Burlington Northern Santa Fe Corporation

Improving Railroad Network Routing Roger Baugher, Director, Service Design

April 13, 2007





The BNSF Network

BNSF Stations

BNSF

BNSF Stations



Portions ® 1990-2025 Install Shield Software Corporation. All rights reserved. Certain mapping and direction data ® 2005 IGAYTEQ. All rights reserved. The Data for areas of Canada in Right of Canada in Right of Canada. ® Queen's Printer for Cream. NA/TEQ and NAYTEQ of BOARD are trademants of NAYTEQ. © 2005 Telle Allias North America, Inc. All rights reserved. Telle Atlas and Telle Atlas North America are Eadmants of Telle Atlas in Telle Atlas and Telle Atlas North America are Eadmants of Telle Atlas in Telle Atlas in Telle Atlas and Telle Atlas North America.

The Car Routing Puzzle

BNSF Stations

BNSF

Hump Yards



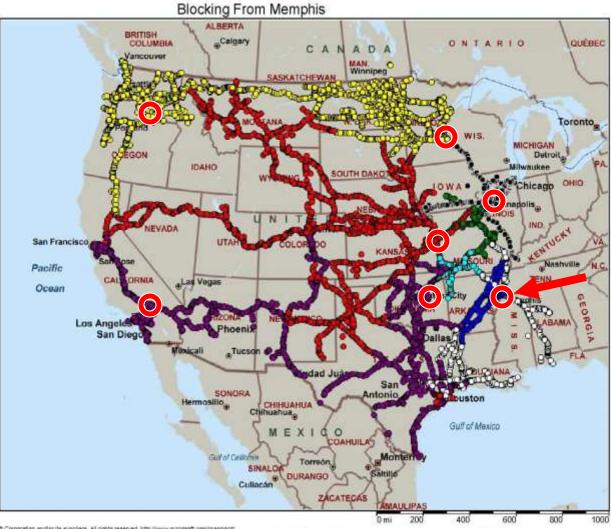
Coordint 6 and (P.) 1559-2009 Microsoft Corporation and/or its suppolers. All fights reserved, this Newson introduction in the Control of Section 6 1559-2009 Intelligible Software Cooperation. A fight reserved. Early mapping and direction 8 1500 (AVYTEQ All rights reserved. The Data for areas of Carada includes into permission from Canadian authorities, including 6 Her Majash the Queen in Right of Canada. @ Queen's Printer for Chairo. NAVTEQ and NAVTEQ ON BOARD are trademants of NAVTEQ. @ 2005 Tele Atlas North America, inc. All rights reserved. Tele Atlas and Tele Atlas North America are badaments of Tele Atlas inc.

One Routing Solution

Memphis Blocks

- GALEIL
- KANCKS
- NORTHT
- O OTHERS
- PINBLU
- SPRIMO
- STLOMO
- TULSOK

Hump Yards



Copyright & and (P). 1989-2009 Microsoft Corporation and arise squaders. All rights reserved that (livery microsoft corporation) is 1 miles reserved. The Data for areas of Canada includes information taken with permission from Canadas authorities, including @ Her Majesty the Queen in Right of Canada, & Queen's Proter for Octaria, NAVTEQ and NAVTEQ on BOARQ are trademarks of (NAVTEQ & 2005 Tale Atlas North America, Inc. All right reserved. The Plate and Tele Atlas and Tele Atlas for the A

Maintaining the Routing Rules A Local Perspective

Traditional System

- Block from Memphis
- Block to Kansas City
- General Merchandise
- Includes
 - Thornton, Delpaso, Plegrove, Marysvill, Mounkes, Craig, Rocklin, Newcastle, Bowman, Colfax, Caphorn, Golrun, Dutflat, Alta, Towle, Midas, Blucanon, Emigap, Cisco, Troy, Norden, Truckee, Oroville, Elsey, Poe, Pulga, Merlin, Camrodger, Belden, Virgilia, Paxton, Sprgarden, Quijct, Sloat, Blairsden, Portola, Hawley, Floriston, Verdi, Mogul, Lawton, Chilcoot, Renjct, Scotts, Doyle, Redhouse, Reno, Sparks, Vista, Hafed, Patrick, Herlong, Flanigan, Sanpass, Sano, Reynard, Wunotoo, Clark, Thisbe ...
- Total of 1823 Stations in this block



