Burlington Northern Santa Fe Corporation

Improving Railroad Network Routing

Roger Baugher, Director, Service Design

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The BNSF Network

The Car Routing Puzzle

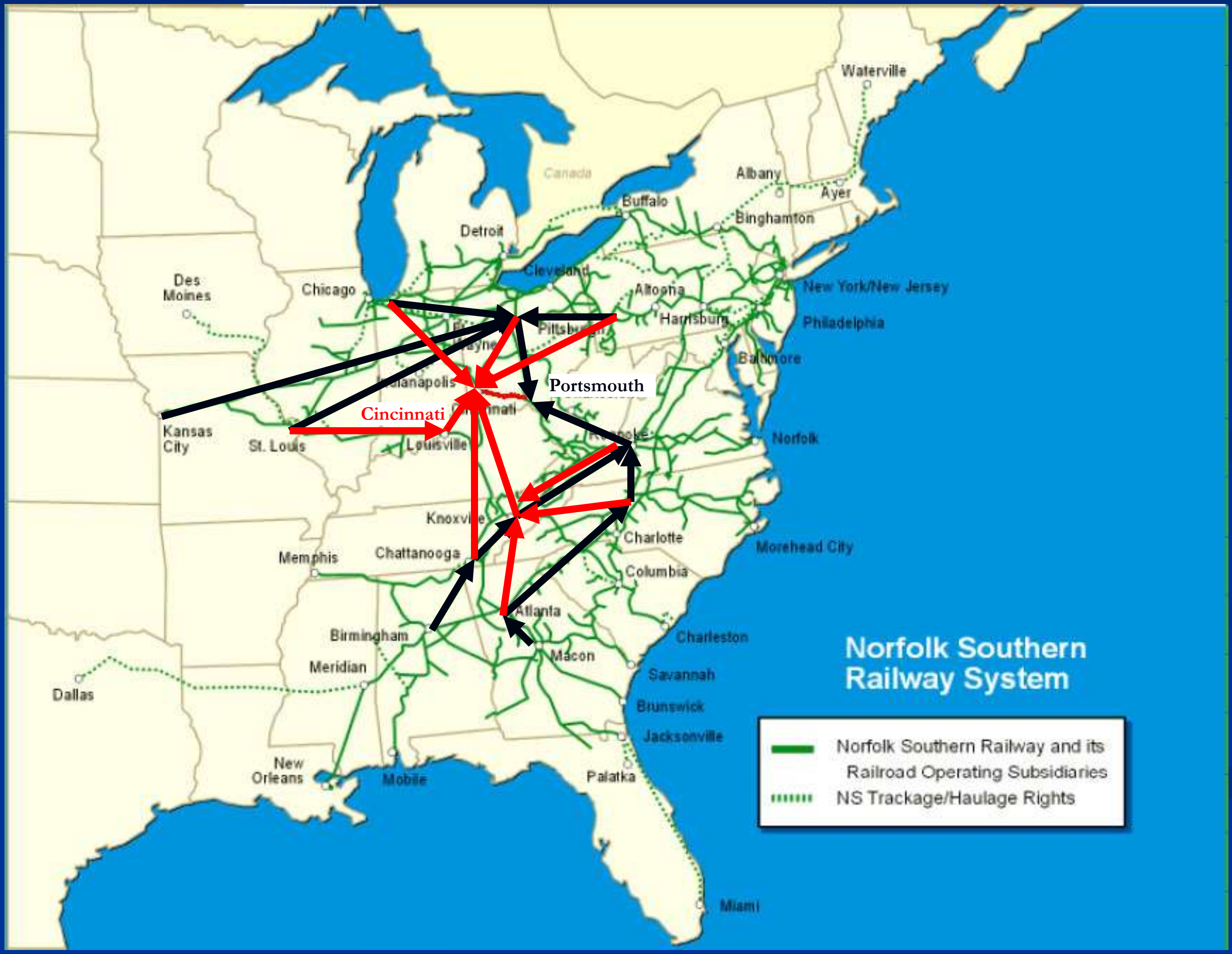
One Routing Solution

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

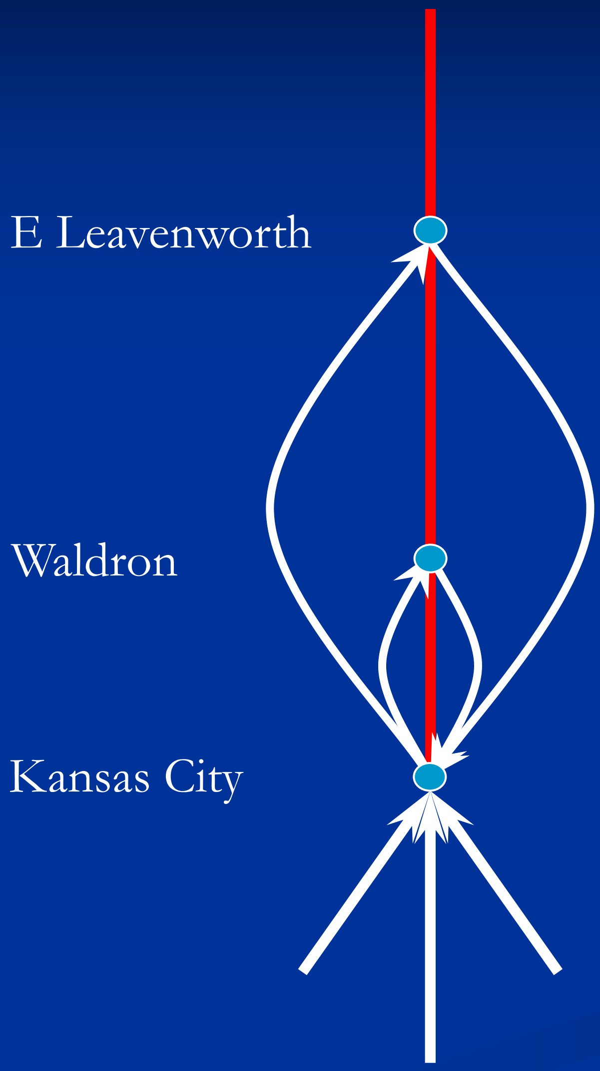
Maintaining the Routing Rules
A Network Perspective



