Adaptive Traffic Signals
Overview
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What is “adaptive” anyway?

► Signal timing is adapted to the measured traffic in real time

► Traffic is measured and/or predicted, calculations are made and timing is implemented

► “Adaptive” systems do not pick the best stored plan to match the measured traffic – that is “Traffic Responsive” (TRPS)
Why Bother with Adaptive Control?

- Pre-stored plans accommodate variations in traffic, therefore never optimal
- Time of day selection also sub-optimal
- Pre-stored plans age quickly
- TRPS difficult to optimize, most successful on arterials, often abandoned
- 1.5 Generation updates plans but suffers from shortcomings of TRPS
Performance of fixed time plans deteriorates
Performance of adaptive systems more stable

Adaptive

Performance Level

Fixed timing plan

Effectiveness of Fixed Timing Plans

Time in YEARS
CAN ADAPTIVE SYSTEMS REALLY IMPROVE TRAFFIC OPERATIONS?
Gresham PM Peak TT
(Eastbound Burnside)
Adaptive Systems Respond to Significant Changes in Demand
HOW DO THEY WORK?
Types of algorithms

- **Sequence based**
  - Use a cycle length, like most coordinated signal systems
  - Have a pre-defined sequence of phases (some with flexibility)

- **Non sequence based**
  - Do not use a cycle length
  - Do not use a pre-defined sequence of phases
Types of systems

- Complete, stand-alone, with full management system capabilities
- Module within proprietary signal management system
- External to proprietary signal management system
Examples of current systems

- Complete, stand-alone
  - SCATS, SCOOT, LA ATCS

- Modules for proprietary system
  - Synchro Green (TrafficWare/Naztec), Centracs Adaptive, McCain QuicTrac, Intelight, OPAC (MIST)

- External
  - ACS-Lite, InSync, Rhodes
Various architectures

- **Centralized**
  - All strategic and tactical decisions at central
- **Distributed**
  - Strategic at central, tactical at local
- **Peer-to-peer**
  - No central supervisor
How do they work?

- Implement one or more operational strategy (See FHWA guidebook)
  - Pipeline to **maximize throughput** (appropriate with oversaturation)
  - Pipeline to **provide smooth flow** (appropriate with undersaturation)
  - **Equitably distribute green times** (appropriate with many turning movements)
  - **Manage queues**
Fixed or variable objective function?
A FEW EXAMPLES...
InSync

**Theory**
- Seeks to minimize a weighted delay objective function at one critical intersection
- Picks next phase (state) that will minimize short term delay function
- Inserts non-coordinated phases at other intersections outside platoon bands (tunnels)

**Practical limitations**
- Maximum wait times, overlapping tunnels, driver expectations
- Effectively runs fixed cycles at critical intersection
- Best with short sections of arterial
InSync “time tunnels”
Success depends on spacing & speed
ACS-Lite

- **Theory**
  - Start with a standard TOD pattern
  - Modify offsets based on detection of arrivals during green
  - Modify phase splits (based on maxouts?)
  - Modify TOD schedule

- **Practical limitations**
  - Cannot adjust cycle length
  - Cannot accommodate traffic markedly different from pattern basis
ACS-Lite architecture

- Monitor performance
- Update Geometry
- Update traffic flow parameters
- Update algorithms

Detector Data
Status Data
Configuration Data
Signal Timing Data

Central System Software (if any)

Proprietary Master to Local

Proprietary

NTCIP
ACS-Lite to Master

NTCIP
ACS-Lite Manager
To field processor

Field Master

Local Controllers
Synchro Green

- Calculation engine like Synchro
- Like Gen 1.5, traffic responsive with regular recalculation of background pattern
QuicTrac

- Estimate platoon speed with system detectors and calculate offsets at master
- Calculate cycle length at master based on local volumes
- Calculate splits at local
SCOOT

