# An Evaluation of Adaptive Traffic Control System in Istanbul, Turkey

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***Abstract*—Adaptive traffic control system is the latest generation of traffic control systems that operates, manages and control the signalized intersections with/without coordination. ATAK is one of the adaptive traffic control system that is developed by ISBAK Inc., in Turkey. It uses the genetic and fuzzy-logic algorithm as an optimization tool. The genetic algorithm is used for optimizing signal timings and fuzzy logic is used for controlling the exceptional cases during the operation of traffic control devices. This study defines the ATAK system as an traffic management tool at signalized intersections. The performance of the system is outlined. Application of the ATAK system at isolated and coordinated intersection showed that the performance improvement is about 10% in terms of cycle time and travel time improvement is about 15%.**

***Index Terms*—adaptive signal control, adaptive control algorithm**

## I. INTRODUCTION

Traffic signal control (TSC) methods, which were first started with isolated junction traffic regulation in USA, Cleveland State in 1913, varies according to properties and requirements of countries. TSC may be categorized into two main groups: 1) Fixed time (time dependent control) and 2) Traffic dependent control. In a fixed time traffic control, the signal plans are prepared (or rarely optimized) based on the historical traffic volume data [1]. In a traffic dependent control, the traffic volume, speed, occupancy rate are instantly measured in the field by the help of traffic sensors in an approaching lanes. Generally, fixed time traffic control systems are preferred since they are stable in operation and they require less maintenance costs, especially in frequent infrastructure works. If traffic flow is stable, fixed timing plans will have give successful results. However, general traffic situation may vary according to traffic demand, incidents or work constructions. In order to overcome the fluctuations on traffic demand, a real-time traffic control is required. Real time traffic control or traffic dependent control can be categorized into three groups: traffic actuated control, traffic responsive plan selection and traffic adaptive control may be further improved by calling adaptive traffic control systems that are full/semi-traffic actuated and real time optimization. Traffic actuated systems are based on principles to extend or reduce phase green periods and to give more greens to phases when demand is high. There are only systems that operate as fully traffic actuated, in which there are sensors on all approach lanes and all green periods at junction are determined according to measured traffic volumes and occupancy data. Adapting green period by following the predetermined order at signal flow diagram is expressed as rule-based control. Entries-exits of private facilities, left turn space, side road and pedestrian button applications are part of semi-traffic stimulation system. Advantages of this system are; a) adapting short term stochastic fluctuations on traffic demand; b) directly meeting demands that occur on junction sections. Multi-plan selection method may be defined as the selection of signal plans that is required predetermined and prepared signaling plans according to traffic demand in case of certain traffic pattern forming. Traffic pattern strategies must previously be determined. Maximum green periods at junction scale cycle and offset periods at arterials are selected in case of emerging predetermined traffic demand. While traffic actuated control management adapts green period according to instant traffic demand and at junction scale, plan selection method performs plans selection by inquiring with 10-15 minutes intervals at arterial or network scale. In traffic adaptive control a traffic flow model and an optimization model is required.

## II. ATAK ADAPTIVE TRAFFIC CONTROL

Adaptive traffic control forms primarily on traffic flow and traffic effect model as real-time based on traffic demand. It provides real time signal optimization. In an Adaptive Traffic Control a requires a wide sensor network located each approach lane at signalized junctions and strong communication and hardware/ software system. The analysis of adaptive systems that are established at intersections, it is seen that delays and average number of stops in a traffic road network may be reduced when it is compared with fixed time plans. The presented adaptive traffic control system ATAK, which is able to optimize traffic signal timings on signalized road network in real-time was developed by ISBAK Inc., with the support of TUBITAK (The Science and Technological Research Council of Turkey) and universities in 2010 in order to reduce traffic congestion in signalized road networks. ATAK system is a real time

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adaptive traffic control systems that control the signalized junction using measured traffic volume and occupancy rate based on genetic algorithm [2] and fuzzy logic methods [3]-[5]. The signal timings are instantly optimized and fed into the traffic control devices. Real time optimization module generates optimum signal timings that will minimize the delay and number of stops for all approaches at signalized junction and/or all arterials in a road network.