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 Definition

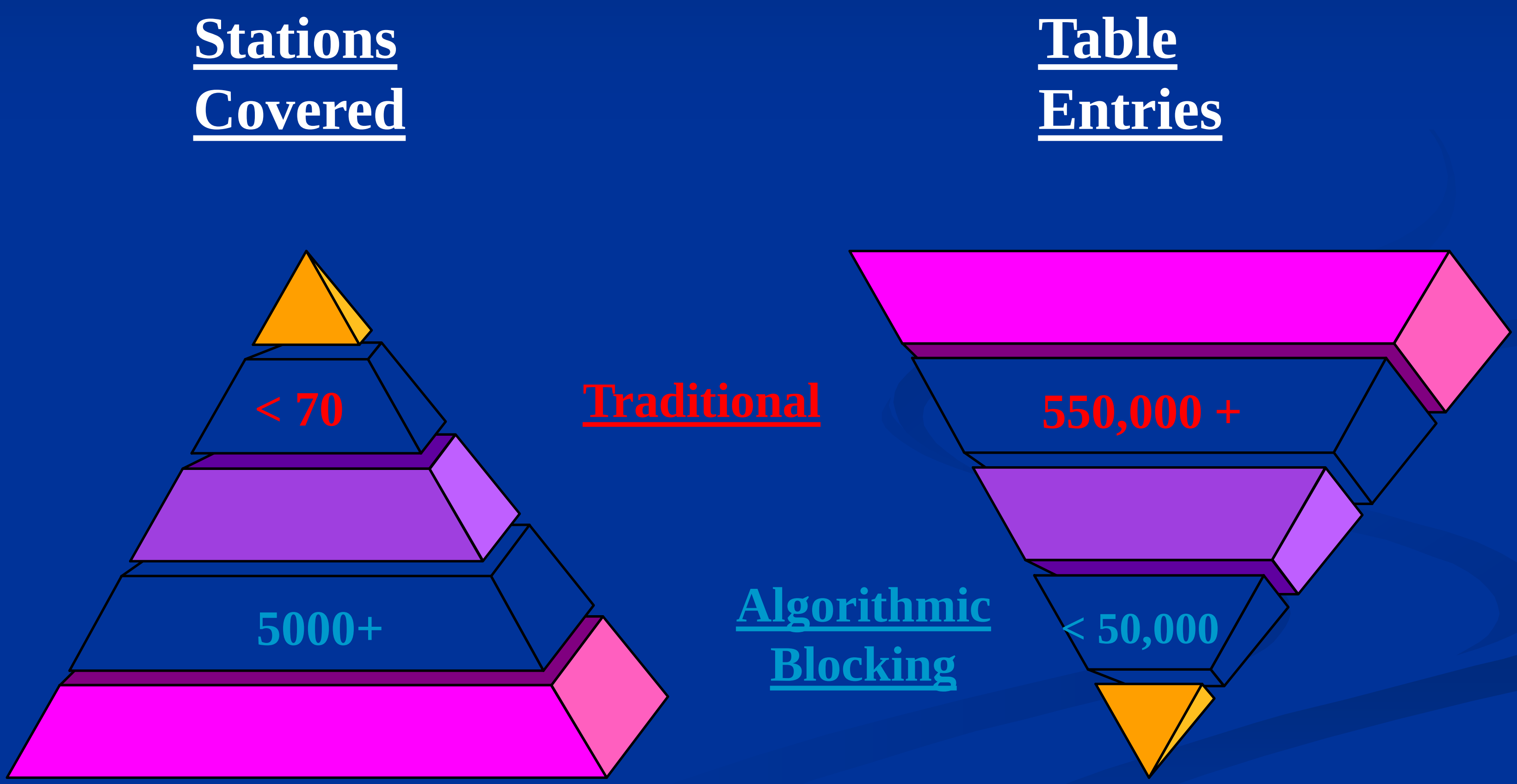
- From Kansas City
- To E Leavenworth
- Any Traffic

Block Definition

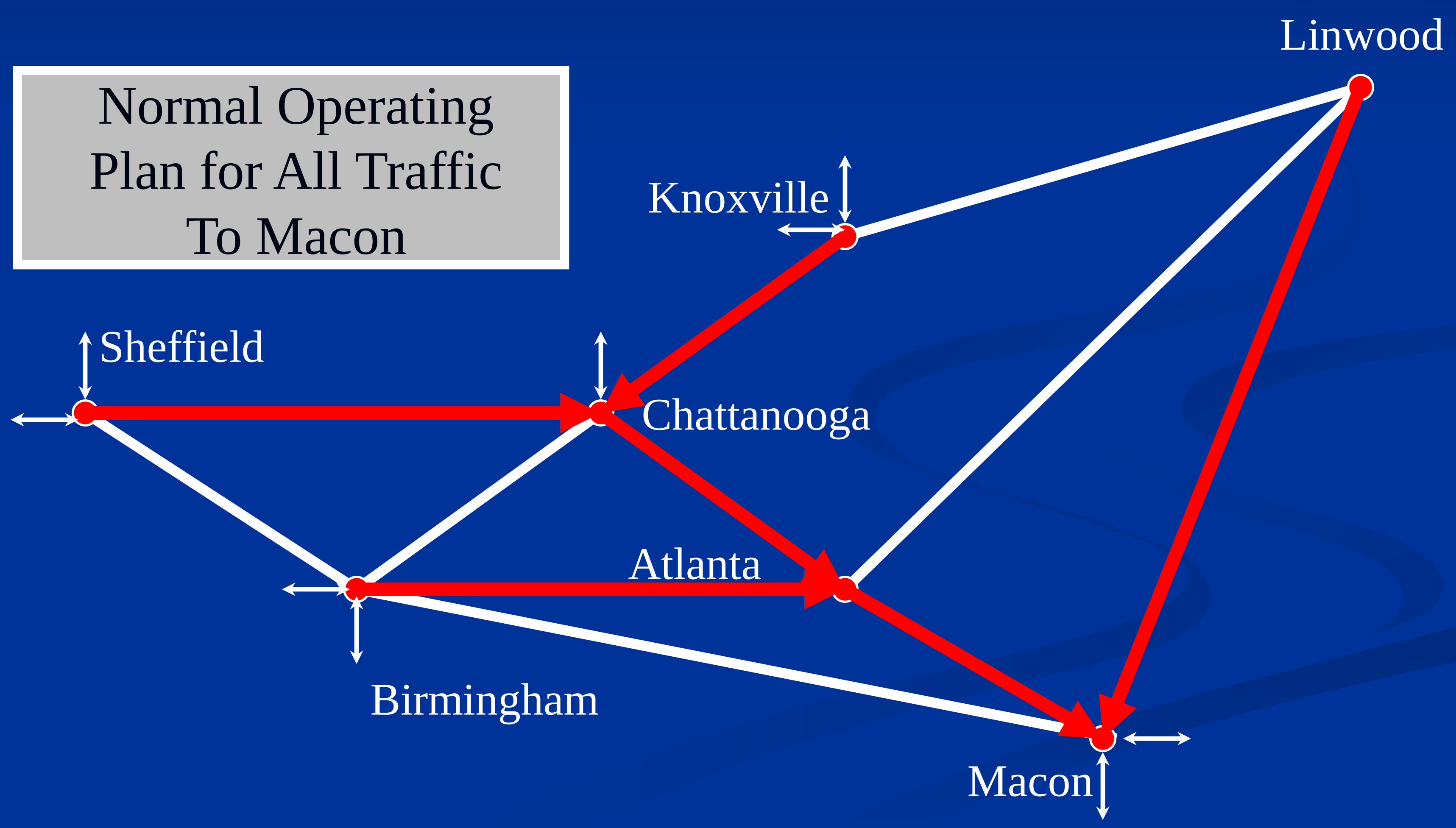
- From Kansas City
- To Waldron
- Any Traffic

