IMPROVING MALAYSIAN TOLLED HIGHWAYS OPERATIONS USING INTELLIGENT TRANSPORTATION SYSTEM(ITS)

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ABSTRACT

Rapid increase in number of vehicles on the road with growth rate of 7% per annum, demand increase of road network throughout Malaysia. Under the privatization concept, tolled roads have become popular in the construction industry in Malaysia. Since the privatization taken off during late 1980's, 20 tolled highways with a total of 1,492.3 km had been constructed by 20 concession companies and 4 new privatized toll highways are under construction.

Malaysian Highway Authority on behalf of the government had imposed the concession companies to provide facilities to improve traffic flow and better informed traffic information to the road users. Electronic Toll Collection system was introduced to improve traffic flow at toll plazas. Various Intelligent Transportation System (ITS) components such as Emergency Telephone System (ET), Closed Circuit Television System (CCTV), Vehicle Detectors System and Variable Message Signboards (VMS) are being used along most of the highways. These components include Traffic Control Centers that are being operated by various concession companies individually.

Since the centers are being operated separately, traffic information is constrained to individual highways and there is no exchange of information. In view of this situation, the Malaysian Highway Authority has initiated the implementation of a National Tolled Highways Traffic Management Centre to integrate and coordinate real time information from all concessionaires Traffic Control Centers.

The implementation of ITS can, not only alleviate traffic jams effectively but also bring great beneficial effect to the strengthening of traffic safety, accelerating the process of handling and aid of traffic accidents, improving the management of the transportation of people and goods and the charging system of highways.

This paper discusses further on the implementation of the National Tolled Highways Traffic Management Centre.

Introduction

The Malaysian Highway Authority (MHA) or the *Lembaga Lebuhraya Malaysia* is a Statutory Body under the Malaysian Ministry of Works. The MHA was established in 1980 under the Act of Parliament as a Monitoring and Regulatory Organization overseeing the development, implementation, operation and maintenance of tolled highways and expressways in Malaysia.

In all highway privatization projects in Malaysia, the primary roles and obligations of the MHA can be summarized as below;

a. To approve design brief and detailed design of works.
b. To acquire and analyze reports on quality control tests and work progress.
c. To make site visits, witness quality control test and inspect site records.
d. To compile information for monitoring purposes which include contracts, specifications and drawings.
e. To acquire land for project.
f. To carry out safety audit and gazette highway opening.
g. To acquire maintenance and inspection reports during operation.
h. To direct further investigations upon detection of noncompliances and the carrying out of maintenance and repair works.
i. To inspect the highway and its facilities to ensure sustained level of services to highway users.
j. To monitor the traffic volume.

Although building of new highways continues to take place in Malaysia, MHA has recognized that the challenges it faces is no longer about planning and supervision alone. The steady increase in traffic volume can no longer be encountered with building of new roads only. It has become critical that MHA embrace solutions available within the Intelligent Transportation System sector to help concession companies optimize current network capacities and facilitate proper empowerment to the public with regards to making journey plans on the highways under the MHA's charter.

In response to this need, the MHA has grown from a civil and construction-centric establishment to become a multidisciplinary outfit that embraces information technology

and electronics to better respond to the challenges it faces at present and in the future. The full fledged IT and ITS department setup is envisioned to take the leadership in coordinating and implementing technologies within the ITS sector for all tolled highways in Malaysia.

History

As at July 2006, there are 20 toll concessions in operation, 4 under construction, and 3 that are in preconstruction stage. By the end of the 9th Malaysia Plan, it is anticipated that 27 tolled highways will be in operation bringing the total highway length to XXXKM. Figures 1 and 2 below illustrate the growth of tolled highways in Malaysia from 1980 to 2010.

