MONITORING AND POWER MANAGEMENT FOR BICYCLES WITHIN THE SELLING USE APPROACH

Prof. Dr.-Ing. Günther Seliger[1], Dipl.-Ing. Daniel Odry[1],
M.Sc. Miroslav Mijajlović[2]

[1]Technical University of Berlin, Department of Assembly Technology and Factory Management, Berlin, Germany

[2]University of Niš, Faculty of Mechanical Engineering, Department of Mechanical Constructions and Machinery, Niš, Serbia

ABSTRACT

Today's metropolitan areas are facing numerous challenges in traffic and transportation due to the rapid growth of their population. Transportation is either achieved by means of individual or collective transportation, e.g. cars and buses. Collective means of transportation usually have a higher use-productivity of resources. With increasing wealth, the individual demand for mobility has continuously grown and the traffic volume has been rising significantly. A promising approach to reduce the traffic volume, increase the use-productivity of recourses and at the same time fulfill the individual demand for mobility, might be the implementation of the "selling use instead of selling the product" business model in individual transportation. This can be realized by a network of service providers that offer different means of transportation in quality, time and location to the customer, e.g. public transportation, rental companies for cars, motorcycles and bicycles. Here several customers can jointly make use of the same mean of transportation, a car for example, at a different time. Adequate use of means of information and communication technology (ICT) within the network of service providers, their stock of equipment and the customer is essential in order to provide a competitive service.

One suitable vehicle in this network might be a bicycle with an integrated product accompanying information system, the so called Life Cycle Unit (LCU). LCUs are integrated into products and are capable of acquiring, processing and communicating relevant product and process data for evaluation purposes throughout the entire product life span. Integrated into the bicycle, the LCU has the tasks to assess, predict, diagnose and monitor the bicycle and its components. For example, monitoring the bicycle's position using the Global Positioning System (GPS), transmitting it via the Global System for Mobile Communications (GSM) to a control station and offering the data on the internet, may enable the customer to find a bicycle near to his location. It may also improve the efficiency of the bicycle's operation to the service provider, e.g. by facilitating condition based maintenance. In further addition condition based power management functionality is integrated into the LCU. This shall enable the demand and priority driven distribution of the available limited electrical energy to the different loads of the bicycle, e.g. the LCUs and the lights.

KEYWORDS

Life Cycle Unit, Sustainability, Mobility, Transportation, Bicycle, Selling Use, Monitoring, Energy Management

1 INTRODUCTION

The World Business Council on Sustainable Development defines Sustainable Mobility as "the ability to meet the needs of society to move freely, gain access, communicate, trade and establish relationships without sacrificing other essential human or ecological values today and in the future."[10].

Social mobility of a society, which means the ability to move in social hierarchies, is often directly bound to spatial mobility. With half the population in developing countries projected to live in urban areas by 2030 huge new demands for mobility are created. Due to the people's desire for affordable goods, exceptional products or advanced technology the world trade is contentiously increasing and regional markets are expanding to a global extent.

Increased mobility may create economic prosperity across the world, lifting millions of people out of poverty and giving them access to better health services, job opportunities and education, as well as ensuring fast and reliable freight of food and other goods. At the same time mobility leads to higher resource consumption (energy, materials, etc.) [4] and environmental pollution due to an increased emission of green house gases [6]. Social tension may arise due to the evitable unequal distribution of wealth. To cope

with the challenges a sustainable approach has to be realized all over the globe.

Passenger transportation is either achieved by means of individual or collective transportation, e.g. cars and buses. Collective means of transportation usually have a higher use-productivity of resources. A promising approach to reduce the traffic volume, increase the use-productivity of recourses and at the same time fulfill the individual demand for mobility, might be the implementation of the "selling use instead of selling the product" business model in individual transportation [5]. This can be realized by a network of service providers that offer multimodal transportation in quality, time and location to the customer, e.g. public transportation, rental companies for cars, motorcycles and bicycles. Here several customers can jointly make use of the same mean of transportation, a car for example, at a different time.