Changing Routes with Algorithmic Blocking

Rule Maintenance Simplification with Algorithmic Blocking



Real-Life Rerouting Problem
1996 Atlanta Olympics

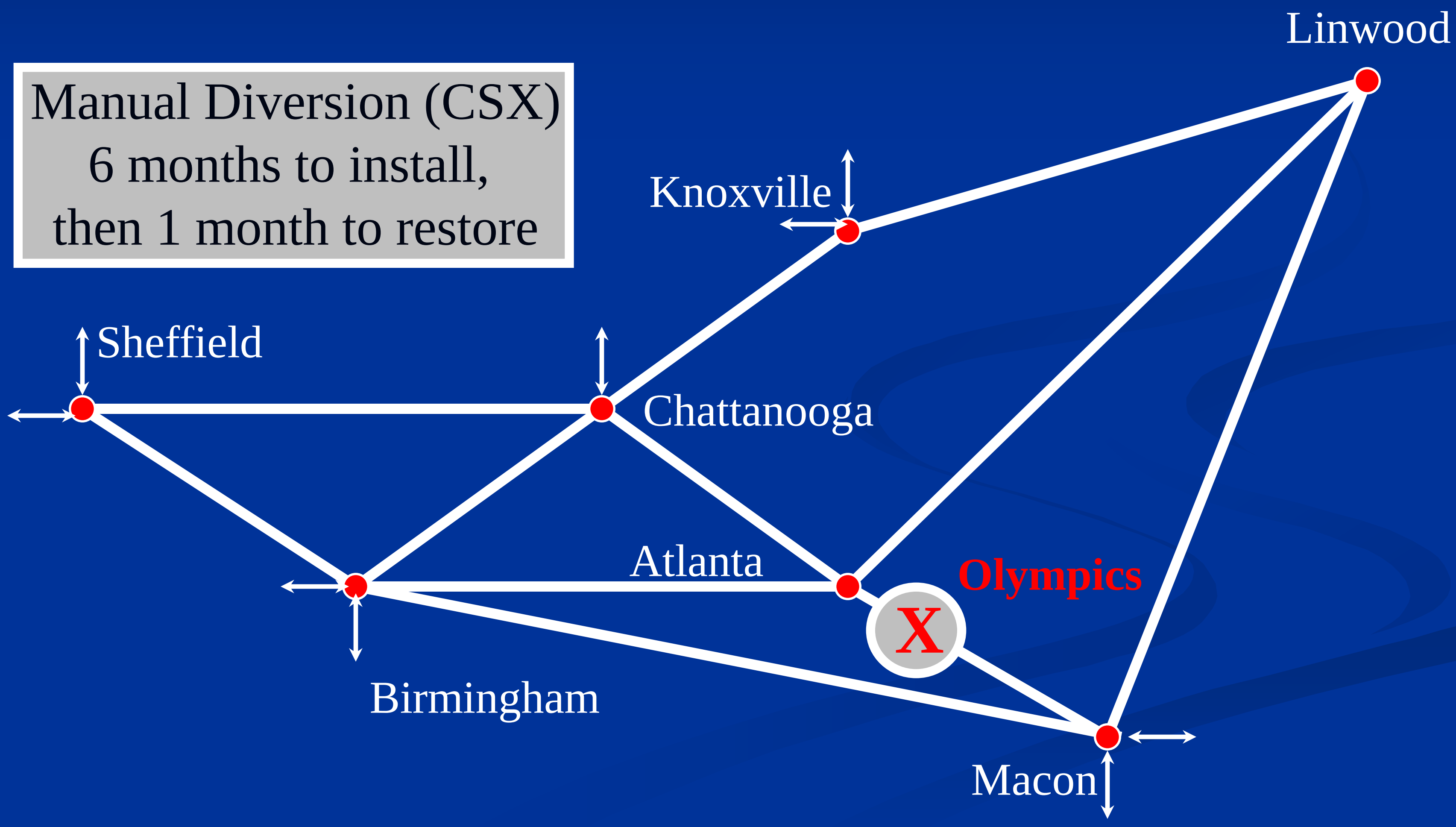


Real-Life Rerouting Problem
1996 Atlanta Olympics

Olympics required rerouting of hazardous material Atlanta - Macon

