SCOOT - Split, Cycle & Offset Optimization Technique

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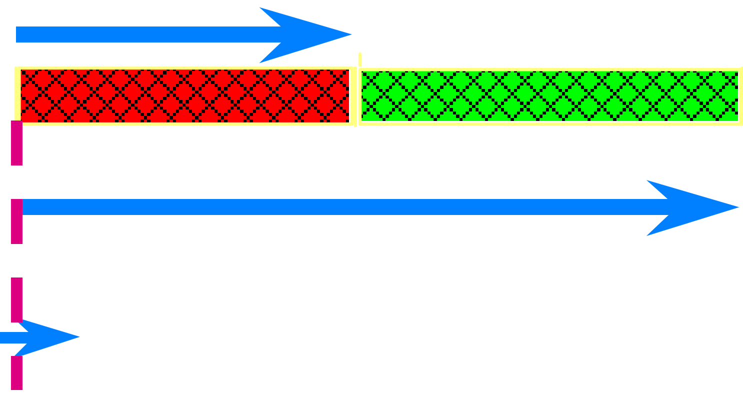
SCOOT Version 3.1

The most effective traffic adaptive control system in the world today.

SCOOT stands for:-



S PLIT

C YCLE

O FFSET

O PTIMIZATION — ***Method***
STOPS & DELAYS

T ECHNIQUE — **FREQUENT, SMALL ALTERATIONS TO:**
- **SPLITS**
- **OFFSETS**
- **CYCLE TIME**

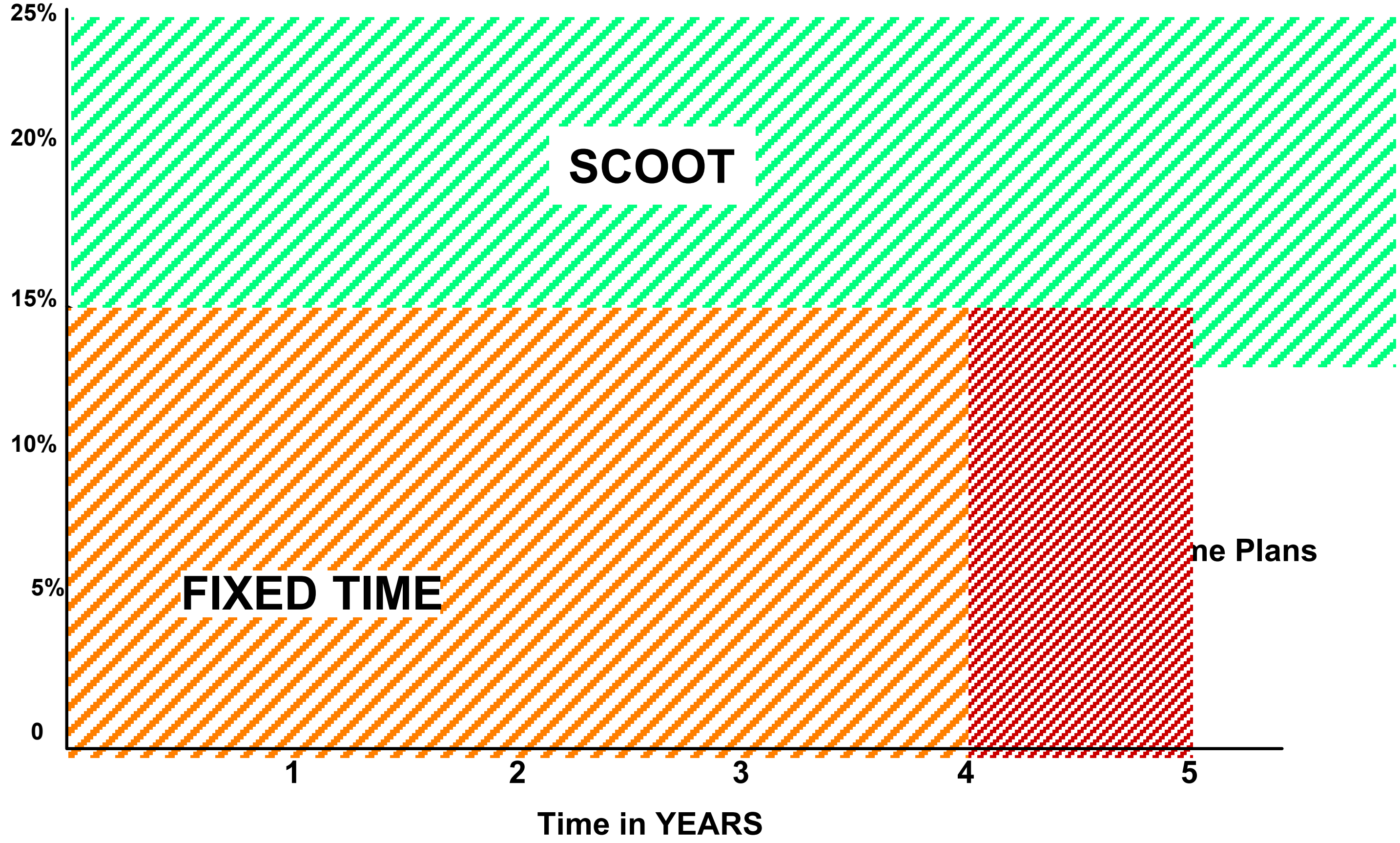
Presentation Contents - SCOOT

- System Architecture
- Data requirements
- Communication Requirements
- Control Variables
- Data Sampling, Filtering and Smoothing
- Phasing flexibility
- Measures of Effectiveness
- Transit and Fire Priority
- Special Features for Oversaturated Conditions
- Additional Features

