TRAFFIC MANAGEMENT IN AN INTERCONTINENTAL CITY: ISTANBUL

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ABSTRACT

Istanbul is the greatest metropolis in Turkey, a dense, cosmopolitan and historic city with a rich cultural and architectural heritage. Managing the city is the responsibility of the local government, and that includes making transportation safe and efficient for drivers, passengers and pedestrians. To those ends, Istanbul Metropolitan Municipality (IMM) has invested on a variety of traffic management solutions and ISBAK Inc.(Istanbul Transportation Telecommunication and Security Technologies Industry & Trade Inc.), which is an affiliated company of IMM, has implemented these solutions and introduced to the public.

Recently developed technologies and communication facilities enabled IMM to accelerate improvements in traffic management. During the last seven years, it has allocated considerable resources to transportation issues: ~400 traffic cameras, ~350 road sensors, 35 weather observation sensors, 7 variable message boards and ~150 electronic violation detection systems have been mounted on Istanbul's highways and two dedicated centers for controlling and directing traffic and operating all traffic equipment have been constructed.

This paper covers "Data Retrieval/Storage," "Traffic Control," "Software Development" and "Internet Applications" topics and describes the development in traffic management in Istanbul with the technologies that have been developed by ISBAK Inc. and used by the Traffic Control Center (TCC) of IMM and the public.

INTRODUCTION

Istanbul is a cosmopolitan city straddling two continents and one of the world's most outstanding cities. Like other megacities, Istanbul has needed to meet the challenges of maintaining transportation accessibility as it continues to grow as an important international metropolis with 13-million-population. Traffic management therefore has become a critical issue, and building and operating an infrastructure for effective traffic observation and management have been the primary responsibility of IMM. On the other hand, ISBAK Inc. is a subsidiary company of IMM who is the executing arm of IMM in traffic and transportation related projects.

Before assessing the progress in the field of transportation, the statistics in the following table gives brief background information about Istanbul traffic:

Metropolitan Surface Area	5,389 km2
# Daily Trips	~21 Million
# Vehicles	~2,6 Million
# Cars	1,6 Millions
# Vehicles in Traffic	1,7-1,8 Million
Vehicles Added to Traffic	~400 vehicles/day
Total Road Network	25,000 Km
# Daily Trips Between 2 continents	~1,3 Million
Avg. Travel Time between Asia-Europe by private car	72 minute
Avg. Travel Time by private car	49 minute
Car ownership rate	133 cars / 1000 people

Table 1: Transportation Statistics

Intelligent Transportation Systems (ITS) use up-to-date technologies to gather data to support the largely automated management of traffic. ITS applications in Turkey were first encouraged by Istanbul Metropolitan Municipality's Directorate of Traffic and implemented by ISBAK. ITS encompasses a broad range of wireless and wire-line information, control and electronics technologies; and when

integrated with the transportation infrastructure, these technologies monitor and help manage the flow of Istanbul's 20 million daily vehicle trips. By increasing the efficient use of existing road capacity, these ITS applications are intended to reduce congestion, decrease traffic accidents, and enhance regional productivity.

Due to its geographical position, Istanbul has two bottlenecks on its two bridges (Fatih Sultan Mehmet Bridge and the Bosporus Bridge) which connect two continents: Asia and Europe. This constraint requires cutting-edge ITS applications to solve traffic related issues in Istanbul. Figure 1 shows the outer and inner view of Istanbul with main arteries and bridges over Bosporus.

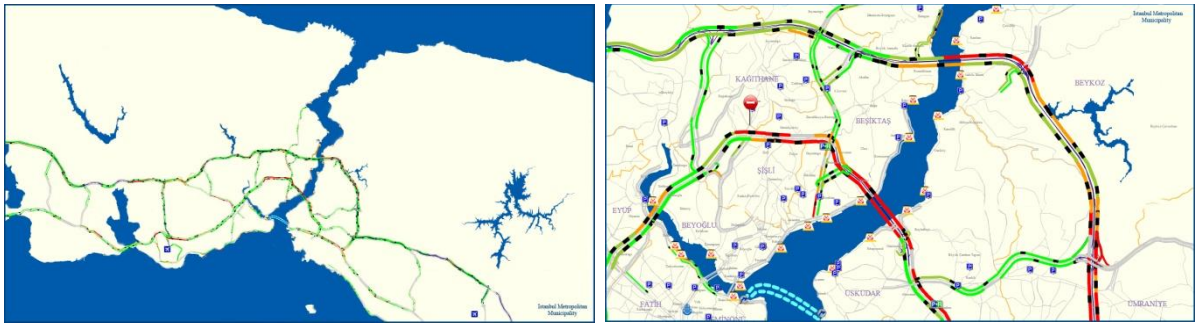

Figure 1: Geographical Position of Istanbul

DATA RETRIEVAL AND STORAGE

Istanbul is a continuously developing city in terms of new road and infrastructure construction. This affects the decision of the type of equipments which collect traffic data from the field. Traffic cameras, road sensors and weather observation sensors are the major data sources for TCC.