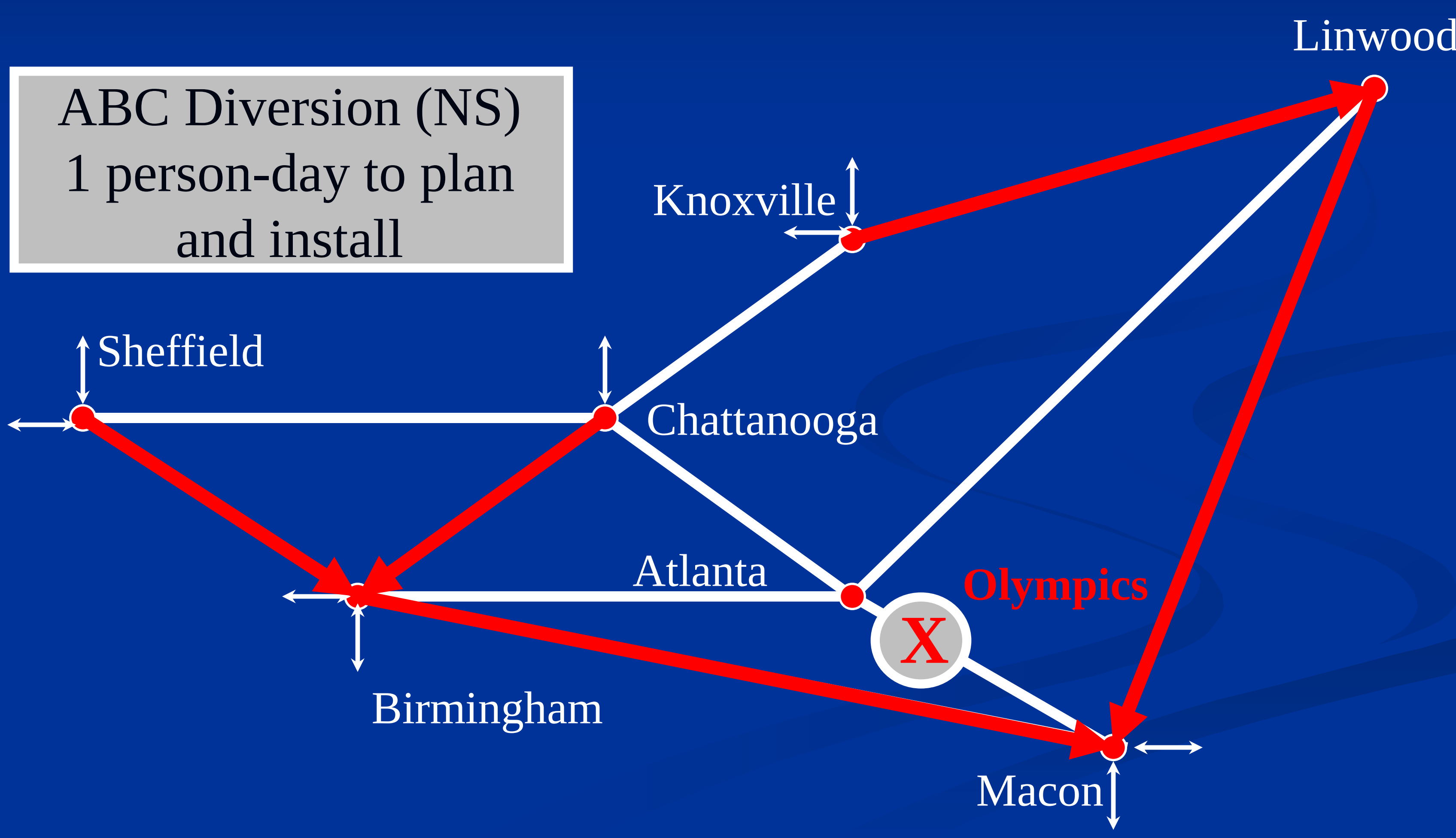
Real-Life Rerouting Problem
1996 Atlanta Olympics

Manual Diversion (CSX)
6 months to install,
then 1 month to restore



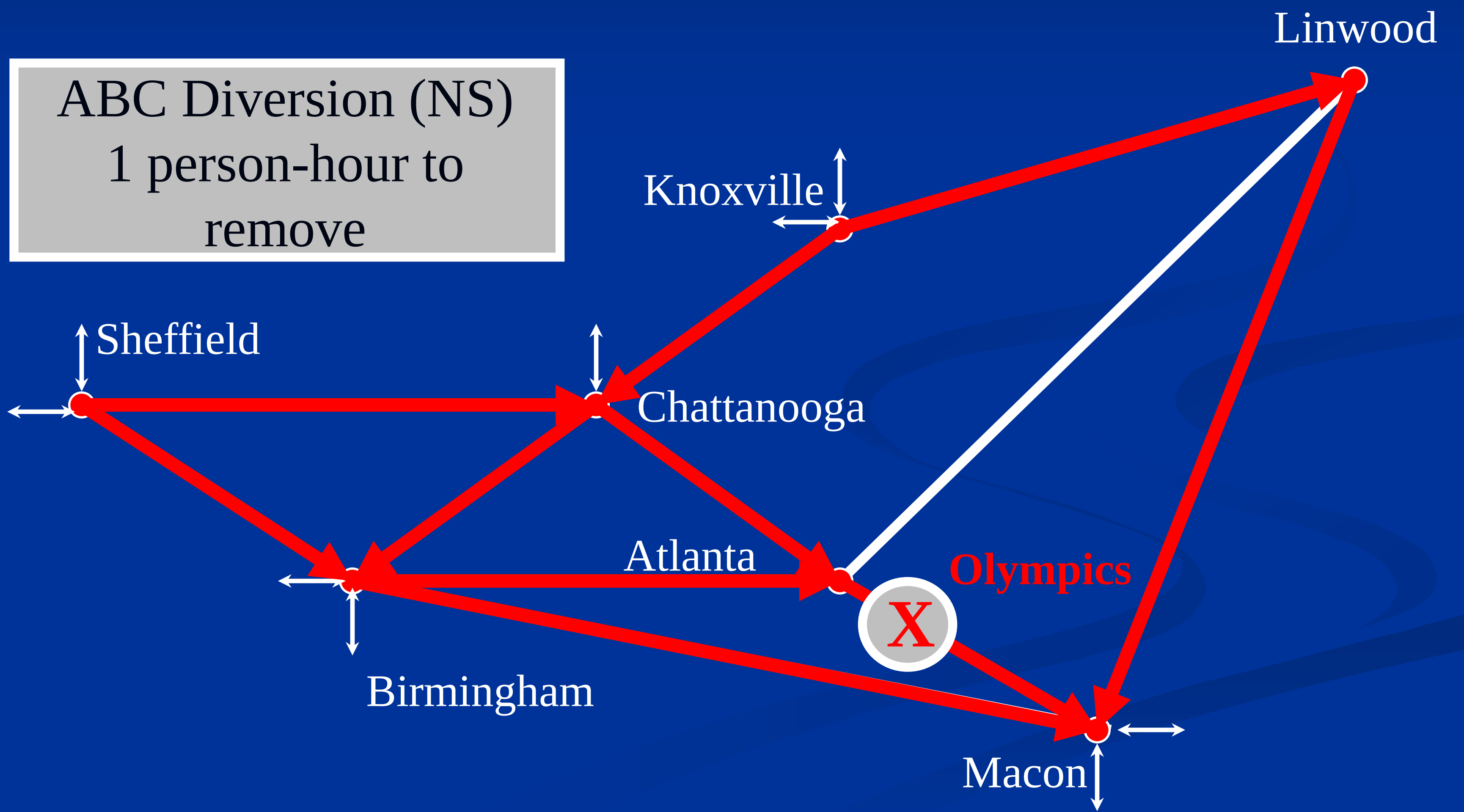
Real-Life Rerouting Problem 1996 Atlanta Olympics

