MIDAS: Proactive Traffic Control System for Diamond Interchanges

Viswanath Potluri[1]

Pitu Mirchandani[1]

[1]Arizona State University, School of Computing, Informatics and Decision Systems Engineering

[2]Arizona State University, School of Sustainable Engineering, and the Built Environment

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What is **MIDAS** ?

Managing Interacting Demand And Supply

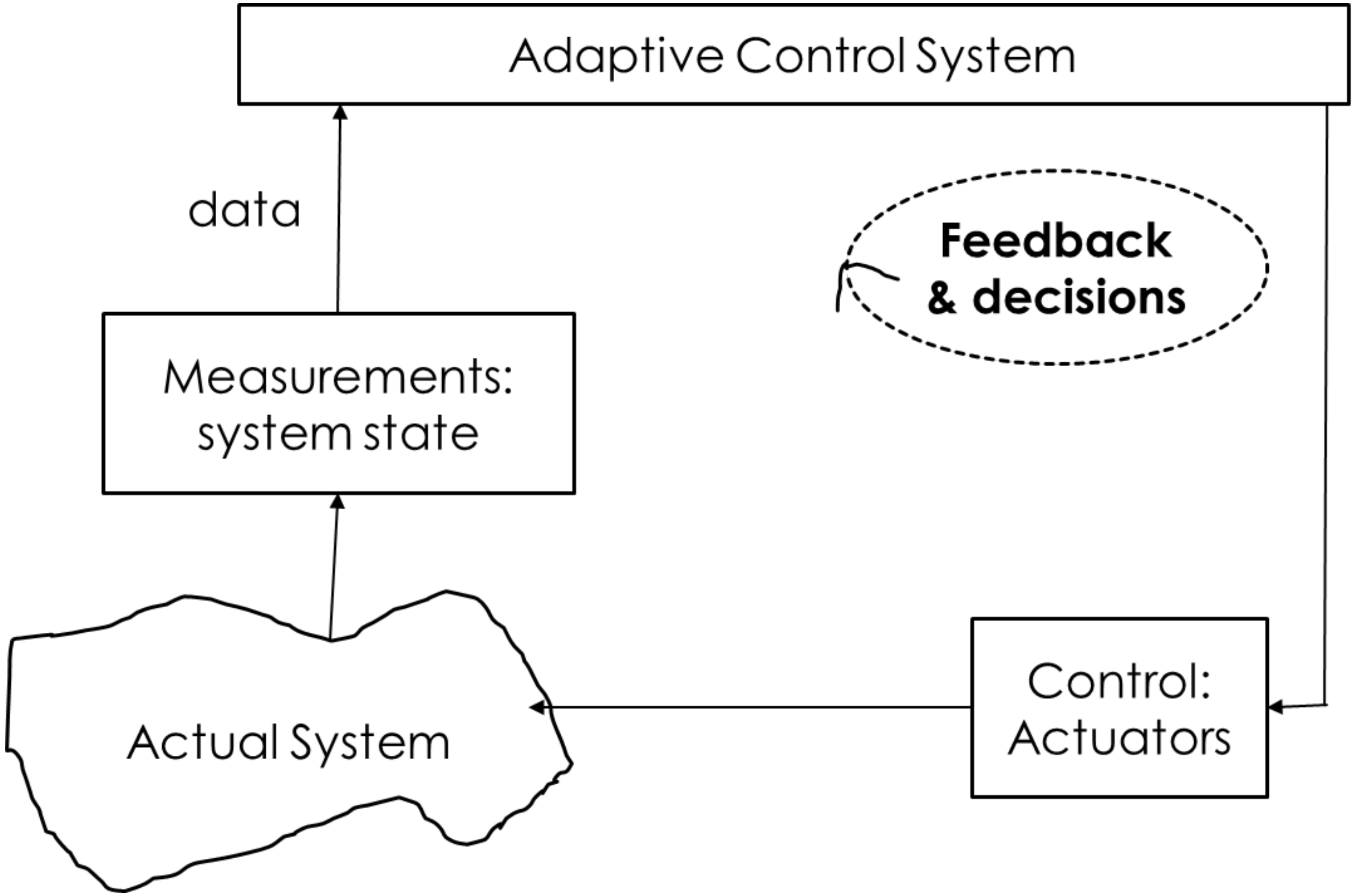
Demand

Supply

A Note on Control Systems

