ISSN: 1231-4005
e-ISSN: 2354-0133
DOI: 10.5604/01.3001.0010.2896

URBAN TRANSPORT SAFETY IMPROVEMENT BASED ON CENTRALIZED TRAFFIC CONTROL SYSTEM, COLOMBIAN CASE STUDY

Julie Stephany Berrío

Mechatronics Engineering, Faculty of Engineering
Universidad Autónoma del Caribe, Colombia
e-mail: julie.berrio@uac.edu.co

Drago Dussich

Sistra S.A.S., Colombia

Janusz Szpytko

AGH University of Science & Technology
Mickiewicza Av. 30, 30-059, Krakow, Poland
tel.: +48 12 6173103, fax: +48 12 6173531
e-mail: szpytko@agh.edu.pl

Abstract

In a modern urban organization, mobility is an important issue for society. Traffic congestion of urban roads undermines mobility is a real problem in major cities This article shows the development and implementation of a centralized traffic control system in the city of Cali Valle (Colombia) applied to control traffic lights located to the east of the city (Simon Bolivar and Ciudad de Cali highways), allowing the central operators directly influence the traffic flow, know and display the status of the lights and generate statistics about the events of the online equipment. Particular real benefits of proposed new system of traffic lights are reflected in green times at each intersection allocated in accordance with the present traffic volumes on the road network at any time of day and in every sector of the city in particular, which of course increases the efficiency of each light installed at each intersection. As demonstrated in this article case study, the congestion scheme has been improved, and the project has opened up vast opportunities for innovative network management strategies for the optimization of network performance. Many of these strategies are developed to give a coordinated high-level control across different traffic control platforms based on real time traffic condition and performance on site.

Keywords: *traffic control, centralized control, software development, wireless communication controller*

1. Introduction

A recent study conducted by recognized experts shows that with the current road infrastructure, traffic in Colombia could collapse in less than ten years. The greater number of cars will have a large impact on the model of development in cities: with regards to their expansion, the number and length of their trips, in the use of public transportation, in the quantity of roads that will be needed, in road congestion, in environmental pollution, in the levels of accidents and in the end, the quality and sustainability of urban life.

In a modern urban organization, mobility is an important issue for society, all causes leading to lower levels of connectivity between habitats of people, such as improper land use, few paths that articulate these spaces, or sufficient ways but with inadequate control system traffic, the increasing demand of automobiles, the absence of effective alternatives of mass transport, lead costs for people that reduce the achieving of higher profit levels potentially useful both households and individuals that make it up, so the longer the trip will lower the utility of individuals [1].

Traffic congestion of urban roads undermines mobility is a real problem in major cities. Traditionally, the congestion problem on surface streets was dealt by adding more lanes and new links to the existing transportation network. Since such a solution can no longer be considered for limited availability of space in urban centres, greater emphasis is nowadays placed on traffic management through the implementation and operation of intelligent transportation systems [2]. In particular, traffic signal control on surface street networks plays a central role in traffic management. Despite the large research efforts on the topic, the problem of urban intersection congestion remains an open issue [3-5].

Traffic jams generates loss of income for the members of society, therefore, the project of the centralized traffic system seeks greater control of vehicular traffic through a software interface that communicates directly with the equipment that drives the traffic lights, providing the operator with control and display the state of them, as well, with proper and efficient operation of the central, the travel time will be reduced, which means less loss of value of society as a whole.

Centralized traffic control in Colombia has been dominated since the mid-70s by the Befa8 Siemens technology. This consists of 6 twisted pair wires that send binary signals through current transducer to operate and know the status of the traffic lights, their main advantage is the simplicity of its operation and its main disadvantage is its high cost of installation and maintenance. This technology is installed in centrals in Bogota (Chico, Paloquemao and Muzu), Cali (Downtown), Pereira, Cartagena, among others. Relatively recently other cities have experimented with new schemes such as Medellin (Phillips), Santa Marta (Tyco) and Cali (Imatic), the last being the subject of this document.