SCOOT TERMINOLOGY

- Area
- Region
- Node
- Stage
- Link
- Detector

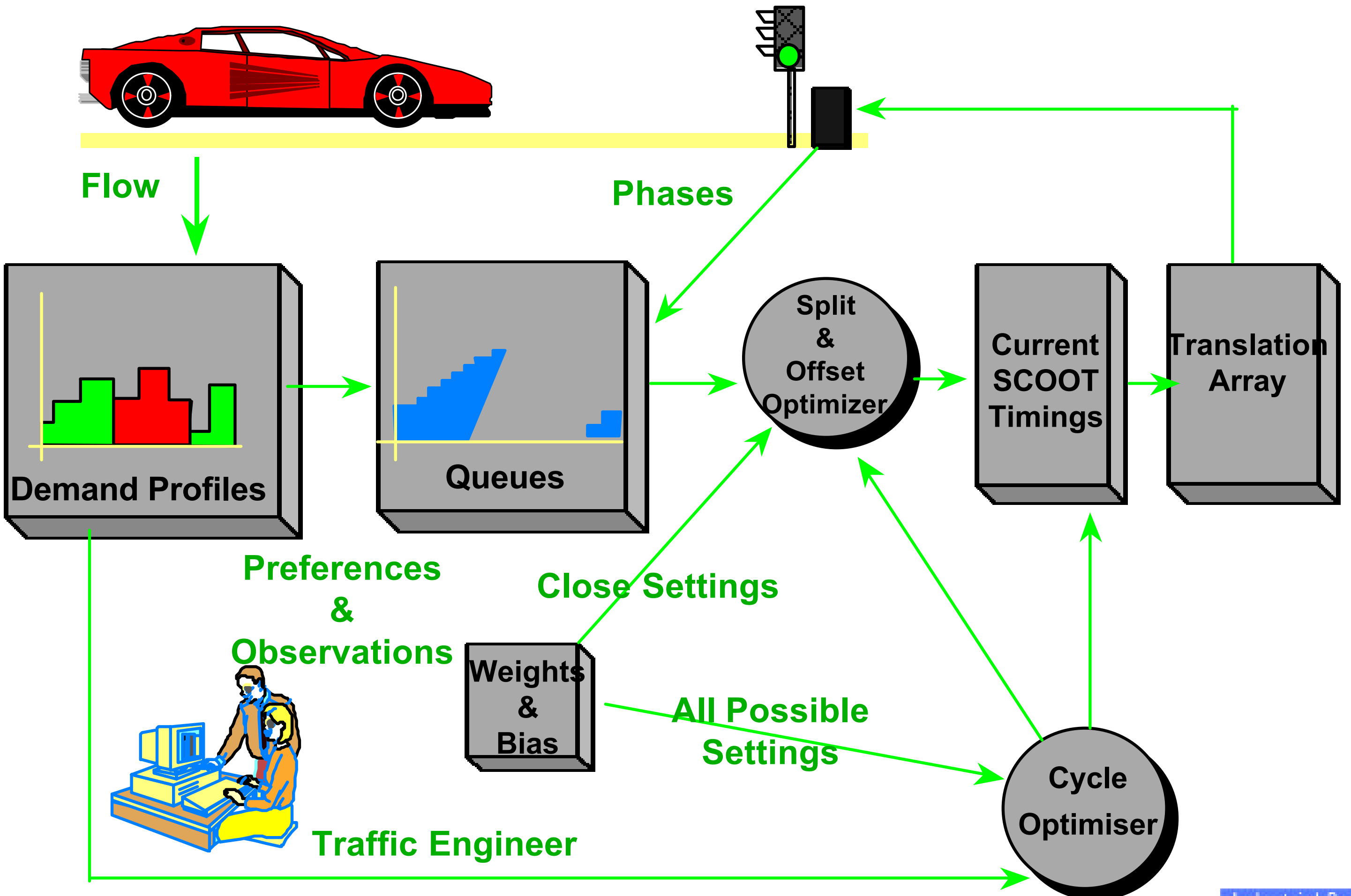
The performance of SCOOT over time



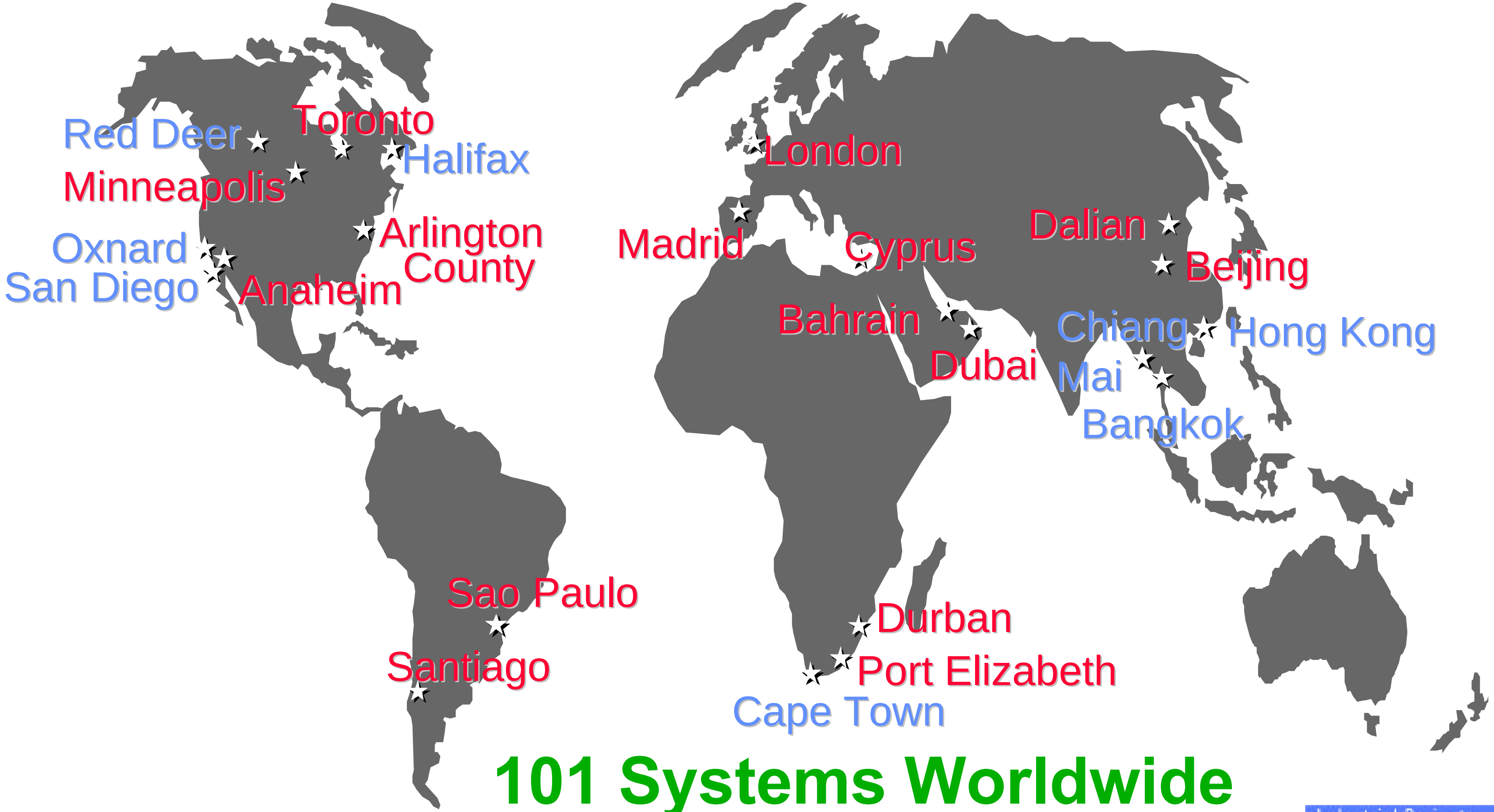
System Architecture

- Second by second system, with timing algorithms in central processor
- Local controller deals with clearance and minimums
- Local vehicle actuation determined by traffic engineering priorities
- Heirarchical transmission system with flexibility to suit local traffic control needs

