



Designing Optimal and Robust Traffic Responsive Plan Selection Control

Closed-loop traffic control systems can be operated in either Time-of-Day (TOD) mode or Traffic Responsive Plan Selection (TRPS) mode. When properly configured, the TRPS mode has the greatest potential to provide an optimal operation due to its ability to accommodate abnormal traffic conditions such as incidents, special events, and holiday traffic. In addition, the TRPS mode can reduce the need for frequent redesign/updates to signal timing plans.

TRPS utilizes several Computational Channel (CC) and Pattern Selection (PS) parameters to activate one of its stored timing plans. Figure 1 shows a general TRPS mechanism in which occupancy and count information from a group of n system detectors (n differs from one manufacturer to another) are aggregated into a CC parameter (i.e., by multiplying each system detector by its corresponding weight W).

The names and number of CC parameters in a TRPS system differ from one manufacturer to another.

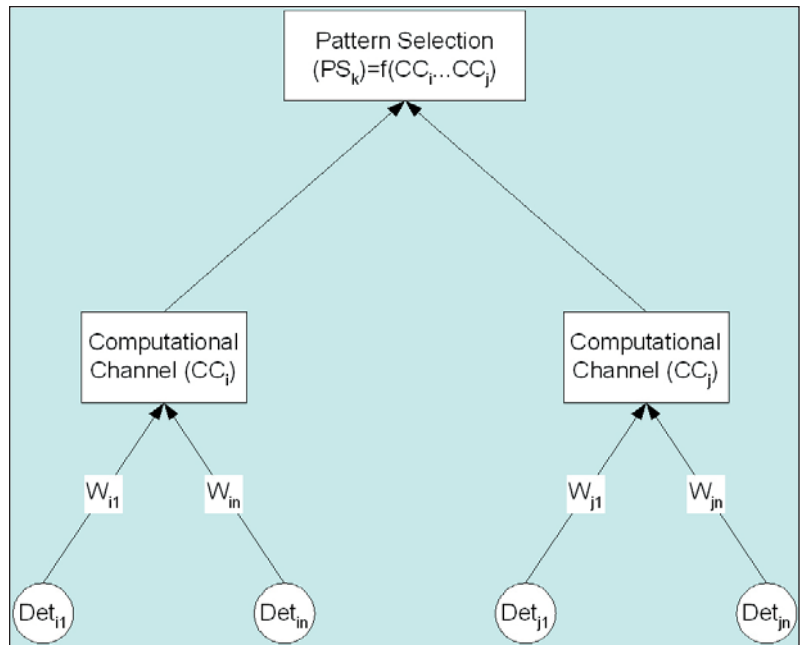


Figure 1. General TRPS Mechanism.

Most TRPS manufacturers, however, agree on the names and number of the PS parameters, namely cycle, split, and offset PS parameters. Each PS parameter is calculated as a function of several CC parameters. Some of these functions are user selected, while others are predefined by the controller manufacturer.

TRPS mode remains an untapped resource due to the complexity of its configuration. Numerous

parameters (e.g., detector weights, thresholds, timing plan lookup tables, timing plans) have to be set up correctly for the system to work as intended. To date, there have not been any formal guidelines for selection of robust and optimal TRPS system parameters and thresholds. Due to the lack of formal, clear, and comprehensive guidelines, traffic engineers usually revert to the TOD mode of operation for its ease of setup.



What We Did...

The objective of this research was to develop a methodology and guidelines for selection of optimal and robust TRPS control parameters and thresholds for arterial networks. Researchers worked to develop guidelines that would:

1. be based on a scientifically sound procedure as opposed to a system fine-tuning approach and
2. be presented in a simplified manner in the form of charts or tables for ease of implementation.

These objectives were achieved through the following activities:

- Study the TRPS control mechanism.
- Evaluate the state of the practice in TRPS setup.
- Develop a procedure for optimal overall system performance.
- Develop a scientific procedure for determination of the TRPS system parameters and thresholds.
- Develop guidelines for the selection of optimal TRPS system parameters and thresholds.
- Present the developed guidelines in tables or graphs for ease of implementation.

The methodology followed in our research was based on the realization that TRPS control is essentially a pattern recognition problem of different traffic states. Every intersection approach movement in the closed-loop system is a dimension in the TRPS traffic state space. Variation

