic and stochastic parameters and distributions.

We outline this important difference between numerical and simulation based models: the first ones concentrate usually on a single module of the process, but the optimization algorithm is more sophisticated. Cross effect of the optimization of various modules is however not analyzed. Simulation models give a good overview of the whole process and it allows analysis of various scenarios, but the implemented processes are usually not supported by complex algorithms, only empirical data.

4. Characteristics and structure of the proposed simulation model

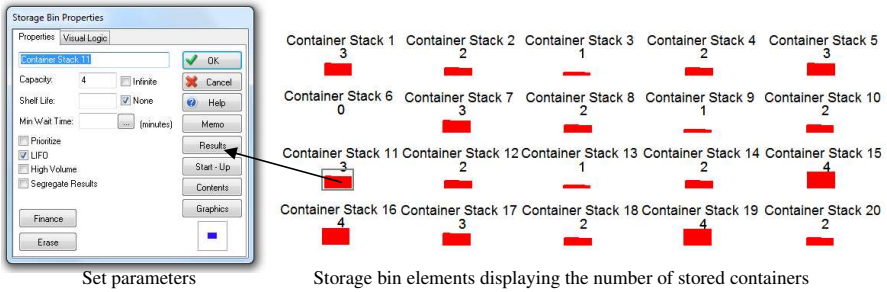
Upon the experiences from the described papers we concluded that modelling and optimization of terminals results in economic benefits. For the proposed simulation model following priorities has been set:

- Simulation model should be modular like in [2].
- For the various simulation modules we propose implementation of behaviour-based control. These methods are widely used at other areas of intelligent computing. That means each module may work in various operational modes. The modules continuously observe behavioural-states of the other modules and change their own behavioural-state if necessary. For example, if the container yard module recognises that the berthing module requires more intensive container placement then it will change his priority from 'placing the container to the optimal position' into 'placing the container into the quickest available position'.
- We intend to implement our model with adaptive features as well. For the implementation we intend to use soft computing e.g.: neuro-fuzzy

algorithms. This way we expect that the operational features are improved as well. Such methods are known in logistics, for example Orbán and Várlaki [8] proposed an adaptive fuzzy system for the modelling of loading systems in logistics. This systems can change it's behaviour depending on the relation of current demand and serving capacity of the loading system.

- We intend to give the containers a more active role in the processes. We analyze the effect of handling the containers like passengers in traffic systems. That means each container tries to leave the incoming transport vehicle as soon as possible, tries to get into the most appropriate position in the stacking, and tries to reach the outgoing transport vehicle in time. These will generate prioritized transport demands, carried out by the load handling cranes, stackers, AGVs.

Development will be carried out using Simul8 2008 logistic simulation software. Main features of this software are the modular structure, and the object oriented capability of the models. There are several components available in the Simul8 environment but we need to use two of them. Static container stacks, other storage areas, decks and cargo bays of ships and the railway carriages are modelled using a set of simple static 'Storage Bin' elements with LIFO principle (see Fig. 3.). Each stack represents containers loaded at the top of each other, that means only the top container is available for unloading. If a lower container should be accessed then it generates additional loading operations for movement of the upper container.



Set parameters

Storage bin elements displaying the number of stored containers

Figure 3. Proposed modelling of container stacks in Simul8

Loading and transporting machinery, such as quay cranes, reach stackers, AGVs are modelled by a set of 'Work Centers' and 'Storage Bins', see Fig. 4. Each machine's movement is divided into empty move in order to reach the container and loaded move, which include load handling as well. If Quay crane 1 in the example receives a container handling task, it gets a virtual work item into the 'Container demand for QC1' Storage Bin. When it is appropriate the model starts Quay crane 1 by putting a virtual work item into 'Start Quay crane 1' Storage Bin. This virtual work item will 'go through' the loop of simulation elements, signalizing the actual state of the handling process. After the handling process Quay crane 1 will only be free for other tasks again, if it gets a signal about the successful transition of the container to another material handling unit, via a virtual work item into 'Finished Quay crane 1' element.

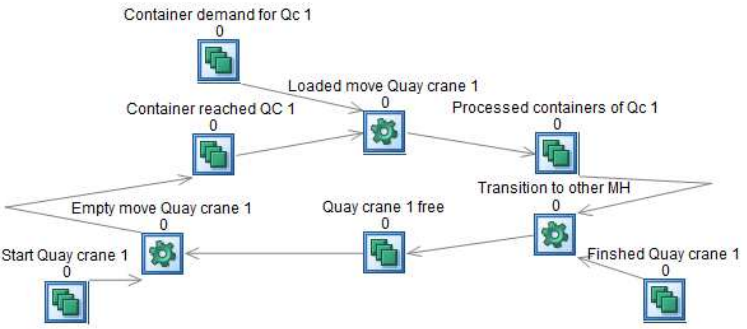


Figure 4. Proposed modelling of loading and transporting machines in Simul8

Each container should be supplied by the following parameters (in Simul8 so called 'labels'.

- container type (important for proper stacking)
- destination information (ID of the outgoing transport train/truck/ship)
- 'reserved' state (if the container is assigned to a loading/transport machine but it hasn't been taken)

In container terminals material handling relations of the loading machines are not static, because for example reach stackers may work at different areas of the terminal. Therefore global functions should be implemented in the model as well. These have following functionality:

- Loading machines' allocation,
- computing of actual behaviour of the modules via adaptive soft computing methods,
- assignment of the containers to the loading machines, depending on the operational behaviour of the modules and the state of the machines,
- determination of the containers' position inside the stacking areas.

We remark that these functions can be supported by numerical algorithms given in chapter 3.

There are two proposed inputs for the model. The long-time scheduling of incoming and outgoing containers gives the number of containers, their destination approximate arrival time of the vessel/train/truck. Using this information the model can arrange quay cranes and storage areas in advance. The other input is the actual arrival, this way effect of the difference between the actual and the planned time can be analyzed as well.

Outputs of the model can be several. A Simul8 based model can easily compute the used total material handling capacity, the utilization of the machines, and lateness of the incoming/outgoing transport vehicles.

5. Summary and further steps

This paper presents possibilities and highlights of container terminals' modelling in logistic simulation environment. In the current state simulation modules of the terminal have been developed, and the necessary computational methods for global functions have been surveyed. Next steps of the research are to construct and analyse a model of a typical container terminal, in order to research the necessary behaviours of the modules and to develop the necessary global modules.

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The Special Excise Goods Logistics Processes

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Abstract: Excise goods have been existing for a long time. Although what excise goods are has changed several times over the centuries, the excise tax paid according to the price of the goods remained the most important source of income of the state budget. Of course the fact that the payment of this tax is always tried to be avoided has not changed either over the centuries just to make the price of the goods more favorable and this way the better price makes an easier and bigger sale possible. In my article I would like to find out what excise goods are, and how they differ from the logistical process of non-excise goods. These products are present in trade as well, as elements of these processes. Their high value, on the other hand, requires a special treatment, which ensures the intactness of these products and the fact that with their purchase and consumption the state obtains incomes to enrich the state budget.

Keywords: excise goods, tobacco, industry, State budget,

1. Introduction

The CXXVII law in 2003 regulating the excise goods is the guide of those economical events in which excise products are touched apart from the logistical events they participate in. Being purchased, used up in manufacturing, sales, storing or treating it as waste, dealing with excise materials differs in some ways from dealing with non-excise materials. It is here that I would like to point out that "Not knowing the law does not exempt from responsibility". So it is worth to be taken up with the theme so as not to meet some surprises in our activity later which are due to our honest intentions or ignorance. The law unambiguously regulates excise products as well as the events which require obligation to report from the given natural or legal persons. The income from the excise tax contributes considerably to the incomes of the state budget and the keeping of the letter of the law is checked by NAV (National Tax and Customs Office).

But what are excise products really?

2. Basic economic trends

According to some sources the word comes from the translation of the German "Gefall" or the English excise, but beyond its origin it means the whole income of the state based on its financial sovereignty. They mean the economic and financial burdens to be paid with the commercial movement of the product. So excise goods are those

goods the distribution of which is regulated by the state. It meant the same in the past too.

Their appearance goes back to XVI century, and by the end of the century the system was completed and the state could get hold of such revenues which provided an important part of its budget.

In the XVI century the system of salt sale was called chamber system. Salt as an unique non-organic spice and the one spice which assured the preservation of food besides making them tasty. So salt was extremely important for the people of the age as it was known by the monarch as well. It was not the only product in this respect, as there were monopoly products such as the commerce of the gun powder, money minting or much later the monopoly of lottery but they are not included in the excise products circle any more. Over the centuries there were changes in what the state considered to be an excise product or what was excluded of it, what else entered the regulation of excise products. According to the current interpretation alcohol, tobacco products and mineral oil are excise products.

Tax obligation after excise goods originates in the production or at importing excise goods. In our case inland means Hungary. With excise goods coming from a 3rd country as (with non-excise goods as well) there is customs examination. During it the customs fee is determined and VAT is imposed. It is important that if the customs examination is not done in Hungary, an indirect customs representative can proceed on behalf of the company. During customs examination he can provide his own bank guarantee for the administration, the expenses of which are imposed on the assigner. The customs examination with an indirect customs representative can as well mean the right of self-assessment (in most cases it is even solicited) and this way VAT need not be paid after customs examination. However, with paying the customs fee the regulations of the affected country are authoritative. For example if a given company does not possess an extended customs pay permit, but it does the customs examination in the Netherlands and its representative has the possibility, he can pay the relevant customs fee postponed. In assessing the percentage of customs fee the regulations of the European Union are uniform, as there is no difference where the customs examination is done. The amount of the customs fee is the income of the European Union, but Hungary is legally entitled to a quarter of it. So it is the interest of Hungary as well to make the customs examination inside the borders and not in other countries of the European Union, as the customs fee can enter and increase the State budget.

There is no uniform purchase tax in the European Union and only the lowest level of the excise tax is determined.

I am doing my investigation with reference to Hungary.

3. Tax stamps

The taxed quality of excise products is assured by tax label. But it cannot be carried out with all excise products. It can only be applied with products of the spirit and tobacco industry. The products of mineral oil cannot be followed this way. The bottles and the products of tobacco industry are tax labelled.

The tax stamp on the products demonstrates the origin of the product (the stamp is on Hungarian) and it proves that the product is liable to tax. The law orders an obligatory invoice or receipt to be given at sale which also proves that the product is taxed.

The tobacco products in Hungary are tax labelled. Compared to the tax label, the tax stamp contains the price and type of the product. It proves that the tax has been paid for the product liable to tax by the manufacturer. Tax labels are used with spirits and tax stamps with tobacco products. Tax stamp always present the name of the product cigarette, cigar, consumer tobacco.

The fact that products must have a tax label or tax stamp is stated by the law, so the customer can make sure right at the moment of purchasing that buying the product meets his excise tax paying obligation, and at the same time the product is identified and has an appropriate quality. As the excise duty increases the price of the product considerably, this clause promotes "black commerce" punished by the law.

Out of the tax stamp products I would like to deal with tobacco products and their commercial characteristics, their excise nature and the logistics processes and feature connected with tobacco products.

The logistics activity carried out with excise goods does not differ from the logistics of non-excise goods in some cases, but there are cases when it cannot be performed in the same way even because of the particularly high value or the excise value of the product. This does not only make a difference in forwarding, transportation or storing, but in many cases in production or in inverse-logistics solutions you must find particular ways.

3.1. Sales of the excise goods (tobacco)

The changing of tax content of tobacco products influences the sales possibilities. As I have already mentioned the first regulation is the one with the tax stamps. A product cannot be sold or to be more precise the tobacco products cannot be brought out of the warehouse without tax stamps. As the tax stamp itself contains the amount of tax, this way it is a means of representing value like other funds. So tax stamps must be assured for selling or without them products are unmarketable. What I know from experience is that the placing of the tax stamp on the products is the last step of the manufacturing process, before the final packaging. This means that you must possess the tax stamps for finalizing the production, and they must be financed by the manufacturer in advance. The cost of production of a tax stamp is 8 HUF in March 2012, the high expense rather means paying the excise tax which is the condition to get them.

Because of the intensive changes of taxes there are other regulations referring to sales. According to the changing of tax content the product is sold at a new price. The product becomes more expensive, naturally its excise tax content will be higher so more money will flow into the State budget with purchasing and consumption of products, also because the VAT will be higher too.

The tax content changes are not considered new at all on the market of tobacco products. Following the former free price era the price of the products became fixed by the authorities thus the amount of tax coming from it was regulated according to the law. Market relations are strongly influenced by the price of the products and this way

there appeared a pronounced competition among the manufacturers. Naturally the lower limit of the competition was to recover expenses, the upper limit was the highest price that could be asked for it by keeping the trade unchanged. After the free price era the prices were fixed and a considerable competition started on the market. The producers quickly recognized that they could achieve an important advantage because of the tax content changes. From time to time they have to raise the price of their products on the market. The higher price, however, drives the customers to producers having lower prices. This leads to a trade recession which may result in the regrouping of market coverage.

Times have long passed when some of the country's tobacco factories (Eger, Debrecen, Sátoraljaújhely, Pécs, Budapest) produced the same products according to quotas.

Competitive market economy requires from every manufacturer to achieve the highest possible trade with their own products. Due to the causes mentioned above each manufacturer quickly recognized that he could protect his company most efficiently against tax changes (and against the possibly falling demand caused by higher prices) if he creates the biggest stock as possible. Thus he can supply the market in the future too with lower prices even after the rice of prices. This measure gave him an important advantage on the market and profit as well. Naturally not to forget the financial conditions in the way they had to take care of the storing and quality of the product. At the same time these possibilities were only for the wealthy companies, while the smaller ones could not profit of it or only in a small extent. This way the advantage of the competition was mostly assured by the amount of capital and the financial indices.

In the sense of the changed law this way cannot be followed any longer. According to the regulation of the current law "after the 30th day following the coming into force of the changing of the law the trader and importer possessing the excise license and after the 60th day the non-excise licensed merchant can sell products only with tax stamps according to the valid tax content". So the wholesaler can sell his products having old tax stamps for 30 days and the retailer for 60 days only after the date of change. As I have mentioned before, the tax stamps must be financed in advance, this way the possibility of selling the products must be assured as well. If it is not possible - as circulation cannot be specified for 100 % - the products must be carried back to the manufacturer.

3.2. Inverse logistics of the excise goods (tobacco)

Products can be sorted out because of different reasons. One can be the above mentioned tax changes or quality failures but there can be damages either in the warehouse or during transportation. These products cannot get to the consumers, their sorting out is demanded. Naturally the value of the product is deficit, not only the missing profit, but on them the tax label as well, as the excise goods tax has already been paid for it. Certainly the law assures a possibility to solve these problems. The returned products must be taken back to the factory. During transportation (will be dealed with in details later) some preventive regulation must be taken for the protection or the product, as it represents high value. About them a registering must be done as the law says. The returned products must be protected while being stored. These products

are excise goods longer, having much financial value so they must be stored in the excise goods warehouse possessing a severe registration obligation until their destruction. Cigarettes are usually not dismantled but consumer tobacco is worth taken out of the wrapping and gathered because one can contain 120-180 gr of tobacco. The dismantling can only be done under the supervision of NAV and with a strict administration of the dismantling goods. Besides the sorting out of different tobacco products the highest value lies in the tax stamps. Their serial number must be sent to the tax office. After all these you can reclaim the money.

Cargos must be followed in all cases by documentation of course, as any other cargos. This refers to the by-products of tobacco industry as well. Tobacco dust and win overs transported abroad is considered waste at the moment, however, after a small transformation it returns to the factory as tobacco foil for further use. But as being a waste the regulation of the European Union refer to it (1013/2006/EN (REGULATION (EC) No 1013/2006 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 14 June 2006 on shipments of waste) and the company is obliged to fill in the number VII supplement of the order. This must also contain a reference to its being hazardous waste or not according to the Basel agreement. Naturally this tobacco by-product does not belong to hazardous waste. In the production of tobacco industry different adhesives are used, but these are adhesives of food industry and their containers are not contaminated with hazardous waste either. In the production no hazardous waste comes into being only oily rags are the only hazardous waste in the factory. Their transportation is certainly done according to the obligation of law by filling in an „SZ" sign.

3.3. Transportation of the excise goods (tobacco)

Essentially there are 2 halves of transportation solutions in the life of a tobacco factory: the one of raw material and the one of finished goods.

3.3.1. Raw materials

In the tobacco industry we do not usually talk about excise goods. The different packaging materials, the softening and flavor materials are not excise goods, nor are the raw or fermented tobacco leaves. The fine cut tobacco leaves are not excise goods either, when in production prepared for using up. However, if the fine cut tobacco leaves are sold (e.g. another producer wants to make cigarettes, consumer tobacco or pipe tobacco) these products are excise goods. As excise goods they represent higher value and higher security regulations refer to it. There exists a secondary product (tobacco dust) which is recycled in paid work by the company. The high celluloid content of tobacco is similar to that of the paper which makes possible to produce tobacco foil of it. The tobacco foil goes back to the company and it becomes the covering of cigarillo. Although this economical event occurs, it is not frequent in the life of a tobacco factory. Naturally if the production capacity makes it possible the factory favors his own production and makes the products mentioned above. But it can happen that the purchaser needs are so high that they can only be fulfilled by other partners by paid work.

3.3.2. Finished goods

The possible finished goods of a tobacco factory are almost all excise goods. Some additional products do not belong there only as the filter of RYO products (roll your own) that can be placed into the cigarette by the smoker himself, or the cigarette cover which are not produced by using tobacco or tobacco derivative. But other products (cigarette, cigarillo, consumer tobacco or pipe tobacco) are excise goods. Their being excise goods and their being taxed is certified by the tax stamps on them. The tax stamps are placed on them in the last stage of production. The purchaser pays the price on the tax stamp which already contains the excise tax and VAT.

The finished goods of the tobacco factory are valuable products moreover they already contain the amount of excise tax and VAT and this way they represent high value concentrated to a small place. Their storage must be done under strict regulation and there transportation must be made in maximum security.

The removing of final products from warehouses and their loading on trucks is done under the safety of a security guard. The company makes an effort to maximum security and also takes separate precautionary measures for the higher supervision of certain points. After loading the truck is sealed with a numbered seal, even in the case if the transportation is done to an outer warehouse. The trucks transporting finished products have GPS trail following system. The truck's trail can be followed even where it stopped and how long it waited. The drivers always have mobile phones that can be checked at any moment. The trucks are boxed, as canvas covered trucks cannot be used, they are not safe enough as canvas can easily be cut and the load is in no proper safety. Referring to transportation abroad the exceptionally high value transport must be assured as at eventual stealing or robbing the tax will be affordable for the state. Guarantee for the company is assured by a financial institution (bank or an insurance company) which of course generates more expenses. In the case of a tax change if the product cannot be sold any longer it must be recollected from wholesalers and retailers. Recollection must have the same security regulations. These products are excise goods apart from tax changes or prohibition of their sale in spite of the fact that they face destruction.

3.4. Warehousing of the excise goods (tobacco)

As for raw materials of excise goods we mention tobacco and NTM (Non Tobacco Material) materials. As I have mentioned above they are not excise goods. Their storing and warehouse logistics activity does not differ from the storing activity of any products.

Storing is different with finished goods as excise products. The warehouse is a tax-warehouse. Warehouses can be entered by authorized people only. As in the warehouse there is a repackaging activity as well, only authorized people can enter besides workers (cleaners and maintenance men). There is a card entrance system. In the 3 storey warehouse it is specified where the wrapping materials, where the waste originated from packaging, where the finished goods are and where packaging and errands are made. The record of provision must be precise. It is both required by the company and the law. It can be checked by the authority /NAV National Tax and Customs/ at any time.

The movement of provisions is also documented by the company. At present it can mean too much paperwork, on the other hand, we are planning the electronic bookkeeping and the introduction and organization of following of goods.

It will certainly lighten the administrative tasks and results in the better using of working hours, or a higher efficiency of work. Of course it needs investment and expenses, but in my opinion they will recover in a year.

Conclusion

Dealing with excise goods differs in many cases from the logistics of non-excise goods. This special way is required not only by the high value, but also by legal regulations and the controlling supervisory authority. There are strict regulations in some cases for purchase (tax stamp, which represents the same value as banknote) for production (the finished product is excise goods) and in some cases the cut tobacco as well, so it must have a tax stamp for storing and transportation of finished products (trail following protection).

Regulations related to the trade of excise goods or their administration limit the scope for action. The excise law prescribed the conditions of producing excise goods, the trade with them even in earlier times and defined the way of treating them so that even their change cannot avoid excise goods taxing regulations. Over the centuries it has often changed which products belong to excise goods. We do not pay excise tax for salt nowadays and there have been changes in the amount of excise tax and we can say that the law is more precise, it covers the protection of excise goods, their trade and taxation.

This is necessary for the state to assure this very important and essential source of its budget as precisely as it can.

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Taxonomy for Choosing BI Systems into an Existing Infrastructure

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Abstract Business intelligence, as a phrase was first used in 1989. The main reason for this was, that the commercial and sales experts at software development companies felt this expression could be better sold, than the used „decision support system". Since, there is no practical border between the two expressions. There is only a minor difference in adaptability: is the problem structured enough? Decades ago, it had to be, if the company wanted to use a decision support system, but today, it is not necessary the condition: At the business intelligence systems, there are many ways to solve a problem, the focus is always on the analysis, and thanks to the technological development, serious automation is possible, with more detailed decision support.

Keywords: business intelligence, business processes, software, platform, infrastructure

1. Introduction

In many occasions appears the following situation at logistics service providers as well: a new business intelligence system needs to be connected to the already existing (and running) infrastructure. On the other hand it would be helpful, if the connection (the system introduction) procedure would not affect the systems and business processes. So it would be ideal to have a business intelligence taxonomy, which could help the experts choose those solutions worth considering, and those not worth considering. The examination will process the systems' compatibility issues, and the taxonomy will process the business intelligence needs of the provider.

As for every company these days, business intelligence becomes more and more important for logistics service providers too [15]. Logistics service providers can make use of business intelligence in many ways: using the logistics-specialized functions (carrier performance evaluation, mode-cost analysis, supplier compliance analysis, carrier relationship management, capacity planning, cycle time analysis, routing and scheduling, truck and driver performance analysis, root cause and claims analysis [13]), inventory and warehouse functions [18] (inventory analysis, warehouse performance analysis, assigning warehouse costs, picking analysis, warehouse space utilization analysis), functions in relation with added value (cost-benefit analysis, reverse logistics, assembly analysis, kitting), and of course the „usual" BI functions as well (supply chain visibility, forecasting and customized reports), with management information services

(dashboard reporting with KPI indicators), marketing and sales (customer service portfolio and customer profitability analysis with customer service level analysis), HR (reports, manpower allocation, training and succession planning with the usage of HR portals) and financial (budgetary analysis, fixed asset return analysis and financial ratio analysis) analytics services [12].

Int he second part of the article handles the usual challenges in connection with business intelligence system introductory planning – concerning compatibility and connectivity issues – the critical points will be reviewed as well. The third part contains the results of the examination, with the focus on the available business intelligence systems, and their operating environment – taking into consideration their capabilities and given functionality. The last thought contains a well-known and approved taxonomy for BI (BI – business intelligence) systems, and a more modern and easier to understand taxonomy.

So, let us examine, how is it possible to adopt the most modern BI solutions into an environment with an already existing infrastructure – including hardware and software – and if it is possible to develop a usable taxonomy [16].

2. Business intelligence systems and their existing environment

The assumption is current, because there are numerous studies on how to build cost effective corporate IT systems with integrated business intelligence solutions from scratch, but the majority of these studies do not focus on factors really typical to the corporate layer: the first factor is, that most companies do have a considerable past, and has to operate during the introduction process as well – or just very small halt is acceptable. The second factor is, that these corporate systems are very heterogeneous – on both hardware and software sides. The reason for this is in the evolutionary development of the companies, at many companies, the old systems are kept for a long time – either because it is needed, or there are no funds for replacing them.

At the planning / design stages of business intelligence system introductory projects those factors require extra attention – which often gives a crossroad opportunity for software engineers. The more expensive solution is always, if at the time of the introductory project refactoring and modernization gets place, with the re-thinking of the used solutions [1]. The more cost-effective solution is, however if we examine, if the already existing infrastructure could handle the extra load, and if so – would it be possible to place the BI system on top. If that is not the case, a wider range of possible solutions are needed to be examined.

Of course, the requirements, that the new BI system has to meet, have to available at an early stage of the project, so the developer team can form the infrastructure in time [1].

If the soon-to-be-realized expectations are known, the resource needs can be calculated. As a general rule, the functions can be grouped as low resource requirement or high resource requirement.

The low resource requirement group contains typically periodical (so, continuous functionality or continuous calculation is not required, so the load waves can be dispersed smoothly) tasks, for example the daily statistical calculations.