Instead of loop sensors, IMM prefers non-invasive microwave radar sensors to obtain traffic flow information such as average speed, the number of vehicles and their classification, and the occupancy of roads from up to eight used defined detection zones. These customized sensors are mounted onto road poles that are seven meters from and seven meters up the road and can measure up to 60m (200ft) away [1].

Figure 2: Radar Sensor

RTMS (Remote Traffic Microwave Sensor) is a traffic sensor that detects vehicle presence and calculates traffic parameters for multiple lanes, without being affected by weather conditions such as fog, snow, rain, winds or sunlight. The RTMS transmits low-power microwave signals with a changing frequency and forms an elliptical footprint on the road surface. Any non-background targets will be detected.

Accumulated traffic information is transferred to a GPRS modem via RS-232 serial port and transmitted to a TCC server through GPRS network in short-time pre-defined message periods which – 60 seconds on highways or 300 seconds on arterial streets close to signalized intersections. The data consist of Volume (total number of vehicles), Occupancy, Average Speed and Classification (up to four user-defined groups according to vehicle length) for each detection zone. Occupancy indicates the percentage of the time period in which a zone is occupied. At the end of each message period, buffered data are transmitted and internal counters of the detector are cleared. There are approximately 350 road sensors on Istanbul highways.

The traffic cameras that are mounted to 400 critical points have a 360-degree rotation. Cameras are located on the top of 20 meter-high poles. Central arteries' traffic situation is observed in real time.

Camera systems have integrated Pan/Tilt/Zoom features. It is possible to make the necessary adjustments via their web-based interfaces. After encoding the analog video between 150k and 400k, it is converted into digital video and transferred to TCC via 1Mbit or 2Mbit capacity G.SHDSL line.

In TCC's server room, encoded videos are decoded in order to obtain high quality videos. Afterwards, these videos are multiplexed in order to be transferred to other related centers.

The damage resulting from severe weather conditions can become even greater if necessary precautions are not taken in a timely manner. Fog and sight distance data, wind speed and direction, temperature, road surface temperature and road fluid thickness data are obtained from weather observation sensors via GPRS network.

INTERPRETATION OF DATA

All types of raw data is collected in TCC and preprocessed before publishing to the public. This preparation is run on different types of servers in TCC's server room.

Collected road sensor data are received in binary format which needs to be parsed, processed and finally stored to the databases. Relational Database model is preferred due to its easy and fast querying capabilities.

Not only the computational processes, but also interpretation is necessary since the same data may refer to different meanings in different characterized highways. For instance, while 50 km/h implies runny traffic on southern coastal roads in Istanbul, it refers to heavy traffic on main highways. A plenty of algorithms and methods are applied to implement web-based and mobile applications such as coloring the density map and travel time by using these data.

Taken pictures of the cars that violate the red light or drive through safety lane are also sent to TCC and saved in databases. Since the IMM has legally no right to punish violations, officers from police department submit the fine to the drivers as they see the pictures of violations via Electronic Violation Detection System (EDS) of TCC.

Figure 3: Violation fine sample

DATA PRESENTATION

Processed traffic information is published via various ITS applications such as:

- Traffic Density Map,
- IMM Mobile Traffic,
- TCC's web site (http://tkm.ibb.gov.tr),
- Variable Message Signs,
- Lane Control Systems
- Call Center

Traffic Density Map:

The Internet is a powerful and indispensable communication tool for traffic control in Istanbul. Traffic Density Map represents various categories of information using an easily understandable, vivid, interactive and elegant graphical user interface. It is a color based digital map that represents current average speeds obtained from RTMS's, weather condition data and video snapshots from traffic cameras. It automatically refreshes itself every minute to renew the map with updated data. It is represented by red, orange, dark green and light green colors according to pre-defined average speed ranges. TCC presents three sequenced camera images in order to clarify the movement of traffic flow. These images are renewed in every minute. Statistical and graphical presentation of the traffic speed changes during a defined period is also available in this map. Any computer connected to the Internet can use the Traffic Density Map; no special software is necessary.

