Warning

• This presentation contains graphic images depicting serious violations to the co-ordination of traffic signals and may not be suitable for some members of the audience
City of Toronto

- Largest Canadian City
- 2.5 million people
- 632km² (244mi²)
Transit in Toronto

- GO Transit
  - Interregional
    - Heavy Rail
    - Bus

- TTC
  - Local (24-hour)
    - Subway (3 lines)
    - ICTS (1 line)
    - Streetcar (11 routes)
    - Bus (138 routes)
    - Paratransit
  - 405 million annual trips
In a nut shell

- Over 14 years signal priority experience
- Over 155 equipped intersections on streetcar routes
- Over 115 equipped intersections on bus routes
- Aggressive expansion plan
The Beginning

- 6-intersection demonstration on a streetcar route in 1990
  - track switching equipment used for detection
  - controller pre-empt functions
  - simple algorithms
Study Conclusions

• 5 to 9 seconds of two-way delay reduction at each intersection
  – Up to 20% transit travel time reductions
• Other traffic not significantly affected
• Detection system proved effective
Study Recommendations

• Priority be considered for application throughout the streetcar network
• Implement one route at a time
• Investigate cheaper streetcar detection system
• Improve priority algorithm
Streetcar Detection System

• Use onboard RF track switching transmitters
• RFP for wayside check-in/check-out receiver
Detection System

- Loop based vehicle to wayside communication
- Overhead wire or spread spectrum radio wayside to controller communication
Algorithm Enhancements

- Detect different directions separately
- Design for 14-second extension
- Allow 30-second maximum extension
- Side-street truncation to minimum green
- Transit callable/extendable phases
- Transit only phases
- Use offset recovery routine for additional priority or for cross street compensation
Typical Signal Priority Algorithm

- Display LTGA up to 16 seconds
- LTGA Decision Point
- Extension Decision Point
- Optional Offset Recovery Interval
- Offset Recovery Interval
- Extend Green up to 30 seconds
- Start FDW
- Truncation Decision Point
- Truncate to Minimum Side Street Green
- Start SS FDW
Controller Functions for Priority

- Pre-empt functions used for extensions and truncations
- Normal controller functions used for transit callable and transit only phases
- Offset recovery used to provide additional passive priority
Impacts on “Normal” Signal Operation

• Streetcars have considerable control of the signal operation

• Co-ordination - not an issue on most streetcar routes
  – all traffic on approach must stop for passenger boarding/alighting
TTC/City Signal Priority Negotiations
Why So Much Control?

• Transit - Very important component of Toronto’s transportation system

• Priority equipped streetcar routes
  – provide very frequent service (2 to 5-minute peak period frequencies)
  – carry large number of passengers (31,000 to 52,000 passengers a day)
  – high transit modal split
Business Case for Signal Priority
Payback less than 5 years

- $15,000 to $25,000 per intersection
  - 12 to 16 seconds saved
- $500,000 to $850,000 per route
  - 7 to 11 minutes saved
- 1 to 2 fewer streetcars required
  - $200,000 plus annual operating cost savings
- Faster transit service
Streetcar Priority Applications

- Over 155 intersections equipped
- 7 streetcar routes
- 10 fewer streetcars
- Over $1 million a year in operating costs saved
Expansion to Buses

• 10-intersection demonstration in 1997
  – enhanced algorithms
  – infrared based vehicle to wayside communication
  – spread spectrum radio wayside to controller communication
Bus Demonstration Conclusions

• Transit delay decreased up to 46%
• Auto delay decreased marginally
• Cross street traffic not significantly affected
• Bus detection system reliability problems
  – reflection of signal
  – missed detection (alignment problems)
Bus Demonstration Study Recommendations

• Implement priority on 29 Dufferin bus route to confirm benefits
• Use loop based bus detection
  – less expensive
  – equip bus division with RF transmitters
• Develop long term expansion plan
  – identify and prioritize candidate routes
29 Dufferin Installation (1998)

- 33 intersections equipped
- Benefits confirmed
- 2 buses saved
- $235,000 operating costs saved annually
- Other traffic not significantly affected
Impacts to “Normal” Signal Operation

- Control of traffic signals same as streetcars
- Impacts on signal coordination raised as an issue
  - Discussions on the effectiveness of coordination
Perspectives on Co-ordination

• Signal co-ordination is an important tool in reducing signal delay and optimising road operations

• Signal co-ordination is an outdated tool with few applications in today’s environment
TTC Perspective on Co-ordination

• Effective in minimising vehicular delays
  – One way streets
  – Arterial roads with highly tidal flows

• Effective in minimising overall person delays in very limited circumstances
  – only if transit modal split is low
Toronto Environment

• Very few one-way arterial roads
• Opposing Traffic flows are equalising
• High transit usage
  – few vehicles carrying large numbers of passengers
  – different travel time characteristics from autos
Toronto’s Official Plan

- 540,000 new residents
- 540,000 new jobs
- Additional travel demand focused on transit
  - new road capacity is prohibitively expensive
  - community opposition to new roads
  - existing infrastructure utilised more efficiently
    - more transit signal priority
    - more dedicated transit lanes
Bus Priority Applications (to date)

- Over 115 intersections equipped
- 3 bus routes
  - 1 route  reduced running time and 2 fewer buses
  - one route  same or more running time
  - one route  not yet activated
    - Differences on transit operation philosophies within TTC
    - Program suspended for 2 years
Conflicting Goals

• New route management strategy
  – enough running time to complete every trip
  – all running time should be drive time (no recovery time)

• Buses without/broken transmitters assigned to priority equipped routes
  – 20% of buses not equipped, 10% broken
  – transmitter repair a low priority
What’s next?

• Continuing to equip buses with transmitters
• Operations Department is reviewing the route management strategy
• Equipment staff have been asked to ensure transmitters working
• Restart program in 2004 (1 route a year)
• Expand program 50% starting in 2005
The TTC's Signal Priority Program
Longer Term Objectives

- Test new algorithm for major intersections
- Migrate to new traffic signal control system
- Test transit signal priority within SCOOT
- Provide priority only to late vehicles
  - during periods of less frequent service
  - AVLC system accuracy improved
Transit Goals

• Maximise transit benefits of signal priority opportunities
  – improve service
  – reduce operating costs
  – improve competitiveness of transit
  – encourage more transit use
  – maximise person carrying capacity of the road network
Operating Challenges

• Wise and effective use of the power to manipulate signal operation
  – No killing time in detection zones
  – No operator change over in detection zones
Operating Challenges

• Optimize transit operations to maximize signal priority benefits
  – reduce service frequency (larger vehicles or Multiple Unit operation)
  – reduce passenger service delays (Proof of Payment)