Burlington Northern Santa Fe Corporation

Improving Railroad Network Routing Roger Baugher, Director, Service Design

April 13, 2007





The BNSF Network



Copyright @ and (P) 1559-2008 Microsoft Corporation and/or its suppliers. All rights reserved, http://www.microsoft.com/mappoint/

Potions © 1990-2025 Instal Sheld Software Corporation. All rights reserved. Certain mapping and direction data © 2005 INAV TBD. All rights reserved. The Data for areas of Canada Installers Instantian Statements of Installers and International Sheld Software Instantians and International Canada Installers Installers and International Canada Installers Installers Installers and International Canada Installers Install

The Car Routing Puzzle



Copyright @ and (P) 1969-2000 Microsoft Corporation and/or its suppliers. All runtis reserved, http://www.microsoft.com/mappoint/

Potions @ 1990-2020 Instal Sheld Software Corporation: All rights reserved. Certain mapping and direction data @ 2005 IAV TBD. All rights reserved. The Data for areas of Canada Includes Information taken with permission from Canadian authorities, including @ Her Maleki the Queen in Right of Canada. @ Queen's PrinterTed Critatio. NAV/TEQ and NAV/TEQ. All rights reserved. The Data for areas of Canada Includes Internation taken with permission from Canadian authorities, including @ Her Maleki the Queen's Right of Canada. @ Queen's PrinterTed Critatio. NAV/TEQ and NAV/TEQ and NAV/TEQ. @ 2005 Tele Allas North America, Inc. All hights reserved. The Atlas and Tele Atlas North America are traditionation of Tele Atlas. Inc.

One Routing Solution



Copyright @ and (P) 1999-2006 Microsoft Corporation and/or its exaptiens. All nohts reserved, http://www.microsoft.com/inspoon//

Performe B104-2005 Installabilitied Sphines Corporation. At inplicement of management and direction data Stationary 2005 NATEC At ratio reserved. The Data for arress of Canada includes information taken with permission from Canada and Andre withordise, including @ Her Mayeety the Queen in Right of Canada, @ Queen's Photon for 2005 ATEC AN TEC ON BCARD are trademarks of (AVTEC). 82005 Tele Atas Noth America, Inc. At rights reserved. The Atas and Tele Atas and Tele Atas Noth America are trademarks of (AVTEC). 82005 Tele Atas Noth America, Inc. At rights reserved. The Atas and Tele Atas and Tele Atas Noth America are trademarks of Tele Atas. The Atas Noth America, Inc. At rights reserved. The Atas and Tele Atas and Tele Atas Noth America are trademarks of Tele Atas. The Atas Noth America and trademarks of Tele Atas. The Atas Noth America are trademarks of Tele Atas. The Atas Noth America and Tele Atas and Tele Atas Noth America are trademarks of Tele Atas.

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

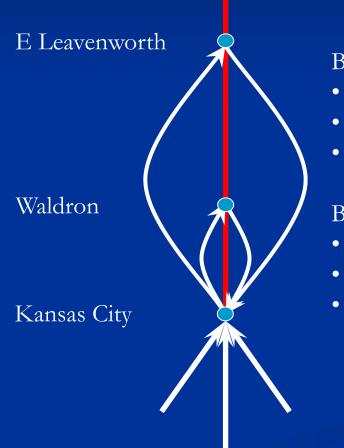
Traditional Blocking

- 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



- Block DefinitionFrom Kansas CityTo E LeavenworthAny Traffic
- Block DefinitionFrom Kansas City
- To Waldron
- Any Traffic

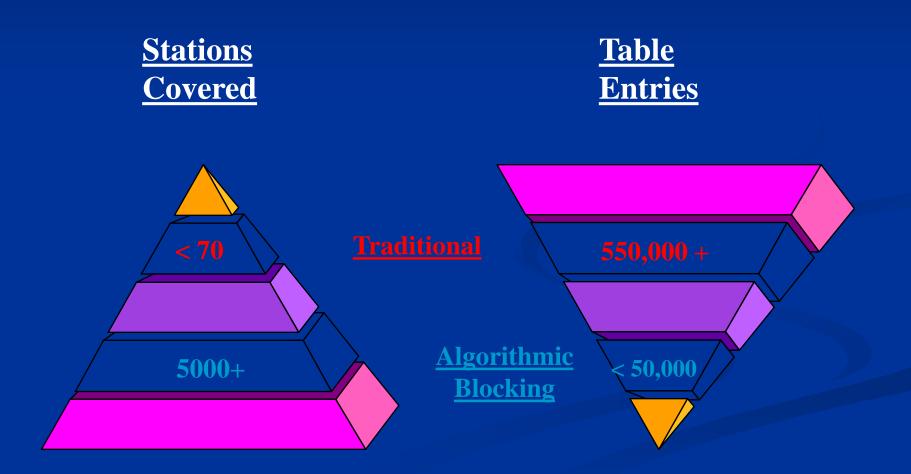
Changing Routes with Algorithmic Blocking