SCOOT - Schematic Overview



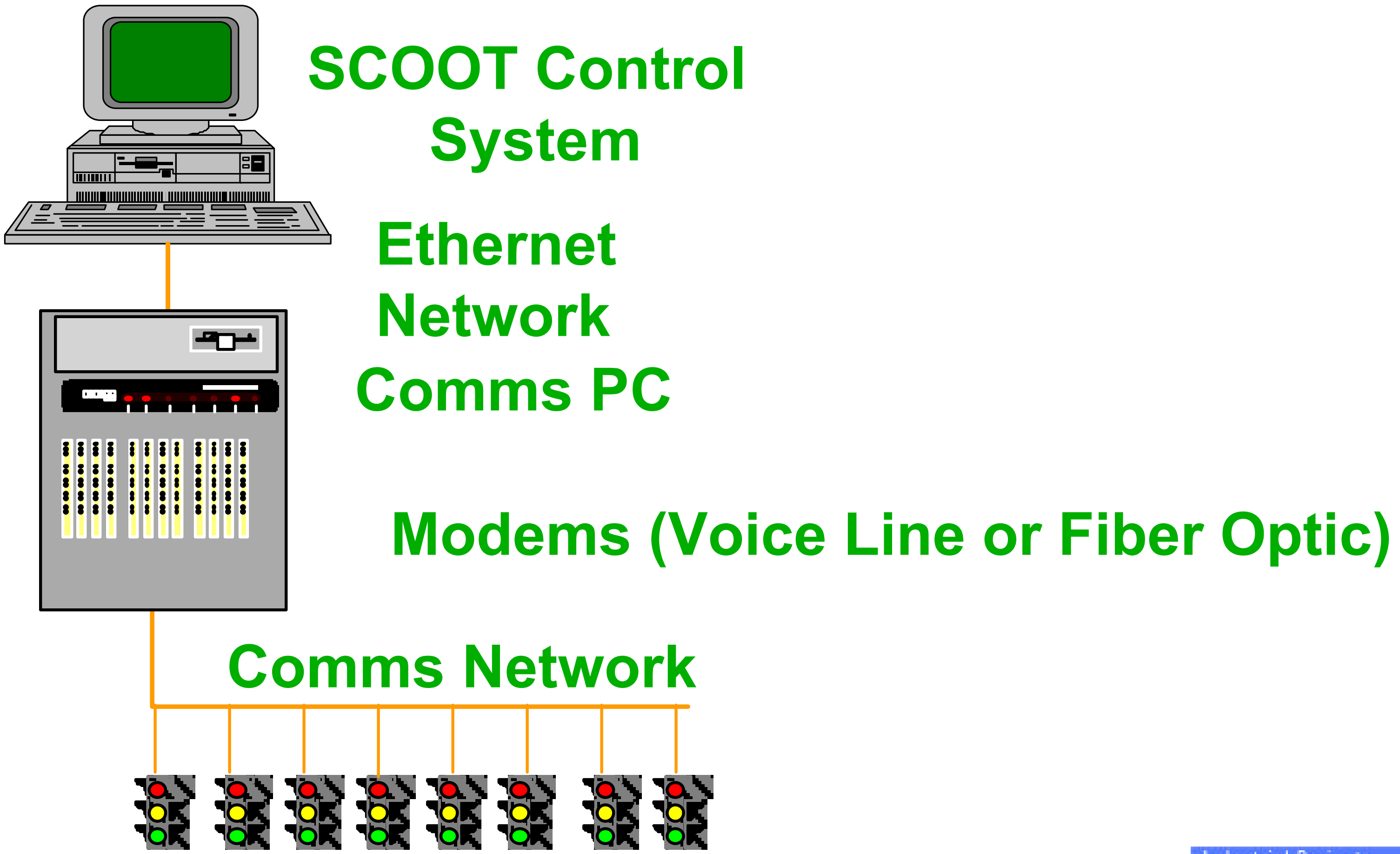
SCOOT Systems around the World



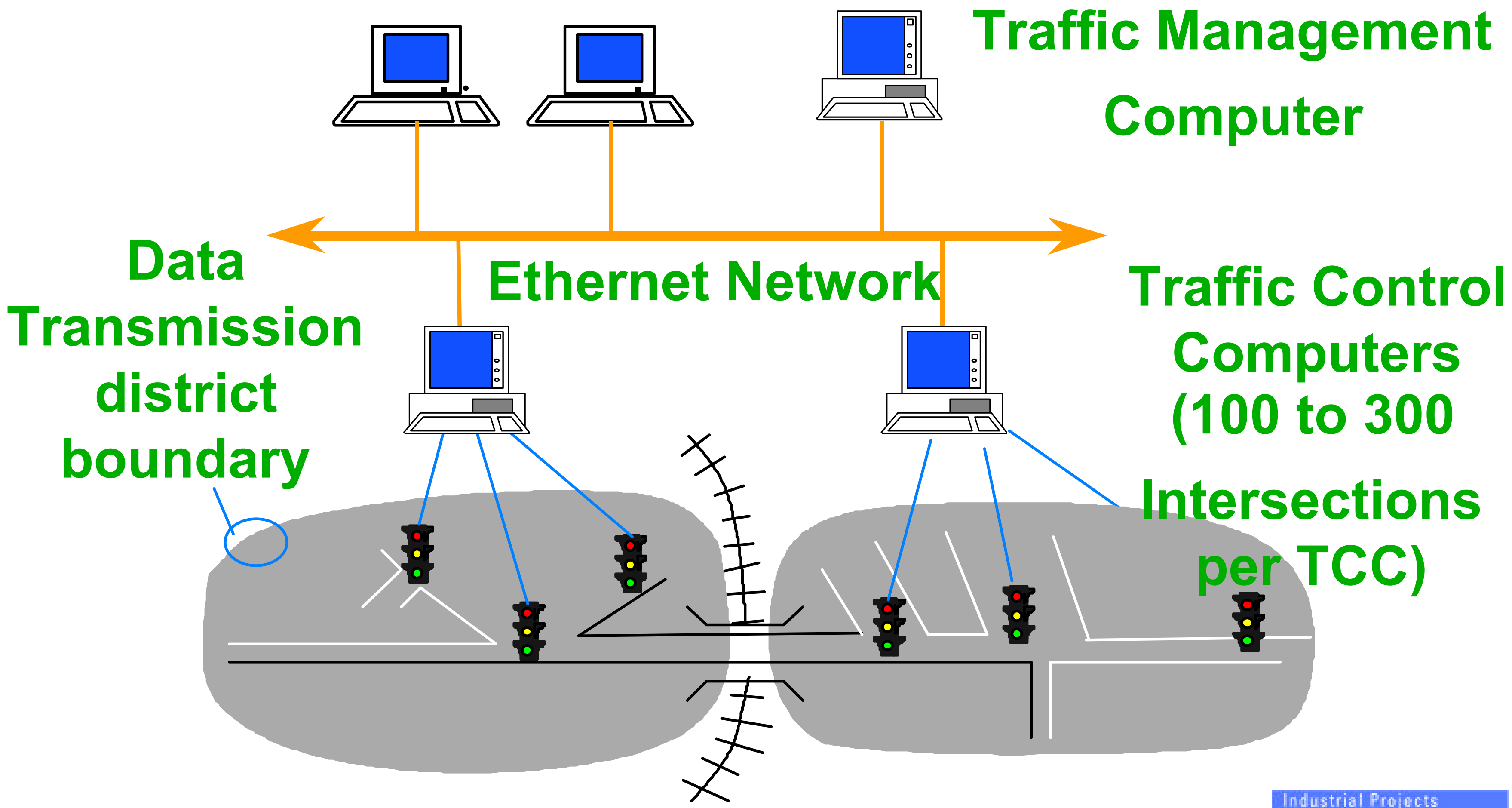
SCOOT - Where will it work?

- SCOOT works on both Arterial Streets and Grid Networks
  - Arterial streets - examples
    - » Toronto - Lake Shore Boulevard
    - » London - Cromwell Road
    - » Oxnard, Ca
    - » Sao Paulo - Rio Branco
  - Networks - examples
    - » Toronto - CBD
    - » Dubai
    - » London - West End
    - » Madrid - Central area
- SCOOT works on networks from <10 intersections to >1000
  - Cambridge (UK) - 9 nodes initially
  - Sao Paulo (Brazil) >1000 nodes