This article shows the development and implementation of a centralized traffic control system in the city of Cali Valle (Colombia) applied to control traffic lights located to the east of the city (Simon Bolivar and Ciudad de Cali highways), allowing the central operators directly influence the traffic flow, know and display the status of the lights and generate statistics about the events of the online equipment.

2. Components, features and benefits

A traffic control centre is a specially equipped room, which allows management and monitoring of transit equipment drivers of the city from commonplace. The aim of centralizing traffic control is performance optimization of adjusting parameters such as traffic lights cycles, stop or green times and that the system suits unexpected traffic flows; the fundamental principle of urban traffic control is to respond to dynamic changes in demand for traffic [6].

The centralized traffic control system combines two essential components: Hardware, comprising equipment connectivity, computers and uninterruptible power supplies (UPS); on the other hand we have the software, which are programs responsible for managing and controlling the Hardware, and at the same time to represent graphically and intuitively maps and diagrams that can be displayed quickly and easily on the computer screen or a video-wall.

The installation of a transit central gives the city a tool for traffic control and integration, allows the optimization of the circulation in the streets and avenues, setting the proper functioning of large cities (a road level). Main operational characteristics of a central:

A) Monitors the operation of signalized intersections in the city;
B) Detects the absence of bulbs in traffic lights;
C) Detection, identification and registration of potential failures in the drivers;
D) Optimization of time as required green traffic (by decision of the operator or based on sensors);
E) Parameter change structures and remote operation;
F) Fault and burned lamps Statistics (can identify type, make, power and hours of life);

G) Simulation of operation of traffic lights;
H) Display and identification devices (controllers and traffic lights) on maps;
I) Execution of plans from the control centre.

Main economic advantages:

A) Reduce the amount of travel of control patrols maintenance;
B) Reduce the average times of urban transportation;
C) You can audit the use of spare parts and equipment maintenance;
D) Optimizes fuel consumption;
E) Reduce pollution produced by vehicles stay less time detained at intersections.

3. Hardware

The controller of road traffic is designed to operate in isolated intersections, networks coordinated signalling or to be included in a centralized control system, therefore, its programming can be done easily and smoothly so that no matter the place where the controller is. The teams have the ability to be programmed by the user with simple manual programming, i.e., that without knowing a language in particular and, without making a specialized course is possible to program computers to the need arises.

The road traffic controller (CTV) used to intersections from two groups to 32 groups of traffic (lamp assembly controlling a vehicular flow), independently controllable. The Controller consists of 28 digital inputs for detectors demand (vehicle and pedestrian), pedestrian push buttons, flashing and stop cycle (manual stop green for one phase).

The controller features a GPRS modem to transmit data between the computer and the central, bringing the following advantages: Wireless transmission, decreasing civil engineering costs substantially, GPRS customer can be connected all the time want, charging for data transfer volume, excellent speed transmission rapid deployment of this network provides similar to current levels reached in GSM geographic coverage.

It should be noted that the controller responds to various commands sent from the exchange such as: date and time assignment to equipment, turn off the crossing, turn on and off the crossing, Reading controller events, switching current plan, signal assignment plan, flash from centre, stop cycle from centre and restart.

Hardware implemented in the Central Traffic is composed of:

A) Computer Centre/Workstations: Site where operators, according to the user level that have, can access the application features.
B) Server: Contains information on system configuration, protocols and command devices, historical records, measurements detectors system and the programming of each controller in the field.
C) GPRS Modem: Device used for data transmission from the central to each of the controllers via the cellular network.
D) Video Wall (Fig. 1): System consists of 6 screens 40" in a 2x3 configuration, with total size of 1.83 m wide by 1.6 m high, which allows a comprehensive view of how intersections through a digital map and the inclusion of icons showing the status of each traffic light status and installed driver, allowing system operators to respond quickly to any anomalies.