- Calculation engine similar to TRANSYT/7F
- Based on signal timing theory
- Measures volumes entering a link
- Calculates cycle length, splits and offsets
- Makes regular small steps to follow changing traffic patterns
- Coordinated groups fixed. Usually some VA
SCOOT platoon arrivals
SCOOT cycle by cycle changes
SCATS

- Measures degree of saturation at stop line to calculate cycle length and splits
- Measures volumes entering links to select best direction of offset
- Practical implementation of how traffic engineers set up coordination patterns
- Determines which intersections need coordination – flexible grouping
- Selects appropriate objective function based on V/C regime
Sunnyvale: Extension of SCATS
Sunnyvale SCATS
LA ATCS

- Over 3500 intersections under control
- System being expanded
- Apparently operates well, but not really as adaptive as it sounds
- Not well documented
- Better supported in last few years
Other systems

- Intelight adaptive (new)
- Surtrac (experimental – Carnegie Mellon)
- OPAC
- Rhodes
- SPOT
What is good? What is not?

- **SCOOT** – well proven in many countries, variable in USA
- **SCATS** – well proven in many countries, generally good in USA
- **InSync** – rapidly growing, variable results
- **Synchro Green** – steadily growing, satisfactory
- **ACS-Lite** – slow progress, several vendors
- **Centracs Adaptive** – integrated and improved ACS-Lite
- **QuicTrac** – several successful deployments
- **RHODES** – development continues, practical results patchy
- **OPAC** – variable results, not growing
- **LA ATCS** – apparently good, little published data, expanding beyond City of LA.
Is an adaptive system right for you

- Do you have a corridor or closed network?
- Does demand exceed the theoretical and practical capacity of your corridor?
Should I consider adaptive control?

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
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<tbody>
<tr>
<td>I manage a large city, with over 1000 traffic signals, I'm considering adaptive signal control for some intersections, but how do I determine the right place for adaptive?</td>
<td>I need to improve my network to comply with new air quality standards. Is it time to consider adaptive control?</td>
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<td>I'm a technologist and want to use the latest and greatest. I just heard about adaptive control and it sounds great; I want one! What do I do next to get it?</td>
<td>I have been working with my consultant/vendor for many years and they have been telling me about new adaptive traffic control systems that I should consider. What locations would be the best fit for an adaptive control system?</td>
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<td>I have a very old traffic control system and with my recent grant I think I can afford a new system. Is it time to consider adaptive control?</td>
<td>I am getting calls on a couple of my intersections and I cannot solve the cycle/phase issues. Will adaptive control help?</td>
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<td>I have tried time of day coordination and even traffic responsive plan selection, but I feel there could be something better. Could adaptive control be a better solution?</td>
<td>I have a corridor on which I run time of day coordination, but occasionally diverting traffic overwhelms the corridor. Could adaptive control provide a better solution?</td>
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<td>The planners are telling me that in the next ten years there will be 50% growth along the main corridor in the city. The current traffic signal system will not handle the traffic based on the current capacity. Is it time to consider an adaptive control?</td>
<td></td>
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What do the opponents say?

- I know exactly what will happen on my street on Monday morning.
- The transitions cause too much disruption and are counter productive
- The detection costs too much and is not reliable
- The communication costs too much or is unreliable
- I don’t believe the claims
- I have too much investment in my current system
How should I get an adaptive system?

- If any Federal funds involved, must provide a systems engineering analysis, commensurate with the scale of the project.
- Selection must be competitive, but recommend AGAINST low-bid process.
- You are buying technology, with every product different, not buying pavement complying with a physical specification.
Procurement options

Best Value
- Requirements
- RFP
- Proposal
- Selection
- Implementation
- Acceptance

Low Bid with SE Support
- Requirements
- PS&E
- Bids
- Selection
- Submittal
- Construction
- Acceptance

“Consumer Reports”
- Market Research
- PS&E
- Bids
- Selection
- Submittal
- Construction
- Acceptance

DKS
Would you do it again?

Source: Adaptive Traffic Control Systems in the United States, Matt Sellinger, HDR Engineering, Inc.