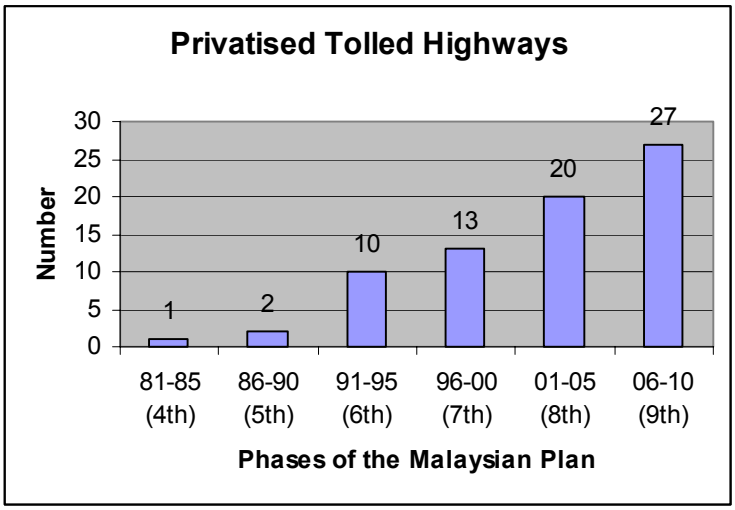

Figure 1. Tolled Highway implementation from the 4th to 9th Malaysia Plan

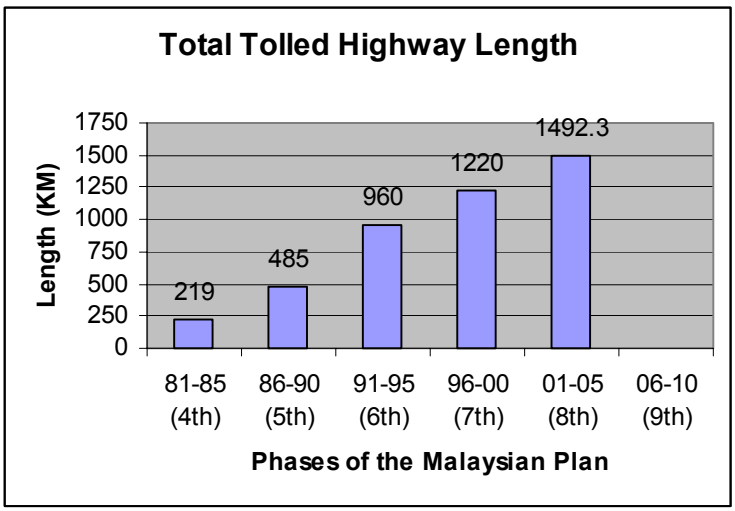

Figure 2. Tolled Highway Length from the 4th to 9th Malaysia Plan

Tolling System

The tolling system in Malaysia consists of both open and closed systems. Two types of toll equipments used allow for manual and automatic toll collection.

a. Manual Toll Collection

With this equipment, toll is paid in cash by the highway users and the operators record the transaction into the toll collection system manually.

b. Electronic Toll Collection (ETC)

The ETC system allows highway users to pay toll electronically. In 1995 the first ETC system implemented used a proximity card approach. It is a smartcard using Mifare technology developed by Mikron/Philips. The BridgeKAD was put in operation at Penang Bridge Toll Plaza from year 1995 till 2000 for all vehicle classes ranging from Class 1 up to Class 8.

One piece tag developed by SAAB Combitech using 2.45 Ghz microwave communication system call BridgeTAG was used at Penang Bridge Toll Plaza from 1995 till 2000 dedicated for vehicle class 2 (ie: passenger car).

The BridgeKAD was then change to Touch N Go using the similar technology and was in operation since year 2000 till now. The Touch N Go card is applicable for all type of vehicle classes from Class 1 to Class 8.

The Bridge Tag was then upgraded to a two piece tag consisting of Touch n Go card and On Board Unit which operate by using infra red communication system. The Smart TAG is applicable for vehicle class 2 (ie: passenger car) only. It was in operation since year 2000 till now.