4. Software

When starting the evaluation of the issues relating to the implementation of the project should take into account two fundamental factors, the first was the existence of a tool such as the .NET platform on which there is not only a wide experience within the organization but on the other hand had elements from the architectural point of view is sought for the project, a service oriented architecture (SOA) and a strong orientation to objects that allow the reuse and updating application components, the second is the existence of an application called Cronos that developed in the past for programming and reading equipment controllers.

Fig. 1. The video wall system example

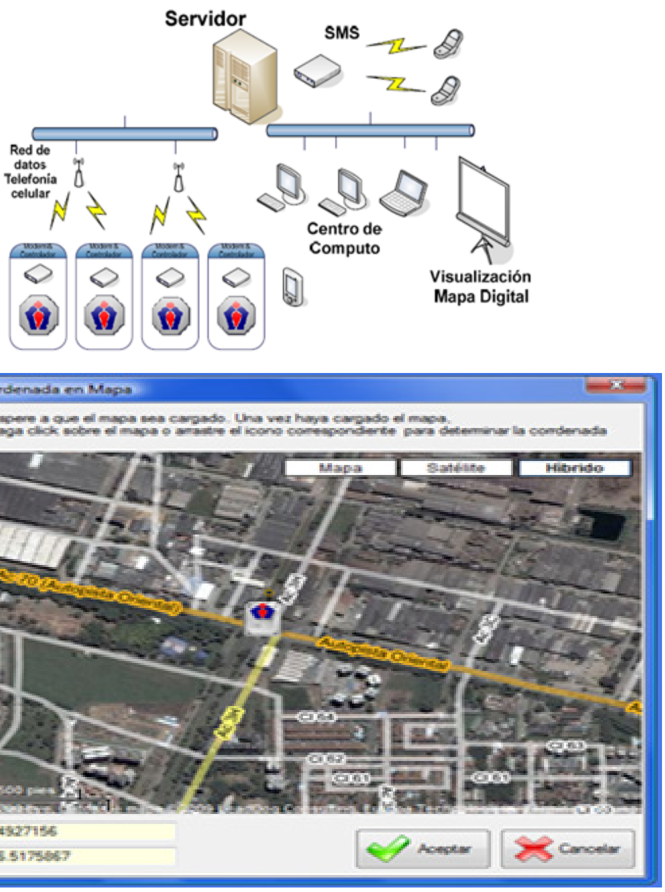

Fig. 2. The Central Traffic application: a client-server architecture and screen sample

Although if it is demonstrable that any implementation undertaken by object orientation is likely to be encoded by structured programming, the level of abstraction and encapsulation achieved with object-oriented programming and distributed processing technologies aimed at not justify the selection of a platform that it would not object-oriented [7].

Among these architectures Java Beans, CORBA and Microsoft .NET [8, 9] technology, are counted here once without expressly say that it is the best option, .NET technology was selected by the existing knowledge within the company and for being the original development platform for the programming interface equipment called Cronos traffic lights.

The Central Traffic application has a client-server architecture, some strongly oriented user components become part of the client application, while components aimed at the implementation of the protocol and to enable communication with the device become part of the application server (Fig. 2).

The display state of the traffic lights in the map takes place through events received from the drivers that indicate the change of plan signals from currently viewing; it is the result of simulation of the team's plans present in the database of the plant, until another plan change event where the process is repeated receipt.

5. Compiler

The aim of the compiler is the validation of the programming created for the team before transmission, in order to meet minimum safety standards in traffic light described by the ministry of transport.

The checks performed by the compiler are related to:

A) Review of intermediate times;
B) Duration of red-yellow and yellow;
C) Schedule of the team's plans;
D) Signs (synchronization, connection, stops and advances) plans;
E) Groups friends.