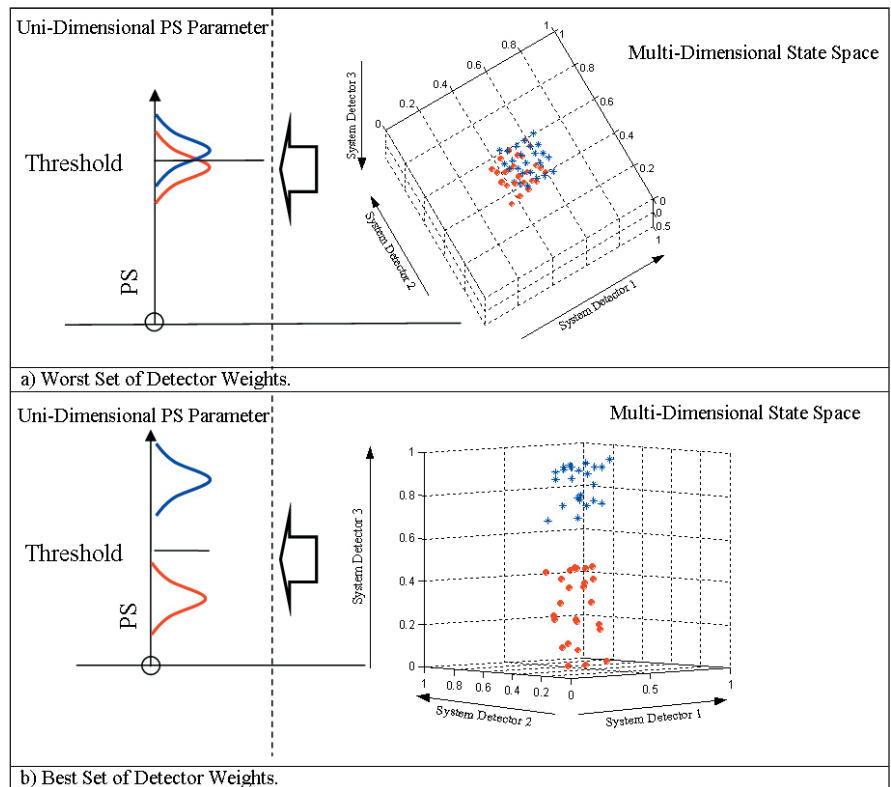


Figure 2. Effects of Detector Weights on the TRPS State Space.

in the traffic state variable along any of these dimensions can be potentially “sensed” through the occupancy and count information obtained from a system detector placed at that approach.

Figure 2 illustrates this concept. Figure 2 is a simplified three-dimensional space that shows sample occupancy distributions from two different traffic states. Figure 2a shows a set of detector weights that provide poor separation of the two states, while Figure 2b shows the best set of detector weights which provides total separation of the two states.

In order to cover all reasonable traffic states in this analysis, a global perspective was used to look at all possible traffic states. The global perspective classifies arterial volume into three major

superimposed movements as shown in Figure 3:

- 1) major external movement to the arterial,
- 2) additional cross-street movement, and
- 3) internal local movements.

Preliminary PASSER runs were conducted to find the realistic limit of each movement in a four-intersection system so that the intersections are not oversaturated.

In addition to traditional performance measures (stops and delay), the researchers defined a new measure of effectiveness, Degree of Detachment (DOD), for the purpose of clustering traffic states. The DOD measures the degree by which a traffic state is detached from adjacent states. In this context, detachment occurs when the adjacent state (state



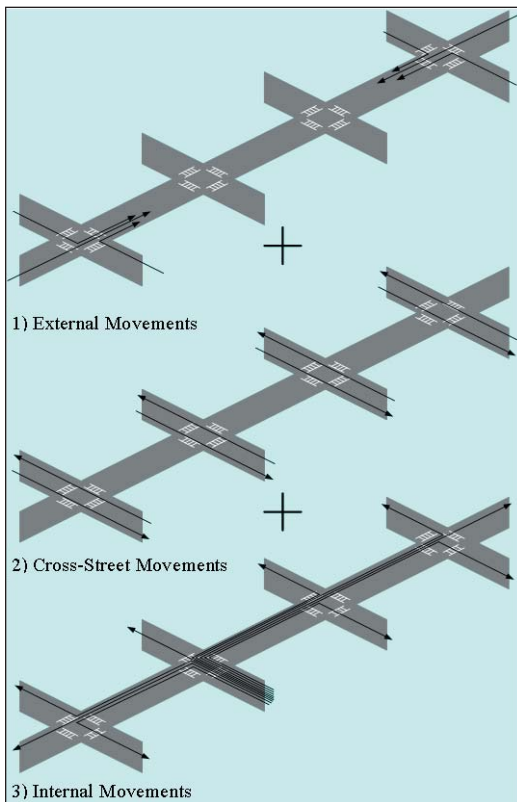


Figure 3. Generalized Arterial Volume Distribution.