Another implementations of contactless payment method was introduced in 2001 and operated using the 5.8GHz microwave frequency.

In 2004, the government standardized the ETC and all highway operators have now adopted contactless payment method based on the IR frequency. For non contactless payment, the special purpose Touch N Go proximity card system is adopted.

However, the frequent use of highways causes daily bottlenecks at tollgates and forms severe back-ups. Based on international statistics, bottleneck at tollgate accounts for 30% of the total congestion classified, and also the increased from approximately 230 vehicles per hour using manual toll collection compared to approximately 800 vehicles per hour using ETC tollgate.

To further improve traffic movement, Malaysia is now working towards Free Flow Toll Collection System.

Traffic Management

a. Early Traffic Control & Surveillance System (TCSS)

Early efforts in implementing TCSS systems began in the 1980s through the implementation of Emergency Telephone System (ETS). Beginning from the 1990s, the MHA has put a mandatory condition for all new tolled highways to implement TCSS which include systems like Closed Circuit Television (CCTV), Vehicle Detection System (VDS), Variable Message Signs (VMS)

Primary objectives of the TCSS implementation are;

i. Information collection
ii. Information processing
iii. Information dissemination
iv. Decision execution and enforcement

Nevertheless, until the turn of the millennium, the implementation had been done in small isolated pockets and emphasis on a unified central control system which is able to bring all equipment interfaces into a single presentation layer was missing. In almost all cases, subsystems like CCTV, VDS, VMS, and ETS are managed through different workstations. Decision making was manually evaluated and triggered.

b. Present state of ITS system at concessionaires

Since the late 1990s, through MHA's continuous efforts and benefits reaped by the concessionaires, most tolled highways have expanded the scope of implementation with regards to the TCSS components.

For highways implemented over the last 5 years the composition of the ITS components are as below;

i. Dedicated Traffic Control Center (TCC). Varying degrees of unified centralized management software can be observed.

ii. Gigabit fiber optic network as the backbone along the highway alignment.

iii. Closed Circuit Television (CCTV), preference for IP based video system is on the rise.

iv. Vehicle Detection System (VDS). Loop based and video based detectors are the most common.

v. Centralized Signalized Junctions Control.

vi. Variable Message Signboard (VMS).

vii. Emergency Telephone System (ETS).

CURRENT AND FUTURE TRAFFIC MANAGEMENT CHALLENGES ON MALAYSIAN TOLLED HIGHWAYS

In the highway construction sector, the early emphasis of the government was to construct quality transportation means to spur and support the nation's growth. In the 1980s especially, the IT industry in Malaysia was not yet viewed as major force in the local economy and the ITS sector specifically was still in its infancy. Hence, priority was not given to the needs to establish Standards for ITS system implementations. This has however resulted in inconsistent implementations driven by various parties that were not aware or concerned of the impact of the lack of standardization in the longer term. The MHA, in its regulatory capacity however sees the establishment of Standards plays a key role in ensuring the investment put into building expansive infrastructures continue to serve the objective of providing good transportation service to the public. Over the long run, establishing proper standards will help to curb uncontrolled implementation of strictly proprietary systems that restricts integration capabilities in the future for new highways

The second major challenge is that at this age of information, management of highways can no longer be effective if each highway is managed as a separate entity. Physical growth of urban areas and emergence of highway to highway intersections demand that different highway operators work together as well as with local authorities responsible for non-tolled roads. The management of highways must take into account the following factors;

- Highways are part of a larger road network. This notion becomes much more important for urban highways where there are important interfaces to non-tolled roads.
- As the highway network grows, the need to become efficient becomes pressingly crucial. Therefore there is a serious need for an integrated management solution whereby each subcomponent is not managed independently.
- Automated and guided decision making must become more prominent in the interest of increasing efficiency.