The high resource requirement group contains typically continuously operating functions, or functions with real-time requirements. Business intelligence is usually seated in this group with other CRM and decision support solutions, since these functions require complex calculations. As the processable data size grows, so does the resource requirement of the operation.

In case, if there are no high resource requirement functions present in the specifications, it is verifiable through experience, that the already existing infrastructure will be able to handle the claims. Knowing the load waves (which can be determined at the early stages of the introductory projects situation analysis) so the regular functions executions can be timed not to be placed in a heavy load period – so the overload periods can be avoided.

In the probable case on the other hand, when there is a claim for functionality with high resource needs, it is necessary to think through the opportunities [2]:

- Rent infrastructure as a service: the full outsourcing of the IT infrastructure, known as the IaaS renting model.
- Renting platforms as a service: paying for the development platform (with the operating ones as well) with infrastructure – known as the PaaS service model.
- Using software as a service: the highest level service, many types are known, but the usage-dependent pricing with the fix pricing models are the most widespread.

These three levels of service can be perceived as a pyramid, where the most detailed service level is represented at the top – using software as a service, while at the bottom – with the lowest level – is the infrastructure as a service model [17].

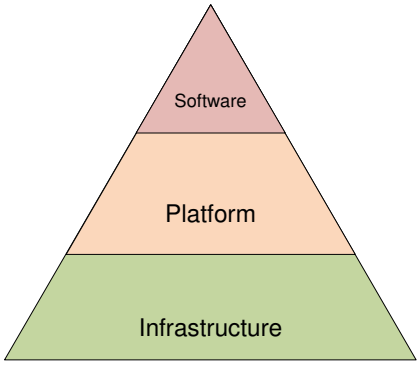

Figure 1. The usable service levels

It has to decided in the early stages of the design phase, which service level to use (if any) – it is a good practice, to handle these levels as inputs for the Kesselring algorithm.

The number of business intelligence related software is around approximately around 60. (Of course, it does worth mentioning, that there are more complex software bundles, and there are simple systems with limited functionality – or specialized for only one task, for example data integration or data visualization.) Although that market has many competitors and of course there are less complex systems, it is hard to draw a line between these two categories.

The connection between the already existing infrastructure and the BI system has usually 2 critical points:

- The first one is the operating system (which handles the communication with the underlying hardware),
- And the second is the connection to the existing databases.

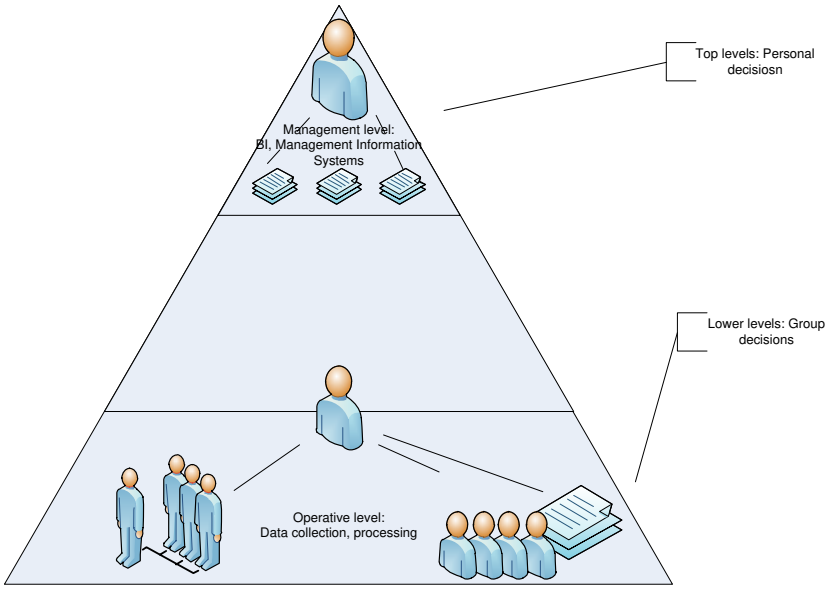

Figure 2. Place of BI in the company hierarchy

So, before putting the BI system into the infrastructure (or better said, on top of it – Fig.2.), it has to be taken into consideration, if it will be able to operate on the operating system, and use the existing databases. After the filtering, the remaining solutions have to be examined, on the functional side – if they are capable of meeting the requirements.

To decide whether it is possible, to integrate a BI solution into the existing infrastructure (or at least on platform and database sides), the available solutions have to be examined [17].

54 of the business intelligence solutions were processed in the examination. Most of these systems are commercially available, but there are free software, and open-source software between them.

3. Examination and results

The examination proved on hand, that the leaving the classical client-server architecture is in progress, aiming web architectures. On the other hand, it was revealed, that those systems built on the classical client-server architecture or simply desktop applications are using the widespread frameworks, like JAVA technology and .NET. The positive side of this is, that these frameworks are available on many of the used operating systems.

As for the operating systems on the already existing servers (if there are new hardware elements purchased along the way – at the introductory project, that will assign the whole project to a higher price range, but frees the project from dependencies) the elasticity of the products differ. Looking from this viewpoint, grouping upon, if more operating systems are supported looks like a good basis.

The bigger, more complex systems (especially those, with decades of development) thanks to their evolutionary development, can be said, that usually support the industry-standard operating systems on server side. These are:

- z/OS: The operating system for IBM mainframes. Supports backward compatibility, large memories and a series of mainframe technologies.
- Unix / Linux: Since the development of Unix in 1969, a series of unix-like operating systems came into use (Linus, BSD). The widespread available, free and open source solution was the Linux (and many versions are still), but has commercially available versions too.
- Solaris: A unix-like operating system developed by Sun Microsystems to support SPARC and x86 servers and workstations.
- Suse Linux: the oldest open source Linux version – there is a supported version for enterprises.
- Red Hat Enterprise Linux: the other enterprise Linux, having a considerable share.
- Windows: The Microsoft Windows had three versions on server side, which laid the foundations on the server side headway: Windows NT, Windows Server 2003 and Windows Server 2008 – the R2 release is also available. Typically used because .NET server side need, or IIS web server requirement.

The other group contains the less complex systems, providing less or a narrower range of functionality, capable only to solve a few, typical problems, and having less elasticity. These systems are generally not capable of server-side computing, and does not have server side functionality as well – so defined as desktop applications. Since it is easier to implement these systems with advanced developer tools, most of them were created using JAVA or the .NET framework. The benefit of a realisation like this is, that running the application will have only the prerequisite of installing the framework – those are available on most commercial operating systems.

While 25,9% of the examined solutions was written in JAVA language, 48,1% of these were developed to be run in windows environment. The two sets do not overlap, but worth mentioning, that all of the open source and all of the free systems were developed with JAVA.

The availabilities of JAVA environment are show in the following (Table 1.) table:

Table 1. JAVA availability

	32-bit version	64-bit version
Microsoft Windows 7	X	X
Microsoft Windows XP	X	X
Microsoft Windows Vista	X	X
Microsoft Windows Server 2003	X	X
Microsoft Windows Server 2008	X	X
Microsoft Windows 2000	X	
Sun Solaris	X	X
Linux	X	X
Apple OS X	Exist, own version.	

The .NET framework is available on the Microsoft operating systems (in certain versions it is preinstalled, and freely upgradable) and available on Linux as well, it is developed in the Mono project (Mac OS X and Solaris are supported too) – usually one step older version, than the newest available.

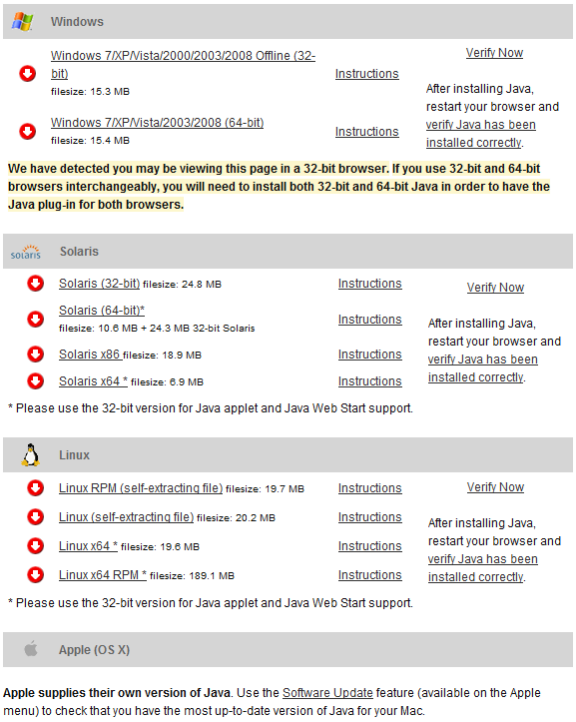

Figure 3. JAVA availabilities from the official JAVA page.

The question – whether (which is less expensive) to use free software with more expensive support and staff or use commercial software, with cheaper support and staff – often induces heated debate on professional (and on-line) forums.

The other important technological factor is the database connection. It had to be examined, what database connectivity capabilities do the available business intelligence solutions have. Of course, in this aspect, there are many ways, if the native support is no available: for example third-party ETL software, or mid-tier applications. During the examination the following database connection opportunities were covered:

Working with developer-specific / product-specific data sources: specially the feature for large software bundles, from developer companies, which are capable to give the full technology stack needed for enterprises. These products a trying to drive their clients to integrate more and more of their solutions, by preferring these data sources. Approximately 44,4% of the examined solutions are capable of using product-specific data sources.

SQL: the simple query language, known by almost every database-related software [5]. However there are product-specific differences from the standard, like Ms-SQL or the PL/SQL used by Oracle. All of the examined solutions were capable of using SQL, but worth mentioning that in some cases, because of a different programming language, those commands needed to be wrapped in a way.

XML: the text format of W3C, specially designed to deliver internet documents. It does support Unicode characters, usable in many programming languages, and by producing web services or data sources [6]. The usage requires a special API, but that is available in all languages – 72% of the examined solutions were capable of using XML.

ODBC: Open DataBase Connectivity, an interface developed to be independent from programming languages and operating systems [7]. With its help, the knowledge of the ODBC-defined interface is enough; and from then it is the duty of the driver present, to translate the commands to the database management system [8] – 54% of the examined solutions were capable of using ODBC data sources.

JDBC: Java DataBase Connectivity, an API to JAVA language, to reach relational databases [9]. With the help of the JDBC-ODBC bridge, Java can access the original ODBC functionality. The equivalent for .NET environment is the ADO.NET [10]. Naturally, every single solution written in JAVA was able to use JDBC data sources.

Thanks to the application of these standards, the business intelligence systems are capable of using the optional databases. There are exceptions of course, and in the these cases it is expedient to look for other connection opportunities – if necessary.

4. Goals and importance of the taxonomy

Taxonomy is a hierarchical classification or ordering method, which can be done at any number of dimensions.

A very important expectation to any taxonomy is, that every element of the described space has to have a place in it, so in this case: we have to be able to place every singe business intelligence application (already existing or future development).

If every solution has a place in a taxonomy, then it can be used at the inspection of alternatives, at a system introductory process – or in other words: an advise can be made based on limited number of information, shrinking the circle of available systems, so it will be easier to choose the right solution.

4.1. The origin of business intelligence taxonomy

Since business intelligence systems are one of the most popular IT systems of the decade, the number of publications in connection grew great – which turns out to be much less, if we do not count the marketing aimed publications.

The most cited and still valid taxonomy was created by Colin White. (He is a leading researcher in BI, a speaker at many significant conferences, and he is in connection with http://bi-research.com and http://www.b-eye-network.com web portals – he has periodical publications int he topic.) That (first) taxonomy was done in 2004. The base of the taxonomy was to divide the business intelligence applications (which only cover a part of the whole BI process) from business intelligence platforms (which can provide a base for building integrated, more sophisticated, company-wide systems).

According to the taxonomy, business intelligence applications can be groupped in many ways. The first of these is the timeframe, and the decision level, which they support: so strategic decisions (of creating strategic plans), tactical or operational decisions. These systems can be grouped according to their granuality: the outputs can be detailed or summarized. The next grouping rule is the type of the used data store: data warehouses, data marts, OLAP cubes, immediately accessible stores, data caches, snapshots and virtual views. The next dimension is the applicable business rules: these can be transformations, analyses, using metrics, creating actions, handling exceptions and advices, which action to take [11].

Every type of business intelligence can have different timeness or latency, so the diversification follows: there are real-time, near real time and historical systems. The next dimension is the type: there are applications capable of handling transactional data, using business / performance / special field indicators, and those, which are able to automate warnings, actions and offers.

The more complex systems, which are made up many integrated and cooperating applications were already sold in packages; so that is the next dimension: there are developer packages, data integration packages, coordinating, designer and forecasting packages.

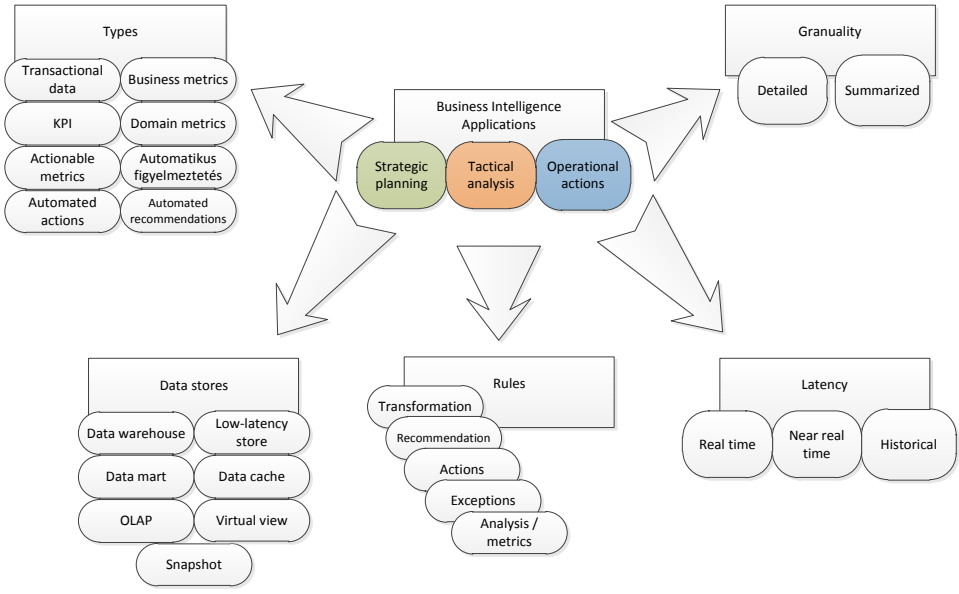

Figure 5. An already existing taxonomy for business intelligence applications

The developer package is defined by the dashboard-making application, some kind of interactive development environment, rule engine, analytical application, a reporting studio and performance management application. A data integration package is defined be the data modeller and exploratory applications, the ETL designer with metadata management capabilities, considering data quality as well. A designer and forecasting package usually contains data mining and text-mining solutions, cost management and

forecasting applications. A system introductory package and a teamwork promotional package is described by CMS, dashboard, portal and teamwork enabling services. A bit more divided, but the last dimension is the place, where these systems are used: front-office, middle-office or back-office [11]. Aside from this, during the last decade a respectable amount of categorisation was created.

4.2. New order – new taxonomy

The mentioned and described taxonomy is considered good, but the 8 years, since it was created contained many new business intelligence solutions, and the market competition is ever-sharpening in this sector. Beside that, many new systems can cover more areas, and reordering of the market caused the blurring of borders in these categories. But the greatest reason for making the taxonomy more simple is the causal relation created by market trends (the price of technology dropping).

To create a simplified taxonomy it is needed to reduce of dimensions in the model. The easiest way doing this is looking for relationships between dimensions. During the search, 3 methods were used: the mentioned BI research, interviews conducted with professionals and years of practice.

According to the results, the granuality of the results is not necessary, since almost every system has settings to provide detailed or summarized results. Keeping the timeframe is useful on the other hand, to diversify between strategic planning, tactical and operational decisions.

Keeping the latency in also proved useful, although the examination and the interviews showed, that there is a weak connection between latency and timeframe: in most cases, a product capable of strategic planning, can also use historical data, and products with tactical decision support are capable of using near real-time data, and of course the operational decision supporting systems usually capable to use real-time data. However, these categories should not taken strictly.

In my opinion, the third dimension should contain the development capabilities of a given product (Fig. 7.). So, in this dimension the following categories are expected: COTS products (Commercially-Off-The-Shelf, or commercially available) – these products can be described with easy installation process and limited settings with simple functionality, Customizable COTS products (products with a wide range of settings and connection points, but no development environment in IT sense), COTS products with development suite (containing a development environment, usually containing a programming language) and in-house developments (specially designed to solve a specific problem).

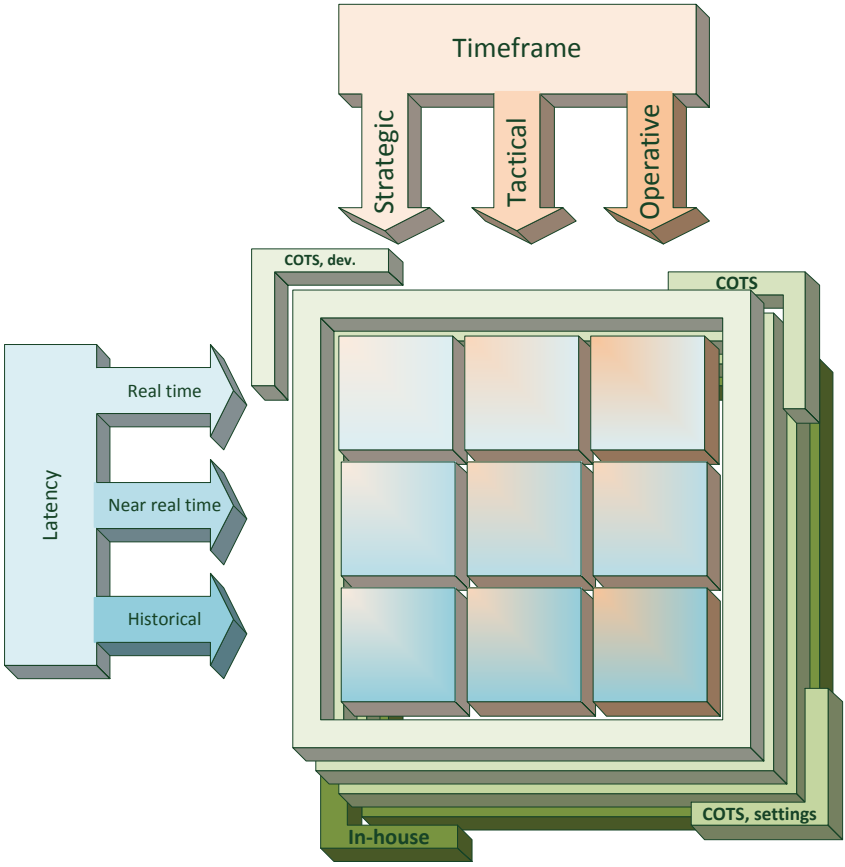

Figure 6. The new taxonomy

Since the taxonomy has to be capable of classification of every single BI solution; it has to be tested. Let the example be the SAS Enterprise Guide application (Fig. 7.). This software is capable mostly of strategic planning, and less of tactical decision support – since it is a management information system; mostly capable of using historical data, but the possibility is given of using near real-time data as well. Itself is a COTS product, with a wide range of customization available. It is a different question, that the developer of this product (SAS) offers a whole development environment, and a wide range of BI support products as well – so given the chance, and buying the whole package would cover the entire space in the taxonomy.

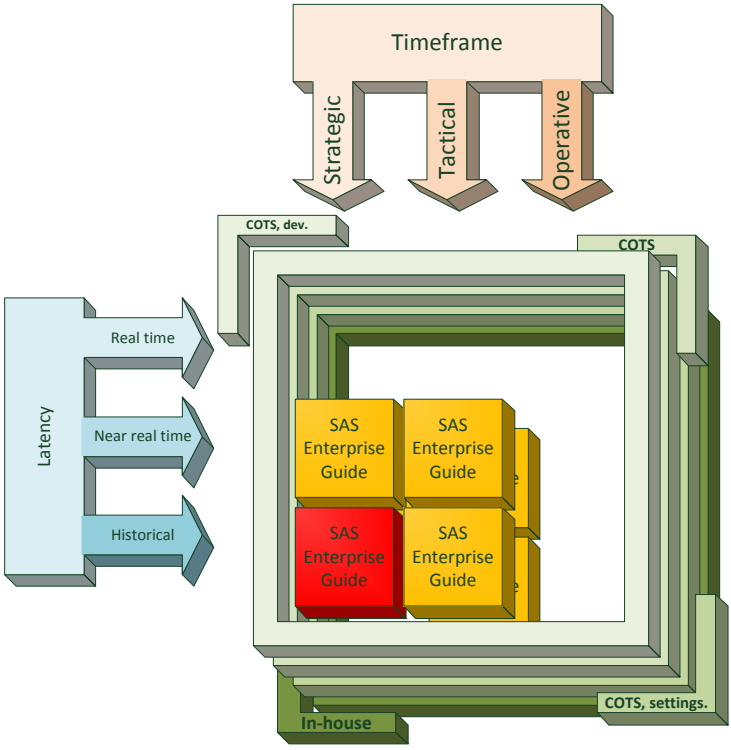

Figure 7. SAS Enterprise Guide placed in taxonomy

All 54 of the BI applications can be placed in a same way into the taxonomy. During the interviews, the question arose, if the interactive publication of the whole survey would help (or would make easier) at the beginning of a system introductory project. Nearly 70% of the answers were solid yes' with the constraint, that even with the taxonomy, there are many solutions with similar functionality, so feasibility studies (the second part of the article contains the compatibility issues) and introductory plans are needed, to clarify, how can those solutions serve the company's needs.

5. Conclusion

At last, it can be said – without citing the need for BI systems, or their efficiency – that it is a great challenge to implement a business intelligence solution into a existing infrastructure.

It is not easy to conquer the challenge: the same preparation is needed, as any other software project (even a specialized methodology exists, proportioning the task to steps) and the same amount of attention – if not more – is needed. One of the initial steps is choosing the applicable software components: it is important, that it has to be compatible with the already running (existing) systems, databases, infrastructure and data sources.

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Environmental Conditions Causing Change of Colour on the Packaging of Products

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Abstract The primary task of the packaging of goods is to preserve the quality of goods. During distribution it is unavoidable that the products are exposed to harmful environmental effects but the intensity of these effects may be different. We are able to avoid applying the time-consuming and expensive product analyzing methods if we can estimate the quality of the product by examining the quality of its packaging. Our study wants to find out whether we can select those products in which quality deterioration processes might have started due to external environmental effects via the examination of the colour change of the packaging material.

Keywords: packaging, ageing, colour space, rg-histograms,

1. Introduction

The basic concept of our study is to elaborate such a procedure that makes it possible to show the environmental effects on the packaging of food and, indirectly, on the product itself via the change of colour of the packaging.

During transportation of the goods, it is impossible to avoid that they are exposed to harmful environmental effects such as mechanical effects, solar radiation, humidity, moisture, temperature, oxygen, physical contamination, chemical contamination, microorganisms, insects, rodents and people, for a shorter or longer time.

We are to examine the effects of solar radiation on the products through the possible alteration of the colour of the packaging.

Apart from opening the packaging of the products, the technology that is described and tested by us can help to decide what type of environmental effects have reached the given product and for how long, whether quality deterioration has been caused by these effects. If we can show it on the packaging that the product has been exposed to harmful effects, the product has to undergo further inspection.

1.1. Elements of packaging

First and foremost, it is important to set the basic terms of packaging. Packaging has two meanings. In the one hand it means all the processes with which the cover of the goods is made, on the other hand, it means all the materials and devices that make up the cover. Traditionally, packaging has three functions:

- the protection of the product against external environmental effects
- encasing the product into a safe and practical unit
- satisfying the costumers' needs and product promotion

These functions may predominate the phases of the distribution chain with different emphasis. When we talk about packaging it is essential to distinguish between packaging materials and packaging devices. Materials include metal, wood, glass, paper and plastic, which are used in packaging. The packaging devices are packets that you can close, tubs, hollow-ware, pots, boxes, drums, etc. that are made of the above mentioned materials and become waste after the product has been consumed. [1]

2. Elements of colorimetry

Second, it is essential to define the basic colorimetry terms in order to understand the process of our new method.

Colour can be defined as a perception in our brain. We need optical radiation (what we commonly refer to as light) which, after entering our eyes and being absorbed by our retina induces nervous signs. In case of monochromatic radiation the perceived colour depends on the wavelength of the radiation in case of complex radiation the perceived colour is determined by the amount of energy the radiation transfers in different wavelength ranges. Colour can be defined as a property of an object and this property shows in what ratio the object absorbs or reflects the different-wavelength components of the light that shines it. However this refers to a property of surfaces.

