The Questions of Acquisition and Use of Operational Information in Urban Public Transport

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Abstract: In this article, we examine that beyond current standard methods which opportunities there are to obtain information about the traffic and in connection with this the use of this additional informations in planning and management.

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1. Introduction

The development of information technologies has brought great changes also in public transport. The first attempts to monitor the vehicle during the traffic was made in the '60s in Munich, still based on control points. Faced with this technology about 20 years later the satellite positioning became available as alternative option. Today, the GPS-based management and information systems spread to the extent that they are regarded as routine solution. The other main element is the electronization of the ticket system. In this area, more problems still seem to be solved, but in many parts of the world, the electronic ticket has long been a part of everyday reality. The future is definitely promising, in addition to the movement of vehicles about passenger traffic will also be possible to obtain complete information. Based on the huge amount of information further progress can be achieved in the field of planning and management methods, which allows the creation of more efficient intelligent transportation systems. In this article, we examine that beyond current standard methods which opportunities there are to obtain information about the traffic and in connection with this the use of this additional information in planning and management.

The public transport system can be divided into three major parts: design, operational and accounting components. Each of these components have streams of information which may play from the point of view of the individual components input or output role. The planning is based on the data of carried passengers which is an output of the operation, the output of accounting is the evaluation of the effectiveness of the system. The transport system must operate in continuously changing environment, that is, to adapt to environmental changes. The adjustment is done by means of feedback. Based on the feedback cycle time, we can distinguish between strategic, tactical and operational levels. Their schematic diagram is shown in Fig.1.

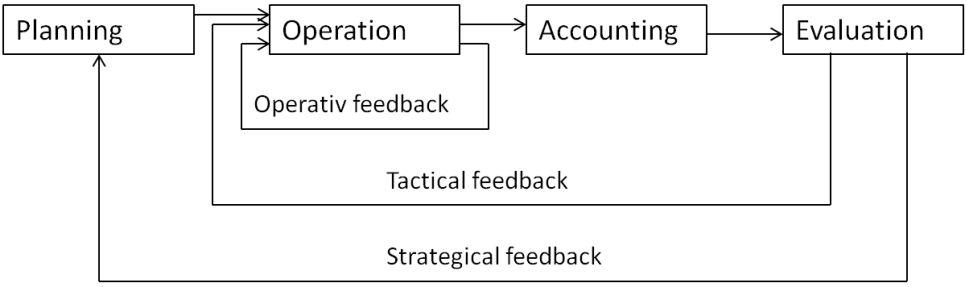


Figure 1. The strategic, tactical and operational level illustration

The quality of feedback is the decisive factor in how the system reacts to the outward changes, that is in which extent can be regarded as intelligent. The quality of feedback basically depends on information supply and due to character of transport the most important are the traffic information.

2. Resources of and ability to obtain traffic information

In the public transport the movement of people traveling and the movement of vehicles can be distinguished. In the course of operation these two processes temporarily are united, then the actual delivery is made. The planning and operating management are based on data of these two processes. Understanding the vehicle process is basically important for the running time planning and operational traffic management, understanding the "passenger process" is of relevance for the network and schedule planning and operational management.

2.1. Passenger traffic data

One and perhaps the most important source of information to recognize travel needs are the data of trips done. Full information you can talk about when about each trip is known

- the stop and time of boarding
- the service (vehicle run) travelled
- the stop and time of alighting
- the kind of the ticket
- all in such a way that
  - the change travels can be mapped and
  - trips by the same person within a period can be gathered from.

The automated data collection tools of passenger traffic include: passenger counting device, video camera and image processing system, electronic ticket detection, tickets on mobile phone detection, use of mobile cell phone information.

2.1.1. Automatic Passenger Counter

The counters are able to measure the number of boarding and alighting passengers or the number of occupants in the vehicle, so are only suitable for cross-sectional data service. However, the measured data can be used in monitoring and, if necessary, to correct OD data.