Data Transmission Network



Central Office Network



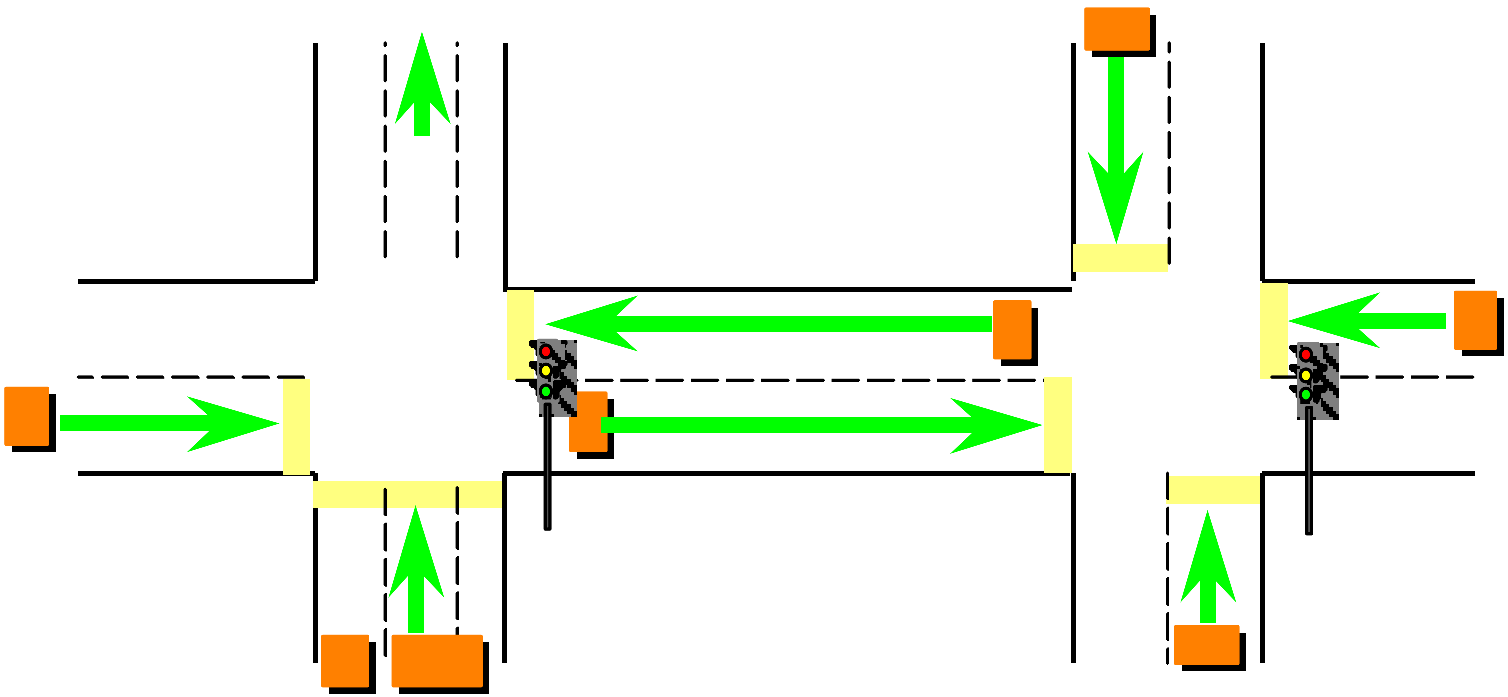
SCOOT - Hardware requirements

- Central Computer
  - DEC Alpha workstation(s), running OpenVMS
- Operator workstations
  - Dedicated network possible
  - Interface to existing network / workstations possible
- Data transmission
  - Copper cable, fiber optic, or combinations
- On-street equipment
  - No need to replace existing on-street hardware!
  - Implementation of SCOOT can be achieved by:-
    - » Controller firmare upgrade, or
    - » Addition of dedicated comm unit

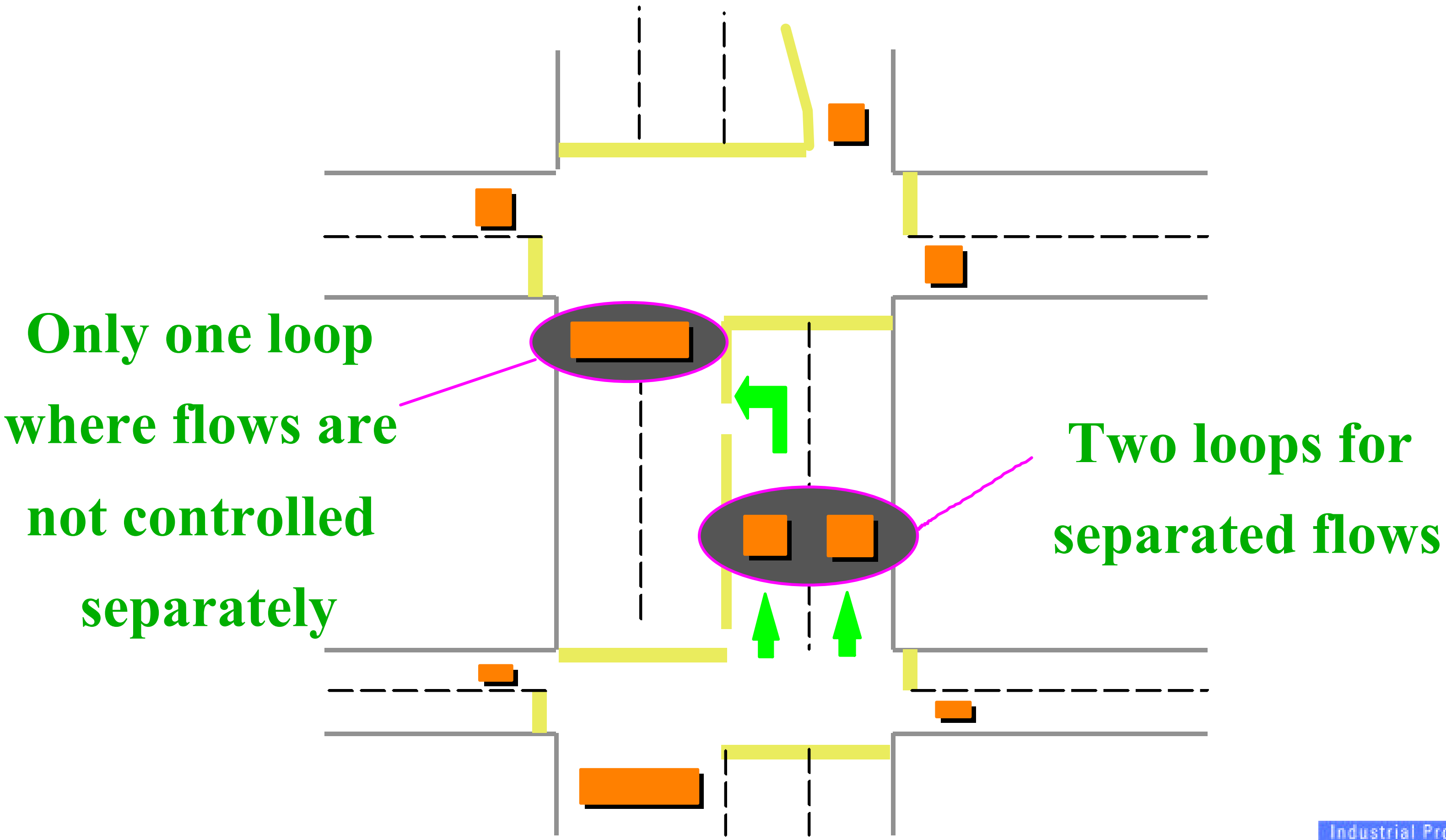
Data Requirements

- Detection on every link for which full optimization required
- Detectors generally located at upstream end of link
- Connection to central computer achieved via upstream intersection
- Links with no detection run fixed length or can have data derived from upstream links
  - Fixed length phases can be varied by time of day

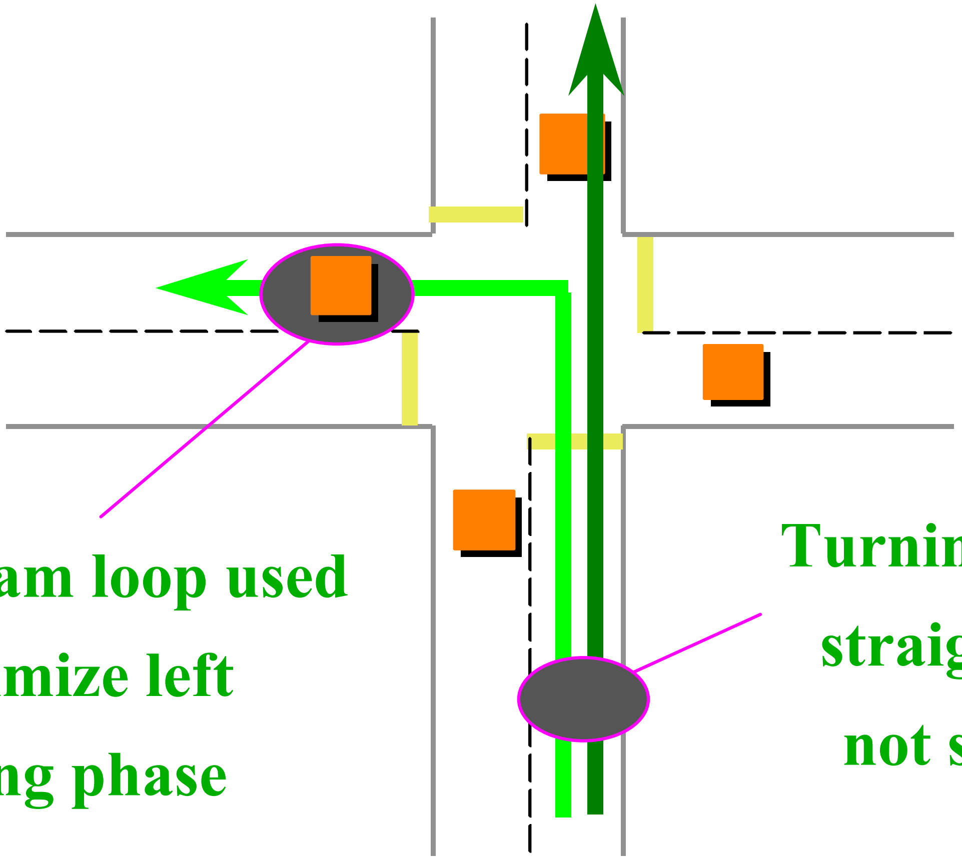
Positioning SCOOT detector loops



Upstream loop for turning movement



Downstream loop for turning movement



Downstream loop used to optimize left turning phase

Turning flow and straight-ahead not separated

Communication

- Dedicated multi-drop transmission lines to outstations
- Second by second comms to and from outstation
- Typically six to eight intersections / drop @ 1200 Baud