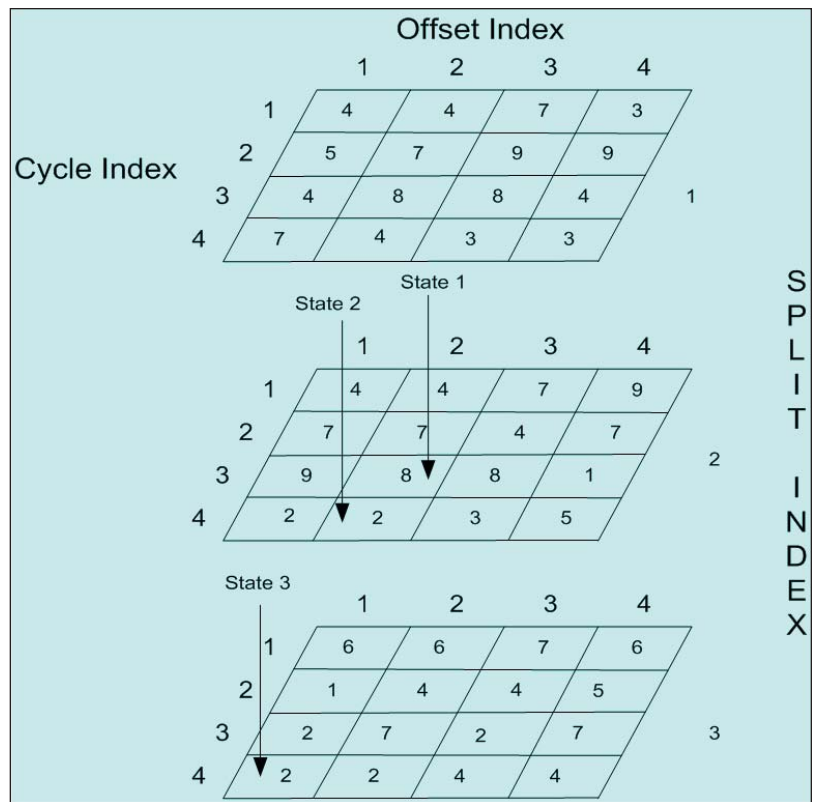


Figure 5. Timing Plan Assignment in Lookup Table.

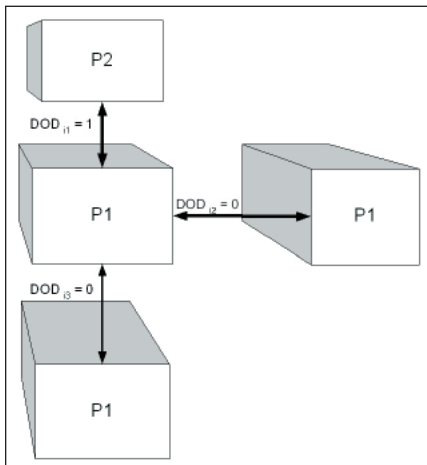


Figure 4. DOD Concept.

that has a level one below or one above the current state's level) is associated with a different timing plan (Pi). Figure 4 shows the DOD value for three levels in the traffic state space.

Researchers used a multi-objective evolutionary algorithm to select optimal timing plans. The algorithm was used to minimize overall system delay, stops, and the newly defined DOD measure.

What We Found...

Fourteen timing plans were identified to provide optimal control of the traffic system, with an average savings of at least 53 percent in delay and 19 percent in number of vehicle stops.

Researchers used hardware-in-the-loop simulation to verify the guidelines. Three different traffic states of 30 minutes each were simulated. Figure 5 shows the index and the plan assigned to the lookup table entry. TRPS was found to bring up the most

appropriate timing plan in a stable and timely fashion.

The Researchers Recommend...

The researchers recommend the use of the guidelines developed in this project to make better use of existing closed-loop systems. In addition, the researchers recommend the following future research:

- development of a procedure to customize the TRPS guidelines for a particular range of traffic conditions,
- development of computer software for TRPS configuration for a particular system, and
- development of improved TRPS control mechanism.



For More Details...

Research is documented in Report 0-4421-2, *Guidelines for Determination of Optimal Traffic Responsive Plan Selection Control Parameters*.

TxDOT Project Director: Henry Wickes, P.E., Traffic Operations Division, (512) 506-5125, hwickes@dot.state.tx.us

TxDOT RTI Research Engineer: Wade Odell, P.E., (512) 465-7403, wodell@dot.state.tx.us

Research Supervisor: Montasir M. Abbas, Ph.D., P.E., Texas Transportation Institute, (979) 845-9907, m-abbas@tamu.edu

Researchers:

Nadeem Chaudhary, Ph.D., P.E., Texas Transportation Institute, (979) 845-9890, n-chaudhary@tamu.edu

Geza Pesti, Ph.D., Texas Transportation Institute, (979) 845-9878, g-pesti@tamu.edu

To obtain copies of reports, contact Nancy Pippin, Texas Transportation Institute, TTI Communications, at (979) 458-0481 or n-pippin@ttimail.tamu.edu. See our online catalog at <http://tti.tamu.edu>.

YOUR INVOLVEMENT IS WELCOME!

TTI.PSR0501.0605.580 PSR 0-4421-S

Disclaimer

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Federal Highway Administration (FHWA) or the Texas Department of Transportation (TxDOT). This report does not constitute a standard, specification, or regulation. Its contents are not intended for construction, bidding, or permit purposes. The use and names of specific products or manufacturers listed herein does not imply endorsement of those products or manufacturers. The engineer in charge of this project was Dr. Montasir M. Abbas, P.E. (#92989).

Texas Transportation Institute/TTI Communications
The Texas A&M University System
3135 TAMU
College Station, TX 77843-3135