ABC Diversion (NS)
1 person-day to plan and install



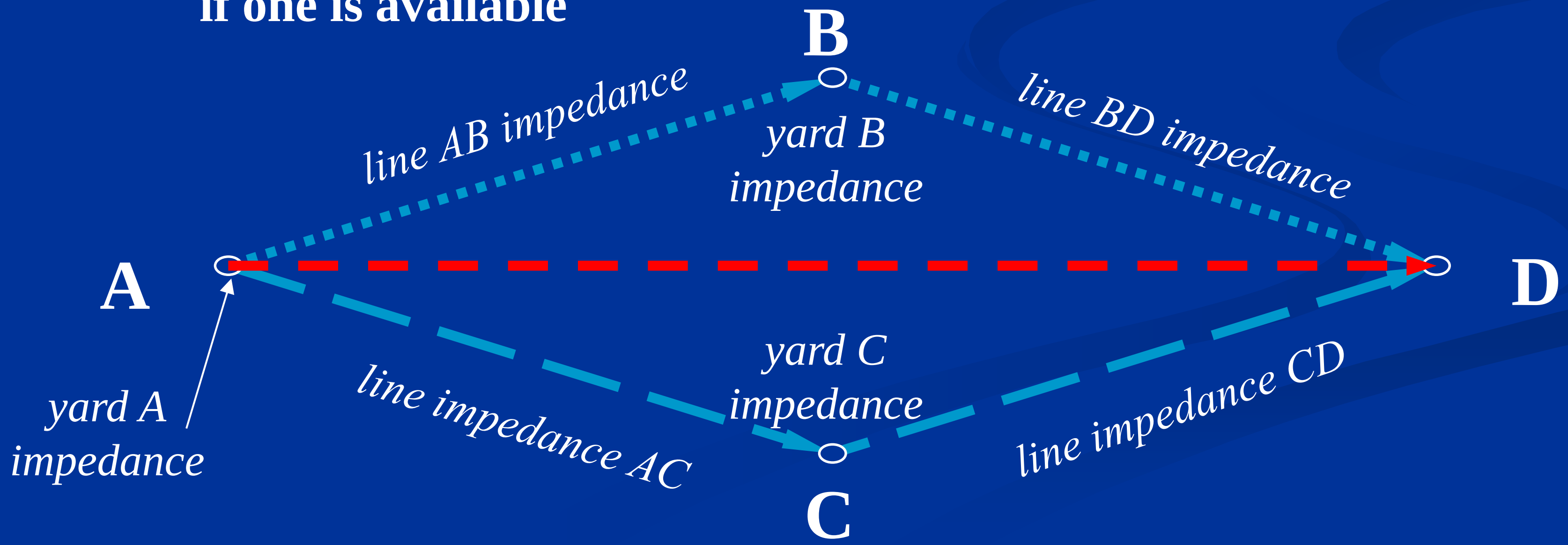
Real-Life Rerouting Problem
1996 Atlanta Olympics

ABC Diversion (NS)
1 person-hour to remove



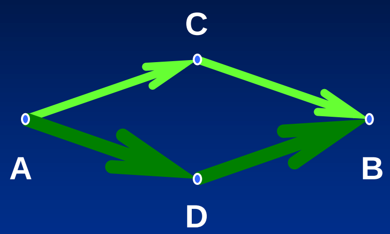
The Fundamentals of Algorithmic Blocking

- **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**

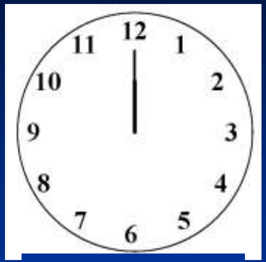


Limitations of Algorithmic Blocking

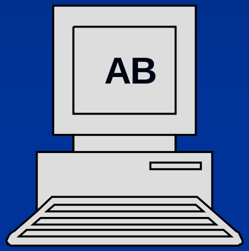
- Routes across a sequence of blocks
  - No consideration of trains and train connections
  - No consideration of time
- No ability to consider capacity constraints
  - Blocks do not have capacity constraints – trains do
  - Capacity is a function of time, so failure to consider time prevents capacity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