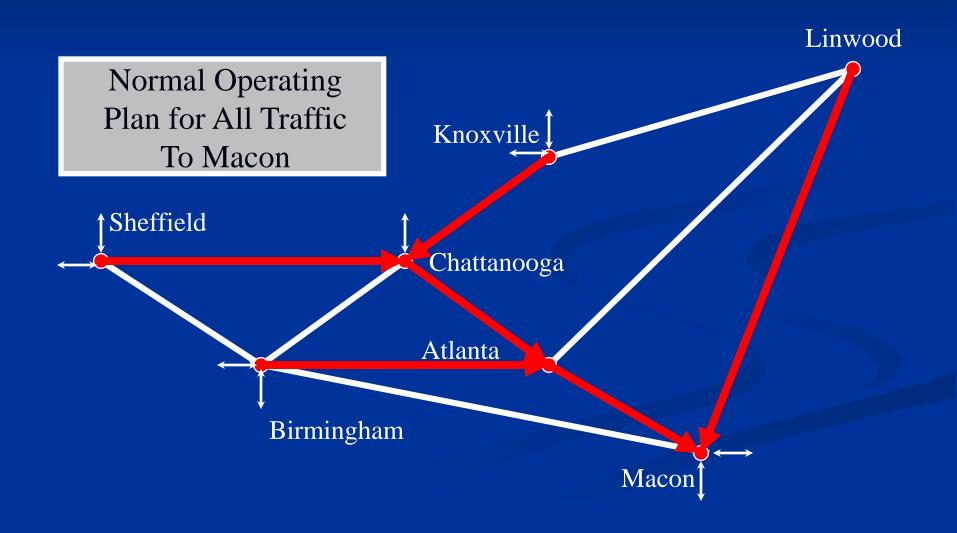
Set "Valves" (impedances) to Route Traffic as Desired