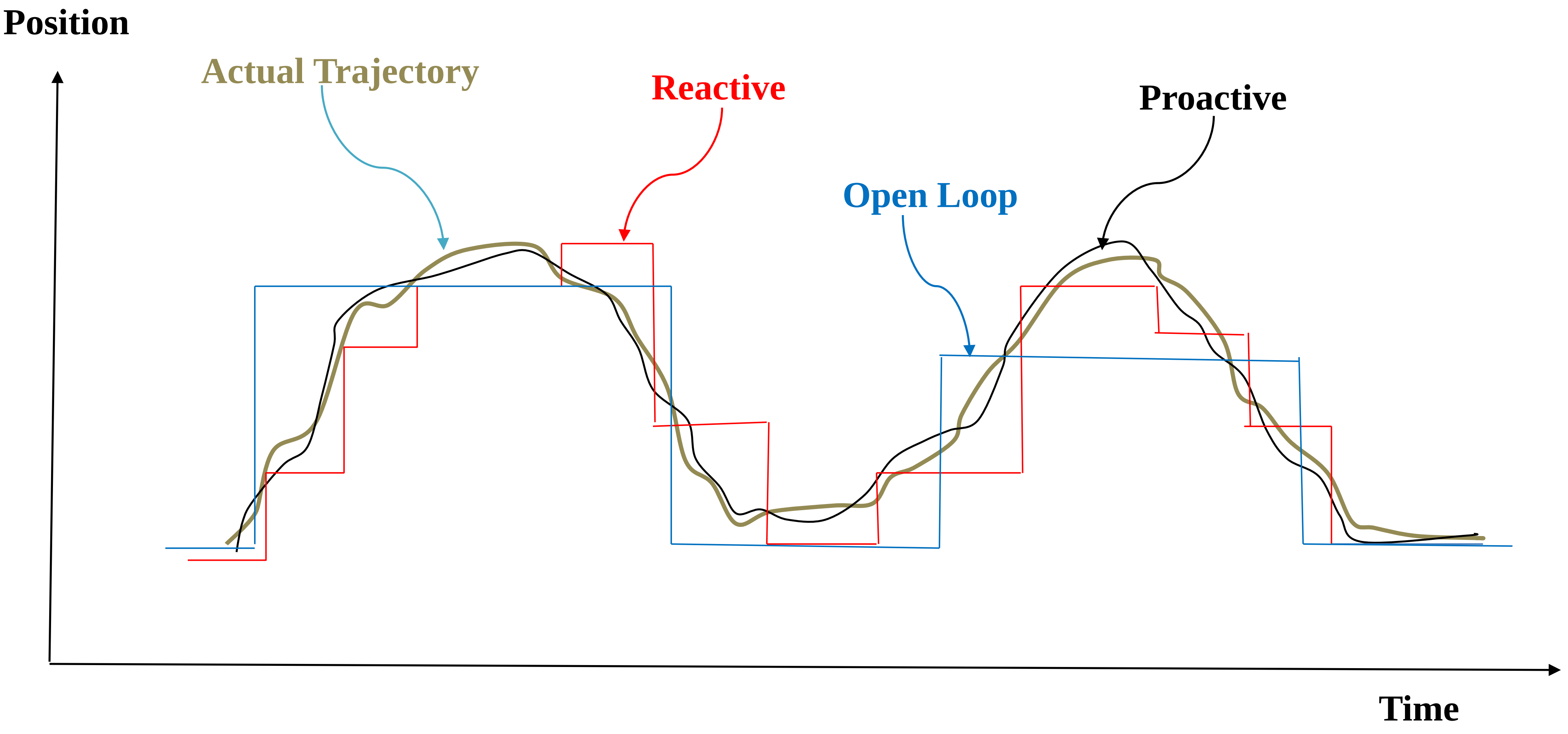
- Classification of control systems
  - Open Loop
  - Closed Loop (defined by feedback path)
- Open Loop
  - In open loop control systems, output is not fed-back to the input. So, the control action is independent of the desired output.
  - Fixed time signal control.
- Closed Loop
  - In closed loop control systems, output is fed back to the input. So, the control action is dependent on the desired output.
  - Actuated signal control & adaptive traffic control systems.