Maintaining the Routing Rules A Network Perspective

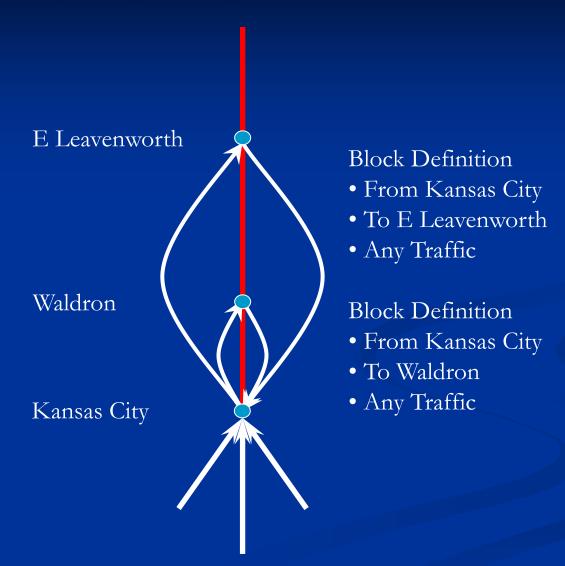


Creating a New Paradigm Using A Shortest Path Algorithm

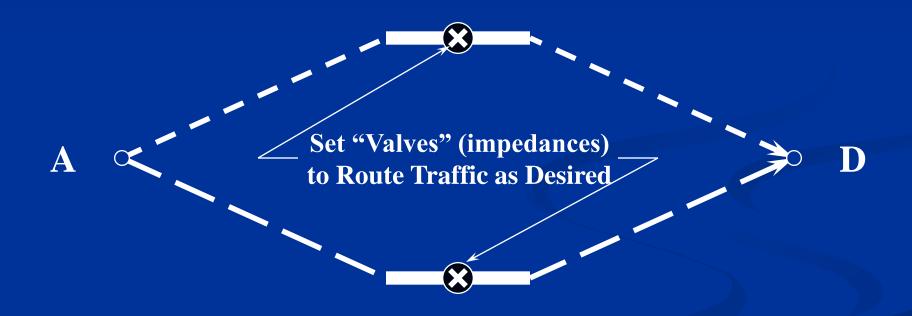
- Traditional Blocking
 - Design manager must completely specify routing manually; computer adheres to specified routing
 - Routing preferences hard coded into rules
 - Routing changes, even minor local ones, may require network-wide revision of rules

- Algorithmic Blocking
 - Design manager manually specifies routing options using skeletal block definitions; computer logic selects routes
 - Routing preferences reflected in "impedances"
 - Routing changes of any size may be implemented quickly and their impacts predicted with models