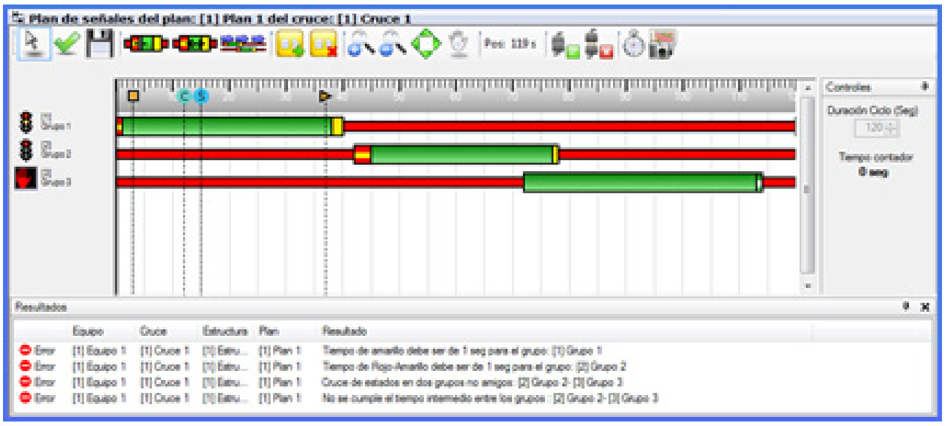

Fig. 3. The compiler screen sample

6. System Tests

One of the main advantages of the model component reuse is that if it has achieved an adequate level of encapsulation is possible to avoid duplication of efforts by testing and proven components, thus limiting testing new components and integration [12].

Within the set of tests performed on the application, we have:

1) Testing unit. Tests are performed on each of the components separately, from the point of view of development in .NET is the testing of each of the projects that are part of the solution;

2) Integration Testing. Evidence of interaction between the various components;
3) Stress testing and concurrency. With help from the customer's own tests on simultaneous access, we are performed and repeated to the different functions of the application for 30 users, which is five times the actual number of users who will operate the system concurrently. One Testcomm emulate application that allowed a large number of virtual traffic controllers to verify the release of memory sockets in the server application and test concurrency is also developing;
4) Safety Tests. He had a team unrelated development that attempted to access the system, having full knowledge of architecture but not the keys to access the system. Enforcement is also allowed during a week of the application without the protection of a firewall with which it was evident that received at least one attack, which the application was able to cope without problems;
5) Acceptance Tests. Tests conducted in collaboration with officials from the Ministries of Traffic and Transportation Bogotá (Current Secretary of mobility), Pereira and Cali. In addition to presentations to governmental entities as ITS Colombia;
6) White-box testing. Tests performed by the system developers knowing from conception and thoroughly testing their functions;
7) Black box testing. Testing conducted by personnel unrelated to know within the system, and their knowledge was limited to its experience in similar systems and reading the manual functions;
8) Field tests. Tests performed during the execution of the project in collaboration with the authorities, i.e., in collaboration with traffic wardens, proceeded to demonstrate each of the system's functionality in a real crossroads.

7. Centralized traffic control system

Currently, the system is connected to a total of 40 drivers with 52 signalized intersections. In the future, through appropriate budget allocations, the necessary contracts are made to expand the system to a greater number of drivers, with expandability up to 500 inter-sections. The system has a database for storage of up to 6400 signal plans, three billion of unanticipated events, 40 million meters of historical data from vehicles, 10 million historical records of users and allows users to create different 17000 access levels. An additional benefit to the start-up of this new system is the reduction in fuel consumption and consequent reduction of air pollution.

The system will detect online, the damage arising in any of the 40 intersections, either by lights in disrepair as other damage that adversely affect the operation of traffic lights at a specific point in the city. You can then immediately sent a maintenance crew to make the respective repair, without waiting, that any citizen reports the fault. The chances of traffic accidents occur because of malfunctioning traffic lights and minimized.