Adaptive Control System

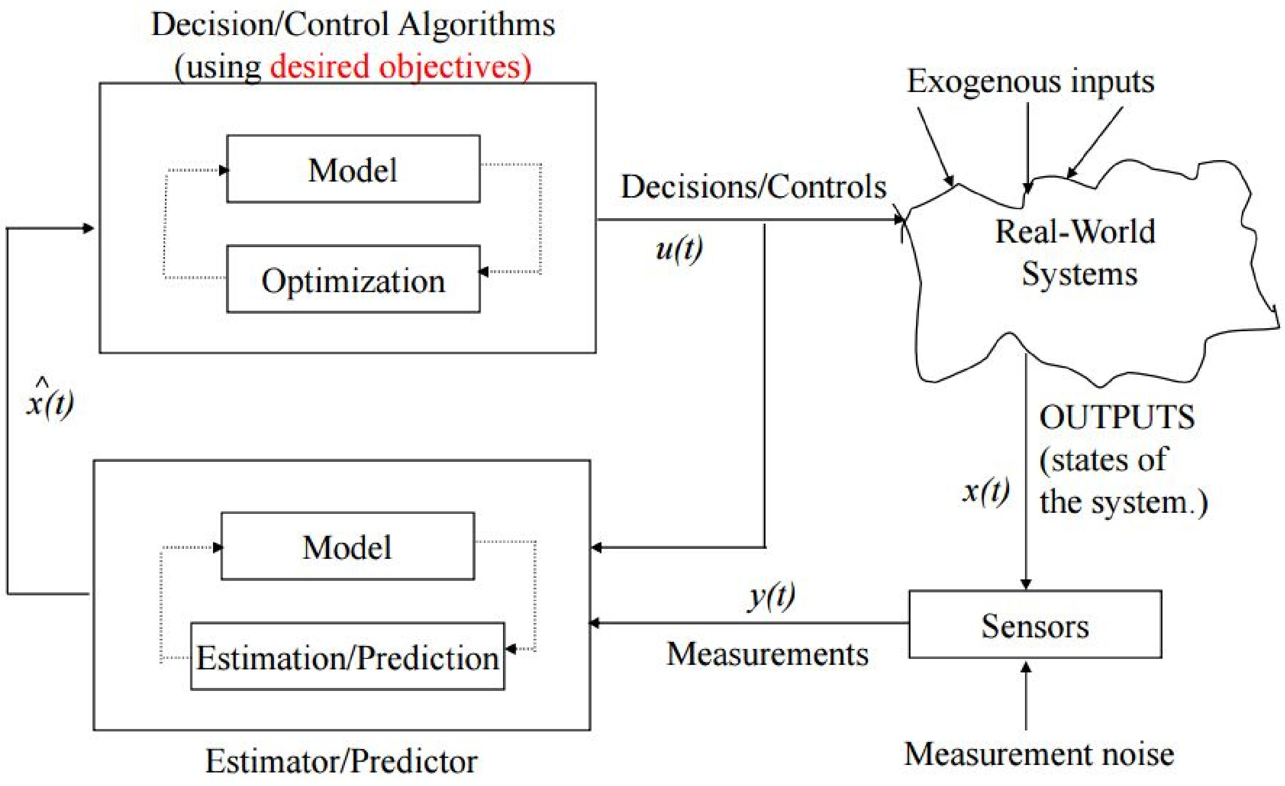


- Proactive
- Reactive

Open-loop vs Reactive vs Proactive



General Proactive Control Architecture



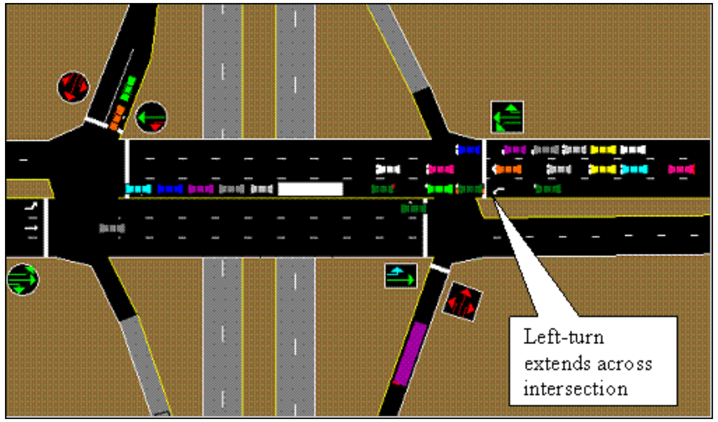
Measurements

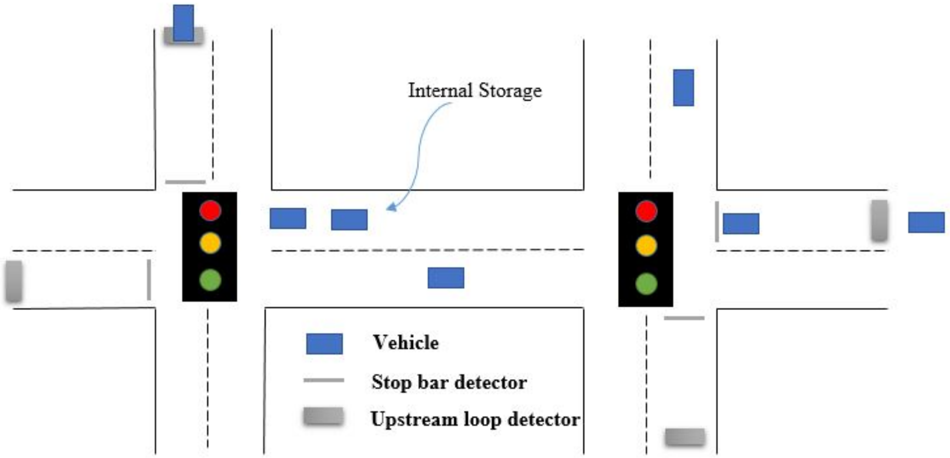
- Eulerian Measurements
  - Data collected at a fixed point in space, also called point detectors.
  - Inductive loop detectors, video detectors, etc.
  - They give traffic counts and approximate vehicle speeds.
- Lagrangian Measurements
  - Data collected from mobile detectors that move with flow of traffic.
  - Cell phones, GPS-based locator, etc.
  - They give travel times, vehicle trajectories, speeds, etc.