## III. Architecture of ATAK System

ATAK system which determines the optimum signal timings according to measured real-time traffic volume and occupancy. It operates with central computer. ATAK automatically calculates and sends new signal plans to the control devices at the end of each cycle. It also operates under the structure of central and local traffic management system that utilize all these signaling plans. ATAK system software provides communication with site through central communication and control interface. Control elements within ATAK center is given in Fig. 1.

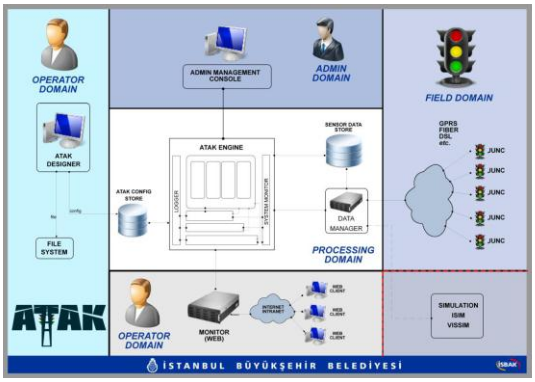


Figure 1. Architecture of ATAK system

### A. *ATAK Communication Engine (Communication Software)*

Server software that provides communication between Center and Junction control devices and it is directly linked to Junctions. Data transfer of server and clients with junction control devices are provided by ATAK communication Engine.

### B. *Online Traffic Management Server Software*

It is a traffic modeling software that optimizes traffic signal timings based on genetic algorithms and fuzzy logic. Connection with junction control devices on a site is controlled by ATAK Central software. ATAK central software determines and optimizes cycle time and it is corresponding phase green times.

### C. *Database*

The measured traffic volumes, speed, occupancy, etc., are stored in a database for all junctions that are connected with ATAK System.

### D. *Web Monitoring (Web Monitoring Software)*

Geographical locations, identification information of their junction, latest generated planning periods, cycle and traffic volumes and occupations of all junctions that are connected to ATAK management system are provided to the user through visual web interface.

### E. *ATAK Designer (ATAK Design Software)*

It is the interface in which junctions that are connected to ATAK management system are solely entered to system and sensor points and limitations are determined. Information such as geometrical information of junction, adaptive control parameters may be entered.

### F. *Admin Manager (Manager Interface Software)*

This is a software that enables ATAK project team to test various algorithms. This is user interface in which current algorithms may be selected. Data and optimized timings periods are monitored. Fine tuning may be made in Admin Manager through operation period.

### G. *Simulation Interface*

This interface enable ATAK to communicate with VISSIM microscopic traffic flow simulation tool to evaluate the ATAK system previously.

## IV. ATAK Data Collection

ATAK evaluates the sensor data by considering the states of signal outputs. Traffic volumes and occupancy data that are collected for each phase from sensors constitute the basic parameters of adaptive traffic control. It is determined that the counts that are being received from sensors belong to flow of which direction. Three different location choices are made for sensor allocation.
Output sensors: They are positioned around 10-20 meters from junction exit. Through these sensors, queuing at junction exits is detected and performance of the junction may be measured.

Input sensors: These sensors are positioned between 50 and 200 meters from the stop line in direction of junction approach. This distance is varied according to flow speed of arterial and longest queuing delay.

Side road sensors: They are positioned approximately 10m away from the junction stop line on side roads when they are no high traffic demand. These sensors engage relevant phases by considering the demand arising from side road and prolong the phase period according to vehicle amount.

ATAK management system may give different reactions according to user demand in case of malfunction at sensors. System is able to predict incomplete data from previous data and relevant phase may be operated according to predetermined planning periods, if requested. In case of malfunction on sensors that are considered very critical, adaptive system may be disabled by enabling to weekly plan at the device. Noncritical sensor malfunctions may be ignored.

## V. ATAK Control Method

Measured traffic volumes and occupancy data that are received from sensors are eliminated from outlier data by processing them through filtering layer and volume and occupational data are generated. By using prediction algorithm using measured data, expected traffic volume and occupational periods are determined. When next phase is initiated, the optimum phase lengths are obtained by processing the measured traffic volume and occupancy rate.

Total cycle period that is calculated by using the data is processed in calculation period phase. Total delay that will occur when cycle period is distributed to each signal phase. Cycle period that will minimize the total delay and signal period, in which it is distributed to signal phases are determined. Optimal signal timings are produced by utilizing genetic algorithms.