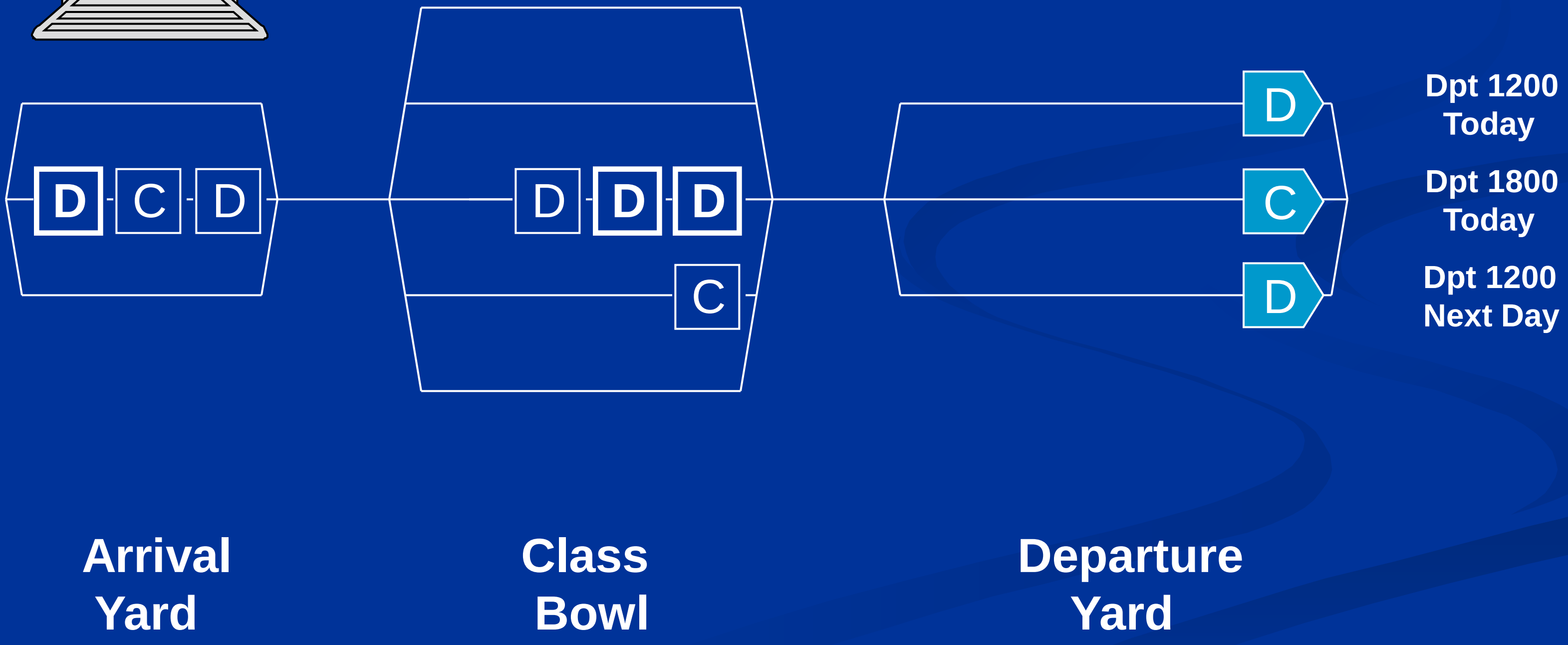


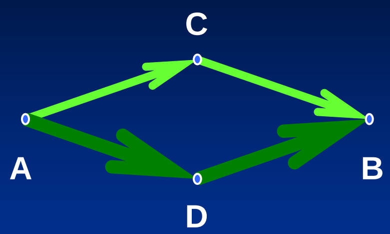
A Look at a Terminal
Cars At Yard A
Algorithmic Blocking