Figure 4: Traffic Density Map

IMM Mobile Traffic: "IBBCepTrafik" enables drivers to access real time traffic information from everywhere. IBBCepTrafik is a mobile application that people access over mobile phones. Updated real time traffic camera images can be viewed over mobile phones, and the Traffic Density Map allows drivers to see current traffic density information. Users select their starting and destination points and can access real time camera images and traffic information, including estimated travel time for the selected path. In addition, TCC publishes alerts over IBBCepTrafik application regarding negative situations affecting traffic, such as accidents or road excavation work.

This application has easy access to current traffic information and can work on all GSM carriers' network in Turkey. In order to install IBBCepTrafik, the mobile phone needs to be JAVA supported.

Variable Message Signs: VMSs inform drivers about traffic conditions such as traffic density, accidents, road excavation works, weather conditions and other situations which affect traffic and direct drivers to alternative routes.

On Istanbul highways, there are currently 7 VMSs. Traffic messages sent to these VMSs are manually updated by traffic operators who are the personnel of TCC. By using customized software, the operators add, delete or update messages that are to be displayed. The transmission environment is either GPRS or G.SHDSL network.

Call Center: TCC broadcasts to 15 TV and 32 radio channels 75 times a day and 3500 calls each day. Call Center operators inform other units and agencies about traffic breakdowns and accidents and update VMS messages according to current traffic conditions. They also inform drivers and passengers during their travels, guiding and directing them to reach their destination in shorter time. Call Center has recently initiated an application about received calls. Usually, 80% of the incoming calls are due to the questions about the availability of two bridges. Therefore, a recorded voice system is embedded to the responding system of calls. An operator records his voice in every 15 minutes during rush hours. The drivers can optionally listen to this record and hence they are not redirected to operators. It reduces duplications of responses of call center operators and increases the throughput. The number of incoming calls is 5000 in 2009 and 6500 in 2010 while it is 3500 currently although it is expected to be 7000 calls daily.

RESULTS

There is a wide usage of all traffic applications in Istanbul since the number of total vehicle is 2.6 million, the number of daily trips between two continents is 1.3 million and 400 new cars are added to traffic daily. There is also a common standpoint which leads the traffic to be more complicated: Asian side is more appropriate and confortable to live although most of the business offices are located in European side of Istanbul. Since there are only 2 bridges that connect two continents, the high demand and congestion on these bottlenecks needs to be resolved and managed by public authorities.

- There are totally more than 1.000.000 individual users of IMM Mobile Traffic in Istanbul. In 2009, the total number of connections for the application is 10.5 million and in 2010, it is 16.5 million.
- TCC's official web site has published traffic information since 2006. After being advertised on VMSs, TV channels and the 2006 CeBIT Eurasia Exhibition, daily utilization of it has increased and currently takes 1 million hits per day.
- Hard shoulder violations are reduced 84% and red light violations are reduced 77% since 2007 by Electronic Detection System.
- TCC's Call Center receives approximately 3500 calls where 7000 calls are expected per day.

The information available to drivers through all ITS applications plays an important part in ensuring the best use of Istanbul's available traffic infrastructure. Estimated travel times, calculated on the basis of road sensor data, indicates that although alternative routes are often longer in distance, drivers are reaching their destinations in less time. Consequently, a smaller amount of air pollution is generated for the same trip. Another benefit is presumably that drivers who spend less time stuck in traffic jams experience less stress from traveling in Istanbul.

CONCLUSION

Since the year 2000, many infrastructure improvements have been made to facilitate mobility throughout the city. As the city has grown, there has been exponential growth in the number of vehicles in use, and though it is difficult to demonstrate that average travel times have been reduced, common sense suggests that the implementation of these information technologies has reduced travel times as compared to what they would have been without it.

There are too many factors which affect Istanbul's traffic such as weather condition, the day of the week (Monday mornings and Friday evenings), special big events etc. On the other hand, due to its geographical position, Istanbul has two bottlenecks on its two bridges which connect two continents: Asia and Europe. This constraint requires cutting-edge ITS solutions to solve traffic related issues in Istanbul. Thus, IMM carries out many projects through its subsidiary companies. In this context, ISBAK Inc. is in charge of developing and implementing ITS solution on behalf of IMM.

REFERENCES

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AUTHOR

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