But today's barriers of multimodal transportation are already visible in freight traffic. Obsolete technology and poor efficiency, even in an industrialized nation such as Germany, has lead to an unilateral shift from inland water and rail transportation to the more flexible, but also far more resource consuming, road transportation. Adequate use of means of affordable information and communication technology (ICT) within the network of service providers, their stock of equipment and the customer is therefore essential in order to provide a competitive service.

ICT can also enable competitive new forms of collective freight transportation, i.e. a message in the bottle service that provides each household with every day goods, such as food or cosmetics. But also new usage of venerable environmentally friendly means of transportation offers a chance to increase their competivity. Magnetic levitation trains could transport passengers and goods at the same time in up to now unrivaled speeds over ground and thereupon directly compete with airplanes.

To realize the vision of multinational multimodal transport of passengers and goods a pragmatic shift in infrastructure and an efficient cross-linking of customers, service providers, producers, governmental and non-governmental organizations in traffic relations has to be realized. If being successful, this could stand up as an example and might give the growing economies of the less developed and developing countries the chance to fulfill their people's demand for more mobility with less resource consumption. At the same time they could profit from the knowledge they have to acquire in order to develop, adapt and use these modern means of transportation and their ICT.

One exemplary suitable vehicle in this network might be a bicycle with an integrated product accompanying information system, the so called Life Cycle Unit (LCU). For example, monitoring the bicycle's position using the Global Positioning System (GPS), transmitting it via the Global System for Mobile Communications (GSM) to a control station and offering the data on the internet, may enable the customer to find a bicycle near to his location. It may also improve the efficiency of the bicycle's operation to the service provider, e.g. by facilitating condition based maintenance.

The bicycle is a very mobile vehicle and changes can be adapted easily. Bicycles equipped with LCU are facilitating greater use-productivity of transportation and minimal negative impact on the environment, e.g. pollution [3].

2 BICYCLE AS TRANSPORTATION MEAN

The bicycle is individual and very popular transportation mean used all over the world for transportation, sports etc. Popularity of the bicycle has increased thru history and with the increase of human population, bicycle production, in general, has grown (Figure 1).

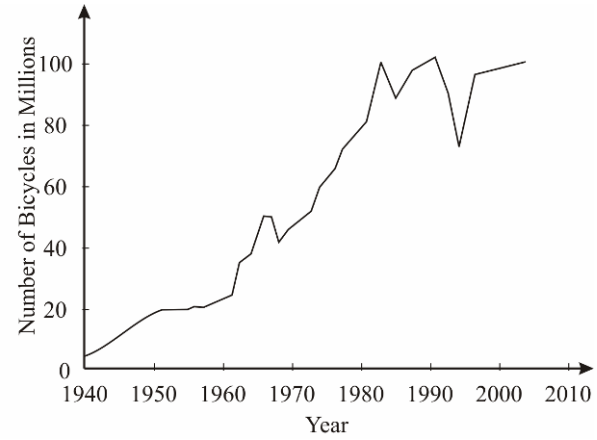

Figure 1: World's bicycles produce [7]

A bicycle is mobile, adaptable to changes, reliable and easy to maintain. It also keeps people healthy.

Compared to the other vehicles on the streets, the bicycle is slow-accelerative vehicle. In big cities, where dynamical shifting from stop-to-go state of vehicle is one of the greatest factors for safer and more effective transportation, bicycles are potentially unsafe transportation means. Safety of the bicycle riders is enlarged by special traffic lines for bicycles. The number of bicycle riders' casualties in traffic is minimal (Table 1).

Advantages of a bicycle, such as mobility, make it very useful transportation mean, but still use-productivity of bicycles are low (Table 1). New approaches and implementations to the bicycle should increase use-productivity. Also interesting is the enlargement of bicycle's use-productivity might reduce production of bicycles and decrease usage of available resources [5].