The spectrum of a light source, the reflectance function of a colour sample, can be defined as the amount of energy transferred on a given wavelength or rather how big its radiated power is. Any spectrum as colour stimuli can be described with three values, R (red), G (green), B (blue), because of the types of receptors in the human eyes. One of these cones is sensitive in the short, the other in the medium, and the third in the long wavelength domain. In case of displays, printers and digital cameras, we are using now the sRGB (standard RGB) system developed by HP and Microsoft instead of the CIE RGB colour space which was developed by the International Commission on Illumination in 1931 because it fits better to the modern hardware [2]. The gamut of the sRGB system in other words the group of colours that can be presented in the colour space is shown in figure 1.

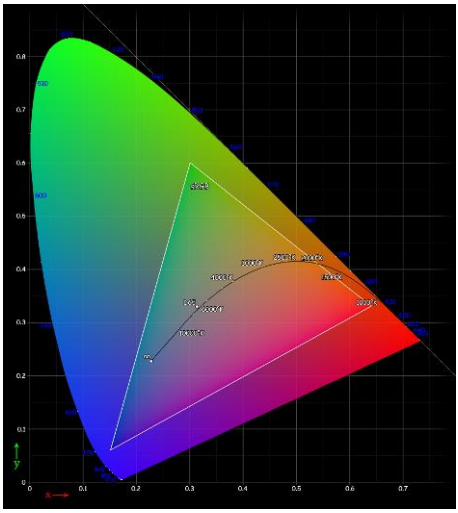


Figure 1. The gamut of the sRGB colour space

Although the metamer colours are perceived in the same way, their spectral power distribution is different. The sameness may be true for more colours. If colour A is identical with colour B, and colour B is identical with colour C, then colour A is identical with colour C as well. Therefore, it means that the colour determined with values R, G, B can be provided with several spectra.

2.1. Gamma correction

In CRT (Cathode Ray Tube) monitors, the light intensity varies nonlinearly with the applied anode voltage (Figure 2). Altering the input signal by gamma correction can cancel this nonlinearity, such that the output picture has the intended luminance [3].

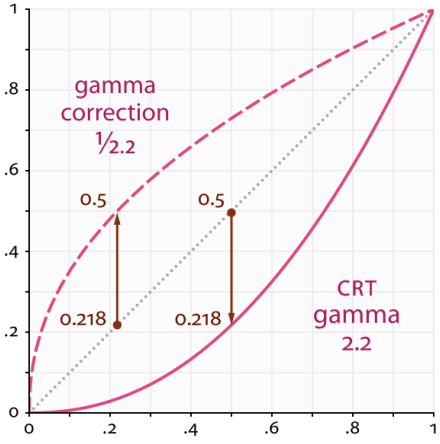


Figure 2. The gamma correction of CRT monitors

3. Tests on product samples

Our tests have the starting assumption that the colour of the packaging of different product samples that are exposed to different environmental effects will change even if slightly, differ from the original one. This change may be unperceivable for the human eyes, so the original and the altered samples are metamers for us. It is possible to reveal the difference between the original samples and the ones altered by external effects with our method.

As the first step, we examined how a bus season ticket and a luncheon voucher had changed in the bright sun and in a freezer. The samples spent 8-8 hours in the sun and in the freezer, then, they were digitalized and compared to the original reference samples.

Second, the changes on a chocolate wrapper and on a milk carton were tested. The products were lit to simulate the fading effect of the Sun in the laboratory. We used an *Accelerated Weathering Tester*, *QUV Spray* machine and a device called *Xenonstahler*. The former device was used to examine the effect of the UV-light. The samples were lit for 8 hours, they were conditioned for 5 hours, and they were lit for another 8 hours. The samples spent 21 hours altogether under the Xenon-light in the other device. Then the samples were photographed in the same conditions and the digital images underwent a comparative process.

Furthermore, it was examined how the packaging had changed after being lit with UV-light for different time periods. In this case, a fruit juice carton and a medicine carton were lit for 8, 24 and 48 hours and digitalized every time. After digitalization, we compared the samples with our method.

3.1. Testing method

The essence of the method is to make a digital fingerprint of every picture and to compare these fingerprints. The method shows the difference between the samples which are metamers for the eyes. This digital identification is determined as it follows.

The R, G, B values of each pixel of the image under examination are read and these values are normalized (1).

$$r = \frac{R}{R+G+B}, \quad g = \frac{G}{R+G+B}, \quad b = \frac{B}{R+G+B} \tag{1}$$

$$r + g + b = 1 \tag{2}$$

It is enough to have two data to describe the colour of a pixel as the third value can be calculated with the help of equation (2).

$$V_{linear} = \begin{cases} \dfrac{V_{srgb}}{12.92}, V_{srgb} \le 0.04045 \\ \left(\dfrac{V_{srgb} + 0.055}{1.055} \right)^{2.4}, V_{srgb} > 0.04045 \end{cases} \tag{3}$$

In order to eliminate the effect of the gamma correction and to obtain linear R, G, B colour space, inverse gamma transformation of the scanned values is performed. The sRGB gamma cannot be expressed as a single numerical value (3), where V_{linear} is R_{linear}, G_{linear} or B_{linear} and V_{srgb} is R_{srgb}, G_{srgb} or B_{srgb} .The frequency of the read and normalized r-g value pairs appearing in the picture are fixed in a two-dimensional matrix. The row and column indices of the matrix are corresponding to the r g values, so the value in the rth row and the gth column of the matrix shows that how many of the given r-g pairs can be found in the picture. Making a graphical presentation of the matrix gives the unique digital fingerprint of the given photograph. This r-g plot is an important property of the pictures.

For the sake of a better comparison, we even derived the difference between the rg-histograms of the original and the examined image, the positive and the negative differences are shown with different colours.

The program was written in Python [4] language with the OpenCV modul. The reason why this language has been chosen is that it makes easy to code the algorhythm quickly and efficiently, moreover, it has the necessary tools to handle digital images.

In order to describe the differences between the rg-histograms numerically, the embedded functions of OpenCV were applied. Correlation, chi-square [5] and optical flow [6] were calculated. The latter described the differences due to the shift of the samples and of the patterns on the samples. The average length of the vectors of optical flow was weighted with the values of the rg-histograms, so the shifts of the brighter parts were considered with higher weight. Besides numerical description, the vectors of optical flow were given graphically. The following figure shows the graphical presentation of the optical flow with an enlarged section (Figure 3). Further on, these figures will not be displayed owing to lack of space. The smaller value of correlation refers to a bigger difference, on the other hand, the higher values of the chi-square and the optical flow refer to bigger differences among the tested samples.

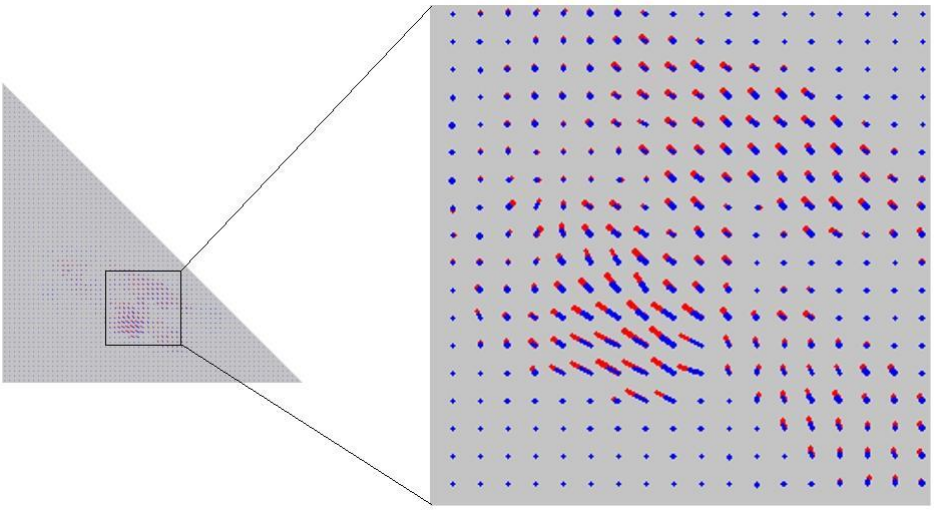
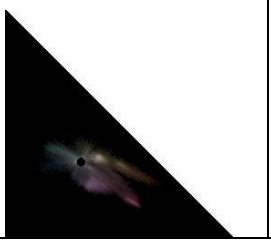
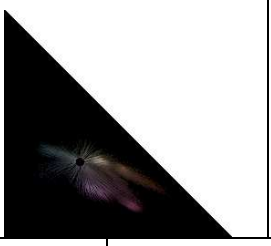
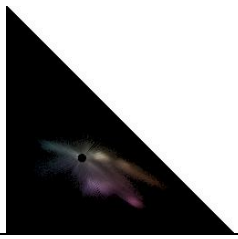
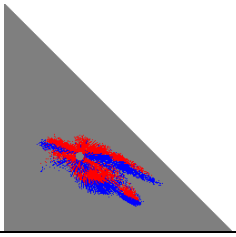
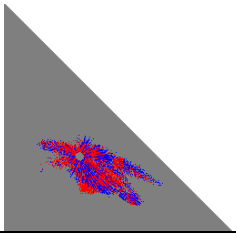


Figure 3. Graphical representation of optical flow

3.2. The results of the tests

The final results of the tests are as follows. Examining the season ticket and the voucher first, it became unambiguous that the method helps to show the changes of colours. (Table 1). The second rows of the tables show the samples, the third row shows their rg-histogram, and the fourth one shows the rg-histogram of the difference from the original sample. The values for *r* are plotted on the horizontal axis, from left to right, the values for *g* are plotted on the vertical axis. It is clear from the numbers in the last row that the method reveals the difference that is not perceived by the eyes. There is a significant, numerical difference between the sample lit by the sun and the reference sample. In case of freezing, the difference is less significant, but verifiable.

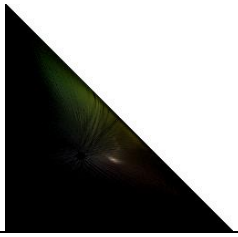
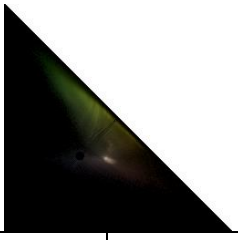
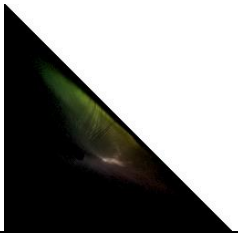
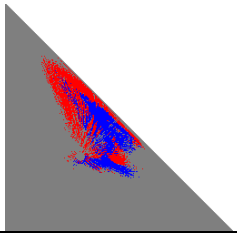
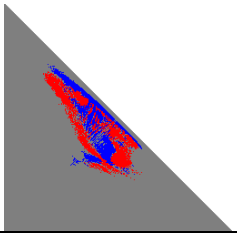
Table 1: Bus season ticket

Sun-lit	Original	Frozen
		
		
		
correlation: 0.6836 chi-square: 1.4661 optical flow: 3.6516	correlation: 0.9544 chi-square: 0.1565 optical flow: 0.8370	

The tests on the luncheon voucher led to similar results. The changes were provable and the sample lit by the sun changed more in this case as well.

Secondly, we show how the samples have changed in the laboratory under the xenon light and the UV light (Table 2). Similarly to the above, the pictures of the samples are shown first, then the rg-histograms, third, the graphical presentation of the differences from the original samples, finally, the figures.

Table 2: Milk carton

Xenon light	Original	UV light
		
		
	
correlation: 0.2642 chi-square: 4.7413 optical flow: 2.6028	correlation: 0.6489 chi-square: 1.7879 optical flow: 1.3083

Our method resulted in such differences on the other sample that are well-described with figures, though the reference sample and the sample exposed to light seened to be the same.

Next, it is shown how the sample changed when it was exposed to UV light for different time periods. Even spending eight hours under the UV light caused a minor change, and the change of colour continued increasing monotonously (Figure 4). The tendencies were similar in case of the other sample and when the resolution was halved during digitalisation.

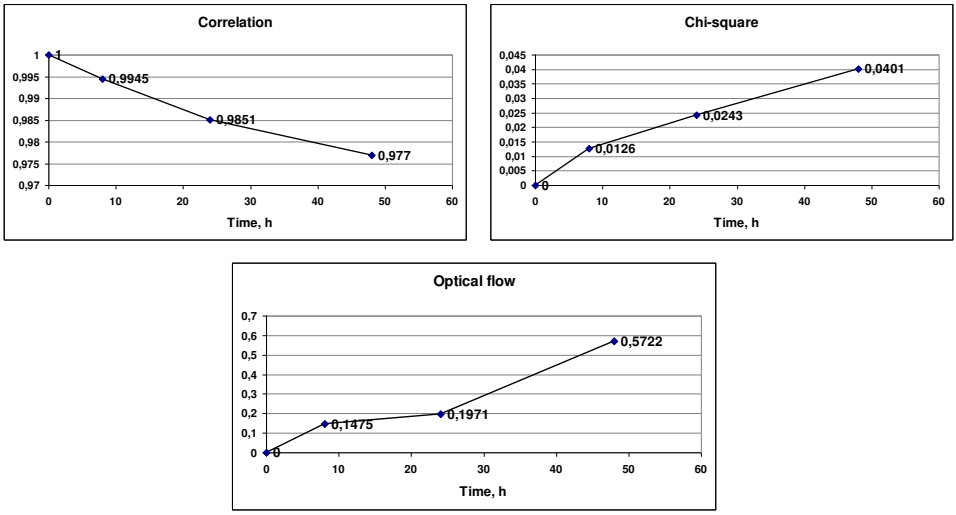


Figure 4. The changes of numerical data in time

Finally, we examined how big the differences were after having digitalised the same picture with a scanner or a camera three times. We wanted to know whether it causes a significant difference in the histograms if we modify the position of the sample on the scanner a little bit, or rotate it with 180°, what difference appears when we modify the position of the camera. Finishing these tests, we could claim that the correlation results, which were higher than 0.99, the chi-square results, which were under 0.01 and the optical flow results, which were around 0.1, proved that the method was less sensitive to differences due to measuring inaccuracy.

4. Summary

The method described briefly in the article makes it possible to decide whether a product has spent too much time in the sun. This method provides a pre-test in those cases when we assume that the product has not been stored properly. If the method shows that the product has not been stored in proper conditions, further examinations are necessary.

Acknowledgement

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The Analysis of GIS Provided Economic Benefits in Packaged-Products Track and Tracing

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Abstract: Nowadays the various IT solutions provides possibilities in all fields of life for collect and detailed analysis of data. With the help of these devices an opportunity presents itself to measure and record the effects which are occur in products during transportation. These data also can be pared with the geographical coordinates of the transportation facilities. The goal of the article is to sketch and present an IT solution, which can prevent the product and packaging damages or help to establish the origin of the damages with the use of this data. After the operation describing of the principles, the article presents the possibilities of the application by means of a case study.

Keywords: packaging-products, transportation, GIS providing, damage.

1. Introduction

As it is shown in the interpretation, logistics as a part of supply chain management equal with the planning, implementation and management process with the will to meet the customer's requirements that the materials, semi-finished and finished products, and the related information are to be transported from the origin to the location of use in an effective and cost friendly way.

System implementation should be cost-effective. Of course, the situation is more difficult considering we have to calculate with stochastic effects in case of different logistic chains. Against this, conditions and values exist that can be recorded in an easy way using GIS. If you use them during planning phase, the route that was more expensive before, will become more effective and cheaper in total.

Justification on the choice of topic, declaration of the target

The aim is to create the funds of a system that supports the decision on routes. This application is based on database, and supports logistic staff to find a more economical 'route-value' even in more expensive transport route.

We know it from real life that product damage is one of the most significant waste during transportation period that we should avoid in any case. Loss like this occur even in the cases when all of the standards are complied.

The costs can be easily definite but hidden costs emerge usually later. Fuel and wages are costs that can be calculated in a previous time, but wearing of tyres, punctures, and the damages previously unplanned -even in vehicles or in the products - are typical hidden costs if the rate and the punctual time of occur is not known.

However in the vehicle- road destinations the effects that impact the product can be definite with high accuracy. The errors on the road, the rail crossings are fixed points on the route that worth avoiding, so you will be able to reduce the failure factor of the cargo.

The aim is to set up a database with the recording of these coordinates and defining location. By means of the database you are able to minimize the damaging of products during the transportation period, so you will reach higher profit with saving of the products.

2. Logistic stresses during road transportation

During a continental road transportation, which includes the handling and storage processes too, it is quite easy to define the qualitative characteristics of the logistic stresses. These kinds of stresses, which include both mechanical and environmental stresses, have got high importance in the field of product – packaging development [15]. Before the design or development process we have to know all the logistic stresses. The stresses have to be well defined by values, indicators or indexes.

In the followings, we describe shortly, those affects, which have got high importance during road transportation.

- The vibration stress means the major item by the duration. During the complete transportation process, the product packaging systems, like transport loads, get the affects from continuous vibration. These vibrations can be developed from the unevenness or roughness from the road (like railway crossings, pitch-holes, etc.), and the combination of the vehicle's spring characteristic and the force of inertia with the unbalanced loads. The vibrations on the load platform are stochastic type, which means that the combination of the vibration frequency and amplitude strongly fluctuating at time. There are frequencies, where the amplitude exceeds the acceleration. In these moments, the load abandon the platform, but during the continuously appearing platform vibration the fallen down load be able displace [10, 12]. In those cases, where both vertical and horizontal load position displacement appear, we often have to count with product or minimally packaging damages. Extremely, these affects appear as a shock stress.

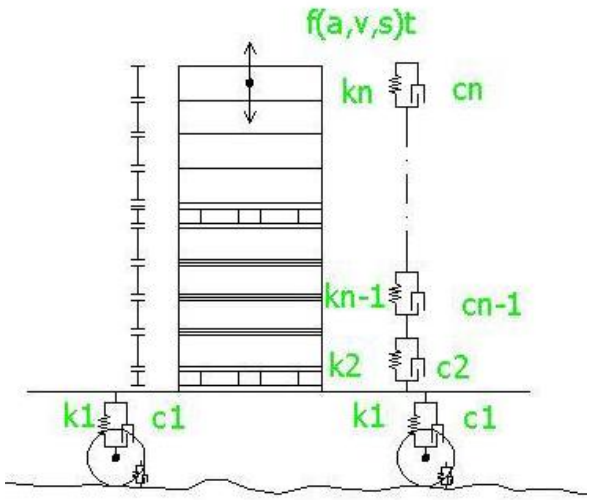

Figure 1. Mass Spring Damper Model
(Source: own drawing)

The Fig. 1. describe the simplified mass – spring model of a stacked load on a truck platform. The k1..n means the spring stiffness, the c1…n mean the spring stiffness.

- The shock and impact stresses appear very often. But if we comparing a two different transport on a quite same route, the results will shows more differences in the number and intensity of the impacts. These characters highly influenced by more personal negligence and technical parameter. For example an improperly – means higher vehicle speed – passed railway crossing or road section, be able generate extreme high number impacts with extreme g values. The shocks and impacts also are able to appear in both vertical and horizontal versions. The horizontal impacts can cause, slipping of the loads [9]. For stacked loads the vertical impacts also can cause tippling or tip over. If we know the exact transportation way, the vertical impacts may be defined in quite good conditions, and critical areas and points also be able to predict well. During the handling and warehousing the impact characters also are able to forecast [1]. The Fig.2.clearly describe those shock parameter interrelation, where the packaged product has got damge or not. The limits of the non – damage areas can be defined only be measurements.

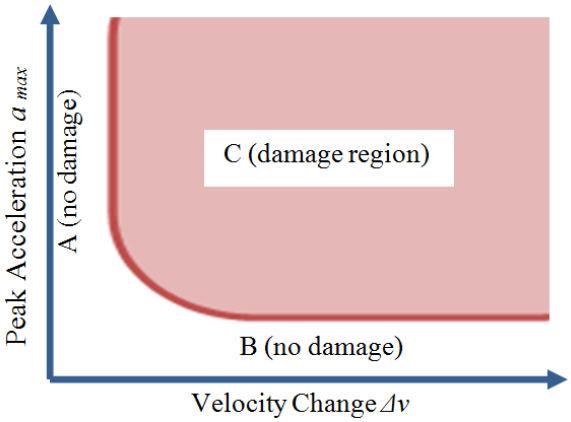

Figure 2. Damage Boundary Curve of a packaged product
(Source: own drawing)

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- Stacking during transportation or storage is a wide spread process, because by this we can improve more logistic indicator [4]. So this parameter is essential during the product - packaging system development, but when we also count with the above mentioned stresses, we will get a very complex task, which conceal more design problem. Stacking stress can be appearing as a dynamic and as static stress too. Both types influenced by both technical and personal parameters on a wide range. By the improperly transportation and/or handling the distributed load is able to transform to a local load, which often cause product damage [2].
- During an exact logistic process, which including the transportation, warehousing and handling, there is one more stress which continuously appear and attaching to the different mechanical stresses. This is affect is the different appearing forms of environmental or climatic stresses. During continental road transportation, the form and the exact values or parameters of the climate affects, can be well described and these are countable. A transport packaging which developed only for road transportation, the major effects are the relative humidity of the air, the temperature and its changes. The appearing versions of these parameters can highly influence the product protection function of the packaging system. There are many transportation task, when the developed packaging system has got good logistic and economic indicators and values, but the unknown or fail counted environmental stresses be able to reduce the efficiency and possible cause product damages [3].

3. The summary of the operation

The device is tightly fixed to the load so it moves together with the goods when an impact presents on the road. The device writes the time, the latitude, the longitude and the measured values to its memory. After forwarding the collected data get copied into a computer. With the collected data the system is capable of looking for the cause of

damage or building a database. In the first case it is possible to fix the time and position of the damage, and we can decide whether the damage could have been caused by driving, road conditions, weather conditions or other external factor. In the second case we can build a database by parametering a map with which we can decide which one of the two possible routes is the best.

When some damage happens after transporting then it is important to write down the typicals of the damage [5]. After that the process of the collected data is coming. The task is to select those data which are higher than the standard values.

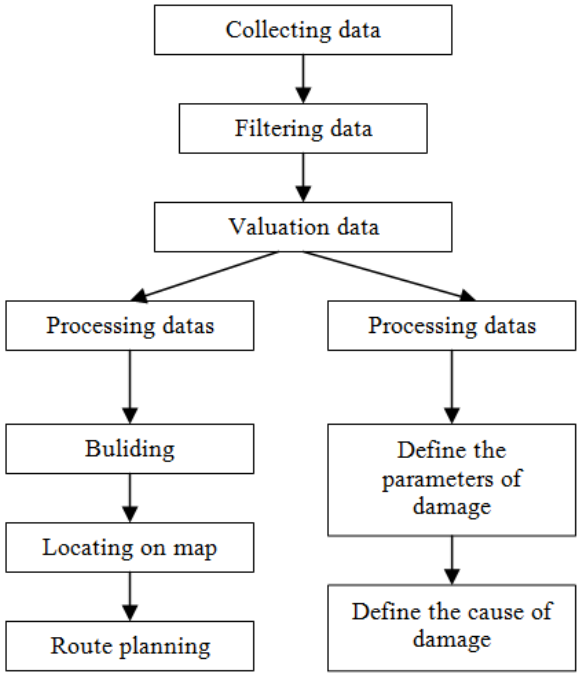

Figure 3. The summary of the operation
(own editing)

So the task is to analyze the data of one route. Only the different values are important. The scale and the type of the value can explain the type of the damage. When these data are paired with latitudes and longitudes, the places of the events can be located. With the help of a map it is easy to decide whether the quality of the road, or a driver or other different external event is the cause of the damage [14].

A parameterised map helps to choose different routes between two points in forwarding. Different routes had different distances, different road quality, different weather conditions, etc. So we can decide, that our product is packed strong enough for a shorter but harder route or we must choose a longer and more expensive route because the goods are too sensitive against external influences [16].

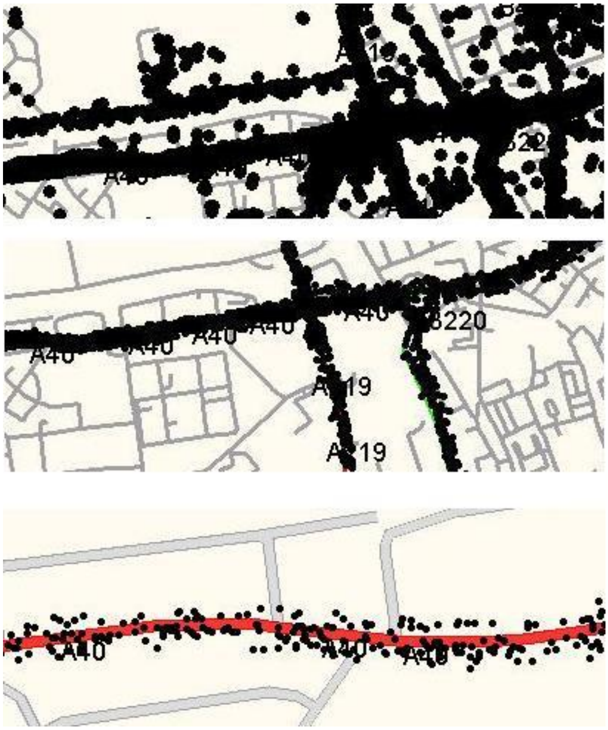

Figure 4. Steps of filtering
(own editing)

In this case a good map is required and a lot of collected data. The first step is to cut the normal values. The next step is to filter those data which are caused by the driving style. The model must point out just the road caused differences [6]. When most of the collected data show the same differences on the same latitudes and longitudes then the possible place of the damage could be determinated. The latitude, longitude and the effect of the damage can be saved in the map database which is useful for the route planning. So with the help of the map and the database we can specify the suitable route and the exact cost of the forwarding.