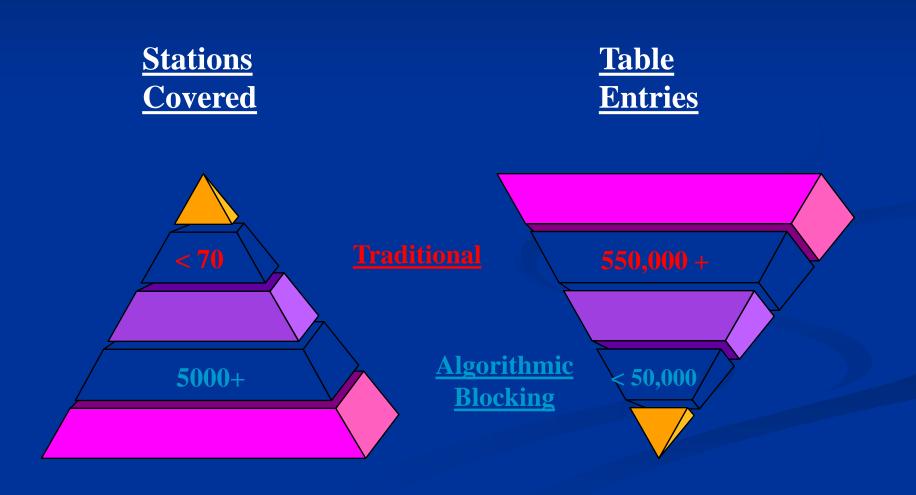
Setting Up Algorithmic Blocking

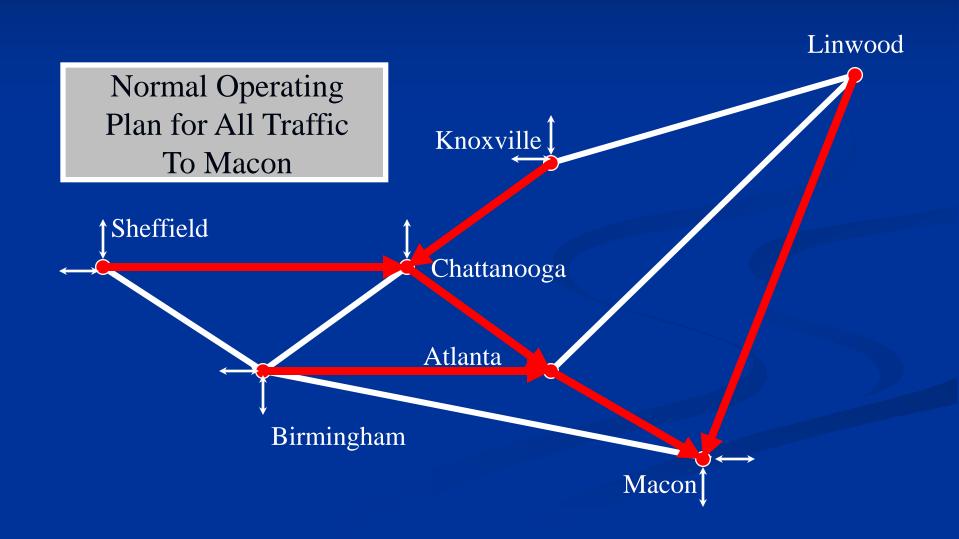


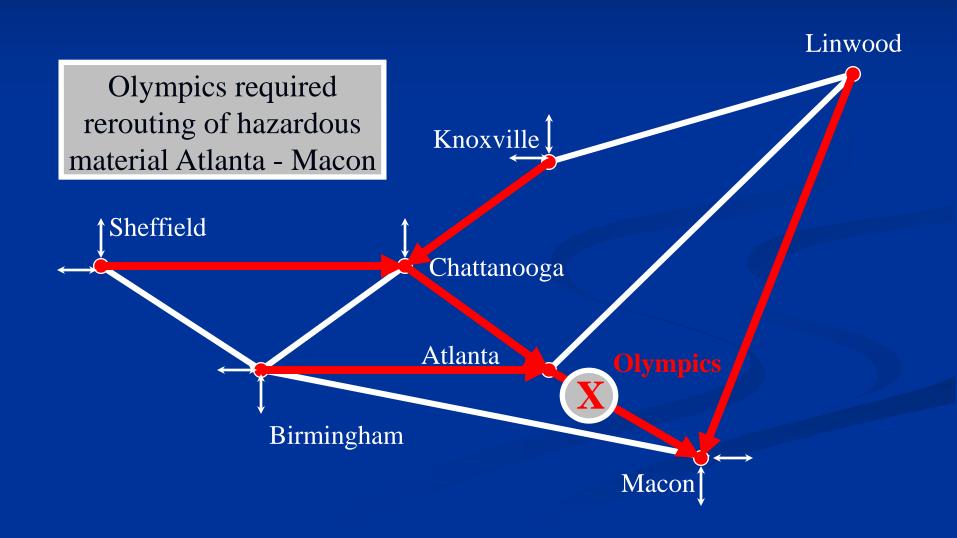
Changing Routes with Algorithmic Blocking