Control Variables

- modelling uses measured vehicle demand (occupancy) and calculated queue length
- optimization uses demand (flow profiles) and calculated delay/saturation
- approach is to make small, regular changes to timings to minimize transients
- seven primary validation parameters (to correlate internal traffic model with the real world)
- dozens of parameters to allow the traffic engineer to tune system performance
  - a full library of default values is provided
  - these are changeable by time-of-day, or manually

Validation parameters

- Basic Validation
  - Journey Time
  - Saturation Occupancy
  - Maximum Queue
  - Start Lag at Beginning of Green
  - End Lag at the End of Green
  - Main Downstream Link
  - Default Offset

- Fine Tuning
  - Split weighting
  - Offset weighting
  - Fixed or biased offsets
  - Congestion offset
  - Gating (action at a distance)
  - On-line saturation occupancy

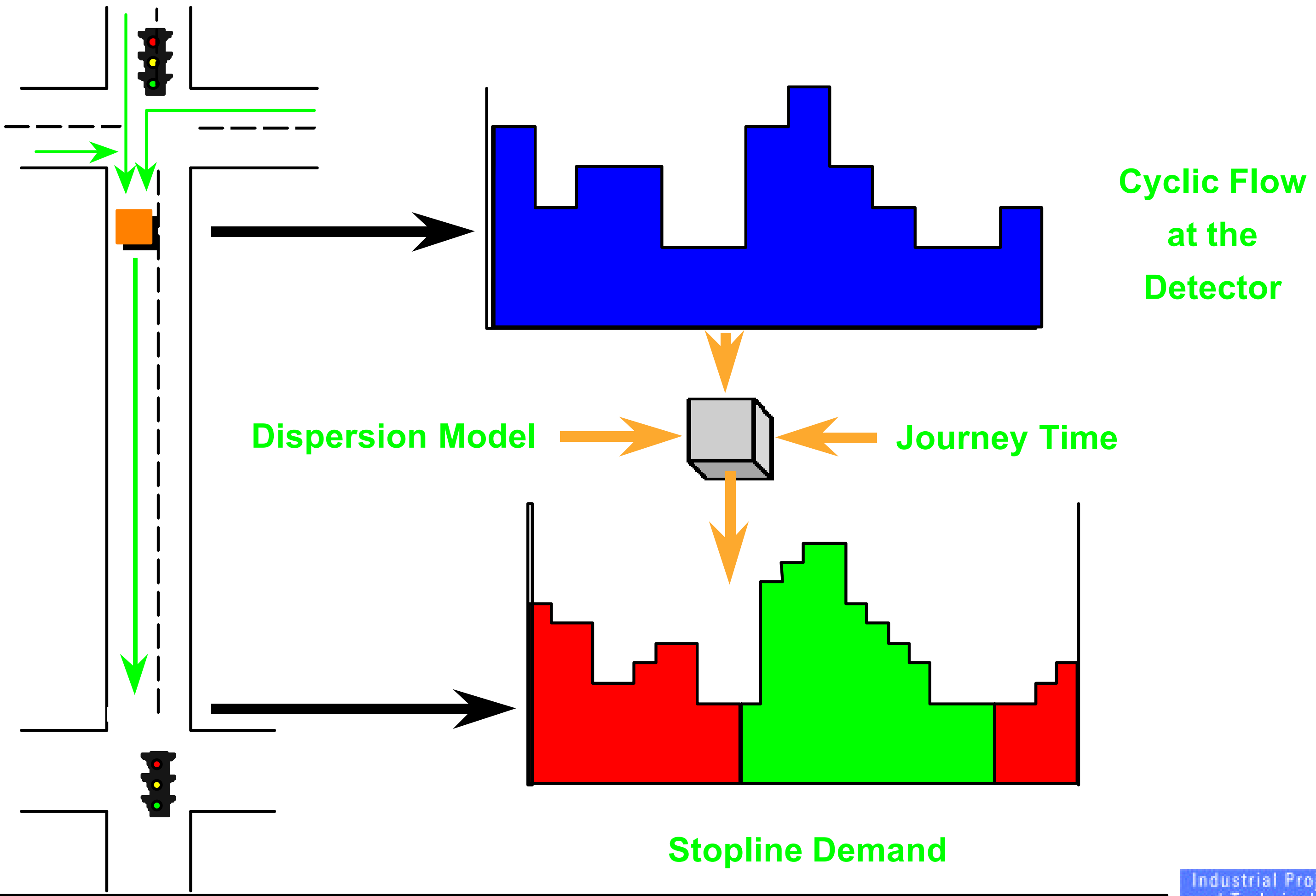
Traffic Engineering parameters (examples)

- REGION level
  - Fast Down flag
  - Max / Min cycle Time
  - Cycle Trend Flag
- NODE level
  - Force Double Cycle
  - Offset authorities
  - Split Authorities
  - Switch Split / Offset optimizers on / off
  - Specify translation array
  - Specify saturation thresholds
- “STAGE” level
  - Default stage lengths
  - Max / Min stage lengths
- LINK level
  - Congestion importance
  - Congestion offset
  - Congestion weighting
  - Congestion link definition
    - » importance
    - » weighting

Data Sampling, Filtering and Smoothing

- Detection based on vehicle occupancy
- Detector is typically a loop, with length 2m in direction of travel
- Sampling rate is 0.25s
- Algorithm processes raw data into LPUs based on linear discounting
- Demand profile for each link is built up in four second increments
- Controller phase replies used to enhance modelling

Generation of SCOOT Demand Profile



SPLIT OPTIMIZER

- Aim
  - Equalise saturation + congestion
  - Considering one stage at a time
- Method
  - All upstream and filter links at a node
  - Link merit values for advance, stay and retard
  - Move stage change time by -4, 0, +4
  - Revert to permanent change of -1, 0,+1
  - (Standard values for adjustment quoted - may be varied by the user)

SPLIT OPTIMIZER

- Frequency
  - Once per stage change
  - 5 seconds before stage change time
- Constraints
  - Minimum and maximum stage lengths
  - Fixed length stages
  - Split weighting
- Feedback
  - Adjust optimiser for stages which do not appear

OFFSET OPTIMIZER

- Aim
  - Minimise delay and stops + congestion
  - Considering one node at a time
- Method
  - Each upstream and downstream normal link
  - Link performance index for advance, stay and retard
  - Minimise sum of PI's for all the links
  - Move stage change time by -4, 0, +4

OFFSET OPTIMIZER

- Frequency
  – Once per region cycle time
  – During nominated stage
- Constraints
  – Offset weighting
  – Fixed and biased offsets
- Feedback
  – No account of stage demands