3.1. Technological demands

The most significant participant in the system is a device, the data logger. When the data logger collect all the required datas and the measuring frequency is thick then the collected datas are useable for a database. Of course not necessary to collect all the measured datas [13]. Practical if the data logger can filter the datas after they divergence and so collect just the datas what are above the limits.

The collecting of following datas is indispesable:

- temperature in the range -20°C - +60°C with min. 0,5°C resolutoin,

- humidity in the range 0 - 100% RH with min. 0,5% RH resolution,
- pressure in the range 300-1200 mbar with min. 0,5 mbar resolution,
- shock in the range 1,2-10 G with min. 0,01 G resolution.

For the accurate data collecting is necessary a few functional feature:

- wide operating environment, the device must work accurate when the temperature, humidity, pressure, shocks are in extreme value,
- long operating time, the duration of a forwarding from departure to arrival can be four or five weeks long and so the functioning and the data collecting must be continuous at this time,
- memory and communication, a large quantity of datas come into being during a route, this datas must be saved on the devices memory or if its possible to send via GSM/GPRS,
- recording rate, just the dense data recording give useful result, so the min. 0,5s recording rate is expecting.

The another significant participant is a good map. Not the levels of the map is the most significant in this case. A street level map is unnecessary. The most significant is the editing possibility of the map. In other words the adjustment of the sections of the roads with the collected datas [8]. So during the planning we can se the highest shock value between the start point and the end point and with the datas of the packagings we can decide, that the selected route is suitable or we must choose another route for the transport. A possible solution can be Google Maps, which is a well usable device. With an easy software we can compare the datas of the routes with the datas of the goods and we can choose the best alternative [7].

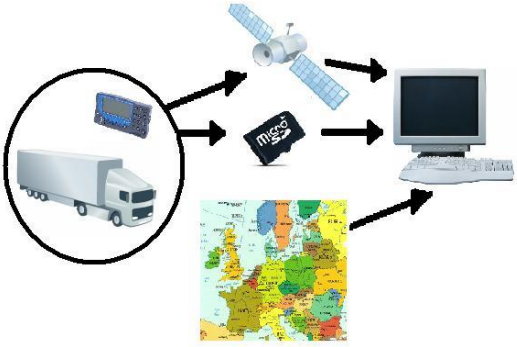

Figure 5. The components
(own editing)

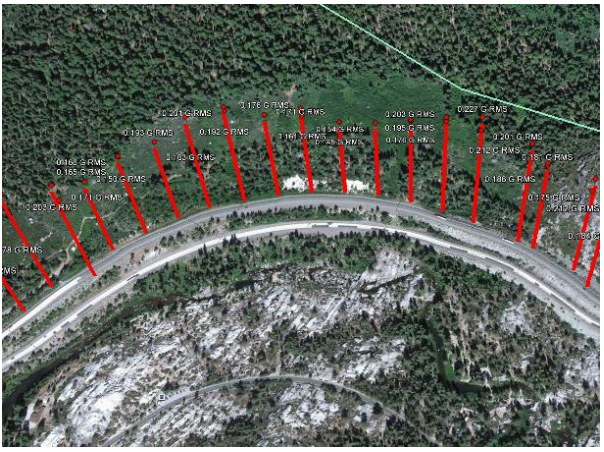

Figure 6. Measured g values imported to Gmaps
(Source: own measurement and Lansmont Ltd)

To absolve those requirements, which we describe, and to be able to measure the mechanical and climatic values, we have applied the apparatus with the following technical parameters.

- sampling frequency 50 – 10.000s/channel
- acceleration (3 channel) [warning and limit settings]
- temperature -55 - +85 ^{o}C
- continuous data recording
- moisture (0-100% RH)
- GPS to GMap
- The battery life 30 days

4. Case study

In Arad (Rom) produce company automotive products. They will transport regularly for a new partner to Moskva (Rus) these items. In the case of one sample's damage, the partner sends back the whole transport (as regular, according to the automotive requirements).

From Zhytomyr (Ukr) to Moskva the only possible road is main road. But from Arad to Zhytomyr are two possible ways. One is through Romania, and the other one is through Hungary. The Romanian roads are in worse conditions like the Hungarian roads, but the distance is lower at Rumanian version. What is the better decision? Shorter route with more stronger and expensive boxes, or longer distance with cheaper but not so minimalized strength boxes.

The order quantity is 52 palettes. The usable vehicle is a 24t lorry. The shipment is on 1000×1200 mm palettes, 40 boxes on one palette. So when the palettes are in two stacks on the lorry, one lorry is enough for the transport of the order quantity.

The used box quality type is 22B. But the shorter way is main road with long mountain sections and over twenty rail crossings to Zhytomyr. So the 22B box type is not enough strong for stacking on the vehicle. In this case the company sends the order quantity with two lorries or use stronger box type for stacking to reach better logistic indexes. Based on mechanical and climate stresses and its simulation, the 32BC box quality type is necessary for this way.

The longer way is motorway in Hungary, there aren't mountain sections or rail crossings. The 22B box is enough strong for stacking.

The manufacturing costs are 0,42 EUR (22B) and 0,55 EUR (32BC) per box with 310 HUF/EUR rate.

The km cost of the lorry is 1,1 EUR/km., based on hungarian company's information

Quantity of the boxes: 52 x 40 = 2080 pcs

Manufacturing cost of the order quantity:

- 22B: 2080 x 0,42 = 872 EUR
- 32BC: 2080 x 0,55 = 1141 EUR

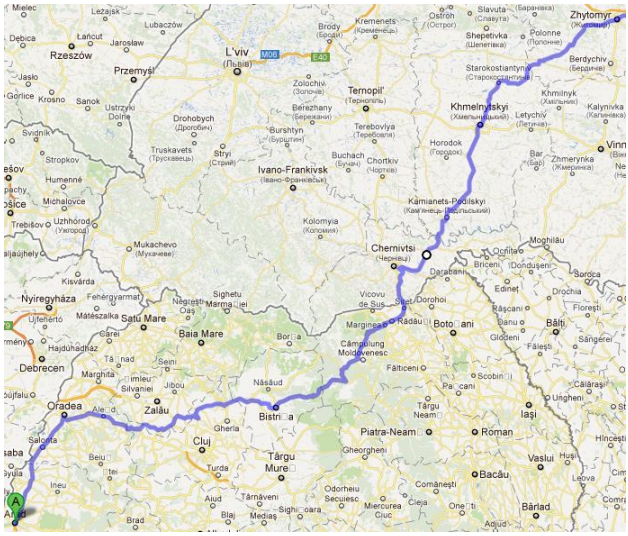

Figure 7. The shorter way
(source Gmaps)

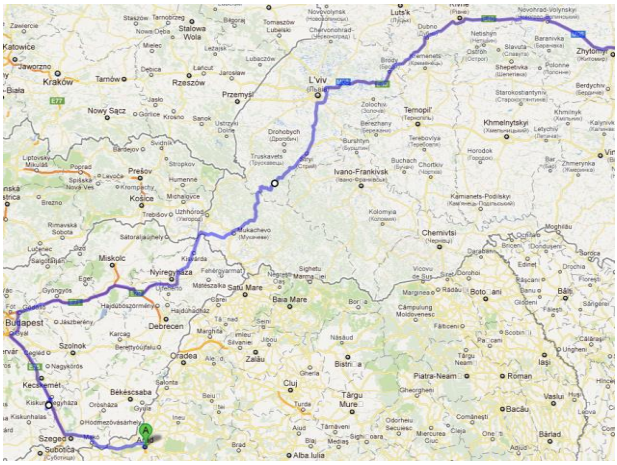

Figure 8. The longer way
(source Gmaps)

Table. 1.

Version	**1**	**2**	**3**
Way	Shorter way	Longer way	Shorter way
Box type	22B	22B	32BC
Distance (km)	1974	2257	1974
Transport cost (EUR)	2 x 2171	2483	2171
Box cost (EUR)	872	872	1141
Overall cost (EUR)	5214	3355	3312

Based on the costs established that the transport costs are higher than the box costs so necessary to transport the order quantity stacked with one lorry, so version 1. is not useful. On other hand the difference of overall cost of version 2. and version 3. is just 43 EUR, ~ 1,3 % of the overall costs.

Comparing the results, the difference is minimal, but if we considering the below written complex packaging problems and the earlier measured logistic stresses, and the actual requirements of the automotive industry, we should chose that version, where the risk are less.

So additional factors be able to influence the decision between the versions.

5. Conclusions

Based on the previous measurements and the earlier performed data collection about the described route, it is clearly emerging, that the personal (driver) and infrastructural (road, etc.) parameters has got high importance in the transportation quality and the product damages.

The main task was to optimize the transport and packaging cost, and minimize the product damages on a constant road transport direction.

We compared two direction version, and additionally calculated the transport and different kind of packaging costs. The main difference were that the distances and road qualities are different in the versions, these parameters and the mechanical and climatically stresses influence the possible applied box material qualities, which also affects the stack ability of the loads. The quality of the boxes has got high importance about stacking and transport efficiency.

From the calculations and the measured values, it is clear that costs of the longer route, with minimized quality boxes, are quite same with the short route with higher box material quality (both types are stacked). The originally applied version with low quality and shorter route showed worse values because in that case we could not apply stacking on the platforms, because the high risk product damages. If we count with the described additional effects and not only with the cost, it is clear that the longer route with more transport cost is worth.

The described methodology should be a good process to investigate the logistic stresses and should be good support to develop suitable product packaging system , both economical and logistic aspects.

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Pedestrian Traffic and the Closed Inner Courtyards in the 21st Century

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Abstract: In the significant part of the historical city centers can be found such buildings which having inner courtyards. In many cases these courtyards will be opened to the pedestrian traffic, which thanks to in the courtyards smaller shops, stores are created. But not just shops, but also depending on the size of the courtyard such another functions as playground, terrace, restaurant, ice cream shop, etc. also could be located in it. In the future more and more people will be living in cities, and one possible way the increase of open public spaces in the city centers the opening of the inner courtyard houses, primarily to the pedestrian traffic. Therefore this study is looking for the answer that an inner courtyard house how could join in to the historical city centers open public spaces network. How much are used in them can be found functions, and how much traffic have they.

Keywords: inner courtyards, pedestrians, traffic, traffic counting, passageway, courtyard functions, traffic density, traffic performance, pedestrian characteristics, public open space, network

1. Introduction

With the pedestrian traffic related researches are mostly directing into the pedestrian accidents, and car conflict researches. Although there are other areas where it is worth to study the movement, and the habit of pedestrians. One of these is the closed inner courtyards which formation can't be made very regret (18-19th Century).

But what is actually a "closed inner courtyard"? We called so those buildings courtyards which are open during the day for the public traffic but at night will be closed. However these courtyards are usually provides shops, restaurants, etc. areas. Another specificity of the closed inner courtyards that on the surrounding buildings floors apartments can be found. So it can be said that such inner courtyards having buildings are unite the function of the private and public area. Because until the courtyard of the building is owned by the house and being managed until in the courtyard can be found shops, restaurants, etc are limited time open for the public traffic.

According to an English study made in 1999 increasing part of the world's population (currently 50%) lives in cities and that number will only grow in the future. In spite that

Europe's total population declines. On one hand is due to that into the Western countries cities coming increasing number foreign workers. However the cities having significant labor force absorption effect, so due to better living more and more people moves into there. Therefore the report highlights that the city's public open spaces will have particularly important role in the future form the aspect of society. Because that is the place where independently from gender, religion, age, nationality, etc. every social class can be found in a city. They can there relax, actively or passively recreating, fun having or even engage in dialogue. But not just from the foreigners or from the aspect of the different nationalities are important that but as the English study has also pointed from the aspect of the disabled and elderly people too. Because currently it the Western societies aging can be experienced and from the aspect of equal opportunity it is important that the disabled could also easily approaching the public open spaces.

In 2005 in Helsinki was held the „Forward Look in Urban Science" called international final conference which main topic was the future of the European sciences. On the conference was said an interesting presentation from another English study which was pointed on that thanks to the land privatization the use of the public open spaces changes. Because thanks to the more increasing number appearing private areas people are excluded from the former free used public open spaces. And this further strengthens the social conflicts because it creates on the private areas the "in remained" and on the public areas the "excluded" world.

According to the 1999 English study the public open spaces even should be function as a public space of democracy where the characteristics of single social groups, and the different cultures signs appearing. So everyone could express himself on the public open spaces which through they could easier integrate into the society the same way disabled people such as ethnic minorities or the rich and the disadvantaged people.

Against this background the second finding of the study was that it would be worth the open public spaces connecting as a network in the cities. This network would include parks, pedestrian streets, public open spaces, etc. But not just the existing public open spaces but also after revitalization at the present neglected smaller and larger parks, unused rail tracks, river banks, canals, etc. Because it was proved that in the city living people for they wealth definitely needs the connection with the green environment. In today's cities it could be increase the amount of the green areas if such "green corridors" would connect with each other the different squares, parks, pedestrian streets etc. However the study doesn't explain that in the case of the historical cities how could be working this process. And it is a question that the inner courtyards could be also a part of this network. Or would it be worthy it the city centres creating a completely different kind of public space network? All this what kind of importance has for the pedestrians? The article looking for answers to those questions.

2. The city centre's closed inner courtyards as the part of public space networks

The historical city centres characteristic is that besides of the residential function, shops, restaurants, offices etc. can be found in them. These functions during in the 20th Century has begun significant expansion and complemented with office buildings, parking houses, hotels, Shopping centres, etc. This is mostly due to the Second World

War after most of the historical buildings were destroyed or due to the significant disrepair were demolished. So in many cases not just the city centres built density but also the population has significantly increased. Similar process took place also in one of Budapest district called "Erzsébetváros" which thanks to was formed the Gozsdu court (Figure 1.).

Figure 1. The Gozsdu court

In Budapest at the end of the 19th Century was on top the tenement house building which then the first then the Second World War has stopped in. Not has been made a significant change until the regime change. Namely from the 90s row appearing the newer commercial service or with administrative functions having buildings. In the case of Erzsébetváros that was the situation where thanks to the rental houses until then high density has continued to increase the newer office buildings, hotels, Shopping Malls, public institutions, etc. The situation has been further aggravated that this new buildings has filled in the gappy parts but with its ad hoc arrangement as an inclusion were enclosed into the urban texture.

Namely the characteristics of bunk tenement houses has come from that into the street front overlooking apartments were the civil apartments in the internal closed so called "gangos" courtyard sideway and behind the room and kitchen proletarians. So the biggest disadvantage of the courtyard apartments was that they have become lighting only from the courtyards side. Until the civil apartments also had from the street and the courtyard side windows. The "gangos" houses had become this kind of design in the 19th Century which was thanks to that in their place available former village houses parcels were built up. And the specificity of these parcels was that they have kept their former long and narrow filed shape which during the later land division only in cross direction could be further divided. So when the first tenement houses were built up towards in the greater benefit they have tried to develop apartments in them for all social classes. Thanks to this on the lots U form bunk houses were built which besides of the street front all side was close in the middle of the inner courtyard.

The leaders of Erzsébetváros into the 20th Century have realized the problem that in long term in order to the district development they must somehow loosen the previous high density. All this with the use of the district's endowments utilization, and with the ensure of the reconstruction by property without such a specific urban planning interventions like street openings. Besides of that it has to be ensure that into the district continued settling of the different shops, offices, etc. continues to strengthen the city centre function of the district. Therefore the municipality of the district in the middle of the 90s has announced their passageway housing program which was called Gozsgu gardening. The essence of the program was, that on the ground floor of the tenement houses passageways were opened which connecting with each other the formerly closed courtyards. So the building of the plots street front was still required however in the courtyards harmony with the neighbour buildings cross wings could be opened. With this the city organizer has been succeeded that the previous U shaped building was replaced by the L shape building pair, in which not just apartments but on the ground floor shops, offices, catering units etc. were placed. And thanks to the passageway housing courtyards loosened the former high density because they have begun functioning as an open public space.

Figure 2. The Bécsi and the Hungária courts in Győr

So in the case of Erzsébetváros the passageway housing has been functioning but it is questionable that outside such a capital city like Budapest elsewhere could be working this kind of development. Because as it could be seen in Erzsébetváros first of all it was therefore necessary the connection of the inner courtyards because the district built has become too dense as well it was needed the until then dark and closed tenement houses some kind of reconstruction which cloud according to the age every need meet in a city centre district. Therefore to answer this question it would be worth to study the Bécsi court in Győr (Figure 2.).

The Bécsi court can be found in the edge of the former castle wall surrounded city centre next to Fehérvári gate which was the south entrance of the city. The Arany János

Street which has once ran directly next to the castle wall, form the 18th Century has begun to infiltrate. Then one to two floor houses has been built which courtyard wings relied on the castle wall. The demolition of the castle walls has begun on the second half of the 19th Century, so the city has begun to increase also into south direction. No longer after that in the end of the 19th Century at the beginning of the 20th Century on the ground floor of the houses appeared to the city centre today also typical shops, banks, restaurants, etc. But during the second world war a lot of buildings has been destroyed in the city centre and after 1970 the ground floor houses were also demolished. In all three historicizing building has been left from the old building the Arany János Street 18, 20, and 22. From this three building the number 22 stands on the busiest pedestrian street of Győr, in the corner of the Baross and the Arany János Street. This three building was a separate house until the end of the 80s. Then they were renovated and the three building's courtyard was connected with passages similar to the Gozsdu court, then was born the present Bécsi court.

The Bécsi court can be divided into two large parts where between the 18th and the 20th houses part not just shops but coffee, ice cream shop, and a restaurant can be found. The restaurant has three entrances which from one can be found on the east side of the building and opens into the Baross Street. The north side into the Arany János Street until the south behind the Bécsi court can be found parking place. All three entrances will be closed by night and only next day morning will be opened. With this solution the Bécsi court works similar just like the shopping centres with the difference that in the courtyard apartments also can be found. However the courtyard functions as an open public space until the shopping centres Streets and Squares are private property.

Other specificity of the Bécsi court that not far away from it, into east direction can be found the Hungária court (2.figure) which though doesn't has gates which it would be closed at night, but also an inner courtyard. The Hungária court also differs from the Gozsdu, and the Bécsi court therein, that there is no shop, office, etc. on it. However on its south side it can be found a fast food restaurant and in the middle of the courtyard a smaller park with playground, benches, statues. This park has a quite big popularity which also due to the fact, that it ensures a direct corridor between the Baross Street and the Czuczor Gergely Street which has bicycle and passenger car traffic also. So its east-west way pedestrian traffic can be said significant of the Hungária court which has significant impact of the Bécsi court's traffic also. The two courtyard therefore on the one hand ensures connection between the largest pedestrian traffic Baross Street, the Czuczor Gergely Street and the Arany János Street. On the other hand in the Bécsi court can be found shops, coffee shop, ice cream shop, and in the Hungária court can be found park, playground, and fast food restaurant complement each other well. Therefore it can be said that both courtyard works well as a network in such a medium size city like Győr too. However it is worth study that concretely how much traffic has this to courtyard. And as well how use it the pedestrians what makes to them attractive.

All to answer this first of all it must be known the characteristics of the pedestrian's movement.

3. The characteristics of the pedestrians traffic

On the field of transport the pedestrian are those whom apply the most little rules which has its own disadvantages and advantages too. One of the greatest advantages of the pedestrians unlike to the vehicles that they are not bound to traffic lane. So they can choose free their speed, and the direction too, where they just want to go. However, just form this comes they vulnerability too, because they could anytime cross even a passenger car, bicycle, motorcycle, etc. way. And this in many cases leads to an accident.

The pedestrian at the same time to archive its aim always looks for the shortest and the most comfortable way. So unconsciously places before its safety the comfort. He doesn't likes bypass roads and the level differences (stairs, inclines, etc.) therefore if he can avoid them.

The other dominant element of the pedestrian traffic is the smallest distance keeping. Because the people during they traffic, always seeking of that, to keep they freedom of movement therefore according to the next and before them going they are trying to keep some smallest distances. However these distances can be different next to one way or two way traffic, pedestrian crossing point, stairs travelling on, as well as in the case of different speed.

In order to get more accurate picture from the pedestrian's movement, and behaviour, always under different groupings will be study it. All of these are needed because in the case of single groups significant differences cloud be experienced for example in the field of speed. The pedestrians can be grouped about the following aspects:

- pedestrian's age (old, young, children)
- pedestrian's gender (male, female)
- pedestrian's area use (targeted traffic, looking around, walking, etc.)
- pedestrian's area knowledge
- pedestrian's space requirements

Besides of grouping it is important also to study the physical space requirements of the pedestrians. But the space requirements of the people could be also different e.g. by gender or nation. In general the human body is often compared to an ellipse from above view, which two diameters is the shoulder width, and body thickness of the human. Based on this it can be said that the pedestrian's collisions zone is approximately 0,75 m². However all to this must be counted also, that usually every pedestrian carries something with him, as well in many cases people are traveling in groups (e.g. pairs). But it should be not forget form the disabled people, and neither with the disabilities living people because in their cases can further increase the space requirement for example a wheelchair or a white cane. Therefore under the space requirement generally by the following aspects are distinguished the pedestrians:

- solo pedestrian
- pedestrian with packages, umbrella

- in group walkers (e.g. families, pairs, group of friends, etc.)
- walkers with stick, crutch
- with wheelchair travellers
- pedestrians with dog

So apparently several aspects affecting it also, that how the pedestrians traveling. But in any case it must be also study that for what purpose they doing this. However to this at present there is no unified methodology yet, because in many different ways can be grouped the goals of the walks. Similar to the space requirements this can be also different by areas, or even cultures. But if we want to group them perhaps it is worth by the following aspects:

- Commuters (Work, School)
- Shopping
- Profession Traffic
- Free time traffic

The current study deals with the inner passageway courtyards where under the listed criteria first of all the free time, and the shopping aimed traffic typical. All this is due in the courtyards can be found shops, restaurants, etc. However, because the inner courtyards also functioning as a square, beside of the above mentioned aspects must be taking into account another one, namely the uninterrupted position. In the inner courtyards similar to the squares there is not just passage traffic but also standing pedestrians too who are waiting for someone or staring a shop window. Therefore similar in the central mixed used areas found squares it must be taking into account by the scaling of the inner courtyards also the following values to accommodate the standing masses:

- undisturbed position: 1,2 m²/person
- strongly disturbed position: 0,7-0,9 m²/person
- crowded position: 0,2-0,3 m²/person

So in the movement of pedestrians many things must be study for which in the case of the inner courtyards more special aspects can be associated with. Based on this it is worth to determine the traffic density, performance and service level of the given inner courtyard. Because with the help of these it is determined that how much used the questioned inner courtyard, and its traffic services are appropriate.

In the paper studied and presented Bécsi court and Hungária court in Győr pedestrian's traffic study was also the goal that under the above mentioned aspects uncover how these two courtyards working. Therefore in both courtyard traffic counting has been made in 2011 and in 2012.

4. The traffic of the „Bécsi court" and the „Hungária court"

In the study of the Bécsi court took place in August 2011 and the Hungária court in June 2012 in a given week on three different days and three different times. The three days were Monday, Wednesday, and Friday, and the chosen times a morning (from 9:00 to 10:00), an afternoon (from 13:00 to 14:00) and a late afternoon (from 16:00 to 17:00). By the dates selection it was an important aspect in the case of the morning that it should be not the morning rush hour period, because this role has received the late afternoon time when the after work pedestrian traffic was relevant. Each time points meaning one hour intervals in 15 minutes breakdowns. And in the selection of the three day was the most important aspect that it should be such days when probably it was the largest the traffic in the two courtyard.

I the case of both courtyards the pedestrians, the bicyclist, bench occupants and the dog walkers were also counted. Beside of that in each courtyard were such local functions which served as a benchmark of the courtyards traffic, and utilization. So in the case of the Bécsi court the users of the there can be found coffee terrace, and the number of the standing in line by the ice cream shop has been census. In the Hungária court can be found a smaller park with a playground and a fast food restaurant which terrace area is located in the south side of the courtyard, so there the users of these two functions were counted. Both courtyards have a terrace area, but during the counting only in the case of the Bécsi court have been succeeded in the adult and children category also counting to the table occupants.