At present, most of the Traffic Control Centers are operating individually for each highway and they are not connected to one another. With the current condition, there is no sharing of information among the highway operators. Therefore, there is also no coordination amongst the various centers. This critical shortcoming is especially felt during occurrences of emergencies. There is also no automation of information dissemination to the road users and reliability of reaction and response time in emergencies is a concern because system is too human dependent.

THE LLM TMC OVERVIEW

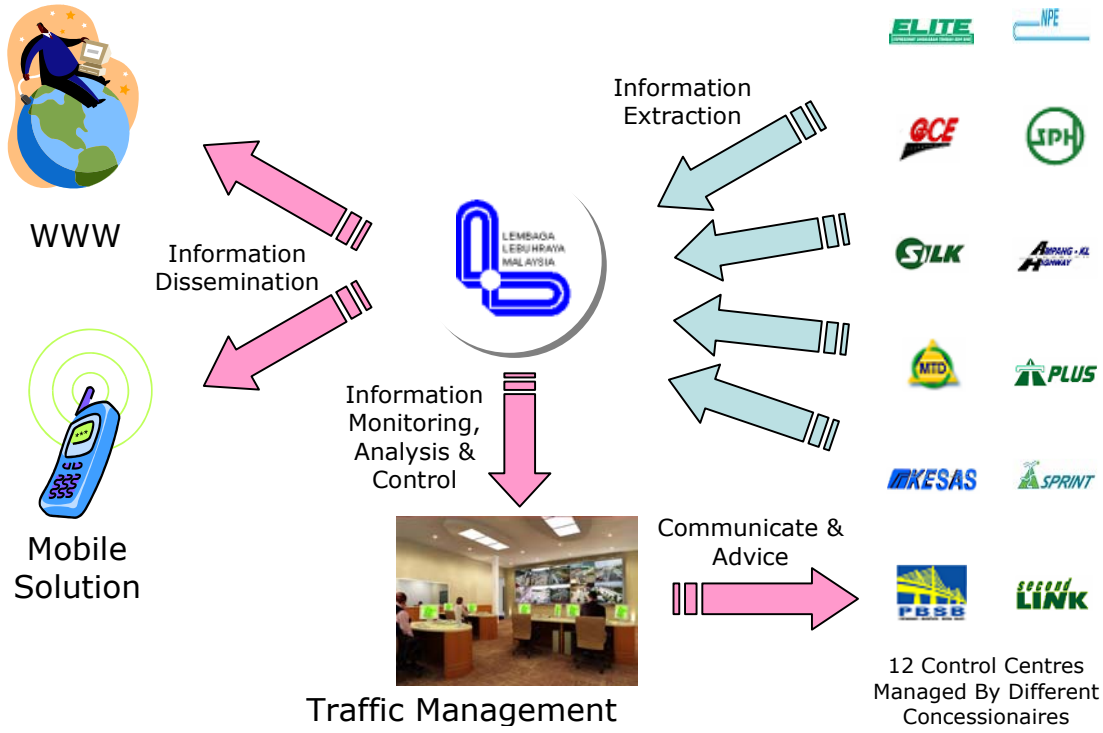

Figure 3. The LLM TMC concept overview

Brief Description

The LLM TMC is the response to the challenges posed in managing an elaborate network of tolled highways. Essentially, the LLM TMC is a centralized traffic management facility which integrates 12 different, independent control centre systems. Each centre operates on a different operating systems and stores data in various formats. These data have to be converted into a common data format and send to the TMC via a secured and highly reliable (>99% uptime) transmission mechanism within the IP environment. The 12 highways are part of the first phase of implementation and the MHA envisions that all tolled highways shall be connected to the LLM TMC in the near future.

The LLM TMC extracts from the 12 highway control centers the followings;

a. Live and recorded video images
b. Vehicle detection system data
c. VMS information and logs

Communication between the LLM TMC and each highway control center allows video, data and voice traffic to be transmitted in real time.