## VI. Evaluation of ATAK on Istanbul Arterial

ATAK system that is applied to an example junction is given in Fig. 2, Fig. 3, Fig. 4. All sensor points are shown in this figure. Results are compared with multi-plan traffic control system. Results showed that 4% saturation degree and 10% cycle time have improved per vehicle in the ATAK system.

Isolated intersection has evaluated with saturation degree value that has collected automatically by detector.

Figure 2. Junction and Analysis

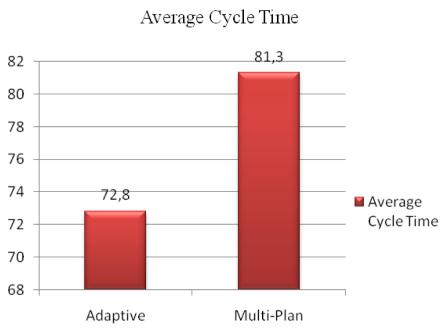


Figure 3. Isolated junction and analysis

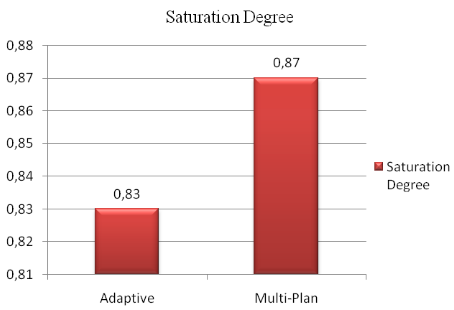


Figure 4. Isolated junction and analysis

Analysis for isolated junctions are performed for 24 hours by operating adaptive and fixed timing plan for 2 consequent days. As a result it can be seen that adaptive plan meets the demand for all approach sections with optimum timings.


Figure 5. Coordinated junctions

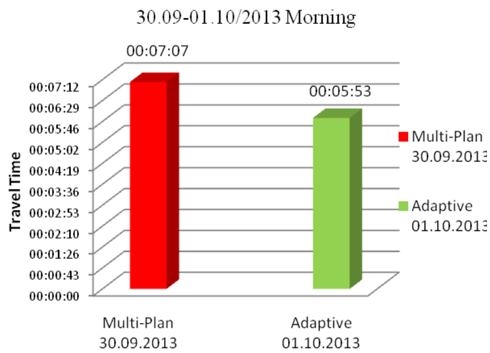


Figure 6. Morning peak travel time analysis

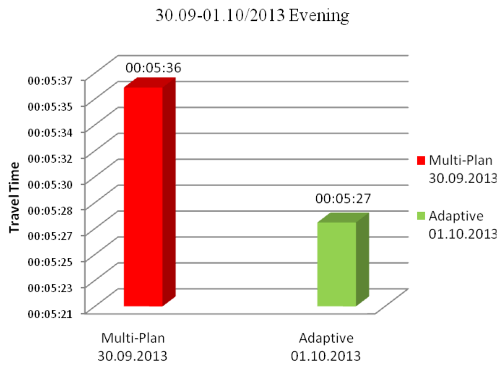


Figure 7. Evening peak travel time analysis

For travel time operation on arteries that are composed of coordinated junctions is used chronometry method or plate processing system. Operation artery that is formed by 5 junctions in coordination is 2.6 km as given in Fig. 5, Fig. 6, Fig. 7. A before-after analysis given Fig. 6, Fig. 7 that was conducted by converting the video record that is obtained on site into plate record at office environment. According to 15% improvements that are provided at travel times, approximately 10% C (Carbon) and derivative gas emission to environment are reduced. Results showed that benefit of adaptive system will be much higher than that of enabling dynamic intervention to traffic volume at off-peak hours when there are fluctuations at traffic volume. Fig. 3 shows that the travel time improvement on an example arterial. Especially, morning and evening peak times, we can see the performance of adaptive system. Results showed that travel time improvement is about 15%.

## VII. Conclusions

ATAK performs less complicated optimizations due to genetic algorithms. Fuzzy logic method that is used for exceptional cases enable ATAK to 7/24 continuously manage the junction by solving over saturation cases that is solved by analytical methods. Results showed that ATAK system may successfully be applied to junction control in a 7/24 hour manner. It prevents the problem for growing at exit road by sending excess number of vehicles from the entry by applying proper signal timings in case of where the exit section is not properly working and provides positive contribution to faster solution.

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