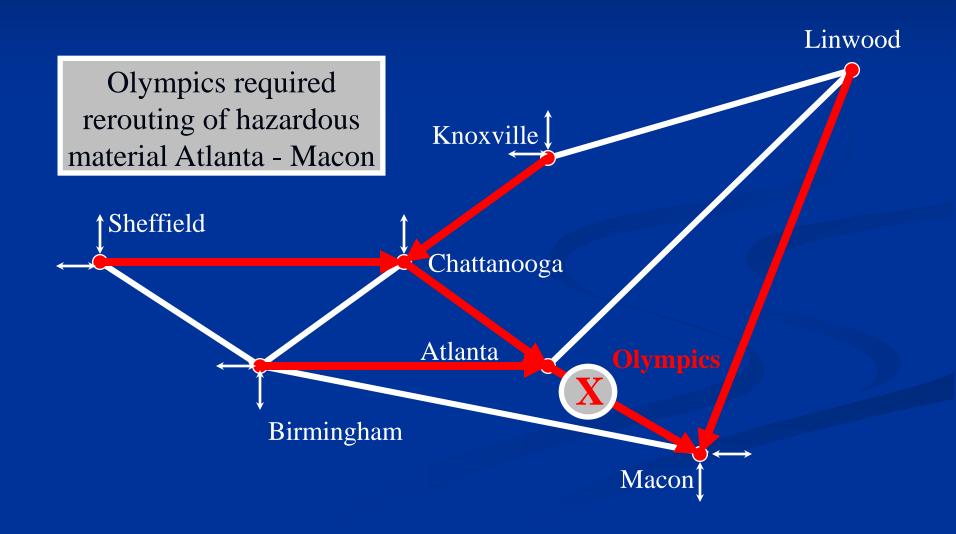
A

D

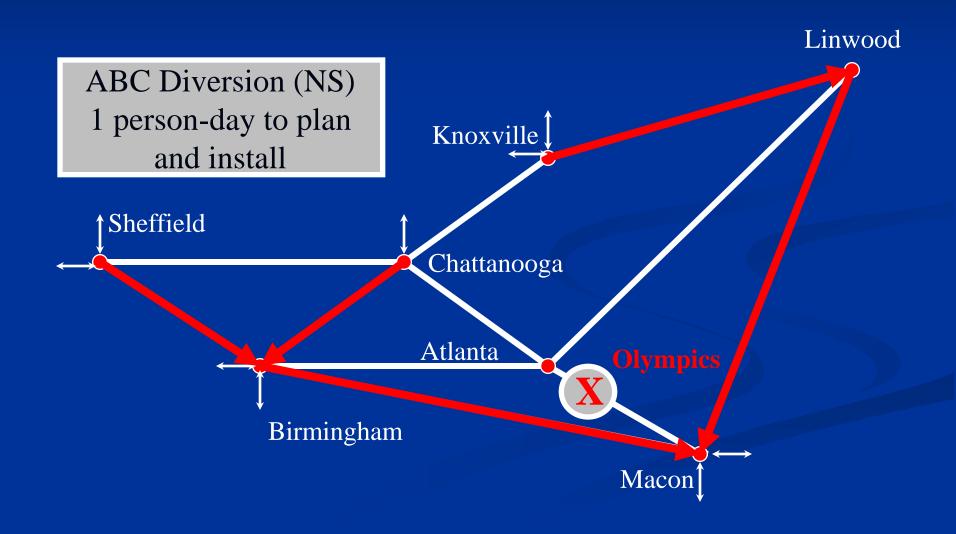
Rule Maintenance Simplification with Algorithmic Blocking

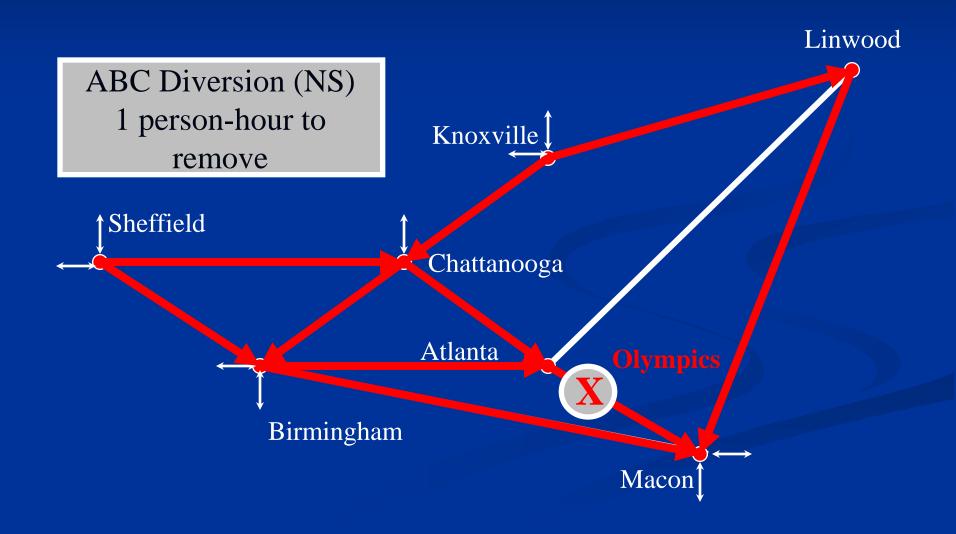












The Fundamentals of Algorithmic Blocking

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 В line AB impedance line BD impedance yard B impedance A line impedance AC line impedance CD