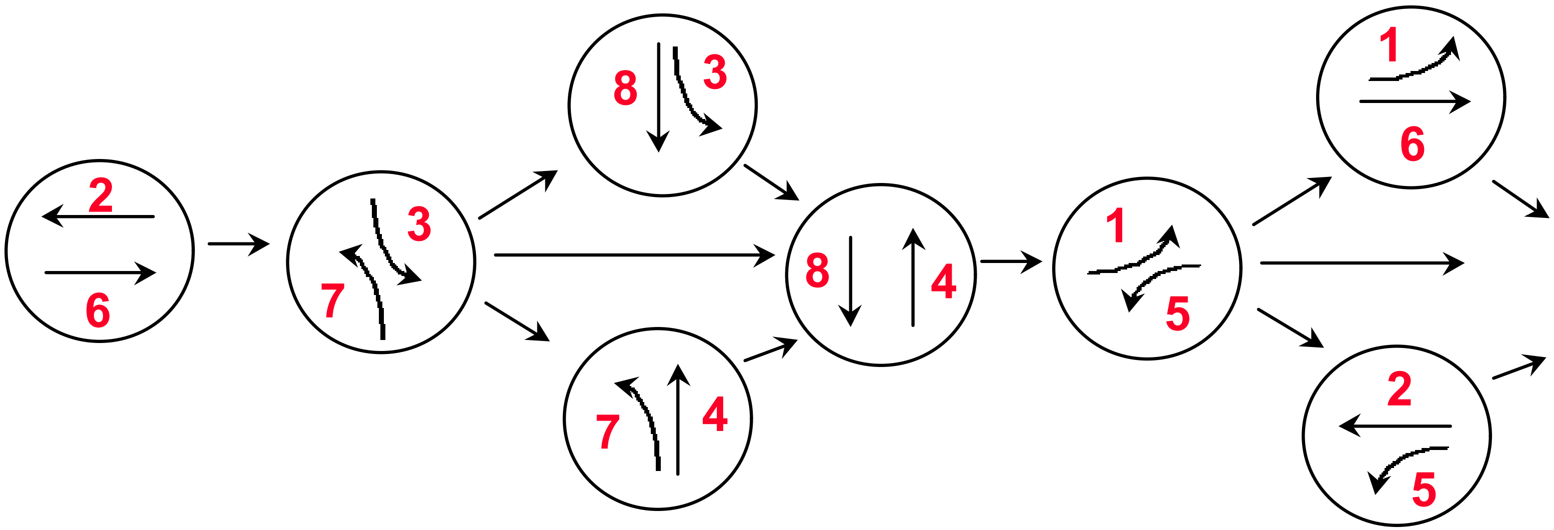
CYCLE OPTIMIZER

- Aim
  - Minimise delay
  - Considering one region at a time
- Method
  - Minimum practical cycle time for each node at 90% normal saturation or 80% target saturation
  - Consider range from maximum MPCY to maximum region cycle time
  - Consider double cycling if possible
  - No preset critical node

CYCLE OPTIMIZER

- Frequency
  - Usually every 5 minutes
  - Every 2.5 minutes when cycle rising
  - Every 2.5 minutes when cycle is falling (if required)
- Constraints
  - Maximum region cycle time
  - MPCY's of nodes
  - Minimum node cycle time
  - Forced single cycle or forced double cycle (if possible)
- Feedback
  - Stage demands taken into account

Phasing Flexibility - SCOOT to Dual Ring NEMA Controller translation



SCOOT stages - Method A					
1	|--------- 2 ---------|		3	|--------- 4 ----------|	
SCOOT stages - Method B					
1	2	3	4	5	6

Measures of effectiveness

- Optimization targetted in general at minimising delay
  - User specifies relative importance of stops and delay
- Split at a node balances degree of saturation on adjacent links
  - subject to weighting parameters from the local traffic engineer
- Offset determined by node performance index
  - choose best offset to minimise stops and delays on all adjacent links
- Cycle time maintains all links at no more than 90% saturation

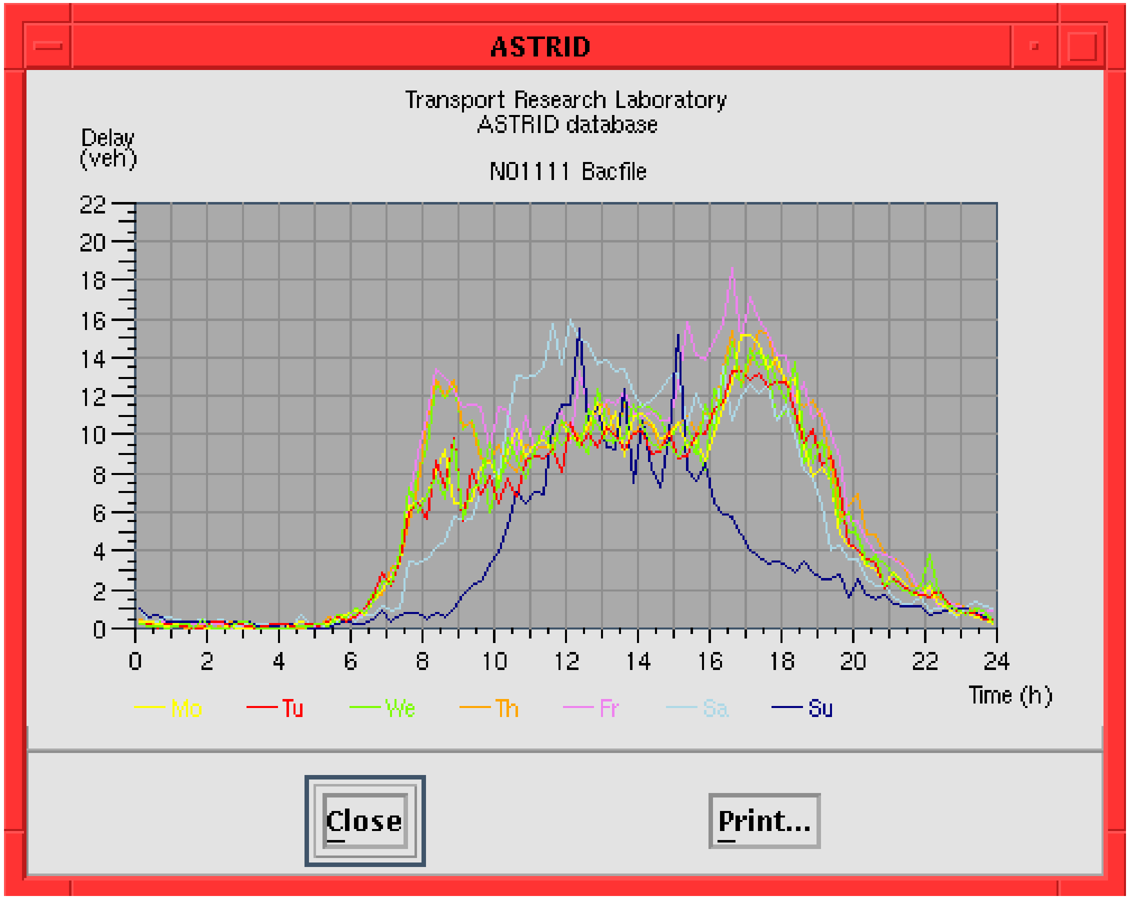
MOE s

- Data from SCOOT to demonstrate how it is achieving the above targets?
- “Event Driven messages” from SCOOT M02 / M03 / M04
      - » 02 = link
      - » 03 = node
      - » 04 = region
  - – Stops (vehicle.stops / hour)
  - – Delay (vehicle.hour / hour)
  - – Flow (vehicle / hour)
  - – Congestion (intervals / hour)
- All this data can be processed by ASTRID

ASTRID with SCOOT

- Historic database of key link and detector based values generated by SCOOT
- The SCOOT model provides the input data for ASTRID using standard messages
- SCOOT flows, stops, delays, congestion, percentage saturation, detector flows and occupancy, phase lengths and journey times
- The ASTRID software package is available as a fully integrated element within the SCOOT central processor, or on a stand-alone workstation
- Improved performance in the event of detector failure
  - SCOOT Version 3.1 accepts default link profiles from ASTRID

ASTRID DATABASE



Transit Priority

- Transit priority is a standard feature within SCOOT V3.1
- Dealt with by optimizing the priority provision
  - Extensions to running stage
  - Recall on minima via normal stage sequence to bus stage
  - Recovery to previous offset as quickly as possible
  - AVL and loop detection

Fire Priority

- Fire priority is a standard feature within the SCOOT system
- Optimization suspended during absolute priority, but modelling continues
  - Fast recovery to normal conditions at end of priority period
- V4.2 (available early ‘99) will have recovery algorithms (not the same as bus priority)