The system can perform the following functions directly on equipment controllers that are connected to the centre:

a) Turn off corridor: Turn off all intersections of the road corridor,
b) Turn off crossing: Turn off an intersection of a particular controller,
c) Assign date and time: Date and time assigned to a particular controller,
d) Assign date and time to all controllers: Date and time assigned to all controllers,
e) Switching current plan: Change the current plan for an intersection indicated by the user,
f) Flashing corridor: set flashing to all intersections of the road corridor,
g) Flashing crossing: set flashing one intersection,
h) Switch on corridor: Turn on all intersections of a corridor,
i) Switch on crossing: Turn on an intersection ,
j) Read controller events: Read events from a controller,
k) Stop cycle: Stops the current cycle for a specified time,

l) Program the controller: Program the controller according to the data stored in the database.
m) Restart the controller: Restart a particular controller

6. Conclusion

The centralized traffic control system has contributed to the improvement of road organization of the city, due in large part to their good use by operators. Until now, drivers have a greater connection stability 90%, allowing data transmission, event reporting, allocation plans and sent command signals in a reliable way, and the creation of reports the states of traffic lights and controllers that are connected.

Even when communication is sufficiently stable, the controller design allows operation of the traffic lights (depending on the plans signal held by the driver at the time) without being dependent on the communication.

Particular real benefits of this new system of traffic lights are reflected in green times at each intersection allocated in accordance with the present traffic volumes on the road network at any time of day and in every sector of the city in particular, which of course increases the efficiency of each light installed at each intersection.

This is the main benefit received by drivers when driving on the road network in the east of the city, formed by the City of Cali Avenue and Avenue Simon Bolivar, where travel times have been significantly reduced. Bystanders have also benefited from the system by using the pedestrian push buttons, in which they seek to cross the street, reducing the risk of accidents and traffic flow stopping only when it is really necessary.

As demonstrated, in this case study the congestion scheme has been improved, and the project has opened up vast opportunities for innovative network management strategies for the optimization of network performance. Many of these strategies are developed to give a coordinated high-level control across different traffic control platforms based on real time traffic condition and performance on site.

Acknowledgments

The work has been financially supported by the Polish Ministry of Science and Higher Education.

References

[1] Robles, D., Ñañes, P., *Control y simulación de tráfico urbano en Colombia*, Revista de ingeniería, Universidad de los Andes, Bogotá, Colombia, Mayo de 2009.
[2] Di Febbraro, A., Giglio, D., Sacco, N., *Urban traffic control structure based on hybrid Petri nets*, IEEE Transactions on Intelligent Transportation Systems, Vol. 5 (4), pp. 224-237, 2004.
[3] Lo, H. K., *A cell-based traffic control formulation: Strategies and benefits of dynamic timing plans*, Transportation Science, Vol. 35 (2), pp. 148-164, 2001.
[4] Papageorgiou, M., *Automatic control methods in traffic and transportation*, Toint, P., Labbe, M., Tanczos, K., Laporte, G. (Eds.), *Operations research and decision aid methodologies in traffic and transportation management*, pp. 46-83, Springer, Berlin 1999.
[5] Dotoli, M., Pia Fanti, M., Meloni, C., *A signal timing plan formulation for urban traffic control*, Control Engineering Practice, Vol. 14 (11), pp. 1297-1311, November 2006.
[6] Zhiyong, L., *A Survey of Intelligence Methods in Urban Traffic Signal Control*. IJCSNS International Journal of Computer Science and Network Security, Vol. 7 (7), Julio 2007.
[7] Thai, T. L., Lam, H., *NET framework Essentials*, O'Reilly & Associates, 2003.
[8] Marmol, F., *Programación orientada a objetos en C#*, Universidad de Murcia, Julio 2004.

[9] Montilva, J., Gharawi, K. H. M., *The watch model for development business software in small and midsize organization*, IV World Multiconference on Systemics, Cybernetics and Informatics (SCI'2000), Orlando, Florida (USA), Julio 2000.
[10] República de Colombia, Ministerio de Transporte, *Manual de Señalización vial: Dispositivos para la regulación del tránsito en calles, carreteras y ciclo rutas de Colombia*, 2015.