- MIDAS uses Lagrangian measurements.

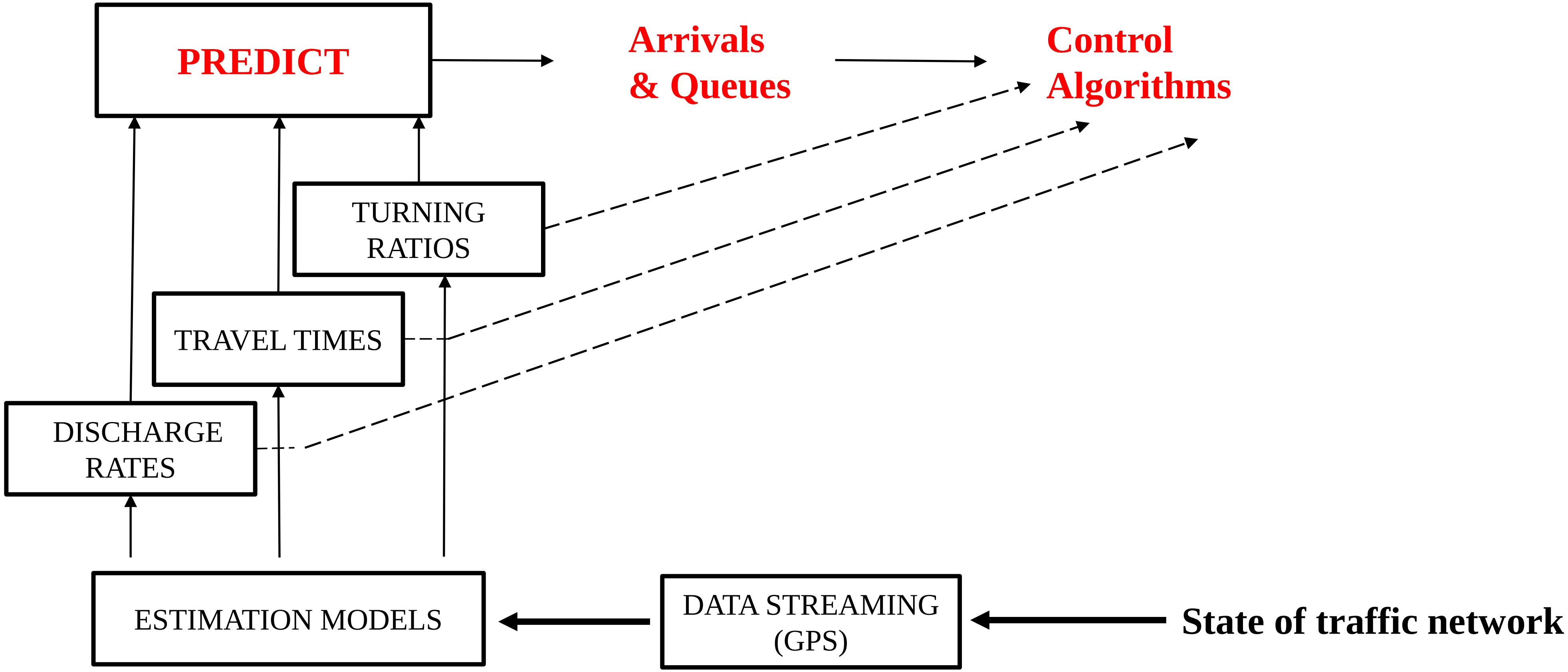
MIDAS for Diamond Interchanges

- Signal control of two closely spaced intersections at diamond interchange faces following challenges
  - ➢ Complicated traffic movements
  - ➢ Phase overlaps
  - ➢ Limited inter storage capacity for queued vehicles
  - ➢ Fluctuating demand and heavy off-ramp traffic