Averaged on the three day measured data turns out that the Bécsi court has much more pedestrian traffic than the Hungária court (Figure 3.). In the Bécsi court average maximum 94 adult passes through of an quarter hour, but in the Hungária court only 56 people. In this difference presumably plays a serious role is that in the Bécsi court, in contrast to the Hungária court, smaller stores and shops also can be found. And these shops could be generating more traffic than in the Hungária court can be found fast food restaurant.

But in terms of the number of the children significant differences can be experienced between the two courtyards. Because until in the Bécsi court measured 15 minutes period never was more than 20 pedestrian children, until in the case of the Hungária court 36 people passed through it.

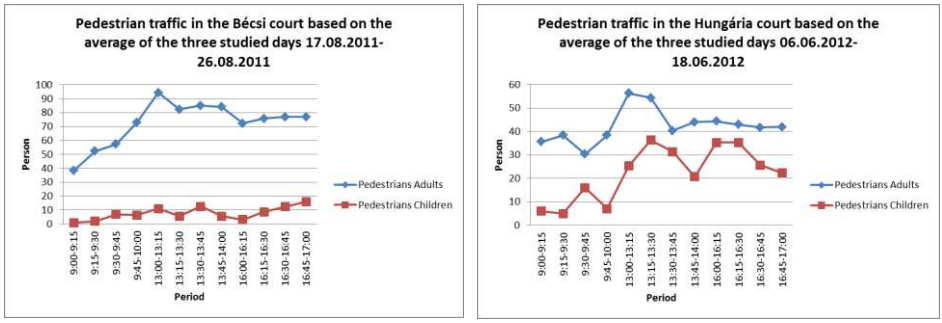

Figure 3. Pedestrian traffic in the Bécsi and the Hungária court based on the average of the three studied days

This difference can have several reasons, but probably it has a significant role in it, that in the Hungária court is a playground which is very popular among the children. The other reason is into the Hungária court opening fast food restaurant, which is mostly among the high school students has great popularity. During the location study it was observed, that the general and high school students mostly after the school education, from 13:00 pm were the most in the courtyard. But as it can be seen on the graph, after 16:00 pm gradually has begun to decrease their number. The traffic count of the studied days data separate considering also confirming this except Friday. Namely on this day after 16:00 pm has begun to grow the number of the children in the Hungáia court. This reason is thanks again to the high school students who are at the beginning in the weekend starts going to the city centre to having fun.

In the case of both courtyard average between 13:00 and 13:15 turned on the most people. Interesting way this is true for each day of the study. The explanation of this maybe could be that in this period is lunch break, and so in the city centre workers than goes out or even back to their workplace. However the eight hour working time in the case of the most people ends at 16:00 o'clock, but after that wasn't as much traffic neither one of the courtyard as during in the last already mentioned quarter hour period.

In terms of the number of the bench and chair occupants can be already significant difference experienced between the two courtyards (Figure 4.). Maybe this is also thanks to that until in the Bécsi court due to its size chairs were placed as street furniture, until in the Hungária court still benches are available for the people who wants to relax.

The first conspicuous difference, that in the Bécsi court from the first measurement of the day with smaller fallbacks, but continuously has grown the number of the bench occupants. However all this is only true in the case of the adults, because the number the children showed much more moderate growth. As well as on the graph seems, there were time intervals when none child has been sitting on a chair. The Bécsi court on a Wednesday made traffic count for example in all only one child has sat down during the time of the study.

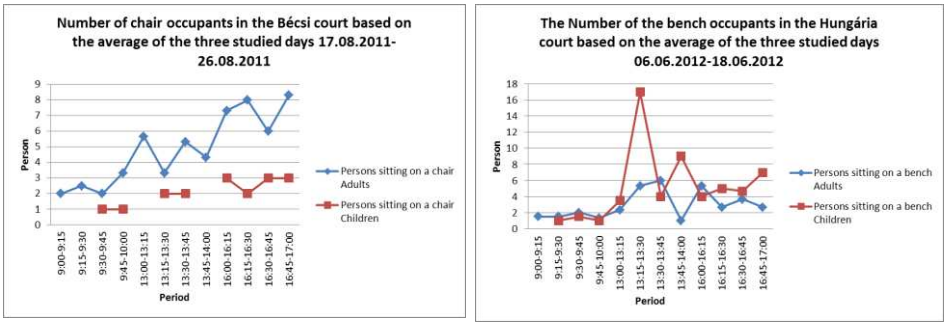

Figure 4. The number of the chair occupants in the Bécsi court, and the number of the bench occupants in the Hungária court based on the average of the three studied days

The Hungária court at first sight shows a quite interesting picture by the three days average. Namely in the morning hours nearly the same proportion have sitting down on the benches the adults, and also the young people. However on the study's Friday between 13:15 and 13:30 29 children had sat down which good presents also the graph's sharp increase. And in the afternoon hours, with one or two people, but the children were more on the benches.

In terms of the number of the adults under the three day average is true of both courtyards that neither of them has been sitting more than 10 people during in a quarter of an hour. But it is an important difference that until in a Bécsi court has continuously increased the number of the chair occupant adults, until in the case of the Hungária court the number of the bench occupants after a slight increase, has stagnated, than after 16:00 has begun to decline. This was true for the studied days separately also. However after 16:45 though slightly, but the number of the bench sitting children has begun to grow. It can be said from the average of the three day, that in the Hungária court an average of 3 adults, and 5 children had sit down in a quarter of an hour. And in the Bécsi court at the same time period an average of 5 adults and 2 children had sit down on a chair, in other words its broadly inverse the rate in the two courtyard.

What definitely should be noted in the case of the Hungária court, that two "peaks" can be observed at the bench sitting children and adults too. The first by the children was between 13:15 and 13:30, the second between 13:45 and 14:00. And by the adults between 13:30 and 13:45 and as well between 16:00 and 16:15. In the case of the children the two times coincide with the end of the last hour of the school, and by the adults, probably similar to the pedestrian traffic, the lunch break means the first time period, and the second the end of the working time. At the Bécsi court also can be observed after 13:00 hour two such "peak time", but as it could be seen in the graph the number of the chair occupants every day in the last quarter hour of the study was the highest.

As it were mentioned in the beginning of the chapter both courtyard has a terrace, which in the case of the Bécsi court belongs to a coffee shop, and in the Hungária court to a fast food restaurant. But as it were also mentioned only at the former has been succeeded separately by adults, and children study its "traffic".

The count of the terrace occupants was done therefore during the study, to see how much are they used as a public open space functions.

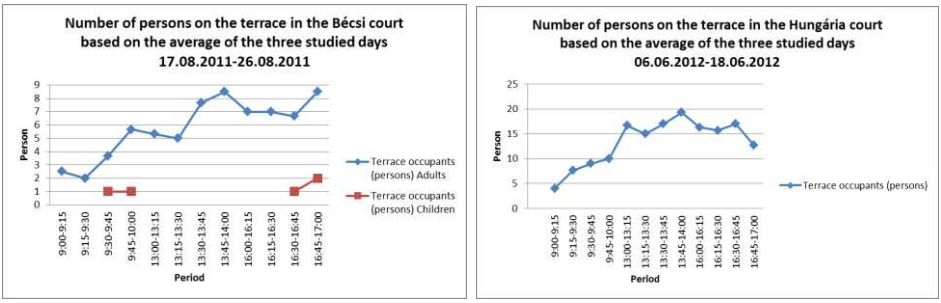

Figure 5. Number of persons on the terrace in the Bécsi and the Hungária court based on the average of the three studied days

What at first sight appears on the two graphs (Figure 5.), is that in the Hungária court can be found terrace area of the fast food restaurant has a significantly higher traffic, as the terrace area of the coffee shop has in the Bécsi court. In addition, the number of persons on the terrace though next to smaller fallbacks, but similar to the chair occupants shows an increasing trend. In contrast, in the Hungária court after between the 13:45 and 14:00 peak time has begun to decrease the traffic of the terrace.

The significant traffic difference of the terrace area both courtyards primarily comes from that proportionally the Hungária court is much larger, so the there can be found fast food restaurant has also a significant size terrace. And the other reason is, which was during the on-site monitoring also perceptible, that the fast food restaurant had much higher traffic as the coffee shop. This is primarily thanks to that the fast food restaurant among the young generation (school, high school, university students) popular, and the coffee shop was mostly visited by the middle-aged and older people. This is supported by the fact that based on the three day average not more than two children hasn't sitting down to the terrace of the coffee shop. And as it can be seen on the graph too, together there is only such four quarter hour time period in which children were also stayed there.

The terrace area of the coffee shop according to the measured data more in the late afternoon early evening time can be very busy, and the fast food restaurant by the three major "peak time" in the lunch break, as well at the end of the working day, and the end of the school. Overall it can be said that on the terrace of the coffee shop in a quarter hour an average 6 adults and 1 children sits down, and to the terrace area of the fast food restaurant 13 people.

To Both courtyards specific, that not just pedestrians, but bicycles also ride on it. Therefore besides the pedestrian traffic, the bicyclist was also studied to determine, that how can this mean conflict situation between pedestrians and bicyclist.

What can be said of both courtyards, that none of them has more than 5 bicyclist ride in a quarter hour, which form the average of the three days is also good visible. Based on that in the Bécsi court in every quarter hour an average maximum two, and in the Hungária court 4 adults had cycled through (Figure 6.). With the number of the children the situation is different because in the Bécsi court much more less children had cycled, as in the Hungária court. In terms of the three day average that meant two children in every quarter hour in both courtyard, but as it can be seen also in the graph, there was a lot more such a time period too in the Bécsi court, when doesn't had cycled through it a child.

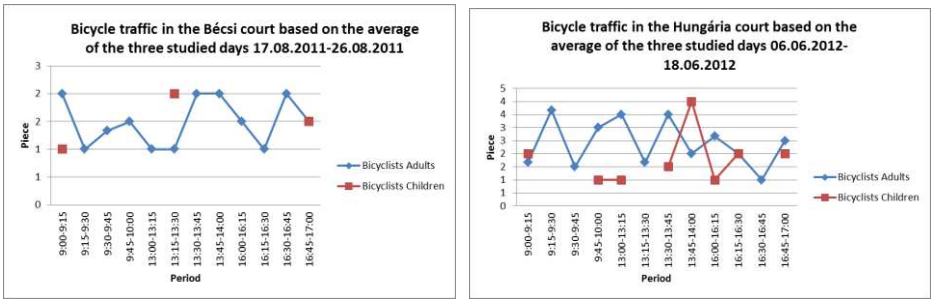

Figure 6. The bicycle traffic in the Bécsi and the Hungária court based on the average of the three studied days

In the case of the Hungária court has been more frequently drive through the children with bicycle mostly between 13:30 and 16:30 which "peak time" was between 13:45 and 14:00. This peak time has fall again at the end of the last hour of the school, and because the Hungária court is located between the Baross Gábor street the pedestrian street of Győr downtown and the Czuczor Gergely street on which painted bike lane also can be found, so many students walks through the courtyard into the direction of the city centre.

According to the Number of the bicyclist shows a very varied picture the Hungária court because as it can be seen also on the graph mostly it changes between 2 and 4 pieces until 16:00 hour, than it begins to decrease sharply, and in the last quarter hour jumps back to 3 pieces. Proportionally similar traffic can be observed in the Bécsi court also with the difference that in there mostly between 1 and 2 adult cyclist drives through in every quarter hour. So the bicyclist traffic not at all can be said significant either of the courtyards.

In both courtyards can be found more such additional functions which mostly generating pedestrian traffic. But during the study it would be impossible to study one by one each of them. This is especially true to the Bécsi court where several smaller shops, coffee shop, and a restaurant also can be found. Therefore in each courtyard just that function's traffic was studied which under the on-site observation had generated the largest traffic. So fell the choice in the case of the Bécsi court to the ice cream shop and in the Hungária court to the playground.

The ice cream shop of the Bécsi court can be said a quite popular, this is supported by among other things also, that under the average of the three day, an average of 19

people stands in row before it. But if we study more detailed the traffic of the ice cream shop it turns out that in the morning form 9:00 it shows continuous growth (Figure 7.). This process separately studied of each day, all of them was true. Most people always in the last quarter hour stood in line at the ice cream shop, which on one day had exceeded more than 40 people also. In addition it's clearly visible two larger "peak time" on the graph which from the first were between 13:00 and 13:15, the second between 13:45 and 14:00.

In the Hungária court the traffic of the playground hasn't shows such a clear picture as the ice cream shop in the Bécsi court. Because during the three day study it turned out, that the visitors of the courtyard uses quite varied the playground. But during of the three day it was also observed, that with more than 8 people stayed rarely in 15 minutes on the playground. Averaged the traffic of the three day it can be said that 6 people uses it in every quarter hour.

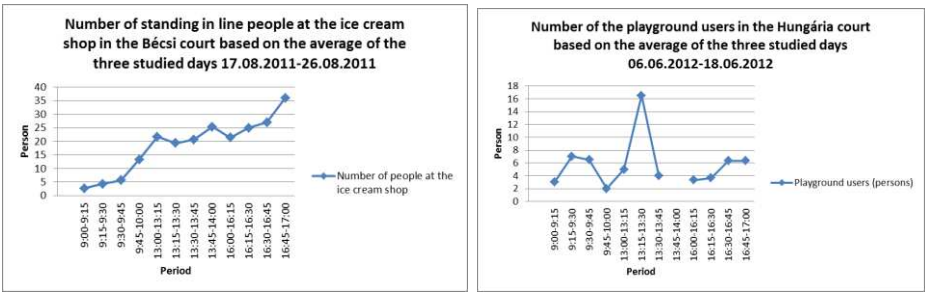

Figure 7. Number of the standing in line people at the ice cream shop in the Bécsi court and the number of the playground users in the Hungária court based on the average of the three studied days

As it can be seen on the graph there was such one time period between 13:15 and 13:30, when the number of the playground users was 17 people. This is thanks to that on Friday of the study in this quarter hour in a unique way 26 people has turned around on the playground. That is also therefore interesting because on the playground two swings can be found, so in contrast to the ice cream shop its capacity is much more limited. This is mainly due to among other also that usually more than 8 people weren't on the playground. However, it should be mentioned, that in front of the playground it can be found a bench on which usually the parents sit down until the children swing soaking. Therefore at the traffic study the bench occupants also have been included into the number of the playground users. So it can be said form the average of the three days received 6 people that during a quarter hour usually two 3 person family uses the playground. So the playground has a quite great popularity in the Hungária court.

The last study in both courtyards has studied the number of the dog walkers. All this was made because on a lot of open public space causes the dogs trouble for different reasons primarily thanks to the wrong behaviour of their owners. Namely the owners often don't comply for example to clean up the dog waste which however legislation provides for. And this in such a park where a lot of children also playing could be means a serious hygiene problem. But this is true also to the inner courtyard buildings where on a smaller "closed" area not only shops, but even ice cream shops, coffee

shops, and restaurants also could be. Or even a playground as also in the case of the Hungária court.

From the study of the two courtyard it turned out, that none of them are significant the number of the dog walkers. This is particularly true to the Hungária court where none of the studied days were walked more than one dog in a quarter hour (Figure 8.). However the Bécsi court already shows a little bit more varied picture but does not differ significantly from the Hungária garden. By the average of the three day in every quarter hour two dog walkers were in the Bécsi garden until in the Hungária garden only one. But as it can be seen in the graphs it was also more quarter hour time period when doesn't were walked a dog in none of the courtyards. And in the case of the Bécsi garden it is an additional curiosity that in the morning hour was "higher" the number of dog walkers, which was decrease at the early afternoon, than again from 13:45 it has begun to "increase". Under the on-site observation this is thanks to that in the courtyard and around it living mostly older people, who are kept a dog, then brought down walking their pets into the city center. However, it is important to note form the seen things, that only a few could hold a dog of those who living in the Bécsi garden.

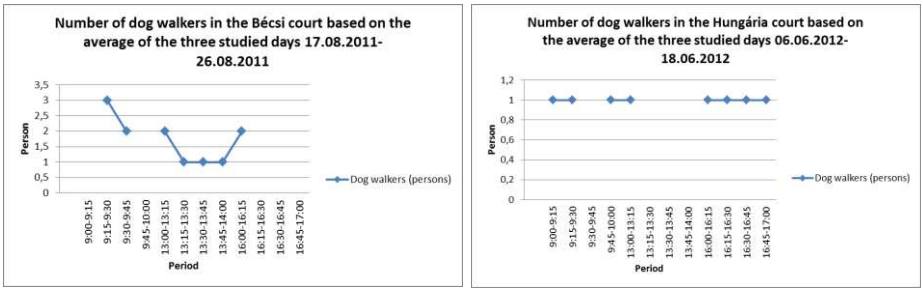

Figure 8. Number of the dog walkers in the Bécsi and the Hungária court based on the average of the three studied days

Summarized the traffic of the two courtyards the following can be concluded:

- The Bécsi court has more significant pedestrian traffic as the Hungária court
- On the Bécsi court much less children walking through as in the Hungária court
- In the Bécsi court the adults sitting down in significant number to the chairs, and in the Hungária court the children to the benches
- In the Hungária can be found terrace of the fast food restaurant has much higher traffic then the terrace of the coffee shop in the Bécsi court
- The difference between the two terraces traffic mainly comes from their size, the size of the two courtyards, and as well as from the generational age difference of the fast food restaurant and the coffee shop visitors
- In the Hungária court is more significant the bicycle traffic as in the Bécsi court

- The difference of the bicycle traffic mainly thanks to the location of the Hungária court and size difference of the two courtyard
- In the Bécsi court the ice cream shop has a significant traffic
- In the Hungária court the playground has a significant traffic
- The number of the dog walkers none of the courtyards are significant

So the traffic of the buildings with inner courtyard not only depends on their size, but from the therein included functions, the location of the courtyard and from the characteristics of each functions (size, type of service, amount, etc.).

As it can be seen in both courtyards the determining traffic was meant by the pedestrians. Therefore to determine that this traffic is how significant it must be known the traffic performance of both courtyards. Because with the help of these it is determinable that what kind the level of service of the two courtyards.

5. The Bécsi and the Hungária court pedestrian traffic performance

In the previous chapter it was also mentioned that the traffic study of the Bécsi and the Hungária court took three days, the former in August 2011until the latter in June 2012. In both cases summarized and averaged the three days data it had managed to get the most important data from the traffic of the two courtyards.

In the Bécsi court an average 72 adult and 8 children turned around in every 15 minutes under the average of the three days (Table 1.). And the largest traffic in one of the studied quarter hour meant 114 adults, and 25 children. During the three days of the traffic counting in all 2606 adults and 273 children had walked through in the Bécsi court. From this, and from the data of the Table also clearly visible, that the pedestrian traffic is significant in the Bécsi court.

Table 1. Traffic counting summary of the Bécsi court

The total traffic counting data of the Bécsi court (17.08.2011-26.08.2011)										
Studied period	Pedestrians		Persons sitting on a chair		Persons sitting on a terrace		Bicyclists		Standing in line by the ice cream shop (Persons)	Dog walkers (Persons)
	Adults	Children	Adults	Children	Adults	Children	Adults	Children		
Maximum	114	25	12	5	14	2	4	2	48	3
Minimum	25	1	1	1	1	0	1	0	1	1
Mean	72	8	5	2	6	2	2	2	19	2
Sum	2606	273	170	28	175	5	30	6	667	16

In the Hungária court also the pedestrian traffic was dominant where one of the quarter hour 82 adults, and 62 children turned around on it (Table 2.). However during the three days an average of 42 adults and 22 children. Similarly way from the summarized data of the three days not only that turned out, that the pedestrian traffic is significant in the Hungária court, but in total 1526 adults and 799 children had walked on it during the time of the June study.

Table 2. Traffic counting summary of the Hungária court

The total traffic counting data of the Hungária court (06.06.2012-08.06.2012)									
Studied period	**Pedestrians**		**Persons sitting on a bench**		**Bicyclists**		**Playground users (Persons)**	**Persons sitting on a terrace**	**Dog walkers (Persons)**
	Adults	**Children**	**Adults**	**Children**	**Adults**	**Children**			
Maximum	82	62	8	29	6	4	26	33	1
Minimum	27	2	1	1	1	1	2	1	1
Mean	42	22	3	6	2	2	6	13	1
Sum	1526	799	89	116	68	17	136	481	10

Therefore with the help of the above data first the pedestrian traffic density has been determined. To get a more accurate picture of that how much is the actual traffic in both courtyard, therefore the maximal (*d* max) and the average (*d* átl) traffic density has been determined with the help of the following formula:

$$d = \frac{F}{f}$$

Where:

d – the pedestrian traffic density (person/m²)

F – volume of the pedestrian traffic (person)

f – the used surface (m²)

The area of both courtyards were with the help of the base map of Győr determined, which according the area of the Bécsi court 379,01 m², and the area of the Hungária court 1716,26 m². In the case of the Bécsi court the area includes the area of the passageways because there can be found the entrance of the shops also, and under the on-site observation the passageways had the same significant traffic as the courtyard itself.

During the determining of the traffic density the number of the adults and children has been added together also in the case of the maximal and average pedestrian traffic. The so obtained results include the Table 3.

Table 3. Pedestrian traffic density in the Bécsi and the Hungária court

Pedestrian traffic density of the Bécsi court	***d* (person/m²)**
Average traffic density (*d* átl)	0,21
Maximal traffic density (*d* max)	0,37
Pedestrian traffic density of the Hungária court	***d* (person/m²)**
Average traffic density (*d* átl)	0,04
Maximal traffic density (*d* max)	0,08

And the pedestrian traffic density calculation it was therefore necessary, that with the help of these getting the pedestrian performance of both courtyards busiest passageway. Because the pedestrian facilities traffic performance it shows that in given time unit how many people could pass through on its cross section. And the busiest passageway

in the case of both courtyards is into the Baross street opening (Figure 9.), which is the busiest pedestrian street of the downtown in Győr.

Figure 9. To the Baross street opening passageway of the Bécsi and the Hungária court

To the calculation of the pedestrian facilities performance besides of the traffic density it was needed also the pedestrian speed (*v*), the useful width of the passageways (*szh*), and to that given time period (*t*) which shows how many pedestrians could go through the passageway.

During the time of the study not has been measured the speed of the pedestrians, therefore it was replaced during the calculation in the road management technical regulations "Design of the pedestrian traffic road facilities" document indicated pedestrian average speed which is *v*=1,34 m/s.

The width of the Bécsi court's east passageway 3,25 m and the Hungária court's 4,81 m which data has been also with the help of the base map of Győr determined. During the study in 15 minutes time periods has been counted in both courtyards the pedestrians. Therefore at the counting of the passageways performance also that time period (900 s) has been replaced in the formula.

The performances of the two pedestrian passageways were with following formula determined:

$$K = v \times d \times sz_h \times t$$

Where:

K – performance of some pedestrian facility (person)

v – the pedestrian traffic speed (m/s)

d – the pedestrian traffic density (person/m²)

szh – useful width of the facility (m)

t – the considered time interval (s)

From the obtained results turned out that the Bécsi court's eastern passageway average pedestrian performance in 15 minutes 827 person, the Hungária court's south-western passageway 216 person. Counted with the maximal traffic density (d max) this result changed in the case of the Bécsi court for 1437 person and in the Hungária court for 487 person (Table 4).

Table 4. The pedestrian performance of the Bécsi and Hungária court busiest passageway

Pedestrian performance of the Bécsi court's eastern passageway	**K (person)**
The performance of the passageway by the average traffic density (d átl)	827
The performance of the passageway by the maximal traffic density (d max)	1437
Pedestrian performance of the Hungária court's southwestern passageway	**K (fő)**
The performance of the passageway by the average traffic density (d átl)	216
The performance of the passageway by the maximal traffic density (d max)	487

The results showing well that even in the case a small courtyard also as the Bécsi court an average more than 800 people could go through in a quarter hour its busiest passageway. But in the case of maximal traffic density also can in 15 minutes more than 1400 people walking through on the eastern passageway. And from this result well below during the on-site study measured distance, but even the maximal pedestrian traffic also.

Due from the sizes of the Hungária court it had much lower pedestrian traffic density, as the Bécsi court. This is mainly due to that even next to the maximal traffic density also only 487 people the pedestrian performance of the southwestern passageway. As it can be seen in the table also, its average performance is less than the half of the maximum (216 person).

However in the case of both courtyards it should be noted, that not just one, but they have several passageways too. In the Bécsi court for example in all three can be found, so by the obtained results next to maximal traffic also, in that direction walkers could comfortably walking through it. And in the Hungária court beside of the southwestern passageway another three provides an opportunity to approaching it.

So from the results it turned out that the two courtyards is capable to conducting the pedestrian traffic of the downtown Győr, and joining to that network. All this in such way, that the pedestrians could comfortably fit next to each other in the passageways, and in the courtyards too.

6. Summary

In the present paper studied Bécsi and Hungária court turned out that they are well-functioning, and "living" passageway housing courtyards, which having a significant

role in the downtown of Győr. In them can be found different functions are also quite popular and used. This proved in both courtyards done traffic counting also, from which significant differences turned out between the courtyards. Because as it can be seen the traffic of the courtyards not only depends on their size, but from in they can be found functions, and the location of the courtyard in the city. However in both courtyards the pedestrian traffic was determining, but as it can be seen from the traffic density, and the pedestrian performance calculation, this traffic can without obstacle passing through on them.

