Optimized Policies for Adaptive Control (OPAC)

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TRB Signal Systems Committee
Adaptive Signal Control Workshop
January 9, 2000
Washington D.C.
Session 1 - Principal Theories

- Adaptive vs Fixed-Time
- Basic Philosophy of OPAC
- Control Variables
- Data Sampling
- Phasing Flexibility
- Measures of Effectiveness
- Oversaturated Conditions
- Preemption
- Network Type
Adaptive versus Fixed-Time

◆ UTCS-1GC:
  • pre-stored timing plans which are developed off line, using historical data
  • developed timing plans may not be responsive to dynamic and volatile traffic demands
  • most of the time these plans are outdated due to high cost of data collection and new plans development
Adaptive versus Fixed-Time

- Adaptive Systems:
  - real-time signal timing optimization in response to both short term and long term variations in traffic
  - eliminates cost of signal retiming
  - reduces maintenance and operations cost
  - requires more extensive deployment of traffic detectors
What is OPAC?

- A distributed real-time traffic signal control system
- Calculates signal timing to minimize a performance function of total intersection delay and stops
- OPAC is a self-calibrating, self-adjusting algorithm
What is OPAC?

- Once initialized and calibrated, there will be no need to future adjustments
- Provides optional cycle length and offset optimization
- Provides individual intersection control and network-wide coordination capability
OPAC Conceptual Design

Signal Timings

Traffic Network
- Detector data

Platoon Prediction
- Flow profiles
- Average speed
- Occupancy

Phase Flow Characterization

Field Signal State
- Elapsed time since last signal status changed
- Signal status

Intersection Optimization Logic
- Intersection Objective
- Operating Constraints

Network Synchronization
- Virtual cycle
- Cycle Constraints

Downstream Intersection Simulation
- Offset
- Flow profiles
- Parameter and state estimation:
  - Queue length
  - Stops
  - Delay

Principal Intersection Simulation
- Initial parameters
- Intersection geometry
- Discharge characteristics

OPAC
Flow Profiles & Queuing

Upstream detectors can provide an actual history for a short portion of the profile.
Developing Flow Profiles

- Upstream detectors can provide an actual history for a short portion of the profile
- Smoothed volume can be used for uniform profiles
- Platoon identification and smoothing can be used for cyclic profiles
Cycle Optimization: Virtual Fixed Cycle (VFC)

- Real time identification of “critical” intersections for cycle length optimization
- The yield point or local cycle reference point is allowed to range about the fixed yield points
- Allows the synchronization phases to terminate early or stay later
Cycle Optimization: Virtual Fixed Cycle (VFC)

- Meets phase switching timing determined by local conditions, while maintaining a capability for coordination with adjacent intersections.
- Using a cycle length constraint, the cycle length can start or terminate only within a prescribed range.
Control Variables

- OPAC optimizes a weighted performance function of total intersection delay and/or stops subject to min/max green times
- Under coordination, signal timings are also constrained by the current cycle length
- Current Counts, Occupancy, and Speed (measured or calculated)
- Real-time estimates of phase specific parameters: queue length, speed, travel time
Data Sampling

- Develops a flow profile for each phase using a user-specified time interval
- Head of the profile is actual counts from the recent past
- The tail of the profile is projected for the future using smoothed volume
- Smoothed data: volume, occupancy, speed, platoon headways, flow profiles, and phase duration
Phasing Flexibility

- Optimization of up to eight phases in a dual ring configuration
- Supporting all combinations of left turn lead/lag phasing
- Phase skipping in the absence of demand
- Phasing sequence based on time of day
- Monitoring PED crossing to provide the needed min green
Measures of Effectiveness

- Volume, occupancy, speed by detector and phase
- Estimated measure of queue, delay, and stops by phase
Oversaturated Conditions

- Isolated intersection mode:
  - Provides maximum green to the affected phase(s) if occupancy exceeds a user-specified threshold

- Coordinated mode:
  - Provides maximum green to congested phases, subject to the current cycle length
  - Adjusts cycle lengths in response to increasing congestion
Preemption

- Preemption will always take priority over OPAC
- Prioritizes transit and emergency vehicles if they are restricted to particular lanes
- Recovers from a preemption immediately
Network Type

- Coordinated OPAC originally designed for networks
- Current installations include arterial streets. Examples:
  - New Jersey Route 18
  - Reston Parkway
Session 2 - Equipment Requirements

- System Architecture
- Data Requirements
- Communication Requirements
- Local Controllers
- Central Hardware Requirements
- Installation Cost
- Operation & Maintenance Cost
System Architecture

- Isolated intersection control - fully distributed
- Coordinated system control - distributed except for the following tasks:
  - cycle length determination is made at central
  - peer-to-peer information could be communicated through central if adjacent intersection controllers are not linked physically
Data Requirements

- Ideal detector location is about 10 seconds upstream of stop line or upstream of the worst queue on each lane of all through phases
- One count detector on each lane of left turn pockets as far upstream as possible
- Volume, occupancy, and speed measured in the field
- The system will work with loops, radar, and video detectors
Typical Detector Layout

- 6'x6' loops
- Stop bar loops
Communication Requirements

- Communications with Central: OPAC status is polled
- Communications with Signal Control Software: every second
- Peer-to-peer communications
Communication Requirements

- OPAC will run autonomous if the communications between the central and local is failed.
- The system can function without central system and by getting detector data.
Local Controllers

◆ Types of Controllers:
  • 2070 or 170 controllers with 68360 processor
  • NEMA controllers

◆ VME or Pentium processor to run OPAC
Central Hardware Requirements

- 2 to 3 standard PCs for Operator Interface, Server, Data base, Device Drivers and Communications
- Controls up to 220 intersections with no additional hardware upgrade
- Windows NT platform
Installation Cost

- Central Hardware: $20k to $50k
- Central Software: $100k to $200k depending on type of the local controller and firmware
- Local Controllers: cost of controller + adaptive processor. Examples:
  - 2070 controller + 68060 board: approx. $6,000
  - NEMA controller + Pentium board: approx. $4,000
Installation Cost

- Communications: dependent on type of the communication systems:
  - phone line (leased or owned)
  - fiber optics
  - wireless
- Detectorization: dependent on detection technology, communication system, and intersection geometry
Operations & Maintenance Cost

- Central System:
  - Hardware: No additional O&M over normal PC costs for OPAC
  - Software: up to 10% of software cost

- Local Controllers: No additional cost over normal O&M cost for controllers

- Communications: cost of a dedicated line between intersection controllers and central

- Detectors: dependent on detection technology