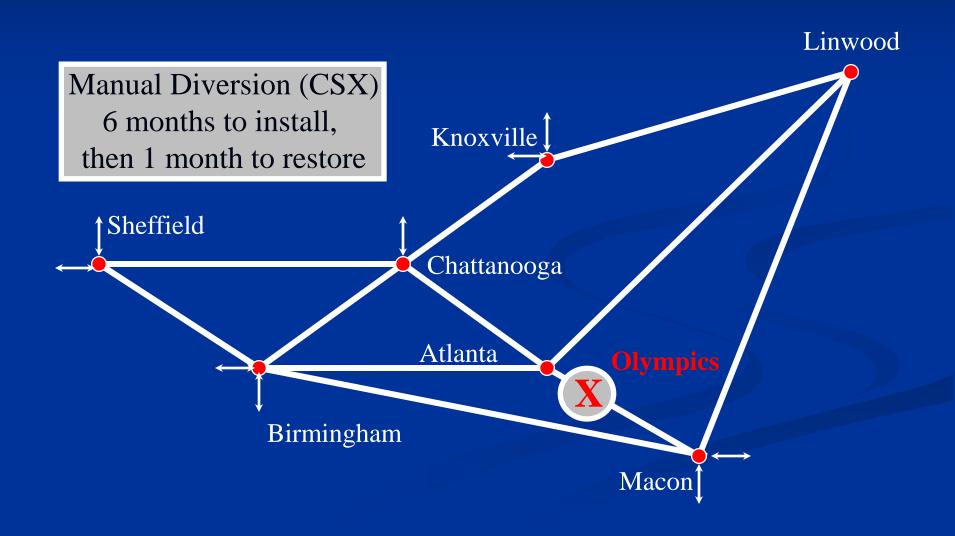


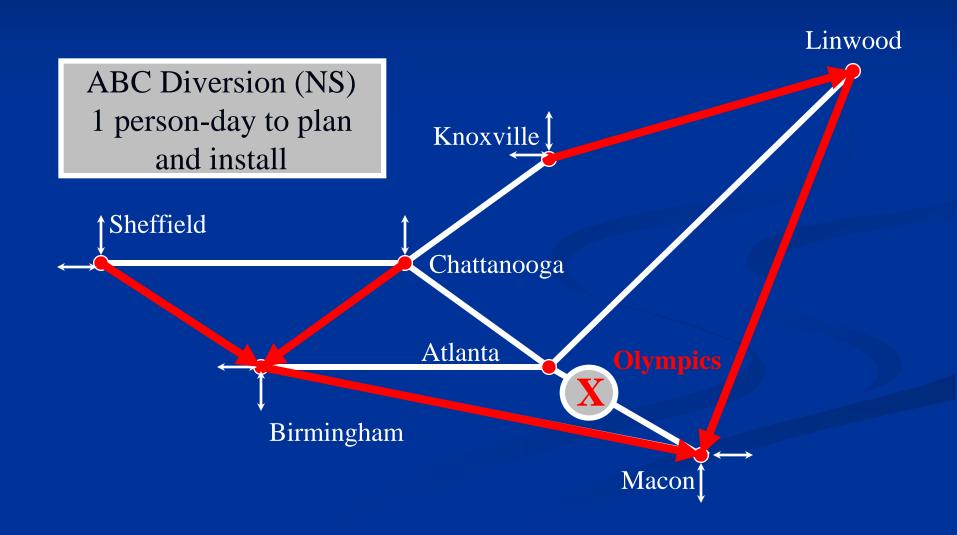
Rule Maintenance Simplification with Algorithmic Blocking