How the LLM TMC addresses the needs and challenges

The LLM TMC specific objectives are as follow;

- To provide real time supervision and management centre for highway network under the authority of LLM.

- To double as an emergency situation control and supervision centre.

- As foundation and basis for integration and standardization of Traffic Management Centers for privatized highways.

- As focal point for national level integration to other road networks (Municipalities, Non-privatized roads).

Key Features of the LLM TMC

The LLM TMC system has the following primary features;

- Obtain and provide operational current and historical status of all roadside equipment.
- Provide full Geographical Information System (GIS) featuring relevant details like emergency services, landmarks, and other locations of interest within 25KM radius from highway alignments. Information are presented in various layers to allow for effective filtering, searching and viewing
- Provide incident management tools which allow comprehensive and closed loop information sharing between operators of the TMC. Flexible 'On Screen Markers' with incident details and various log alarms ensure that all details collected in one operation shift is transferred to the next shift and not overlooked.
- Provide effective Incident Detection and Response Plans. Algorithms are built into the management system to detect certain traffic conditions upon which alarms and notifications are raised to the LLM TMC traffic operators. These powerful tools reduce decision making time due to pre-planned actions which are automatically sorted by the system according to matching percentage. Recorded Incidents can also be used to refine response plans hence increasing the level of effectiveness.
- Provide traffic condition with details for various level of traffic flow and congestion.
- Provide on-line real time data and voice over IP communication means between the TMC and highway concession control centres.
- Provide relevant and useful information dissemination to the public via the mobile phones and dedicated LLM TMC website.
- Employ last mile wireless access to achieve fast track implementation schedule.

Adoption of critical Technology

One of the most fundamental task to be fulfilled is to establish a robust, secure, and cost effective Center to Center means of data transmission. These are achieved though the implementation of the following technologies;

Web Services

It is inevitable that the 12 control centre systems come with different communication protocols. The solution to the mentioned integration challenges is Web Services. Web Services are the industry standard in system integration. Web Services use XML to provide effective data exchange between systems without exposing the implementation details. In other words, Web Services allows seamless cross platform integration, thus significantly reducing the time required for integration with other applications.

Data from the concessionaire control centers are encrypted with 192 bits 3DES encryption algorithm. The transmissions are also authenticated through this service. The store and forward mechanism at each control center allows restart-ability and prevent data loss due to possible network failure.

Messaging Technology

The Traffic Management Centre is fitted with Microsoft Windows Message Queuing (MSMQ) that provides reliable Messaging Technology and guarantees the traffic operators real-time transmission of information. This is crucial in a safety-critical environment by reducing performance bottlenecks.

Using this mechanism, messages can be communicated effectively due to its robust design and prioritization functions. More urgent or important messages can be received before less important messages, so you can guarantee adequate response time for critical applications. The messages are also secured, where messages sent or received are encrypted and authenticated.

Considerations for the Future

The Traffic Management Centre has to facilitate future integration needs as new highways are built. Since the architecture and data communication mechanisms of system to be implemented in the future is unknown, the integration mechanism that LLM adopts today must be a commonly used industry standard to assure future system interoperability without any technology or integration barriers.

Integration interfaces should be easily consumed regardless of platform, computer languages and operation system that are adopted by the future highway operator.

Keeping this in mind, the Traffic Management Centre is built on a multi-tier architecture, which is known to provide open flexibility, long term scalability and high resource availability. This allows the Traffic Management Centre to be conveniently operated, configured, maintained and expanded without causing disruption to its functions. This lays the basis to readily meet LLM's changing or future requirements.

Scaling the system for increased processing capacity can be achieved by simply adding additional application servers. The usage of multiple servers ensures high data availability by supplying redundant services and fail-over protection in case of server failure.

In addition, this architecture enables the operation of other ITS equipment and is accompanied with Application Programming Interface (API) interface that allows third-party organizations to develop and integrate new ITS functions.