Table 1: Usage and Safety of cycling in selected countries of European Union 5

Country ⇩	Cycling kilometers per person per day	Killed cyclists per 100 million kilometers
Great Britain	0.1	6.0
Italy	0.2	11.0
Austria	0.4	6.8
Norway	0.4	3.0
Switzerland	0.5	3.7
Finland	0.7	5.0
Germany	0.8	3.6
Sweden	0.9	1.8
Denmark	1.7	2.3
The Netherlands	3.0	1.6

3 "CALL-A-BIKE" SERVICE

An exemplary bicycle hiring service "Call-A-Bike" will be introduced in the upcoming chapter [2]. "Call-A-Bike" is available in big cities in Germany. It is different than other bicycle hiring services, because bicycles are not located on few central system's centers in the city. With "Call-A-Bike" bicycles are available on the numerous, seeable places in the city: on the streets, squares, bus stations etc. and tied by an electronic lock to immoveable objects. People can use bicycles only if they have registered at service and have adequate Personal Identification Number (PIN), provided by the hiring service. To engage bicycle (that was just found in the city) user requests the password for the bicycle's lock from the Main Control Center (MCC) of the hiring service by Short Message System (SMS). User sends his PIN and number of bicycle to MCC, as well. The MCC checks PIN, number of the bicycle and availability of the bicycle and sends password for bicycle's lock. From that moment on, the bicycle is hired.

User is entitled to hire the bicycle as much he needs it. When he/she decides to stop hiring, the user engages the lock and a new password is shown on the user interface (UI). User has to send SMS to MCC, with his PIN, bicycle number and new password form UI. MCC checks this data, stops hire of bicycle and sends SMS to user with confirmation about end of hiring and price of hire. Bicycles and MCC have no communication. Information about the bicycles, available for MCC, is only about bicycle's status (available or not). MCC has no data about bicycle's position and condition. Bicycle may be malfunctioned, but MCC would not be informed about that until mobile repairing units of hiring service find it and report malfunction.

4 BICYCLE LIFE CYCLE UNIT

System's function is realization of the tasks considered by designer of system. Time and degradation processes of the system can not be stopped and the LCU is present to show degradation process and keep the system functional [9].

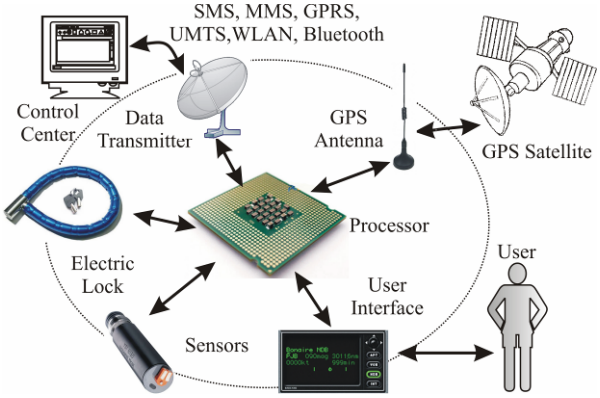

Figure 2: Structural schema of bicycle's LCU

Easier realization of the providing services like "Call-A-Bike" is might be accomplished by usage of LCUs. The general tasks of a LCU are to acquire, process, and communicate relevant product and process data throughout the entire product life span. Integrated into the bicycle, the LCU has the tasks to assess, predict, diagnose and monitor the bicycle and its components. Structural schema of LCU is shown in Figure 2.

The LCU acquires relevant data from user, form sensors and other components implemented to the bicycle and from MCC. Data provided by user is his PIN, necessary for identification of user. Data concerning about bicycle condition and position are received from sensors and other components. Sensors give information about air pressure in tires, bicycle's speed and mileage etc. Position of bicycle is provided by Global Position System's (GPS) antenna. MCC gives information and instructions to bicycle (by LCU) concerning user and usage of bicycle e.g. to lock or unlock, how much is user going to be charged for usage etc.

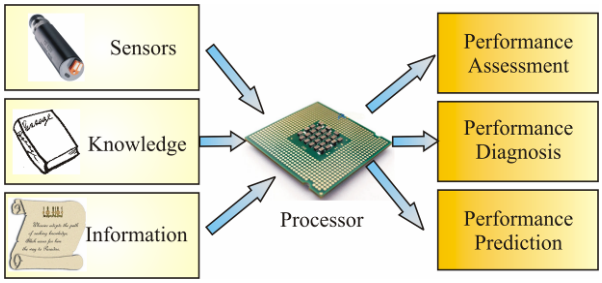

Figure 3: Functional schema of the information processing

The LCU processes acquired data to provide information about bicycle's performance assessment, diagnosis and prediction (Figure 3). That information is communicated to MCC via SMS, Multimedia Messaging Service (MMS), General Packet Radio Service (GPRS), Universal Mobile

Telecommunications System (UMTS), Bluetooth or Wireless Local Area Network (WLAN).