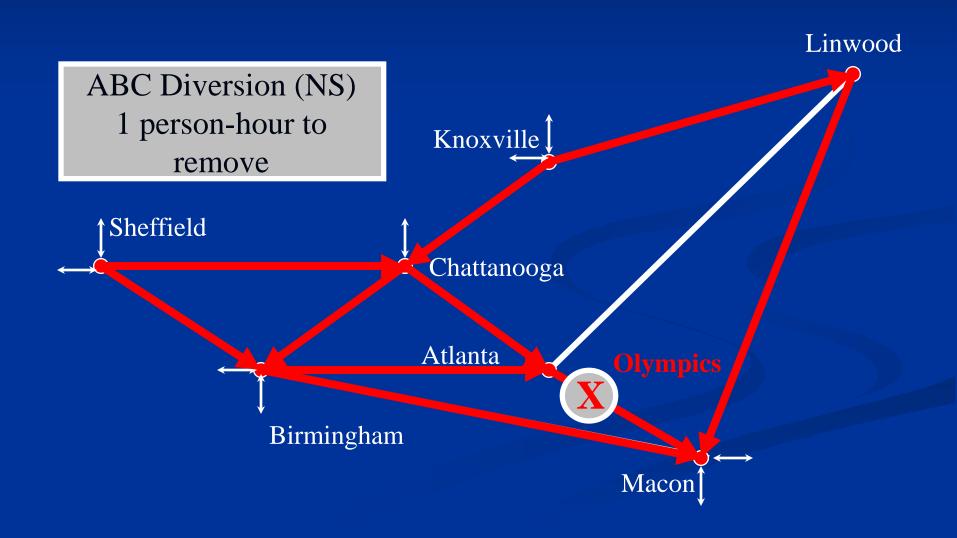












The Fundamentals of Algorithmic Blocking

Find blocks which can carry traffic (feasible blocks)

Feasible blocks -- AB, AC, BD, CD

Infeasible blocks -- AD (weight restriction)

Find "lowest impedance" route over feasible blocks

Impedance ABD = Yard A Impedance + Line AB Impedance +

Yard B Impedance + Line BD Impedance

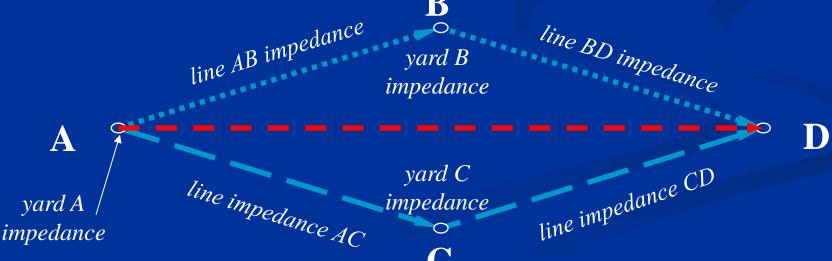
Impedance ACD = Yard A Impedance + Line AC Impedance +

Yard C Impedance + Line CD Impedance

Lower impedance route is chosen

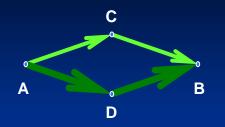
If a route is blocked, Algorithmic Blocking will find another,

if one is available



Limitations of Algorithmic Blocking

- Routes across a sequence of blocks
 - No consideration of trains and train connections
 - No consideration of time
- No ability to consider capacity constraints
 - Blocks do not have capacity constraints trains do
 - Capacity is a function of time, so failure to consider time prevents capacity planning
- Some traffic should be routed to minimize costs, others to minimize transit time

