Knowledge Systems Design

CaseStudy

Transportation Case Study

Freeway Traffic a Big Job for State DOT

California's freeway system is one of the largest and busiest on the planet. The California Department of Transportation (Caltrans) Division of Traffic Operations is responsible for monitoring the freeways and responding to any incidents that occur on the freeway network. To handle this task Caltrans maintains Transportation Management Centers (TMC) in each major County in California. Operators are on duty around the clock in these TMC's to monitor the freeways and respond to incidents as they occur.

Client: California Department of Transportation

Challenge: Develop a system automate appropriate responses to incidents on the freeway network. Determine what resources to use and automatically configure the resources in response to the incident.

Solution: Develop a Knowledge Base that captures the key operator knowledge used to determine a response to an accident on the freeway system. Integrate the Knowledge Base into the existing real-time operations system in the Caltrans Traffic Management Centers.

Results: The Knowledge Base is deployed and in use in Caltrans Traffic Management Centers. Traffic operations operators use the system to quickly generate and implement response plans for freeway incidents. The KB reduces incident response time by automating key portions of the operator response plan generation and implementation.

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A Knowledge Base for Incident Response

KSD worked with Caltrans traffic operations personnel to integrate a real-time Knowledge Base (KB) into the existing traffic operations environment available in the Caltrans TMC's. The goal of this Knowledge Base is to support operators in generating effective responses for incidents occurring on the freeway. A quick and effective incident response reduces the traffic impact of an incident thus cutting congestion and pollution from traffic queues. This incident response Knowledge Base was integrated into Caltrans existing Advanced Traffic Management System (ATMS).

A key characteristic of this Knowledge Base is its requirement for real-time response. The KB takes operator inputs about an incident then analyzes the current traffic situation and determines an effective and limited set of responses for the incident. Incident response plans are presented to the operator within a few seconds of their request.

A series of actions that make up a response plan is presented to the operator for final approval. When the operator approves a specific plan action, then this part of the plan is automatically implemented by the system. Appropriate commands are sent through the ATMS to control the various traffic control devices, for example posting messages on the roadside Changeable Message Signs (CMS).

Knowledge Capture a Key Project Challenge

One of the key project challenges was capturing the incident response knowledge from the most experienced traffic operations operators. KSD used a technique called Cognitive Task Analysis to accurately capture incident response knowledge. This process involved working through simulated incident response situations

with the operator and walking through a structured process to elicit key decision parameters and logic.

The incident response knowledge within the KB incorporates many factors, for example the location of the incident, the lane blockage pattern, the type of incident, the types of vehicles involved, and both current and expected traffic conditions on the freeway. Based on this information the KB generates a response plan that uses appropriate and available traffic control devices. Determining the right traffic control devices can be complex. For example if using roadside CMS the upstream location of the signs must be determined along with an appropriate message for each sign. A serious incident may require using signs on connecting upstream freeways. Besides roadside CMS other response resources must be considered. For example, depending on the seriousness of the incident and the traffic conditions Highway Advisory Radio broadcast may be recommend, or a specialized alert that goes out to radio stations may be suggested. Other Caltrans resources such as hazmat teams, maintenance crews and contract tow trucks may be offered as part of a response plan depending on the incident and projected traffic conditions. All of these elements must be integrated as part of an overall response plan.

A response plan must be measured and appropriate for the type of incident. Small incidents with minor traffic impact require a limited response to avoid disrupting the traffic flow unnecessarily. In more significant incidents the response had to consider a portion of the freeway network to appropriately route traffic around the incident area.

On-Line Knowledge Enhances Freeway Management

To embed the use of the KB within the operator's current work processes, interaction with the KB was integrated with the user interface of the existing ATMS. From this existing user interface the operator can input incident information, request a response plan from the KB, review response actions suggested by the system, and click to initiate those that they deem the best.

KSD worked in partnership with Caltrans through all phases of the project, from operator knowledge elicitation, through development, testing and deployment. The deployed system results in faster response plan implementation for incidents on the freeway. Faster response helps reduce congestion and traffic delays associated with an incident. As motorists travel the freeway network they cross boundaries between different TMC districts. With the KB in place, the incident response behavior is more consistent across TMC districts, for example the motorist warning messages appearing on the roadside CMS all have a consistent structure and verbiage.