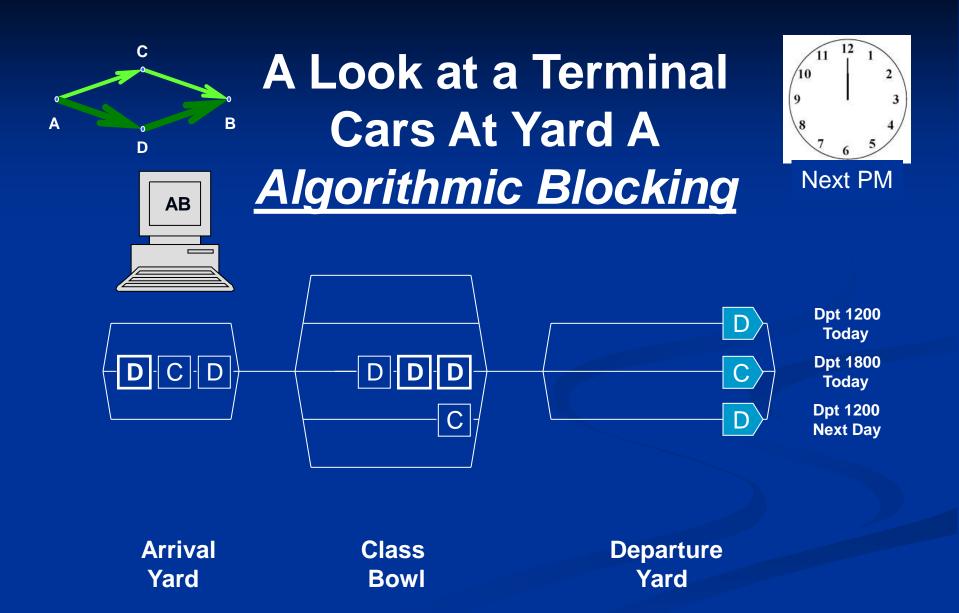
vard C

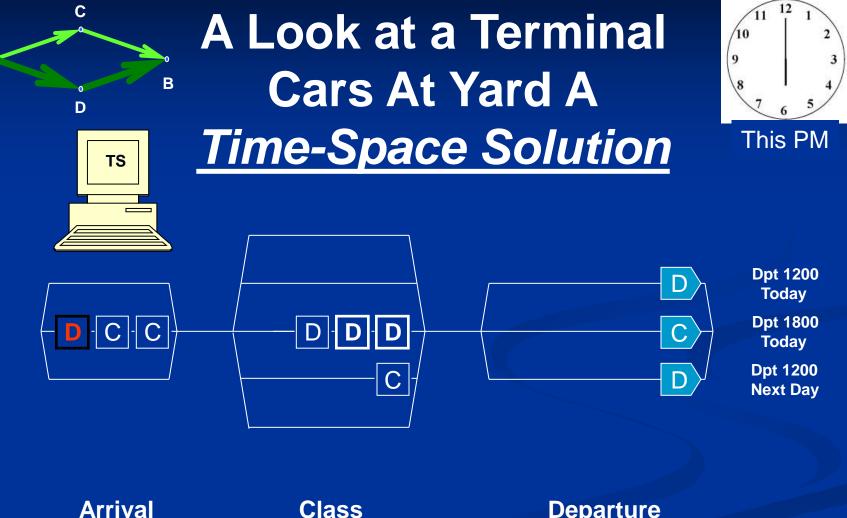
__impedance

vard A impedance

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



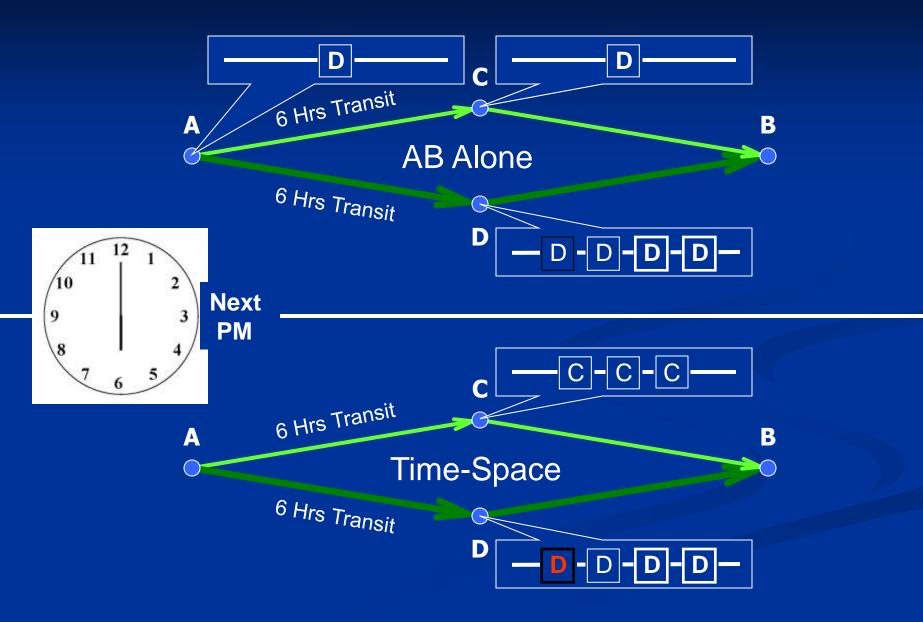


Yard

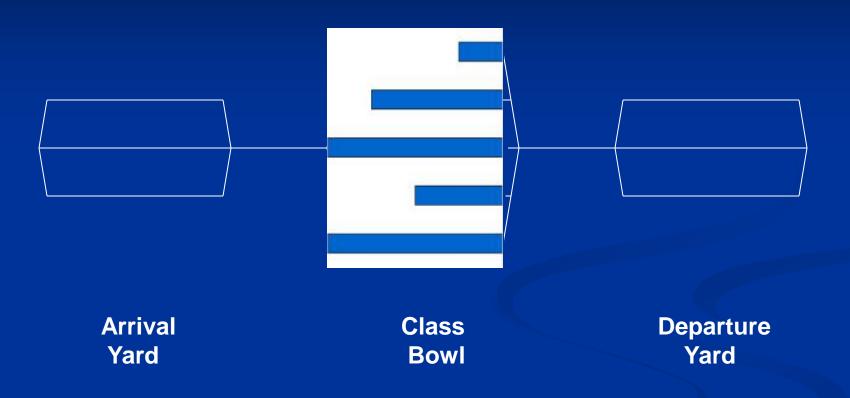
Α

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.