2.1.2. Video recording and image processing

The video and image processing is already suited to identify the passengers boarding and recognize again by alighting, so that can provide information of OD character. It is also possible that passenger making changes are recognized in the second vehicle again, and so the transfer travel information is ascertained. This requires that the face recognition software generates the same identification code to the same person by each camera and this data will be kept in a central database and be matched daily or periodically. The technical development of face recognition and identification software will certainly progress further, and this method will become more reliable and cheaper, but by this method the ticket-related information remain unknown. It is unrealistic to expect that the recognition software will be able always to identify people changing the appearance day by day, (or even within a day as well). So all trips taken by the same person over a longer period shall not be settled together, for example can not be known how many travels are performed with a monthly pass etc. The more in-depth analysis of travel habits can be ensured by this system in a number of respects only partially.

2.1.3. E-ticket

The electronic ticket is the only known means by which each - listed above - data can be acquired. Due to the fact that without condition, and fully free travel under the present state of knowledge is not considered a realistic alternative, we can say that a fare is definitely needed. In such cases, it is obvious that it is the e-ticketing system which should be the passenger data collection tool as well, i.e. the ticketing system has to be developed in such a way that on this basis all the above listed data could be produced.

In today's generally accepted view the radio frequency identification (RFID) technology is the best because it does not require to insert ticket to the ticket machine. Radio signals emitted by the reader unit activates the unit on the ticket, which is about in response, transmits the information stored there. The technology is bound to work only a short distance, so passengers have to pass in close proximity to the sensor. In transport, this seems to be less a problem because the vehicle doors can serve as natural "entrance gate".

Attributes of the passenger traffic can be obtained by recording and processing tickets scanned data (including the ticket identification code). Incorrect data may occur, in congestion the sensation may be incomplete, or passengers alighting in order to give place to others when boarding again will be identified as new passengers. These errors may be reduced or eliminated by means of software.

In application of electronic tickets there are some critical issues not yet fully resolved.

2.1.4. Way of ticket handling by alighting

There are systems where ticket identification is required also by alighting. The recorded data together with the data of boarding allow to determine the relation of trip. It works if boarding and alighting may happen only on designated doors, and it is respected by passengers It is possible that boarding and alighting are allowed on all doors and the reader device determines whether boarding or alighting happened. In this case several lines of sensors should be placed on, and the succession of detection is the key, based on which boarding or alighting can be isolated. These solutions have the disadvantage that they wish some cooperation from passengers, and sometimes (especially in the case of congestion) may provide incorrect information.

2.1.5. Determination of entitlement to use

Valid tickets will only be eligible for travel by a person authorized to use it. Methods for the automatic ticket checking are not yet offered a good solution to this problem. Since this problem is not linked to the cause of traffic data acquisition, it is not detailed in this issue.

2.1.6. The issue of one-way tickets

The problem is that, compared to the price of a single-use ticket a ticket with a chip unrealistically expensive, although it may be for the future this will not be a problem. Based on the current situation as a solution for the problem can be considered when buying one-way ticket is possible only on stop or vehicle from ticket vending machines and the ticket data are stored by the machine. In this case the boarding ticket control is done not by electronic ticket reader, but in other ways, such as reading printed on the ticket barcode or QR code. By purchasing ticket on stop the starting point of trip is a priori given and it is conceivable that while buying ticket the ticketing device may request the destination stop. The data of the tickets issued are stored by the ticket machine. The situation is similar for tickets purchased from vehicle driver. Under the system logic elsewhere (in advance) one-way ticket would not be available for purchase.

Enter the destination stop seems natural, in cases where the fare depends on the distance of travel as well. The pretty standard today's "flat rate" against the use of distance-related charges, originates rather in control and computer difficulties than than economic or other justification for this operation. If the electronics progress these difficulties may disappear, it is likely - especially in the larger cities, that tariffs reflecting the travel distance will be more extensively used.

2.1.7. Buying ticket on the vehicle

There is demand - mostly in small towns - for ticket purchase in vehicle from the driver. In this case, we must resolve that by issuing the ticket the data of the trip will be recorded, possibly with destination stop.

2.1.8. The processing of electronic ticketing information

Further information can be obtained by further processing of the recorded data. Trips with change can be identified. If several trips were made with the same ticket, the travel chains and travel habits can be studied. In many cases, it is possible to estimate the alighting stop even if no note has been recorded by alighting. The software tool will complement the primary data recorded during the trip.