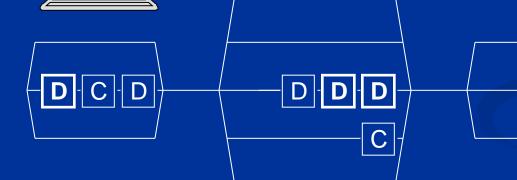


AB

A Look at a Terminal Cars At Yard A Algorithmic Blocking



Next PM



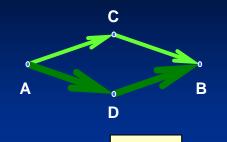
Dpt 1200 Today

Dpt 1800 Today

Dpt 1200 Next Day

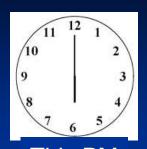
Arrival Yard

Class Bowl Departure Yard

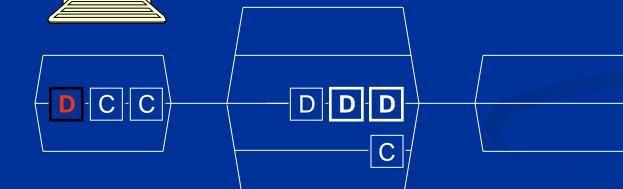


TS

A Look at a Terminal Cars At Yard A Time-Space Solution



This PM



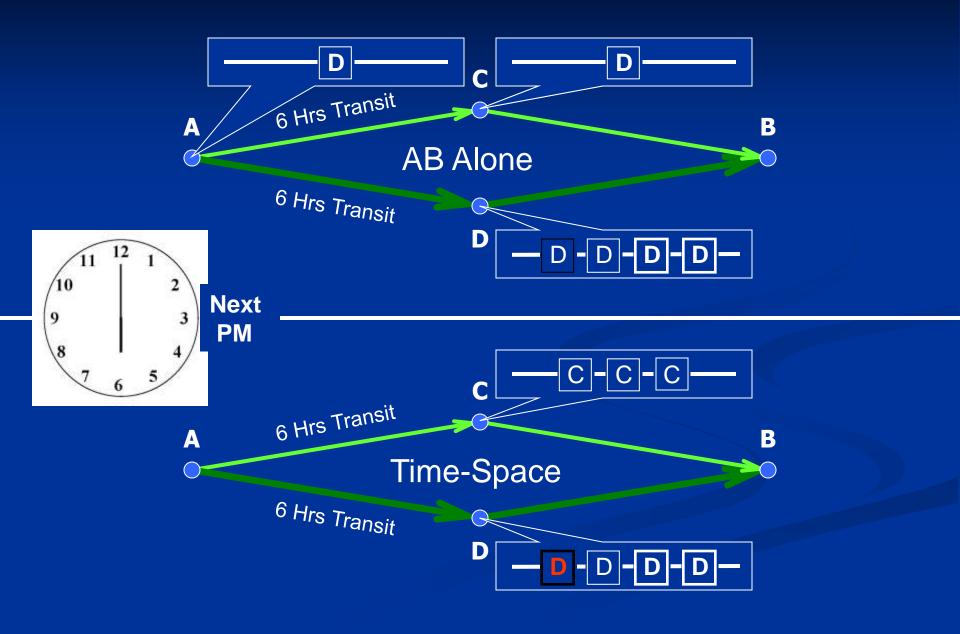
Dpt 1200 Today

Dpt 1800 Today

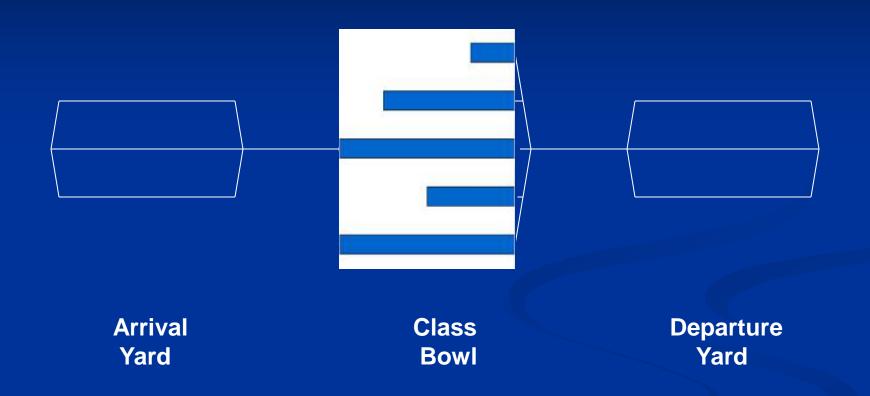
Dpt 1200 Next Day

Arrival Yard Class Bowl Departure Yard

Another Look at the Network



Convergence of Terminal and System Views



Convergence of Terminal and System Views



Where Do We Go From Here?

- Some form of algorithmic blocking in place or being implemented at four North American railroads.
- BNSF has a form of time-space algorithm without algorithmic blocking.
- Much work within and between railroads will be needed if railroads are to become more scheduled and their service more predictable.