However the current study did not address yet such questions, that how affecting the traffic of the inner courtyard for example that surrounding streets traffic. Because the now presented Bécsi and Hungária court not only limited by the busiest pedestrian street of Győr, but it is located in one of the busiest area of the historical city center. But it is questionable what would happen than, when another part of the city center would be located these courtyards, or less busy street would be limit them. Or affecting this traffic in the nearby can be found bus stops, offices, shops, etc.

In the Bécsi court more smaller shops can be found besides of the previous chapters already mentioned ice cream and coffee shop. In the future in any case must be study, that in the passageway housing inner courtyards can be found shops how affecting the pedestrian traffic. Decrease or maybe increase it, depending on that how many can be found in them, or what kind of functions they having. This is true for such other functions as well as the chairs, benches, terraces, plants, fountains, etc. Because as the traffic counting data also proved the traffic of the Hungária court has been significantly affected by the there can be found fast food restaurant, which is mostly among the younger generation popular. Same way in the Bécsi court the ice cream shop had also great popularity, but the coffee shop's terrace already has been visited by the older generation. But it is questionable, that the other shops of the Bécsi court how much had affecting that the passers-by turned into there.

So in the field of the closed inner courtyards and the passageway housing courtyards exists many other research opportunities. And these areas should be in any cases study, because as it can be seen, in the future the cities can be found public open spaces will have an especially important role. In the case of the historical inner cities the inner courtyard making could be providing the best opportunity to the expansion of the public open spaces. So ensuring the sustainable urban development for the future generations.

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Effects of Infrastructure Extension on the Competitiveness of Hungarian Logistics Providers

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Abstract: As based on international rankings, like the Global Competitiveness Index and the Logistics Performance Index, the competitiveness of Hungary has decreased recently. The present article investigates the correlation between the above mentioned indices, and explores the underlying reasons and aims motivating the railway network extension (bypass line V0), while also considering its possible future effects on the Hungarian logistics providers and the economy on the whole.

Keywords: competitiveness, railways, LPI, GCI

1. Introduction

The competitiveness of Hungary has seriously decreased in the last years. The World Economics Forums (WEF) ranks the countries each year according to their competitiveness; their respective study in 2012 comprised 144 countries and 111 indicators. In 2011, Hungary was 29th from the 130 states investigated, while it was only ranked 60th this year [21]. Accepting the judgement of Chikán it can be stated that "regarding the post socialist countries, Hungary who had been among the leaders has now joined those lagging behind" [7]. Being aware of the importance of having "responsible supply chains", through LPI, the authors examine the effect of the V0 railway network extension to the country's competitiveness, while also keeping in mind that shift to railways is a vital goal of the European transport strategies as well [10, 11].

2. International rankings

2.1. Rankings in GCI and LPI

"Quality of the railway infrastructure" is one of the indicators measured as part of the World Economic Forum's Global Competitiveness Index. Here, with mark 4.4, Hungary is ranked 50th and the level of insufficiencies has increased to one and a half of the value of two years ago, nearly reaching the level measured in 2008.

Parallel to the World Economic Forum, the World Bank has also conducted a survey ranking countries, but with a different approach. The survey to determine the Logistics Perfomance Index (LPI) was carried out three times since 2007 including 150 countries worldwide and ranking the states from a logistics perspective. The LPI evaluates the countries as based on 6 indicators. One of these indicators is the quality of infrastructure, in which Hungary was rated 35th, 52nd and 40th in 2007, 2010 and 2012, respectively [1]. The scores characterizing the quality of infrastructure in Hungary were the following: 3,12 (2007), 3,08 (2010), 3,14 (2012), while the maximum value was 5.

2.2 Correlation between the rankings

The question arises whether there is a correlation between the LPI index and the (WEF) competitiveness index of Hungary. If an increase in the individual indicators of LPI can be achieved, will this also influence the WEF competitiveness index? Chikán argues that this hypothesis should be true. According to his opinion, "the logistics performance of Hungary is equal to its general competitiveness", and in boosting logistics, there is an unused potential for competitiveness at hand [9].

Figure 1. shows the respective ranking weights for Hungary on a year by year basis. It has to be noted, that the LPI values are only available for years 2007, 2009 and 2011, as it was only in these years that the LPI survey was carried out. Hence, the weights indicated with a cross in the diagram have been calculated by means of interpolation, so as to enable the correlation to be calculated and presuming that the values have changed linearly between the measured data points.

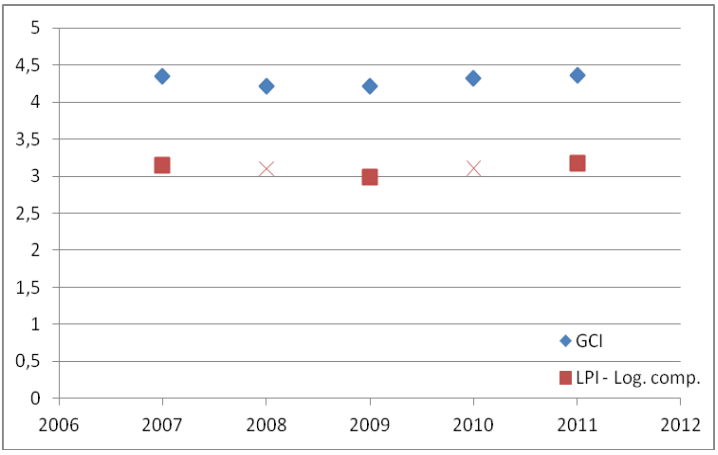

Figure 1. Measured and calculated GCI and LPI values of Hungary

The function utilized for calculating the interpolated values is the following:

$$y = 0{,}005x - 6{,}9417 \quad (1)$$

Correlation (r) between the two data series has been calculated according to the following, usual function:

$$r_{xy} = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2 \sum_{i=1}^{n}(y_i - \bar{y})^2}} \quad (2)$$

where n is the sample size, and x, y are the data from the two series.

The correlation found between the two series shown in Figure 1. is 82.70%, meaning that indeed, there is a very close relationship between the GCI and LPI values, and it can be rightly assumed that an increase in LPI will entail an amplification of the GCI value as well. Thus, what has been introduced as the opinion of the expert, has also been proven by the result of objective evaluations as well.

3. Effects of V0 infrastructure development

3.1. The need for constructing a bypass line

A further question to be asked is, whether there is a correlation between railway network extension, meaning especially V0, and the country's rank at the LPI list, and thus also between the infrastructure development and the GCI ranking. According to the opinion of the relevant experts and stakeholders, this is necessarily so.

Hungary is in competition with the other, neighbouring, countries, and "if we are fumbling around, the significant international logistics providers will sidestep Hungary, as the neighbouring countries are not wasting their time in this context"- expressed the secretary of state, *János Fónagy*, at the Transport Logistics Conference. The development of railway infrastructure is decisive for Hungary, as precise and reliable rail transport is essential for the development of big industrial enterprises and this also influences their stay in the country [2].

It is also well known from experts, that there is a serious lack of capacity at the Hungarian railways: it takes a train in average 18 hours to cross the country [13]. If the plans to build a new railway line (V0) bypassing the capitol, thus alleviating railway traffic density on the networks in and around Budapest, will be realized, the above mentioned timeframe may be reduced to 6 hours [15]. It is important to note that the new network section should from the beginning be able to cater for the transport of trains with an axle load of 22.5 tons [17].

The board of directors of the Hungarian Logistics Service Centres' Association (MLSzKSz) finds that the targeted development of the logistics sector is inevitable for maintaining and strengthening the regional competitiveness of Hungary [20]. Logistics is capable of increasing the competitiveness of the economy: by reducing the transaction costs and the general cost level of the economy, and by providing customer services of higher added value and service export it can boost economic growth and it can contribute to Hungary's competitiveness by also taking advantage of the expansion of the logistics market [9]. According to the opinion of MLSzKSz, the potential for excellence of the Hungarian transport logistics sector lies in building the railway bypass line (V0), in enhancing the logistics competitiveness of the Záhony region, in improving

the Hungarian situation of intermodal (combined) transport, and in further developing the logistics service centres [20].

3.2. Details of the planned network extension

The first railway line in Hungary was inaugurated on 15th July 1846, and looking at the map of the Hungarian-Austrian Empire from the era, it is evident, that even at that time there were efforts to ease the burden of traffic in the middle of the country [3].

At the moment the feasibility study of V0 considers two different versions: one northern-southern and a southern line. It is planned to create an electrified, double-track line, fulfilling the highest expectations regarding quality, with a speed limit of 160 km/h, and an axle load of 225 kN on the whole length of the track. According to the present plans, V0 will connect *Komárom* and *Szolnok,* passing Székesfehérvár (or northern to that, in the region of *Bicske* and *Ercsi*), crossing the river *Danube* on a new bridge, and meeting the main railway line No. 100 by *Cegléd*. Depending on the alternative chosen, it requires the investment of 270 to 600 billion HUF and the length of the line will be 190 to 280 km [4]. The project is to be financed from national and European sources.

Provided that the necessary governmental level decisions are reached and both the financial resources and the necessary land are available, the constructions can be started in 2017, and the line would be finished in 2023 at the soonest [15].

3.3. Discussion and effects of the railway extension

Developing railway speed and axle load features among the transport development priorities of the New Széchenyi Plan, thus, this project matches the goals of Hungarian economic development perfectly. The observed international tendencies favour the Hungarian situation [9]. This international tendency is also backed up by the strategy of Rail Cargo Hungária (RCH), which highlights that by the stabilization of the international economy, rail freight transport will develop and the eastern and south-eastern markets will gain importance [16]. Implementing V0 will largely contribute to the success of the strategic endeavours of RCH.

The executive board of RCH was assigned with the task of designating as many trains as possible through Romania and Bulgaria, aiming at the Greek, but even more importantly at the Turkish markets, in order to expand in southeast Europe. At present, this goal is to be fulfilled through Hungary. However, after the successful privatization of Croatian and Serbian companies, deploying an "own" rail freight company and getting round Hungary in order to serve the Balkan region may prove to be an alternative.

Naturally, the new executive board of MÁV (Hungarian Railways) does not want to lag behind either, and it takes "firm steps to ensure that the goods arriving from Asia to Europe are transported through the Hungarian railway network. By means of the related track access fees, this may yield an important revenue for Hungary" [8]. During the meeting of the C*oordinating Council on Trans-Siberian Transportation*, *Ilona Dávid*, Head of the Hungarian Railways, met *Vladimir Yakunin*, Head of the Russian Railways

and they agreed to elaborate measures that, among others, make a better use of the Hungarian transit and logistics opportunities" [8].

The question can be asked, whether international competitiveness can be seen as a notion in itself or is Paul Krugmann right in saying that it is really the companies which compete with each other [6]. Demján argues, that the competitiveness of the enterprises is determined by the social costs [19]. As based on these opinions, it can be stated that the competitiveness of the companies and the countries are strongly interdependent, and "the questions regarding international competitiveness, be they political or economic, are becoming more and more of a cultural nature" [12]. The halt of project to be outlined in the next paragraph may also be attributed to the problem of cultural differences.

Looking at the development endeavours of the neighbouring countries, the states of the region can be observed to be participating in several infrastructure development projects in order to enhance their competitiveness. One outstanding example is the fact that there are preparations going on for building the wide gauge track *Kosice-Bratislava-Vienna* crossing Slovakia [5]. According to plans, this would be the European part of a 8000 km long wide gauge track, along which 16 million tons of goods would be transported annually from Chinese metropolises (*Beijing, Shanghai*) and from Vladivostok to Europe, with a transport time of 15 days.

Due to the high investment costs, the hesitating attitude of the Russians and the loss of potential of the Slovaks (the added value logistics activities in *Ágcsernyő* are being transformed into transit services), and also despite the strong Austrian intentions, the project has come to a halt. It remains to be seen what financial resources will be deployed to realize the project. It is highly probable, that the private investments and the subsidiaries given by the individual countries will not be sufficient, and the support of the European Union will be required. These resources are also limited, and the support provided by the Cohesion Fund may be reduced by 20-25% in the next budget period of the EU (2014-2020).

Consequently, it can be stated that Hungary and the neighbouring countries will have to exert an intensive lobbying effort and compete with each other to secure funds from the European Committee on Budgets, so as to realize projects enhancing their competitiveness. Analysing the data from the past years, it can be presumed that the Slovak project, if it is carried out, will be of vital influence to the LPI of the countries concerned, and thus, also to the competitiveness of the given countries.

The expected positive effects of the Hungarian railway network extension (the V0 bypass line) are the following:

- V0 will be able to alleviate the traffic of the Southern railway bridge connecting *Kelenföld* and *Ferencváros*, which is a line passing close to the centre of *Budapest*;
- it enables the increase of rail freight performance by at least 10% annually;
- it might trigger economic activity in the region of *Szolnok* and *Debrecen*. These economic regions might become quicker to reach from the ports of the Adriatic and the Northern Sea. The reduction in travel times may be hours, or even days. The *Szolnok Regional Logistics Centre*, operated by *BI-KA Logisztika Kft.* has already started reactivating its industrial railway line, and

has prepared several Memorandums of Understanding, which will enable serving its partners on rail and which will contribute to the growth of rail freight transport in the region [18];

- it creates the basis for logistic investments in the *Záhony* region as well [15];
- it enhances the logistics competitiveness of Hungary and it contributes to positioning Hungary as an important transit corridor;
- it facilitates Hungary becoming the logistics centre of Central and Eastern Europe;
- it improves the situation of intermodal (combined road – rail – inland waterways) transport, thus enabling the development of a modern transport system. It improves the competitiveness of transit rail freight transport and revitalizes the inner rail transport market. By shifting a part of road freight transport to railways and inland waterways, it reduces maintenance costs, the quality of roads will not deteriorate as rapidly and the extent of emissions (air pollutants and noise) will also be reduced, just as well as the risk of accidents triggered by the presence of trucks on the roads [14];
- the building of V0 bypass line may be the most important development of the railway infrastructure in the next two decades. The project may provide work for the Hungarian labour force and for Hungarian enterprises.

4. Conclusions

Hungary has a favourable geopolitical position, which may support the strategic aim of becoming the logistics centre of the Central-European region. To reach this goal, however, considerable investments shall be carried out in the field of transport and logistics infrastructure. One of the major investments planned is the realisation of V0 railway line, which facilitates the increase of rail freight transit going through Hungary. There are other positive effects of this infrastructure development, which have been analysed in detail.

The evaluation of GCI and LPI data has shown that there is a correlation between competitiveness and the state of transport/logistics infrastructure. That is why it is an important task of policy makers to pay special attention to the development of infrastructure elements playing a determining role in the logistics market. Such an improvement can be in Hungary the railway line development described above. Nevertheless, before starting the project it is worth investigating its impacts not only on competitiveness but also on efficiency [15].

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Spectral Reconstruction on the Basis of Several Samples and Principal Components Analysis

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Abstract: One important problem of colorimetry is that how to determine the spectral characteristics of colour samples with the help of some known parameters. If we take the spectral reflection features of a big amount of sample sets and use a linear algebraic-statistical method, the principal component analysis, we can determine that handful of parameters whose linear combination helps to reconstruct the spectral distribution of the elements of the original sample sets. The average vector given by this method and the first couple of eigenvectors can reproduce the elements of the samples with a good approximation, therefore, in case of a large set of colour samples, it is enough to weigh the first few base vectors to reconstruct the samples.

Keywords: spectral reconstruction, principal component analysis, eigenvector

1. Introduction

When we want to determine the spectrum and the reflectance function of colour samples, we need a spectrophotometre in the first case. However, it is sometimes not possible to purchase a spectrophotometre, and even if we have one, it is difficult to use it. It is especially difficult when it is not easy or even impossible to get closer to the samples. So the question arises as to how we can replace it with an everyday, easy-to-use device. In nearly all cases, there is a digital camera from which it is easy to extract three values that comply with an additive colour mixing model and determine a colour stimulus. It is shown, as follows, how the reflectance function of the coulour stimulus that is given with three values can be determined with the help of several samples and the principal component analysis.

2. Elements

2.1. The concept of colour

Colour can be defined as a perception in our brain. We need optical radiation (what we commonly refer to as light) which, after entering our eyes and being absorbed by our retina, induces nervous signs. In case of monochromatic radiation, the perceived colour depends on the wavelength of the radiation; in case of complex radiation, the perceived colour is determined by the amount of energy the radiation transfers in different wavelength ranges.

Colour can be defined as a property of an object and this property shows in what ration the object absorb or reflect the different-wavelength components of the light that shines it. However, this refers to a property of surfaces.

2.2. Spectrum, reflectance function

The spectrum of a light source, the reflectance function of a colour sample *(φ(λ))* can be defined as the amount of energy transferred on a given wavelength or rather how big its radiated power is. Spectra may be continuous (Figure 1.), when all the values appear between two wavelengths. For instance, incandescent metals, solids in general and liquids emit such spectra, whose model was given by Planck. Spectra may be linear (Figure 2.), where only few lines appear in a narrow interval. Such spectrum is provided by incandescent gases that are made up of atoms or simple molecules. In case of secondary lights, namely surfaces that are exposed to light and reflect it somehow, we talk about reflectance function. (Figure 3.)

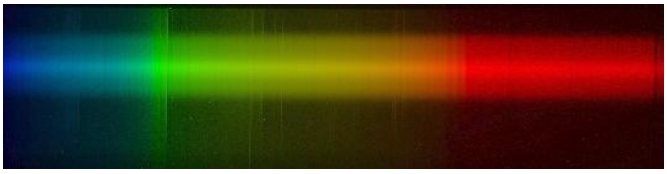

Figure 1. Continuous spectrum

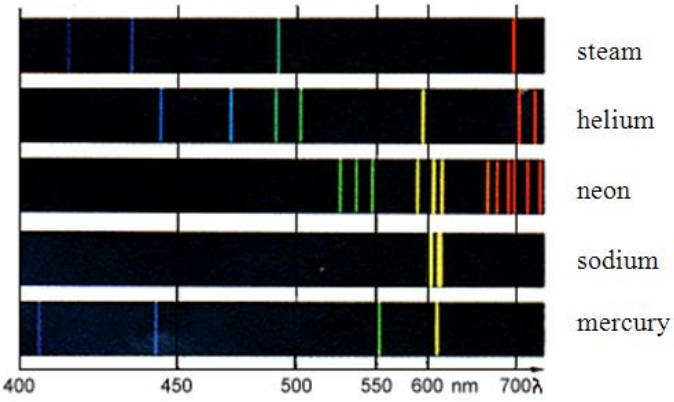

Figure 2. Linear spectra

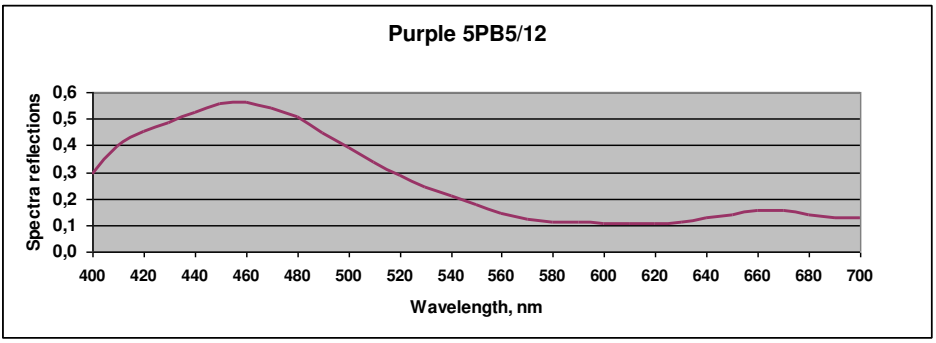

Figure 3. The reflectance function of the 5PB5/12 Munsell sample

Any spectrum as a colour stimuli can be described with three values (X, Y, Z) because of the types of receptors in the human eye. These values are the so called colour-stimuli components, which are calculated with the use of colour matching functions ($\bar{x}$ (λ), $\bar{y}$ (λ), $\bar{z}$ (λ)) that are considered as weighting functions (Figure 4.).

$$X = k \int_{380nm}^{780nm} \varphi(\lambda)\bar{x}(\lambda)d\lambda \,,\; Y = k \int_{380nm}^{780nm} \varphi(\lambda)\bar{y}(\lambda)d\lambda \,,\; Z = k \int_{380nm}^{780nm} \varphi(\lambda)\bar{z}(\lambda)d\lambda \quad (1)$$

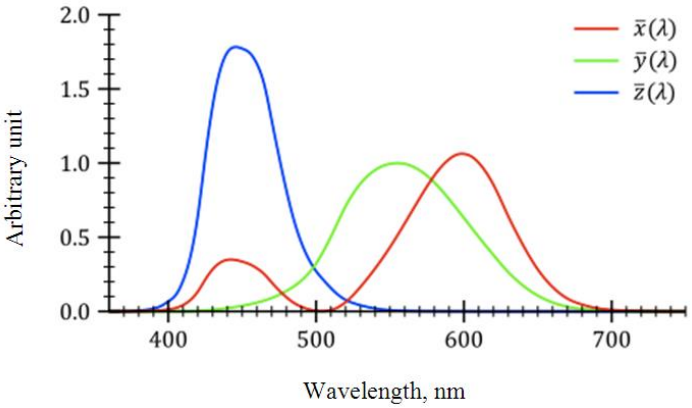

Figure 4. $\bar{x}$, $\bar{y}$ és $\bar{z}$ colour-matching functions of CIE

2.3 Metamerism

Although the metamer colours are perceived in the same way, their spectral power distribution is different. The sameness may be true for more colours. If colour A is identical with colour B, and colour B is identical with colour C, then colour A is identical with colour C as well. Therefore, it means that the colour determined with values X, Y, Z can be provided with several *φ(λ)* spectra.

3. Mathematical method

The following description is based on László Koltay mathematician's lecture notes [1].

Let $\xi:\Omega \to R^p$ be a vector probability variable. The expected value of vector ξ as a probability variable is denoted by $E(\xi)= m \in R^p$, and its covariance matrix is denoted by $\mathrm{cov}(\xi,\xi)=V \in R^{p\times p}$. Let the centralised ξ be $\xi^*=\xi-m$. Let us denote the eigenvalues arranged in decreasing order of the covariance matrix V by $\lambda_1 \geq \lambda_2 \geq \ldots \geq \lambda_p$. It follows from the properties of the covariance matrix that all its eigenvalues are non-zero.

The orthogonal and normalised system of the eigenvectors relating to the eigenvalues $\lambda_1 \geq \lambda_2 \geq \ldots \geq \lambda_p \geq 0$ is denoted by $v_1, v_2, \ldots, v_p \in R^p$. The summary above implies that the scalar probability variables are called the *principal components* of the vector ξ probability variables.

$$\tau_i = v_i^T \cdot \xi^*, \; i=1,2,\ldots,p \quad (2)$$

It is an extremely important property of the principle components that the original probability variable can be given by the linear combination of them in the following way.

$$\xi = \sum_{i=1}^{p} \tau_i \cdot v_i + m \quad (3)$$

This property was applied in the study about day-time radiance distribution [2] as well, moreover, the minimal number of eigenvectors was determined with this method to produce real samples [3]. We can read about how to produce the original samples from characteristic vectors in publication [4], and about the role of the mean vector in publication [5].

4. The examination of Munsell-colour samples

The Munsell colour range is a widely-accepted system of colorimetry, which describes the colours with three features (hue, value, saturation). The colour range was worked out by Albert Henry Munsell, American painter and professor in order to make the names of colours mean the same for everybody (Figure 5.). This system is based on the human colour perception, each colour is denoted by a combination of lettres and numbers.

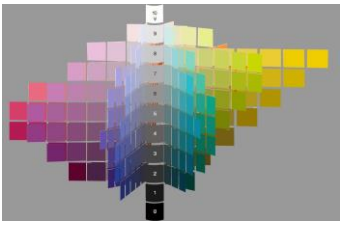

Figure 5. The Munsell colour system

373 colour samples of the system was examined. The known spectral reflectance factors of the samples are the probability vectors. The reflectance factors are given at 10-nm equidistant intervals between 400 nm and 700 nm, therefore, the vectorspace is 31-dimensional.

The values X, Y, Z belonging to given samples may be determined with the help of colour matching functions (Table 1.).

Table 1: Values X, Y, Z belonging to the 5PB5/12 sample

	Original
X =	2.0266
Y =	2.0470
Z =	5.4070

The eigenvalues of the eigenvectors relating to the covariance matrix of 373 colour samples are determined with the use of Matlab software (Table 2.).