2.1.9. Ticketing by mobile phone

Amongst the visions on the future of IT technologies it is often emerges that we will conduct a large part of our payment transactions with mobile phone (or with some sort of smart mobile devices which will be the successor of mobile phone). The traffic data collection can only be done if the ticket is purchased so that data can not only be red visually on a mobile device's screen, but also in electronic format. It is possible that the mobile device transmits the data by boarding, but it does not seem practical solution as the passenger should launch a specific application. Determination of the alighting stop is a further problem. Seems more realistic, if your mobile phone can only be used as payment for any ticket purchase, including ticket vending machine, and ticket is actually issued by any purchase. Of course the use of a mobile device for this purpose is conceivable, but specific application needs to be developed further into the future.

2.1.10. Use of mobile phone cell information

Theoretically the movement of cell phone holder is cognizable based on the cell information. By means of software the public transport users can be filtered. However, you can not assign a passenger to a certain vehicle run if more than one vehicle are at any given time in parallel motion, on the other hand, the dimensions of the cells do not make it possible to obtain data with sufficient accuracy. Mobile phone can give good information so that if cooperative passengers let a special application run on their phone during the journey. Distant future, of course, it is possible that mobile device will be able to present the required information, but it needs to be developed specifically for this purpose.

2.2. Number of passengers waiting at the stops

This is important information for traffic control, which is less pronounced in existing systems. Routine solution to install cameras at main stops and images are transmitted to the dispatch centre. The information obtained can be important in the daily control work, but since it does not provide a complete and exact data may not be a perfect solution. By today's development of image processing technology it is not a problem to determine the number of occupants in a designated area. Applications covering all stops will be probably commonly spread in the future.

2.3. Data recovered from travel planning services

The journey planning systems basically provide information to travellers, but a by-product may contribute to the understanding of travel needs as well. Search on a planner is not regarded implemented journey, as it is not certain that the person seeking the recommended route is actually going to travel, and secondly, if so, then we will fix the

ride of the vehicle takeoff. Searches are nevertheless provide useful information because analyzing the relationships sought by frequency changes over time, and other aspects can complete the knowledge we have from the data of completed trips.

3. Information relating to the vehicle

The most important information about what is happening with the vehicle in the traffic, also at present is given by the systems already operating. In the following, only the critical elements and possible expansions are expected to be discussed here.

3.1. Identification of the vehicle and driver

The vehicle will get into operation if activation of the in-vehicle equipment happens. Since a driver belongs to each vehicle in operation, identification of the driver is also necessary at the same time. To prevent false registration, the driver must have some identifiable means For putting the vehicle into operation the joint activisation of vehicle and driver device is required. In addition to the identification function, ideally the drivers' device is suitable

• to accept the disposition of control centre or receive the signal that disposition arrived onto the vehicle on-board instrument , if the driver is not in the vehicle,

• for voice connection to the dispatch centre,

• to register the driver's job performance, the time spent at work and the data of the work performance are stored and are retrievable, viewable, so the driver can monitor the advancement of his working performance,

• to receive and display the provisions relating to the driver's work schedule, the monthly duty rosters and its occasional changes.

The functions of this driver's device are particularly important if a vehicle is operated by more than one driver within a working day and there are no paper-based documents on the drivers' work.

3.2. Location information and status characteristics of the vehicle

Obtaining the location data of vehicles by GPS (or entering into operation soon Galileo satellites) can be regarded as solved. Within the vehicle status characteristics traffic (operational) and technical data can be distinguished.

Traffic characteristics include all the factors that are related to quality of service. Among them is the number of passengers in the vehicle, as it shows the level of service and is the best factor to show the level of crowdedness, in addition is an important input information to the traffic management Obtaining this data are basically ensured applying the methods outlined above in point 2.1., but because of the there indicated inaccuracies an actual passenger load counter is also recommended. Thus, there will be two sets available of passenger numbers (measured by the instrument and revealed from the ticketing), these two sets of data together contain more information than either of those two alone. More traffic type parameter is considered as the temperature, the door position (open, closed), the lighting and air condition (off, on), and possibly other, similar factors. The acquisition of these data is a measurement routine.

By technical characteristics we mean the operating parameters of the structural components of the vehicle, we deal with these no longer.

The location and condition specific data must be sent to the dispatch centre. The frequency required to submit data depends on the nature of the data, for example, number of passengers in the vehicle is only one stop intervals (e.g. after leaving the stop) actually new information, by location and other data a greater frequency may be justified.