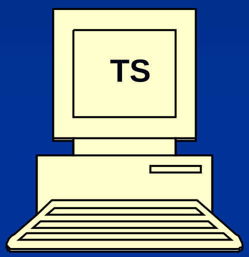
Next PM

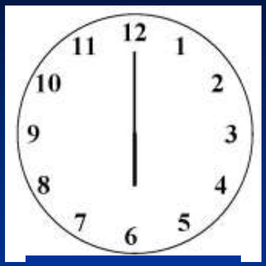






A Look at a Terminal
Cars At Yard A
Time-Space Solution





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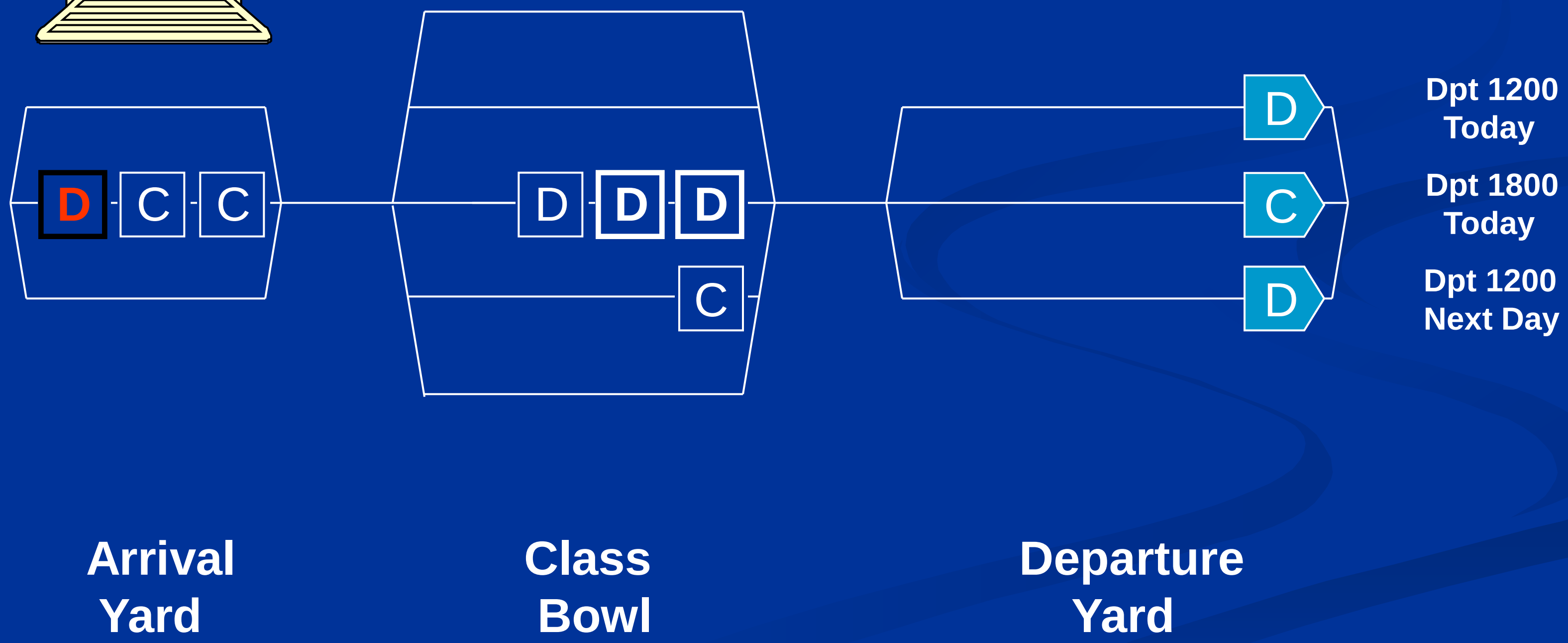
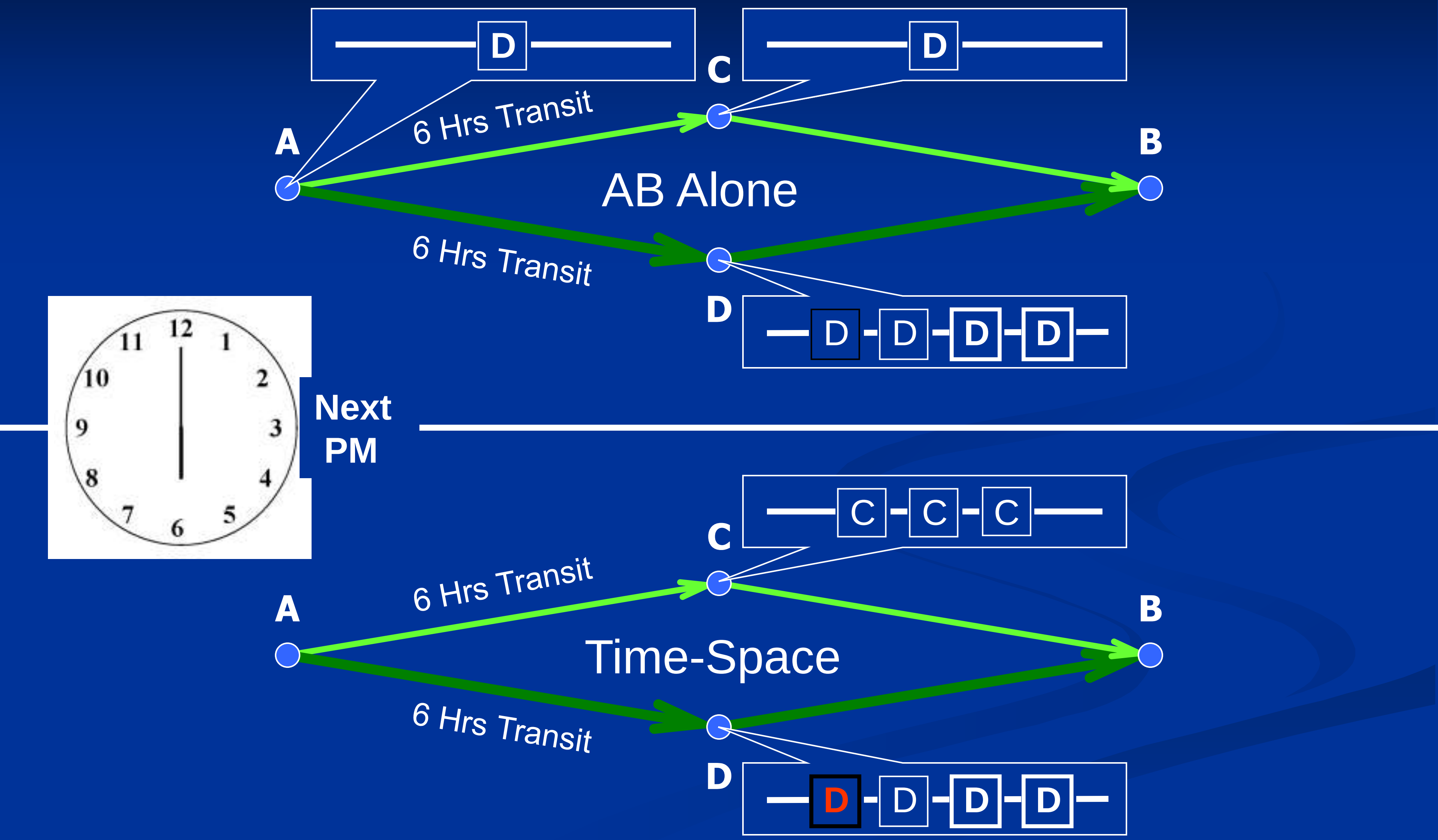
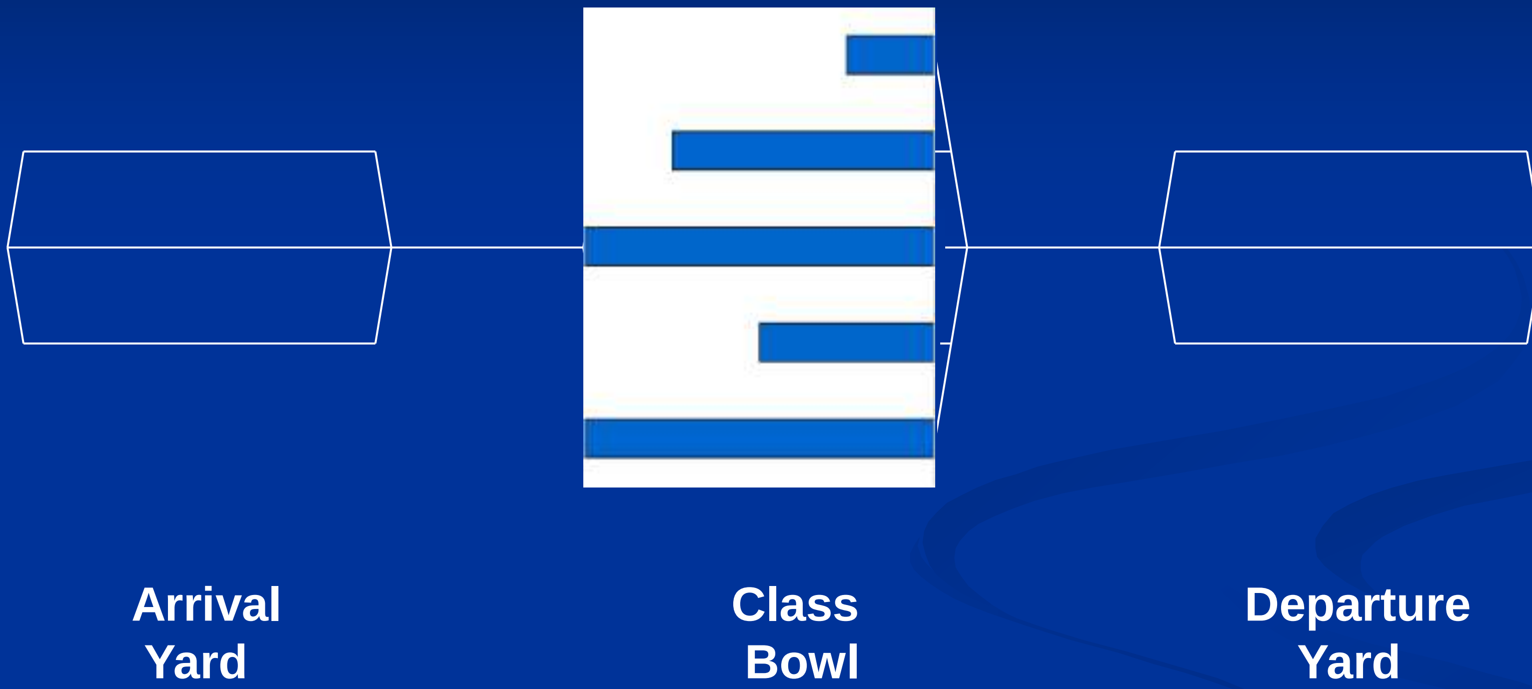