Table 2: A fragment of the components of the mean vector and the first five eigenvectors

Mean vector	0.1804	0.2355	0.2572	0.2635	0.2677	0.2716	0.2765	0.2822
v_1	0.0894	0.1344	0.1544	0.1589	0.1605	0.1613	0.1622	0.1628
v_2	-0.0921	-0.1464	-0.1765	-0.1897	-0.1994	-0.2093	-0.2200	-0.2306
v_3	0.1410	0.2077	0.2326	0.2315	0.2219	0.2047	0.1777	0.1364
v_4	-0.1214	-0.1632	-0.1653	-0.1492	-0.1345	-0.1157	-0.0853	-0.0344
v_5	-0.0603	-0.1508	-0.1929	-0.1832	-0.1391	-0.0731	0.0150	0.1277

Each eigenvector may also have negative values, except the one belonging to the highest eigenvalue. It is shown that the eigenvector of the nth eigenvalue as an abstract spectrum has (n-1) zero values. We can use the *Solver* function of Excel to determine the weights that are needed in the linear combination of the eigenvectors. The constraints are chosen on the basis that whether we know or not the reflectance function of the sample. In case of a known reflectance funcion, we minimalise the squared sum of the deviations between the known and reconstructed function values and use it as a constraint. It is proved that the samples can be generated approximately well with the mean vector and the first five eigenvectors (Figure 6).

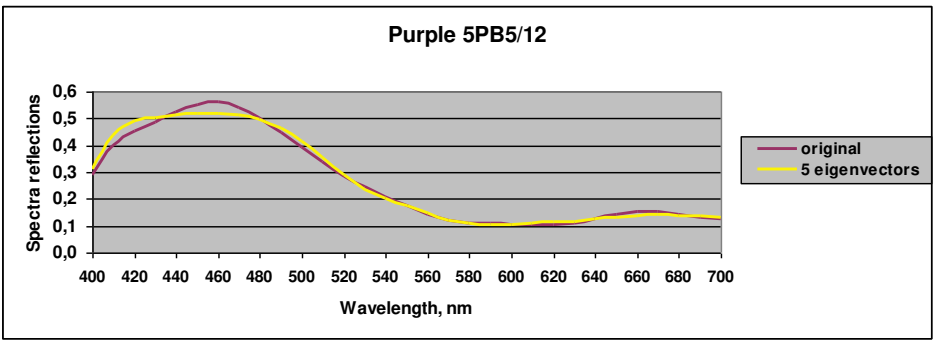

Figure 6. The original and calculated reflectance function

In case of unknown reflectance function, we set the constraint that the derivative of the squared sum of the deviations between the original and the reconstructed values X, Y, Z must be minimal (Table 3.). We use the mean vector and the first five eigenvectors in this case, too (Figure 7.).

Table 3: The original and reconstructed X, Y, Z values

	Original	Reconstructed
X =	2.0266	2.0266
Y =	2.0470	2.0470
Z =	5.4070	5.4070

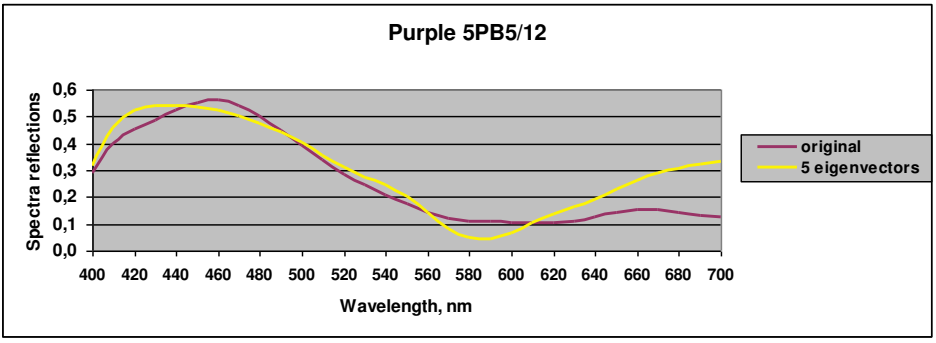

Figure 7. The original and calculated reflectance function

We give a constraint for the first derivative in order to reach a better interpollation between the original and the reconstructed function. To reduce the number of local minima and maxima, the second derivative is limited. A further condition is made, the reconstructed function cannot have negative values. *Solver* is used to set the constraints (Figure 8.).

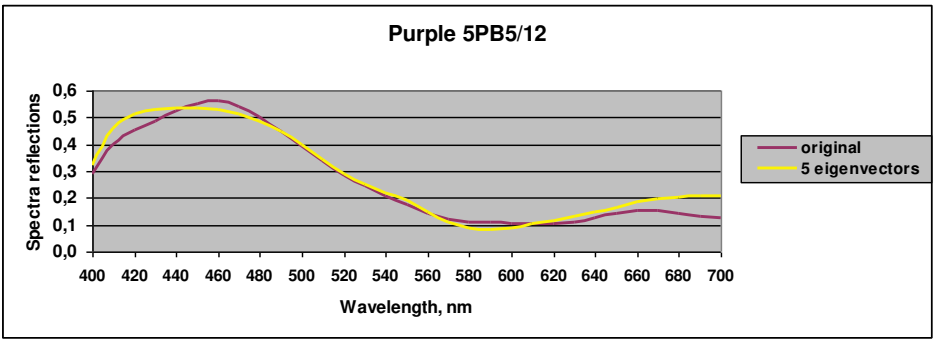

Figure 8. The adjusted reflectance function

5. Summary

We can conclude that it is not necessary to apply all the 31 eigenvectors to generate 373 samples within measuring accuracy, it is enough to apply the mean vector and the first five eigenvectors. Using this method, any colour sample given by values X, Y, Z can be related to a metamer after a short time of calculation. This method works in case of spectra that are different from the spectra belonging to the training samples.

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Evaluation of Short-Range Wireless Technologies for Automated Meter Reading (AMR) Systems

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Abstract: The paper presents the results of the evaluation of some short-range wireless technologies suitable for communications in AMR systems. The typical AMR system structure is described, an overview of three candidate technologies, Wi-Fi, ZigBee and wireless M-Bus, is provided. The evaluation of these technologies is given, based on a selected set of properties, and the results of measurements in two real-world scenarios are summarised.

Keywords: AMR, automated meter reading, Wi-Fi, ZigBee, M-Bus

1. Introduction

Automatic meter reading (AMR) is the technology of automatically collecting consumption, diagnostic, and status data from different utility metering devices and transferring that data to a central database for billing, analysing and troubleshooting. AMR devices are basically water, gas, electricity, and heat meters. However, automatic meter reading requires the deployment of an appropriate infrastructure. An enhanced variant of such an infrastructure is called AMI (Advanced Metering Infrastructure) that, besides collecting metering data, also enables two-way communications with the meter. AMIs usually include hardware, software, communications, consumer energy displays and controllers, customer associated systems, meter data management software, and supplier business systems. The AMR/AMI technology saves utility providers the expense of periodic visits to each physical location to read a meter and the metering data can be collected remotely with arbitrary periodicity in an efficient and economic way. In addition to that, thanks to the continuous monitoring of the meters failures or misuse can be detected immediately making possible instant intervention. Moreover, billing can be based on near real-time consumption rather than on estimates. This timely information and its analysis can help both utility providers and customers to better control the production and consumption of public utility services.

The paper is organized as follows. In Section 2, we give an overview of a typical AMR/AMI system architecture. The current general AMR/AMI system architecture follows a two-level, hierarchical model with the main elements as follows: i) meters – traditional ones with transmitters attached to it via optical or electrical interface or

integrated meters; ii) data collection unit, concentrator or gateway; and iii) data processing centre – usually at the site of the utility company, or at a central controlling site in case of a municipality network with AMR service. This architecture can be extended to a three-level one by adding an intermediate level, in which a concentrator collects data from individual house or apartment concentrators. For communications between the meters and the (lower level) concentrator, wired connections (e.g., PLC, Ethernet, M-Bus) or wireless connections (e.g., ZigBee at 868 MHz and 2.4 GHz, Wireless M-Bus at 868 MHz, Wi-Fi, proprietary radio), while between the individual concentrators and the processing centre wired connections (e.g., PLC, PSTN) or wireless connections (e.g., cellular radio/GPRS, Wi-Fi, WiMAX) are typically used.

Section 3 contains an overview of the potential wireless technologies and their comparative evaluation, based on a set of properties that are important for AMR systems. We highlight Wi-Fi, ZigBee, and Wireless M-Bus technologies. We do not include cellular solutions, like GSM/3G/4G, in this overview even if such implementations can be found on the market, because they seem to be technologically and economically suboptimal for AMR systems. For evaluating the aforementioned technologies the following set of properties will be used: i) network topology and architecture; ii) propagation properties and area coverage; iii) possibilities for QoS provisioning; iv) manageability; v) security and privacy issues; and vi) existing applications, products, vendor support. Based on the outcome of this comparison we selected the 868 MHz version of ZigBee and the Wireless M-Bus (also operating in this frequency band) technologies for further investigation and carried out some real field measurements.

The last part of this paper, Section 4, contains our measurement results. For the tests we used standard-based Wireless M-Bus adapters produced by Amber Wireless, with built-in antennas only, and we also used Texas Instrument's 868 MHz chips on evaluation boards. The measurements were carried out in two realistic scenarios: in a family house and in a multi-dwelling house environment.

2. AMR/AMI system architecture

This section gives an overview of AMR system architectures, and deals with local data collection and forwarding the data to the central site with the appropriate communication technologies and protocols.

Based on our survey of AMR system suppliers we can arrive to a conclusion that the current general AMR/AMI system architecture is a two-level, hierarchical one, see Figure 1, with the main system elements as follows:

1 Meters (traditional ones with transmitters attached to it via optical or electrical interface or integrated meters)

2 Data collection unit, Concentrator, Gateway (different names used by different vendors)

3 Data processing centre (usually at the site of the utility company, or at a central controlling site in case of a municipality network with AMR service)

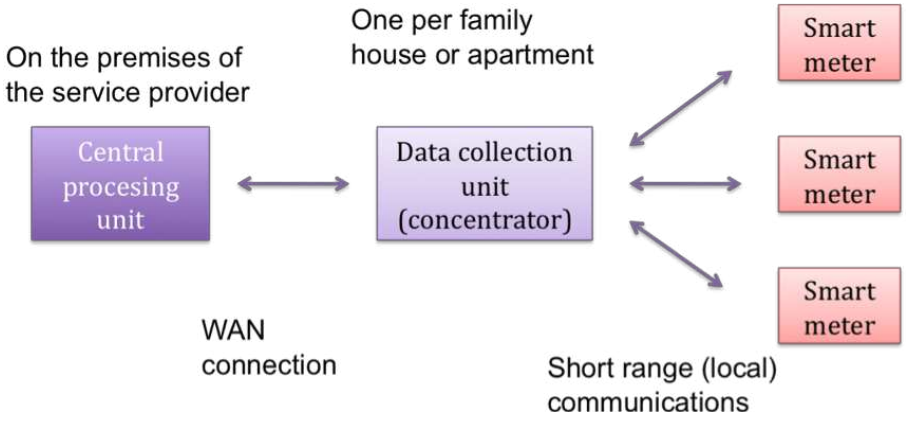

Figure 1. Typical high-level AMR system architecture

This architecture can be extended to a three-level one by adding an intermediate level where a concentrator collects data from individual house or apartment concentrators.

A typical practical architecture is more complicated than the high level one described above. This is mainly because usually more than one short-range communications technology is used for connecting the meters to the concentrator. For example, the system architecture of Holley Metering [1] consists of several sub-systems, as follows:

1. Meters connected via wired connection, using a RS485 repeater.
2. Meters connected via PLC, using a PLC/RS485 converter.
3. Meters connected via low frequency wireless network, using a wireless/RS485 converter.
4. Meters connected via ZigBee, using a ZigBee/RS485 converter.

In the Holley Metering architecture, the last part is actually a wireless mesh network.

Solutions for the communications between the meters and the (lower level) concentrator include:

- wired connections: PLC, Ethernet, M-Bus,
- wireless connections: transceivers in 450-470 MHz band (FCC), 433 MHz, ZigBee 868 MHz and 2.4 GHz, Wireless M-Bus (868 MHz), Wi-Fi, proprietary radio.

Solutions for communications between the individual concentrators and the processing centre include:

- wired connections: PLC, PSTN,
- wireless connections: cellular radio (most frequently GPRS), Wi-Fi, WiMAX.

Note that municipal/community wireless networks are often used as a communications infrastructure for AMR system, mainly in the USA (see [2]). In these cases, the wireless technology is mostly Wi-Fi mesh and occasionally WiMAX is used as a backbone.

As for the wireless communications between the meters and the concentrator, which was our main subject of study, *ZigBee, Wireless M-Bus and Wi-Fi* are based on

worldwide standards and gained wide acceptance in the solutions of large vendors. We provide an overview and a comparative evaluation of these three technologies in the next section.

3. Wireless technologies for AMR systems

3.1. Wi-Fi

3.1.1. Overview

Wi-Fi is a trademark of the Wi-Fi Alliance and the term was originally created as a simpler name for the IEEE 802.11 standard family [3] to create wireless local area networks (WLANs). The original version of the IEEE 802.11 standard was released in 1997 and clarified in 1999, but is today obsolete. In the meantime, several amendments to the original standard were developed, and in 2007 a single document was created merging 8 amendments (802.11a, b, d, e, g, h, i, j) with the base standard and named to the current base standard IEEE 802.11-2007. In 2009, the IEEE has approved the 802.11n amendment that improves upon the previous 802.11 standards, and this can be considered as the latest standard, widely supported by the device manufacturers.

To position Wi-Fi among the relevant wireless communication technologies we can say that it belongs to wireless LAN technologies providing up to some hundred meters communication range and up to some hundred Mbps bandwidth

3.1.2. Main characteristics

A) Network topology and architecture

Wi-Fi can work either in infrastructure or in ad hoc mode. In infrastructure mode, Wi-Fi wireless LANs follow a cellular architecture. Each cell (called Basic Service Set or BSS) consists of mobile nodes (MN) and is controlled by a base station (called Access Point or AP). Most wireless LANs are formed by several cells, where the APs are connected through some kind of backbone (called Distribution System or DS). This backbone is typically wired, using e.g. Ethernet technology. The whole interconnected wireless LAN, including the different cells, their respective APs and the Distribution System, is known as Extended Service Set (ESS) and also called as SSID (Service Set IDentifier).

In ad hoc mode, the users build up the wireless LAN without using APs. Such a network is a kind of wireless self-organized network built of a collection of diverse nodes. The nodes are basically hosts and at the same time mobile routers that are connected by Wi-Fi links and communicate spontaneously, and which form a multi-hop network with an arbitrary network topology without relying on any pre-existing infrastructure or central administration. These routers organize themselves in a self-configuring manner, thus the network's wireless topology may change rapidly and unpredictably. An ad hoc network may operate in a standalone fashion, or may be connected to the Internet.

The infrastructure and ad hoc communications can be combined into a mesh topology. An infrastructure Wi-Fi mesh network is a communication network built of static Wi-Fi nodes organized in a mesh topology in an ad hoc manner. End hosts can access this mesh cloud via the Wi-Fi nodes that serve as APs. However, Wi-Fi nodes do not necessarily play an AP role, they can be just mesh points, but all the Wi-Fi nodes act as routers to transmit data from nearby nodes to peers that are too far away to be reached in a single hop, resulting in a network that can span larger distances. A mesh network is reliable, can self form and self heal and offers redundancy. It has a relatively stable topology except for the occasional failure of nodes or addition of new nodes. The traffic, being aggregated from a large number of end users, changes infrequently. When a node can no longer operate, the rest of the nodes can still communicate with each other, directly or through one or more intermediate neighbors.

B) Propagation properties and area coverage

The 802.11 protocol covers the physical and MAC (Media Access Control) layers. The original standard defines a single MAC layer that interacts with three physical layers (later on this was revised and extended by additional physical layers).

The four major physical layer specifications are defined in 802.11a, 802.11b, 802.11g and 802.11n. These standards use different ISM (Industrial, Scientific and Medical) license free frequency bands and radio modulation techniques resulting in different data rates and interoperability properties. The physical layer specified by 802.11a works in the 5 GHz frequency band, since 802.11b/g standards specify the 2.4 GHz frequency band for operation, thus 802.11a devices cannot interoperate with 802.11b/g devices. The 802.n standard specifies the use of both bands. The 5 GHz frequency band, for much of the world, offers at least 23 non-overlapping channels rather than the 2.4 GHz frequency band, where only 13 (in some countries 11, in Japan 14) channels are available and all the neighbouring channels overlap (channels far enough from each other, such as channels 2 and 7, or channels 1, 6 and 11, are non-overlapping in this range). Because of this choice of frequency band, 802.11b/g/n devices may occasionally suffer from interference from microwave ovens, cordless telephones and Bluetooth devices.

Table 1 summarizes the channel bandwidth, modulation technique, data rates and communications range of these physical layer standards.

Table 1. Comparison of 802.11 standards

Standard	**Freq. [GHz]**	**Chnl bwidth [Mhz]**	**Mod. techn.**	**Compa-tibility**	**Max. data rate, Mbps**	**Commun. range [m]**
802.11a	5	20	OFDM *)	802.11n	54	Indoor: 30-90 Outdoor: 100-300
802.11b	2.4	20	DSSS **)	802.11g /n	11	
802.11g	2.4	20	DSSS/ OFDM	802.11b /n	54	
802.11n	2.4/5	20/40	OFDM	802.11a/ b/g	600	

*) *Orthogonal Frequency Division Multiplexing*

**) *Direct Sequence Spread Spectrum*

C) Possibilities for QoS provisioning

The IEEE 802.11e standard defines a set of Quality of Service enhancements for wireless LAN applications through modifications of the MAC layer. The standard is considered to be of critical importance for delay-sensitive applications, such as Voice over Wireless LAN and streaming multimedia.

The basic medium access method of IEEE 802.11 is the DCF (Distributed Coordination Function), which is basically a Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA). This method uses a collision avoidance mechanism together with a positive acknowledgement scheme. The CSMA/CA-based MAC protocol does not provide any QoS. Beyond the basic DCF, there is an optional MAC mechanism called PCF (Point Coordination Function), which may be used to implement time sensitive services, like voice or video transmission. This PCF makes use of higher priority access and the AP issues polling requests to the stations for data transmission, hence controlling medium access. In order to still enable regular stations to access the medium, there is a provision that the AP must leave enough time for distributed access, too. Unfortunately, most of the off-the-self products do not support PCF.

The 802.11e enhances the DCF and the PCF, through a new coordination function: the hybrid coordination function (HCF). Within the HCF, there are two methods of channel access, similar to those defined in the legacy 802.11 MAC: Enhanced Distributed Channel Access (EDCA) and HCF Controlled Channel Access (HCCA). Both EDCA and HCCA define Traffic Categories (TC). With EDCA, high priority traffic has a higher chance of being sent than low priority traffic. In addition, EDCA provides contention-free access to the channel for a period. The HCCA works like PCF. However, the HCCA, which is not mandatory to implement for 802.11e APs, allows for the controlled access phases being initiated almost anytime during a contention period.

HCCA is generally considered as the most advanced (and complex) coordination function. With the HCCA, QoS-enabled stations have the ability to request specific transmission parameters (data rate, jitter, etc.) that should allow advanced applications like VoIP and video streaming to work more effectively on a Wi-Fi network.

D) Manageability

The 802.11 standards define 'frame' types for use in transmission of data as well as management and control of wireless links. Frames are divided into very specific and standardized sections. Each frame consists of a MAC header, payload, and frame check sequence (FCS). Some frames may not have the payload (e. g., control frames). The first two bytes of the MAC header form a frame control field specifying the form and function of the frame. The maintenance of communications is done by the management frames. They provide functions for device authentication, association, sending beacons to announce the existence of the network, etc.

Furthermore, power and radio management possibilities are also provided in 802.11 networks. When the transceiver is off, it is in sleeping or power-saving mode. When the transceiver is on, it is active or awake. Power conservation in 802.11 is achieved by minimizing the time spent in the latter stage and maximizing the time in the former one. Power management can achieve the greatest savings in infrastructure networks. All traffic for mobile stations must go through APs, so they are an ideal location to buffer traffic. By definition, access points are aware of the location of mobile stations, and a mobile station can communicate its power management state to its AP. Access Points have two power management related tasks. First, because an AP knows the power management state of every station that is associated with it, it can determine whether a frame should be delivered to the wireless network when the station is active or buffered when the station is asleep. An AP's second task is to announce periodically which stations have frames waiting for them. Moreover, it is possible on most of the Wi-Fi interface cards to tune the transmission power, which extends the battery lifetime of the mobile node in certain scenarios.

E) Security and privacy issues

The WLAN lacks even the minimal privacy provided by a wired LAN. The 802.11 Wired Equivalent Privacy (WEP) mechanism provides protection at a level that is felt to be equivalent to that of a wired LAN. Data frames that are encrypted are sent with the WEP bit in the frame control field of the MAC header set. The receiver decrypts the frame and passes it to the higher layer protocols. Only the frame body is encrypted, this leaves the complete MAC header of the data frame unencrypted and available to even the casual eavesdroppers. Unfortunately, WEP provides only minimal protection to frames in the air and is not too difficult to decrypt the frames even for a causal attacker.

Thus, the Wi-Fi Alliance announced an interim specification called Wi-Fi Protected Access (WPA) based on a subset of the then current IEEE 802.11i draft. The final IEEE 802.11i standard (also known as WPA2) uses Advanced Encryption Standard (AES)

instead of RC4. The modern recommended encryption for the home/consumer space is WPA2 (AES Pre-Shared Key) and for the enterprise space is WPA2 along with a RADIUS (Remote Authentication Dial In User Service) authentication or similar, and a strong authentication method such as EAP-TLS (Extensible Authentication Protocol – Transport Layer Security).

F) Existing applications, products, vendor support

There are many applications of Wi-Fi connectivity, starting from home-based Wi-Fi enabled devices to many public places that are supplied with Wi-Fi connectivity to access Internet, like cafés, restaurants, hotels and clubs to attract the clients. Wi-Fi hotspot concept is popular among business communities and mobile workers, too. Applications like VoIP (Voice over IP), videoconferencing and multimedia streaming are getting popular with the latest Wi-Fi standards providing high data rates and QoS support.

On the market, a huge number of Wi-Fi products are available, including access points, gateways/routers, interface cards, adapters, antennas, Internet radios, spectrum analyzers, power supplies, bar code scanners, cameras, compact flash cards, intrusion prevention systems, multimedia devices, handheld devices/PDAs. Among the biggest Wi-Fi vendors are Cisco/Linksys, Intel, Ericsson, Nokia, Netgear, D-Link, Proxim, Apple.

3.1.3. Summary

Wi-Fi is the dominant wireless technology today to build wireless LANs. With the proliferation of Wi-Fi devices many vendors' products are available for very low price with strong support. The long history, operation experience, high data rate, low cost, enhanced security and QoS support make attractive this technology also in a wide range of application scenarios, such as cordless connection among devices or wireless VoIP using Wi-Fi connections.

On the other hand, this high level of popularity converts one of the most beneficial properties of Wi-Fi, the license free operation, to a serious drawback. The different Wi-Fi applications and devices can interfere with each other, which can result easily in performance degradation, or interruption of operation. This factor should be kept in mind when one considers Wi-Fi technology for new application areas.

3.2. ZigBee

3.2.1. Overview

ZigBee is the specification of the Zigbee Alliance [5], which is based on and enhances the IEEE 802.15.4 standard. 802.15.4 is a member of the IEEE 802.15 PAN (Personal Area Network) family which aimed at standardizing protocols for low cost, low energy consuming devices communicating with each other, without or with a minimal infrastructure (as opposed to the 802.11/Wi-Fi). The technology intended to be less

expensive and more energy-efficient than the other PANs such as Bluetooth. As usual, the IEEE standard only embraces 1.5 layers, the physical layer and the MAC (Medium Access Control) layer. ZigBee extends the IEEE basic architecture with network and security layers and an application framework. ZigBee Alliance, just like Wi-Fi Alliance, focuses on interoperability and certification testing of ZigBee compliant devices and publishes the list of certified products. In addition to the base standards (the so-called ZigBee 2012 and ZigBee IP), ZigBee Alliance developed a number of specific standards to address the needs of a particular application area, including: Commercial building management, Consumer electronics, Energy management, Health care and fitness, Home management, Retail management, Telecommunications.

3.2.2. Main characteristics

A) Network topology and architecture

Three types of network elements are specified:

- ZigBee Coordinator: controls the creation and maintenance of a network;
- ZigBee Routers: extends the range of networks;
- ZigBee End Devices: limited functionality devices that perform specific sensing or control functions.

The Coordinator (there is only one in a network) initiates the network and stores information about the network. All devices communicate with the Coordinator, it has also routing functionality and can serve as a bridge to other networks. The Router is an optional component, when exists, performs routing between nodes thus extending network coverage. It also manages local address allocation/de-allocation. The End Device is the cheapest device type and it is optimized for low power consumption. End Devices communicate only with the Coordinator.