3.3. Alarms

The automated traffic management systems usually have alarm function that can be activated by the driver (often hidden switch). This function can be completed by an automatic alert system. The typical emergency sound effects can be filtered out by software tool and an automated alarm signal can be given on this basis. When the alarm is activated microphones placed in the vehicle are activated as well and what happens in the vehicle becomes audible and can be recorded in the dispatcher centre.

4. The dispatch centre

Information ensured by the outlined IT solutions is available in the dispatching centre (DC). The information flows are shown in Fig. 2. Hereinafter we made the assumption that all the information is available, which can be obtained from the operating process.

The processing of incoming information serves a dual purpose:

- display the traffic situation for the traffic management operational activities,
- storing the data for additional processing for a variety of purposes.

By the application type the further processing can be divided into three groups:

- processing for the passenger information system
- preparation and updating of historical data for traffic management,
- accounting and statistics.

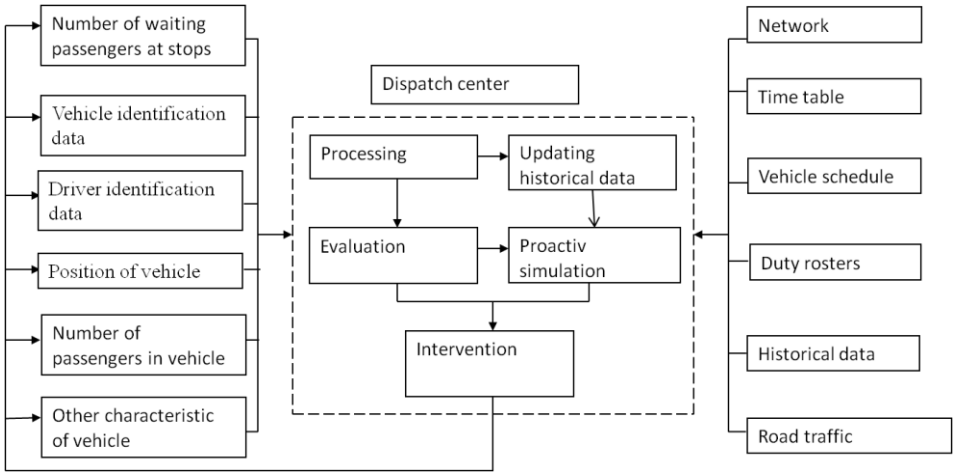


Figure 2. Operational information flows

4.1. Display the traffic situation

Formal elements of displaying the traffic situation as regards the vehicles are well established, for details of that are not discussed. Significant development in this area is desirable only to the extent that the saturation level of the vehicle (the amount of crowd) also reflect the show. The information system described contains the basic information you need to do so.

The number of waiting passengers on stops is other important information for the traffic control, the graphical representation of this is considered appropriate. This raises the question of whether the numerical data, the magnitude of the category, the trend of change, the deviation from the regular headcount, etc. should be included with the display. Of course, behind the graphical representation of data retrieval should be possible.

4.2. Processing of passenger information

The passenger information systems require both static and dynamic information. The dynamic information is taken from the operating process. On the stops beyond the usual information the saturation of the vehicles expected to arrive can also be displayed.

4.3. The historical data

Through continuous collection and processing of the passenger traffic data and data about movement of vehicles a historical data basis can be created. By analyzing the time profile of passenger volume and vehicle running time fluctuations homogeneous periods can be determined, within which almost the same parameters are prevalent. In this way typical time periods can be distinguished which depend on the month and day type, and may be further broken down by some other criterion (e.g., weather). The specific boundaries of each period for specific lines, where appropriate, may differ. A historical database will include for all of such periods of time

• the average values and distribution of vehicle running time between the stops for each lines

• the number and distribution of passengers loading and alighting on each stop for each services operated.

5. A proactive traffic control

In possession of advanced information technology and large databases a traffic control can be achieved that uses not only information about the current situation but also historical data in addition to these. In essence, on the basis of historical data the information system forecasts the further development of the existing situation and also evaluates the expected status. In doing so, the problems can be detected before their development, and actions for the prevention can be done occasionally The term "proactive" refers to this preventive character.