MIDAS Prediction & Control; Arterial

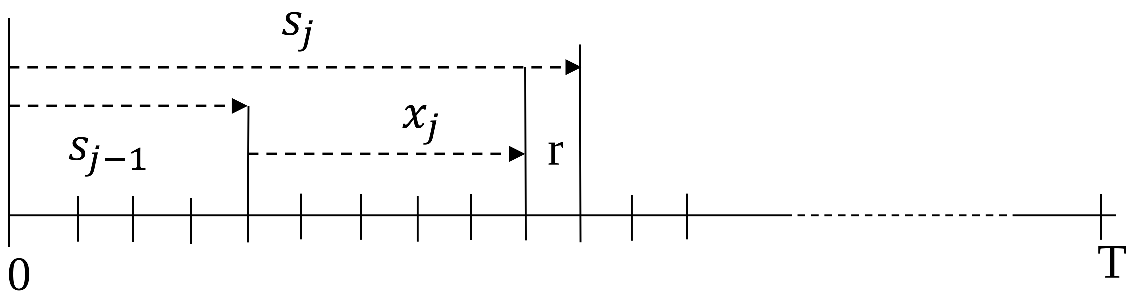


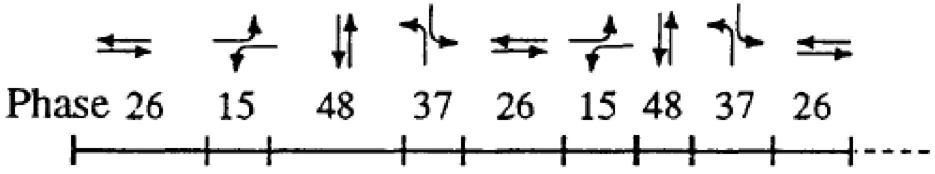
MIDAS Signal Control Algorithm

- MIDAS employs efficient Dynamic Programming(DP) approach to optimize traffic movements at the intersection, at a lane level resolution.
- Determines optimal phase sequence & duration of phases.
- Totally cycle free control strategy.
- Employs forward recursion DP approach to solve and backward recursion to retrieve optimal phase schedule.
- Flexible enough to optimize user defined performance measure, like stops, delays and queues, etc. over a finite time horizon that rolls forward.

MIDAS Signal Control Algorithm

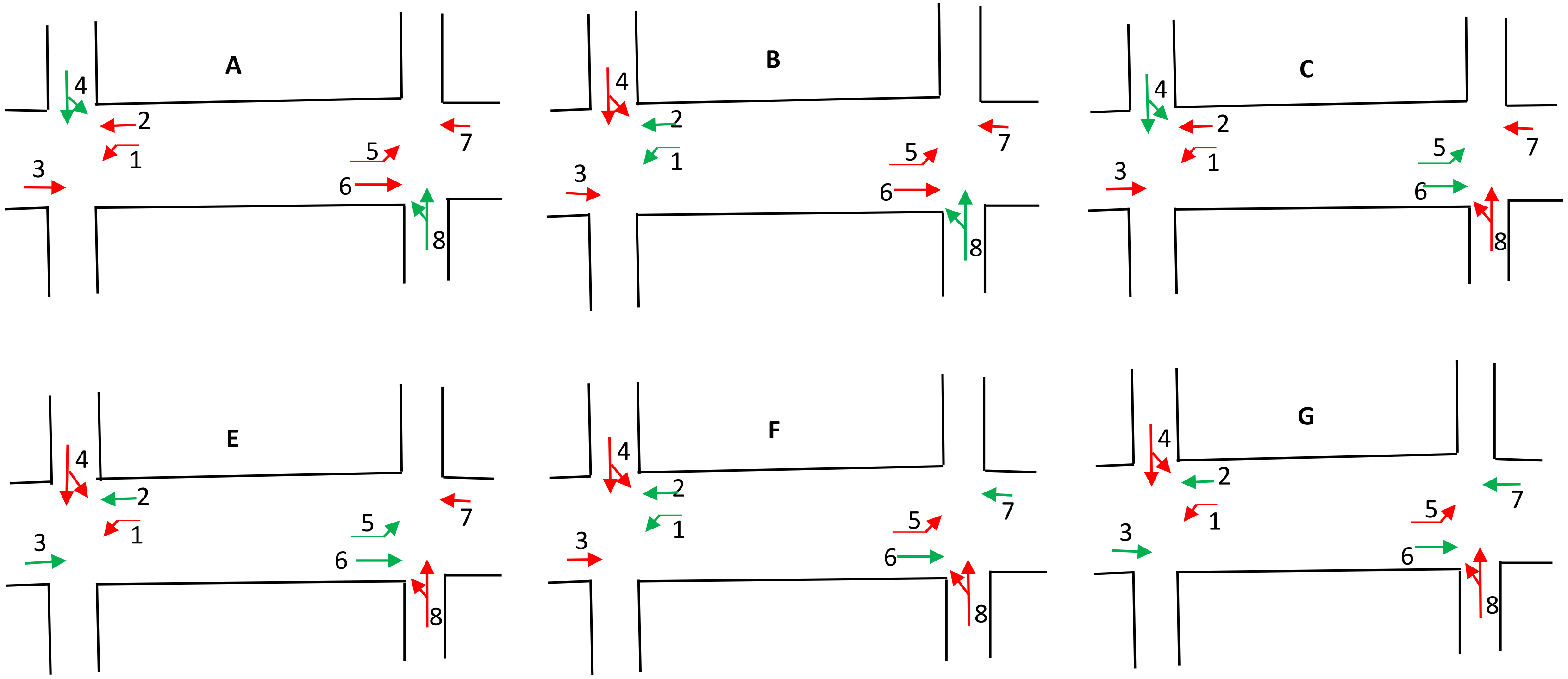
- Decision variable: x_j (Phase duration of stage j)
- Stage: Phase j
- State variable: s_j (time horizon with stage j)
- Incremental value of objective function: $f(s_j, x_j)$
- Cumulative value of objective function: $V_{j-1}(s_{j-1})$
- $V_j(s_j) = \min\{f(s_j, x_j) + V_{j-1}(s_{j-1}), \forall x_j \in X_j$