In a ZigBee network, the basic topology is mesh. Point-to-point, star of tree structures are also possible. A network consists of maximum 65535 nodes, each node having a unique 64-bit identifier. Each network needs a central controller that has a permanent power supply and is responsible for sending beacon messages, setting up the network and communications among the nodes.

The protocol architecture consists of three layers: silicon, ZigBee stack (firmware) and applications. The silicon layer is basically what is covered by the IEEE 802.15.4 standard. The ZigBee protocol stack consists of logical networking, security and data protection procedures and application profile. The latter can be user-defined, however, only public profile by Zigbee Alliance ensures interoperability among different vendors's devices ("ZigBee Certified Product").

The physical layer specification is different for the different frequency bands. In the 2.4 GHz band, O-QPSK (Orthogonal QPSK - Quadrature Phase Shift Keying) modulation scheme is used, with 4 bits per symbol rate while in the 868/915 MHz band BPSK (Binary Phase Shift Keying) is used (1 bit/symbol rate). In both cases, interference protection is achieved by using DSSS (Direct Sequence Spread Spectrum) technique with spreading factor of 32 and 15 bits, respectively.

The MAC layer is responsible for multiple access. The MAC protocol offers both contention-based access and controlled (reserved) access in beacon mode. The

contention procedure is the CSMA/CA (Carrier Sense Multiple Access with Collision Avoidance) protocol, a method widely used in the case of Wi-Fi devices. There are two types of access mechanisms, depending on whether the network is a beacon-enabled or non-beacon enabled one. In the former case, a slotted CSMA/CA access is used, while in non-beacon-enabled mode, unslotted CSMA/CA is the channel access mechanism.

B) Propagation properties and area coverage

Propagation properties and area coverage are defined by the characteristics of the frequency bands where ZigBee is allowed to operate, see Table 2.

Table 2. ZigBee frequency bands

Band	Usage	Availability	Data rate [kbps]	No of channels
2.4 GHz	ISM	worldwide	250	16
868 MHz	with restrictions	in Europe	20	1
915 MHz	ISM	in America	40	10

In Europe, the 2.4 GHz ISM band is the obvious possibility. Here the average distance range that can be covered by ZigBee devices is 10 m to 75 m, sometimes more, in line-of-sight (LOS) conditions. Non-LOS propagation, in particular the penetration through concrete walls, is typically not very good (1-2 concrete walls can be allowed at best). Mutual interferences with devices using this band, especially with Wi-Fi, should be investigated. The two UHF bands could offer better propagation in NLOS environment, however, the 915 MHz band is only available in America, and the 868 MHz band, generally available for use in Europe, can be used under specific circumstances (limitation of the output power) [6]. For example, the output power is limited to 25 mW ERP and the duty cycle should be at most 1%.

C) Possibilities for QoS provisioning

Time-critical data can be sent via a timeslot reservation mechanism. The GTS (Guaranteed Time Slot) mechanism allows a device to operate in a specified portion of the superframe. A GTS can only be allocated by the PAN coordinator that can allocate up to seven GTSs at the same time. GTS allocation is performed by the coordinator based on (i) requirements of the GTS request, and (ii) the currently available capacity in the superframe. A GTS can be de-allocated by the coordinator whenever it decides to do so or based on the request of the device.

D) Manageability

The Network Layer (NWK) of the ZigBee protocol architecture is responsible for network management and offers a number of services to accomplish it such as initialization, maintenance and control of the network. Routing protocols are defined at the network layers for star, tree, and mesh topologies.

E) Security and privacy issues

The ZigBee security architecture includes security mechanisms at two layers of the protocol stack. The NWK and APS (Application Support Sublayer) layers are responsible for the secure transport of their respective frames. Furthermore, the APS sublayer provides services for the establishment and maintenance of security relationships. The ZigBee Device Object (ZDO) manages the security policies and the security configuration of a device.

F) Existing applications, products, vendor support

ZigBee is being used as short range wireless communication technology for many AMR suppliers including Develco (Denmark), ELSTER (Germany), ITRON (USA), Holley (China), Honeywell (USA), Landys&Gyr (Switzerland), TBNEnergo (Russia), Nuri Telecom (Korea). Products include electricity, gas, water, and heat meters, and vendors offer complete solutions with concentrators and backhaul connections. The ZigBee technology itself is often purchased from Telegesis (UK), a leading vendor specialized in ZigBee modules.

3.2.3. Summary

The ZigBee technology is one of the best candidates for short-range data collection in AMR systems. It enjoys wide industrial support due to its standardization status (within the IEEE 802 family) as well as due to the additional standardization, interoperability testing and application development within the ZigBee Alliance.

From technical point of view, the data rates it offers are enough for AMR applications, real-time transmission is also supported by the medium access protocol, security and management tasks are also taken care of by the ZigBee protocol stack and the products based on it. Its limitations (in Europe), when operating in the 2.4 GHz ISM band, are similar to Wi-Fi: the large number of devices cause mutual interferences, and the propagation properties are also not ideal, in particular when reliable communications have to be established in NLOS environment, for instance in large buildings with concrete separating walls. Communications with remote water meters in rural and suburban environment can be a problem where the meters are usually installed in concrete shafts with metal lids at a depth of about a meter below the surface.

3.3. Wireless M-Bus

3.3.1. Overview

The Metering Bus, or in short M-Bus, originally developed as an interface for heat meters, is considered as a basis for new advanced metering infrastructure (AMI) installations in many regions of the world. Their wireless implementation brings a competitive advantage; also they are products easy to install and maintain. The M-Bus standard is a European Standard [8], actually a family of standards, and its Wireless M-Bus component [9] defines the wireless communication between meters for water, gas, heat and electricity, and the data concentrators.

3.3.2. Main characteristics

A) Network topology and architecture

M-Bus is a field bus, which is specialized for transmitting metering data from gas, heat, water or other meters to a data collector. It is described by the aforementioned European standard which includes the specification of wired and Wireless M-Bus. The specification is divided into five parts:

- *EN13757-1: Communication systems for meters and remote reading of meters - Part1: Data exchange.* It describes the basic communication between the meters and a central data collector and provides an overview of the communication system.
- *EN13757-2: Communication systems for meters and remote reading of meters - Part2: Physical and link layer.* This part includes the specification of the physical data transmission using wired connections. It also contains the description of the protocol to transmit the data.
- *EN13757-3: Communication systems for meters and remote reading of meters - Part3: Dedicated application layer.* The third part of M-Bus describes an application protocol, which allows the data transmission of meters' multivendor capability.
- *EN13757-4: Communication systems for meters and remote reading of meters - Part4: Wireless meter readout (Radio meter reading for operation in the 868 MHz to 870 MHz SRD band).* This part specifies the wireless communication of M-Bus. It includes the Physical and the Data Link Layer for wireless devices, and it corresponds to specification EN13757-2 for wired communication.
- *EN13757-5: Communication systems for meters and remote reading of meters - Part5: Relaying.* This last part includes different proposals for relaying the meter data to overcome the range problem between remote meters and data collectors.

The network architecture follows the OSI model but only Layers 1, 2 and 7 are implemented. Up to now, the application layer implements all other protocol layers required for a specific device. Especially if routing is required, it resides in the application layer. This lack of modularity might be one reason why standardized routing algorithms are not available currently for Wireless M-Bus. But the reduced modularity leads to compact implementations running on very small devices with minimum computing resources.

The M-Bus supports asymmetric network topologies with low-cost or low-power metering devices on the one side and data collectors or gateways with higher performance on the other side. Currently, only *point-to-point or star* network topologies apply. Mesh networking is not possible, as the required routing algorithms are not specified yet.

The wireless M-Bus standard specifies the communication between a meter and an "other" system component, e.g. mobile/stationary readout devices, data collectors.

Three different meter modes are defined, for the communication between a meter and an "other" device:

- S-mode - Stationary Mode;
- T-mode - Frequent Transmit Mode;
- R-mode - Frequent Receive Mode.

Sub-modes X.1 and X.2 specify whether one-way or two-way communication is

performed, respectively. Thus for example Mode T2 indicates a two-way T-mode device.

The EN13757-4 specifies the physical layer and the data link layer for communication between the meter and the concentrator. This includes:

- Radio parameters;
- Packet frame format;
- Access method.

The Wireless M-Bus specification has several options for the radio parameters. Three different data rates are specified: 4.8 kbps for R2, 32.768 kbps for S1/S2 and 100 kbps for T1/T2.

All the modes are specified to use the 868 MHz license-free ISM band for Europe, but each of the different modes has its own radio requirement such as the specific channel, frequency accuracy, data rate tolerances, etc.

One of the important features for Wireless M-Bus is that meters are battery-operated. Gas and water meters are normally not connected to the electricity network and therefore have limited energy available. In addition, the replacements of meters are costly so the battery lifetime should be several years. Actual lifetime requirements may vary from country to country, typically 10 – 20 years. To handle the battery lifetime requirements, the radio in the meters is in sleep mode for most of the time, and transmits only in small timeslots. The concentrator can never initiate any communications since the meter will be in sleeping mode most of the time. Two-way communications is enabled by the meter going into receive mode for a short time after transmission, thus allowing the concentrator to send messages at these specific timeslots. The timing is different for different modes and the timing is specified in the standard.

The addressing scheme in Wireless M-Bus is similar to the wired M-Bus. It is only the meters that have addresses, and the meter address is used both when transmitting to, and from, the meter. Hence, the concentrator must have a table of the meters connected to it. These meters will be registered at the concentrator during the installation phase.

B) Propagation properties and area coverage

Wireless M-Bus devices operate in the 868 MHz UHF band that offers good propagation in NLOS environment. This band is generally available for use in Europe, and can be used under specific circumstances (limitation of the output power). For example, the output power is limited to 25 mW ERP and the duty cycle should be at most 1%.

C) Possibilities for QoS provisioning

None.

D) Manageability

None.

E) Security and privacy issues

None.

F) Existing applications, products, vendor support

Several semiconductor/OEM vendors offer Wireless M-Bus modules that can be integrated into different components of an AMR system.

Radiocraft's RC1180-MBUS module can be used in several ways in the following devices: Concentrator; Bridge; Meter. The basic version on the standard RC1180-MBUS module comes with modem functionality. In this case, most of the control is done in the host controller, and the module is used as a communication port [10].

Texas Instruments has both single chip (SoC) and two-chip solutions for Wireless M-BUS. The two-chip solution is implemented with the RF transceiver CC1101 associated with the MSP430. The system on chip solution is based on a CC1110 device with an 8051 MCU core. TI provides software examples to support Wireless M-BUS [11].

Silicon Labs products include C8051 MCU and EZRadioPRO [12].

Analog Devices has a Wireless M-Bus transceiver ADF7020 [13].

Several AMR vendors support M-Bus and Wireless M-Bus interfaces for short-range communication between their data concentrator units and meters, e.g., ELSTER, Sagemcom.

3.3.3. Summary

M-Bus and Wireless M-Bus are European standards, specifically developed for smart metering systems. Wireless M-Bus devices operate in the license-free 868 MHz band thus offering adequate coverage for communications between concentrator and utility meters. Off-the-shelf RF modules are available from several large semiconductor manufacturers and AMR system vendors also support M-Bus and Wireless M-Bus interfaces.

3.4. Comparison of wireless technologies recommended for AMR systems

Table 3 gives a summary of the most important technical parameters of the three technologies dealt with in this chapter and serves as a comparison among them. Radio characteristics, communications and networking capabilities, security and reliability issues and possible application areas are addressed in this summary in detail.

Table 3. Comparison of wireless technologies

	Wi-Fi	**ZigBee**	**Wireless M-Bus**
Radio characteristics			
Frequency band(s) [GHz]	2.4/5	2.4 GHz (16 channels), 915 MHz (USA), 868 MHz (Europe)	868 MHz

Usable bandwidth [MHz]	83,5 (band 2.4 GHz), 200 (band 5.2 GHz), 255 (band 5.6 GHz)	80 MHz (16 channels), 2.4 GHz 20 MHz (10 chnls) in the 915 MHz band, 1 chnl at 868.3 MHz	1 channel at 868.3 MHz
Modulation method(s)	DSSS/OFDM	DSSS/QPSK, BPSK	FSK
Typical/maximal transmitting power	10 mW/100 mW (2.4 GHz), max. 1 W (5.6 GHz)	25 mW ERP allowed, with <=1% duty factor or technique as specified in 1999/5/EC	25 mW ERP allowed, with <=1% duty factor or technique as specified in 1999/5/EC
Typical receiver sensibility	-78 to -85 dBm @ 11 Mbps	-92 dBm	-102 dBm
Typical distance, LOS [m]	Some hundred meters	1500	N/d
Typical distance, NLOS [m]	30-90 (indoor), 100-300 (outdoor)	10-70	N/d
Communication and networking characteristics			
Simplex/half duplex/duplex	Half duplex	Half duplex	Simplex/half duplex
Data rate(s)	Up to 11/54/600 Mbps	250 kbps (2.4 GHz), 40 kbps (915 MHz), 20 kbps (868 MHz)	4.8, 32.768, 100 kbps
Frame size min./max.	Control frame: 14/20 octets, Max. mngment/data frame size: 2346 octets	76 Bytes max.	76 Bytes max.
Frame overhead	28 – 32 octets (management/data frame)	15 Bytes	15 Bytes
Supported topologies:			
- point-to-multipont (master-slave)	Yes	Yes	Yes

- point-to-point	Yes	Yes	Yes
- ad-hoc	Yes	Yes	No
- mesh	Yes	Yes	No
Addressing	MAC addresses	MAC addresses	Data link addresses
Medium access mechanism(s)	CSMA/CA	CSMA/CA, timeslot reservation	N/d
Delay and jitter	N/d	15 ms in sleep mode, jitter n/a	N/d
Security			
Encryption	WEP/WPA/WPA2	AES128	N/d, most likely none
Authentication	Yes		
Individual identification?	Yes, e. g. using RADIUS		
Reliability			
Error protection (ARQ/FEC)	FCS		CRC
ISM/licensed bands?	ISM	ISM bands, mutual interf. with Wi-Fi in 2.4 GHz band	ISM band
QoS capabilities?	Yes, 802.11e	Yes, via timeslot reservation mechanism	N/d, most likely none
Applicability			
Vendors implementing the protocol	Cisco, Ericcson, Netgear, etc.	Ember (leading chip manufacturer), Telegesis (leading vendor of ZigBee modules), AMR suppliers incl. Develco, Elster, Itron.	Radiocraft, Texas Instruments, Silicon labs, Analog Devices
Services using the protocol	Wireless Internet access, VoIP, etc.	AMR, building automation, home automation, health care, smart energy, remote control	Automated meter reading systems

Possibility of use on other (non-wireless) mediums	N/a	N/a	Compatibility with wired M-Bus within the same family of standards
Connection to other networks?	Yes	Yes	No direct connection, only via a concentrator device
Energy consumption and efficiency	Power management capability	Battery life 5...10 years	N/d

N/a - Not applicable, N/d – No data available

4. AMR measurements

4.1. Overview

Based on the comparative evaluation of wireless technologies for AMR systems, we selected the Wireless M-Bus and ZigBee (operating at 868 MHz) technologies for further experimental investigation.

This section contains the results of our measurements carried out by using some standard-based Wireless M-Bus adapters produced by Amber Wireless, with built-in antennas only, and with Texas Instrument's 868 MHz chips on evaluation boards. The measurements were carried out in laboratory as well as in two realistic scenarios: in a multi-dwelling house (Section 4.3) and in a family house (Section 4.4).

The measurements were focused on coverage, reliability, security and energy consumption issues.

4.2. Devices tested

We selected and purchased three different devices from two manufacturers (Texas Instruments and Amber Wireless). TI devices are very similar, but use different frequencies (433 and 868 MHz), while the Amber Wireless devices are Wireless M-Bus compatible ones thus operating in the 868 MHz band. These devices will be referred to as TI433, TI868, Amber868, respectively, in this section. The technical and other important parameters and capabilities of these devices based on datasheets and other vendor information are shown in Table 4.

Table 4. Comparison of measured AMR devices

	TI433	**TI868**	**Amber868**
			
Vendor	Texas Instruments	Texas Instruments	AMBER wireless GmbH
Model	CC1101 Evaluation Module 433 MHz	CC1101 Eval. Module 868 MHz	AMB8465-M
Chipset	CC1101	CC1101	AMB8425-M
Radio characteristics			
Frequency band(s) [MHz]	433	868	868
Usable bandwidth [MHz]	387-464	779-928	863.03 - 868.95
Channel spacing [kHz]	N/A	N/A	60
Modulation method(s)	2-FSK, 4-FSK, GFSK, MSK, OOK, ASK	2-FSK, 4-FSK, GFSK, MSK, OOK, ASK	2-FSK
Default/maximal transmitting power [dBm]	10	12	10
Receiver sensibility at lowest bit rate [dBm]	-116	-112	N/A
Maximum range [m]	N/A	N/A	100
Communication and networking characteristics			
Simplex/half duplex/duplex	N/A	N/A	N/A

Data rate(s) [kbps]	0.6 – 500	0.6 – 500	2.4/16.384/ 66.6 (up to 250)
Supported topologies:			
- point-to-multipont (master-slave)	N/A	N/A	OK
- point-to-point	OK	OK	OK
- ad-hoc	N/A	N/A	OK
- mesh	N/A	N/A	N/A
Medium access mechanism(s)	CSMA	CSMA	N/A
Wireless M-Bus compatible?	OK	OK	OK
OMS support?	N/A	N/A	OK
Security			
Encryption	N/A	N/A	AES-128 in prep.
Authentication	No	No	No
Individual identification?	No	No	No
Reliability			
Error protection (ARQ/FEC)	FEC (½ rate convolutional code)	FEC (½ rate conv. code)	N/A
ISM/licensed bands?	ISM	ISM	ISM
Operation temperature range [°C]	-40 to 85	-40 to 85	N/A
Energy consumption (available only for chipsets)			
Energy consumption in TX [mA]	13.1 to 29.2	16.4 to 34.2	N/A
Energy consumption in RX [mA]	15.0 to 17.1	14.6 to 16.9	N/A
Energy consumption in sleep [nA]	200	200	N/A

Sources: data sheets of the respective vendors [14]-[17]. Several of these important parameters were not available in datasheets. Therefore we had to complete this table with laboratory measurements that are not described in this paper.

4.3. Measurements in a condominium environment

The measurements were performed in a building including 221 apartments in a residential area of Budapest. The construction of the building consists of bearing walls and ceilings made of reinforced concrete and separating walls made of brick (being 30 cm in width). This environment significantly obstructs the propagation and decreases the operating range of the devices. Figure 2 illustrates the layout of the building where the measurements were performed (Floor 1, 2 and 3). The layouts of the three floors are

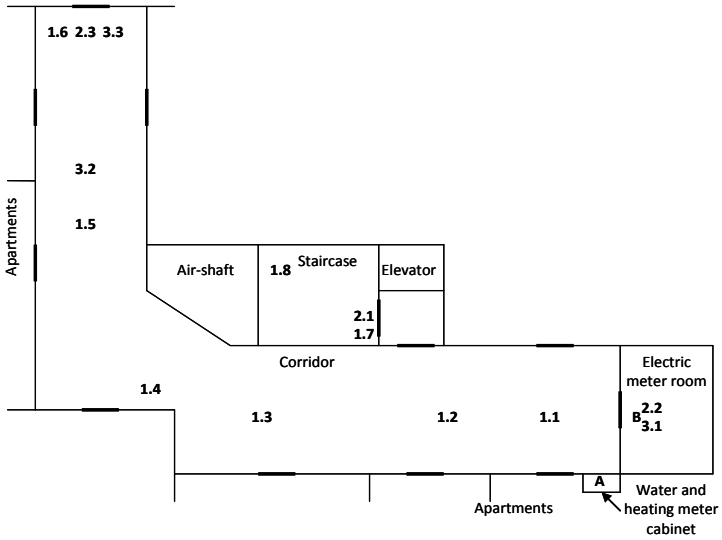

Figure 2. Layout of the condominium measurement area

the same, the floor height is 2.65 m and the thickness of the reinforced concrete ceiling is 0.33 m. The bold black lines indicate doors made of steel.

The receiver was installed in (i) the water and heating meter cabinet with wooden doors and (ii) behind the door of the electric meter room, which is made of steel (higher attenuation). The receiver positions are illustrated in Figures 3 and 4.

Figure 3. Receiver in water and heating meter cabinet

Figure 4. Receiver in electric meter room

During the testing we measured the average values of the Received signal Strength Indicator (RSSI) and Link Quality Indicator (LQI).

4.4. Measurements in a family house environment

In the family house environment, several difficulties can arise due to various circumstances, e.g. longer distances, water meter placed in an underground pit (often covered with a steel plate), various topography and facilities, etc.

The measurements were performed in a hilly, suburban like area of Budapest. 15 measurement points were chosen on this site, according to the potential locations of the AMR concentrator and other units, which allowed for measuring effects of range, walls, buttresses of soil, etc., see Figure 5.

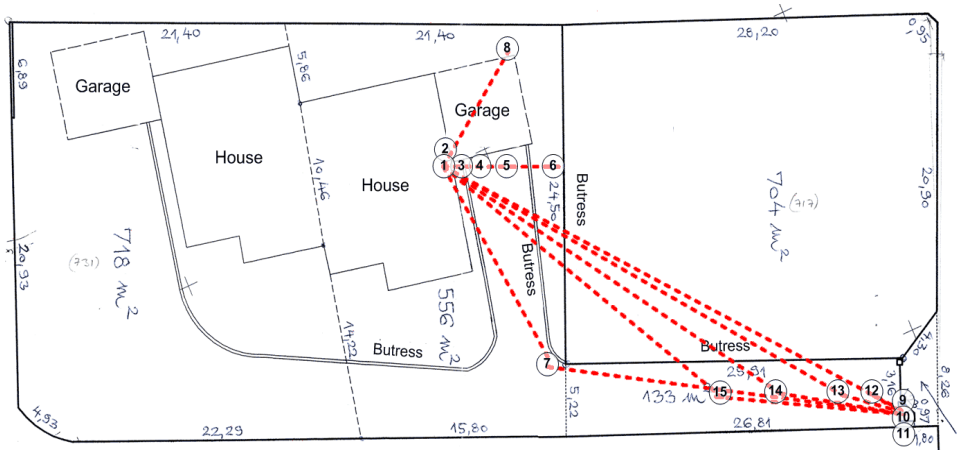

Figure 5. Map of the family house area with measurement points

4.5. Summary of and conclusions on the measurement results

Based on our measurements and tests, we can summarize our findings as follows.

A) Coverage and reliability

- Using 10 dBm transmitting power and 2-3 dBi antennas connected to appropriate devices (TI433 or TI868), a circle with 20 m radius can be covered in almost all circumstances (both condominium and family house environments), but often 35-40 m is available.
- 20 m range can be applied through 2-5 walls made of bricks or concrete, or through 3-4 steel doors, or from a water meter pit with 1 m depth and covered with a steel plate.
- The attenuation values for some obstacles can be estimated as follows:
  - concrete wall: 25-42 dB/m;
  - brick wall: 5-20 dB/m;
  - steel door: 5-15 dB/m.
- In the family house non-line-of-sight (NLOS) environment outdoor and long-range (>10 m) RSSI values are higher with 5-8 dB at 433 MHz than at 868 MHz.
- Locating an AMR device in a water meter pit decreased RSSI by 25-30 dBm, and by additional 10 dB when the steel cover was applied.
- By lowering the date rates higher receiving sensitivity (and larger coverage) can be achieved (but at increased power consumption).
- The LQI parameter is generally not useful (value is about 40 in most of cases), higher values come up only in very bad conditions and near to receiver sensitivity limit.
- At short distances (<8 m) and indoors, RSSI can fluctuate ±5 dB in time and in position due to near-field effects and reflections.
- AMR communication can interfere with remote door opening signals, but the possibility of this event is negligible.

B) Energy consumption

- Consumption of transmitter device can be double or higher than the consumption of its chipset version.
- TI868 devices have lower consumption values compare to TI433, although higher transmitting power (12 dBm compared to 10 dBm).
- Applying devices designed for low-energy consumption is very important.
- Using sleep mode and scheduled wake-up is crucial for long battery replacement period.
- Using higher data rate causes shorter transmission time, so battery replacement period can be 10 times longer or more! (But when using higher data rate the receiver sensibility decreases!)

C) Security issues

- The tested devices have no security features. Only Amber868 is designed to support AES128 block coding natively, but it was not yet implemented in the devices we used.
- Therefore, to ensure security extra effort is needed by implementing this functionality in software or hardware.

5. Conclusion

The three wireless technologies investigated in the paper are potentially suitable for AMR systems, although each of them is optimal for a specific setting and regarding a specific set of features and requirements. Final recommendation is not possible because of the limited scope of the measurements we have been able to carry out so far, however it is very likely that devices operating in the sub-gigahertz band are suitable for reliable communications in an AMR system as opposed to Wi-Fi and and ZigBee/2.4 GHz devices.

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