A proactive control system has to solve the following tasks:

• Based on the current traffic situation, calculating the number of passengers and vehicle travel time for the specified period of forecast,

• based on this calculated values determining the expected vehicle schedules,

• assessment of the resulting simulated traffic, definition of problems,

• simulating the effect of an intervention method selected by the traffic controller i.e. re-running of the forecast with the specified modification, in this way making possible to evaluate how effective this traffic management measure would be.

Normally what happens is that the system is being continuously simulating the further progress of vehicle runs in advance, and displays the characteristic features of the expected traffic situation, for example delayed arrival or departure, the evolution of the crowdedness.

The proactive management of public transport resolve stiffness and gives some flexibility to this service, which can approach to the flexible transport systems (DRT). Of course, there are limits to the flexibility of the service in consequence of what was previously announced, but especially in large cities where the headway is small, it is possible to change within the acceptable range. If this happens, the pro-active management will not only enhance the quality of service, but also can reduce the cost as well.

6. Accounts and statistics

The operating data can be processed into a variety of other purposes. By way of example: drivers' payroll can based on the data of performed services, the case is the same if transport operator reports on the performed service to local council in charge of public transport. The mileage of vehicles forms the basis of accounting, fuel, vehicle maintenance, engineering design, and so on. Information technologies also can ensure that these are based on real, factual data.

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References

[1] Thiagarajan, A., Biagioni, J., Gerlich, T., Eriksson, J.: *Cooperative Transit Tracking using Smart-phones*, http://dl.acm.org/citation.cfm?id=1869993

[2] Oberli, C., Torres-Torriti, M., Landau, D.: *Performance Evaluation of UHF RFID Technologies for Real-Time Passenger Recognition in Intelligent Public Transportation Systems*, IEEE Transactions on Intelligent Transportation Systems, vol. 11, no. 3, 2010

[3] Calabrese, F., Colonna, M., Lovisolo, P., Parata, D., Ratti, C.: *Real-Time Urban Monitoring Using Cell Phones: A Case Study in Rome*, IEEE Transactions on Intelligent Transportation Systems, vol. 12, no. 1, pp. 141-151, 2011

[4] Gardner, N.: *Infostructure: The Smart Future of Public Transport*, Informa Urban Transport Planning Summit Conference, Melbourne, 17 August 2011

[5] Rouas, J.-L., Louradour, J., Ambellouis, S.: *Audio Events Detection in Public Transport Vehicle*, the 9th International IEEE Conference on Intelligent Transportation Systems (ITSC'2006), Toronto, Canada, 2006

[6] Nagy E.: *Operatív menetrendkészítés automatizálásának alapjai a városi közösségi közlekedésben*, Budapest University of Technology and Economics, 2012

[7] Casey, R. F., Labell, L. N.: *Advanced Public Transportation Systems: The State of the Art*, Update '98 U.S. Department of Transportation Research and Special Programs Administration Volpe National Transportation Systems Centre Service Assessment Division, Cambridge, MA 1998

[8] Barbeau, S. J., Winters, P. L., Georggi, N. L., Labrador, M. A., Perez, R.: *The travel assistant device: utilizing GPS-enabled mobile phones to aid transit riders with special needs*, the 15th World Congress on Intelligent Transportation Systems, New York, 16-20 November, 2008

[9] Chuanjiao, S., Wei, Z., Yuanqing, W.: *Scheduling Combination and Headway Optimization of Bus Rapid Transit*, Journal of Transportation systems Engineering and information Technology, vol. 8, no. 5, 2008

[10] Cong, T., Khoudour, A.: Video sequencies association for people re-identification across non-overlapping cameras, Image Analysis and Processing – ICIAP 2009, Lecture Notes in Computer Science, vol. 5716, pp. 179-189, 2009

[11] Csiszár, Cs.: *Elektronikus utastájékoztató rendszerek a helyi közösségi közlekedésben*, Közlekedéstudományi Szemle, vol. 4. pp.147-155, 2004

[12] Csiszár, Cs.: *Az integrált, intelligens utastájékoztatás és információellátás rendszertechnikai modellje*. Közlekedéstudományi Szemle, vol. 5, pp. 161- 174, 2000

[13] Tóth, J., Csiszár, Cs.: *Utasinformációs rendszerek*, Közlekedésinformatika, Minőségi városi közlekedés az új évezredbe c. konferencia, Balatonfenyves, 28-29 September, 2000