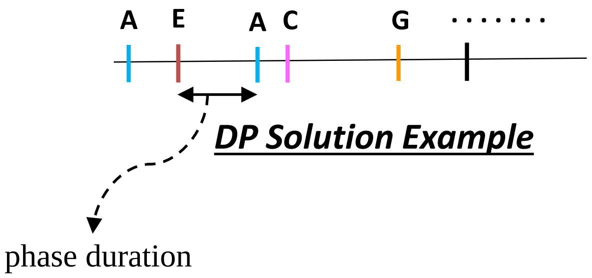


DP Solution

Diamond Interchange DP Solution Example



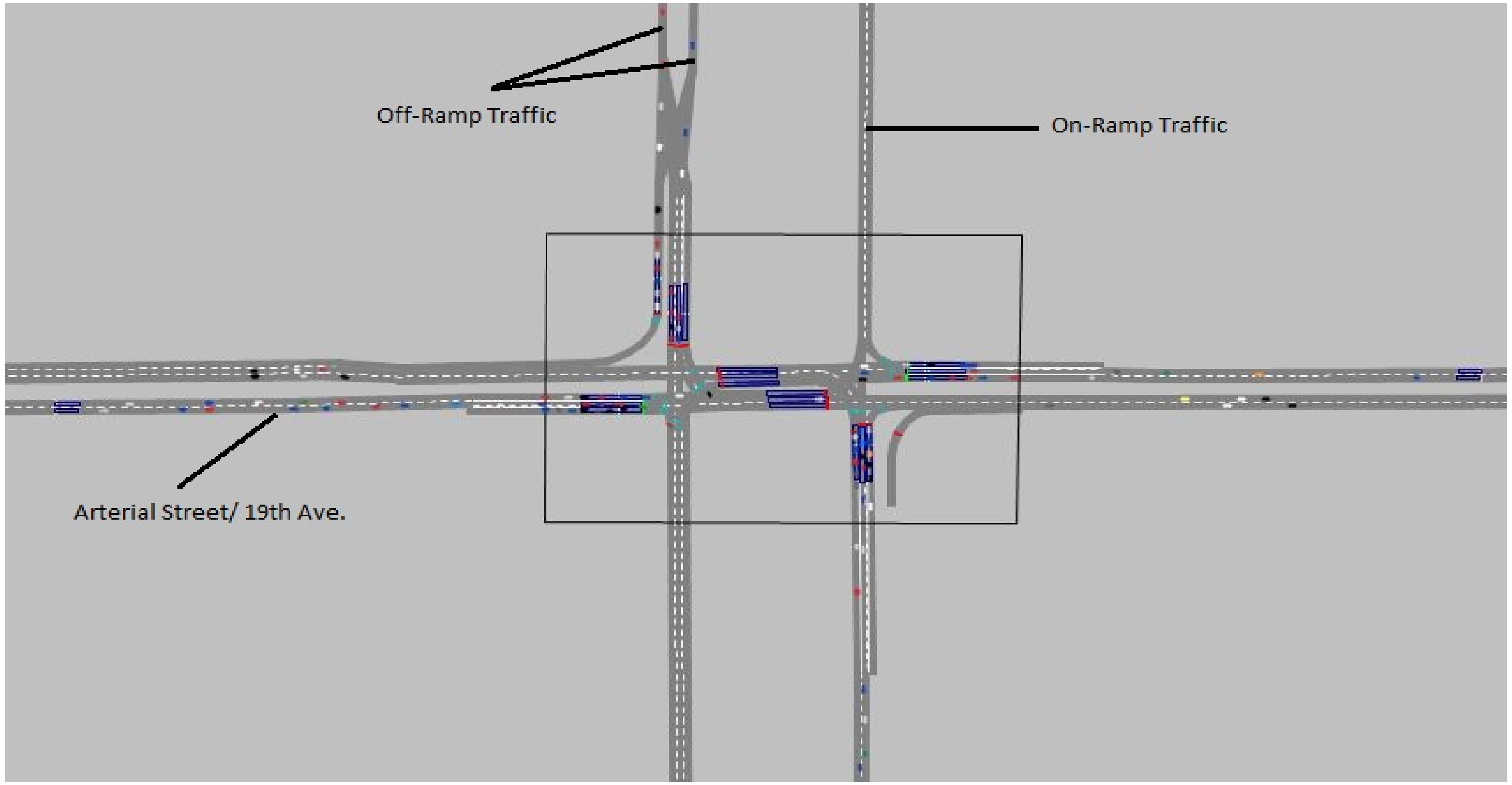
Possible Phase Combination



DP Solution Example

VISSIM Network Simulation

- I-17 & 19th Ave., Phoenix, AZ



Evaluation

- RHODES
  - A predecessor to MIDAS
- Optimal Fixed Time Control (OFTC)
  - VISSIM stage based optimization algorithm
  - Sequence of simulation runs performed to determine best signal program.
  - Signal program is constructed by modifying green times of best & worst stage.
  - The stage with the lowest maximum average delay is selected as the best stage.
  - The stage with the highest maximum average delay is selected as the worst stage.

Performance Metrics

- Delay Average
  - Average of all vehicle delays due to presence of signal controller in their path when compared to free flow, without any signal control.
- Total Delay
  - Sum of all vehicle delays in network, in seconds.
- Stops Average
  - Average number of stops made by a vehicle.
- Average Queue Length
  - Average queue length at any given movement at the stop line of the interchange.
- Total Travel Times
  - Sum of travel times of all vehicles in the network, in seconds.