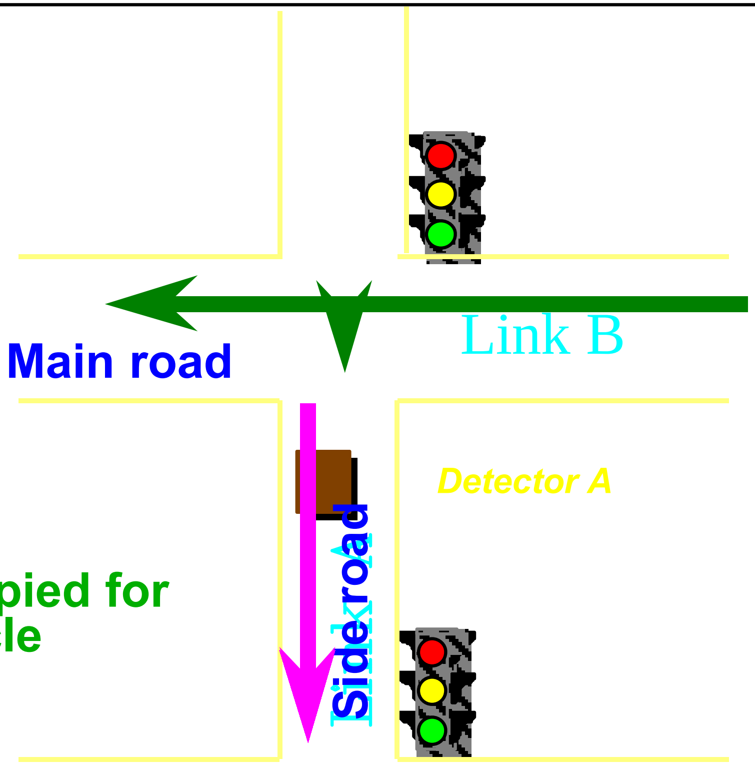
Special Features for Oversaturated Conditions

- Congestion importance factors / congestion offset per link
- Congestion links with congestion importance factors
- Gating
- Variable Node Based Target Saturation for cycle time optimisation

Congestion Importance Factors / Congestion Offset

- Congestion Importance Factor is specified for each link
  - Used to influence Split calculations in favour of the link, when congestion is detected
- Congestion Offset is a fixed offset, specified by the Traffic Engineer, to be used in congested conditions
  - Congestion Weighting Factor allows the engineer to specify the importance of achieving the Congestion Offset

Congestion offset - example of use



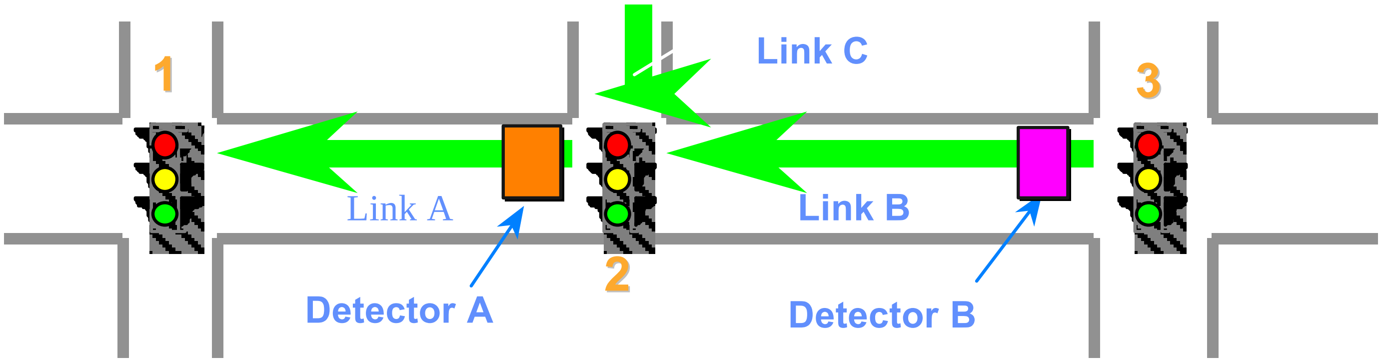
Important to keep main road traffic free flowing

Link A congested -

detector A occupied for part of cycle

Congestion Offset between junctions is set so that detector A is unoccupied when Link B receives green

Congestion Link Facility



Link C - minor side road
Not very important if Detector A is blocked
Important to avoid blocking detector B
Specify link B as 'congestion link' for link A

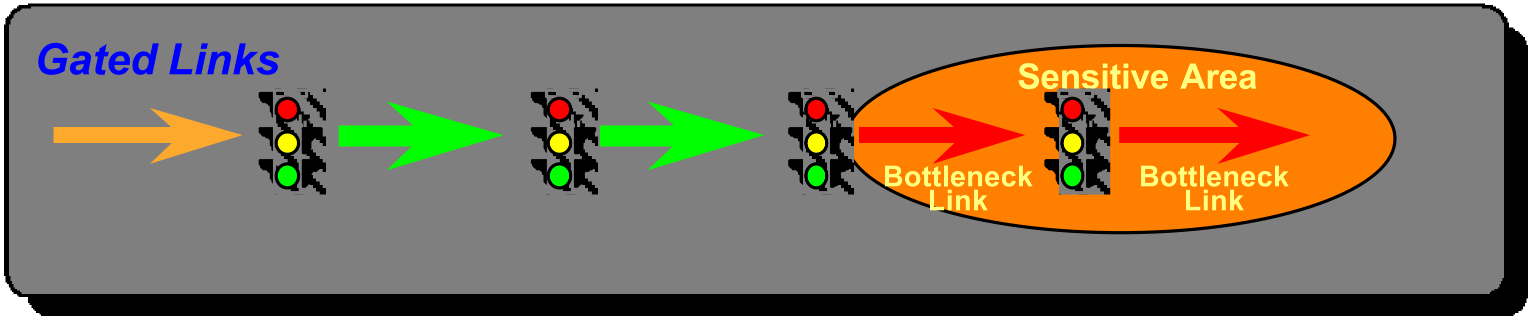
THEN

Detector B supplies link A with congestion information

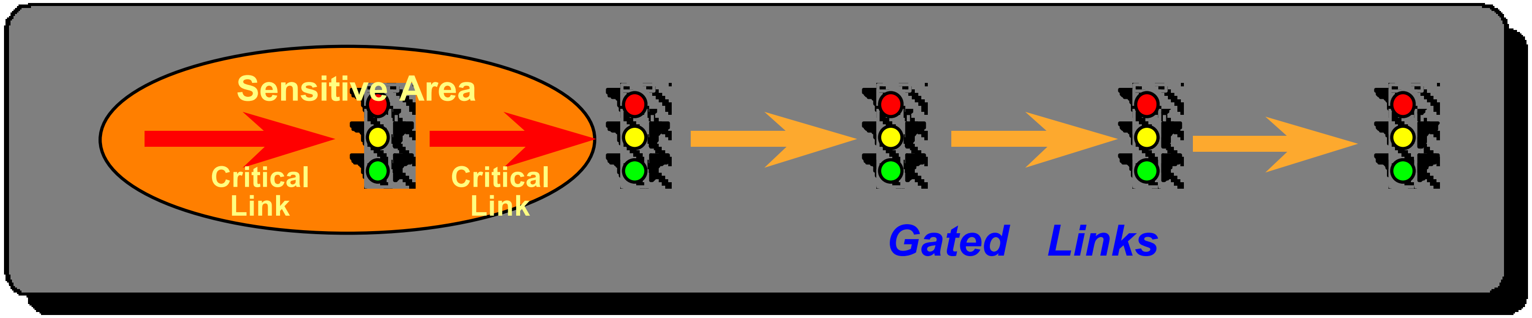
Congestion (blocking) of detector B influences the signal settings at Junction 1

Gating - Action at a distance

Upstream Gating



Downstream Gating



Variable Node Based Target Saturation

- Cycle Optimzer normally uses 90% as its target saturation level
  - (80% when “Trend Flag” set, to give more rapid response)
- Node based target saturation levels may be set by Engineer
  - Low threshold value will produce early increase in cycle time
  - High threshold value will allow early drop in cycle time at end of peak period

Other Features

- SOFT (on-line calibration of sat. flow)
- Use of alternative existing detection (although some reduced efficiency results)
- Variable authorities (i.e. variable bounds on optimiser decisions)
- Flared approaches (V4.2)

ON-LINE SATURATION OCCUPANCY

Predict saturation flow every cycle:

- Queue > 4 vehicles
- Mandatory detector not faulty
- Mandatory detector not blocked > 8 secs