Another Look at the Network



Convergence of Terminal and System Views



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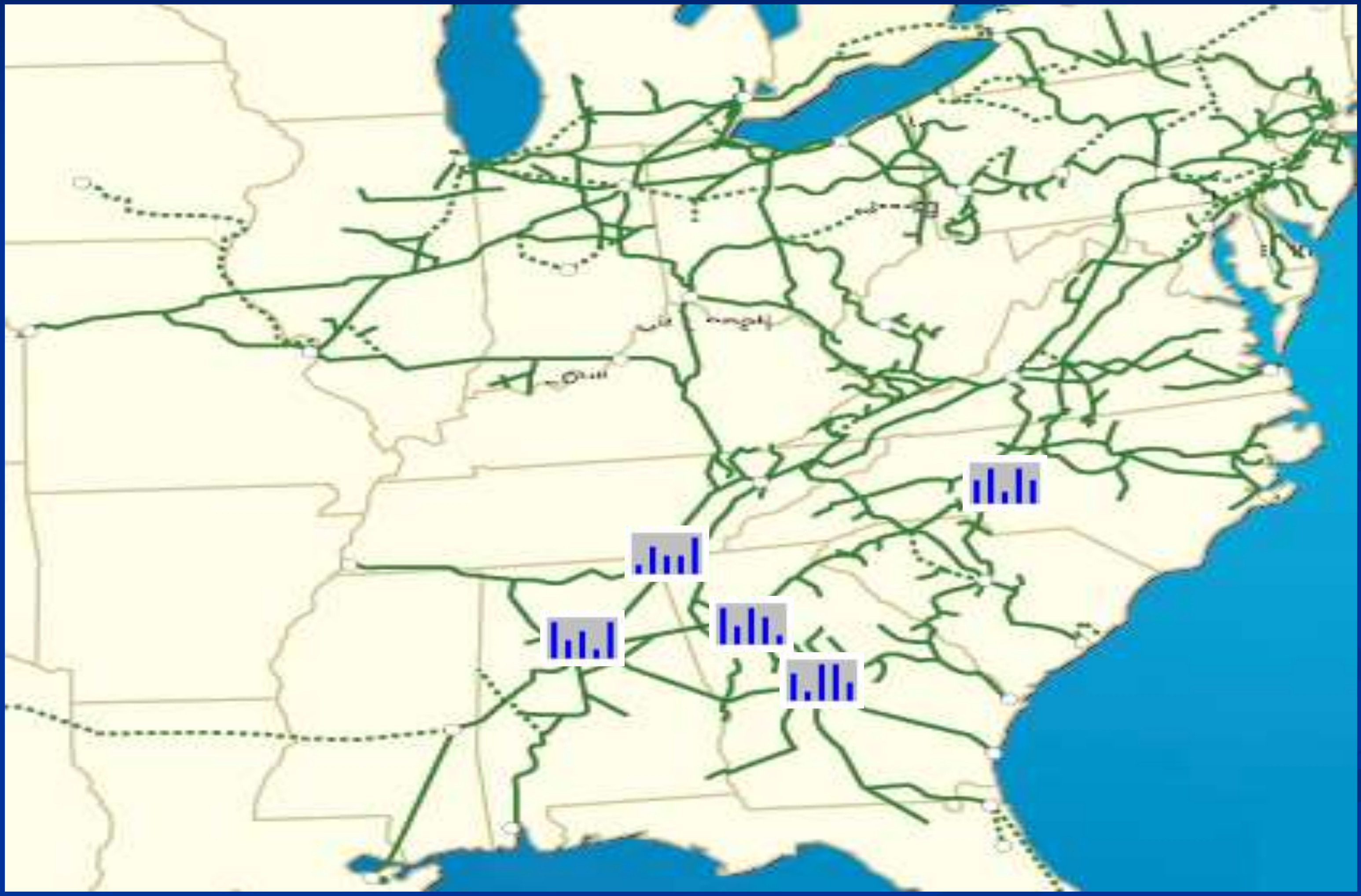

Where Do We Go From Here?

- 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.

BNSF[SM]