Results

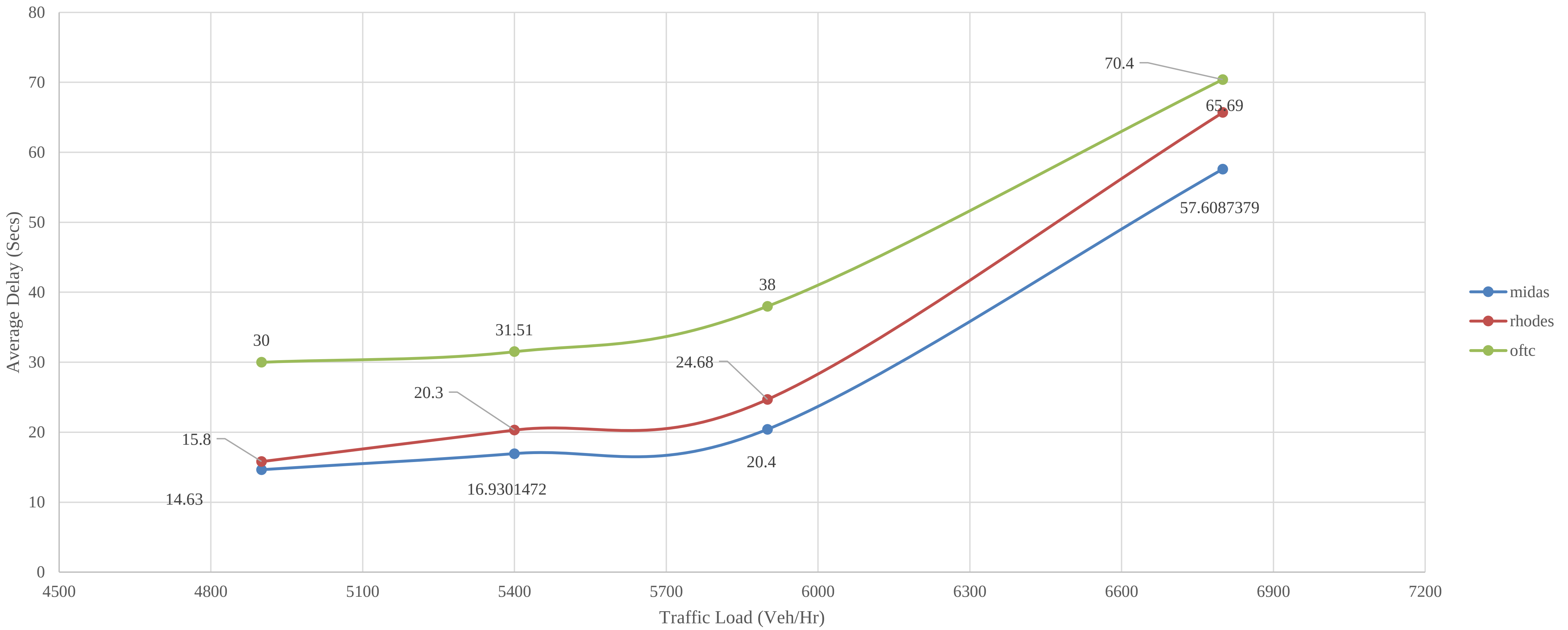
❑ *Network Level Performance*

SC	SimTime(s)	TraficLoad	DelayAvg(s)	TotalDelay(s)	TotalTravelTime(s)
MIDAS	3600	4900	13.25	66235.87	414791
RHODES	3600	4900	14.5	72472.17	421109
OFTC	3600	4900	32.05	160218.469	467528

❑ *Intersection Level Performance*

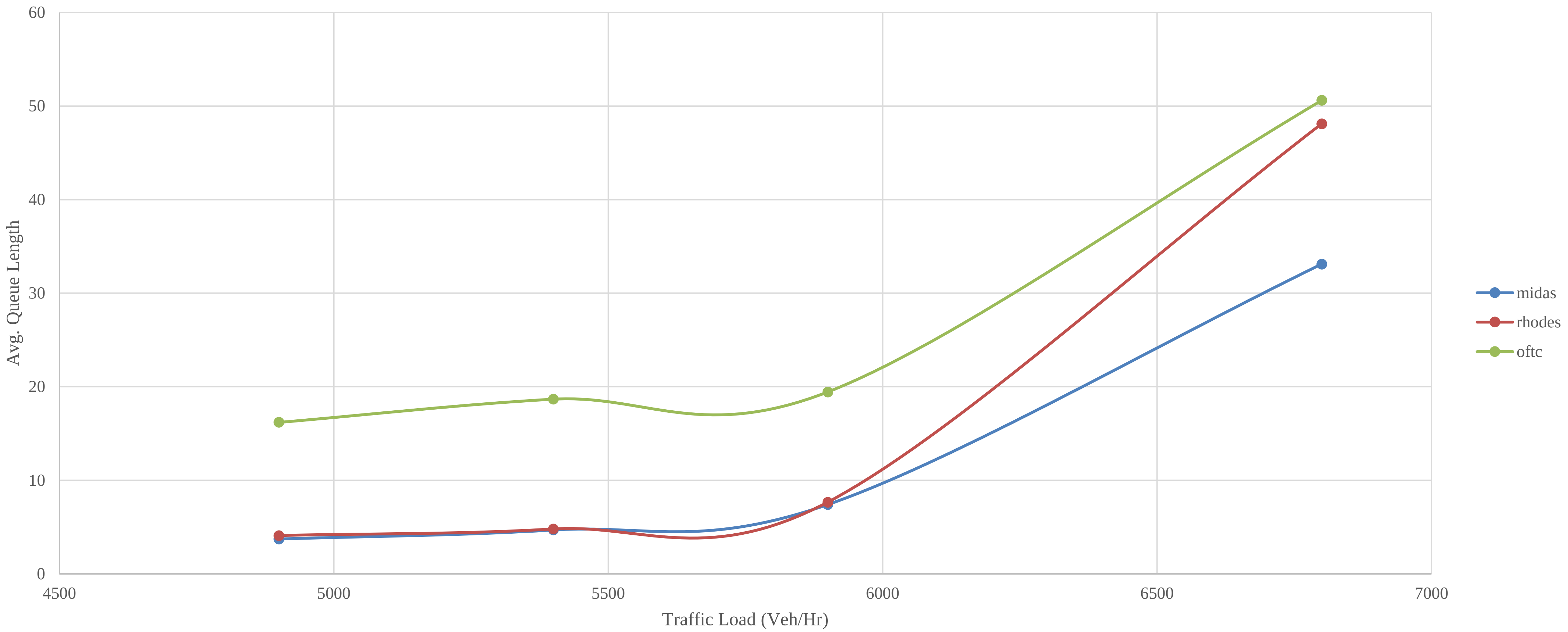
SC	SimTime(s)	TraficLoad	DelayAvg(s)	StopsAvg(s)	TotalStops(s)	AvgQLEN
MIDAS	3600	4900	11.5	0.68	3337	2.47
RHODES	3600	4900	12.9612188	0.807825565	3964	2.74718738
OFTC	3600	4900	25.74	1.01	5902	18.23

Average Delay vs Traffic Load



Average Stops vs Traffic Load

Average Queue Length vs Traffic Load



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Thank You