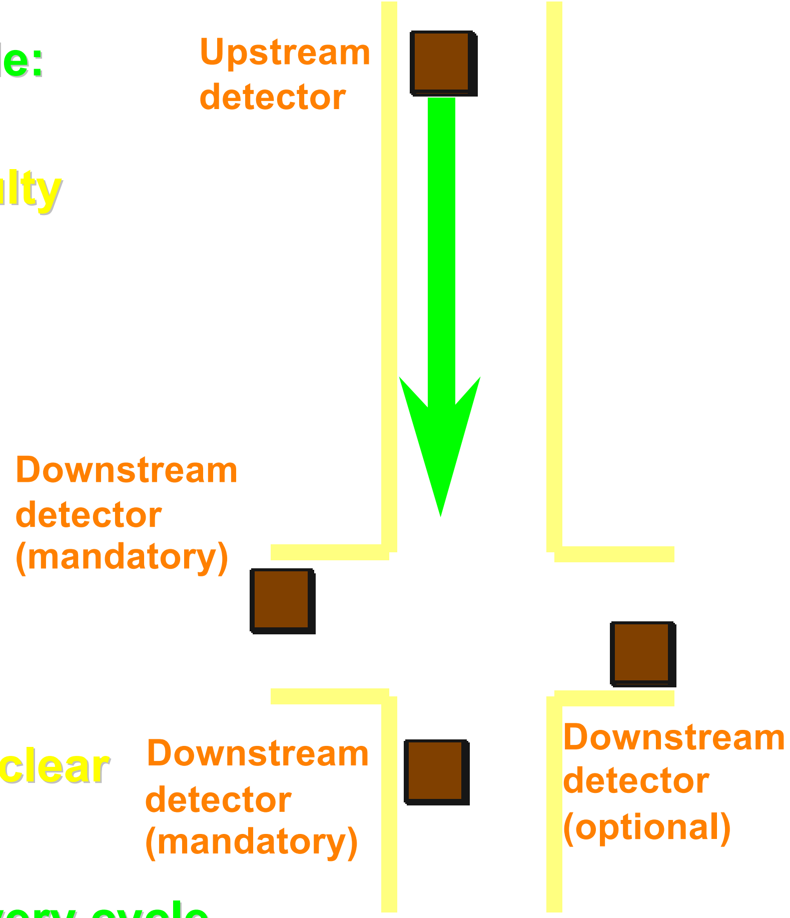
Monitor vehicle behavior

- upstream detector

Convert saturation flow to saturation occupancy on CALIBRATION CYCLES

- Queue > 4 vehicles
- Well defined end of queue clear
- No maximum queue

Predicts saturation occupancy every cycle



ON-LINE SATURATION OCCUPANCY

Good results in normal traffic conditions

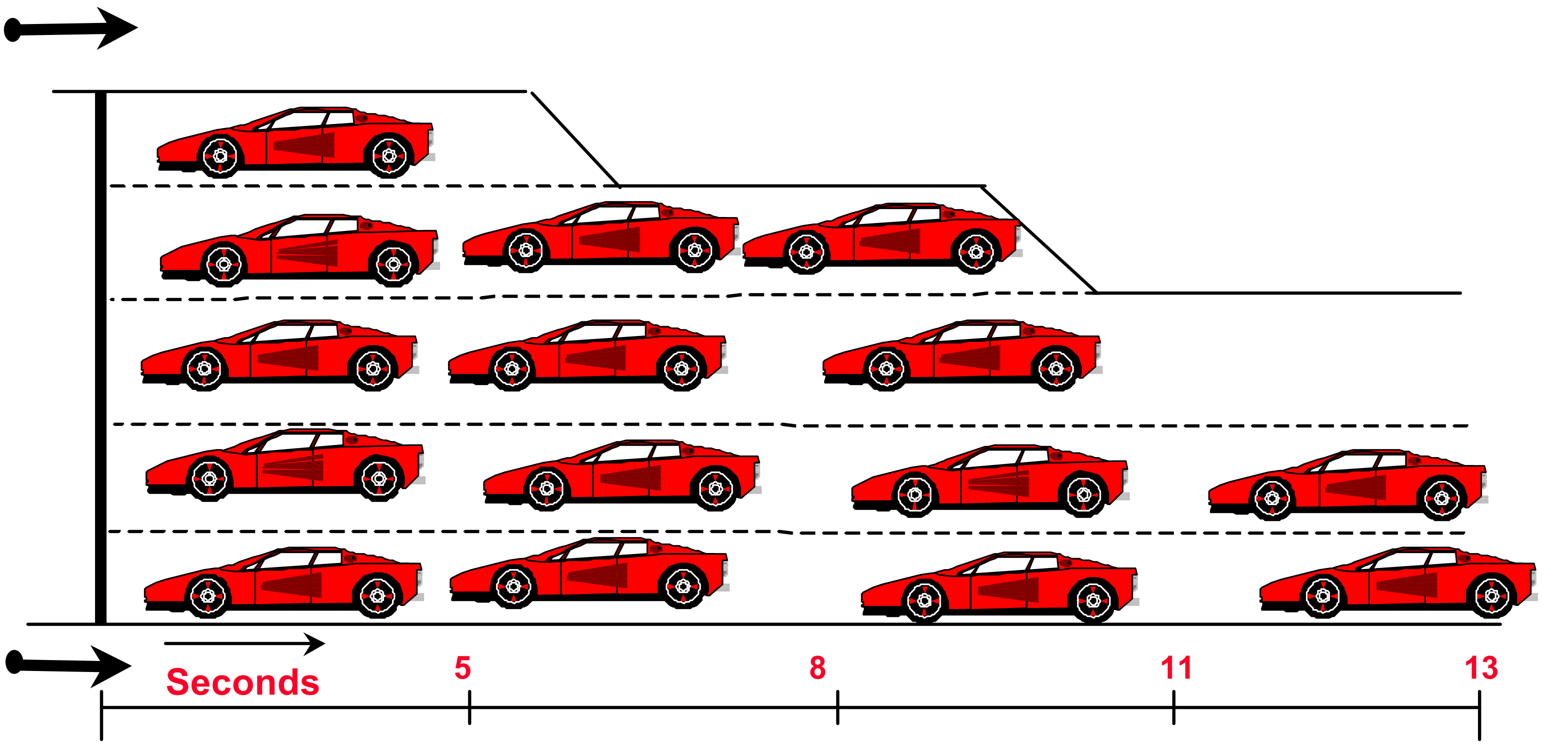
Can be used on approximately 50% of links
Depends on :-

- Detector location
- Short links
- Exit Blocking.
- Maximum Queues

USES

* Reduce time for initial validation
* Respond automatically to changes in saturation flow, e.g. parked vehicles

Flared approaches under SCOOT



Discharge very high
9000 v/h = STOC 35
for the first 5 seconds

Discharge reduces
7200v/h = STOC 28
for the next 6 seconds

Discharge reduces again
3600v/h = STOC 14 for the
remainder of the green

SCOOT Version 3.1

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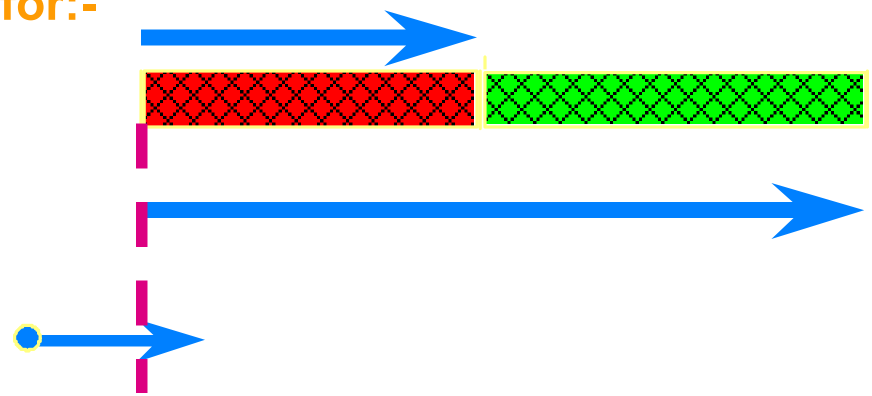
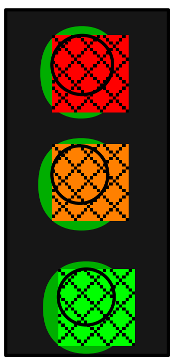


S *PLIT*



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