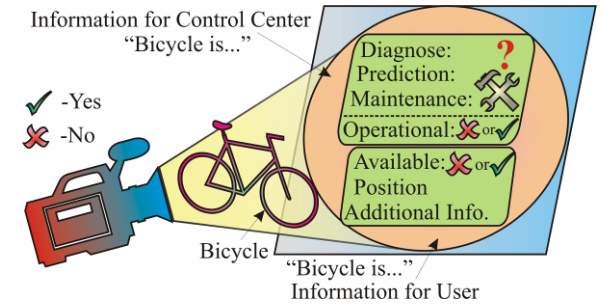

Figure 4: Information provided by LCU

Some of the processed information is available for the user. That is the information about bicycle status (operational or not), position of the bicycle, price of hire, the mileage etc. (Figure 4). This information is presented to the user by UI.

Power for movement of the bicycle is provided by the bicycle rider. Other components implemented to the bicycle, e.g. the lights, some of the sensors, the LCU, require electrical energy for functionality. Electrical energy is generated by dynamo assembled to the bicycle. The dynamo transforms part of mechanical energy provided by rider to electrical energy. Energy form dynamo is being used for components and sufficient energy is being stored in batteries. Since dynamo is additional load for the bicycle rider, the LCU engages dynamo only when rider does not need his full power for movement, e.g. riding down the hill.

5 SUMMARY

A promising approach to reduce the traffic volume, increase the use-productivity of recourses and at the same time fulfill the individual demand for mobility, might be the implementation of the "selling use instead of selling the product" business model in individual transportation [5]. This can be realized by a network of service providers that offer multimodal transportation in quality, time and location to the customer, e.g. public transportation, rental companies for cars, motorcycles and bicycles. For efficient operation of service networks, transportation means need to be equipped with modern ICT.

An exemplary suitable vehicle in this network is a bicycle with an integrated product accompanying information system, the so called LCU. The LCU enables the integration of the bicycle into the transportation network and also helps to improve the efficiency of the bicycle's operation to the service provider, e.g. by facilitating condition based maintenance.

6 ACKKNOWLEDGEMENTS

This research is supported by the National Science Foundation (NSF) award number EEC 0331629 as well as by the Deutsche Forschungs Gemeinschaft (DFG).

REFERENCES

[1] Data from Annual Report of Department of International Economic and Social Affairs, Statistical Office, United Nations, November 22nd, 2005, http://www.un.org/Depts/unsd/mbsreg.htm

[2] http://www.callabike.de, January, 10th, 2006.

[3] L. Alting, J. L. Brobech, "Life Cycle Engineering and Design", CIRP Annals 44/2, 1995:569-580.

[4] G. Seliger, "A German View on Sustainable Manufacturing", Proceedings of the International Symposium on Sustainable Manufacturing, Shanghai, China, 1999:8-11

[5] G. Seliger, S. Consiglio, M. Zettl, "Selling Use instead of Selling Products- Technological and Educational Enablers for Business in Ecological Product Life Cycles, CIRP, Belgrade, 2004.

[6] ACEA, 2003, Monitoring of ACEA's Commitment on CO_2 Emission Reductions from Passenger Cars, Joint Report of the European Automobile Manufacturers Association and the Commission Services, ACEA, Brussels.

[7] Earth Policy Institute, Annual Report, 14th December, 2005, http://www.earth-policy.org

[8] McDonough, W., Braungart., 1998, The Next Industrial Revolution, In: The Atlantic Monthly, October, pp. 82-92

[9] Djurdjanovic, J. Lee and J. Ni, "Watchdog Agent - An Infotronics Based Prognostics Approach for Product Performance Assessment and Prediction", International Journal of Advanced Engineering Informatics, Special Issue on Intelligent Maintenance Systems, Vol. 17, No. 3 - 4, pp.109-125, 2003.

[10] N.N., http://www.wbcsd.org, 14.08.06